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Original article

Using yellow sticky traps in control to *Cacopsylla pyri* (L.) (Hemiptera: Psyllidae) on pear trees

Armut ağaçlarında *Cacopsylla pyri* (L.) (Hemiptera: Psyllidae) mücadelesinde sarı yapışkan tuzakların kullanımı

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ABSTRACT

This study investigates the applicability of a mass trapping method using yellow sticky traps for controlling of the pear psyllid *Cacopsylla pyri* (L.) (Hemiptera: Psyllidae), which is harmful to pear trees. Studies involving Ankara pear-variety saplings were carried out in the Ankara province in three different pear orchards in two different locations in 2012. In the first stage of the study, experiments were conducted using visual yellow sticky traps to determine trap efficiency in the pear orchard. Afterwards, mass trapping studies were carried out with the number of traps determined to be most effective in two different orchards. At the end of the study, it was observed that the yellow sticky traps had a very high ability to attract *C. pyri* adults, but were insufficient to suppress the pest as time progressed. As a result, it was concluded that the use of yellow sticky traps alone in the control of *C. pyri* would not be sufficient. However, it has been concluded that the traps can be used as a monitor in the early spring period when overwintered *C. pyri* adults are present and the beneficial population is inactive.

INTRODUCTION

Pear (*Pyrus communis* L.) ranks second after apple in terms of amount of production among pome fruits grown in Turkiye. Pear is one of the leading export products of Turkiye. There are many pests that threaten pear production. One of them, *Cacopsylla pyri* (L.) (Hemiptera: Psyllidae), is an important pest in pear growing regions. Mixed populations of two *Cacopsylla* species have caused significant economic damage in pear orchards. *C. pyri* is the main pest in Europe (Civolani and Pasqualini 2003, Erler et al. 2007, Jenser et al. 2010) and *Cacopsylla pyricola* (Foerster, 1848) is in North America (Alston and Murray 2007, Horton 1994). Codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) and pear psylla *Cacopsylla pyricola* (Foerster) (Hemiptera: Psyllidae) are the major insect pests attacking commercial pears in North America. It is estimated that 50 to 80% of the costs is associated with controlling arthropod pests in pear orchards (Horton 2004). In Türkiye, Er (2008) has identified the species most harmful to the Ankara variety of pear grown in the Ankara province as *C. pyri*. Kovancı et al. (2000) investigated the population fluctuation of species *C. pyri* and *C. pyricola* that infested pears in the Bursa province and found that

these species overwintered as adults, became active in mid-March, and gave 3-4 generations per year, depending on meteorological conditions. Adult and nymph *C. pyri* are particularly dense in certain regions and cause damage to pear orchards. The nymphs of this pest cause damage mainly by feeding on leaves and shoots, with heavy infestations resulting in inhibited tree growth, leaf and fruit fall, as well as fruit deformation. A sooty mold (fumagine) develops on secreted honeydew that inhibits respiration and photosynthesis, causes overall weakness in the tree, and lowers the market value of the fruit, with the market value of blackened fruit decreasing considerably. Other than this direct damage, it is known to have also indirect effects by acting as a vector of certain plant diseases, such as fire blight and viral disease (Erler 2004). *C. pyri* is defined by Brunner (1982) as an extremely difficult pest to control, and effective management requires an investment in efficient and timely sampling for adults and immature. Summer management of pear psylla is very difficult if the overwintered population is not controlled. Pear psylla is now resistant to many insecticides (Croft et al. 1989, Pree et al. 1990). Cultural measures and biological controls are recommended for the first-line management of this pest, which has the potential to cause significant damage in the presence of an increased population. In recent years increasing problems with pear psylla management in pear orchards treated with broad-spectrum insecticides, have necessitated chemical control which can be compatible with the preservation of natural enemies (Erler 2004). Insecticides have been reported to decrease the activities of the parasites and predators of this pest (Solomon et al. 1989). It has been reported that natural predators are not sufficient to suppress the pest in the early period, and so alternative control strategies are needed for the control of pear psyllid (Erler 2004). Yellow sticky traps are used to determine the accurate time of pest control and to serve as an early warning by predetermining the spreading time of the bug populations (Horton 1999, Horton and Lewis 1997, Krysan and Horton 1991). The only study conducted in Turkiye to date is the study bu Kosovaeri et al. (2014) in which they investigated the use of pheromone yellow sticky traps for the control of *C. pyri*. In this study, which was carried out in Ankara in 2012, the applicability of the mass trapping method using yellow sticky traps was investigated in order to create an alternative control method for the chemical control of *C. pyri* adults.

