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RESEARCH ARTICLE

Seasonal Abundance of Thrips Species (Thysanoptera) and Predatory Bug, *Orius niger* (Wolff, 1811) (Hemiptera: Anthocoridae) on Weeds in an Okitsu Mandarin Grove

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ABSTRACT

Field experiments planned to determine the abundance of thrips species and predatory insects on weeds in Okitsu mandarin were conducted in the Research Area of Agricultural Faculty, University of Çukurova, Adana, Turkey during 2014-2015. Okitsu mandarin grove consists of 10 rows and 20 trees in each row. Four rows of the experimental area were left weedy during the study. During this time most of the weeds had the flowering stage, with different heights. In this study, a total of seven thrips species was determined. The most common and abundant sampled thrips species were *Thrips tabaci* Lindeman, Melanthrips spp. and Frankliniella occidentalis (Pergande) (Thysanoptera: Thripidae), respectively. *Thrips tabaci* were mostly sampled from *Vicia villosa* as well as a predatory bug, *Orius niger* (Wolff, 1811) (Hemiptera: Anthocoridae). Melanthrips species were sampled in high numbers on Sinapis arvensis. Frankliniella occidentalis was found abundantly on Melilotus officinalis. Sinapis arvensis on which Melanthrips species are the most abundant, hosted relatively low numbers of F. occidentalis and T. tabaci indicating Melanthrips species compete well with other two harmful thrips species on this plant. This study suggests that it can be useful to allow the weeds with yellow –and multi-flowered as well as V. villosa to grow in groves without any precautionary measures against weeds. Besides, these weeds may play a role as trap plants for thrips and banker plants for predators mainly Orius species.

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Introduction

Farming systems do not provide favorable ecological conditions for beneficial insects (predators and parasitoids) due to cultural practices and intensive pesticide use (Landis et al. 2000). Habitat management systems such as using ground cover plants provide sheltering, alternative prey, nectars, and pollens, microclimate conditions for beneficial organisms. Because these benefits obtained with the habitat management are not implemented, due to agricultural cultural practices (Bugg and Pickett, 1998; Johsson et al. 2008). These additional benefits provided by habitat management can increase the survival and productivity of insects and therefore can be effectively used in the biological control of harmful arthropod species.

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(Landis et al. 2000). Habitat management can increase plant biological diversity in cropping systems and create a new and different farming system (Russell, 1989; Andow, 1991; Bugg and Pickett, 1998; Landis et al. 2000). With different crop growing systems and increasing plant biodiversity, the variety and abundance of natural enemies can be increased; therefore arthropod pests can be kept under control (Price et al. 1980, Hunter and Price, 1992, Buchanan et al. 2017, Michalko et al. 2019). However, the presence, diversity, and abundance of natural enemies are often reduced, due to the use of chemical pesticides and intensive cultural practices as mentioned in agricultural systems (Russell, 1989; Andow, 1991; Bugg and Pickett, 1998). Plant diversification can modify the behavior of herbivores or improve biological control; thus, in the production system, the abundance and efficiency of natural enemies such as predators and parasitoids can be increased by providing non-host resources (such as weeds), which can reduce the pest population (Barbosa and Wratten 1998, Landis et al. 2000, Gurr et al. 2017).

Weeds are not desired by growers, because they compete with the crop plants for food, water, and soil, and host harmful insects, mites and pathogens that damage arable crop plants. (Van Emden, 1965; Thresh, 1981). However, when crops are grown with weeds or other crop plants, the population density of harmful arthropod species decreases (Altieri, 1980). According to another hypothesis, non-host plants (for example weeds) inhibit the existing chemical stimulants in the environment used by pest arthropods to find their host plants. Non-host plants play a kind of barrier role; thus preventing pest insects to search host plants. Increased plant diversity increases the effectiveness of natural enemies in suppressing pests and reduces producers' dependence on chemical pesticides (Altieri and Whitcom, 1979; Dent, 1991; Gurr and Wrattten, 1999). The weeds are also important because they prevent soil erosion, provide soil moisture and nitrogen fixation of soil (Gliessman et al. 1981; Weil, 1982).

In Turkey, weeds are destroyed by the different control tactics in citrus orchards. These applications are in the form of mowing, plowing, and herbicide usage. The reason for this is that weeds host the disease and harmful factors as explained earlier. Another issue is that weeds compete with the crop plants for food and water, thus negatively affecting the yield. Besides weeds negative effect on ecosystems; weeds provide, nectars, pollens, hibernation, and mating sites as well as shelter to natural enemies particularly predators and parasitoids (Aguilar-Fenollosa and Jacas. 2013; Madeira and Pons, 2015).

Citrus fruits are among the important fruit groups and their production exceeds 137 million tons worldwide annually (FAO, 2019). Thrips accept citrus as hosts and some of them are economically harmful to citrus (Blank and Gill, 1997; Childers and Nakahara. 2006; Costa et al. 2006; Froud et al. 2001; Navarro et al. 2008; Tekşam and Tunç, 2009). They are usually under pressure by applying chemicals (Baker et al. 2004; Morse and Hoddle, 2006; Vassiliou, 2007; Navarro et al. 2012). Chemical pesticide applications are costly and require repetitive applications, potentially preventing IPM (Integrated Pest Mangament) strategies deployed in the citrus (Baker et al. 2004; Morse and Hoddle, 2006). Therefore, alternative methods of control are needed. In recent years, scientific studies have been focusing on the management of covering plants to increase the effectiveness of natural enemies. This is a new ecological approach to augment natural enemies (Jacas and Urbaneja, 2010; Aguliar-Fenollosa et al. 2011a, 2011b, 2011c).

