Population Dynamics of the Greenhouse Whitefly [*Trialeurodes vaporariorum* (Westwood) Aleyrodidae, Hemiptera] in Broccoli Greenhouse in Malatya, Turkey

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Abstract: Malatya, renowned as the apricot capital, has faced significant challenges in recent years as producers have been unable to harvest any yields from their apricot trees due to recurring frost problems in the region. Consequently, farmers have shifted their focus towards cultivating vegetables as an alternative in response to the unyielding frost problems affecting apricot production. Within the realm of greenhouse production, numerous pests exert a substantially impact on both the yield and quality of vegetables. One of the prominent pest responsible for inflicting significant harm to vegetables is the greenhouse whitefly, scientifically known as *Trialeurodes vaporariorum* [Westw.] (Hemiptera: Aleyrodidae). *T. vaporariorum* is a highly prevalent pest that can be found infesting a diverse range of ornamental and horticultural plants. Its adaptability is evident in its extensive host range, encompassing over 300 recorded species that serve as hosts for this pest. This study aimed to into the investigation of population fluctuations of *T. vaporariorum*, a pest encountered in greenhouse broccoli production within the province of Malatya. For this experiment, three yellow sticky traps measuring 15x20 cm were suspended at a height ranging from 15 to 30 cm above the plants within the greenhouse. The number of *T. vaporariorum* individuals captured on the traps was recorded, and the traps were replaced with new ones on a weekly basis. Additionally, *T. vaporariorum* populations were assessed by counting the number of individuals present on ten leaves once per week. The emergence of adult whiteflies was observed in the first year on October 23rd, with a density of 3 adults per 10 leaves. In the second year, the presence of adult whiteflies was noted on November 4th, with a density of 2 adults per 10 leaves. In the first year, the population of *T. vaporariorum* reached its peak, reaching 72 adults and nymphs per 10 leaves. In the second year, the population peaked at 58 adults and nymphs per 10 leaves. In the first year, the populations of greenhouse whiteflies surpassed the economic threshold level by 5 adults and nymphs per leaf on six occasions. Similarly, in the second year, the threshold was exceeded two times. To enhance the quality and efficiency of produce, it is ought to implement control measures for greenhouse whiteflies when their population surpasses the economic threshold value.

Keywords: Damage, Horticultural plants, Pest, Population development, Vegetables

Sera Beyazsineği [*Trialeurodes vaporariorum* (Westwood) Aleyrodidae, Hemiptera] nin Malatya İli Brokoli Serasındaki Populasyon Dalgalanmaları

Öz: *Kayısının başkenti olarak bilinen Malatya ilinde üreticiler ilde yaşanan ilkbahar son don problemleri nedeniyle bazı yıllar kayısı ağaçlarından hiç ürün alamamaktadırlar. Bu sorunlar nedeniyle kayısı dışında alternatif bir üretime yönelme ve kış aylarında sebze yetiştirmeye yönelerek daha fazla kazanç elde etme çabası günümüzde sebze üretimine olan ilgiyi yeniden artırmaktadır. Örtü altında bitkisel üretim yapılan alanlarda birçok zararlı verimi ve kaliteyi önemli ölçüde etkilemektedir. Bölgemizde sebzelerde önemli zarar meydana getiren türlerden birisi de sera beyazsineğidir. T. vaporariorum süs bitkileri ile bahçe bitkilerinde yaygın olarak bulunan bir zararlıdır ve çok geniş bir konukçu yelpazesine sahip olan türün 300'den fazla konukçusu bulunmaktadır. Bu çalışmada örtü altı brokoli üretiminde karşılaşılan sera beyazsineği Trialeurodes vaporariorum [Westw.] (Hemiptera: Aleyrodidae)' nin Malatya ili sera koşullarında popülasyon dalgalanması araştırılmıştır. Sera içerisine bitkilerin 15-30 cm yükseğine 10x15 cm büyüklüğündeki 3 adet sarı yapışkan tuzak asılmıştır. Tuzaklarda yakalanan T. vaporariorum bireyleri her hafta sayılarak tuzaklar yenileriyle değiştirilmiştir. Ayrıca haftada bir on yaprak üzerinde de zararlı sayımı yapılmıştır. İlk yıl T. vaporariorum erginleri ilk kez 23 Ekim tarihinde 0.3 ergin / tuzak yoğunlukta tuzaklarda yakalanırken, ikinci yıl ilk kez 4 Kasım tarihinde 0.2 yoğunlukta tuzaklarda yakalanmıştır. Denemenin ilk yılında en fazla 7.2 ergin + nimf / yaprak olarak belirlenen popülasyon, denemenin ikinci yılında en fazla 5.8 ergin+ nimf / yaprak olarak belirlenmiştir. Sera beyazsineği popülasyonu ilk yıl 6 defa, ikinci yıl ise 2 defa ekonomik zarar eşiğinin (5 ergin+nimf/yaprak) üzerine çıkmıştır. Daha kaliteli ve verimli ürün alabilmek için sera beyazsineği popülasyonu ekonomik zarar eşiğini aştığında zararlıya karşı mücadele edilmelidir.*