MATERIALS AND METHODS

The study materials included *Cacopsylla pyri* (L.) (Hemiptera: Psyllidae) adults, Ankara pear-variety saplings, and yellow sticky traps (20×25 cm). The 2012 study was carried out in three different orchards containing pear saplings. Two orchards were located in the Atatürk Forest Farm (AFF) and third one was located in the other experimental area in Ankara. The study was planned in two stages. In the first stage of the study, trap activity was determined, while the second stage involved a mass trapping study to determine the number of traps that could be considered effective.

Determination of trap efficiency

Yellow sticky traps (20 × 25 cm) were used to determine trap efficiency for use in *C. pyri* (L.) control, with studies initiated in 2012 in an orchard of Ankara pear-variety saplings aged 3–4 years in the experimental area. Accordingly, two yellow sticky traps were hung to monitor the emergence of the first adult, and after the first adult was captured on the trap, the experiment to monitor yellow sticky trap efficiency began. The experiment was initiated on 22 May 2012 when the first adult was identified in the monitor traps in the orchard selected for the experiment. The experimental setup was established according to the paired design and involved 10 replications with 1 trap/tree and 2 traps/tree. The traps were hung on the trees at a height of 1–1.5 m above the ground. The experiment considered two opposing trees as one replication. The traps were hung 1 m above the ground on two parallel lines. Then crossed over to form a transverse shape (in order of A1B1, B2A2, A3B3, B4A4, etc. and A and B represent respectively: 1 trap/tree and 2 traps/tree). A 15 m safety distance was left between the set-up tested traps (Anonymous 2010). The adults caught in the traps were counted weekly, and their numbers were recorded. Counting continued for nine weeks until 17.07.2012. Dirty traps were replaced with new traps.

Mass trapping studies

The study was conducted to investigate the applicability of the mass trapping method using yellow sticky traps for the control of *C. pyri* and was carried out in 2012 in the pear sapling orchard of the Atatürk Forest Farm (AFF). A 2-trap per tree application was found to be effective in the trap efficiency experiment, and was tested by comparing with control parcel to conduct mass trapping studies. After the first adult was identified in the yellow monitoring trap, the mass trapping studies began. Studies were carried out on two different parcels containing 450 saplings each within the AFF. One of the parcels was used for the mass trapping experiment, while the other was 500 m away, and was kept as a control. In the experimental parcel, two traps were hung on each sapling, 100 cm above the ground. Mass trapping trial was set up according to the large plot trial design. The experimental design consisted of 10 replications. In the

control parcel, two yellow sticky traps were hung on two saplings to monitor presence the pest population. The traps were checked weekly, the number of trapped adults were recorded and any dirty traps were replaced with fresh traps. Data on temperature, relative humidity, and precipitation for 2012 in the Ankara-Center, where the studies were conducted, were obtained from the General Directorate of Meteorology. 10 saplings were considered as 10 replications and on each sapling 10 shoots (2 sprouts in each of 4 different directions and in the middle) were counted weekly. By this way 100 sprouts were counted totally on each sapling to determine the effect of mass trapping in decreasing the level of *C. pyri* infestation on the pear saplings. Sprouts with honeydew dripping were considered to be infested. The number of damaged sprouts was determined for the calculation of the infestation rate. The collected data was assessed using an appropriate statistical analysis to evaluate the success of the application.

Statistical assessment

In the trap efficiency experiments, the numbers of adults caught in the test traps were subjected to a t test to identify any difference in activity between the two trap set-ups (one trap/tree and two traps/tree). Following an analysis of variance, Duncan's test was used to determine the level of significance of the differences between set-ups. A count was made of the damaged sprouts in the mass trapping experimental parcel and in the control parcel, and the results were analyzed with a Chi-square test to assess whether the difference between set-ups was significant. The statistical assessment of the collected data was made using SPSS software.

