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Research Article

Population Development and Determination of Infestation Rate of Greenhose Tomato Pests in Karatay and Meram (Konya) Districts

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ABSTRACT

The study was carried out during the 2018-2019 growing season under greenhouse conditions to determine the population development and infestation rates of *Thrips*, Leafhopper species, and *Tuta absoluta* damaging greenhouse tomatoes in Karatay and Meram (Konya) districts. For this purpose, 10 greenhouses of tomato were selected from the two districts. Delta-type sexual pheromone trap, blue and yellow sticky traps were hung in each greenhouse. The traps were placed in the greenhouses alongside tomato seedlings. The pests caught in these traps were counted weekly and recorded. The infestation rate of 25 plants was selected randomly from each greenhouse and their pest infestation was examined. As a result of this study, *Thrips* species in the districts were found in the early stage of the plant in blue traps and were recorded to be 29 and7 pests per week in Karatay and Meram respectively. Leaf hooppers species emerged in yellow sticky traps during the last stages of plant phenology; and in 2018-2019, a maximum of 5-4 pests per week was determined, respectively. *Tuta absoluta*, on the other hand, had a high population at the end of the season; in 2018-2019, a maximum of 636-571 adult pests per week were caught oon the traps, respectively. In 2018-2019, whereas the infestation rate of *Thrips* and Leafhopper species were 0%, the infestation rate of *T. absoluta* was 18.66% and 18.76%, respectively.

1. Introduction

Tomato, an indispensable vegetable of our meals, first grown in Peru and Mexico, is a member of the family Solanaceae which originate from South and Central America. It was brought to Europe by Spanish explorers (Anonymous, 2019a).

The crop is an indispensable product in human nutrition and one of the vegetables with a wide area of use in the food sector; it is one of the most produced, consumed and traded agricultural products in the world. Turkey has risen to the top ranks in tomato production in the world with the favorable climatic conditions for tomato cultivation and the development of the tomato processing industry since the 1970s. As of 2018, China ranks first in tomato production with 56.4 million tons, while Turkey ranks fourth with a production of 12.1 million tons. In 2018, 12.150.000 tons of tomatoes were produced in Turkey, of which 8.414.920 tons were fresh consumed and 3.735.080 tons for tomato paste production (Anonymous, 2019b). In our country, Antalya is ranked first with 2.504 million tons of tomatoes, Mersin with 2.500 million tons, Muğla third with 675 thousand tons and Konya ninth with 163.856 tons of tomato production (Anonymous, 2020).

Approximately 27% of tomato production in our country is done in greenhouses. The share of total tomato production in greenhouse vegetable cultivation is 53.5%. In the Mediterranean Region, 77.6% of greenhouse tomato production takes place. Antalya meets 62.5% of this production (Anonymous, 2018).

There are many diseases and pests that cause quality and quantity losses in tomato production., The pests cause product losses up to 100% if not controlled, Chemical control with pests has many disadvantages and cannot be a solution on its own. *Thrips* species, one of these pests, belong to the family Thripidae of the order Thysanoptera. There is no extensive research on the damage caused by *Thrips* in tomato cultivation areas in

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our country. However, Eltez and Karsavuran (2006) in İzmir, Karsavuran and Gücük (2006) in Manisa, and Canbay et al. (2011) in Erzincan conducted some studies in greenhouses. Leafhoppers are stated in the family Cicadellidae of the order Hemiptera. Güçlü and Özbek (1994) in Erzurum, Karsavuran et al. (2009) in Bursa, Ahmed et al. (2016) in Konya conducted various studies on leafhoppers. *Tuta absoluta* (Meyrick), which belongs to the family Gelechiidae of the order Lepidoptera, was named after Povolny in 1994 (Barrientos et al., 1998). *Tuta absoluta*, originating from South America, is the most destructive pest of tomato. In İzmir (Kılıç, 2010), Antalya (Erler et al., 2010), Mersin (Karut et al., 2011), Konya (Ünlü, 2011; Ünlü et al., 2014; Özkan et al., 2017), in Şanlıurfa (Mamay and Yanık, 2012), Eastern Mediterranean and Southeastern Anatolia Regions (Portakaldalı et al., 2013), Southern Marmara Region (Çetin et al., 2014), Diyarbakır (Bayram and Bektaş, 2014), Uşak (Aksoy and Karaca, 2015), Western Mediterranean Region (Topuz et al., 2016), Central Anatolia Region (Erdoğan, 2016), Erzincan and Iğdır (Canbay et al., 2016) and Kahramanmaraş (Aslan et al., 2017) conducted various studies on the tomato moth. This species, which has a very high damage potential, spread in a short time and became the main pest in the field and greenhouse tomato cultivation in our country.