Anahtar Kelimeler: *Bahçe bitkileri, Populasyon dalgalanması, Sebze, Zarar, Zararlı.*

INTRODUCTION

Despite being predominantly known for apricot cultivation, Malatya province had the capacity to export vegetables to neighboring provinces during the summer months until the 1980s. However, the establishment of apricot orchards in irrigated agricultural regions during this period led to a

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decline in vegetable production. When examining the historical product pattern of Malatya province, particularly in Battalgazi where extensive apricot production takes place, it becomes evident that the soils in the region are highly suitable for vegetable cultivation. As a result, intensive vegetable farming is practiced. In the Battalgazi District, with 85% of the highest soil fertility in Malatya Province, a significant majority of the population is engaged in agricultural activities (Yakar *et al.*, 2004). The occurrence of spring frost issues in the province has resulted in producers facing an inability to harvest any products from their apricot trees (Asma, 2011). Consequently, these challenges have caused a growing interest among farmers to explore alternative production methods and pursue vegetable cultivation during the winter months as a means to generate additional income. As a result of this increased interest, producers have started to explore various vegetable productions. However, it should be noted that the potential pests specific to vegetable crops in the region where greenhouse cultivation began in 1999 remain largely unknown (Yakar *et al.*, 2004). Agricultural activities are conducted across a vast area of 2 056 957 decares in Malatya province. The cultivation practices encompass fruits and spices (987 717 decares, producing 382,729 tons), vegetables (41 914 decares, producing 103 085 tons), cereals (1 027 301 decares, producing 750 744 tons), and ornamental plants (50 000 m², consisting of 160 000 plants). Additionally, greenhouse production is also carried out across 25 decares, yielding 302 tons of produce.

Broccoli (*Brassica oleracea* L. var. *italica*) from the Cruciferae family is a significant vegetable species known for its positive impact on human health (Talalay and Fahey, 2001; Vural *et al*., 2000). The productivity of broccoli is primarily influenced by temperature, as well as water and fertilizer requirements (Nonnecke, 1989; Wur *et al*., 1995). Under favorable conditions, numerous insect species can thrive and reach high populations. Among these, Hemiptera is the predominant pest order found in most commercial vegetable cultivation areas. Whiteflies, specifically, are noteworthy pests affecting both vegetables and ornamental plants (Byrne *et al*., 1990).

In greenhouse environments, the presence of various pests significantly impacts both the yield and quality of crops. Among the major pests encountered are red spider mites (Acarina: Tetranychidae), thrips (Thysanoptera: Thripidae), aphids (Hemiptera: Aphididae) (Canbay *et al*., 2011), whiteflies (Hemiptera: Aleyrodidae) (Öncüer *et al*., 1994; Eltez and Koçer, 2006), and leafminers (Diptera: Agromyzidae) (Yıldırım, 2002).

The greenhouse whitefly, scientifically known as *Trialeurodes vaporariorum* (Westw.) (Hemiptera: Aleyrodidae), is a serious pest inflicting significant damage to vegetable crops. This widely distributed species affects both ornamental and horticultural plants, displaying an extensive host range with over 300 recorded species (John, 2001). While it typically does not thrive in tropical regions, it manages to survive in colder climates by taking shelter in greenhouses during winter.

