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Companion plants associated with kale increase the abundance and species richness of the natural-enemies of *Lipaphis erysimi* (Kaltenbach) (Hemiptera: Aphididae)

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The effects of intercropping of Brassicaceae with coriander (*Coriandrum sativum*), dill (*Anethum graveolens*), African marigold (*Tagetes erecta*) and calendula (*Calendula officinalis*) on the abundance, species richness and diversity of predators and parasitoids of *Lipaphis erysimi* have been assessed. The numbers of aphids, parasitized aphids and natural enemies were determined during two consecutive phases. The first period comprised the vegetative phase of companion plants up to the onset of flowering and the development of kale up to the start of harvesting, while the second period encompassed the late flowering of companion plants up to senescence and the complete harvesting phase of kale. The establishment of *L. erysimi* and its natural enemies during the first period was enhanced by the climatic conditions and the additional nutritional resources offered by companion plants. Over the complete 13 week period, the abundance of natural enemies in kale intercropped with African marigold, calendula, coriander and dill increased by factors of 3.1, 2.1, 2.0 and 1.6, respectively, compared with the kale monoculture, while species richness increased by 1.8-fold in kale/African marigold intercrop and by a factor of 2.7 in the other treatments. The predominant predators were Syrphidae larvae and *Hippodamia convergens* whereas the predominant parasitoid was *Diaeretiella rapae*. The diversity of natural enemies was similar in all crops owing to the high proportion of syrphids in relation to the other groups of insects. The improved resources offered by companion plants can be exploited in the conservative biological control of insect pests.

Key words: Conservation biological control, natural enemies, insect seasonality, Hemiptera, Aphididae, Asteraceae, Apiaceae, *Lipaphis erysimi*, abundance, richness, Syrphidae, ladybird, kale

INTRODUCTION

Increasing plant diversity within an agriculture-dominated landscape can bestow a setting approximating to that of the natural environment. Diversification may also serve to increase the abundance of beneficial insects by providing increased floral resources, alternative prey and hosts, and additional sites for hibernation, mating and oviposition for natural enemies of crop pests (Alignier et al., 2014).

Implementation of an organic production system coupled with diversification represents an alternative strategy to the use of insecticides for regulating insect communities. Indeed, the expansion and intensification of monoculture farming has been considered one of the main factors responsible for loss of arthropod diversity around the globe (Altieri, 2009; Welch and Harwood, 2014). While the selection of appropriate companion plants for successful management of agricultural landscapes is important, relatively few studies have focused on the influence of habitat on the relationship between insect pests and their natural enemies (Chaplin-Kramer and Kremen, 2012).

Kale (*Brassica oleracea* L. var. *acephala* D. C.) is one of the most popular vegetables in Brazil, and is of considerable economic importance, especially to small-scale farmers, so we use this plant as a model, however *Lipaphis erysimi* (Kaltenbach, 1843) (Hemiptera: Aphididae) being one of the most important pests of brassicas on the world. Kale and other species of brassicas crops throughout the world are constantly plagued by *L. erysimi*, a specialist brassica aphid that not only attacks the terminal portions of stems and inflorescences, causing curling and yellowing of the plant, but also acts as a vector for phytopathogenic viruses (Blande et al., 2008).

A number of reports are available concerning the impact of diversification on the population dynamics of insect communities associated with brassica crops (Hooks and Johnson, 2003). It is known that the intercropping of food crops with flowering species of the families Asteraceae and Apiaceae can enhance the efficiency of pest predators by increasing their longevity, fecundity, colonization and permanence in the cropping system (Walton and Isaacs, 2011).

Members of the Asteraceae have been shown to maintain the biodiversity of predators and parasitoids when employed as a companion crop in onion fields (Silveira et al., 2009). Regarding the Apiaceae, aromatic species attract numerous insects that forage for pollen and nectar, while the floral architecture provides shelter for prey and/or preferential or alternative hosts. The bright yellow color of the flowers and the nutritional value of the pollen are highly attractive to ladybirds and wasps, while the floral architecture is compatible with the head morphology and foraging behavior of the coccinellids (Patt et al., 1997; Walton and Isaacs, 2011).

Considering the beneficial effects that companion flowering species may have in the suppression of crop pests, we propose that intercropping kale with species of Apiaceae or Asteraceae in an organic culture system would increase the attraction and permanence of natural enemies of the aphid *L. erysimi.* In order to test this hypothesis, we evaluated the effect of intercropping kale with African marigold, calendula, coriander or dill on the abundance, species richness and diversity of aphid predators and parasitoids.

