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Original article

Determination of different shoot pruning efficiency for controlling *Lasioptera* sp. (Diptera: Cecidomyiidae) in protected tomato cultivation and pests visual preferences

Örtüaltı domateste farklı sürgün budamasının *Lasioptera* sp. (Diptera: Cecidomyiidae) üzerine etkinliğinin belirlenmesi ve zararlının görsel renk tercihi

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ABSTRACT

Lasioptera sp. is one of the problematic pests in the Mediterranean and Aegean regions where protected tomato cultivation is done in Turkey. The larvae that cause tunnel and deteriorations in the plant's main stem by feeding on the core part of the body mostly lead to the death of the plant in a dense pest population. Since harmful larvae live in plant tissue and thus are protected against insecticides and biological agents, control of the pest is very crucial. As an alternative method to pest control, the effects of tomato axillary shoot pruning for controlling the pest were examined. For this purpose, while pruning of axillary shoots in tomato plants as recommended in cultural processes, shoots that are cut off from the body completely and stub-pruning sprouts with 3-5 cm length were assessed in the experiment. The study was carried out in Erdemli district of Mersin province in 2015 and 2017. Although it is ensured that the harmful larvae can feed inside stub-pruned shoots left on the body, the larvae could not reach the plant's main stem and do not cause any damage to the plant. In terms of damaged plants, it was determined that 77.8% and 85.2% of the stub-pruning application are effective in 2015 and 2017, respectively. Additionally, in the study, the attractiveness of visual sticky traps in six different colors including, yellow, black, blue, white, red, and green was investigated. As a result of the study, it was concluded that the colors tested were not sufficient to attract pests.

INTRODUCTION

Turkey has a significant greenhouse and open-field tomato production. Total tomato production area reached to 187 000 ha and production amount reached to 12.600.000 tons in 2016 (TÜİK 2016). Greenhouse tomato production area is 259.709 da, the production amount is 3.399.100 tons. 80.0% of the tomato production is held by the Mediterranean region.

Tomato leafminer [*Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae)], whitefly [*Bemisia tabaci* (Gennadius, 1889) (Homoptera: Aleyrodidae)], vegetable leafminer [*Liriomyza trifolii* (Burgess in Comstock, 1880) (Diptera: Agromyzidae)], and carmine spider mite [*Tetranychus urticae* Koch, 1836 (Acarina: Tetranychidae)] are the main pests in greenhouse tomato cultivation (Bulut and Göçmen 2000, Keçeci et al. 2007, Kılıç 2010, Ulubilir and Yabaş 1996, Yasarakıncı and Hıncal 1999). *Lasioptera* sp., which has spread over a large area after being found in Mersin province in 2011 and Antalya province in 2012 in the Mediterranean region, was also added to these pests (Büyüköztürk et al. 2016).

The pest was identified as a species belonging to the genus *Lasioptera Meigen*, 1818 (Diptera: Cecidomyiidae), which is a cosmopolitan genus consisting of 120 known species in the world. Most of the recorded species of the genus *Lasioptera* were found in the Palearctic region, and none have been reported in tomato and cucumber plants in Europe (Gagné and Jaschhof 2014). However, an unidentified species belonging to the genus *Lasioptera* as a new pest for greenhouse tomatoes and cucumbers in Greece have been reported by Anagnou-Veroniki et al. (2008) and Perdikis et al. (2011).

Most of the known species of the genus *Lasioptera* constitute the trunk gal, some species develop in the galleries of other insects (Gagné and Jaschhof 2014). The larvae of this species live in groups of 4 to 20 individuals, inside the main stem of the tomato plant. The damage usually occurs at the bottom of ripped leaves or in damaged bodies. The larvae feed on the core part of the plant body, causing deterioration and cavities in plant tissue. The damages in the form of brown and dark gray colors on the core part of the body can reach up to 5-6 cm. Larvae feeding sites are usually covered with fungal mycelium (Perdikis et al. 2011). As a result of the feeding of pests in young seedlings, seedlings are broken from the infected part of the plant and die in a short period of time (1-2 days). Unless pests are controlled, the plant's body is damaged from the point of contamination, and these points are weakened and broken. Serious invasions of the pest can lead plants to death (Büyüköztürk et al. 2016, Perdikis et al. 2011).

