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CROP PROTECTION

Natural enemies in alternative plants during the soybean and corn offseason in Cruz Alta, Rio Grande do Sul

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ABSTRACT. **:** Identifying the behavior of natural enemies during the crop offseason is a key tool for integrated pest management. The objective of this work was to evaluate the population density of natural enemies of the plants *Chloris distichophylla*, *Andropogon bicornis*, and *Erianthus angustifolium* and to analyze the influence of the structural complexity of these plants on the present population. During the offseasons of 2014, 2015, and 2016, 150 plants of each species were evaluated and subdivided into different clump diameters. The species *Lycosa* spp., *Eriops connexa*, *Cicloneda sanguinea*, *Coleomegilla quadrifasciata*, *Lebia concinna*, and *Harmonia axyridis* were identified. *A. bicornis* was the plant with the highest population density, followed by *C. distichophylla* and *E. angustifolium*. Plants with greater structural complexities sheltered a higher population density of natural enemies.

Keywords: Glycine max, Zea mays, biological control, ecology, population dynamics.

Introduction

The relationship between insects and host plants is one of the most important interactions between living beings on earth; the processes that formed this interface and the current dynamics are among the most important challenges for ecological research (Lewinsohn, Jorge, & Prado, 2012). In general, these processes generate positive and negative impacts on agriculture; research data report the use of plants by insects considered pests for crops located in areas adjacent to crops are such as soybean, corn and wheat (Klein, Redaelli, & Barcelos, 2012; Pasini, Lúcio, & Ribeiro, 2015; Engel, Pasini, Hörz, & Dalla Nora, 2017). Apart from these pests, there are also reports these plants are used by arthropods considered natural enemies of major agricultural pests for several crops (Souza et al., 2011; Demite, Feres, & Lofego, 2015; Duarte, Navia, Santos, Rideiqui, & Silva, 2015).

These results agree with those of Thomazini and Thomazini (2000), who observed that habitats with more complex vegetation have a community structure that allows for the coexistence of a greater number of species. Dall'Oglio, Zanuncio, Azevedo, and Medeiros (2000) observed increased abundance of natural enemies at close distances to vegetation fragments present in the middle of a eucalyptus culture.

These systems with high diversity of vegetal species function as refuges or natural reservoirs for agents of biological control on agricultural pests and may have an area of influence to the interior of the crop, influencing the control of pests. Certain invaders are important components of the agroecosystem because they positively affect the biology and dynamics of beneficial insects. The presence of spontaneous plants can influence the dynamics of natural enemies in and around crops (Altieri, Silva, & Nicholls, 2003).

Chloris distichophylla, *Andropogon bicornis* and *Erianthus angustifolium* are known in the region of Cruz Alta, Rio Grande do Sul State, Brazil, and in other regions of the state because they have a large distribution around cultivated areas, as well as shelter insect pests such as stinkbugs of the Pentatomidae family during the offseason (Engel et al., 2017). These plants can also occur within the cultivated area and compete with plants being grown, such as soybean and corn (Wandscheer & Rizzardi, 2013; Santos et al., 2015), for water, light and nutrients, characterizing these species as weeds.

Research has demonstrated the population flow of beneficial arthropods from the surrounding vegetation banks into the cultivated areas (Nicholls, Parrella, & Altieri, 2001). These transects can bind native vegetation to the plantations and, thus, allow for the colonization of monocultures by natural enemies. These systems have a high perimeter to area ratio, which favors their interactivity with crops and increases the distribution potential of natural enemies throughout the area under their influence (Altieri et al., 2003).

In addition to the presence of vegetation in areas adjacent to crops, another important factor affecting insect choice of plant is the morphophysiological structure of the plant. According to Howe and Jander (2008), plants with greater structural complexity have an increased capacity to shelter different species of insects and are soon more preferred to the detriment of the others.

However, for *Chloris distichophylla*, *Andropogon bicornis*, and *Erianthus agustifolium*, little is known about the population density of the natural enemies present as well as the influence of these plant's morphophysiological structure on the presence of these arthropods. The objective of this work was to evaluate the population density of natural enemies present in *C. distichophylla*, *A. bicornis* and *E. angustifolium* and the effect of the structural complexity of these plants on the arthropod present population.

