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Orijinal araştırma (Original article)

Pest status of western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), in tunnel-grown strawberry

Örtü altında yetiştirilen çileklerde Batı çiçek thripsi, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae)'nin zarar durumunun araştırılması

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Summary

The western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) is often recognized as a serious pest of strawberries worldwide. Although *F. occidentalis* is known as the dominant species among thrips infesting strawberry plants, limited information is available about comparable data of treated and untreated plots of tunnel-grown strawberry in Turkey. In this study, significantly more larvae and adults of *F. occidentalis* were collected from the flowers, when compared with red or green fruits during the year 2011-2012 ($P<0.05$). Nearly 60% of flowers were infested with 10 or more adults, which is the current economic threshold level (ETL; 10 thrips per flower) in this crop. Furthermore, about 6% of red fruits were found to be infested with one or more adults and larval thrips. However, it was observed that population density i.e. 0.4-0.6 and 15 adults per green or red fruit and flowers, respectively, did not cause any damage to the flowers and fruiting parts. No significant difference was observed in the yields of treated and untreated strawberry plots during 2011-2012. It was concluded that population density i.e. 15 *F. occidentalis* individuals per flower may not cause visible damage. Furthermore, economic threshold level for *F. occidentalis* (ETL; 10 thrips per flower), appears to be too low. It is suggested that the ETL of *F. occidentalis* in strawberry needs to be re-evaluated in Turkey.

Keywords: Western flower thrips, strawberry, plastic tunnel, damage

Özet

Batı çiçek thripsi, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) çileğin önemli bir zararlısı olarak bilinmektedir. *F. occidentalis* Türkiye'de çileklerde ana thrips türü olarak bilinmesine karşın, örtü altında ilaçlı ve ilaçsız parsellerinde bitkiye olan zararına ilişkin karşılaştırmalı veriler bulunmamaktadır. 2011-2012 yıllarında, yeşil ve kırmızı meyveler ile karşılaştırıldığında, önemli sayıda *F. occidentalis* larvaları ve erginleri çiçeklerde bulunmuştur ($P<0.05$). Ekonomik zarar eşiği (EZE) değerine (10 thrips /çiçek) göre çiçeklerin %60'ı 10 veya daha fazla thrips ile bulaşık olmuştur. Ayrıca, kırmızı meyvelerin yaklaşık %6'sının 1 veya daha fazla sayıda thripsle bulaşık olduğu da saptanmıştır. Onbeş ergin thrips /çiçek ve ayrıca yeşil veya kırmızı meyvelerde 0.40 veya 0.60 ergin thrips /meyve ile en yüksek thrips yoğunlukları zarara neden olmamıştır. 2011 ve 2012 yıllarında ilaçlı ve ilaçsız parseller arasında verim yönünden önemli farklılıklar bulunmamıştır. Mevcut ekonomik zarar eşiğinin *F. occidentalis* için oldukça düşük olduğu, çiçek başına 15 *F. occidentalis* bireyinin bile çiçeklerde görünen zarara neden olmadığı kaydedilmiştir. Elde edilen sonuçlara dayanarak, *F. occidentalis*'in EZE'nin yeniden değerlendirilmesi önerilmektedir.

Anahtar sözcükler: Batı çiçek thripsi, çilek, örtü altı, zarar

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Introduction

Turkey is the fourth main strawberry (*Fragaria ananassa* and Rosaceae) producer among the European countries (Anonymous, 2014). Marmara, Aegean and Mediterranean are among the potential strawberry growing regions of Turkey. Mersin province located in the eastern Mediterranean region is the main strawberry producing region in Turkey.

Frankliniella occidentalis (Pergande) (Thysanoptera: Thripidae) is a serious pest infesting a wide range of crops worldwide (Lewis, 1997). It is often considered as a major pest of open field and tunnel-grown strawberries in some countries (Allen & Gaede, 1963; Argaman et al., 1989; Tommasini & Maini, 1995; Linder et al., 1998; Steiner, 2003). *F. occidentalis* which has a sucking-piercing mouth cone, scars plant tissues and finally causes damages of flower abortion, fruit bronzing, and fruit deformations of strawberries. *F. occidentalis* has a habit of visiting many different plant flowers. This issue is more likely due to flowers providing essential resources of nectars and pollens especially for female thrips to produce eggs (Trichilo & Leigh, 1988) and mating site for thrips (Rosenheim et al., 1990). Several species of thrips are having serious pest status in strawberry (Sterk, 1990; Steiner, 2002; Steiner & Goodwin, 2005).

