African Journal of Agricultural Research Vol. 6(24), pp. 5428-5433, 26 October, 2011
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.774
ISSN 1991-637X ©2011 Academic Journals

Full Length Research Paper

Control of western flower thrips (*Frankliniella occidentalis)* with *Amblyseius swirskii* on greenhouse pepper in heated and unheated plastic tunnels in the Mediterranean region of Turkey

Halil Kutuk[1]*, Abdurrahman Yigit[2], Ramazan Canhilal[3] and Mehmet Karacaoglu[1]

[1]Plant Protection Research Institute, PK 21 01321 Adana, Turkey.
[2]Department of Plant Protection, Faculty of Agriculture, University of M. Kemal, Hatay, Turkey.
[3]Department of Plant Protection, Faculty of Agriculture, Erciyes University, Kayseri, Turkey.

Accepted 12 August, 2011

The western flower thrip, *Frankliniella occidentalis* (Pergande) poses a significant risk to many food and ornamental crops in the Mediterranean region of Turkey. Chemical control has been the primary means used to control the population of *F. occidentalis* in protected cultivation systems in Turkey. We evaluated *Amblyseius swirskii* (Athias-Henriot) on peppers following single releases at the rate of 50 adults per m^2 as a predator of *F. occidentalis* in heated and unheated plastic tunnels. The study covered the period when the peppers had started to flower. In both tunnel types, despite greater variation in day/night temperatures in unheated plastic tunnels, the *F. occidentalis* population was maintained at a level of fewer than 2 per flower throughout the experiments in plots where predatory mites were released. The density of the thrips infestation exceeded the action threshold of 3 thrips per flower in control plots. The results of the study show that *A. swirskii* is highly effective for controlling western flower thrips on sweet pepper and can provide long-term thrips control. In the eastern Mediterranean region of Turkey, pepper growers who are considering releases of this predatory mite in plastic tunnels may find *A. swirskii* useful as a new control agent.

Key words: *Frankliniella occidentalis, Amblyseius swirskii,* biological control, heated and unheated plastic tunnels, sweet pepper, Mediterranean region of Turkey.

INTRODUCTION

Vegetable crops are grown throughout the year in greenhouses and open fields on the Mediterranean coast of Turkey (Anonymous 2003) and are damaged by a number of insect pests. The western flower thrip, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), is one of the most significant insect pests found in this Mediterranean region of Turkey. Thrips infestation is the cause of losses to vegetable crops grown in plastic tunnels and greenhouses in this region (Tunc and Gocmen, 1994; Ulubilir and Yabas, 1996; Bulut and Gocmen, 2000; Kececi et al., 2007).

Chemical agents represent the primary means used to control the population of *F. occidentalis* in protected cultivation systems (plastic tunnels and greenhouses) in Turkey. The critical maximum thrips population level that commercial growers will accept is approximately 1 to 2 active stages per flower (Ulubilir et al., 1999). However, an action threshold of 3 thrips (nymphs and adults) per flower has been defined (Anonymous, 2002).

The search for alternatives to insecticides for controlling *F. occidentalis* has attracted increased interest in recent years (Trdan et al., 2007; Laznik and Trdan, 2008). For several reasons, producers in Turkey are unwilling to use large amounts of pesticides because environmental and human health is damaged, biological control of other pests is disrupted, and pests' resistance to insecticides has evolved rapidly. *Amblyseius swirskii*

*Corresponding author. E-mail: h_kutuk@hotmail.com. Tel: ++ 90 (322) 321 9581. Fax: ++ 90 (322) 322 4820.

(Athias-Henriot) (Acari: Phytoseiidae) is a commercially available biological control agent of the western flower thrips and the tobacco whitefly, *Bemisia tabaci* (Gennadius). This predatory mite has been used with considerable success on greenhouse crops (Teich, 1966; Nomikou et al., 2001; Messelink et al., 2005).

The usual season for the production of peppers in plastic tunnels extends from mid-September or mid-October to June or mid-July on the Mediterranean coast of Turkey (Yılmaz et al., 2009a). In Turkey and in several other Mediterranean countries, greenhouses consisting of simple plastic tunnels, often open on the sides during summer; have been used for the production of vegetables and flowers. On the eastern Mediterranean coast of Turkey, optimum daytime temperatures required for pepper production can be achieved in winter, whereas optimum night temperatures cannot. Heating during the night may therefore be necessary to increase fruit yield and improve fruit quality. However, plastic tunnels are usually unheated or are heated only to prevent freezing in winter. Usually, these plastic tunnels are subject to large differences between day and night temperatures. In the Mediterranean region of Turkey, where temperatures sometimes fall below 5 to 6°C during winter, *F. occidentalis* remains active, and its population growth is proportionately less affected by low temperatures in winter. However, unfavorable temperatures may slow the population growth of *A. swirskii* and might therefore allow *F. occidentalis* to escape from regulation.