In this study, it was aimed to detect *Thrips*, Leafhopper species and *Tuta absoluta*, which cause damage in greenhouse tomatoes in Karatay and Meram (Konya) districts using different traps, and to determine the population development and infestation rates of these pests.

2. Materials and Methods

The main material of the study comprised of some pests observed in tomato greenhouses and greenhouses selected in Konya (Meram and Karatay). In the selected greenhouses, blue sticky trap was used to determine the population of *Thrips* species, yellow sticky trap to determine the population of Leafhopper species, and delta type sexual attractive pheromone traps to determine *T. absoluta* population.

In the study, three greenhouses from Karatay district and seven greenhouses from Meram district (Meram-1 and Meram-2) were selected. Studies were carried out in 10 greenhouses in both districts. The areas of the greenhouses were 500 m^2 and their altitude between 1010-1020 m (Table 1).

Table 1
Features of the greenhouses where the study was conducted

Location	Trap Type	Area (m²)	Coordinates		Altitude (m)
Karatay 1	Pheromone - Yellow-Blue	500	37°49’52”N	32°33’40”E	1010
Karatay 2	Pheromone - Yellow-Blue	500	37°49’52”N	32°32’00”E	1010
Karatay 3	Pheromone - Yellow-Blue	500	37°50’60”N	32°32’53”E	1010
$Meram_1$ 1	Pheromone - Yellow-Blue	500	37°46’23”N	32°29’00”E	1020
$Meram_1$ 2	Pheromone - Yellow-Blue	500	37°46’23”N	32°29’20”E	1020
$Meram_1$ 3	Pheromone - Yellow-Blue	500	37°46’23”N	32°29’40”E	1020
$Meram_2$ 1	Pheromone - Yellow-Blue	500	37°45’56”N	32°27’39”E	1010
$Meram_2$ 2	Pheromone - Yellow-Blue	500	37°46’49”N	32°26’54”E	1010
$Meram_2$ 3	Pheromone - Yellow-Blue	500	37°46’55”N	32°29’42”E	1010
$Meram_2$ 4	Pheromone - Yellow-Blue	500	37°46’46”N	32°29’45”E	1010

A pheromone trap, a blue sticky trap and a yellow sticky trap were hung on each of the greenhouse. In weekly counts, all traps were checked one by one, and pests present on the traps were determined.

While tomato seedlings were planted in the greenhouses, traps were hung and a regular count was made every week. Adult insect population check-up continued until tomato harvest. The yellow and blue traps were changed every two weeks and the pheromone capsules every six weeks. The sticky portions on the traps were replaced with new ones when they lost their sticky properties. The number of pests identified on the traps were recorded as a result of weekly checks.

Visual control method was used to determine the infestation rate in tomato plants. All parts of 25 randomly selected plants were examined, the larvae or larval feeding damage of the pest was counted and these plants were accepted as contaminated. The rate of infestation count was made without discriminating fruit / leaf infestation. These steps were repeated separately for each pest.

3. Results and Discussion

1200 tomato seedlings were planted in each greenhouse of 500 m² in the Karatay and Meram districts of Konya. Along with the planting of tomato seedlings in the greenhouses, a pheromone trap, a blue sticky trap and a yellow sticky trap were hung. The traps were conveniently placed 20-30 cm above the tomato seedlings.

The population monitoring of the pests was carried out regularly, and the adult numbers of the pests detected in each trap were recorded. The first insect count was held from April 16th in 2018 to April 20th in 2019. Thrips species, Leafhoppers and Tomato moth were determined in the greenhouses.

