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Effectiveness of mass trapping for control of the pistachio twig borer, *Kermania pistaciella*

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Abstract

For the management of *Kermania pistaciella* Amsel (Lepidoptera Oinophilidae), an important pest in pistachio orchards, mass trapping as an alternative to chemical control methods was implemented from 2010-2014 in Sanliurfa Province (Turkey). Traps baited with sex pheromones were hung in pistachio orchards at 1 lures per 1500 m^2 when pistachio buds started to open in late March - the beginning of April. *K. pistaciella* males first emerged in early to mid- April, and they had a four - five week flight period. The percentage of infestation in twigs decreased from 50.16 to 5.01% in pistachio orchards subjected to the mass trapping method for a three year period, and it decreased from 8.01 to 3.52% in pistachio orchards mass trapped for two years. The decrease was statistically significant in both situations. The infestation rates in treated pistachio orchards fell below the economic threshold, while untreated pistachio orchards remained above that level.

Key words: pheromones, infestation rate, pistachio pests.

Introduction

Kermania pistaciella Amsel (Lepidoptera Oinophilidae) is the most widely distributed pest species with the highest infestation rate in pistachio fields within the Southeast Anatolia Region of Turkey (Küçükarslan, 1966; Mart *et al*., 1995; Yanık and Yucel, 2001; Bolu, 2002). Mehrnejad (2001) specified the pistachio twig borer, *K. pistaciella*, the pistachio psyllid, *Agonoscena pistaciae* Burckhardt et Lauterer (Hemiptera Psyllidae) and other Hemiptera species as the main pests of pistachio in Iran.

The adult moth appears in early April, and lays its eggs on new shoots and in fruit clusters. The newly hatched larvae penetrate directly into the twigs and fruit clusters. Larvae tunnel in the twigs and peduncle of fruit cluster and began to feed. *K. pistaciella* has only one generation per year and overwinter as mature larva (Küçükarslan, 1966). This causes serious economic damage from fruit drop, formation of blind bunches and twig weakening (Küçükarslan, 1966; Tezerji, 2011). In Turkey, the first and the only study regarding the biology of *K. pistaciella* was by Küçükarslan (1966) in the Gaziantep area. Besides that, various studies have been performed on the chemical management of *K. pistaciella* and determining the increase of parasitisation by pupal parasitoids (Mart *et al*., 1995; Yanik and Yucel, 2001; Ozgen *et al*., 2012). Evaluations of pupal parasitoids, population fluctuations measured with pheromone traps, the best pheromone trap type, and chemical management of *K. pistaciella* have also been carried out in Iran (Mehrnejad, 2002; Abbas-Zadeh *et al*., 2006; Mehrnejad and Basirat, 2009; Arbabtafti *et al*., 2012; Zamani *et al*., 2012).

Bolu (2002) specified that the pest was widely distributed in the Southeast Anatolia Region of Turkey due to a lack of knowledge of the pest's biology. This created an inability to use cultural measures, and an inability to correctly determine the time of chemical management against the pest.

The sex pheromone of *K. pistaciella* was first identified by Gries *et al*. (2006). They determined the pheromone was (2S,12Z)-2-acetoxy-12-heptadecene from female *K. pistaciella* collected in Turkey. Field tests in Turkey showed that the synthetic pheromone in capsules attracted numerous male moths. There is no pesticide suitable for integrated management programs against *K. pistaciella* in Turkey (Anonymous, 2011). Thus, mass trapping, which is an alternative management method in controlling this pest, has gained importance. In Turkey, mass trapping for management of *K. pistaciella* by using pheromone traps was first implemented in this study. Here, we determined the effectiveness of mass trapping with pheromones traps in pistachio orchards within the Province of Sanliurfa.

Materials and methods

The main elements of this study were *K. pistaciella* males trapping, pistachio orchards and delta pheromone traps. Insecticide was not applied for *K. pistaciella* control in treated and control orchards.

Mass trapping of *K. pistaciella*

Mass trapping of *K. pistaciella* with pheromone traps was carried out between 2010-2014 at Sanliurfa-Center, Bozova and Hilvan Counties of the Province of Sanliurfa in orchards having 20 trees per 1000 m^2 (table 1).