In previous studies (Atakan and Uygur, 2004 and 2005; Atakan and Tunç, 2010) conducted in the eastern Mediterranean region of Turkey, thrips and their natural enemies and the relationships between them on weeds bordering the field margins have been investigated. As a model study, the seasonal population densities of the two common thrips species on the weeds in the citrus orchards and the predator species known to feed with thrips and their relationships are not known enough. Weeds are also important in habitat management in creation of plant diversity. In the convensional farming system, herbicides are widely used in the control of weeds. The complete removal of weeds from habitats can be harmful to arthropod species and cause an increase in abundance of pest species, because pest increases are more likely associated with the weed-clean plots compared to weed-rich plots (Pimentel and Goodman 1978). Certain weed species, if managed well, can provide nectars, pollens and microhabitates for natural enemies (Gurr et al. 2003; Wyss et al. 1995; Fonseca et al. 2017). In this study, it is aimed to identify beneficial insects primarily. Weeds are mostly self-contained plants in the ecosystem. Therefore, there is no need for an additional expense in order to grow cover plants (some of them are called beneficial weeds belonging to Leguminosa) in habitat. The findings can be used in habitat management in citrus fruits and may show the role of beneficial insects found on weeds in suppressing pest insect species including harmful thrips.

Material and Methods

Experimental Design

Field experiments were conducted in the Research Area of Agricultural Faculty (37° 01.809′ N; 35° 21.694′ E), University of Çukurova, Adana, Turkey during 2014-2015. The experiment planned in an Okitsu mandarin grove consists of 10 rows and 20 trees in each row. The trees were seven-years-old. Height and width of the trees are ranged from 3 to 4 meters. Trees are planted as 5 × 5 m. Each row is 100 in lenght. Four rows of the experimental area were left weedy during the experiment. During this time most of the weeds were in the flowering stage, with different heights. No any control tactic was deployed against the weedy plants inside the grove. Middle two rows of experimental area were selected as a sampling unit. This area was divided into five sub plots to create pseudo replications.

Sampling of Thrips and Predators on Flowers of Weeds

Weeds with at least 10% coverage included *Anthemis arvensis, Melilotus officinalis, Medicago polymorpha, Sinapis arvensis* and *Vicia villosa* are taken into account in sampling. They were sampled at weekly intervals during the sampling period at 08:00-10:00 h. which thrips are more active in that time intervals (Atakan and Uygur, 2005). Four plants from each weedy species in each weedy subplot (totally 20 plants at whole experiment) were randomly selected and tapped onto a plastic container for 5 s. Thrips and beneficial insects (*Orius*) were collected with the aid of mouth aspirator, labeled and placed in plastic tubes (2 mL capacity) containing 60% ethanol. The thrips were slide-mounted. All identified thrips species were adults including females and males.

Thysanoptera species were diagnosed by the first author using identification keys published by zur Strassen (2003) and Balua et al. (2012). *Orius* was identified using the diagnostic key according to their morphological characters (e.g., genitalia) (Önder, 1982). Weeds were identified by

Prof. Dr. Sibel Uygur (University of Çukurova, Faculty of Agriculture, Plant Protection Department, Adana, Turkey).

Statistical Analysis

All data obtained from this study showed normal distribution. Seasonal mean numbers of thrips and *Orius* on the four weedy plant species on selected weedy rows were compared by using Tukey's HSD test at P<0.05 importance level. Relationships between *Orius* and thrips collected from weeds were evaluated by quadratic regression analysis (P< 0.05). In relationship analysis, we did not consider *Melanthrips* spp. on weed species, because of this species are not pests on arable crop plants and they are often regarded pollen feeders, and *Melanthrips* were detected only on weed species, *Sinapis arvensis* at the beginning of sampling period and they were not found on the most sampling dates. All analyses were performed using the Microsoft Statistics Program SPSS 15.0. (SPSS, 2006).

Results and Discussion

Relative Abundance of the Weeds

A total of 15 weed species was identified in this study (Table 1). The coverage area of weeds did not differ between years. *Anthemis arvensis* and *V. villosa* were the more abundant weedy species in both years (for *A. arvensis* 21% in 2014 and 18% in 2015; for *V. villosa* 16% in 2014 and 19% in 2016). The coverage of nine weed species were less than 5% in both years.