Material and methods

The experiment was conducted in the Experimental Area of the University of Cruz Alta, (UNICRUZ) in the municipality of Cruz Alta, State of Rio Grande do Sul, Brazil. The climate according to the Koppen classification is Cfa with an average temperature in the coldest month being below 18°C (mesothermic) and an average temperature in the hottest months above 22°C. There are hot summers, infrequent frost, and the tendency for rainfall concentration to be during the summer months; however there is not a defined dry season (Kuinchtner & Buriol, 2016). The experiment conducted between the months of June and July, corresponding to the soybean and corn offseason of the years 2014, 2015, and 2016.

To estimate the population of biological controllers present around the crops, fifty plants per year of *Chloris distichophylla* Lag., *Andropogon bicornis* L., and *Erianthus angustifolium* Nees. were sampled randomly. Each plant was considered an experimental unit, which at the end of the three years totaled 450 experimental units. In each year, the evaluated plants were subdivided into five different clump diameters, equaling 10 plants for each diameter (5, 10, 15, 20, and 25 cm for *C. distichophylla* and 10, 20, 30, 40, and 50 cm for *A. bicor*nis and *E. angustifolium*). During the three years, the evaluated plants were limited to 20 meters within the edge of the crops.

The arthropods were collected in the plants by direct counting inside the clump of each plant, and the unidentified individuals were separated into morphospecies and taken to the Entomology Laboratory of UNICRUZ for further identification. The data were organized by year, plant diameter and species of biological controllers; this experiment was considered a completely randomized design in a 0 (years) x 3 (plants) x 5 (clump diameters) factorial scheme.

For normalization of the data, data were transformed with the function ((X + 0.5), and afterwards, the data were submitted to ANOVA. To compare the averages between the populations of biological controllers that occurred in each diameter, a T-test was adopted, and to analyze the relationship of the clump diameters, a regression analysis was used. For all statistical analyses, a 5% error probability was adopted.

Results and discussion

The analysis of variance showed a significant interaction between the factors analyzed, and both the year and plant species and their respective morphological structure had an influence on the population density of present arthropods. During the research, 6 species of arthropods were found; *Lycosa* spp., *Eriops conexa* (Germar, 1824), *Cycloneda sanguínea* (Linnaeus, 1763), *Coleomegilla quadrifasciata* (Schöenherr, 1808), *Lebia concinna* (Brullé, 1838), and *Harmonia axyridis* (Pallas, 1773). The total number of arthropods found at the end of the experiment was 915 individuals.

There was a lower occurrence of natural enemies for the three species of plants evaluated during the years 2015 and 2016 compared to 2014, indicating that these individuals did not occur in the study area or that there was intraguild competition, revealing a greater adaptation of the Coccinelidae *H. axyridis* and spiders of the genus *Lycosa* spp. in relation to the other coccinelids identified during the survey; only these organisms occurred during the three years in which samples were taken (Tables 1, 2 and 3). This is in agreement with the spatial and temporal variability that a specific environment can present, interfering in the relationships between arthropods and plants (Anderson & Anton, 2014) and defining species more or less adapted to the environment in which they are presented.

The importance of successive occurrence of wild plants in the surrounding areas of crops relates to the increase in biological controllers and the population flow of these individuals, starting from the surrounding areas and into the cultivated area, thus benefiting crops by reducing the insect pest population (Nicholls, Parrella, & Altieri, 2001).

Table 1

Average population density of natural enemies in different clump diameters of *Chloris distichophylla* during soybean and corn offseasons over three years.