3.1. Population Development of Pests

3.1.1. Population Development of Thrips spp.

The 2018-2019 data of the adult population devolepment in the blue sticky traps of *Thrips* species in Karatay district are given in Figure 1

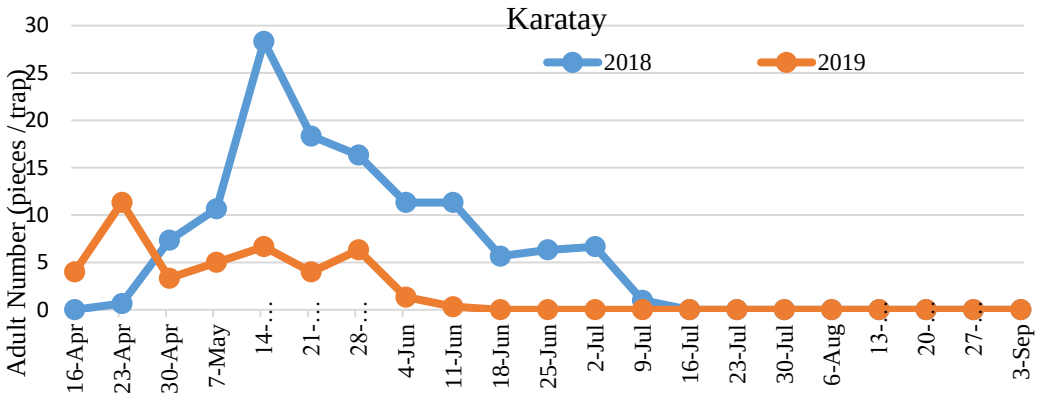

Figure 1
Population development of *Thrips* species in tomato greenhouses in Karatay in 2018 and 2019.

The first adults of *Thrips* species was seen on April 23 (2 pieces/trap) individual in Karatay district in 2018. The highest number of adults was recorded on May 14 (48 pieces/trap). *Thrips* spp. achieved 3 peaks and its population was not seen after 9 July. In 2019, the second year of the study, the first adult emergence started on April 20, and a total of 12 trapped adults were caught in three greenhouses. A total of 34 pieces/trap adults were caught on April 27, this value was determined as the highest average. The 2018-2019 data of the adult population development in the blue sticky traps of *Thrips* species in Meram-1 district are given in Figure 2.

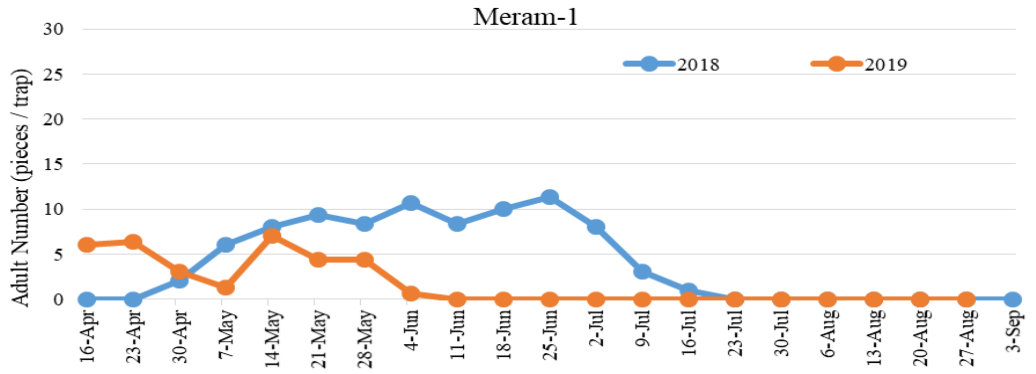

Figure 2
Population development of *Thrips* species in tomato greenhouses in Meram-1 in 2018 and 2019

At Meram-1 location, The dult individuals were seen in traps for the first time on April 30, 2018, and reached the highest level on June 25. The pest, which has achieved an average of three peaks in all three greenhouses disappeared on the traps after 16 July. In 2019, the second year of the study, the first adult emergence started on April 20, and a total of 18 pieces/trap adults individuals were caught. The highest adult was caught on May 18 (10 pieces/trap). The pest, which has 3 peaks in all greenhouses, was not seen on the traps after June 8. The 2018-2019 data of the adult population development in the blue sticky traps of *Thrips* species in Karatay district is given in Figure 3.