Since the larvae feed within the plant body, no successful results can be obtained with the chemical control. In this study, it is aimed to determine the effectiveness of alternative methods to chemical control about pest control and delivering visual traps and stub shoots.

MATERIALS AND METHODS

The trials for determination of the effectiveness of different visual traps and shoot cutting for *Lasioptera* sp. control was conducted in the spring growing period in Aslanlı village of Erdemli district of Mersin province.

Determination of the effect of two different pruning methods

Two different axillary shoot pruning methods including the regular method and shoot pruning made by leaving stub were compared in the trial. In regular shoot pruning, all of the shoots were plucked from the main stem. In stub shoot pruning, the shoot was excised from the main stem with the help of a knife by leaving a 3-5 cm stub piece. Treatment was replicated four times in a pairwise randomized design. In the trial, each plot was 45 m^2 with 150 plants (in two rows 30 m long).

Two experiments were conducted in 2015 and 2017. Tomato seedlings were transplanted into the greenhouse on April 10, 2015, for the first-year study. Regular and stub pruning was done on June 16, 2015. Two weeks after pruning (on June 30, 2015), 20 plants identified were marked in each plot. Damaged plants due to pests were recorded on July 14, 2015.

The second-year study was conducted the same as described above. Tomato seedlings were planted on 30 March 2017. Regular and stub pruning was done on June 5, 2017. The numbers of damaged plants were recorded on July 10, 2017.

A chi-square test was used to analyze data on the damaged plants' number of the regular and stub-pruned parcel (Microsoft Excel). The effect of leaving stub pruning on the pest was determined by Abbott's formula (Abbott 1925).

Determination of attractiveness of visual sticky traps

As a result of the preliminary studies performed in 2014 with yellow sticky traps, it was decided to make a try with different color traps because the pest was rarely caught by yellow sticky traps, even in dense pest populations. Therefore, visual sticky traps (20*25 cm) in six different colors including, yellow, black, blue, white, red, and green were assessed. Traps were obtained from Kapar Organik Tarım Sanayi (Ankara, Turkey). According to the color catalog (The RAL German Institute for Quality Assurance and Certification), the closest RAL color names (Anonymous 2008) of traps are given in Table 1. The trial was set up as 4 replications according to the randomized block design. Each parcel was 50 m^2 (6*8.33 m) and one trap was hanged 10-15 cm above the plant at the center of the parcel. There were approximately 8 m of the distance between two traps in the blocks. Traps were hanged on May 26, 2015, and weekly inspection was performed until the end of July. After the counts, *Lasioptera* sp. adults on traps were cleaned, or the contaminated traps were replaced with new ones.

Table 1. The color information of visual sticky traps used in attractiveness test*

Trap color	Ral No	Ral color name	Trinitron RGB**
Yellow	1026	Luminous yellow	240, 205, 30
Black	9017	Traffic black	56, 52, 53
Blue	5005	Signal blue	80, 130, 205
White	9016	Traffic white	230, 225, 230
Red	3020	Traffic red	214, 55, 50
Green	6038	Luminous green	216, 230, 110

* The closest RAL colour no and name are quoted from Anonymous (2008)
** RGB: Red, Green, Blue

Analysis of variance (ANOVA) was performed to determine the significance of the total numbers of *Lasioptera* adults on traps. The significance threshold for Tukey's HSD test was $P \leq 0.001$.

RESULTS

Pruning

The infested plants due to *Lasioptera* sp. are marked in each row (Table 2). The mean number of damaged plants in stub-pruning plots was 1.50 plant and showed a significant difference compared to regular pruning plots [χ^2 (1): 15.11, p<0.001] (Figure 1, Table 2). Where stub-pruning plots, the efficiency of treatment was 77.8% compared to the regular pruning plots (Abbott 1925) (Table 2). In the preliminary observation, made a week before the main inspection (on July 7, 2015), while infested plants were seen in regular pruned treatment, no infested plants were seen in the stub pruned parcels. Then, very few damages were seen caused by pests entered to the plants from natural wounds in stub-pruned plots. This suggests that pests preferred pruning surfaces mostly to lay eggs in pruned plants; however, very slightly they could also enter the plant from the naturally occurring wounds.

