AGRONOMY (AGRONOMIA)

Floristic composition, phytosociology and weed diversity in chives (*Allium schoenoprasum* L.)

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ABSTRACT: Assessment of floristic composition, phytosociology and diversity of weed communities are crucial for weed control in chives. A survey was conducted on two selected chives cropping fields in the state of Maranhão, northeastern Brazil to identify the weed flora and the most important weed species associated with chives. The weed survey was carried out by the quadrat method with 30 weed samples taken from each chives field. Phytosociological parameters assessed were absolute and relative densities, frequencies and abundances and the importance value of each species. Weed diversity was assessed by the Shannon Diversity Index (H'). We recorded a total of 3,689 individuals from 36 species and 16 families. The two families with the highest species richness were Poaceae (n = 7) and Cyperaceae (n = 5). The greater number of species (30) was recorded in the chives grown in Catucá. The most important species based on the importance value were *Hediotys corimbosa*, *Schoenoplectus juncoides* and *Ludwigia octovalvis,* in Areal and *Eleusine indica*, *Trianthema portulacastrum* and *Cyperus iria* in Catucá. Floristic diversity was higher in Areal (H' = 5.21 nats. ind^{-1}). These results could lead to improved weed management strategies in chives croppping in the state of Maranhão, northeastern Brazil.

Key words: allelopathy; competition; *Eleusine indica*; *Hediothys corimbosa*; vegetables

Composição florística, fitossociologia e diversidade de plantas daninhas no cultivo da cebolinha (*Allium schoenoprasum* L.)

RESUMO: Avaliação da composição florística, da fitossociologia e da diversidade de comunidades de plantas daninhas são cruciais para o controle dessas espécies no cultivo de cebolinha. Um levantamento foi realizado em dois campos cultivados com cebolinha no estado do Maranhão. O objetivo foi identificar a flora de plantas daninhas e as espécies mais importantes associadas à cebolinha. O levantamento foi realizado pelo método quadrado inventário com 30 amostras em cada campo de cebolinha. Os parâmetros fitossociológicos avaliados foram a densidade, a frequência, a abundância e o valor de importância de cada espécie. A diversidade florística foi avaliada pelo Índice de Diversidade de Shannon. Foram registrados 3.689 indivíduos de 36 espécies e 16 famílias. As duas famílias com maior riqueza de espécies foram Poaceae (n= 7) e Cyperaceae (n = 5). Catucá teve o maior número de espécies (30). As espécies mais importantes baseadas no valor de importância foram *Hediotys corymbosa*, *Schoenoplectus juncoides* e *Ludwigia octovalvis*, em Areal e *Eleusine indica*, *Trianthema portulacastrum* e *Cyperus iria* em Catucá. A diversidade florística foi maior em Areal (H' = 5.21 nats. ind^{-1}). Estes resultados podem contribuir para melhorar o manejo de plantas daninhas no cultivo de cebolinha no estado do Maranhão, nordeste do Brasil.

Palavras-chave: alelopatia; competição; *Eleusine indica*; *Hediothys corymbosa*; hortaliças

Introduction

Chives (*Allium schoenoprasum* L.), Alliaceae, from European origin, is a seasoning leafy vegetable with cylindrical, fistulous (hollow), aromatic leaves and inflorescences of the umbel type, with purplish-colored flowers. It is a perennial species that can reach 30 to 50 cm in height and reproduces both by seeds and by tillers produced by the adult plant (Heredia Zárate et al., 2003).

Experimental studies have shown that chives has health benefits (Hanen et al. 2002). Moreover, it is a rich source of antioxidants (Štagner et al. 2011; Xavier et al. 2011), has anti-microbial properties (Sharifi-Rad et al. 2016) and produces phenolic compounds with antiproliferative and tumor arresting effects (Kucekova et al. 2016).

Due to the plant architecture being cylindrical with erect leaves, chives cannot shade the soil. This means that there are enough spaces in the soil for germination, establishment and growth of weeds that interfere with the crop growth and development. Thus, weeds are a major biological constraint limiting chives yield.