The pistachio orchard at Bozova-Baglica where mass trapping studies was carried out was divided to 3 parcels. The parcel in the middle was the control, and the parcels on either both side were treatments A and B. The pistachio orchard was not available on all four sides at Baglica. Pistachio orchards were available around the other orchards where the study was conducted. A control orchard was selected 50 m away from the treated orchards.

Table 1. Pistachio orchards where mass trapping was applied for *K. pistaciella* control in the Province of Sanliurfa, Turkey.

Years	Location	Orchard (number)	Tree age (years)	Orchard size (m^2)
2011-2014	Bozova-Center	1	20-30	18000
2011-2014	Bozova-Baglica	2	20-30	40000
2012-2014	Kızlar village	1	30-35	15000
2012-2014	Hilvan-Alyeli village	1	25-30	20000

Table 2. Average number of *K. pistaciella* male moths captured by pheromone traps hung for mass trapping in pistachio orchards in Bozova County, Sanliurfa Province.

Years	Bozova-Center	Bozova-Baglica A	Bozova-Baglica B	Means*
2011	628.33	532.66	538.66	567.0 a
2012	358.00	281.66	322.99	320.9 b
2013	314.32	67.33	106.32	162.7 c
				p = 0.000

*Means within a column followed by the same letter are not significantly different (p > 0.05; Tukey test).

For these mass trapping studies delta traps with a sticky insert and male attractant pheromone capsules (2S,12Z)-2-acetoxy-12-heptadecene were used at one lure for about 1500 m^2. Rubber septa lure was used. The lures were hung on pistachio trees at eye level (1.5-2.0 m). Therefore, 9 lures in a 13500 m^2 were hung in the orchard at Bozova-Center, 18 lures in a 27000 m^2 were used for the orchards at Bozova-Baglica, and 6 lures in a 9000 m^2 were used for each of the orchards at Kizlar and Hilvan-Alyeli. The pheromone traps were hung in the orchards at the time when twigs and fruit buds start to revive (end of March - beginning of April).

To determine the effect of mass trapping, the fluctuation of males in traps was followed-up by determining the infestation rate of twigs.

Trapping to establish population fluctuations of *K. pistaciella*

In treated orchards, *K. pistaciella* males were monitored by selected three traps. Each orchard considered an experiment with each trap a replicate. Traps in the orchards were examined two-three times a week until the first male was trapped. After that, examinations were performed once a week and the number of trapped males were recorded. The adhesive plates of traps were replaced when required for the counting to be net and faultless, as per the trap losing its adhesive property, or because of the abundance of males. The pheromone capsules were effective for about 12 weeks, so they weren't replaced during the season.

Infestation rate of *K. pistaciella* in pistachio orchards

The infestation rate of *K. pistaciella*, was determined by counting infested twigs during January and February between 2010-2014 at treated and control orchards. Twenty five trees were randomly selected per treated and control orchards, and past years twigs were taken from 4 different directions on each tree. The average (%) infestation rate was calculated from the 100 twigs. These twigs were cut in half at the middle with a pruning shears and the presence of infestations was recorded. The burrowing in the pistachio twigs, which result from feeding of *K. pistaciella* larvae, was the determining factor whether an infestation existed or not.

Statistical analysis

The experiments have tested the hypothesis that the deployment of the traps would reduce populations and infestation rate from year to year. Square root transformation was applied to the numbers of males captured by the pheromone traps, and arcsine transformation was applied to the infestation rates of pests in the recent years pistachio twigs. Reductions of the mean number of males per trap in the orchards in the different years and the percentage of the infestation rates were analyzed by analysis of variance using the Minitab program pack, as per a factorial experimental design on randomized blocks, and the differences were grouped using Tukey's multiple comparison test at the 5% level.