Years	Ø	*Ly*	*Ec*	*Cs*	*Cq*	*Lc*	*Ha*	$\bar{x}$
2014	5	-	0.1 b*	-	-	0.3 a	-	0.4
	10	0.3 b	0.1 c	-	-	0.9 a	-	1.3
	15	0.4 b	0.4 b	0.5 a	0.1 c	0.5 a	0.2 c	2.1
	20	0.6 c	0.3 d	0.9 b	-	1.3 a	0.1 e	3.2
	25	0.8 b	0.1 d	0.8 b	0.5 c	1.5 a	0.4 c	4.1
2015	5	-	-	-	-	-	-	-
	10	0.2^{ns}	-	-	-	-	0.2^{ns}	0.4
	15	-	-	-	-	-	0.1^{ns}	0.1
	20	0.8^{ns}	-	-	-	-	0.7^{ns}	1.5
	25	1.7 a*	0.2 b	-	-	-	1.8 a	3.7
2016	5	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-
	15	-	-	-	-	-	0.1^{ns}	0.1
	20	-	-	0.4 b	-	-	0.6 a	1.0
	25	1.0 a*	-	0.7 b	-	-	1.0 a	2.7
							$\sum \bar{x}$	20.6

*Means followed by different letters in a line differ statistically via T test (p > 0.05), ns (not significant), Ø = clump diameter, x - = mean, x - = total mean. Ly = Lycosa spp., Ec = Eriops connexa, Cs = Cicloneda sanguinea, Lc = Lebia concinna, and Ha = Harmonia axyridis.

Table 2

Average population density of natural enemies in different clump diameters of *Andropogon bicornis* during soybean and corn offseasons over three years.

Years	Ø	*Ly*	*Ec*	*Cs*	*Cq*	*Lc*	*Ha*	$\bar{x}$
2014	10	0.1^{ns}	-	0.1^{ns}	-	0.1^{ns}	-	0.3
	20	0.6 a*	-	0.2 b	-	-	-	0.8
	30	0.7 a	0.5 b	0.7 a	-	0.2 c	-	2.1
	40	0.8 b	0.4 c	1.2 a	0.3 c	0.1 d	-	2.8
	50	1.6 b	0.5 c	2.2 a	0.2 d	0.4 c	0.1 d	5.0
2015	10	0.2^{ns}	-	-	-	-	0.1^{ns}	0.3
	20	0.9^{ns}	-	-	-	-	-	0.9
	30	2.4 a*	-	-	-	-	0.3 b	2.7
	40	3.3 a	-	-	-	-	1.2 b	4.5
	50	3.3 a	-	-	-	-	0.8 b	4.1
2016	10	0.2^{ns}	-	-	-	-	0.1^{ns}	0.3
	20	1.0^{ns}	-	-	-	-	-	1.0
	30	3.0 a*	-	-	-	-	0.2 b	3.2
	40	3.5 a	-	0.2 c	-	-	0.7 b	4.4
	50	3.9 a	-	0.6 c	-	2.5 b	0.6 c	7.6
							$\sum \bar{x}$	40.0

*Means followed by different letters in a line differ statistically via T test (p > 0.05), ns (not significant), Ø = clump diameter, x - = mean, x - = total mean. Ly = Lycosa spp., Ec = Eriops connexa, Cs = Cicloneda sanguinea, Lc = Lebia concinna, and Ha = Harmonia axyridis.

Coccinellids are important natural enemies within the agroecosystem and considered among the largest predators of aphids and other pests. These insects help keep populations of these harmful organisms below the level of economic damage, thus reducing the use of synthetic pesticides.

The successive occurrence of these natural enemies (*H. axyridis* and *Lycosa* spp.) is related to the biological ability of these species to explore the environmental resources available in a given environment during different phases (Garlet, Costa, & Boscardin, 2016). *H. axyridis* came to Brazil in mid-2002 in an accidental manner (Almeida & Silva, 2002) and is known in different regions of the world for being an aphid predator (Koch, Venette, & Hutchinson, 2006) and for its high adaptive capability (Santos, Santos-Cividanes, Cividanes, Anjos, & Oliveira, 2009). *Lycosa* spp. is considered an important biological controller of the general type, being present in several environments including crops such as maize (Silva, Ribeiro, & Lúcio, 2014).

Table 3

Average population density of natural enemies in different clump diameters of *Erianthus angustifolium* during soybean and corn offseasons over three years.