Weeds negatively affect chives cropping by competition for water, nutrients, space and light and by allelopathy, that is, the production and release of toxic substances that inhibit germination and growth of other species associated with them. Moreover, many weed species are intermediate hosts of pests and diseases (Silva et al., 2006).

According to Pereira & Melo (2008), weed incidence in vegetable crops varies depending on the species, particularly with respect to the vegetable plant architecture and different plant spacings, among other factors. It is generally accepted that vegetable crops that shades the soil grow with little interference from weeds.

Weed surveys, associated with phytosociological studies and assessment of floristic diversity, are important to understand the weed community structure and crucial to subsidize weed management practices in chives cultivation.

Floristic and phytosociological surveys of weeds have already been carried out in several vegetable crops, including tomato (*Lycopersicum esculentum* Mill.) (Correa, 2015), okra (*Abelmoschus esculentus* Moench) (Bachega et al., 2013; Santos et al., 2017), turnip (*Brassica napus* L.), lettuce (*Lactuca sativa* L.), sweet potato [*Ipomoea batatas* (L.) Lam.] (Raya et al., 2013), and watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] (Maciel et al., 2008), but there is no report on weed floristic and phytosociological surveys on chives yet.

Chives cultivation has great expressiveness in northeastern Brazil, particularly in the state of Maranhão. Data on the geographical distribution of vegetable production show that, in relation to the number of establishments that grow vegetables in Maranhão, chives occupies the third position, with 1,998 establishments after West Indian gherkin (*Cucumis anguria* L.) with 3,788 establishments and green maize (*Zea mays* L.), with 3,487 establishments (Embrapa, 2016). However, there are no reports on the occurrence of weeds in chives in this region.

In this context, the objectives of this research were to carry out floristic and phytosociological surveys, to compute phytosociological parameters and to assess the floristic diversity of the weed community in chives cultivation in the state of Maranhão, northeastern Brazil.

Material and Methods

Study site

This research was carried out in Areal (4°14'12,2 "S and 44°49'21,8" W) and Catucá (4°09'04 "S and 44°40'40,1" W) villages, located 50 km way from each other in the municipality of Bacabal, in the central portion of the state of Maranhão, northeastern Brazil.

The climate of the region is Aw, according to the classification of Köppen, a tropical climate, hot and humid with one rainy season that extends from January to June and a dry one, from July to December. In the rainy season, the average rainfall reaches about 1,558.86 mm and in the dry season, it is around 166.00 mm (Silva et al., 2016). The average temperature is 25 °C.

The relief is flat and smooth wavy. The altitude is approximately 38 meters. It can be noticed the presence of residual hills in some stretches. These forms were modeled in the siltites, argillites and sometimes clayey sandstones and shales that are part of the lithology of the Itapecuru Formation. Soils of the study sites are classified as Plintosols with clayey texture in Catucá and Latosols, with sandy texture in Areal (IBGE, 1997; Embrapa, 2006).

Vegetation in the two sites is classified as open ombrophylous forest with Babaçu (*Orbignya phalerata* Mart.) Arecaceae, secondary forest fallow regrowth, which had suffered frequent previous slash-and-burn cycles of agriculture (Gehring et al. 2011).

According to information from the local farmers, Areal has been cultivated with chives for about 20 years and Catucá for 35 years.

Description of the chives cropping system

The most traditional chives cultivar planted in the two sites is "Todo Ano", which hails from Europe and has leaves of light green color. It is considered a perennial species, with cylindrical and fistulous leaves, height ranging from 0,30 to 0,50 m, that also produces small conical bulb, surrounded by a rosy film, with tillering and clump formation (Heredia Zárate et al., 2003).

Chives are vegetatively propagated. Seedlings are harvested, cleaned and are prepared a day before planting. Roots and dried sheaths are removed and leaves are cut to leave five cm bulblets. Seedlings are then planted, leaving about four cm of the bulblets uncovered.

Chives planting is done with spacing varying from 20 to 40 cm between rows and 15 to 30 cm between plants within rows in manually prepared beds, with approximately 10 meters long, one meter wide and 30 cm high made by family farmers organized in community associations.

