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Phytosociology of weed community in two vegetable growing systems

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The aim of this study was to perform a phytosociological survey of the weed community present in organic and conventional vegetable growing systems conducted in Alagoas state, in Brazil. The survey was carried out from February 2014 to January 2016, within which 30 samplings were made. The evaluated parameters were given by the calculation of frequency, density, abundance, relative frequency, relative density, similarity index (SI) and importance value index (IVI) for each species. In total, 299 weed species were identified, which were grouped into 11 botanical families: Amaranthaceae, Asteraceae, Commelinaceae, Cyperaceae, Euphorbiaceae, Malvaceae, Molluginaceae, Phyllantaceae, Poaceae, Rubiaceae and Solanaceae. The Euphorbiaceae family in conventional farming, stood out, since it showed an importance value index (IVI) more than, the Amaranthaceae family in the organic farming. In the conventional cultivation, IVI was of 91.53% for Asteraceae and 46.95% for Poaceae. Moreover, a major diversity of weed species was observed in organic cultivation, being superior to conventional one in all phytosociological parameters.

Key words: Diversity, olericulture, weed community.

INTRODUCTION

Vegetable growing in Brazil is diverse with more than 70 species of vegetables being produced and consumed. This production has increased in 33% during the last decade. Even though there has been a decrease of 5% in grown area, yields have been increased in 38% due to adoption of certain cultural practices (EMBRAPA Hortaliças, 2012).

The South and Southeast regions of Brazil are responsible for most part of the domestic production, wherein 60% of the farms are located near the great consumer centers. These greenbelts, as are so-called, are family farms of around 10 hectares, which are intensively exploited (Silva et al., 2015). Information released by the Brazilian Yearbook of Vegetable Growing indicate a production of around 18 thousand tons of vegetables within a planted area of 800,000 hectares, with an average yield of 23 tons per hectare, being equivalent to 94 kg per inhabitant year^{-1} (Anuário brasileiro de hortaliças, 2014).

Growing together with weeds is a factor that compromises yield and quality of agricultural crops, mainly with regard to vegetables. Weed species generally

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interfere with crops by competing for light and nutrients within the soil-plant system (Soares et al., 2010). The degree of interference of weeds in the crops depends on the distribution, frequency and abundance of the species, especially those that are in greater density and diversity (Kuva et al., 2000). Ricci et al. (2006) and Gama (2009) reported increasing frequency of weed species in organic cultivations, where agro-ecological practices are adopted instead of the use of herbicides, in which, even so, there is an increase of undesirable grass species are unwelcome for a selective management.

According to Gomes and Christoffoleti (2008), phytosociological surveys are necessary to bring knowledge of the distribution of a certain species over the others, allowing quantitative interpretation of a studied community, as well as viewing of their biological interrelations, assisting in weed management through the adoption of efficient of controls strategies. When dealing with agro-ecosystems of low yield, special attention should be given mainly with regard to ecological problems arising from the increase in irrigated areas, which enhance germination of weed seeds and soil salinization (Srivastava and Singh, 2014).

The production of safe food in a bountiful way is of great importance to solve the problems of world hunger. However, crop phytosanitary problems with pest insects and weeds hinder the achievement of such production targets. Improvements in pathogen control or coexistence between plants could significantly increase food production. The three major cereals - wheat, rice and maize - grown worldwide provide about 60% of human food. These crops are derived from weeds that have become the three plants abundantly scattered on planet Earth (Tilaman et al., 2002).

This study assumes that phytosociological parameters of a weed community (PPWC) within a farming system show the interaction between adopted management practices (MP) and weed species adaptation within the soil-plant system (WASP), that is, PPWC = MP + WASP. Thus, the aim of this research was to make a phytosociological survey of the weed community in two types of vegetable growing systems, organic (management with natural products) and conventional systems (management with synthetic products).

MATERIALS AND METHODS

The phytosociological survey of the weed community was carried out between the months of February 2014 to January 2016, in a 5.0-ha organic and conventional growing areas located within an environmentally harsh region of the State of Alagoas, Brazil. The survey was conducted in the field at 45 days after transplanting the seedlings, dividing each growing system into 30 plots. The plants in each plot were collected and properly identified following the Angiosperm Phylogeny Group - APG system.

Samplings were conducted by throwing a wooden square of 0.5 m² randomly on the net plot. All weeds within the square were considered as one sample and were identified by botanical family, using method similar to that used by Cunha (2014) and Kuva et al. (2000). Samples of plant material taken from the field were collected along with root system, being spread flat on sheets of newsprint duly identified and separated by botanical species and family; and then dried under Full sunlight at room temperature.