MATERIALS AND METHODS

Experimental design

The experiment was carried out between March and June 2012 at the organic crops research station of the Universidade Federal de Lavras (UFLA) (21°14'43" S; 44°59'59" W; 930 m altitude). The fully randomized block design consisted of five treatments, with five replications each, and involved 25 plots (4 x 1.7 m) comprising kale monoculture (control) and kale intercropped with African marigold, calendula, coriander or dill. Seeds of kale and the companion plants were germinated in a greenhouse in separate polystyrene trays (200 cells per tray) containing commercial Plantmax® substrate (Eucatex Agro, Paulínia, SP, Brazil), and transplanted to the experimental plots 30 days after germination. The soil in the plots was analyzed prior to experimentation and found to contain 11.05 mg dm^{-3} of P, 84 mg dm^{-3} of K, 3.30 $cmol_c$ dm^{-3} of Ca^{2+} and 1.00 $cmol_c$ dm^{-3} of Mg^{2+}.

In each of the plots, kale was arranged in five rows with three plants each (15 plants/plot) spaced 1.0 m between rows and 0.8 m between plants. Companion plants were arranged between the rows of kale, with each of the four rows containing four plants (16 plants/plot) spaced 0.4 m from one another. The applicable plot was considered to be the three central rows containing nine kale plants. Plots within a block were separated by 1.5 m weed-free aisles, and blocks were separated by pathways (1.0 m wide). The soil was covered with plastic mulch to suppress weeds that could interfere with the results and to conserve humidity, and the plants were irrigated daily by sprinkler irrigation aspersion. Meteorological data (monthly mean temperature and relative humidity and monthly accumulated rainfall) were collected at the weather station at the UFLA determined throughout the experimental period.

Sampling procedures

Determination of the numbers of aphids, parasitized aphids and natural enemies present in the kale crops commenced 20 days after transplanting seedlings to plots. Sampling was performed weekly in the morning over a period of 13 weeks until senescence of the companion plants. In order to facilitate evaluation of the fluctuating populations of insects, the sampling period was divided in two stages. The first period (P1) extended from 26th March to the 7th May and covered the vegetative stage of the companion plants up to full flowering, and the development of the kale up to the start of harvesting. During this period, six observations were performed, one at the end of March, four in April and one at the beginning of May. The second period (P2) extended from 17th May to 22nd June, and covered the late flowering of companion plants up to their

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senescence and the complete harvesting phase of the kale. During this period, seven observations were carried out, four in May and three in June.

Since collection and counting procedures at each sampling were carried out on the same plants, the predators and parasitoids had to be removed before counting the aphids and collecting the parasitized aphids (mummies) in order to avoid dispersion of the natural enemies. Predators and parasitoids of *L. erysimi* were collected from three randomly selected plants in each plot (75 plants/week) using a manual aspirator and brush on each whole plant for 5 min. The insects were subsequently transported to the laboratory for counting and identification. Adult insects were placed in acrylic flasks containing 70% ethanol, while immature insects were transferred to Petri dishes containing *L. erysimi*-infested kale leaves and incubated at 24±1°C and 70±10% relative humidity under a 12 h photoperiod until they matured into adults. Taxonomic classification of insect predators was carried out with the aid of specific dichotomous identification keys.

The numbers of aphids present on leaves from plants that had been previously sampled for the presence of natural enemies were determined with the aid of a manual counter. In order to ensure consistency of sampling, leaves were classified as:

Apical – young leaf not fully expanded
Median – adult and fully expanded leaf; and
Basal - senescent leaf with visible yellowing.

One leaf of each type was selected randomly from each plant prior to visualization of aphids on the abaxial side. After counting, mummies were collected from the same leaves.

Statistical analysis

Analyses were performed using R software (R Development Core Team 2014) with the level of statistical significance set at 5%. The effects of sampling period (P1 and P2) and treatments (explanatory variables) on the numbers of predators, parasitoids, aphids and mummies (response variables) were evaluated by analysis of variance (ANOVA) and regression analysis using generalized linear models with Poisson distribution errors and chi-square test (p<0.05) (Buckley et al., 2003; Crawley, 2005).

Subsequently, non-significant qualitative terms for kale monoculture (control) and kale intercropped with African marigold, calendula, coriander or dill factors were compared by contrasts, in order to establish similarities between treatments in the full model. The ecological parameters (*n*, *S* and *H'*) were calculated using PAST software version 2.04 (Hammer et al., 2001), tested for homogeneity of variance, and analyzed by ANOVA and Kruskal-Wallis tests.