Thrips Species on Weed Species in Okitsu Grove

In this study, a total of seven thrips species was determined (Table 2). The most common and abundant species sampled were *Thrips tabaci* Lindeman, *Melanthrips* spp, and *Frankliniella occidentalis* (Pergande), respectively. *Frankliniella occidentalis* was found on *Melilotus officinalis* abundantly. *Thrips tabaci* were mostly sampled from *V. villosa*. Predatory thrips species, *Aeolothrips collaris* were collected in a much smaller number. This species was recorded in similar numbers on *V. villosa* and *M. officinalis*. *Melanthrips* species were sampled in high numbers on *S. arvensis*. *Sinapis arvensis* on which *Melanthrips* species are the most abundant hosted relatively low numbers of *F. occidentalis* and *T. tabaci*, which are commonly found pest thrips species in the region. This may indicate that *Melanthrips* species are good competitive. The *Melanthrips* species were caught very few in April when the flowering of weeds plant species ended. In the previous study, *Melanthrips* species accounted for 81% of adult thrips sampled in February and March (Atakan and Uygur, 2005). These species are not harmful in agricultural crops, they are often considered the species feed with pollens (de Borbon, 2009). Due to this competition, *Melanthrips* might have prevented the development of harmful thrips species including *F. occidentalis* and *T. tabaci* on flowers of multi-flowered weed species such as *S. arvensis* and *Octodium eagyptiacum*, and thus it could hamper pest thrips movements to cultivated crop plants. In several studies, it has been speculated that these species are predators feeding on soft-bodied insects including thrips (Baraowski, 1998; Abdul-Fatah Hamodi, 2012). In the current study, fewer Thysanoptera species were found. In the previous study 24 thrips species were recorded (Atakan and Uygur, 2005). The reason for this may be related to the sampling of large numbers of weed plant species in large three sampling areas in a previous study. Possibly weed species diversity may have affected the number of thrips species. Chellemi et al. (1994) also found that the abundance and diversity of weed host plants affected the abundance of thrips in north Florida.

Seasonal Mean Numbers of some Thrips Species and Orius niger (Wolff, 1811) on Weeds

Table 1. Coverage proportions of naturally growing weeds in the Okitsu mandarin grove

Family/Latin name	Scientific name	Relative abundance (% of total density)	
		2014	2015
Asteraceae			
Anthemis arvensis	Corn chamomile	21	18
Calendula arvensis	Field marigold	1	1
Senecio vernalis	Eastern groundsel	1	1
Brassicaea			
Capsella bursa pastoris	Shephard's purse	1	1
Sinapis arvensis	Wild mustard	12	15
Caryophyllaceae			
Melilotus officinalis	Field melilot	14	13
Stellaria media	Common chickweed	2	1
Euphorbiaceae			
Mercurialis annua	Annual mercury	1	2
Fabaceae			
Medicago polymorpha	Bur clover	15	12
Vicia sativa	Common vetch	10	12
Vicia villosa	Winter vetch	16	19
Fumariaceae			
Fumaria officinalis	Common fumitory	1	1
Geraniaceae			
Erodium molchatum	Musky storksbill	2	2
Lamiaceae			
Lamium amplexicaule	Henbit dead nettle	2	1
Malvaceae			
Malva sylvestris	Large-flowered mallow	1	1

Vicia villosa hosted significantly more *T. tabaci* (in total) than the other ones in 2014 ($F_{4,45}$ = 115.324, P<0.0001) and 2015 ($F_{4,45}$ = 235.398, P<0.0001) (Table 3). Although the total mean number of *F. occidentalis* was significantly higher on *M. officinalis* in 2014 ($F_{4,45}$ = 124.451, P<0.0001), the population densities were similar on *V. villosa* and *M. officinalis* but significantly higher than those on other weed species in 2015 ($F_{4,45}$ = 19.193, P<0.0001) (Table 3). *Sinapis arvensis* hosted significant and high seasonal mean numbers of *Melanthrips* spp. in 2014 ($F_{4,45}$ = 180.451, P<0.0001) and 2015 ($F_{4,45}$ = 39.269, P<0.0001; Table 3).

Total mean numbers of *Orius* were significant on *V. villosa* in 2014 ($F_{4,45}$ = 46.316, P<0.0001) and 2015 ($F_{4,45}$ = 17.023, P<0.0001) (Table 4).

Table 2. Total numbers of thrips species collected from the weed species in 2014-2015

Family/species	***Vicia villosa***	***Melilotus officinalis***	***Medicago polymorpha***	***Sinapis arvensis***	***Anthemis arvensis***	**Total**
Aeolothripidae/*Aeolothrips collaris*[a]	29	23	0	0	6	58
Melanthripidae/ *Melanthrips* spp. (*Melanthrips fuscus, Melanthrips pallidior*)	39	38	13	2247	2	2339
Phlaeothripidae/*Haplothrips flavinctus*	0	1	0	0	0	1
Thripidae/*Chirothrips aculeatus*	0	1	0	0	0	1
Thripidae/*Frankliniella occidentalis*	606	1006	249	67	68	1996
Thripidae/*Thrips major*	4	4	6	3	0	17
Thripidae/*Thrips tabaci*	2090	947	147	226	1271	4681
Total	2768	2020	415	2543	1347	

[a] Predatory thrips.

Table 3. Cumulative mean numbers of two common thrips species on weeds naturally grown inside of Okitsu mandarin in 2014-2015

Thrips species	**Weed species**	**Mean number of thrips per plant**[a]	
		2014	2015
Frankliniella occidentalis	*Vicia villosa*	55.20±3.10b	5.40±0.58a
	Melilotus officinalis	96.20±6.56a	4.40±0.74a
	Medicago polymorpha	24.50±2.15c	0.40±0.16b
	Sinapis arvensis	5.50±0.83d	1.20±0.44b
	Anthemis arvensis	5.40±1.34d	1.40±0.37b
Thrips tabaci	*Vicia villosa*	142.40±9.53a	66.60±2.61a
	Melilotus officinalis	62.20±3.77b	28.50±2.01c
	Medicago polymorpha	9.70±1.94d	5.0±0.57d
	Sinapis arvensis	20.50±2.77c	2.30±0.68d
	Anthemis arvensis	77.90±2.13b	49.20±2.18b
Melanthrips spp.	*Vicia villosa*	3.00±0.55b	0.90±0.40
	Melilotus officinalis	2.80±0.57b	1.00±0.39
	Medicago polymorpha	0.00±0.00b	1.30±0.65
	Sinapis arvensis	126.40±9.27a	98.30±15.52
	Anthemis arvensis	0.00±0.00b	0.27±0.13

[a]The means with the same letter in the columns are not statistically significant according to the Tukey HSD test (P>0.05).