The weed species were quantified according to frequency, which expresses occurrence intensity at different areas, in percentage; to density, which is the number of plants per unit area, expressed in plants per square meter; and to abundance, which shows the concentration of certain species within a certain area. In addition to these calculations, the values of relative frequency, density and abundance were also quantified, with which it was possible to estimate the importance value index (IVI) for each species. This index establishes an integration parameter for the partial variables, joining them into one simple expression, showing the relative importance of each species in a better way when compared to other phytosociological parameters. For the calculations of such parameters, the equations below were used (Cunha et al., 2014):

$$\text{Frequency (Fr)} = \frac{\text{Total number of plots with the species} \times 100}{\text{number total of plots used}} \quad (1)$$

$$\text{Density (D)} = \frac{\text{Total number of individuals per species}}{\text{Total sample area}} \quad (2)$$

$$\text{Abundance (Ab)} = \frac{\text{Total number of individuals per species}}{\text{Total number of plots containing species}} \quad (3)$$

$$\text{Relative frequency (FrR)} = \frac{\text{Frequency species} \times 100}{\text{Overall frequency}} \quad (4)$$

$$\text{Relative density (DeR)} = \frac{\text{Density species} \times 100}{\text{Total density}} \quad (5)$$

$$\text{Relative abundance (AbR)} = \frac{\text{Abundance} \times 100}{\text{Overall abundance}} \quad (6)$$

$$Importance\ Value\ Index = DeR + FrR + AbR \quad (7)$$

Since the number of individuals per species was obtained, a descriptive analysis was made through phytosociological parameters represented by the relative importance (R.I%) (Pitelli and Pitelli, 2008). The IVI was estimated by equation too. The relative importance index was chosen to describe changes on weed community and on each weed species, because such index best expresses relationships among the populations composing the community. Such effectiveness come from the fact that this index considers for each plant population the frequency of occurrence, the number of individuals and the accumulated dry matter (Carvalho et al., 2008).

RESULTS AND DISCUSSION

The botanical diversity was significant, in which the weed community was represented by 299 species grouped into 11 families, being common to both growing systems. The

Table 1. Phytosociology data of weed communities in organic farming.

Species	Freq. (%)	Den. (%)	Abu. (%)	FrR. (%)	DeR. (%)	AbR. (%)	IVI (%)
Amaranthus deflexus L.	83.33	0.22	6.8	11.62	26.92	8.28	46.82
Amaranthus Lividus L.	16.66	0.01	2.00	2.32	1.32	2.43	6.07
Amaranthus spinosus L.	16.66	0.04	6.00	2.32	5.31	7.31	14.94
Amaranthus spp	50.0	0.086	4.66	6.97	10.45	5.67	23.09
Phyllanthus spp	16.66	0.01	4.00	2.32	1.32	4.87	8.51
Phyllanthus niruri L.	50.0	0.016	1.00	6.97	1.99	1.21	10.17
Chamaesyce hirta (L.) Milisp.	50.0	0.06	3.00	6.97	7.54	3.65	18.16
Chamaesyce prostrata (Aiton) Small	33.33	0.07	5.5	4.65	9.30	6.70	20.65
Acalypha communis Mull. Arg.	83.33	0.71	21.6	11.62	83.42	26.32	121.36
Cammelina benghalensis L.	66.66	0.19	7.5	9.30	23.35	9.13	41.78
Sida spp	66.66	0.04	1.5	9.30	4.88	1.82	16
Pennisetum clandestinum Hochst. ex Chiov	33.33	0.046	3.5	4.65	5.98	4.26	14.89
Brachiaria plantaginea (Link.) Hitchc.	16.66	0.006	1.00	2.32	0.67	1.21	4.2
Cynodon dactylon (L.) Pers.	16.66	0.02	3.00	2.32	2.23	3.65	8.2
Ricinus communis L.	16.66	0.02	4.00	2.32	2.65	4.87	9.84
Luziola peruviana juss. ex. J.F.Gmel	16.66	0.006	1.00	2.32	0.79	1.21	4.32
Eleusine indica (L.) Gaertn.	16.66	0.02	3.00	2.32	2.65	3.65	8.62
Pyhysalis pubescens L.	66.66	0.066	3.00	9.30	9.02	3.65	21.97

FrR =relative frequency; DeR= relative density; AbR= relative abundance; Freq = frequency; Abu= abundance; Den.=density; IVI= importance value index.

observed families were Amaranthaceae, Asteraceae, Commelinaceae, Cyperaceae, Euphorbiaceae, Malvaceae, Molluginaceae, Phyllantaceae, Solanaceae, Poaceae and Rubiaceae. Cunha et al. (2016) presented similar families in a phytosociological survey with forage tifton.