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The basic fertilization is done with cattle manure, in the dose of 20 kg m^{-2} of bed. Plants are watered daily using surface irrigation. Weeds are controlled by hoeing between rows and hand weeding within the row once or twice a month, depending on the level of infestation. Pest control is done occasionally and the occurrence of diseases is usually not controlled. Chives with all healthy leaves longer than 15 cm, are harvested at 50 days after planting by cutting leaves at the soil level.

Floristic survey and weed species identification

The weed flora was sampled 25 days after planting, just before the first weeding in order to identify as many species as possible and consequently to evaluate the floristic diversity before the species were controlled by the farmers. Field work was done on May 11th 2016 in Areal and on May 13th 2016 in Catucá villages by randomly launching a 1.0 m x 1.0 m metal quadrat 30 times on the beds planted with chives in each site. The total planted area with chives in each site was 3,000 m^2. Thus the total sampled area was 30 m^2 for each site.

The weeds that remained in the perimeter of the quadrat were cut close to the ground, identified, separated by species and counted. The data were organized in spreadsheets by inputting the scientific name of each species and the respective botanical family. Species were identified by means of comparisons with other species already identified in the literature and also by consulting experts.

The floristic list with families and species was organized according to the classification system established in the Angiosperm Phylogeny Group IV guidelines (APG IV, 2016). All scientific names and their authors were confirmed after verification in the International Plant Names Index (IPNI, 2017).

Computation of phytosociological parameters

The number of individuals of each species identified in the floristic survey served as basis for computing the following phytosociological parameters: absolute and relative frequencies, absolute and relative densities, absolute and relative abundances, and the importance value of each species (Muller-Dombois & Ellemberg, 1974).

Although all the absolute and relative values of the phytosociological parameters were computed, we presented and discussed only the relative data, in percentage.

The phytosociological parameters were computed using the following Equations 1, 2, 3, 4, 5, 6 and 7.

$$AFi = \frac{NSi}{TNS} \qquad (1)$$

where: AFi = absolute frequency of the species i; NSi = number of samples with the presence of the species i; TNS = total number of samples.

$$RFi = \frac{AFi}{\sum AF} \times 100 \qquad (2)$$

where: RFi = relative frequency of the species i; AFi = absolute frequency of the species i; ∑ AF = sum of all absolute frequencies.

$$ADi = \frac{TNi}{A} \qquad (3)$$

where: ADi = absolute density of the species i; TNi = total number of individuals of the species i; A = area sampled in hectares.

$$RDi = \frac{ADi}{\sum AD} \times 100 \qquad (4)$$

where: RDi = relative density of the species i; ADi = absolute density of the species i; ∑ AD = Sum of all absolute densities.

$$AAi = \frac{TNi}{TNSi} \qquad (5)$$

where: AAi = absolute abundance of the species i; TNi = total number of individuals of the species i; TNSi = total number of samples with the presence of the species i.

$$RAi = \frac{AAi}{\sum AA} \times 100 \qquad (6)$$

where: RAi = relative abundance of the species i; AAi = absolute abundance of the species i; ∑ AA = Sum of all absolute abundances.

$$IVi = RFi + RDi + RAi \qquad (7)$$

where: IVi = importance value of the species i; RFi = relative frequency of the species i; RDi = relative density of the species i; RAi = relative abundance of the species i.

Assessment of floristic diversity

Floristic diversity of each site was assessed by the Shannon Diversity Index (*H'*) based on natural logarithm, which considers equal weight among rare and abundant species. It is considered that the higher the value of *H'* the greater the floristic diversity will be (Shannon & Weaver, 1949). The Shannon Diversity Index was computed by the Equation 8.

$$H = -\sum_{I=1}^{S} pilnpi \qquad (8)$$

where: ln is the natural logarithm; pi = ni/N; ni is the number of sampled individuals of the species i; and N is the total number of sampled individuals. The result is expressed in natural digits (nats) per individual, because the formula uses a log base e. It varies from 1.5 to 3.5 and hardly exceeds 4.0 (Kwak & Peterson, 2007).

Results and Discussion

We recorded 16 families with 36 species represented by 3,689 individuals (Table 1). The largest number of individuals, 2,160 (58.6%) was recorded in chives grown in the Areal village.