All three species of thrips were collected on pollen-rich and yellow multi-flowered weedy plant species. Weed species with yellow-colored and are bearing high numbers have been reported to particularly attract to *F. occidentalis* (Yudin et al. 1986). The significant collection of *F. occidentalis* on *M. officinalis* may be related to the absence of competition with other thrips species (mainly *Melanthrips*) on this plant. Besides, the reason of sampled weedy plant species having different attractiveness to different thrips species may be related to different plant morphology and their chemical contents. In this study, we did not aim to find out the chemical components of plant species sampled. The different effects of the chemical ingredients of the sampled weeds or other weed species on thrips or other pest arthropods species are not yet known. However, aromatic plants are particularly valuable for the essential oil they produce. While many insect species use the volatile components of essential oil to find suitable host plants, plants defend themselves againist hervivores by producing deterrent and/or toxic compounds (Harrewijn et al. 1994; Regnault-Roger, 1997). Different effects of essential oils on thrips species including *F. occidentalis* and *T. tabaci* such as plant defensive compounds, atractants, repellents, antifeedants and oviposition. deterrents and botanical insecticides has been reviewed well by Koschier (2008). Further studies are needed for this issue.

Table 4. Cumulative mean numbers of *Orius niger* (Wolff, 1811) on weeds grown naturally inside of Okitsu mandarin area in 2014-2015

	Mean numbers per plant[a]	
Weed species	2014	2015
Vicia villosa	11.8±1.14a	5.70±0.86a
Melilotus officinalis	2.00±0.57b	1.90±0.67b
Medicago polymorpha	0.00±0.00c	0.00±0.00c
Sinapis arvensis	1.20±0.38c	0.70±0.15c
Anthemis arvensis	3.80±0.77b	2.10±0.43b

[a]The means with the same letter in the columns are not statistically significant according to the Tukey HSD test (P>0.05).

In the current study, only *O. niger* was recorded as general hemipteran predator. This may be related to the bio-ecology, prey species, host plants and climate factors of predators. In the previous study, general predators related to genera *Geocoris*, *Piocoris* and *Nabis* were mostly collected in the summer period (Atakan and Tunç, 2010). A significant number of *O. niger* gathering on *V. villosa* may be associated with the thrips (mainly, *F. occidentalis*; Table 5), which are prey for *Orius*. *Thrips tabaci* was also recorded on this plant in a significant number. Although *T. tabaci* was found in a large number on *V. villosa*, only the relationships between *O. niger* and *F. occidentalis* were found to be significant on this beneficial weed species. Atakan and Pehlivan (2020) detected significant relationships between *T. tabaci* and *O. niger* in 'Okitsu' mandarin flowers. This may be related to the morphology, anatomic structure of the plant species and the different chemical compounds in the different plant species.

In this study, thrips and predator *O. niger* were collected mainly from *V. villosa*. *Vicia villosa* (hairy vetch) is a wintery plant from the family Leguminosa, fixing the nitrogen from the soil (Bongsu and Daimon, 2008; Seo and Lee 2008; Anugroho et al. 2009). This plant species is considered as a cover plant in the agroecosystem (Ruffo and Bollero, 2003; Brandseater et al. 2008). When it is used as a winter plant and also mowed, it acts as a dead mulch, suppressing weeds with allelopathic effects (White et al. 1989; Bradow et al. 1990; Hill et al. 2007). *Vicia villosa* is used in soil erosion control. It is also considered as animal feed due to its high protein content. Even if this feature is not taken into consideration in this study, it has a high rate of thrips (mainly *T. tabaci*). The average number of predatory bug, *O. niger* was also recorded to be high on this beneficial weed species. This plant can be regarded as a trap plant for the thrips and can be considered as a banker plant for beneficial insects. The rich plant variety leads to high numbers of beneficial insects. (Sotherton, 1984, 1985; Thomas et al. 1991). However, as shown in this study, only *Orius* and predatory thrips could be detected on weeds sampled. Other general predators could not be found during this period. This may be related to the ecology of beneficial insects, the climate, and their preference of different prey. Tillage of weedy plants from vegetation and using herbicides affect the relationship between thrips and predators negatively. Although the presence of weeds in and around the crops is known to be good for the augmentation and development of natural enemies, growers are not willing to adopt such a strategy due to the negative effects of weeds on crop yields (Risch, 1981; Altieri, 1995).

The number of thrips was found higher in weeds than 'Okitsu mandarin' flowers (Atakan and Pehlivan, 2020). This may indicate that weeds are much more attractive to thrips than citrus flowers. As a model study, the results obtained from this study can be adapted against thrips (especially in lemons) in other citrus groves. *Thrips hawaiiensis*, as an invasive thrips species, was the first time introduced to lemon groves in Turkey in 2015. This thrips has caused damage on young fresh lemon fruits and quickly spread over the eastern Mediterranean region of Turkey in a year. Control of this pest thrips by pesticides is difficult because it is mostly in flowers. Weed varieties, particularly *V. villosa* as a cover plant species may be evaluated in controlling of pest thrips species such as *T. hawaiiensis* in lemon groves. Additionally, yellow and multi-flowered weed species such as *S. arvensis* and *O. eagyptiacum* bearing high numbers of *Melanthrips*, can be allowed to grown naturally (not allowing them to develop excessively) between citrus rows to prevent development and growth of pest thrips species such as *T. hawaiiensis* damaging citrus mainly lemons.