Ecological parameters

The true number of species or species richness (*S*) in relation to the observed number of species (S_0) was established using the Jackknife estimator. The Shannon-Wiener diversity index (*H´*; range 0 - 5) was used to characterize diversity since it combines species richness and abundance.

RESULTS

Influence of sampling time and treatments on the population of aphids and natural enemies

The study periods P1 and P2 showed significant effects on the population of *L. erysimi* over time (X^2 = 54215.0; *P* < 0.00001), with the highest incidence of aphids being observed during P1 (Figure 1). Moreover, the incidence of *L. erysimi* was significantly lower (X^2= 73.52705; *P* < 0.00001) in the treatment pair kale monoculture x kale/dill compared with the pair kale/coriander x kale/calendula (Figure 1). The kale/African marigold intercrop resulted in a lower incidence of aphids in comparison with others treatments (153.74; p < 0.00001), and the highest incidence was observed during P1 coinciding with the period in which the population of predators was lower (Figure 2).

In contrast, the study periods did not exhibit significant influence on the population of parasitoids (X^2= 7.5815; *P* = 0.10817) or the occurrence of mummies (X^2 = 2.7910; *P* = 0.09479) over time. Comparison of treatment pairs revealed that the incidence of predators was significantly higher (X^2 = 24.09329; p < 0.00001) in the treatment pair kale monoculture x kale/dill compared with the pair kale/coriander x kale/calendula (Figure 2). However, the kale/African marigold intercrop resulted in a higher incidence of predators in comparison with the other two treatment pairs (X^2 = 94.71723; *P* < 0.00001).

Considering the two sampling periods together, the incidence of parasitoids was not significantly influenced by the treatments (X^2= 7.5815; *P* = 0.1082), although the numbers of parasitized aphids were affected significantly (X^2 = 23.8320; *P* < 0.00001). The number of parasitized aphids was highest in the kale/African marigold intercrop followed by the kale/calendula intercrop (Figure 3).

Influence of climatic conditions on the aphid population

The mean temperature during P1 (March and April) was around 21°C, and the mean rainfall was approximately 39 mm with 75% relative humidity. During P2, average temperatures decreased to 17°C (May) and 18°C (June), and precipitation increased to 42 mm (May) and 95 mm (June) with 84% relative humidity. As shown in Figure 4, the percentage of aphids diminished markedly from P1 to P2 as the temperature decreased, and the humidity increased.

Evaluation of the ecological parameters

The abundances of various groups of natural enemies of aphids observed in kale crops during the period of March to June, 2012 are presented in Table 1. Larvae of aphidophagous Syrphidae (Diptera) were predominant in all treatments, particularly in the kale monoculture where the richness of species was markedly lower than in all other treatments and hoverflies accounted for 62.1% of all specimens collected. *Hippodamia convergens*

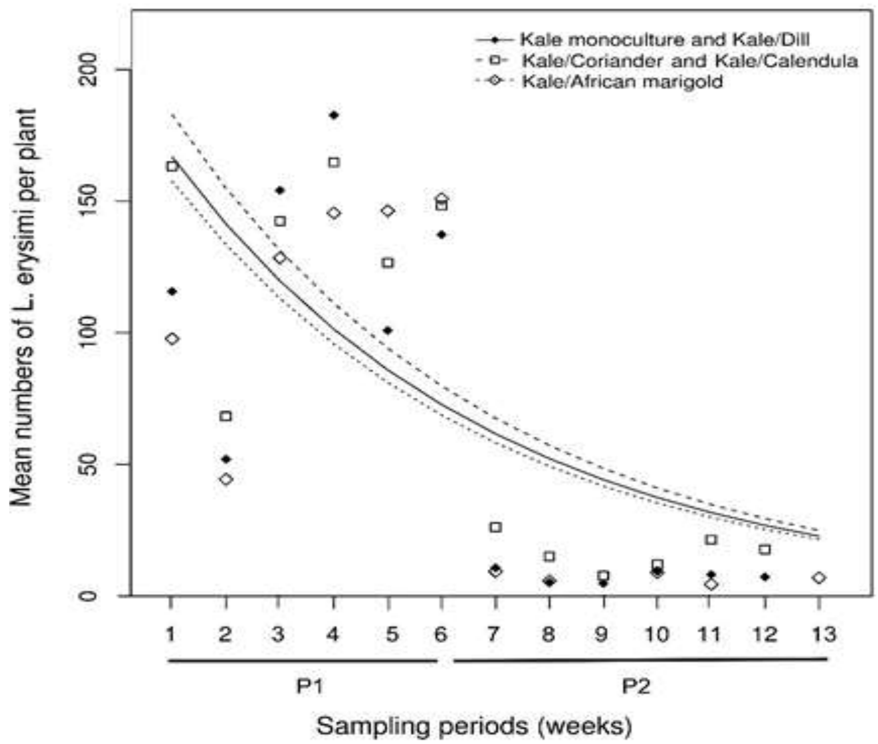

Figure 1. Mean numbers of *L. erysimi* aphids observed in kale crops during the sampling periods from 26 March to 7 May (P1) and from 17 May to 22 June (P2) 2012.