Both adult and nymph stages of *T. vaporariorum* cause three distinct types of harm to plants. Firstly, they directly extract plant sap through suction. Additionally, the extensive sugar secretions by these insects result in plants becoming covered in honeydew. Furthermore, *T. vaporariorum* is capable of transmitting plant viruses (Gamarra *et al*., 2016). The presence of honeydew also creates favorable conditions for saprophytic fungi to develop, leading to the formation of fumagine on the sugary substances they secrete (Lodos, 1986).

Previous studies have highlighted that the cotton whitefly Bemisia tabaci was the prevailing species (Özgür and Şekeroğlu, 1986; Öncüer *et al*., 1994). However, more recent investigations have indicated that *T. vaporariorum* poses a significant threat to various plants cultivated in cool regions within greenhouses (Lodos, 1986), and has been observed in all greenhouses prior to the flowering stage (Yaşarakıncı and Hıncal, 1997; Wintermantel, 2004; Uygun *et al.*, 2011; Yılmaz and Durmuşoğlu, 2012; Dursun *et al*., 2013; Karaca and Gökçe, 2014; Darshanee *et al*., 2017).

Broccoli plants with symptoms of leaf curling, enation, fasciation, dwarfing, vain banding, swelling, and cracking symptoms were observed in greenhouse-grown plants in Malatya province. The presence of white fly was observed on and around the symptomatic plants. Based on sequence data, phylogeny analysis and virtual restriction fragment length polymorphism (RFLP) analysis, an unidentified and uncultured bacterium has been reported in broccoli plants in Malatya. In this study, the population fluctuation of the greenhouse whitefly *T. vaporariorum* encountered in greenhouse broccoli production was investigated in the greenhouse conditions of Malatya province. Broccoli was a new product for Malatya and this subject has been chosen since Malatya has not been studied on this subject before, and due to the suspicion of being a vector of the uncultured bacterium.

MATERIALS AND METHODS

The emergence period and population dynamics of the greenhouse whitefly, *T. vaporariorum*, were investigated in broccoli plants grown in unheated plastic greenhouses in Malatya (Battalgazi) province from 2015 to 2017. The broccoli plants were initially planted on October 1, 2015, in the first year, and on October 7, 2016, in the second year. Cultural practices including irrigation and fertilization were properly implemented throughout the study. However, it's important to note that no pesticides were used in the experiment. To monitor the population fluctuation of the greenhouse whitefly, *T. vaporariorum*, in the greenhouse, plant samples were collected on a weekly basis from the seedling stage until the end of the harvest period. The whiteflies present on the leaves were counted each week, following the methodology outlined by Mound (1966), Hill (1969), Martin (1987), Koca and Kütük (2019). Each week, ten leaves were sampled, and the total number of adult whiteflies, nymphs, and empty shells were counted

individually for each sample. *T. vaporariorum* was identified according to Aguiar and Pita (1995). For further analysis, adult whiteflies were counted, and the leaves containing the insects were carefully collected and placed in paper bags. In the laboratory, these leaves were examined under a stereo microscope to count the nymphs and pupae of *T. vaporariorum* found on them.

To monitoring the activity of adult flies and determine the population fluctuations of the pest, three sticky yellow traps measuring 10 x 15 cm were hung at a height of 15-30 cm above the plant canopy immediately after planting in the greenhouses. These traps were inspected once a week, and the captured adult whiteflies were counted. The traps were then replaced with new ones to ensure accurate monitoring of the population dynamics of *T. vaporariorum*.

RESULTS AND DISCUSSİON

In the first year of the study, adult *T. vaporariorum* were initially observed in the broccoli greenhouse on October 23, with a density of 0.3 adults per leaf (Fig. 1). Subsequently, on December 4, 2015, and February 26, 2016, the population of adult whiteflies reached its peak, reaching the highest level of 6.3 adults per leaf (Fig. 2-3-4). Notably, the intensity of the pest on the leaves during the vegetation period exhibited notable peaks on November 20 (5.2 adults per leaf), November 27 (5.7 adults per leaf), December 4 (6.3 adults per leaf) in 2015, and February 26 (6.3 adults per leaf) in 2016 (Fig. 1). The nymph population of the white fly, *T. vaporariorum*, was first observed on November 6, 2015, with a density of 0.2 nymphs per leaf. On January 1 and February 4, 2016, the nymph density was recorded as 0.1 nymphs per leaf, which was the lowest observed during the study period. The highest density of nymphs, reaching 0.9 nymphs per leaf, was observed on December 4, 2015. Additionally, the number of empty pupa shells, which were first observed on November 6, 2015, was found to reach its peak (1.1 nymphs per leaf) on December 4, 2015, and February 12, 2016.