RESULTS AND DISCUSSION

Trap efficiency

In the first stage of the trapping study, conducted in 2012 to identify an alternative approach to the control of *Cacopsylla pyri* (L.), trap efficiency was established. For this purpose, an experimental setting was created with a paired design on 22 May in the experimental area. The mean numbers of *C. pyri* adults caught in the yellow sticky traps in the trap activity (2 traps x 1 trap) experiment are presented in Table 1 and Figure 1. As seen in Table 1 and Figure 1, the adult population of *C. pyri* peaked on 26 June and 3 July among the counting dates. Collected data revealed no statistically significant difference between the traps in terms of the total number of *C. pyri* adults caught in the parcels throughout the season (t= -0.862; p>0.05).

No difference was identified in the number of adults caught in the traps between the one trap/tree and two traps/tree set-ups, based on weekly counts. Although no statistically significant difference was found between the two set-ups, the two traps/tree approach was preferred for the mass trapping studies, as a greater number of adults in totally were caught in the two traps/tree set-up. Since the traps will be used when deciding to control of *C. pyri* in mature trees in the pear orchards in early period, two traps per tree character were preferred during the mass trapping studies. Yellow sticky traps might be used to determine the population status prior to making a decision on the control of *C. pyri*.

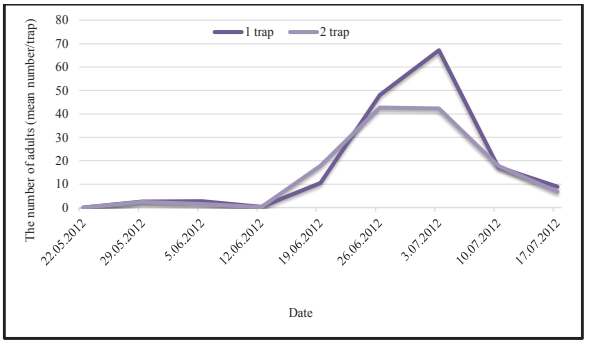

Figure 1. The number of *Cacopsylla pyri* (L.) adults caught in the yellow sticky traps in the trap experiment conducted in the Ankara province in 2012

Table 1. Average number of *Cacopsylla pyri* (L.) adults caught on traps in trap efficiency experiment in 2012

Counting Dates	Average number of adults caught in the trap (number/1 trap)	Number of adults caught in the trap (number/2 traps)
	Mean±St. Error (Min-Max)	Mean±St. Error (Min-Max)
29.05.2012	2.60±0.89 (0-10)	2.45±0.42 (0-10)
05.06.2012	2.70±0.78 (0-8)	1.5±0.38 (0-11)
12.06.2012	0.30±0.30 (0-3)	0.15±0.10 (0-3)
19.06.2012	10.50±3.22 (0-27)	17.80±4.27 (2-126)
26.06.2012	48.10±10.60 (7-100)	42.70±7.36 (18-197)
03.07.2012	67.20±14.30 (0-141)	42.35±11.66 (17-328)
10.07.2012	17.30±5.77 (0-63)	17.85±4.87 (2-142)
17.07.2012	8.90±1.19 (4-16)	6.75±1.04 (2-27)

Table 2. The number of *Cacopsylla pyri* (L.) adults caught in yellow sticky traps in the mass trapping parcel in 2012

Counting Dates	Number of adults caught in the yellow sticky traps in the mass trapping parcel (total number/2 traps)										
	Trap number										
	1	2	3	4	5	6	7	8	9	10	Total
12.06.2012	Traps hung										
18.06.2012	116	100	66	54	17	52	49	64	39	31	588
26.06.2012	47	185	23	44	21	217	274	76	87	37	1011
02.07.2012	454	367	292	148	233	324	350	255	216	195	2834
09.07.2012	752	753	553	680	226	880	567	556	341	575	5813
16.07.2012	445	452	397	416	479	493	541	487	464	475	4649
23.07.2012	367	359	245	473	367	350	562	449	311	423	3906
30.07.2012	351	268	270	195	200	292	327	286	232	133	2554
Total	2532	2484	1846	2010	1543	2608	2670	2173	1690	1869	21425