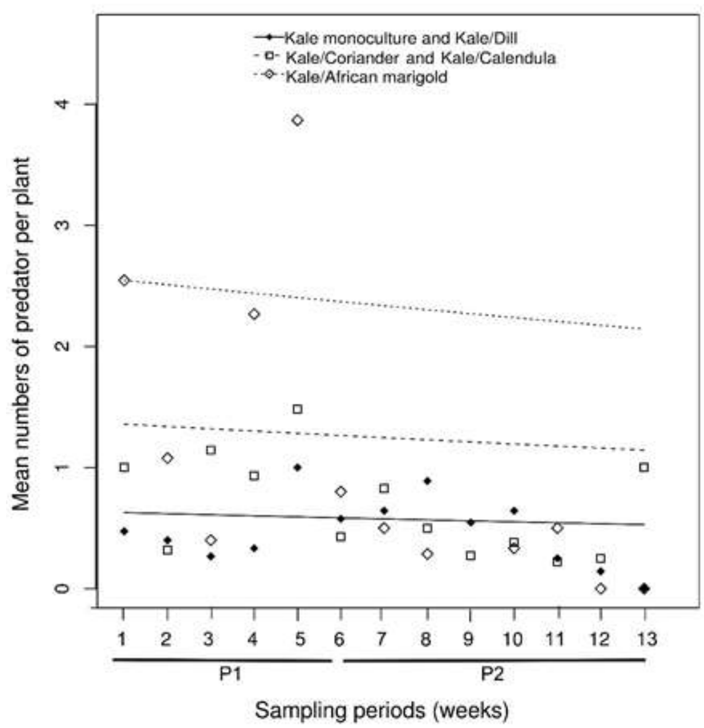

Figure 2. Mean numbers of predators observed in kale crops during the sampling periods from 26 March to 7 May (P1) and from 17 May to 22 June (P2) 2012.