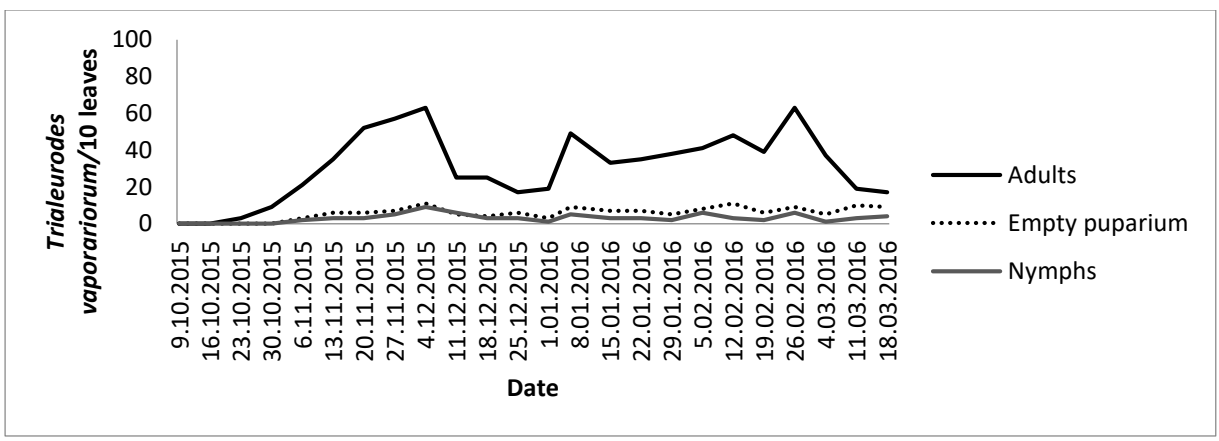

Figure 1. Trialeurodes vaporariorum population fluctuations in the broccoli greenhouse in Malatya province Battalgazi district in October 2015-March 2016

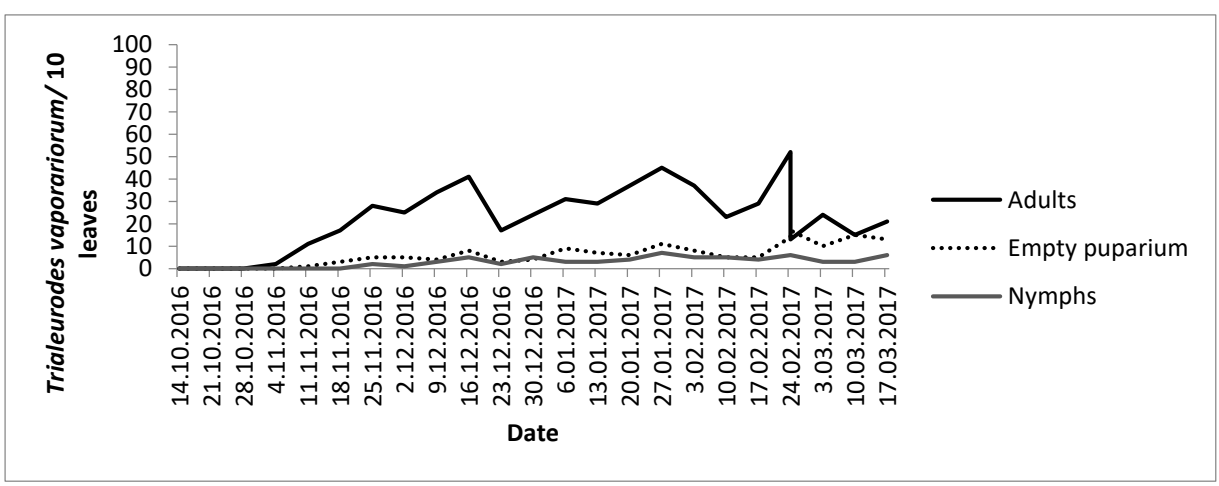

Figure 2. Trialeurodes vaporariorum population fluctuations in the broccoli greenhouse in Malatya province Battalgazi district in October 2016-March 2017