The two families that had the highest species richness were Poaceae (n = 7) and Cyperaceae (n = 5). These families collectively accounted for 33% of the species sampled in the weed floristic composition of the two sites (Figure 1).

Qian et al. (2008) also reported similar results, with the Poaceae family as the most representative in a weed survey carried out on chives in Xanghai, composing 20% of the sampled species.

Research results with other vegetables, such as cowpea, [*Vigna unguiculata* (L.) Walp.] carried out by Marques et al. (2010) in the state of Maranhão and a phytosociological survey of weeds carried out in lowland tomatoes (*Lycopersicum esculentum* Mill.) grown in the states of Goiás, Minas Gerais
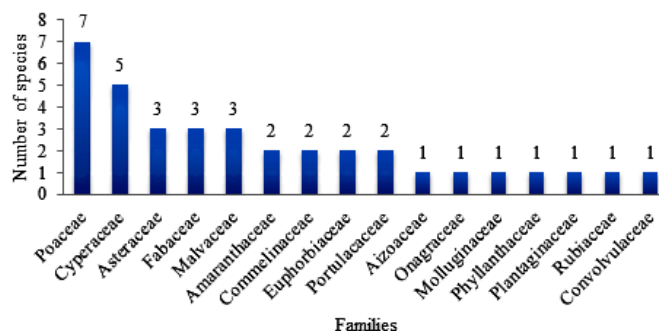
Figure 1. Floristic composition of the weed community in chives grown in Areal and Catucá villages, in the municipality of Bacabal, state of Maranhão, northeastern Brazil.

and São Paulo, by Correa (2015), showed that Cyperaceae and Poaceae were the more representative families in relation to species richness.

Moreover, Raya et al. (2013) in floristic weed survey on vegetables such as turnip (*Brassica napus* L.), lettuce (*Lactuca*

Table 1. List of species, families and number of individuals of weeds in chives grown in Areal and Catucá villages in the municipality of Bacabal, state of Maranhão, northeastern Brazil.

Species	Family	Number of individuals	
		Areal	Catucá
Trianthema portulacastrum L.	AIZOACEAE	4	262
Amaranthus lividus L.	AMARANTHACEAE	17	39
Amaranthus retroflexus L.	AMARANTHACEAE	1	----
Eclipta prostata L.	ASTERACEAE	1	----
Emilia coccinea (Sims) G. Don	ASTERACEAE	----	1
Emilia sonchifolia (L.) DC	ASTERACEAE	----	34
Commelina benghalensis L.	COMMELINACEAE	34	11
Murdannia nudiflora (L.) Brenan	COMMELINACEAE	22	105
Ipomoea triloba L.	CONVOLVULACEAE	----	1
Cyperus aggregatus (Willd.) Endl.	CYPERACEAE	----	1
Cyperus iria L.	CYPERACEAE	96	150
Fimbristylis miliacea (L.) Vahl	CYPERACEAE	3	5
Pycreus lanceolatus C. B. Clarke	CYPERACEAE	48	----
Schoenoplectus juncoides (Roxb.) Palla	CYPERACEAE	425	12
Chamaesyce hirta (L.) Millsp.	EUPHORBIACEAE	161	104
Chamaesyce prostrata (Aiton) Small	EUPHORBIACEAE	87	3
Crotalaria incana L.	FABACEAE	8	----
Crotalaria spectabilis Roth	FABACEAE	----	1
Desmodium adscendens (Sw.) DC.	FABACEAE	----	6
Sida cordifolia L.	MALVACEAE	3	----
Sida glaziovii K. Schum	MALVACEAE	7	20
Sida rhombifolia L.	MALVACEAE	----	7
Mollugo verticillata L.	MOLLUGINACEAE	3	----
Ludwigia octovalvis (Jacq.) P.H. Raven	ONAGRACEAE	233	2
Phyllanthus niruri L.	PHYLLANTHACEAE	65	7
Lindernia crustacea (L.) f. Muell	PLANTAGINACEAE	126	70
Cenchrus echinatus L.	POACEAE	3	33
Cynodon dactylon (L.) Pers.	POACEAE	----	1
Digitaria sanguinalis (L.) Scop.	POACEAE	8	38
Echinochloa colona (L.) Link	POACEAE	----	24
Eleusine indica (L.) Gaertn	POACEAE	44	451
Paspalum distichum L.	POACEAE	----	1
Sporobulus indicus (L.) R. Br.	POACEAE	124	11
Portulaca oleracea L.	PORTULACACEAE	34	101
Talinum paniculatum (Jacq.) Gaertn.	PORTULACACEAE	2	2
Hedyotis corymbosa (L.) Lam	RUBIACEAE	601	26