Results and discussion

Mass trapping *K. pistaciella* with pheromone traps

The averages of numbers of *K. pistaciella* trapped by the lures at Bozova-Center, Baglica A and B orchards, where the three years mass trapping was applied, there was a statistically significant decrease in the number of male moths in the 2nd and 3rd years compared to the 1st year ($F = 13.99$; d.f. =2, 18; $p = 0.000$). In addition, there was no significant difference between the orchards ($F = 2.45$; d.f. = 2, 18; $p = 0.115$) and in the interaction of year × orchard ($F = 0.86$; d.f. = 4, 18; $p = 0.509$) (table 2). In contrast, when averages between years were compared at orchards in the villages of Kizlar and Hilvan-Alyeli, where two years mass trapping was performed, there was no significant difference in the number of moths ($F = 0.57$; d.f. = 1, 8; $p = 0.533$), and the difference between orchards was statistically significant ($F = 54.45$; d.f. = 1, 8; $p = 0.000$). However, there was no significant difference the interaction of year × orchard ($F = 0.10$; d.f. =1, 8; $p = 0.765$) (table 3).

Table 3. Average number of *K. pistaciella* males captured by pheromone traps hung for mass trapping in pistachio orchards in the Sanliurfa-Center Kizlar village and Hilvan-Alyeli village Counties of Sanliurfa Province.

Years	Kizlar	Hilvan-Alyeli	Means*
2012	1297.66	232.33	765.0 a
2013	1435.66	329.66	882.7 a
			p = 0.533

*Means within a column followed by the same letter are not significantly different (p > 0.05; Tukey test).

At the orchards in Kizlar and Hilvan, it appeared that two years mass trapping was not sufficient to decrease the number of males. Similarly, the number of male moths captured at the orchards in Bozova had gradually decreased in three years. In Iran, the adult population of *K. pistaciella* significantly decreased by the end of the third year of mass trapping, compared to the first two years depending on region, temperature and type of pistachio (Hassan Daroogheh, personal communication).

Population fluctuation of *K. pistaciella* measured by pheromone traps

Based on the pheromone traps, the first flights of *K. pistaciella* starts by mid-April, and ends by the second week of May, with a flight period of about four-five weeks (figure 1-2). This provides significant information regarding the timing of mass trapping application in orchards. Similar results related to flight period were reported by Küçükarslan (1966), Abbas-Zadeh *et al*. (2006) and Zamani *et al*. (2012).