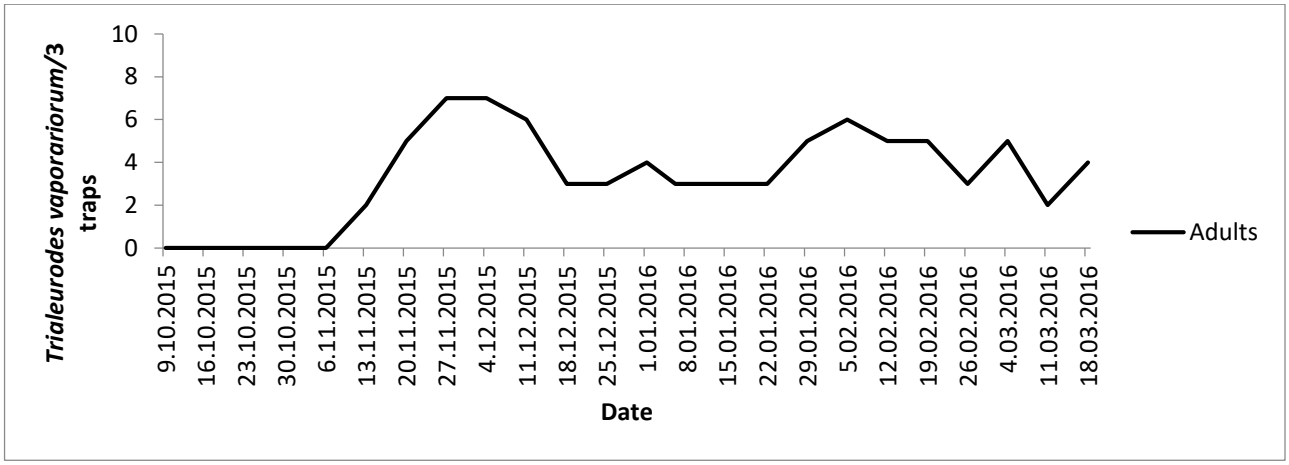

Figure 3. Trialeurodes vaporariorum population fluctuations in the broccoli greenhouse in Malatya province Battalgazi district in October 2015-March 2016

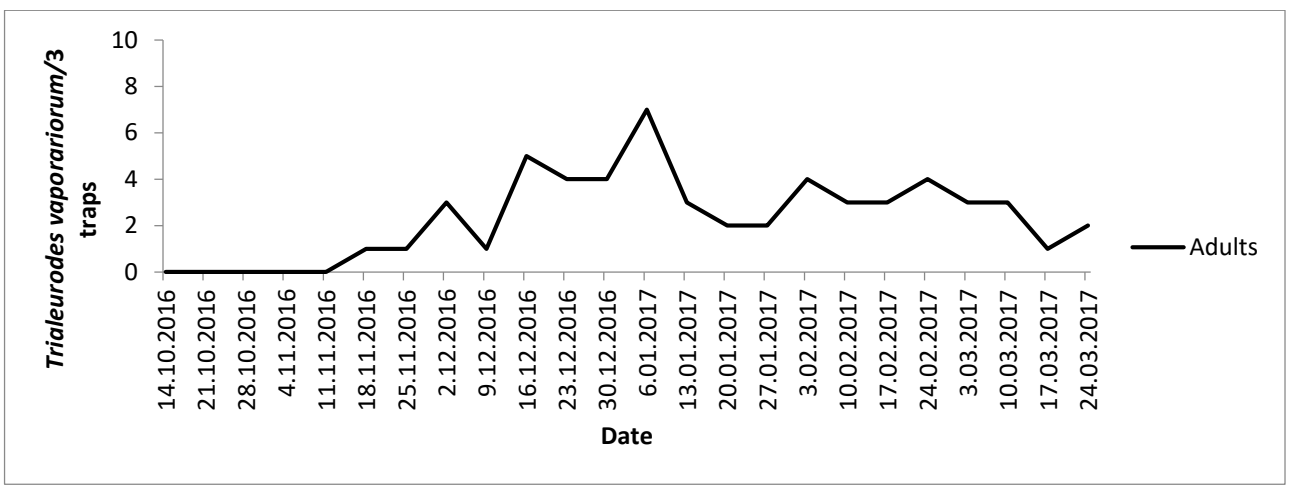

Figure 4. Trialeurodes vaporariorum population fluctuations in the broccoli greenhouse in Malatya province Battalgazi district in October 2016-March 2017