sativa L.) and sweet potato [*Ipomoea batatas* (L.) Lam.] in Malaysia also reported that these botanical families accounted for 43% of the sampled weed species.

In one hand, Poaceae family species richness is related to the way most of their species grow with dense clumps or the presence of rhizomateous and stolonipherous individuals widely scattered in the weed community. This is considered a major feature of the dominance of this family in many cropping fields (Munhoz & Felfili, 2006).

On the other hand, Cyperaceae family species richness reflects the competitive advantage, that is, the ability of vegetative propagation through a complex underground system consisting of rhizomes and tubers with many species having underground stolons (Munhoz & Felfili, 2006). In addition to this, formation of a significant seed bank is an important regeneration component for many species of this family (Leck & Schütz, 2005; Mesquita et al., 2013).

The greatest number of species was recorded in Catucá (n = 30), and the lowest in Areal (n = 27), however, the weed density was higher in Areal, with 180 plants. m^{-2} against 127 plants. m^{-2} in Catucá. Differences in the number of weed species and weed density are due to the history of the areas and weed management adopted by the farmers; Catucá, for example, is under chives cultivation for a longer time (35 years) than Areal (20 years), therefore the weed community is higher in Catucá. Although weed control practices by hoeing between rows and hand weeding within rows are similar in both sites, data of weed density indicates that weed control is more efficient in Catucá where weed density was 29% lower than in Areal.

Of the 36 species recorded in this study, 20 (56%), were common to the two sites: *T. portulacastrum, A. lividus, C. benghalensis, M. nudiflora, C. iria, F. miliacea, S. juncoides, C. hirta, C. prostrata, S. glaziovii, L. octovalvis, P. niruri, L. crustacea, C. echinatus, D. sanguinalis, E. indica, S. indicus, P. oleracea, T. paniculatum* and *H. corymbosa*. This indicates that they have not only great plasticity, that is, the capacity to adapt to different sites, but also tolerance to stress imposed by the weed control methods used by the farmers.

In contrast, six species were recorded only at Areal: *A. retroflexus, E. prostrata, P. lanceolatus, C. incana, M. verticilata* and *S. cordifolia,* and 10 species were found only at Catucá: *E. coccinea, E. sonchifolia, I. triloba, C. aggregatus, C. spectabilis, D. adscendens, S. rhombifolia, C. dactylon, E. colona* and *P. distichum*.

The occurrence pattern of herbaceous plants such as weeds in space is heterogenous and complex. Climate variables and different microhabitat conditions in the soil can act as regulators of populations in the herbaceous community, reflecting in the variations of birth and mortality rates, and in density, favoring the emergence of certain exclusive species in a given habitat (Araújo et al., 2005; Silva et al., 2016).

On the other hand, Munhoz & Felfili (2006), observed that some species may have different establishment strategies in time and space. In addition, differences in weed species occurrence in cropping fields may be related to the history of the areas and the crop management practices.

The predominant weed species in chives cultivation in the Areal village, considering the Importance Value (IV), in decreasing order, were *Hedyotis corymbosa*, (IV = 55.96%), *Schoenoplectus juncoides* (IV = 42.43%) and *Ludwigia octovalvis* (IV = 27.21%). In contrast, in Catucá village, the most important weed species were *Eleusine indica* (IV = 54.77%) *Trianthema portulacastrum*, (IV = 36.39%) and *Cyperus iria*, (IV = 24.65%).