It is reported that sticky traps can be useful when deciding upon the means of control of *C. pyricola*, although there are other factors affecting the *C. pyricola* density in the trap counts. The number of adults caught in traps hung on large mature trees has been found to be higher than those hung on young trees, which, it has been reported, may be attributed to the different light intensities to which small and large trees are exposed (Horton and Lewis 1997). A study using yellow sticky traps was conducted to establish the optimum spraying time against Diaphorina citri Kuwayama (Hemiptera: Psyllidae), which is harmful to citrus fruit and to estimate population density. Accordingly, 10 trees were selected to apply one trap/one tree and three traps/one tree set-ups, and weekly counts were performed. The population level was reported to be low in the three traps/one tree experiment, and changes in temperature and solar radiation besides sunlight were found to be effective in decreasing the number of adults caught in the traps (Hall 2009). In another study conducted with traps, it was reported that the number of winter form *C. pyri* adults caught in traps increased between morning and noon, were highest at midday, and decreased in the afternoon. Accordingly, *C. pyri* was reported to engage in greater flight activity in warm and sunny conditions than in cool and cloudy conditions (Brown et al. 2009, Horton 1994). In another study about use of sticky traps was referred that care must be taken in interpreting the results, used sticky traps as monitoring tools could underestimate the actual insect population in the field. Sticky traps are cumulative, but catching efficacy is affected by the position in the orchard and thus hamper the acquisition of correct results (Adams et al. 1983, Adams and Los 1989).

Mass trapping

The efficiency of two traps/tree set-up that was envisaged to be effective in mature pear orchard in the trap activity experiment was tested for management of *C. pyri* by mass trapping. The mass trapping experiment was carried out in two orchards in the Atatürk Forest Farm. A mass trapping experimental set-up was established in one of the orchards, while the other one was kept as a control. Yellow sticky traps were used for the mass trapping studies for the alternative control of *C. pyri*, with 20 traps hung on 10 trees, with 2 traps/tree, in the experimental orchard located in the AFF on 12 June 2012, when the pear trees were leafy. The numbers of adults caught in the traps during the mass trapping activity are provided in Table 2, in which it can be seen that the highest number of adults was caught and the population of summer generations peaked on 9 July in all replications. The data collected during the mass trapping study were assessed and the time x trap interaction could not be established ($p>0.05$).

For mass trapping studies only 2 yellow sticky traps were hung on the control character to monitor adults. The numbers of adults caught in the monitor trap in the control parcel are provided in Table 3.

Table 3. The numbers of *Cacopsylla pyri* (L.) adults caught in the yellow sticky traps in the control parcel in the mass trapping activity in 2012

Counting Dates	The number of adults caught in sticky traps in the control parcel (number/trap)
12.06.2012	Trap hung
18.06.2012	55
26.06.2012	73
02.07.2012	97
09.07.2012	36
16.07.2012	83
23.07.2012	56
30.07.2012	48
Total	448

The infestation rate counting was done during harvest. The infestation rate was determined as 87.67%±3.97 and 35.00%±4.98 in the mass trapping parcel and control parcel, respectively. The infestation rates in the mass trapping parcel and the control parcel are presented in Figure 2. The infestation rate in the control parcel was found to ve lower than in the mass trapping parcel, which we believe may be because the

traps attracted *C. pyri* adults, while the increased adult density in the area led to an increase in the infestation rate.

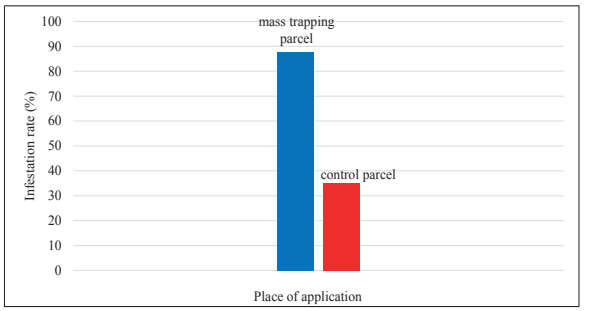

Figure 2. The infestation rate of *Cacopsylla pyri* in the mass trapping parcel and control parcel

Figure 3 presents the temperature, relative humidity and precipitation data for March-August 2012 in the Ankara province, where the study was conducted. The climate conditions were not observed to have a negative effect on the population development of the pest during our studies.