Relationships between Numbers of Orius and Thrips on Weeds

Table 5. Relationships between numbers of *Orius niger* (Wolff, 1811) and thrips on weed species in 2014 and 2015

Weeds	Relationship	df	R^2	F	P	Equation
2014						
A. arvensis	*O. niger-T. tabaci*	2,5	0.73	7.032	0.028	$Y=-16.331x^2+42.098x+1.949$
A. arvensis	*O. niger -F. occidentalis*	2,5	0.27	0.949	0.447	$Y=0.276x^2+0.630x+0.257$
S. arvensis	*O. niger-T. tabaci*	2,5	0.24	2.589	0.140	$Y=-17.500x^2+19.750x+0.60$
S. arvensis	*O. niger -F. occidentalis*	2,5	0.03	0.087	0.918	$Y=1.309x^2+21.823x+11.969$
V. villosa	*O. niger -T. tabaci*	2,5	0.11	0.335	0.730	$Y=0.0915x^2+2.059x+17.156$
V. villosa	*O. niger -F. occidentalis*	2,5	0.71	6.251	0.032	$Y=1.309x^2+21.823x+11.969$
2015						
A. arvensis	*O. niger -T. tabaci*	2,6	0.69	7.807	0.019	$Y=-27.771x^2+38.150x+0.068$
A. arvensis	*O. niger -F. occidentalis*	2,6	0.09	0.300	0.751	$Y=-0.609x^2+0.424x+0.149$
M. officinalis	*O. niger -T. tabaci*	2,6	0.01	0.033	0.968	$Y=-4.975x^2+3.038x+2.951$
M. officinalis	*O. niger -F. occidentalis*	2,6	0.13	0.475	0.643	$Y=-2.267x^2+0.220x+0.636$
V. villosa	*O. niger -T. tabaci*	2,6	0.08	0.266	0.775	$Y=3.363x^2-2.808x+7.072$
V. villosa	*O. niger -F. occidentalis*	2,6	0.75	10.262	0.013	$Y=0.858x^2-1.691x+0.800$

Relationships between numbers of *O. niger* and thrips on weeds are given in Table 5. On *A. arvensis*, significant but negative relationships between *Orius* and *T. tabaci* were noted in 2014 and 2015 ($P< 0.05$) (Table 5). Correlations between numbers of *Orius* on *V. villosa* were significant and positive in 2014 and 2015 ($P<0.05$) (Table 5). This issue may indicate that thrips were more suffered by predations of *O. niger* on *V. villosa* or *A. arvensis*. There was a good and positive relationship between mean numbers of *F. occidentalis* and *O. niger* on *S. arvensis* surrounding the faba bean experimental plots in same ecological area (Atakan, 2010). The reason for the lack of correlation between the number of thrips and the *Orius* on *S. arvensis* may be related to *Orius*'s preying on different thrips on this weed species. *Melanthrips* species were recorded in large numbers on *S. arvensis* as previously described.

Conclusions

Yellow and multi-flowered weed species were found to be very attractive for thrips, especially for *Melanthrips* species which are considered often pollen feeders. *Melanthrips* species appeared to be more competitive with the other pest thrips species identified in the current study, preventing population development of the pest thrips species on flowering weeds especially *S. arvensis*. *Thrips tabaci*, one of the harmful thrips species, was more attracted by beneficial weed species namely *V. villosa*. This weed also hosted abundant numbers of predatory bug, *O. niger*. There were also significant relationships among thrips and *Orius* numbers obtained from this weed species in both years. These weed species (not allowing excessive growth of them in orchards) could be used as trap plants for thrips and banker plants for especially predatory bugs in pest management of thrips in orchards. It is beneficial not to mow weeds in citrus orchards. Because these flowering weeds have many thrips than the flowers of the trees, and thus they could play a role as trap plants for thrips and banker plants for predatory insects (mainly, *O. niger*).

Author Contribution

EA and SP conceived and designed the research. EA and SP conducted experiments. EA analyzed data and wrote the manuscript. All authors read and approved the manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

Abdull-Fatah Hamodi, A., 2012. New record of predator *Melanthrips pallidior* Priesner (Thysanoptera: Melanthripidae) on Baghdad-IRAQ. *Bulletin of the Iraq Natural History Museum,* 12(1): 11-17.

Aguilar-Fenollosa, E., Ibanez-Gual, M.V, Pascual-Ruiz, S., Hurtado, M., and Jacas J.A., 2011a. Effect of ground-cover management on spider mites and their phytoseiid natural enemies in clementine mandarin orchards (I): bottom-up regulation mechanisms. *Biological Control,* 59(2): 158-170.

https://doi.org/10.1016/j.biocontrol.2011.06.013

Aguilar-Fenollosa, E., Ibanez-Gual, M.V., Pascual-Ruiz, S., Hurtado, M., and Jacas J.A., 2011b. Effect of ground-cover management on spider mites and their phytoseiid natural enemies in clementine mandarin orchards (II): top-down regulation mechanisms. *Biological Control,* 59(2): 171-179.

https://doi.org/10.1016/j.biocontrol.2011.06.012

Aguilar-Fenollosa, E., Pascual-Ruiz, S., Hurtado, M., and Jacas, J.A., 2011c. Efficacy and economics of ground cover management as a conservation biological control strategy against *Tetranychus urticae* in clementine mandarin orchards. *Crop Protection,* 30(10): 1328-1333. https://doi.org/10.1016/j.cropro.2011.05.011

Aguilar-Fenollosa, E., and Jacas, J.A., 2013. Effect of ground cover management on Thysanoptera (thrips) in clementine mandarin orchards. *Journal of Pest Science,* 86(3): 469-481.