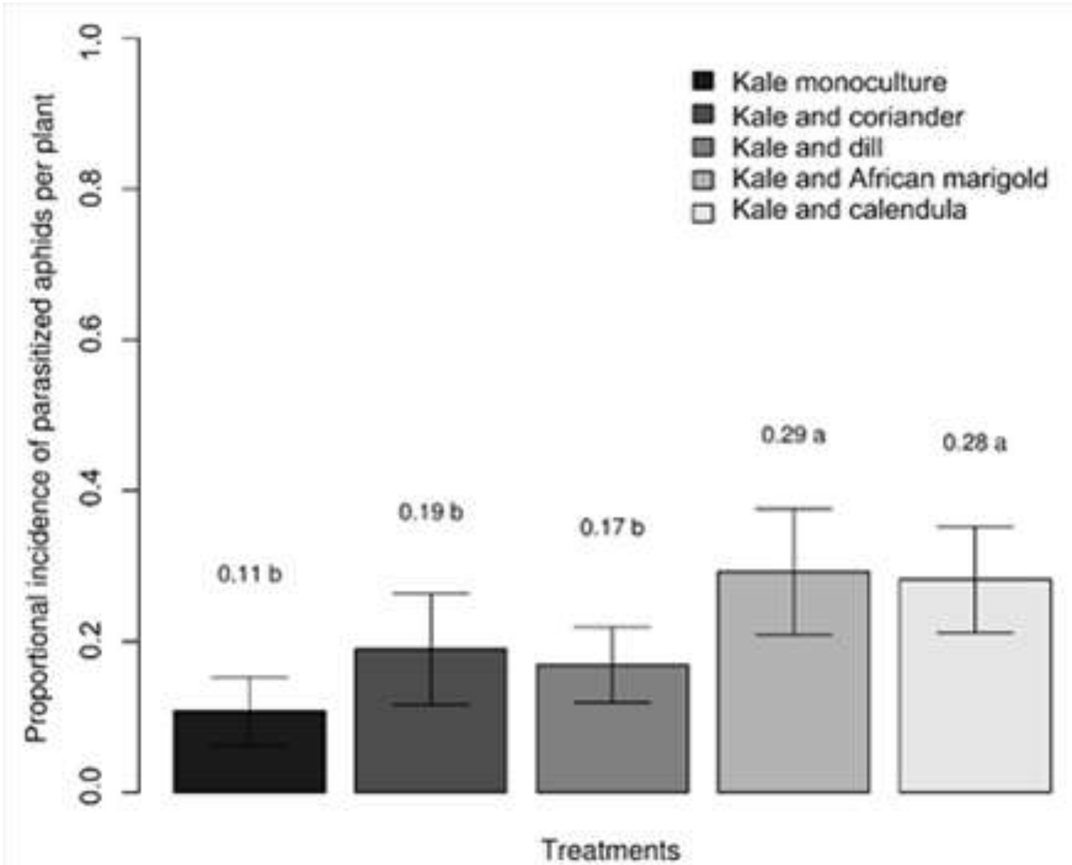

Figure 3. Incidence of parasitized aphids observed in kale monoculture or kale intercropped with companion plants during the whole sampling period from March to June 2012. Mean values (shown above the bars) followed by dissimilar lower case letters are significantly different (χ^2 test; $P < 0.05$).

(Guérin-Méneville, 1842) was also observed in all treatments, but the frequency was considerably higher in the kale/African marigold intercrop where the convergent lady beetle accounted for 21.1% of all natural enemies collected.

Parasitoid wasps accounted for around 10% of the natural enemies of aphids identified in the kale crops and included *Diaeretiella rapae* (McIntosh, 1855), which was present in all crop treatments and accounted for 89.6% of all parasitoids collected, *Aphidius colemani* (Viereck, 1912) (8.62%) and *Praon volucre* (Haliday, 1833) (1.72%) (Table 1). The highest abundance of *D. rapae* was observed in the kale/dill intercrop with 18 individuals collected.

Regarding the overall abundance (*n*) of natural enemies, significantly more beneficial insects were observed in the kale/African marigold, then Kale/ Calendula intercrop in comparison with the other treatments (Table 2). Species richness (*S*) in the kale monoculture was considerably lower in comparison with those of the intercrops, but no statistically significant between-treatment differences were observed in the Shannon-Wiener diversity index (*H'*).

DISCUSSION

Factors that are intrinsic to the host plant, especially those related to nutritional quality, influence the colonization and performance of phytophagous insects. For example, the reproductive rate of aphids is associated positively with the amounts of nitrogen in the plant (Zarghami et al., 2010) and these, along with the levels of proteins and carbohydrates, vary as the plant matures (Staley et al., 2011). In the present study, the colonization of kale plants by *L. erysimi* was markedly higher in P1 than in P2 (Figure 1), a finding that probably reflects the greater concentrations of soluble nitrogen translocated through the phloem in the young leaves of P1 compared with the old leaves of P2. According to Agarwal and Datta (1999), young leaves of mustard greens (*Brassica juncea*) are of superior nutritional quality in comparison with older leaves and, therefore, support the highest rates of fecundity and survival of *L.*