During the periods when the highest number of pupa shells were observed, it was noted that the total count of adults and nymphs combined exceeded the economic threshold level, defined as an increase of 5 adults and nymphs per leaf (Anonymous, 2009).

Furthermore, in the greenhouse where the study was conducted, the first occurrence of white fly adults on the yellow sticky traps was observed on December 13, 2015, with a count of 2 adults per trap. The highest number of white fly adults caught on the traps was recorded on November 27 and December 4, 2015, with a count of 7 adults per trap. The population of greenhouse white flies, T. vaporariorum, exhibited an increase and surpassed the economic threshold level on multiple occasions. This occurred on November 20 (5.5 adults + nymphs per leaf), November 27 (6.2 adults + nymphs per leaf), December 4 (7.2 adults + nymphs per leaf) in 2015, as well as on January 6 (5.4 adults + nymphs per leaf), February 12 (5.1 adults + nymphs per leaf), and February 26 (6.9 adults + nymphs per leaf) in 2016.

In the subsequent period, from October 2016 to February 2017, *T. vaporariorum* adults were observed for the first time on the broccoli plants. The initial occurrence had a density of 0.2 adults per leaf on November 4, and it reached its peak level with 5.2 adults per leaf on February 24, 2017. Throughout the vegetation period, the pest density on the leaves increased, particularly on December 16, 2016 (4.1 adults per leaf) and January 27, 2017 (4.5 adults per leaf), as depicted in Figure 2.

The density of the *T. vaporariorum* nymph population was initially observed on November 25, with a density of 0.2 nymphs per leaf. The lowest nymph density, recorded on December 2, 2016, was 0.1 nymph per leaf. The highest density of nymphs was observed on January 27, 2017, with 0.7 nymphs per leaf. The number of empty pupa shells, which were first detected on November 11, 2016, reached its peak on February 10, 2016, with 1.5 empty pupa shells

per leaf. On February 24, 2017, the number of empty pupa shells further increased to 1.7 per leaf.

In the three yellow sticky traps placed in the greenhouse, the first white fly adults were observed on November 18, 2016, with a density of 1.0 adult per trap. The highest number of white fly adults caught in the traps was recorded on January 6, 2017, with 7.0 adults per trap.

Throughout the vegetation period, the density of the pest on the leaf increased, particularly on January 27, 2017 (5.2 adults + nymphs per leaf), and February 24, 2017 (5.8 adults + nymphs per leaf), reaching the economic threshold level (adults + nymphs per leaf).

In study, Yaşarakıncı *et al*. (2009) found that white flies were present in the greenhouse throughout the entire growing season. During autumn, the white fly adult population peaked in the 46th and 50th weeks of November and December, respectively, with densities of 18.4 and 22.2 adults per trap per week. In the second week of January, the population density increased to 61.8 adults per trap per week. The researchers reported the highest densities of 1442 and 1506.4 adults per week per trap in the 17th and 19th weeks at the end of April. Regarding the nymph and pupa population, they observed a mid-range density of 0.1 nymphs and pupae per leaf in the 51st week. However, they found the maximum density in the spring, specifically in the 19th week at the beginning of May, with a density of 1.9 nymphs and pupae per leaf. In this study, pesticide application was not carried out despite the pest population exceeding the economic threshold value of 5 adults and nymphs per leaf (Anonymous, 2009). It was observed that the pest exceeded the economic threshold value six times in the first year of the study and twice in the second year. It is speculated that implementing pesticide applications when the pest population exceeds the economic threshold value would lead to a decrease in the pest population in subsequent periods (Yaşarakıncı *et al*., 2009). This intervention could potentially prevent the white fly population from reaching the economic threshold value again.