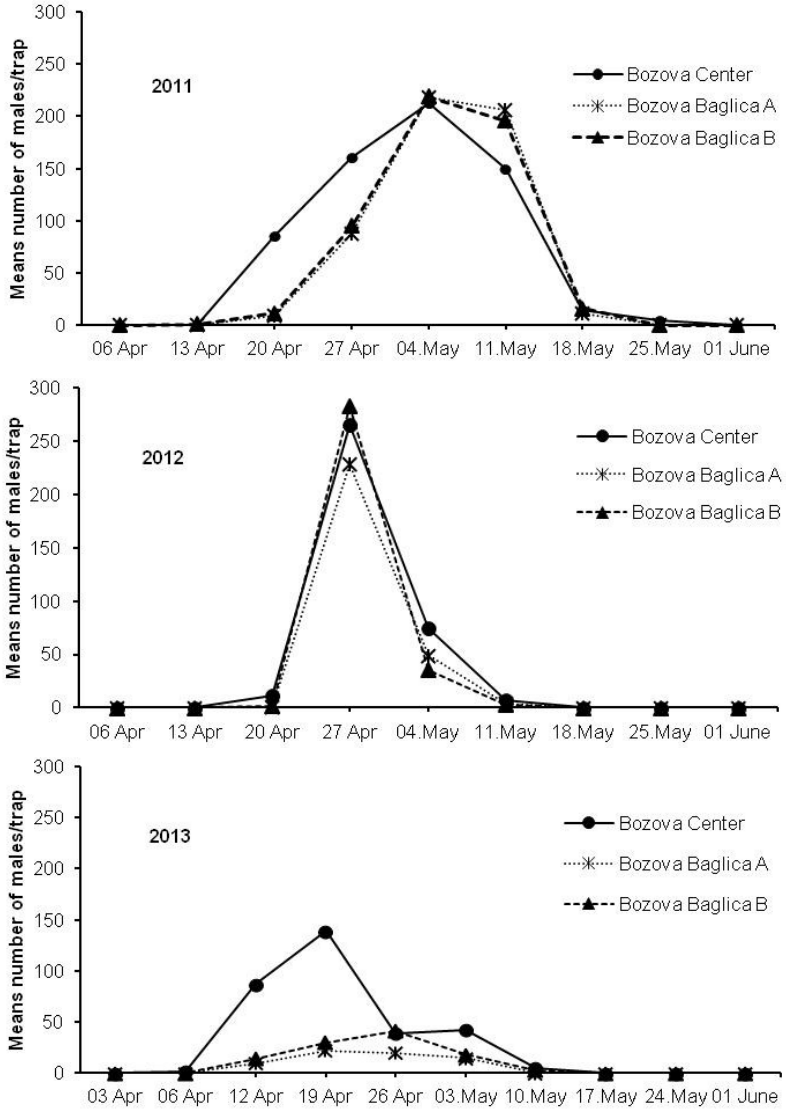

Figure 1. *K. pistaciella* males captured by pheromone traps in pistachio orchards where mass trapping was implemented between 2011-2013 in Bozova County of Sanliurfa province.

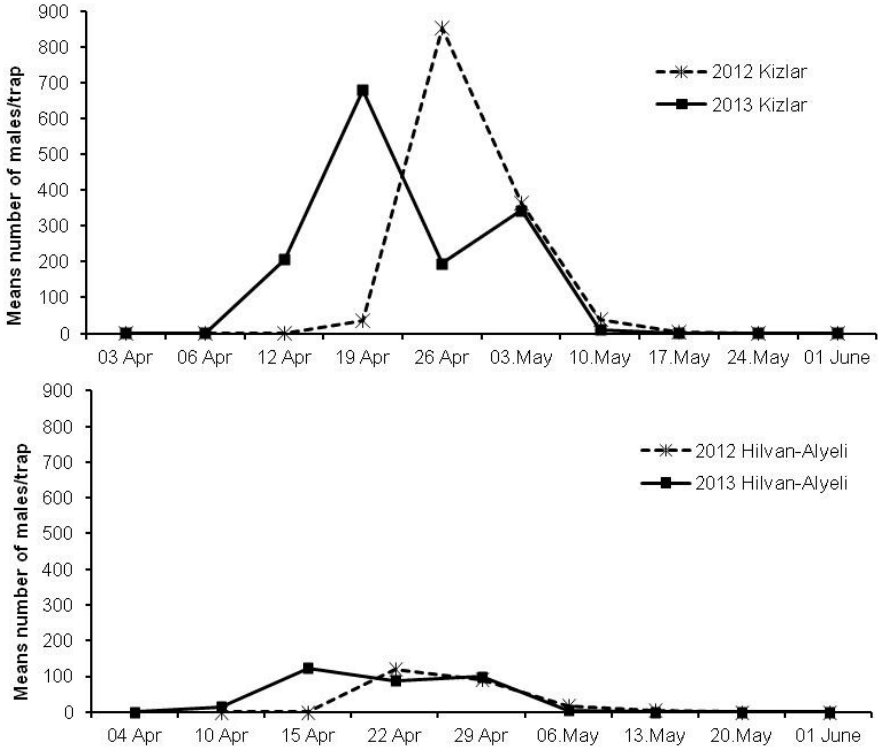

Figure 2. *K. pistaciella* males captured by pheromone traps in pistachio orchards where mass trapping was implemented between 2012-2013 in Kizlar and Hilvan-Alyeli villages of Sanliurfa province.

Infestation rate of *K. pistaciella* in pistachio orchards

When the mass trapping and control orchards are compared for Bozova County, there is statistically significant difference in infestation rates of twigs of the past year, between years ($F = 65.04$; d.f. =3, 39; $p = 0.000$), in pheromone application ($F = 19.88$; d.f. = 1, 39; $p = 0.000$) and in the year × pheromone interaction ($F = 9.27$; d.f. = 3, 39; $p = 0.000$). In addition the infestation rate decreased significantly in the orchards where mass trapping was applied (table 4). In Kizlar and Hilvan, where a two years mass trapping technique was applied, were compared with the control no significant difference was found between years in the infestation rates of recent years pistachio twigs ($F = 0.88$; d.f. =2, 29; $p = 0.426$) between treatments and controls. There was a significant difference in pheromone application ($F = 13.91$; d.f. = 1, 29; $p = 0.001$), and in the interaction of year × pheromone ($F = 8.36$; d.f. = 2, 29; $p = 0.001$). The infestation rate at orchards where pheromone traps were hung, significantly decreased compared to the control orchard.