Frankliniella occidentalis which was recorded for the first time in Turkey in 1993 (Tunç & Göçmen, 1994). Recently, it has been reported as the dominant pest species in strawberry fields of the eastern Mediterranean region of Turkey (Atakan, 2008). This thrips has not been reported previously as a pest of strawberry grown in open fields in the southeastern Mediterranean region of Turkey (Şekeroğlu et al., 1998).

Generally, it is difficult to manage thrips species due to their wide geographical distribution, high reproductive capacity, as well as large numbers of host plants and feeding on flowers, buds and other plant organs (German et al., 1992). Additionally, insecticides are not capable to control cryptic stages (i.e. their eggs being in the plant tissues and pre-adult stages, pre-pupa and pupa present in the soil or in hidden sites) leading to reduce apparent efficacy of pesticides against *F. occidentalis* (Immaraju et al., 1992). Chemical control is commonly used against pest thrips species, but frequent use of insecticides may induce problems such as destruction of natural enemies and resurgence of insecticide resistance (Desneux et al., 2007; Nauen & Denholm, 2005)

The *F. occidentalis* damage results in flower abortion, fruit bronzing, and fruit deformation on strawberries. Flowers may provide the all the essential elements for life, such as nutrition (Trichilo & Leigh, 1988) and mating site (Rosenheim et al., 1990). Therefore, some observations associated with thrips on strawberry suggest that *F. occidentalis* infestation affects mainly the development of strawberry flowers and fruits. In Turkey, economic threshold level of flower inhabiting thrips in strawberry is 10 individuals (adult or larval thrips) per flower. According to Atakan (2008), over 15 adults of *F. occidentalis* per flowers had caused slight necrotic spots around petals or beneath the calyx of fresh strawberry flowers (Atakan, 2008). Despite of these well-known facts, strawberry growers in the Çukurova region generally rely on pesticidies for the management of this pest (Şekeroğlu et al., 1998; Atakan, 2011). Furthermore, comparable data associated with a described relationship between thrips infestation levels in flowers or on fruits and the yield and quality of strawberry in treated and untreated plots of tunnel-grown strawberry crop have still been lacking.

Main objective of this study is to determine abundance of thrips on various plant parts and population dynamics of larval and adult flower thrips in insecticide-treated and untreated plots and thus to confirm whether insecticide application done against the thrips on strawberry is realistic at the current economic damage level.

Material and Methods

Study site

The experiments were conducted in high plastic tunnels at the Yaltır Agricultural Produce Corporation (Adana province, Turkey) during the years 2011 and 2012. The total area of the experiment was nearly 0.25 ha. Plot size was 62.5 m^2 (10 m length x 5 row x 1.25 m in between rows). The middle two rows were selected as sampling unit in each plot. Half of the plots were treated with active ingredient spinosad 480 SC (Laser 480 SC, Dow AgroSciences, Turkey) 200 ml ha^{-1} when *F. occidentalis* infestation reached to the economic threshold level (10 thrips per flower), the other half served as control (untreated). There were two main treatments: insecticide treated-plot and untreated plot. Each treatment was replicated for four times. All plots were treated with acaricides such as bifenazate (Floramite 240 SC, Hektaş, Turkey) 60 ml per 100 l water and spiromesifen (Oberon 240 SC, Bayer Crop Science, Turkey) 50 ml per 100 l water against red spider mites *Tetranychus cinnabarinus* (Boisd.) (Acarina: Tetranychidae). All plots were also treated with fungicide pyraclostrobin + boscalid WG 12.8 + 25.2% (Signum WG, BASF Türk, Turkey) 150 g per 100 l water to prevent grey mould (*Botrytis*) infection. A knapsack sprayer with a 15 l tank was used to apply all of the pesticide treatments in the experiment. Spinosad were used against thrips on 29 March and 24 May in 2011 and on 16 May in 2012 in treated plot. Both of treated and untreated plots were sprayed with spiromesifen (12 April and 12 May in 2011, and 11 April and 9 May in 2012), bifenazate (19 April in 2011 and 25 April in 2012) and pyraclostrobin + boscalid (12 April in 2011 and 11 April in 2012). Experimental plots (treated and untreated) were irrigated by the drip irrigation system. Magnesium sulphate 16% (50 kg ha^{-1}), zinc sulphate 23% (25 kg ha^{-1}), iron 6% (2000 gr ha^{-1}), nitrogen (200 kg ha^{-1}), fumic acid (10 l ha^{-1}) and phosphoric acid 85% (45 l ha^{-1}) were applied to all plots in March, April and May.