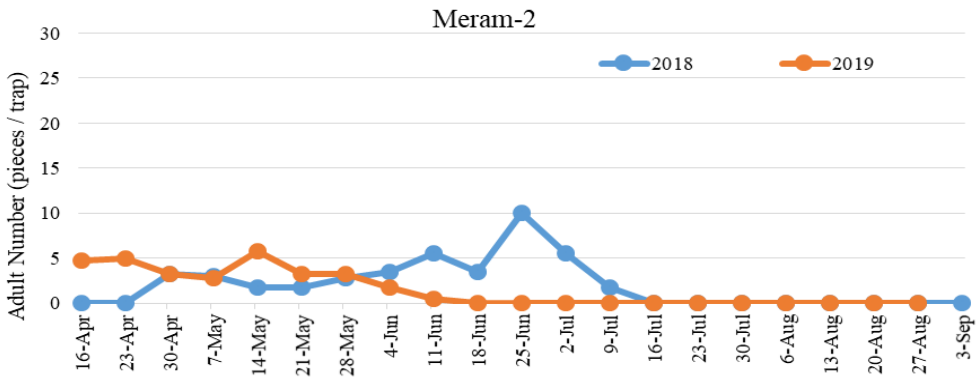

Figure 3
Population development of Thrips species in tomato greenhouses in Meram-2 in 2018 and 2019.

In the Meram-2 location, the first adults appeared in traps on April 30, 2018, and the highest value of the pest that reached three peaks was recorded on June 25 (40 pieces/trap). The pest could not be seen on the traps after 9 July. In 2019, the second year of the study, first adult was determined on April 20. It was determined that the pest that reached the highest value on May 18 (23 pieces/trap) made two peaks. The pest was not seen on the traps after 15 June.

In the study, *Thrips* species were seen only in blue traps and no leaf and fruit infestation was found. The absence of *Thrips* on the traps in late June-early July indicates that this pest is an early pest. In 2018, the highest adult was seen in the district of Karatay (48 pieces/trap) in all traps and the weekly highest value was recorded as 85 pieces/traps. In the second year of the study, a maximum of 13 pieces/traps were caught in the district of Karatay, while a total of 34 pieces/trap adults were caught weekly.

Eltez and Karsavuran (2006) determined the population of *Thrips tabaci* as 1-86 individuals/leaf in their study in the industrial tomato areas of İzmir province between 2003-2004 and recorded a value of 1-20 individuals/leaf in their study in 2005. Two weeks after planting in tomato leaves, the number of adult individuals was high and they saw a decrease in population density from the second half of July in general. In this study, it was determined that the population of *Thrips* species in all greenhouses was low, could not exceed the economic damage threshold and could not cause leaf/fruit infestation. Canbay et al. (2011) reported in their study in Erzincan that *Thrips* species exceeded the economic damage threshold in cucumber greenhouses, but not in tomato greenhouses.

3.1.2. Population Development of Leafhoppers

Our study was carried out without species identification of leafhoppers. The 2018-2019 data of the adult population development in the yellow sticky traps of Leafhoppers in Karatay district are given in Figure 4.

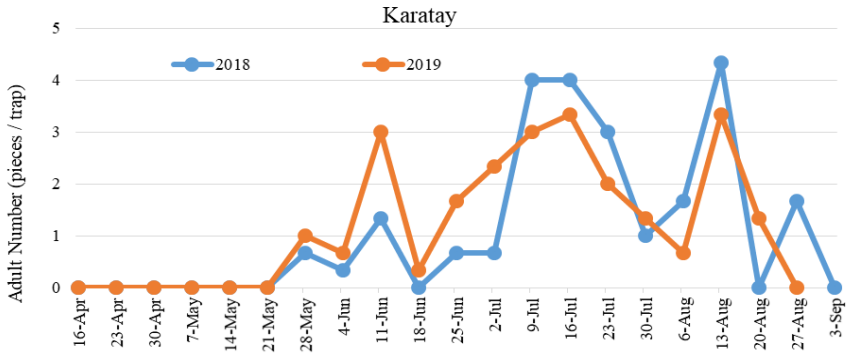

Figure 4
Population development of Leafhoppers in tomato greenhouses in Karatay in 2018 and 2019.