The economic threshold for pistachio twig borer is 10% infestation rate in the twigs of the recent year

Table 4. Infestation rate (%) of *K. pistaciella* in twigs of pistachio in the province of Sanliurfa.

Years	Bozova-Center		Bozova-Baglica A		Orchards (Means)*	
	Pheromone	Control	Pheromone	Control	Pheromone	Control
2010 untreated	52.27	45.99	48.04	50.03	50.16 a	48.01 a
2011 mass trapping	19.96	9.95	20.02	29.98	19.99 b	19.97 b
2012 mass trapping	5.94	14.97	7.96	28.05	6.95 c	21.51 b
2013 mass trapping	4.99	18.06	5.02	26.05	5.01 c	22.05 b
Year					$F_{(3)} = 65.04$, $p = 0.000$	
Pheromone					$F_{(1)} = 19.88$, $p = 0.000$	
Year × Pheromone					$F_{(3)} = 9.27$, $p = 0.000$	
Years	Kizlar		Hilvan-Alyeli		Orchards (Means)*	
	Pheromone	Control	Pheromone	Control	Pheromone	Control
2011 untreated	6.00	4.01	10.01	8.02	8.01 ab	6.02 ab
2012 mass trapping	6.00	14.05	6.03	9.98	6.02 ab	12.02 a
2013 mass trapping	4.01	14.97	3.03	10.96	3.52 b	12.97 a
Year					$F_{(2)} = 0.88$, $p = 0.426$	
Pheromone					$F_{(1)} = 13.91$, $p = 0.001$	
Year × Pheromone					$F_{(2)} = 8.36$, $p = 0.001$	

* Means within a column followed by the same letter are not significantly different ($p > 0.05$; Tukey test).

(Anonymous, 2011). According to that, the infestation rate at all of the study orchards in Bozova, prior to the hanging of pheromone traps, was five times the economic threshold, about half of the threshold value in Kizlar, and at the threshold level in Hilvan. In all these mass trapping areas the infestation rate in the orchards decreased to half of economic threshold, and it was about 1.5-2 times above the threshold in control orchards, except at Hilvan. At Hilvan, the control orchards had about at the threshold level. Küçükarslan (1966) reported that the infestation rate of *K. pistaciella* in Gaziantep (the neighbouring province of Sanliurfa) Province changed between 5-35% at different orchards between the years of 1962-1964. As observed here, the infestation rate changes between years and between orchards.

In general, the producers either become late to make control managements for *K. pistaciella* or they do not make management at all. Because, they might not be aware of the damage caused by *K. pistaciella* for the current year. While there is no licensed pesticide suitable for an integrated management program against *K. pistaciella* in Turkey (Anonymous, 2011), mass trapping is gaining importance as one of the only alternative management methods for bringing the pest under control. Sex pheromone traps have become an important component for monitoring and mass trapping of pest species in agricultural area. Many successful studies have been made about the mass trapping and monitoring of pest species with sex pheromone traps (Maini *et al*., 2000; Broumas *et al*., 2002; Hegazi *et al*., 2009; Rohani and Samih, 2012; Sufyan *et al*., 2013; Santi *et al*., 2015).

Conclusions

This study on the management of *K. pistaciella*, revealed the number of male moths captured by the pheromone traps, at pistachio orchards with one trap for about 1500 m^2, decreased from 567.0 to 162.7 male moths (71%). The infestation rate of twigs had decreased from 50.16 to 5.01% in pistachio orchards where mass trapping was implemented for three years and from 8.01 to 3.52% where mass trapping was implemented for two years. A significant decrease in infestation rate was determined for all orchards where this study was carried out. At an orchard where the infestation is high, 3 years of mass trapping are needed. Moreover, not implementing mass trapping at other pistachio orchards around the those where mass trapping is performed will require hanging one pheromone traps for about 1500 m^2 each of three years. For effective management of the pest, local hanging of pheromone traps is being suggested.

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