Altieri, M.A., 1980. Diversification of corn agrosystems as a means of regulating fall armyworm populations. *Florida Entomologists,* 63(4): 450-456.

https://doi.org/10.2307/3494529

Altieri, M.A., 1995. *Agroecology: the Science of Sustainable Agriculture*. Boulder, CO: Westview Press.

Altieri, M.A., and Whitcomb, W.H., 1979. The potential use of weeds in the manipulation of beneficial insects. *Hortscience,* 14: 12-18.

Andow, D.A., 1991. Vegetational diversity and arthropod population response. *Annual Review of Entomology,* 36(1): 561–586. https://doi.org/10.1146/annurev.en.36.010191.003021

Anugroho, F., Kitou, M., Nagumo, F., Kinjo, K., and Tokashiki Y., 2009. Growth, nitrogen fixation, and nutrient uptake of hairy vetch as a cover crop in subtropical region. *Weed Biology and Management,* 9(1): 63–71.

https://doi.org/10.1111/j.1445-6664.2008.00319.x

Atakan, E., 2010. Influence of weedy field margins on abundance patterns of the predatory bugs *Orius* spp. and their prey, the western flower thrips (*Frankliniella occidentalis*), on faba bean. *Phytoparasitica,* 38(4): 313-325.

https://doi.org/10.1007/s12600-010-0105-9

Atakan, E., and Tunç, I., 2010. Seasonal abundance of hemipteran predators in relation to western flower thrips *Frankliniella occidentalis* (Thysanoptera: Thripidae) on weeds in the eastern Mediterranean region of Turkey. *Biocontrol Science and Technology,* 20(8): 821-839. https://doi.org/10.1080/09583157.2010.481725

Atakan, E., and Uygur, S., 2005. Winter and Spring Abundance of *Frankliniella* spp. and *Thrips tabaci* Lindeman (Thysan., Thripidae) on Weed Host Plants in Turkey. *Journal of Applied Entomology,* 129(1): 17-26.

https://doi.org/10.1111/j.1439-0418.2005.00918.x

Atakan, E., and Uygur, S., 2004. Seasonal abundance of the some thrips species and their predators on weeds. *Turkey Journal of Entomology,* 28(2): 123-132.

Atakan, E., and Pehlivan, S., 2020. Influence of weed management on the abundance of thrips species (Thysanoptera) and the predatory bug, *Orius niger* (Hemiptera: Anthocoridae) in citrus mandarin. *Applied Entomology and Zoology, 55*(1): 71-81. https://doi.org/10.1007/s13355-019-00655-9

Baker, G., Keller M., Purvis, S., Jackman, D., and Crisp, P., 2004. *Improving the management of Kelly's Citrus Thrips in citrus: Summary, conclusions and recommendations of the 2000-04.* Kelly's citrus thrips research project. http://www.sardi.sa.gov.au/pestsdiseases/horticulture/horticultural_pests/kelly_citrus_thrips/research_report_2000-2004?SQ_DESIGN_NAME=. Accessed 29 Nov 2019.

Balou, M.M., Tong, X.L,, and Chen, X.X., 2012. A new record and description of a new species of the genus thrips with an updated key to species from Iran. *Journal of Insect Science,* 12(1): 1-15.

Baranowski, M., 1998. Faunistic observations of Thysanoptera on sugar beet plantations in Middle Ukraine. In: *Proceedings of Sixth International Symposium on Thysanoptera,* Antalya, Turkey, 13–18.

Barbosa, P., and Wratten, S.D., 1998. Influence of plants on invertebrate predators: implications to conservation biological control. In P. Barbosa (ed.), *conservation biological control.* Academic Press, San Diego, CA, 83–100.

Blank, R.H, and Gill, G.S.C., 1997. Thrips (Thysanoptera: Terebrantia) on flowers and fruit of citrus in New Zealand. *New Zealand Journal of Crop and Horticultural Science,* 25(4): 319–332. https://doi.org/10.1080/01140671.1997.9514023

Bongsu, C., and Daimon, H., 2008. Effect of hairy vetch incorporated as green manure on growth and N uptake of sorghum crop. *Plant Production Science,* 11(2), 211–216. https://doi.org/10.1626/pps.11.211

Brandsaeter, L.O., Heggen, H., Riley, H., Stubhaug, E., and Henriksen, T.M., 2008. Winter survival, biomass accumulation and N mineralization of winter annual and biennial legumes sown at various times of year in Northern temperate regions. *European Journal of Agronomy,* 28(3): 437–448. https://doi.org/10.1016/j.eja.2007.11.013

Buchanan, A.L., Hermanni S.L., Lund, M., and Szendrei, Z., 2017. A meta analysis of non-consumptive predator effects in arthropods: the influence of organismal and environmental characteristics. *Oikos,* 126(9): 1233–1240. https://doi.org/10.1111/oik.04384

Bugg, R.L., and Pickett, C.H., 1998. Introduction: enhancing biological control-habitat management to promote natural enemies of agricultural pests. In C.H Pickett, R.L. Bugg, (Eds) *Enhancing Biological Control,* Berkeley, CA, USA, University of California Press, 1–23.