Sampling and identifying of thrips species

To determine the abundance of *F. occidentalis* and other arthropods in the flowers, five flowers from each sampling unit were randomly selected, yielding 20 flowers each treatment on each sampling date. Flowers were gently removed and placed in plastic tubes (50 cc) individually. Five red or green fruits in each plot were also randomly selected, yielding 20 green or red fruits from each treatment. Fruits were also gently removed and immediately inspected for the presence of thrips by aid of a hand lens. Flower samples were stored in tubes in an ice-chest and transported to the laboratory for further processing. For extraction of insects, only flowers were submerged into 60% ethanol and agitated for 25 sec. Flowers were dissected carefully to remove any remaining thrips and rinsed in 60% ethanol for 25 sec. Thrips collected from the flowers were put into small plastic vials (2 ml) containing 60% ethanol for slide-mounted processing. Each empty collection tube was washed into a Petri dish with ethanol (60%) for two times in the same way to get any remaining thrips. Adult thrips were slide-mounted and identified to species. Thrips adults were counted under the stereomicroscope with 45x magnifications, and immature thrips (thrips larvae) were pooled into a single category.

Distribution of *Frankliniella occidentalis* on plant parts

To determine the preference of adults and larvae on various plant parts (fresh and fully opened flowers, young green fruits and mature fruits) of strawberry, were sampled throughout the sampling dates in 2011. A total of five plants were randomly selected on each sampling date. One flower or fruit (green and red fruits) from each plant was taken. Fruits were removed and immediately inspected for the presence of thrips by aid of a hand lens. Flowers were picked into plastic tubes and stored in an ice-box. *F. occidentalis* were removed by rinsing the samples with ethanol in the laboratory to determine the number of larvae and adults in the collected samples. Collected *F. occidentalis* and other thrips species were identified using above mentioned method. Thrips collected at each sampling date were divided by the number of examined fruiting parts i.e. flowers, red and green fruits sampled to obtain an average number of thrips per sampling unit. The mean numbers of adults or larvae on fruiting parts at each sampling date were pooled over a month because there were few numbers of thrips on red and green fruits. Effects of plant parts on the abundance of adults and larvae (monthly mean number of larvae and adults) were analysed.

Yield

All plants of strawberry in each experimental plot were harvested by hand picking on 19 April, 17 May, 21 May and 4 June in 2011, and 15 May and 19 May in 2012. The harvested fruits were classified as first and second degree, and mature fruits were weighted.

Statistical analysis

Means of thrips (larvae and adult) numbers on various plant organs were compared by Tukey's honest significance test at $P<0.05$. Total number of thrips in flowers was plotted against percentage of flowers infested with 10 or more thrips in 2011 and 2012. Linear regression analysis at $P<0.05$ was completed to describe the correlation between these two variables. A total of 15 data points per year were used to determine linear correlation between the above mentioned two variables as well as between the percentage of red fruits infested with 1 or more thrips and total numbers of thrips in flowers. Densities of thrips in treated and untreated plots as well as yield of strawberry in treated and untreated plots were compared by Student t-test at $P<0.05$ (independent two-tailed test). All analyses were performed by using the statistical program SPSS 15.0. (SPSS, 2006).

Results

Distribution of *Frankliniella occidentalis* on plant parts

Distribution of larvae and adult *F. occidentalis* on fruiting bodies of strawberry is presented in Figure 1. Significantly more larvae (March: F= 12.957, df= 2,57, $P<0.0001$; April: F= 46.901, df= 2,57, $P<0.0001$; May: F= 75.507, df= 2,57, $P<0.0001$) and adults (March: F= 94.2957, df= 2,57, $P<0.0001$; April: F= 98.8101, df= 2,57, $P<0.0001$; May: F= 179.286, df= 2,57, $P<0.0001$) were collected from the flowers in sampling months in treated experimental plot during 2011. Similarly significantly more numbers of larvae (March: F= 24.223, df= 2,57, $P<0.0001$; April: F= 39.643, df= 2,57, $P<0.0001$; May: F= 105.281, df= 2,57, $P<0.001$) and adult (March: F= 95.234, df= 2,57, $P<0.001$; April: F= 32.023, df= 2,57, $P<0.0001$; May: F= 245.771, df= 2,57, $P<0.0001$) of *F. occidentalis* were detected in flowers in untreated experimental plot during 2011. A relatively low number of *F. occidentalis* was recorded on green or red fruits compared to the flowers. Red fruits hosted more larvae or adults than immature green fruits but these differences were not statistically significant ($P>0.05$). Significantly more numbers of adult *F. occidentalis* in flowers were recorded in May for each of the treatment.