Furthermore, it is known that avoiding chemical control of pests in the greenhouse can promote the proliferation of natural enemies. Topakçı and Keçeci (2017) also highlighted that widespread chemical control methods for pests can have detrimental effects on human health and the environment, as well as harm the existing natural enemies. Yoldaş *et al*. (1999) emphasized the significance of cotton whitefly (Bemisia tabaci) and greenhouse whitefly (*T. vaporariorum*) (Westwood) as important pests in greenhouse vegetable cultivation. They found that the release of the biological agent Encarsia formosa (Gahan) at a rate of 1 larvae per leaf could effectively suppress the nymph population of the pest by 5 nymphs per leaf in autumn-season tomato crops. Similarly, a study conducted in İzmir demonstrated that the nymph population of *T. vaporariorum* could be reduced and suppressed through the presence of naturally occurring Macrolophus caliginosus Wagner (Yaşarakıncı and Hıncal, 1997). Assche *et al.* (1991) further supported these findings by reporting that M. caliginosus naturally suppresses the pest in tomato greenhouses during the summer period.

Yaşarakıncı and Hıncal (1999) suggested that taking preventive measures to control temperature and humidity in greenhouse vegetable production, ensuring optimal ventilation, and preserving the population of natural enemies can help prevent an increase in pest population density. They also highlighted the importance of considering economic thresholds and the density of natural enemies when implementing pest control strategies. Selecting pesticides that have minimal side effects on natural enemies and using low-dose pesticides were recommended as means to minimize harm to natural enemies and preserve the natural populations of beneficial species.

Throughout the vegetation period of broccoli, the presence of *T. vaporariorum* adults and nymphs was consistently observed at varying densities. Eltez and Koçer (2006) noted that *T. vaporariorum* nymphs were consistently present at various densities throughout the vegetation period of tomato plants. The study further revealed that due to excessive damage to the plants and decreased yield, the tomato plants had to be removed after the second week of July. Similarly, in the present study, the observation of broccoli in the greenhouse was terminated in the first year on March 21, 2016, and in the second year on February 28, 2017, as the plants must harvested during those periods because of whitefly damage.

In the study, it was observed that there was not a direct correlation between the counts of adult individuals and the changes in nymph counts. This discrepancy could be attributed to the fact that yellow sticky traps might have attracted more adults from the surrounding area, leading to a higher count of adults in the traps compared to the actual number of live nymphs in the greenhouse. Additionally, the capture of adults in the traps may have prevented them from laying eggs, resulting in a decrease in the number of nymphs. During the first year of the study, on October 23 (0.3 adult/leaf) and October 30 (0.9 adult/leaf), only adult individuals were found on the leaves. The subsequent counts showed an increase in both nymph and adult populations, indicating a population growth in the sampled greenhouse. Similarly, in the second year of the study, the count on November 4 revealed 0.2 adults/leaf, and this was followed by an increase in both nymph and adult populations in the subsequent counts on November 11, November 18, and November 25, 2016. These findings indicate an overall increase in the population within the sampled greenhouse. However, when examining the population change over the course of the year, there was no consistent relationship between the nymph and adult populations in the greenhouse.

Indeed, Yaşarakıncı *et al*. (2009) reported that establishing a numerical relationship between the number of adults captured in the greenhouse and the nymph population in studies on greenhouse whitefly (*T. vaporariorum*) population dynamics and parasitization is challenging. Despite similar population trends, a notable increase or decrease in nymphs compared to the captured adults could not be detected. This finding aligns with the observations made in our study.

It was observed that the population density of whiteflies reached high levels in both years, leading to a decrease in economic efficiency in the greenhouse. As a result, the plants had to be removed prematurely. These pests have the ability to hinder leaf growth and fruit formation by absorbing the plant's stem and reducing chlorophyll synthesis (Jeppson *et al.*, 1975). Therefore, it is crucial to implement measures to prevent the spread of these species to the region. To ensure early prevention, it is recommended that seedlings should not be sourced from other provinces, and producers should obtain their seedlings from the local region. When the population of whiteflies exceeds the economic threshold value, it is imperative to employ control methods. Once this threshold is crossed, it becomes necessary to take action in order to manage and mitigate the negative impact of these pests.

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