Years	Ø	*Ly*	*Ec*	*Cs*	*Cq*	*Lc*	*Ha*	$\bar{x}$
2014	10	-	-	-	-	0.1^{ns}	-	0.1
	20	0.3 a*	-	0.1 b	-	-	-	0.4
	30	0.7 a	-	0.1 c	0.1 c	-	0.3 b	1.2
	40	0.8 a	0.1 b	0.8 a	0.1 b	0.2 b	0.1 b	2.1
	50	1.2 a	0.1 d	0.9 b	0.3 c	0.4 c	0.1 d	3.0
2015	10	0.3^{ns}	-	-	-	-	0.3^{ns}	0.6
	20	1.3 a*	-	-	-	-	0.3 b	1.6
	30	1.2 a	-	-	-	-	0.3 b	1.5
	40	1.9 a	-	-	-	-	0.6 b	2.5
	50	2.8 a	-	-	-	-	1.8 b	4.6
2016	10	0.3^{ns}	-	-	-	-	0.3^{ns}	0.6
	20	1.5 a*	-	-	-	-	0.3 b	1.8
	30	1.6 a	-	-	-	-	0.6 b	2.2
	40	2.2 a	-	0.2 c	-	-	1.1 b	3.5
	50	2.7 a	-	0.6 c	-	-	1.9 b	5.2
							$\sum \bar{x}$	30.9

*Means followed by different letters in a line differ statistically via T test (p > 0.05), ns (not significant), Ø = clump diameter, x - = mean, x - = total mean. Ly = Lycosa spp., Ec = Eriops connexa, Cs = Cicloneda sanguinea, Lc = Lebia concinna, and Ha = Harmonia axyridis.

A. bicornis had the highest population density followed by *E. angustifolium* and *C. distichophylla*. The diversity of insect species is linked to the presence of host plants and adequate food for their development and to the suitability of a plant to the species of colonizing insect, which can vary based on plant architecture, volatile emissions, epidermis texture, presence or absence of trichomes, and climate characteristics of the environment. Thus *A. bicornis* was more adequate in relation to *C. distichophylla* and *E. angustifolium* for the present arthropod population.

The behavior of the occurring arthropod species was similar for the three plant species evaluated during the three years in which the survey was carried out. Plants with greater structural complexities obtained higher population densities (Figures 1, 2, and 3).

Host plants are selected by considering the motivations associated with the search for shelter with temperature, humidity, radiation and controlled action of the winds (Meiners, 2015). In this way, plants with greater structural complexity sheltered a greater population density of biological controllers. Plants having intrinsic characteristics that made them preferable either for offering adequate shelter, less competition for space, or greater quantity of sheltered prey caused the prey population to concentrate around these plants.

The obtained results are supported by a those reported by Howe and Jander (2008), who conclude that plants with greater complexity tend to shelter a greater diversity and abundance of insects. Knowledge of this behavior of natural enemies during the offseason may provide support for the determination of sustainable, integrated management strategies during the harvest.