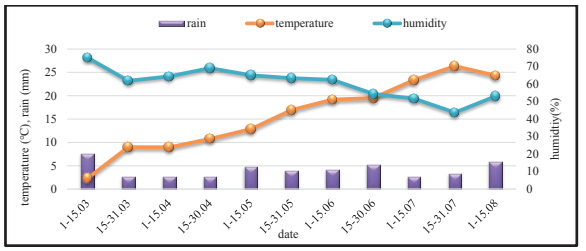

Figure 3. Temperature, relative humidity and precipitation data for March–August 2012 in the Ankara province

At the end of the study an analysis was done to make comparison. It was determined that the number of adults caught in the traps and the infestation rate revealed a negative correlation between the two ($r= -0.415$; $p<0.05$). In line with the findings of the present study, Cooper et al. (2010) found yellow sticky traps to have the potential to aid in the estimation of population size and in the determination of approaches to the control of *C. pyricola* before bud opening in the spring. Among the factors affecting sticky trap counts are such factors as the sex and reproductive status of the insect, the trap color and absence of foliage all of which are reported to affect population density (Horton 1999). Yellow sticky traps have been found to be helpful in estimating the population size of *C. pyricola* and in steering decisions on its control before bud opening in the spring (Cooper et al. 2010). There have also been studies conducted using yellow sticky traps to estimate population size (Hall 2009). A previous study utilized yellow sticky traps, transparent traps, and the beating method to sample the pear psyllid *C. pyricola*, and it was found that more adults were caught in the transparent trap on pear trees before bud opening in the early spring, while more adults were caught in the yellow trap after the green parts became evident. The captured adults were found to be mostly male (Krysan and Horton 1991). In the study by Kosovaeri et al. (2014) conducted in Turkiye regarding the use of yellow sticky traps alone for the control of *C. pyri*, it was demonstrated that yellow sticky traps were highly effective in catching *C. pyri* (L.) and Agonoscena pistaciae Burckhardt&Lauterer (Hemiptera: Psyllidae) adults. The authors, however, reported being unable to achieve a promising outcome in the control of *C. pyri* and *A. pistaciae* when yellow sticky traps and the pheromone formulation were tested together.

The present study, which was conducted to establish an alternative control method, found yellow sticky traps were considerably successful in attracting *C. pyri* adults, although they were also found to attract natural predator species from the Coccinellidae, Chrysopidae, Syrphidae and Vespidae families, as well as pollinator bees. Intended to enlighten an alternative approach to the control of *C. pyri*, the present study found yellow sticky traps lack the ability to sufficiently control the pest after population grew up, and did not lead to a decrease in the infestation rate in the bunches of flowers. It was observed during the study that the traps also attracted beneficial species, such as Coccinellidae. It was concluded that it would be appropriate to use yellow sticky traps only to monitor the first emergence of the adult and the population size in the early period. Use of traps would be appropriate when beneficial species are inactive and have a low population size, and when the *C. pyri* overwintering adults start to become active, and to use them before bud opening in the spring. As a conclusion, yellow sticky traps might be used to establish the population density prior to making a decision on the control of *C. pyri*. We believe that the findings of the present study will contribute to the implementation of integrated pest management programs in pear orchards to decrease the number of sprayings for the successful control of *C. pyri*.

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ÖZET

Bu çalışma ile armut ağaçlarında zararlı armut psillidi *Cacopsylla pyri* (L.) (Hemiptera: Psyllidae) mücadelesinde sarı yapışkan tuzakların kullanımı ve kitlesel yakalama yönteminin uygulanabilirliği araştırılmıştır. Çalışmalar 2012 yılında Ankara ilinde Ankara armudu cinsi fidanların dikili olduğu iki farklı alanda bulanan üç ayrı bahçede yürütülmüştür. Çalışmanın ilk aşamasında tuzak etkinliğini belirlemek için görsel sarı yapışkan tuzaklarla deneme yapılmıştır. Etkili olduğu belirlenen tuzak sayısı ile kitle halinde tuzakla yakalama çalışmalarına geçilerek iki farklı bahçede denemeler yürütülmüştür. Çalışmanın sonucunda sarı yapışkan tuzakların *C. pyri* erginlerini çekme kapasitesinin oldukça yüksek olduğu, ancak dönem ilerledikçe zararlıyı baskı altına almada yetersiz kaldığı görülmüştür. Sonuç olarak, sarı yapışkan tuzakların tek başına *C. pyri*´nin mücadelesinde kullanılmasının yeterli olamayacağı, ancak faydalı populasyonunun aktif olmadığı ve kışlayan psillid erginlerinin bulunduğu erken ilkbahar döneminde ergin popülasyon yoğunluğunu takip etmek amacıyla monitör olarak kullanılabileceği kanısına varılmıştır.

Anahtar kelimeler: *Cacopsylla pyri*, armut, kitle yakalama, sarı yapışkan tuzak

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