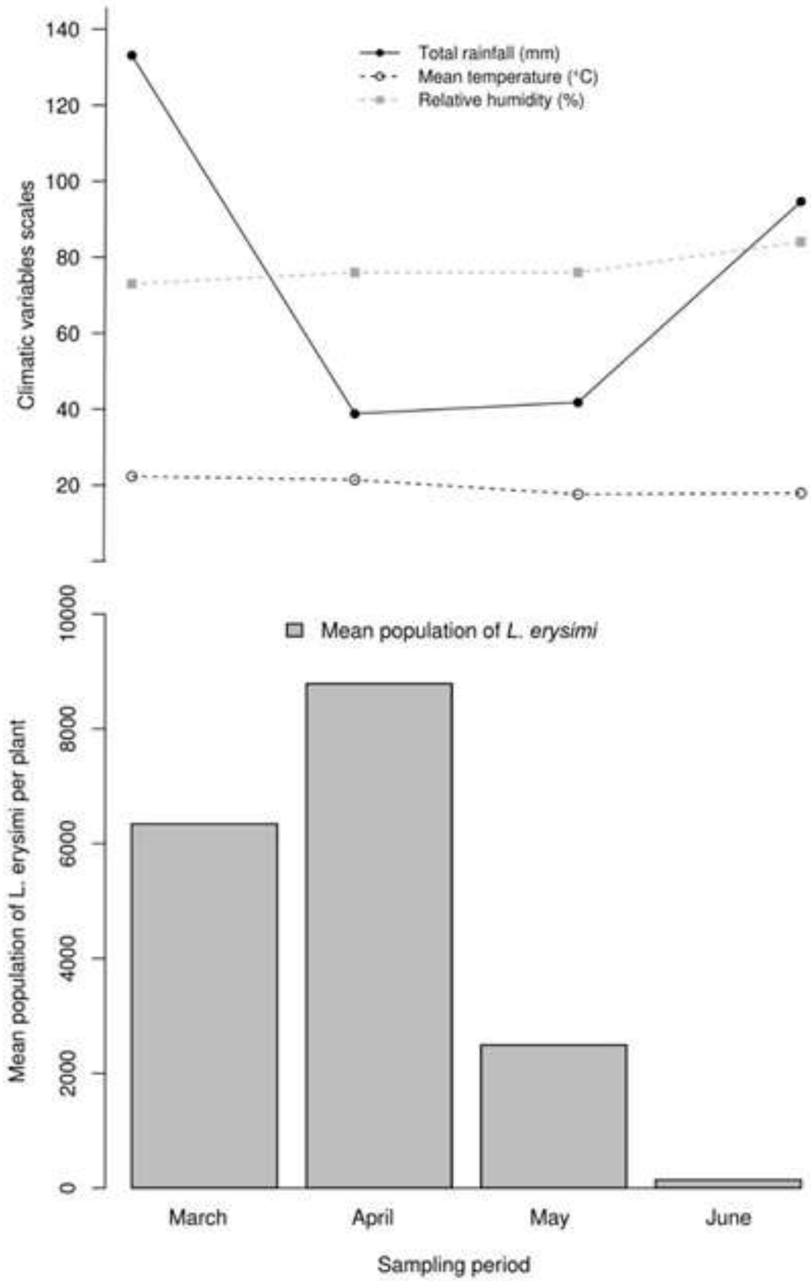

Figure 4. Variation in *L. erysimi* aphid population, rainfall, temperature and relative humidity during the whole sampling period of March to June 2012.

erysimi.

In the present study, the highest density of natural enemies of *L. erysimi*, particularly predators, was maximal in P1, the period during which the companion plants attained full bloom and the aphid population was at its highest level. During the flowering stage, members of the Apiaceae and Asteraceae are very attractive to the natural enemies of aphids, and the favorable dietary conditions serve to enhance the longevity, fecundity and preying capacity of beneficial insects (Walton and Isaacs, 2011) and, as a consequence, the aphid population tends to diminish.

Evaluation of the influence of treatments on the populations of aphids and their natural enemies during the crop cycle revealed that the kale/African marigold and Kale/Calendula intercrop attracted more predators than the other intercrop and also exhibited the lowest incidence of aphids (Figure 1). This is a promising result

Table 1. Abundance (*n*) of natural enemies of *L. erysimi* observed in kale monoculture and kale intercropped with companion plants during the whole sampling period of March to June 2012.

Taxon	Kale monoculture		Kale intercropped with companion plants							
			Coriander		Dill		African marigold		Calendula	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Syrphidae larvae	43	62.1	62	48.1	47	48.5	104	59.2	48	42.0
Cantharidae	0	0	2	1.57	3	3.09	2	1.14	0	0
Carabidae	0	0	0	0	0	0	0	0	3	2.63
Coleomegilla maculata	0	0	4	3.14	1	1.03	4	2.28	0	0
Cycloneda sanguinea	0	0	3	2.36	0	0	0	0	1	0.87
Diomus sp.	0	0	0	0	0	0	0	0	1	0.87
Eriopis connexa	0	0	0	0	0	0	1	0.57	0	0
Harmonia axyridis	0	0	0	0	1	1.03	1	0.57	1	0.87
Hippodamia convergens	2	2.89	18	14.7	6	6.18	38	21.1	21	18.42
Hyperaspis sp.	0	0	0	0	0	0	0	0	1	0.87
Psyllobora rufosignata	0	0	0	0	1	1.03	0	0	0	0
Scymnus lowei	0	0	0	0	0	0	0	0	1	0.87
Scymnus rubicundus	0	0	0	0	1	1.03	0	0	1	0.87
Staphylinidae	0	0	1	0.78	0	0	3	1.71	0	0
Geocoris uliginosus	0	0	1	0.78	0	0	0	0	0	0
Macrolophus basicornes	0	0	6	4.72	0	0	0	0	2	1.75
Orius insidiosus	0	0	1	0.78	0	0	0	0	0	0
Orius thyestes	0	0	1	0.78	0	0	0	0	0	0
Paraproba sp.	0	0	0	0	0	0	2	1.14	1	0.87
Franklinothrips vespiformis	0	0	1	0.78	1	1.03	0	0	0	0
Stomatothrips angustipennis	0	0	0	0	1	1.03	0	0	0	0
Crisoperla externa	4	5.79	0	0	0	0	0	0	2	1.75
Hemerobiidae	0	0	2	1.57	0	0	0	0	0	0
Doru luteipes	0	0	2	1.57	1	1.03	0	0	0	0
Mantodea	0	0	1	0.78	0	0	0	0	0	0
Dolichopodidae	0	0	0	0	1	1.03	1	0.57	1	0.87
Aphidius colemani	2	2.89	0	0	0	0	0	0	3	2.63
Diaeretiella rapae	6	8.69	7	5.51	18	18.55	7	4.57	14	12.28
Praon volucre	0	0	0	0	1	1.03	0	0	0	0
Araneae	12	17.39	15	11.81	14	14.43	11	6.28	13	11.4
Total	69	100	127	100	97	100	174	100	114	100