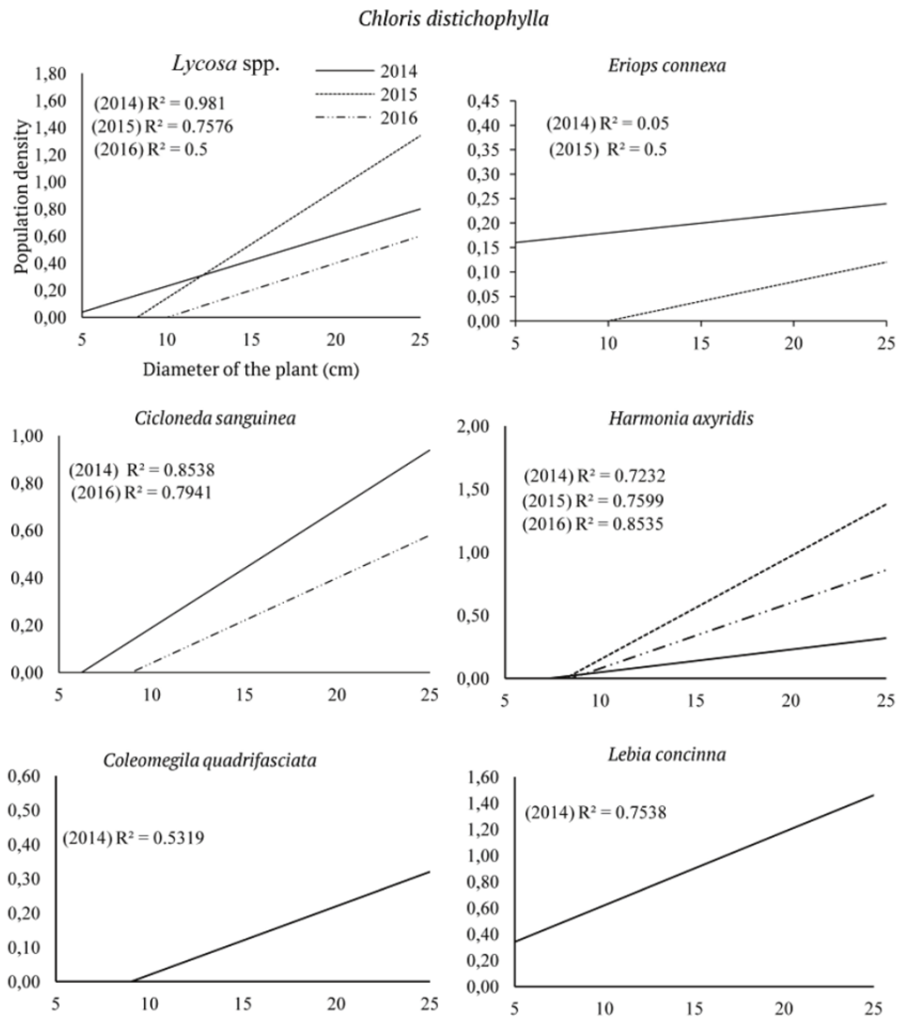

Figure 1

Relationship between the diameter of the host plant. *Chloris distichophylla.* with the average population density of natural enemies sampled during the offseason of different years.