Chellemi, D.O., Funderburk, J.E., and Hall, D.W., 1994. Seosonal abundance of flower-inhabiting Frankliniella species (Thysanoptera: Thripidae) on wild plant species. *Environmental Entomology,* 23(2): 337–342.

Childers, C.C., and Nakahara, S. (2006). Thysanoptera (thrips) within citrus orchards in Florida: species distribution, relative and seasonal abundance within trees, and species on vines and ground cover crops. *Journal of Insect Science,* 6: 1–19. https://doi.org/10.1673/031.006.4501

Costa, L., Mateus, C., Zur Strassen, R., and Franco, J.C., 2006. Thrips (Thysanoptera) associated to lemon orchards in the Oeste region of Portugal. *IOBC WPRS Bull,* 29(3): 285–291.

De Barbon, C.M., 2009. A redefiniation of *Dorythrips* (Thysanoptera: Melanthripidae) with a description of a new species from Argentina. *Zootaxa,* 212(1): 17-26.

Dent, D., 1991. *Insect Pest Management.* (Wallingford: CAB International).

Koschier, E.H., 2008. Essential oil compounds for thrips control – A review. *Natural Product Communications,* 3(7): 1171-1182.

F.A.O., 2019. *FAOSTAT, Statistics Division, Food and Agriculture Organization.* http://www.fao.org/faostat/en/#data/QC (Accessed date: 19 February 2019).

Fonseca, M.M., Lima, E., Lemos, F., Venzon, M., and Janssen, A., 2017. Non-crop plant to attract and conserve an aphid predator (Coleoptera: Coccinellidae) in tomato. *Biological Control,* 115: 129–134. https://doi.org/10.1016/j.biocontrol.2017.10.005

Froud, K.J, Stevens, P.S., and Steven, D., 2001. Survey of alternative host plants for Kelly's citrus thrips (*Pezothrips kellyanus*) in citrus growing regions. *New Zealand Plant Protection,* 54: 15–20.

Harrewijn, P., Minks, A.K., and Mollema C., 1994. Evolution of plant volatile production in insect-plant relationships. *Chemoecology,* 5(2): 55-73.

Gliessman, S.R., Garci´a, E.R., and Amador, A.M., 1981. The ecological basis for the application of traditional agricultural technology in the management of tropical agro-ecosystems. *Agro-ecosystems,* 7(3): 173-185.

https://doi.org/10.1016/0304-3746(81)90001-9

Gurr, G.M., and Wratten, S.D. (1999). 'Integrated biological control': a proposal for enhancing success in biological control. *International Journal of Pest Management,* 45(2): 81-84. https://doi.org/10.1080/096708799227851

Gurr, G.M., Wratten, S.D., Landis, D.A., and You, M., 2017. Habitat management to suppress pest populations: progress and prospects. *Annual. Review of Entomology,* 62: 91–109.

https://doi.org/10.1146/annurev-ento-031616-035050

Gurr, G.M., Wratten, S.D., and Luna, J.M., 2003. Multi-function agricultural biodiversity: pest management and other benefits. *Basic and Applied Ecolology,* 4(2): 107–116. https://doi.org/10.1078/1439-1791-00122

Hill, E.C., Ngouajio, M., and Nair, M.G., 2007. Allelopathic potential of hairy vetch (*Vicia villosa*) and cowpea (*Vigna unguiculata*) methanol and ethyl acetate extracts on weed and vegetable. *Weed Technology,* 21(2): 437–444. https://doi.org/10.1614/WT-06-167.1

Hunter, M.D., and Price, P.W., 1992. Playing chutes and ladders: heterogeneity and the relative roles of bottom-up and top-down forces in natural communities. *Ecology,* 73(3): 724–732.

Jacas, J.A., and Urbaneja, A., 2010. Biological control in citrus in Spain: from classical to conservation biological control. In: Ciancio A, Mukerji KG (eds) *Integrated Management of Arthropod Pests and Insect Borne Diseases,* Springer, Netherlands, 57–68.

Jonsson, M., Wratten, S.D., Landis, D.A., and Gurr, G.M., 2008. Recent advances in conservation biological control of arthropods by arthropods. *Biological Control,* 45(2): 172–175.

https://doi.org/10.1016/j.biocontrol.2008.01.006

Landis, D.A., Wratten, S.D., and Gurr, G.M., 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annual Review of. Entomology,* 45(1): 175–201. https://doi.org/10.1146/annurev.ento.45.1.175.

Madeira, F., and Pons, X., 2015. Effects of weed density on the dispersal of *Orius majusculus* Reuter (Heteroptera: Anthocoridae) within maize. *Journal of Applied Entomology,* 139(9): 712-720.

https://doi.org/10.1111/jen.12213

Michalko, R. Pekár,S., and Entling, M.H., 2019. An updated perspective on spiders as generalist predators in biological control. *Oecologia,* 189(1): 21–36.

https://doi.org/10.1007/s00442-018-4313-1

Morse, J.G., and Hoddle, M.S., 2006. Invasion biology of thrips. *Annual Review of. Entomology,* 51: 67–89. https://doi.org/10.1146/annurev.ento.51.110104.151044.