In the second-year study, the mean number of damaged plants was 1.00 and 6.75 in stub-pruning and regular pruning plots, respectively and significantly different [χ^2 (1): 17.06, p<0.001] compared to the regular pruning method, a reduction of 85.2% was obtained in the stub-pruned treatment (Table 2).

Traps

The data on the attraction of *Lasioptera* sp. to color sticky traps at weekly intervals is given in Figure 2. The first pest caught in traps was on June 9, 2015. Then the populations showed a relative increase by the middle of July. The data given in the Table 3 indicated that white and green colored traps significantly attracted more number of *Lasioptera* sp. with a total mean population of 74.75 and 74.50 adults/trap over nine weeks, respectively. The other best treatment to attract the pest population was yellow (54.25 adults/trap) and blue colored sticky traps (50.25 adults/trap). The red and black colored traps were least effective for attracting *Lasioptera* sp. (Figure 2). It was also concluded that the number of flies trapped in all color traps was quite low, even though the pest present in almost all plants and flew intensively during this period (Figure 2, Table 3).

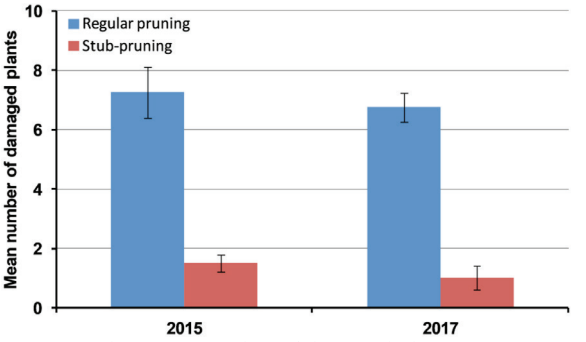

Figure 1. The mean number of damaged plants (mean±SE) at regular pruned and stub-pruned treatments in 2015 and 2017

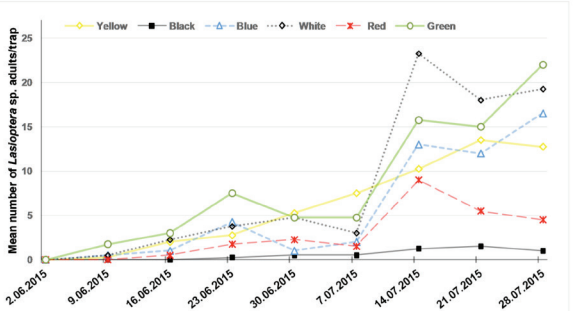

Figure 2. The mean number of captured *Lasioptera* sp. adults on different traps

Table 2. Mean number damaged plants and effects of different pruning methods (calculated with Abbott's formula) for controlling *Lasioptera* sp. in 2015 and 2017

	2015		2017	
Treatment	No. of damaged plants (±SE)	Efficiency (%)	No. of damaged plants (±SE)	Efficiency (%)
Regular pruning	7.25±0.85	-	6.75±0.48	-
Stub-pruning	1.50±0.29	77.8	1.00±0.41	85.2
χ^2 (df), P	15.11 (1), P<0.001		17.06 (1), P<0.001	

* Means followed by a different letter differ significantly at P < 0.001

Table 3. Total mean numbers of *Lasioptera* sp. adult captured on different visual sticky traps over nine weeks in 2015

	Yellow	Black	Blue	White	Red	Green
Total no. of *Lasioptera* sp. adult (mean±SE)/trap	54.25±3.47 ab*	5.00±1.35 c	50.25±8.93b	74.75±3.75a	25.00±2.16c	74.50±9.22a

* Means followed by a different letter differ significantly at P < 0.001

DISCUSSION

This study aimed to determine an alternative method for controlling *Lasioptera* sp., a new pest that recently appeared in tomato greenhouses in Turkey.

Although plant rotation, early planting, and soil tillage are recommended against other Cecidomid species as cultural control methods (Chen and Shelton 2007, Chen et al. 2009, Franzmann et al. 2006), currently there is no suggested method for controlling the *Lasioptera* sp.