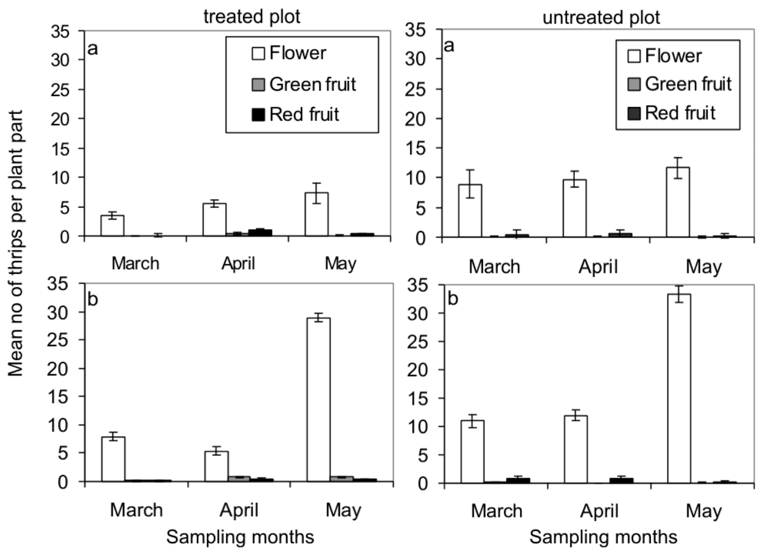

Figure 1. Distribution of *Frankliniella occidentalis* on various plant parts of strawberry in larvae (a) and adult (b) in treated and untreated plots during 2011.

Population dynamics of *Frankliniella occidentalis* in flowers

Mean numbers of *F. occidentalis* in flowers of treated and untreated plots in 2011 is given in Figure 2. In treated plots minimum larval (0.45 per flower) and adult populations (0.08 per flower) were recorded on 22 March and 8 March, respectively. The highest larval (5.05 per flower) and adult (11.75 per flower) densities were recorded on 29 March and 24 May, respectively. The number of adults and larvae peaked in flowers (5.05 larvae and 5.98 adult thrips per flower) on 29 March. Thrips population density (total density) exceeded the action threshold level on that sampling date. The total number of thrips slowly but steadily increased after the treatment. The abundance of adults had a second peak with 11.75 adults per flower on 24 May. The abundance of adults sharply declined to low level after 31 May. In mid-June very few larval and adult *F. occidentalis* were extracted from the flowers.

Although population trends of larvae and adults in untreated plots were in general similar to that of in treated plots, there were some significant differences on some sampling dates (Figure 2). In untreated, minimum larval (0.25 per flower) and adult population (0.12 per flower) was recorded on 7 June and 15 March, respectively in 2011. The highest larval (6.30 per flower) and adult (9.00 per flower) densities were recorded on 24 March and 24 May, respectively. Abundance of larvae and adults in untreated flowers peaked on 29 March and 24 May. The highest recorded abundance of total thrips was 11.2 thrips per flower on 24 May.