In the district of Karatay in 2018, leafhopper adults emerged on May 28. The highest number of adults was determined on August 13 (13 pieces/trap). Although it was not seen very intensely, the pest's presence on the traps continued until the end of August. According to the data of 2019, which is the second year of the study, the pest emerged on the traps on June 1, and the total number of adults (10 pieces/trap) reached on August 17. The 2018-2019 data of the adult population development in the yellow sticky traps of Leafhoppers in Meram-1 district are given in Figure 5.

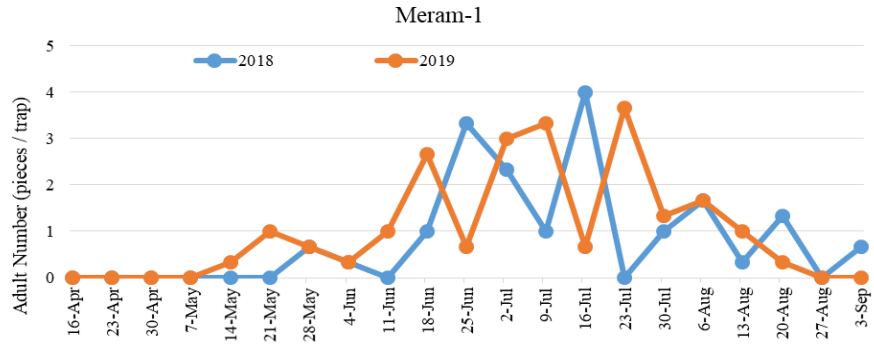

Figure 5
Population development of Leafhoppers in tomato greenhouses in Meram-1 in 2018 and 2019.

In the Meram-1 location, on May 28, 2018, leafhoppers adults were first seen in yellow sticky traps. The average highest number of adults was reached on July 16 (12 pieces/trap). Although it was rarely seen until the end of the greenhouse production season, its presence in

traps continued. The first adult emergence of the leafhoppers in 2019 started on May 18th. The highest number of adults occured on July 27 (11 pieces/trap). The 2018-2019 data of the adult population development in the yellow sticky traps of Leafhoppers in Meram-2 district are given in Figure 6.

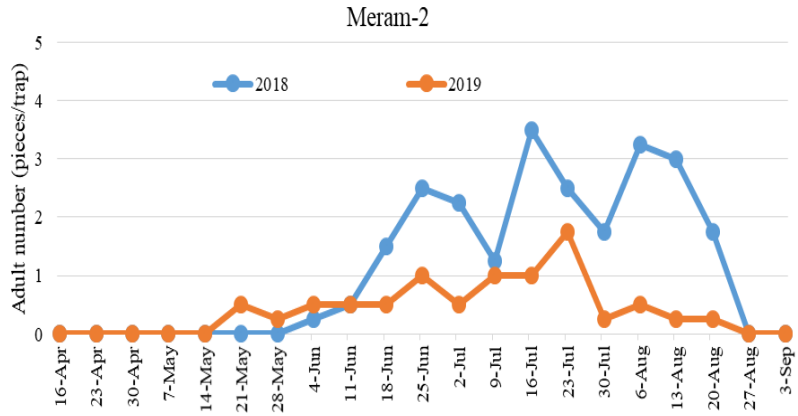

Figure 6
Population development of Leafhoppers in tomato greenhouses in Meram-2 in 2018 and 2019.

In the Meram-2 location in 2018, first adult Leafhoppers was caught on June 4. The total number of adults reached (the highest number) was 14 pieces/trap on July 16. In 2019, the second year of the study, the first adult emergence was recorded on 25 May. The highest total number of adults was reached on July 27 (7 pieces/trap).

The Leafhoppers were seen only in yellow sticky traps and no damage was observed on the plant. In 2018, the weekly maximum number of adults was recorded as 9 pieces/trap, and the total weekly highest value was recorded as 14 pieces/traps. In 2019, the weekly maximum number of adults was recorded as 6 pieces/traps, and the total weekly highest value was recorded as 11 pieces/traps. The pest, which started to be seen on the traps at the end of May, continued to exist until the end of August. The specimens encountered on the traps in both years could not reach the high population value for Konya province.