The removal and destruction of the attacked and damaged plant parts are recommended as a method of cultural control same as bark beetle control in fruit trees (Donaldson and Seybold 1998). The control method applied in our study is mostly based on the principle that more pests are attracted to injured plant parts. In this method, pests lay their eggs on stub shoot part and the larvae hatched of the egg here cannot reach the main stem of the tomato plant or cannot complete growing as sprout separates from the body and falls down. As a cultural control of the pest, it is suggested to control with leaving stub axillary shoot.

It is thought that this pest which is first detected in tomatoes in Turkey shall cause considerable damage when an appropriate condition occurs. As the larvae of this pest are fed into the body of the plant, recognition, and control are very difficult and pose a serious threat to tomato cultivation. n the present study, the attractiveness of different colors visual sticky traps was also investigated as an alternative control method. It is considered that the effective use of visual sticky traps in controlling the pest is not possible. There are no studies made on the effectiveness of different colors visual sticky traps was also investigated as an alternative control method. There are no studies made on the effectiveness of visual traps for this pest. Sertkaya et al. (2006) conducted to determine the biology of *Asphondylia capsici* Barnes, 1932 (Diptera: Cecidomyiidae), another Cecidomid species, in a study and they suggested that it was not appropriate to use the yellow-colored sticky trap in the monitoring of adults of this fly. Similarly, following the population of *Contarinia nasturtii* (Kieffer, 1888) (Diptera: Cecidomyiidae), which is harmful to Cruciferae, light traps were found to be much more effective than visual sticky traps (Hallett et al. 2007). Sarzynski and Liburd (2003) stated that *Dasineura oxycoccana* Johnson, 1899 (Diptera: Cecidomyiidae) adults do not react to different colors and visual sticky traps cannot be used to monitor the pests. In order to be able to use these traps, they stated that it can be improved with an attractant such as sex pheromone or host-volatile compound. The results obtained in our study are consistent with the stated literature information. For this reason, it is thought that visual sticky traps can not play an effective role in controlling the pests.

In addition, it is suggested to investigate the effectiveness of stub-pruned and/or colored sticky traps in combination with the use of insect nets and similar methods in order to prevent the spread of outdoor infection into the greenhouses.

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ÖZET

Lasioptera sp. Türkiye'de örtüaltı domates yetiştiriciliğinin yapıldığı Akdeniz ve Ege Bölgeleri'ndeki önemli zararlılardan birisidir. Gövdenin öz kısmında beslenerek, bitki dokusunda oyuk ve çürümelere neden olan larvalar, yoğun bulaşmalarda bitkinin ölümüne neden olmaktadır. Zararlı larvalarının, bitki dokusu içerisinde yaşaması ve böylece kimyasal ilaçlar ve biyolojik etmenlere karşı korunaklı durumda olması nedeniyle, mücadelesi oldukça zordur. Zararlı ile mücadelede alternatif bir metot olarak, domates bitkisinde farklı filiz budamasının zararlı üzerine etkisi incelenmiştir. Domates bitkisinde budama yapılırken normal kültürel işlemlerde tavsiye edilen gövdeden tamamen koparılan filizler ile 3-5 cm uzunluğunda tırnaklı kesilen filizler deneme konusu olarak ele alınmıştır. Çalışma 2015 ve 2017 yıllarında Mersin ili Erdemli ilçesinde yürütülmüştür. Gövdede tırnaklı olarak bırakılan filizlerin içerisinde, zararlı larvalarının beslenebilmesine olanak sağlanmış olmasına rağmen, larvalar bitki gövdesine ulaşamamış ve herhangi bir zarar meydana getirmemiştir. Tırnaklı sürgün bırakma uygulamasının bitkide zararlanma açısından, 2015 ve 2017 yıllarında sırasıyla %77.8 ve %85.2 oranında etkili olduğu belirlenmiştir. Ayrıca çalışmada, zararlının ergin dönemlerinin yakalanması amacıyla sarı, siyah, mavi, beyaz, kırmızı ve yeşil olmak üzere toplam altı farklı renkteki görsel yapışkan tuzakların çekiciliği araştırılmıştır. Çalışma sonucunda test edilen renklerin, zararlıyı cezbetmede yeterli olmadığı kanısına ulaşılmıştır.

Anahtar kelimeler: *Lasioptera* sp., Mersin, tırnaklı budama, domates, görsel yapışkan tuzak

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