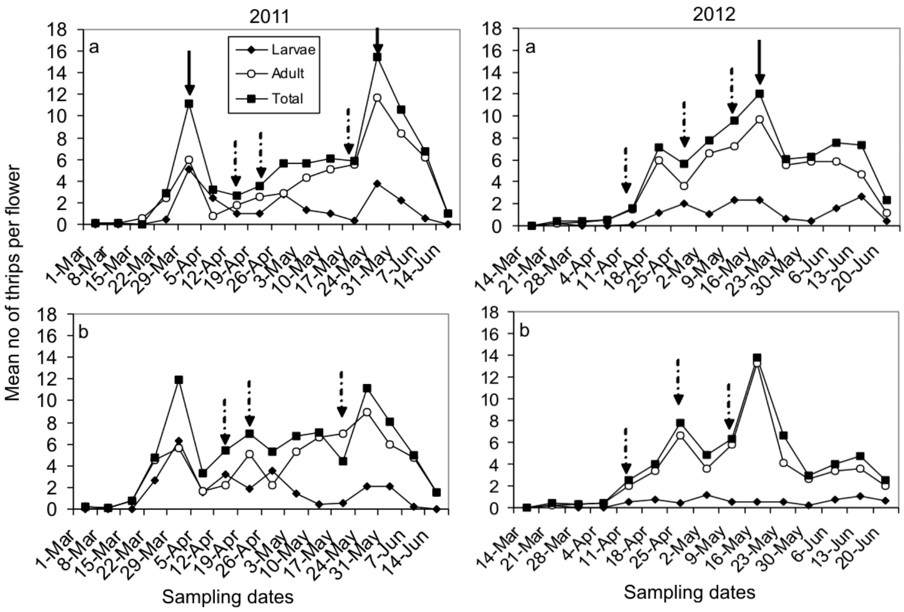

Figure 2. Mean numbers of *Frankliniella occidentalis* in flowers in treated (a) and untreated plots (b) in 2011 and 2012. Solid arrows (insecticide) and dashed arrows (fungicides and/or acaricides) indicate applications [Spinosad were applied against thrips on 29 March and 24 May in 2011 and on 16 May in 2012. Both of treated and untreated plots were sprayed with spiromesifen (12 April and 12 May in 2011, and 11 April and 9 May in 2012) and bifenazate (19 April in 2011 and 25 April in 2012) against spider mites and pyraclostrobin + boscalid (12 April in 2011 and 11 April in 2012) against *Botrytis*].

Total mean numbers of *F. occidentalis* were significantly higher on 22 March *(t*= 3.741, df= 38, *P*<0.001), 19 April (*t*= 3.168, df= 38, *P*<0.001), 24 May (*t*= 2.382, df= 38, *P*<0.05) and 31 May (*t*= 5.139, df= 38, *P*<0.0001) than those found numbers in untreated plots.

Mean numbers of *F. occidentalis* in flowers of treated and untreated plots in 2012 is given in Figure 2. In treated plots minimum larval (0.10 per flower) and adult population (0.20 per flower) were recorded on 11 April and 21 March of 2012, respectively. The highest larval (2.35 per flower) and adult (9.65 per flower) densities were recorded on 16 May. Abundance of larvae and adults in treated plots started to increase in the second week of April (Figure 2). Peak abundance of adults with a mean of 9.65 thrips per flower and larval thrips with a mean of 2.32 thrips per flower was recorded on 16 May in 2012. The abundance of thrips fluctuated between 6 and 7 thrips per flower from late May until mid-July. There were a few adults and larvae of *F. occidentalis* in late-June (20 June). In untreated plots, minimum larval (0.20 per flower) and adult population (0.20 per flower) was recorded on 21 March of 2012. The highest larval

(1.20 per flower) and adult (13.30 per flower) densities were recorded on 2 May and 16 May, respectively. The abundance of thrips fluctuated until 16 May. The observed peak abundance on this date was 13.3 adults per flower. After the peak the population density of adults abruptly declined to a very low infestation level. The mean number of larvae throughout the entire sampling period remained low compared to that of in treated plots. Total mean numbers of *F. occidentalis* were significantly higher on 18 April (t= 3.911, df=38, P<0.001), 9 May (t= 5.223, df= 38, P<0.0001), 30 May (t= 6.764, df= 38, P<0.0001), 6 June (t= 6.693, df= 38, P<0.0001) and 31 May (t= 5.364, df= 38, P<0.0001) than those found in untreated plots.

Correlation between *Frankliniella occidentalis* abundance and flower density

Linear correlation between number of *F.occidentalis* per flower and number of flowers per plant in treated and untreated plots are given in Figure 3. Thrips abundance in any treatment was not correlated to flower density (Figure 3; P>0.05). *F. occidentalis* abundance was relatively low when loads of the flowers on plants peaked. In other words, thrips abundance did not follow flower density on strawberry plants.

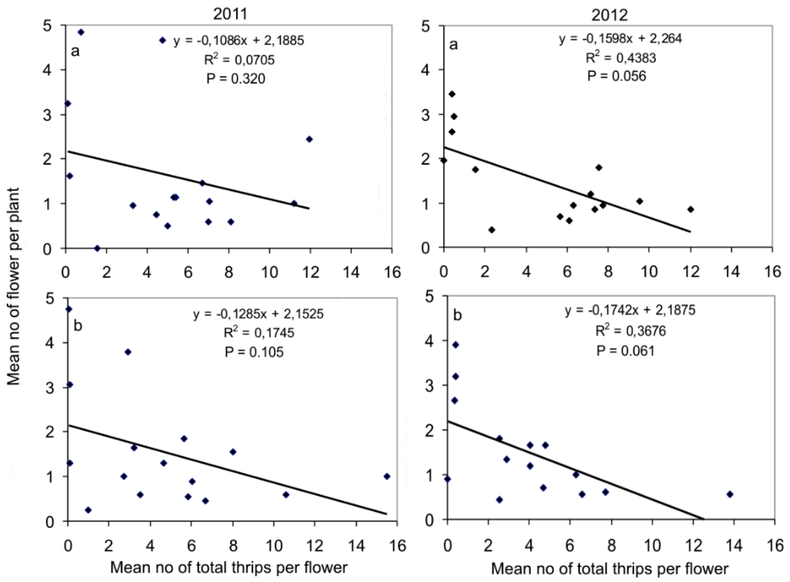

Figure 3. Linear correlation between the mean number of *Frankliniella occidentalis* per flower and the mean number of flowers per plant in treated (a) and untreated plots (b) in 2011 and 2012.