Navarro-Campos, C., Aguilar, A., and Garcia-Mari, F., 2012. Aggregation pattern, sampling plan, and intervention threshold for *Pezothrips kellyanus* in citrus groves. *Entomologia Experimentalis et. Applicata,* 142(2): 130–139.

https://doi.org/10.1111/j.1570-7458.2011.01204.x

Navarro, C., Pastor, MT, Ferragut, F., and García-Mari, F., 2008. Thrips (Thysanoptera) associated with citrus plots in the Valencian Community: abundance, seasonal evolution and spatial distribution. *Bulletin of Plant Health of Pests,* 34 , 53-64..

Önder, F., 1982. *Contribution to the Study of Turkish Anthocoridae (Heteroptera).* Ege University, Faculty of Agriculture, Izmir, 159.

Pimentel, D., and Goodman, N., 1978. Ecological basis for the management of insect populations. *Oikos,* 30: 422–437.

Price, P.W., Bouton, C.E., Gross, P., McPheron, B.A., Thompson, J.N., and Weis, A.E., 1980. Interactions among three trophic levels: influence of plants on interactions between insect herbivores and natural enemies. *Annual Review of Ecology, Evolution and Systematics,* 11(1): 41–65.

Regnault-Roger C., 1997. The potential of botanical essential oils for insect pest control. *Integrated Pest Management Reviews,* 2(1): 25-34.

https://doi.org/10.1023/A:1018472227889

Risch, S.J., 1981. Insect herbivore abundance in tropical monocultures and polycultures: an experimental tests of two hypotheses. *Ecology,* 62(5): 1325–1340. https://doi.org/10.2307/1937296.

Ruffo, M.L., and Bollero, G.A., 2003. Modelling rye and hairy vetch residue decomposition as a function of degree-days and decomposition days. *Journal of Agronomy,* 95(4): 900–907. https://doi.org/10.2134/agronj2003.9000

Russell, E.P., 1989. Enemies hypothesis: a review of the effect of vegetational diversity on predatory insects and parasitoids. *Environmental Entomology,* 18(4): 590–599. https://doi.org/10.1093/ee/18.4.590

Seo, J.H., and Lee, H., 2008. Mineral nitrogen effects of hairy vetch (*Vicia villosa* Roth) on Maize (*Zea mays* L.) by green manure amounts. *Journal of Agronomy,* 7(3): 272–276. https://doi.org/10.3923/ja.2008.272.276

Sotherton, N.W., 1984. The distribution and abundance of predatory arthropods overwintering on farmland. *Journal of Applied Ecology,* 105(3): 423-429. https://doi.org/10.1111/j.1744-7348.1984.tb03068.x.

Sotherton, N.W., 1985. The distribution and abundance of predatory Coleoptera overwintering in field boundaries. *Journal of Applied Ecology,* 106(1): 17–21.

https://doi.org/10.1111/j.1744-7348.1985.tb03089.x

SPSS., 2006. *SPSS base 15.0 user's guide*. Chicago, IL, USA: Prentice Hall.

Teksam, I., and Tunc, I., 2009. An analysis of Thysanoptera associated with citrus flowers in Antalya, Turkey: composition, distribution, abundance and pest status of species. *Applied Entomology and Zoology,* 44(3): 455–464. https://doi.org/10.1303/aez.2009.455

Thomas, M.B,, Wratten, S.D., and Sotherton, N.W., 1991. Creation of 'island' habitats in farmland to manipulate populations of beneficial arthropods: predator densities and emigration. *Journal of Applied Ecology,* 29(2): 906–917.

https://doi.org/10.2307/2404521

Thresh, J.M., 1981. *Pests, Pathogens and Vegetation: The Role of Weeds and Wild Plants in the Ecology of Crop Pests and Diseases*. Cambridge, MA: Pitman.

Van Emden, H.F., 1965. The role of uncultivated land in the biology of crop pests and beneficial insects. *Scientia Horticulturae,* 17: 121-126.

Vassiliou, V.A., 2007. Chemical control of *Pezothrips kellyanus* (Thysanoptera: Thripidae) in citrus plantations in Cyprus. *Crop Protection,* 26(10): 1579–1584. https://doi.org/10.1016/j.cropro.2007.02.004

Weil, R.N. (1982). Maize – weed competition and soil erosion. *Tropical Agriculture,* 59(3): 207-213.

White, R.H., Worsham, A.D., and Blum, U., 1989. Allelopathic potential of legume debris and aqueous extracts. *Weed Science,* 37, 674-679. https://doi.org/10.1017/S0043174500072623

Wyss, E., Niggli, U., and Nentwig,. W., 1995. The impact of spiders on aphid populations in a strip-managed apple orchard. *Journal of Applied Entomology,* 119(1-5): 473–478.

https://doi.org/10.1111/j.1439-0418.1995.tb01320.x

Yudin, L.S., Tabashnik, B.E., Cho, J.J., and Mitchell, W.C., 1986. Host range of western flower thrips *Frankliniella occidentalis* (Thysanoptera: Thripidae), with special reference to *Leucaena glauca*. *Environmental Entomology,* 15(6): 1292-1295.

Zur Strassen, R., 2003. *The Terebrant Thysanoptera of Europe*. Verlag Goecke and Evers, Kentern, Germany, 277.