Table 2. Abundance (*n*), species richness (*S*) and Shannon-Wiener diversity index (*H'*) of natural enemies of *L. erysimi* observed in kale monoculture and kale intercropped with companion plants during the whole sampling period of March to June 2012.

Treatment	*n* [1]	*S*	*H'* [2]
Kale/African marigold	122.31±16.14[a]	11	1.18±0.08
Kale/calendula	83.46±9.85[ab]	16	1.77±0.21
Kale/coriander	80.31±9.77[bc]	16	1.60±0.15
Kale/dill	63.85±7.78[bc]	16	1.27±0.25
Kale monoculture	39.46±6.24[c]	6	1.81±0.15

[1] Mean values of *n* bearing the same superscript letter are not significantly different (Tukey test; $P >$ 0.02); [2] Mean values of *H'* are not significantly different (*Kruskal-Wallis test; P* > 0.05).

considering that the counting of natural enemies was performed on the kale plants themselves where predatory action against the aphids was more likely to occur. Silveira et al. (2009) demonstrated that African marigolds offer conditions that favor the maintenance of natural enemies of onion pests. Climatic conditions have been shown to influence the density of *L. erysimi* (Bapuji Rao et al., 2013).

Landin and Wennergren (1987) studied the intrinsic rate of increase of *L. erysimi* under different temperatures and concluded that the highest growth rate occurred around 25°C, while Bakhetia and Sidhu (1983) established that temperatures within the range 20 to 30°C favored the development and reproduction of the aphid. In the present study, the mean temperature of 21°C recorded during P1 probably contributed to the high incidence of aphids observed on kale crops during the first study period. Increased precipitation, which is considered to be a natural mortality factor of *L. erysimi* (Dogra et al., 2001), coupled with the reduced temperatures (17 to 18°C) registered during P2 were partly responsible for the increased aphid mortality observed during second study period. In contrast, relative humidity varied little between P1 and P2 (75 and 84%, respectively), and these levels were within the 75 to 85% range cited by Kulat et al. (1997) as favorable for the presence of *L. erysimi* in the field.

It is concluded, therefore, that relative humidity alone was not a factor in determining the variation in population size of the aphids during the kale cropping cycle.

Meteorological data gathered during the crop cycle are also important since climatic conditions may constitute a decisive factor in determining the timing of absence or peak infestations of aphids in the field (Chattopadhyay et al., 2005).

In the present study, predators predominated over parasitoids throughout the crop cycle. According Venzon et al. (2013) predators can benefit not only from the floral resources of the companion plants but also from the that allowed them to survive longer in the field, a factor that is particularly important when pest density is low. Most of the sampled predators were generalists or zoophytophagous (that is, spiders, syrphids, ladybird beetles and thrips) and were prevalent from the start of the culture period until the senescence of the companion plants. The main advantage of generalist predators is their ability to colonize an agro-ecosystem before the arrival of the primary pests and to remain in the field throughout the crop cycle by feeding on alternative prey (Aguiar-Menezes, 2003; Amaral et al., 2013).

Nevertheless, the results indicate that the density of predators accompanied changes in the phenology of the plants but that *S* was greater than S_0, most likely because the experiment was field-based and predators constantly appeared from the surrounding areas.