Correlation between damage threshold and *Frankliniella occidentalis* abundance in flowers and red fruits

Linear correlation between number of thrips per flower (x) and percentage of strawberry (y) flowers with a minimum of 10 thrips are reported in Figure 4 and Table 1. Negative correlation was observed between these two variables in treated and untreated plots during both years. Percentage of flowers with 10 or more adults *F. occidentalis* in treated plots in 2011 and 2012 were 63% and 52%, respectively. Percentage of flowers with 10 or more adults *F. occidentalis* in untreated plots in 2011 and 2012 were 56% and 60%, respectively. Percentage of flowers with 10 or more adults + larvae of thrips in treated and untreated plots was equated to 3%.

The percentage of red fruits with 1 or more thrips and the number of adult thrips per flower are plotted in Figure 5. The correlation between these two variables was significantly positive in treated and untreated plots in 2011 (treated plot: F= 10.342, df= 1,15, P= 0.0006, R^2 = 0.42, Y= 1.8184x + 4.005; untreated: F= 7.304, df= 1,15, P= 0.017, R^2= 0.34, Y= 2.314x + 4.674).

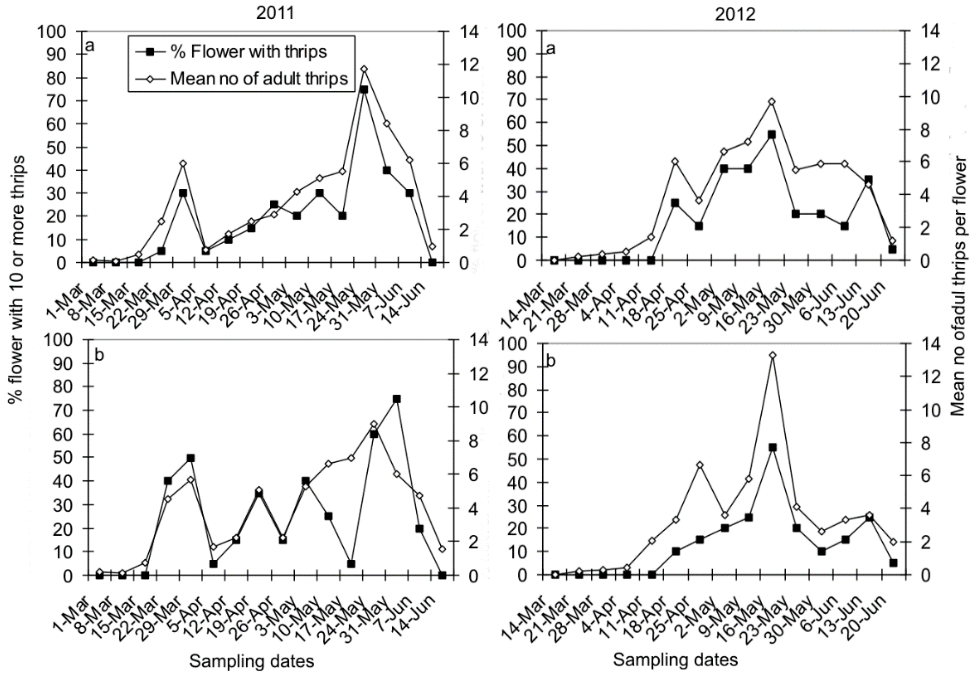

Figure 4. Percentage of flowers with 10 or more thrips and the mean number of adult *Frankliniella occidentalis* per flower in treated (a) and untreated plots (b) in 2011 and 2012.