Ahmed et al. (2016), in their study in Konya (Meram) in 2011, reported that the highest number reached by *Zyginidia sohrab* was 153 adults/100 sweepnet in tomato, and 51 adults/100 sweepnet in *Empoasca decipiens*.

3.1.3. Population Development of Tuta absulata

The 2018-2019 data of the adult population development in the pheromone traps of *Tuta absoluta* in Karatay district are given in Figure 7.

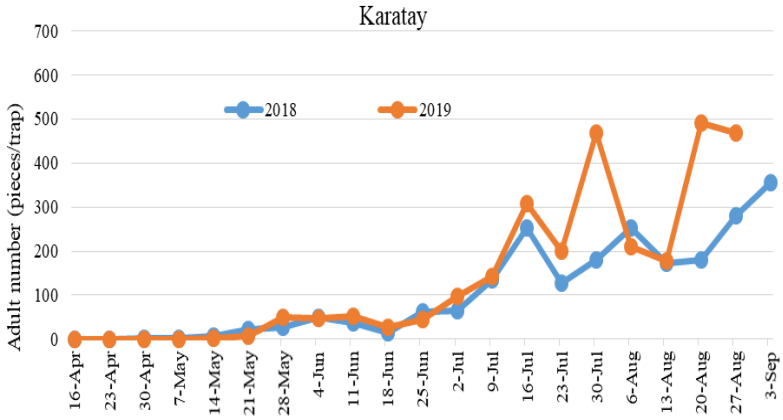

Figure 7
Population development of *Tuta absoluta* in tomato greenhouses in Karatay in 2018 and 2019.

In 2018, Tomato moth was first seen on the traps in Karatay district on April 30. The population of the pest, which reached an average of four peaks in the greenhouses, increased in July-August. The highest number of adults (475 pieces/trap) was recorded at the end of the greenhouse production season. On the traps in three unit greenhouses in Karatay district, the weekly average maximum value was 356 pieces/trap. The pest's presence on the traps ended with the uprooting of the tomato plants. In 2019, the second year of the study, the pest appeared on the traps on May 4. The highest number of adults reached on August 24 (612 pieces/trap). The weekly average highest value was 490 pieces/trap (Figure 7).

The 2018-2019 data of the adult population development in the pheromone traps of *T. absoluta* in Meram-1 district are given in Figure 8.

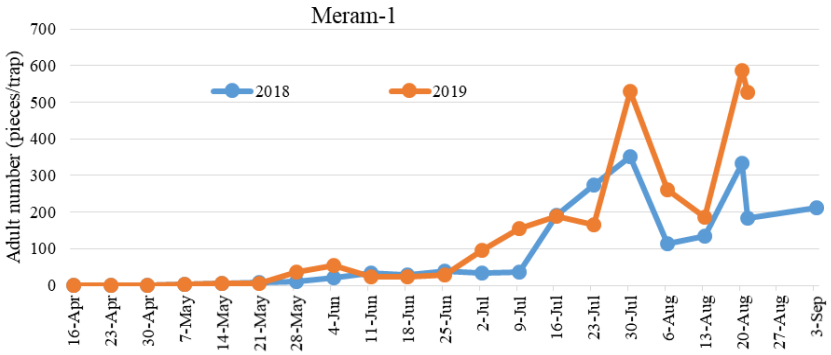

Figure 8
Population development of *Tuta absoluta* in tomato greenhouses in Meram-1 in 2018 and 2019.

According to the data of 2018, the adults of the tomato moth started to be seen on the traps on April 30 at Meram-1 location. Populations of the pest that form 3 peaks in the greenhouses in this region increased in July and August. The highest number of adults (639 pieces/trap) was reached at the end of the greenhouse production season, and the weekly average maximum value was 352 pieces/trap in each of the three greenhouses where the study was conducted. The counts ended with the removal of the tomato plants. The counts ended with the process of removing the tomato plants from the greenhouse. In 2019, the second year of the study, adult emergence started on April 20. The highest number of adults reached 621 pieces/trap on 24 August. The weekly average highest value was recorded as 587 pieces/trap. The 2018-2019 data of the adult population development in the pheromone traps of *T. absoluta* in Meram-2 district are given in Figure 9.