The three species of parasitoids observed were host-specific and all belonged to the Aphidiinae subfamily of parasitic wasps (Starý et al., 2007). This specificity explains the decrease in parasitoid density during P2, which occurred because of the decline in the *L. erysimi* population within this period (Figure 4). The results obtained herein indicate that the relative abundance and species richness of the natural enemies of *L. erysimi* vary according to the phenology (vegetative, flowering and senescence phases) of the companion plants, thus confirming previous reports relating to species of the families Asteraceae and Apiaceae (Silveira et al., 2009; Resende et al., 2012). In general, insect populations change over time according to the availability of food resources, microclimate and shelter offered by the host plants, and these elements clearly favored the continuous richness and addition of species during the present study.

In the present study, although the highest number of specimens of natural enemies was collected in the kale/African marigold intercrop (*n* = 174), species diversity was similar in all treatments as shown by the *H'* values (Table 2). This result was due to the high number of coccinellids, particularly *H. convergens*, which were present in all intercrops but mainly in the kale/African marigold treatment. A study conducted by Medeiros et al. (2010) demonstrated that the most common pollen grains found in populations of *H. convergens* within and around horticultural areas derived from members of the Asteraceae, thereby showing the importance of pollen as a food resource for these beneficial insects in a conservative biological control program. In contrast to the intercrop treatments, the kale monoculture presented a low *S* value with only 69 specimens collected, a finding that may be explained by the absence of extra food resources and the predominance of Syrphidae larvae (62.1%).

Although the other treatments also presented a preponderance of these larvae, there was greater homogeneity in the overall distribution of natural enemies compared with the kale monoculture. Syrphidae larvae were observed during the entire experimental period and their permanence in the kale monoculture and intercrops was favored by the constant presence of *L. erysimi*. The predator-prey dependency between aphidophagous Syrphidae and aphids observed in this study is also noteworthy. Tenhumberg and Poehling (1992) demonstrated that syrphids are sensitive to reduction in the aphid population, and examples of predator-prey dependency have been described involving larvae of *Aphidoletes* sp. and *L. erysimi* in cabbage crops (Silva et al., 2011). It is possible to infer that the permanence of syrphids in the present study depended on the presence of *L. erysimi*, since the density of these predators was associated with the density of aphids in the kale crops. Clearly**,** predator-prey interactions must be taken into account during the evaluation of the abundance of insect groups in field cultures, while the understanding of this relationship is very important for devising biological control strategies.

The attraction of syrphids towards Apiaceae plants has been widely investigated, and floral structure is considered to be one of the key factors. The morphology of flowers of the Apiaceae is compatible with the short mouthparts of adult Syrphidae hoverflies, thus facilitating access to nectar and pollen (Morales and Köhler, 2008). Flowers of the Asteraceae, including marigold species, are also attractive to syrphids, as verified by Robertson (1929), who reported that 25% of the 257 species of this family serve as hosts for hoverflies, and by Sajjad and Saeed (2010) who established that the Asteraceae is one of the families most visited by Syrphidae.

In the present study, *D. rapae* was the most abundant of the three species of parasitoids and was present in all treatments, especially in the kale/dill intercrop. The exposed nectaries of dill flowers emit odors that attract adult parasitoid species and the floral architecture facilitates their feeding behavior (Patt et al., 1997). The results of the present study indicate that the factors influencing the dynamics of multitrophic interactions present in an agro-ecosystem should be considered when assessing the population patterns of the pests and their natural enemies. However, the influence of climatic factors and the structure of the local landscape on the dynamics of arthropod populations require further elucidation in order to establish plant associations that would confer extra benefits to the main crop through the response of herbivores and their natural enemies.

Conclusion

The results presented herein revealed that establishment of *L. erysimi* and its natural enemies in kale crops were influenced by the climatic conditions and nutritional resources of the host plant. The abundance of natural enemies in kale intercropped with African marigold, calendula, coriander and dill increased by factors of 3.1, 2.1, 2.0 and 1.6, respectively, in comparison with the kale monoculture, while species richness increased 1.8-fold in kale/African marigold intercrop and by a factor of 2.7 in the other three intercrops. The data presented in this study support the original hypothesis that intercropping kale with Apiaceae or Asteraceae species in an organic culture system increases the attraction and permanence of the natural enemies of *L. erysimi* by virtue of the improved resources offered to these beneficial insects. Moreover, the information collected will be used to forecast the period when kale crops in the study area are more susceptible to the attack of pests, and to make suitable management decisions to reduce pest populations in a planned manner, that is, by configuring the kale crop and companion plants in such a way that natural enemies are attracted during the critical phase.

Conflict of Interests

The authors have not declared any conflict of interests.

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