In organic farming, the highlighting species from Euphorbiaceae family were *Acalypha communis* Mull. Arg. (121.36%), *Chamaesyce prostrata* (20.65%) and *Chamaesyce hirta* (L.) Milisp. (18.16%). Data revealed that under conventional cultivation, Asteraceae family was predominant, which is considered one of the largest families of weed in number of species. The representative species were *Ageratum conyzoides* L. and *Conyza bonariensis* (L.). Surveying in sweet pepper cultivations, Cunha et al. (2014) found weed species similar to this research.

In the same way, Erasmo et al. (2004) reported similar results when assessing weed communities in wetlands of Viçosa in Minas Gerais state (Brazil); the authors highlighted the Euphorbiaceae family for showing the largest number of species in the studied areas. The high number of weed species in organic systems observed in this study may be due to the high potential viability of a seed bank to germinate where there is no herbicides applied.

Silva et al. (2007) stated that all agricultural land is a potential weed seed bank, holding about 2,000 and 50,000 seeds per square meter within the upper 10 cm of the soil profile. In vegetable crops, rhizosphere is quite shallow, which increases germination chances, even though in a given period, only 2 to 5% seed would germinate whereas the rest remain dormant.

The species of major importance in organic farming was *Acalypha communis* Mull. Arg., with an IVI of 121.36, found in plots at a frequency of 83.33% and density of 0.71 plant m^2 (Table 1). Vaz de Melo et al. (2007) noticed that Bidens pilosa was the species of greatest relative importance in crop of sweetcorn. Another genus that stands out is Amaranthus, commonly known as pigweed. Kissmann and Groth (2000) stated that there are about 60 plant species belonging to this genus (pigweed or caruru), among which 10 are important weed in crops (Table 1).

The genera Acalypha and Amaranthus showed major similarity indexes respectively, in the organic cultivation. In this environment, mulch is widely used, which hampers germination of soil seed bank. Nevertheless, this system presents a greater diversity of weeds compared to the conventional farming system growing the same vegetables (Braga et al., 2012).

The similarity index (SI) was used to verify the similarity among the weed species found in the plots in areas of organic cultivation. Through that, it was possible to detect similar genera existing among all evaluated plots; for instance, the species *A. communis* Mull. Arg. and *A. deflexus* L. showing SI of 83.72 and 26.35% (Table 2). For values above 25%, it is said that the species are adapting themselves to the current growing system, remaining their genotypes through seed bank (Table 2).

Table 2. Similarity index (SI) among all plot in the research area – organic farming.

Species	SI (%)
Amaranthus deflexus L.	26.35
Amaranthus Lividus L.	1.55
Amaranthus spinosus L.	4.65
Amaranthus spp	10.85
Acalypha communis Mull. Arg.	83.72
Brachiaria plantaginea (Link.) Hitch	0.77
Chamaesyce hirta (L.) Milisp.	6.97
Chamaesyce prostrata (Aiton) Small	8.52
Commelina benghalensis L.	23.25
Cynodon dactylon (L.) Pers.	2.32
Eleusine indica (L.) Gaertn.	2.32
Luziola peruviana Juss. ex J.F.Gmel	0.77
Pennisetum clandestium Hochst. ex Chiov.	5.42
Phyllanthus spp	3.10
Phyllanthus niruri L.	2.32
Sida spp	4.65
Ricinus communis L.	3.10
Pyhysalis pubescens L.	9.30

These values were higher than those found by Braga et al. (2012), who estimated this index for species found in no-till and conventional tillage, with or without limestone applications and at different times of evaluation. These authors found a value of 81.1%, which is considered high. Similar results were encountered by Duarte Jr. et al. (2009), who reported an index of 85.71% for infesting plants in different planting systems.

Among 41 individuals found in conventional farming, seven botanical families were identified, among which Asteraceae and Poaceae were the mostly present groups. These botanical families represent the main groups of existing weeds in Brazil. Furthermore, these families do not only occur in conventional crops, but also have great importance in other distinct production systems, such as sunflower, farming in wetlands and even in areas of lawns (Maciel et al., 2008; Brighenti et al., 2003; Tuffi Santos et al., 2004).

The species *A. conyzoides* (L.) and *Pennisetum clandestinum* Hochst. ex Chiov. were of great highlight in the conventional farming system. *A. conyzoides (*L.) is an annual herbaceous species that grows across the country, especially in areas cropped with garlic, onions, carrots and tomatoes. Yet, *P. clandestinum* Hochst. ex Chiov is an annual grass, less clumped and grown throughout the country for biomass production and incorporation to the soil.