Table 1. Linear correlation between the percentage of strawberry flowers with a minimum of 10 *Frankliniella occidentalis* (y) and the mean number of thrips per flower sampled (x). The action threshold is calculated from the equation

Year	Plot type	Stage(s)	Damage threshold Used	Linear equation	R^2	Action threshold for minimum number per unit
2011	Treated	Adult	10	6.512x-1.473	0.54	63%
		Adult+larvae	10	0.126x+2.138	0.71	3%
	Untreated	Adult	10	5.844x-2.212	0.92	56%
		Adult+larvae	10	0.205x+0.979	0.95	3%
2012	Treated	Adult	10	5.363x-3.039	0.85	52%
		Adult+larvae	10	0.201+1.353	0.89	3%
	Untreated	Adult	10	6.137x-1.368	0.91	60%
		Adult+larvae	10	0.234x+1.340	0.83	3%

Yield

Strawberry yield in the treated and untreated plots are given in Table 2. There was a significant difference between treated and untreated plots only on 21 May, 2011 (*t*= 4.243, df= 1,6, *P*= 0.005) and no difference in strawberry fruit yield between treated and untreated plots on other harvesting dates was found in both years (*P*>0.05)

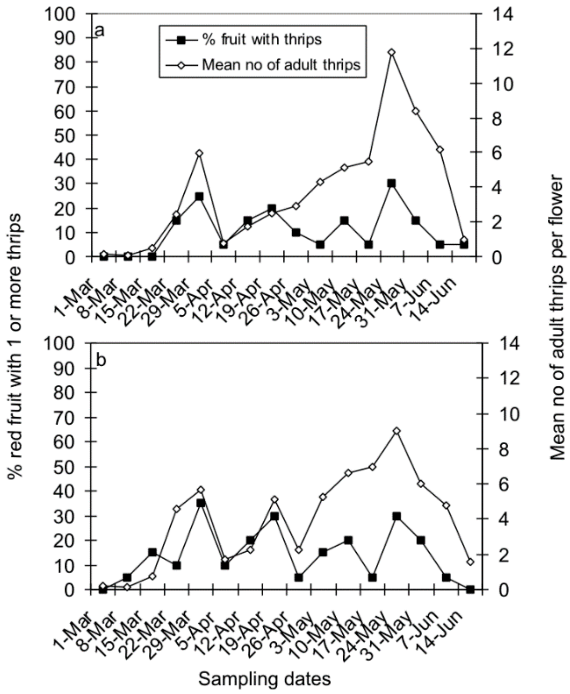

Figure 5. Percentage of red fruits with 1 or more thrips and the mean number of adult *Frankliniella occidentalis* per flower in treated (a) and untreated plots (b) in 2011.

Table 2. Strawberry yield (kg ha^{-1}) in treated and untreated plots in Adana province, Turkey in 2011 and 2012

Year	Sampling dates	First class Treated*	First class Untreated	Second class Treated	Second class Untreated
2011	19 Apr	2440.00±17.73a	2400.00±61.27a	640.00±10.20a	400.00±13.65a
	17 May	1440.00±20.65a	1280.00±22.40a	440.00±12.00a	400.00±13.85a
	21 May	1200.00±8.24a	720.00±8.01b	220.00±14.00a	240.00±15.87a
	4 Jun	2050.00±13.06a	1902.00±8.24a	400.00±13.85a	520.00±12.00a
	Total	6400.83±47.10a	6800.00±52.86a	1700.00±35.53a	1540.00±26.60a
2012	15 May	1200.00±20.13a	1160.00±7.65a	480.00±9.23a	440.00±12.75a
	19 May	1440.00±2.13a	1200.00±8.50a	1040.00±15.31a	800.00±16.00a
	Total	2600.00±16.49a	2440.00±23.88a	1520.00±15.45a	1240.00±24.78a

* Means with same letters in rows are not statistically significant according to Student t-test at $P<0.05$.

Discussion

Frankliniella occidentalis were collected mainly from flowers and relatively low numbers of this thrips were recorded on green and red fruits of strawberry. Therefore, it is suggested that it is more appropriate to sample flowers in order to estimate thrips abundance in strawberry. Our results are in agreement with the findings of Steiner & Goodwin (2005) reported that the majority of *F. occidentalis* were detected in flowers in Australian strawberry fields. Furthermore, immature green and red fruits can be used for sampling when flowers are not available in adequate numbers for monitoring of *F. occidentalis.*

During late season relatively high population of *F. occidentalis* was recorded in strawberry flowers, this might be due to migration of the *F. occidentalis* from the surrounding wild vegetation to the strawberry flowers being in less numbers in that period. *F. occidentalis* (mainly adults) has been noted on the majority of the flowering weeds grown nearby the experimental area. This thrips left the spring annual weedy plants when these host plants lost their flowers or nutritional contents in late spring period (May) in Çukurova region (Adana province) (Atakan & Uygur, 2005). Abundance of *F.occidentalis* in general and abundance of larvae in particular was significantly greater in flowers of treated than untreated plots on some sampling dates (Figure 2). Reason of this issue remained unknown.