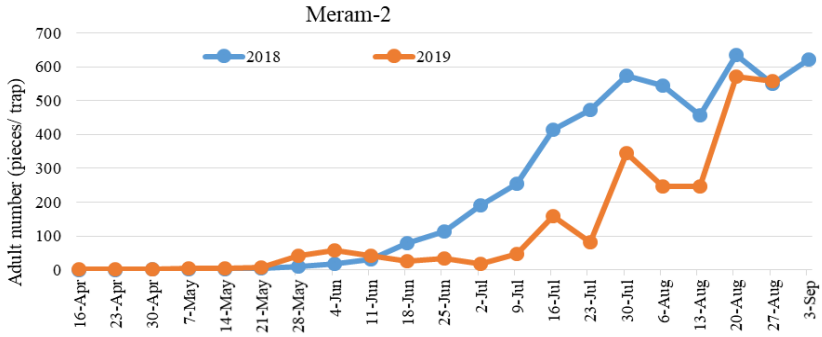

Figure 9
Population development of *Tuta absoluta* in tomato greenhouses in Meram-2 in 2018 and 2019.

In 2018, the adults of the tomato moth were seen on the traps at the Meram-2 location on April 30. The pest, which increased in population in August, formed three peaks. The highest number of adults was reached on 20 August (721 pieces/trap). The weekly average highest value was recorded as 636 pieces/trap. The pest's presence in greenhouses ended with tomato harvesting on September 3. In 2019, the second year of the study, the first adult emergence started on April 20. The highest number was reached on August 24 (628 pieces/trap). The weekly average highest value was 571 pieces/trap.

Since there was no heating system in all greenhouses in Konya, tomato production season covers the beginning of April and the end of August. *Tuta absoluta* began to appear oon the traps two weeks after the traps were set (towards the end of April). While damaging the leaves towards the end of June, the damage to the fruit was found towards the end of August. Due to the harvesting of the crop from the greenhouses in Konya at the end of August, the pest's existence ends in August. It was observed that it is active for 4 months in the greenhouses. In the weekly counts in 2018, a total of 1069 (pieces/trap) adults were caught oon the traps in Karatay district, 1057 (piece/trap) adults in Meram-1 location and 2544 (pieces/trap) adults in Meram-2 locations. It was observed that the presence of the pest, which formed three peaks, oon the traps reached its highest levels at the end of August. In the second year of the study, a total of 1472 (pieces/trap) adults were caught on the traps in Karatay district, 1761 (pieces/trap) adults in Meram-1 location and 2284 (pieces/trap) adults in Meram-2 locations.

Mamay and Yanık (2012) stated that the first adult emergence of *T. absoluta* in the open field occurred in the first half of May, and that it could give four offspring in nature by forming four peaks in July, August, September and October. They also reported that their flights continued actively for seven months until November. Özkan (2012) stated that he detected the presence of pests in greenhouses in Konya, that the pest was densely found in tomato greenhouses, damaged the leaves and fruits of the plants, and formed 3-4 peaks during tomato production season.

3.2. Infestation Rate of Pests

In the study, since the population of *Thrips* species in all greenhouses was not very high (48 pieces/trap), no contamination was found in tomato fruit and leaves. The infestation rate has been recorded as 0%., The population of the leafhopper species was also low (9 pieces/trap), and the infestation rate was recorded as 0%. The infestation rate of *T. absoluta* in tomato greenhouses was determined as 16.92%, 17.53% and 21.53% at Karatay, Meram-1 and Meram-2 locations, respectively in 2018. The least infestation rate was in the district of Karatay. The reason for this is that the tomato plants in the greenhouse where the trap was located were affected with virus disease towards the end of the season, thus the leaves were dry and the fruit yield was very low. In 2019, the second year of the study, the rate of infestation was determined as 16.30%, 18.76 and 21.23% in Karatay, Meram-1 and Meram-2 locations, respectively. The data on the weekly infestation rate of the tomato leaves and fruits of *T. absoluta* for 2018 and 2019 are given in Table 2.