Partelli et al. (2010) found similar genera in conilon coffee plantations. Maciel et al. (2010) discussed the importance of these studies to decide the best method of control. As observed in the phytosociological data in the system, *A. conyzoides* and *P. clandestinum* stood out due to their IVI values, which were of 91.53 and 46.95% respectively (Table 3). Although under a conventional system, the low use of herbicides allow the emergence of such species with increasing frequency, since seeds remained in the soil for more than one cultivation cycle. These data represented by the sum of relative density, relative frequency and relative dominance which indicate major influence within the weed community (Oliveira and Freitas, 2008) (Table 3).

The results revealed similarity among species, among which the genus Ageratum should be highlighted by its significant index (87.80%), followed by the genus Pennisetum. The species *A. conyzoides* (L.) and *P. clandestinum* (Hochst. ex Chiov.) stood out in this survey, as shown in Table 4. Adegas et al. (2010) stressed the importance of knowing the weed species throughout the crop cycle to enable decision making regarding the best method of control (Table 4).

The absence of routine application of herbicides in both crop systems enabled germination of weed seeds at a higher frequency than the normal. Phytosociological surveys compare different weed populations within a particular location at a particular time. Therefore, when repeatedly performing this study, variations on the level of importance of one or more populations could be observed. Such variations are derived from the adopted agricultural practices and managements. In structural analysis of a particular crop, the phytosociological parameters become reliable measures of weed floristic composition at this niche (Oliveira and Freitas, 2008),

Table 3. Weed phytosociology – conventional farming.

Species	Freq. (%)	Den. (%)	Abu. (%)	FrR. (%)	DeR. (%)	AbR. (%)	IVI (%)
Ageratum conyzoides L.	100	0.12	6.00	20.00	46.87	24.66	91.53
Conyza bonariensis (L.) Cronquist	33.33	0.006	0.33	6.67	2.34	1.35	10.36
Pennisetum clandestinum Hochst. ex Chiov	33.33	0.04	6.00	6.67	15.62	24.66	46.95
Brachiaria plantaginea (Link.) Hitchc.	33.33	0.006	1	6.67	2.34	4.11	13.12
Mollugo verticillata L.	66.66	0.02	2.00	13.34	7.81	8.22	29.37
Bulbostylis capillaris (L.) C. B. Clarke	33.33	0.006	1.00	6.67	2.34	4.11	13.12
Cyperus difformis L.	33.33	0.01	2.00	6.67	3.90	8.22	18.79
Chamaesyce hirta (L.) Milisp.	33.33	0.01	2.00	6.67	3.90	8.22	18.79
Chamaesyce prostrata (Aiton) Small	33.33	0.006	1.00	6.67	2.34	4.11	13.12
Richardia grandiflora (Cham and Schltdl.) Steud.	33.33	0.006	1.00	6.67	2.34	4.11	13.12
Solanum americanum Mill	66.66	0.02	2.00	13.34	7.81	8.22	29.37

FrR =relative frequency; DeR= relative density; AbR= relative abundance; Freq.= frequency; Abu= abundance; Den.=density; I.V.I= importance value index.

Table 4. Similarity index (SI) among the plots of the survey – in conventional farming.

Species	SI (%)
Ageratum conyzoides L.	87.80
Conyza bonariensis (L.) Cronquist	4.87
Pennisetum clandestinum Hochst. ex Chiov	29.26
Brachiaria plantaginea (Link.) Hitchc.	4.87
Mollugo verticillata L.	19.51
Bulbostylis capillaris (L.) C. B. Clarke	4.87
Cyperus difformis L.	9.75
Chamaesyce hirta (L.) Milisp.	9.75
Chamaesyce prostrata (Aiton) Small	4.87
Richardia grandiflora (Cham & Schltdl.) Steud	4.87
Solanum americanum Mill	19.51

and may assist in choosing a control method for them, since they have influence on management efficiency (Maciel et al., 2010).

Conclusions

The phytosociological survey revealed that Euphorbiaceae and Asteraceae families had the highest numbers of individuals in organic and conventional farming systems, respectively. The soil seed bank in the assessed vegetable growing areas showed a wide range of plant genera. Regarding similarity index, all species seems to be well distributed in the dry region of Alagoas; Brazil, showing good adaptability to the local biological, climatic and soil conditions. Further surveys are needed to confirm the adaptation of the weed families to the cultivation regions, complementing the results found in this research.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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