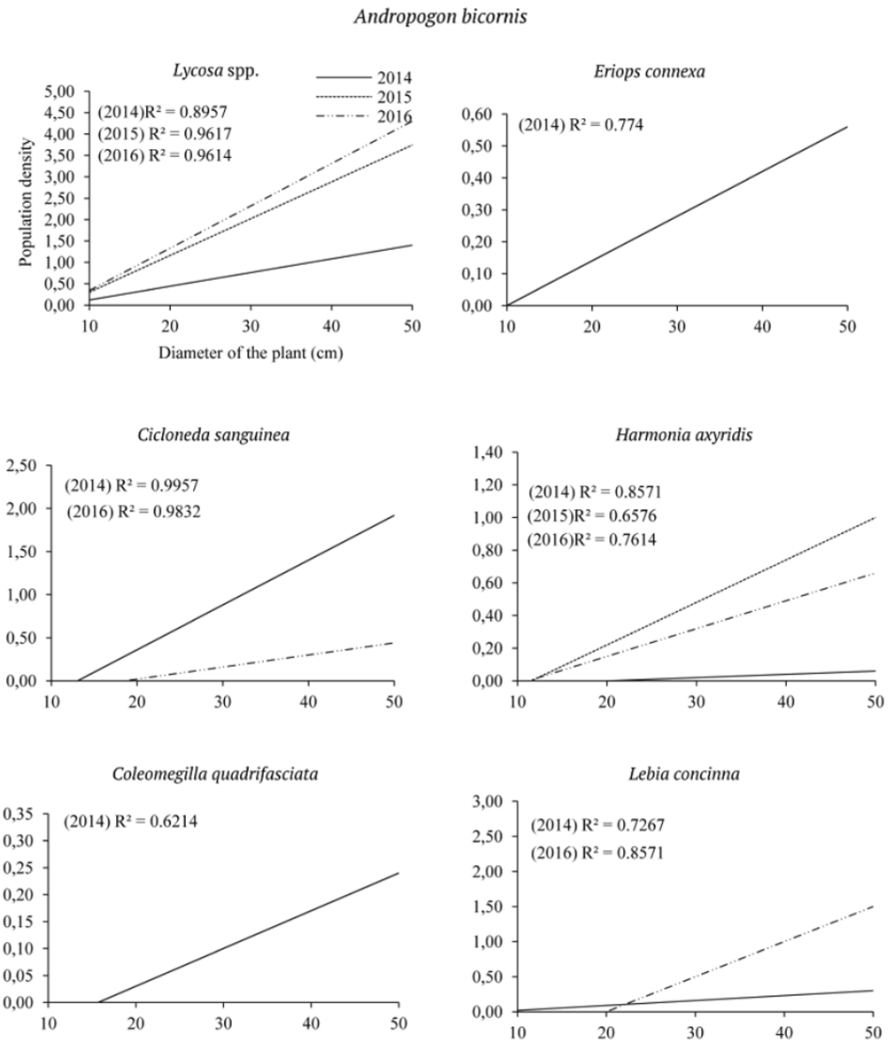

Figure 2

Relationship between the diameter of the host plant. *Andropogon bicornis* with the average population density of natural enemies sampled during the offseason of different years.

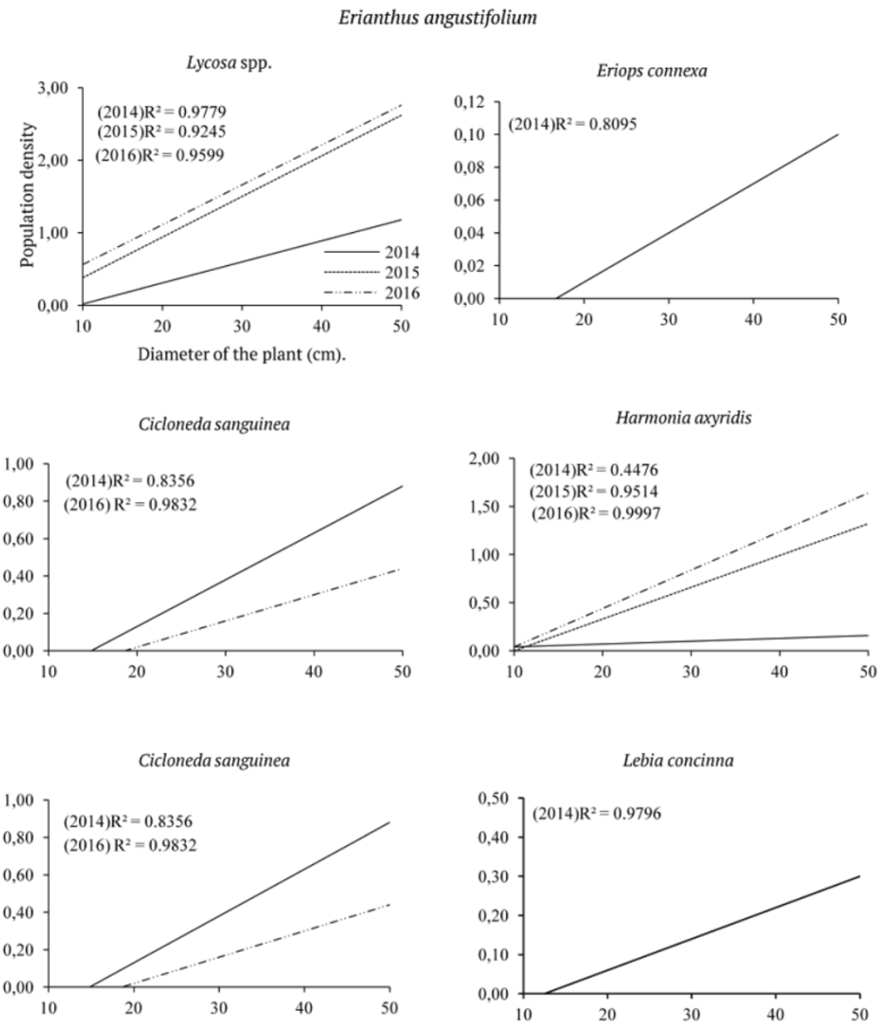

Figure 3

Relationship between the diameter of the host plant. *Erianthus angustifolium.* with the mean population density of natural enemies sampled during the offseason of different years.

Conclusion

Natural enemies use plants of the species *C. distichophylla*, *A. bicornis* or *E. angustifolium* for maintenance of their populations during soybean and corn offseasons. Plants with greater structural complexity sheltered higher densities of natural enemies. The most frequent arthropods were *H. axyridis* and *Lycosa* spp.

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