The phytosociological parameters that most contributed to the Importance Value of the abovementioned species in both sites were the Relative Density and Relative Abundance, indicating that these species had the populations with greater participation in the weed community not only in numerical terms but also in the distribution of individuals in the chives cropping fields investigated, except for *L. octovalvis* in Areal and *C. iria* in Catuca where the Relative Density and Relative Frequency were the most important parameters in the composition of the Importance Value (Table 2).

The differences between the species of greater Importance Value in the two sites with the highest incidence of *E. indica* in the village of Catucá is probably because the soil where the

Table 2. Phytosociological parameters of weed communities with the ten species that stood out with the highest Importance Value in areas cultivated with chives at Areal and Catucá villages in the municipality of Bacabal, state of Maranhão, northeastern Brazil.

					Site				
	Areal					Catucá			
Species	RF	RD	RA	IV%	Species	RF	RD	RA	IV%
Hedyotis corymbosa	9.03	27.75	19.18	55.96	*Eleusine indica*	11.22	29.50	14.05	54.77
Schoenoplectus juncoides	8.74	19.65	14.04	42.43	*Trianthema portulacastrum*	8.35	17.14	11.02	36.39
Ludwigia octovalvis	8.74	10.77	7.70	27.21	*Cyperus iria*	9.10	9.81	5.74	24.65
Chamaesyce hirta	6.20	7.44	7.45	21.09	*Chamaesyce hirta*	9.60	6.80	3.80	20.20
Lindernia crustacea	7.15	5.83	5.07	18.05	*Mudannia nudiflora*	5.36	6.87	6.80	19.03
Sporobolus indicus	5.93	5.73	6.04	17.7	*Portulaca oleracea*	7.48	6.61	4.72	18.81
Cyperus iria	7.15	4.44	3.86	15.45	*Lindernia crustacea*	4.99	4.58	4.90	14.47
Chamaesyce prostrata	4.70	4.02	5.37	14.09	*Amaranthus lividus*	6.61	2.55	2.04	11.20
Phyllanthus niruri	6.58	3.00	2.87	12.45	*Cenchrus echinatus*	1.62	2.16	6.94	10.72
Pycreus lanceolatus	4.70	2.22	2.96	9.88	*Sporobulus indicus*	0.37	0.72	9.25	10.34

RF = Relative Frequency, RD = Relative Density, RA = Relative Abundance, IV = Importance Value.

chives are planted in this village is of clayey texture and more compacted (data not shown). Lorenzi (2008) states that the occurrence of *E. indica* in compacted soils is higher because it has a well-developed fasciculate root system that grows better in more densely soils. Moreover, *E. indica* produces allelopathic compounds, which inhibit the growth and development of other plants including vegetables.

The highest floristic diversity according to the Shannon Diversity Index was observed in Areal (*H'* = 5.21), versus (*H'* = 4.92) in Catucá. Both indices are higher than that obtained by Kostrzewska et al. (2014) in research carried out with pea (*Pisum sativum* L.) in Poland (H'= 0.8) and Chikoye et al. (2003), in green corn (*Zea mays* L.) grown in Nigeria (*H'* = 2.20) indicating the existence of greater weed floristic diversity in chives grown in the state of Maranhão. This is probably due to favorable climatic conditions for weed growth, especially the amount and regular distribution of rainfall during the rainy season.

Conclusions

The floristic composition of weeds varied between chives cultivation in Areal and Catucá villages in the state of Maranhão, northeastern Brazil. The highest floristic richness was recorded in Areal village, with 30 species of 16 botanical families. The two families with higher species richness are Poaceae and Cyperaceae,

The five most important species in chives cultivation in Areal village in decreasing order of Importance Value are *Hedyotis corymbosa Schoenoplectus juncoides Ludwigia octovalvis Chamaesyce hirta* and *Lindernia crustacea* whereas in Catucá, the most important are *Eleusine indica, Trianthema portulacastrum, Cyperus iria, Chamaesyce hirta* and *Murdannia nudiflora.*

The floristic diversity of weeds varied between chives cultivation in Areal and Catucá villages in the state of Maranhão, northeastern Brazil. The highest diversity was observed in Areal.

These results could lead to improved weed management strategies in chives cropping in the state of Maranhão, northeastern Brazil.

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