Abundance of *F. occidentalis* recorded in every treatment was below the action threshold level of 10 thrips per flower at most sampling dates in both years. *F. occidentalis* abandoned strawberry plants after May when the number of flowers per plant was much less than those in April. Yıldırım & Başpınar (2013) also observed that *F. occidentalis* migrated from strawberry plants after early summer (June) in Aydın province, Turkey. In the current study, *F. occidentalis* exceeded action threshold level only once or twice in treated and untreated plots. Nearly 60% of flowers were infested with 10 or more adults of *F. occidentalis*. Additionally, nearly 6% of red fruit was found infested with 1 or more thrips (adults + larvae). However, there was no apparent damage of *F. occidentalis* to flowers even in untreated plots. Our results seem to be in conflict with previous studies carried out in various countries. For example, while Gremo et al. (1997) stated that 10 thrips individuals should be considered as an action threshold, Laudonia et al. (2000) suggested 15 *F. occidentalis* per flower as an action threshold level in Italy. These differences among the studies may be due to different ecological conditions such as climate, different variety of strawberry or different strain of *F. occidentalis*. However, findings of the current study are agreed with findings of Stefania et al. (1999), who reported that 15-20 mobile forms of *F. occidentalis* on strawberry crop grown in plastic tunnels in Italy is economic threshold level. Coll et al. (2006) also suggested that 25 *F. occidentalis* individuals per flower in spring time cause economic damage to strawberries grown in open field in Israel.

Although, there was a weak but statistically significant correlation between the percentage of red fruit with the mean number of adult thrips in flowers, no typical damage (bronzed or scarred fruits) was observed on sampled red or green fruits. At the peak abundance of thrips in flowers (15 total thrips per flower) the mean number of thrips on red or green fruits was very few. In our previous study carried out in a strawberry field outdoors (Atakan, 2008), *F. occidentalis* densities with at least two times higher than the ETL was reported to cause damage in the form of withered stigmas, anthers and slight necrotic spots on petals of some flowers. Additionally, at the peak abundance of thrips in flowers (22-24 thrips per flower), less numbers of the thrips adults or larvae were observed on fruits and their feeding damage resulted in the occurrence of slightly bronzed fruit surface beneath the calyx of red fruits. Contrary to our previous work, Coll et al. (2006) reported that when thrips abundance increased to an infestation level of 25 *F. occidentalis* adults per flower, typical thrips damage with silvering and bronzing of the fruits were encountered. These differences might be due to different strain of *F. occidentalis* and different strawberry variety. However, Steiner (2002) reported that important bronzing damage due to larval and adult *F. occidentalis* feeding upon green or red fruit was crucial when *F. occidentalis* abundance was over 10 thrips per fruit, and relative humidity and temperature were both high. Sampson & Kirk (2012) also reported that there was a good correlation between abundance of larval *F. occidentalis* and strawberry fruit damage in the Midlands, UK.

In conclusion, *F. occidentalis* infestation rarely exceeds the action threshold level and at this threshold level no typical thrips damage was detected on flowers or fruits. Although *F. occidentalis* infests mainly strawberry flowers, no association was found between thrips abundance and the density of flowers on plants. In this study *F. occidentalis* did not affect strawberry yield at all. *F. occidentalis* is the dominant thrips species in strawberry crops cultivated in the South-eastern Mediterranean region of Turkey. However, *F. occidentalis* did not seem to be an economically important pest of strawberry even if they cause damage to the fruiting parts in late-season as previously reported (Atakan, 2008). The registered insecticide active ingredient spinosad is widely used to control thrips in strawberry in Turkey but the residual effect of this insecticide against *F. occidentalis* lasts for less than 10 days. In the Mediterranean region, strawberry growers have used this insecticide frequently in thrips management. Use of the same insecticide at frequent intervals may lead to the selection of a resistant strain in the target pest and cause negative side-effects such as killing of beneficial insects commonly found in strawberry.

Based on our field results, it appears that population rarely exceeds the economic threshold and only for a short period of time, therefore, no control measure should be applied against thrips in strawberry. The current ETL for *F. occidentalis* appears to be too low, and it appears that even 15 thrips per flower may not cause typical damage to flowers. Based on our results, it is concluded that ETL of *F. occidentalis* needs to be re-evaluated in strawberry fields in Turkey.

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