Table 2
The rate of infestation of *Tuta absoluta* in tomato greenhouses in 2018 and 2019 (%)

	Karatay		Meram-1		Meram-2	
Date	2018	2019	2018	2019	2018	2019
11 June	4.00	0.00	8.00	4.00	4.00	4.00
18 June	12.00	8.00	4.00	12.00	8.00	12.00
25 June	8.00	4.00	4.00	8.00	12.00	8.00
2 July	16.00	8.00	12.00	16.00	20.00	12.00
9 July	12.00	16.00	16.00	8.00	12.00	8.00
16 July	24.00	4.00	8.00	12.00	16.00	16.00
23 July	20.00	12.00	16.00	8.00	12.00	8.00
30 July	12.00	16.00	36.00	20.00	24.00	24.00
6 August	8.00	12.00	16.00	12.00	28.00	16.00
13 August	16.00	24.00	24.00	32.00	32.00	28.00
20 August	24.00	32.00	28.00	28.00	36.00	36.00
27 August	28.00	40.00	24.00	44.00	40.00	56.00
3 September	36.00	36.00	32.00	40.00	36.00	48.00
Average	16.92	16.30	17.53	18.76	21.53	21.23

4. Conclusions and Recommendations

As a result of the study, it was observed that there were *Thrips* spp. in blue sticky traps hanged in all greenhouses, Leafhoppers in yellow sticky traps, and Tomato moth in pheromone traps. Although *Thrips* and Leafhoppers constitute a population value below Economic Tresholds, their presence in greenhouses was detected in both years of the study. These pests, seen only on the traps, were not found on the plant.

Although *T. absoluta* started out towards the end of April, it was observed that it reached a high population in July-August. The pest's formation of 2-3 peaks showed that it gave 2-3 offspring during the greenhouse production season. The pest, encountered in the leaf galleries in June, passes to the fruits in August and ends on the traps with tomato harvesting in the greenhouses. In the weekly controls, in 2018, a maximum of 721 adults (pieces/traps) were caught, and a maximum of 2544 adults (pieces/ raps) were caught weekly. In 2019, the second year of the study, the weekly controls were recorded as a maximum of 628 pieces/traps and a maximum of 2284 adults (pieces/traps) were caught weekly. The highest values were recorded at the end of August.

The average infestation rate was 18.66% and 18.76% in 2018 and 2019, respectively. The study was conducted without discriminating the leaf and fruit infestation of *T. absoluta*. Karut et al. (2011) recorded the highest rate of shoot fruit per plant caused by *T. absoluta* larvae as 38.4%. Özkan (2012) reported the highest infestation rate for tomato leaves as 80% and for fruits as 25%. Mamay and Yanık (2012) determined that 100% of tomato plants in the fields were infestated. Aksoy and Karaca (2015) reported that the infestation increased above 50% in leaves and 25% in fruits in closed areas and reached a significant level of 12% in leaves and 8% in fruit in open areas. In our study, it is thought that the reason for the low infestation rate is that the producers regularly apply chemical control methods in addition to the traps; give importance to cultural struggle methods and the removal of tomato plants at the end of August. In addition, it has been observed that biotechnical pest control can be done more easily in greenhouse conditions. It has been determined that this pest, which feeds on all the above-ground parts of the tomato plant, can cause product loss up to 100% if it is not controlled.

In addition to causing quality losses in tomatoes in a high population, it is recommended to keep pests that are virus carriers under biotechnical methods and not to resort to chemical control. It is recommended to install pheromone traps in greenhouses cultivated with tomato seedlings to control the population of *T. absoluta* and to decide the time and method of struggle. On the other hand, Tomato moth traps used by producers in the second year of the study in the greenhouses excluded from the study also played a role in reducing the population.

It has been observed that prioritizing cultural struggle operations supported with biotechnical struggle in the control against *T. absoluta* has a very important role in the fight against pests. It is recommended that chemical control is done according to the adult number on the traps. It is recommended that chemical control, which threatens nature and people, has a detrimental effect on pests as well as beneficial species, should always be considered as the last step and prioritize other methods of management.

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