In view of the large diurnal temperature variation in plastic tunnels, this study sought to investigate the ability of *A. swirskii* to establish and build up a population and to suppress *F. occidentalis* on greenhouse peppers during the fall, winter and spring months in heated and unheated plastic tunnels.

MATERIALS AND METHODS

Cultures

Rearing of *Amblyseius swirskii* was started with a stock culture coming from Koppert Turkey Ltd. Sti. in Antalya, Turkey, six months prior to the experiment. The mites were cultured on plastic arenas (8 × 15 cm) placed on a wet sponge in a plastic tray containing water (Overmeer, 1985). Strips of wet tissue were placed on the plastic arena along its periphery such that the predators had access to water. A culture of *Carpoglyphus lactis* (Acari: Acaridae) was maintained on dried apricots. Small dried apricots infested with all stages of *C. lactis* were supplied to *A. swirskii* on plastic arenas as a food source. Additionally, pine pollen (*Pinus brutia*) was made available to predators as food by dusting it on the arenas twice per week. The predatory mite cultures were maintained in a climate room (25°C, 60% RH, 14/10 daylight).

Pine inflorescences (*P. brutia*) collected in 2008 at the base of Toros Mountain were put in trays in layers of less than 3 cm and dried in an oven for three days at 37°C. After the inflorescences had been crushed, the pollen was sieved out through gauze with mesh size of 150 um, collected in small jars, and kept in a refrigerator.

Plastic tunnel experiments

The experiments were carried out at the Adana Plant Protection Research Institute (Adana, Turkey) in two adjacent 96 m^2 plastic tunnels: a "heated" plastic tunnel (minimum 10°C in winter) and an "unheated" plastic tunnel (minimum 0°C in winter). In each plastic tunnel, peppers were planted in 30 rows 0.8 m apart, each with 10 plants spaced 0.4 m apart, on 16 September 2009. The plants were watered individually with drip irrigation and fertilized according to the grower's practice. Each plastic house was divided into two plots by constructing barrier of 6 mm thick clear polyethylene film. Five contiguous sections (each 3 rows) were established in each plot by polyester fabric. Each plot section acted as replicates. Colonization and efficiency of *A. swirskii* were studied in one plot. On 17 October 2009, when the plants had started to flower, a single release of predatory mites from the stock culture as a preventive measure was made at the rate of 50 adults per m^2 on the plants in one of the two plots. The other plot was kept as an untreated control.

Three weeks after the predator was released (Ramakers, 1990) the plots were sampled weekly for 28 and 18 weeks in heated and unheated plastic tunnels, respectively, to monitor thrips and predators, beginning on 6 November 2009. Samples of 10 leaves and 5 flowers were randomly collected from each section, wrapped in a paper towel to prevent moisture buildup, placed into plastic ice bags and returned to the laboratory. The number of *F. occidentalis* (nymphs and adults), *A. swirskii* (all stages) and other predators was recorded from each leaf and flower examined under a binocular microscope at 30 times magnification.

The areas within both plastic tunnels (including release plot and control plot that were being monitored) were treated with the compatible insecticides chlorantraniliprole and pymetrozine against *Spodoptera littoralis* and *Aphis* spp. on November 15 (one day before week 5), November 18 (three days before week 6) and December 28 (two days before week 7), respectively. Differences in thrips abundance in the release and control plots continued to increase week by week after these insecticide applications. This observation indicated that chlorantraniliprole and pymetrozine were not negatively impacting the *A. swirskii* (cf. "the www.allaboutswirskii.com website"). Likewise, relative to pretreatment values, *Amblyseius swirskii* densities were not reduced following these applications (Figures 1 and 2).

Statistical analysis

The effects of release treatment on densities of *F. occidentalis* were analyzed using repeated- measures analysis of variance (ANOVA), with the sample date as the repeated measure. When differences in *F. occidentalis* densities and the interaction of treatment and time were significant, Student's t-tests ($p \leq 0.05$) were used to detect significant differences in *F. occidentalis* densities between the release and control plots. The percentage suppression of *F. occidentalis* obtained with predator release was calculated as 100 × [1-(density of *F. occidentalis* in the release plot/density of *F. occidentalis* in the non-release, control plot)].

RESULTS

Heated plastic tunnels

The mean numbers of *F. occidentalis* in the predatory mite release plot and in the control plot differed significantly (F= 54, 22; df =1, 8; P = 0.000). In addition, the effect of time (F=4.74; df = 27, 216; P = 0.000) was significant, but no significant the treatment-by-time

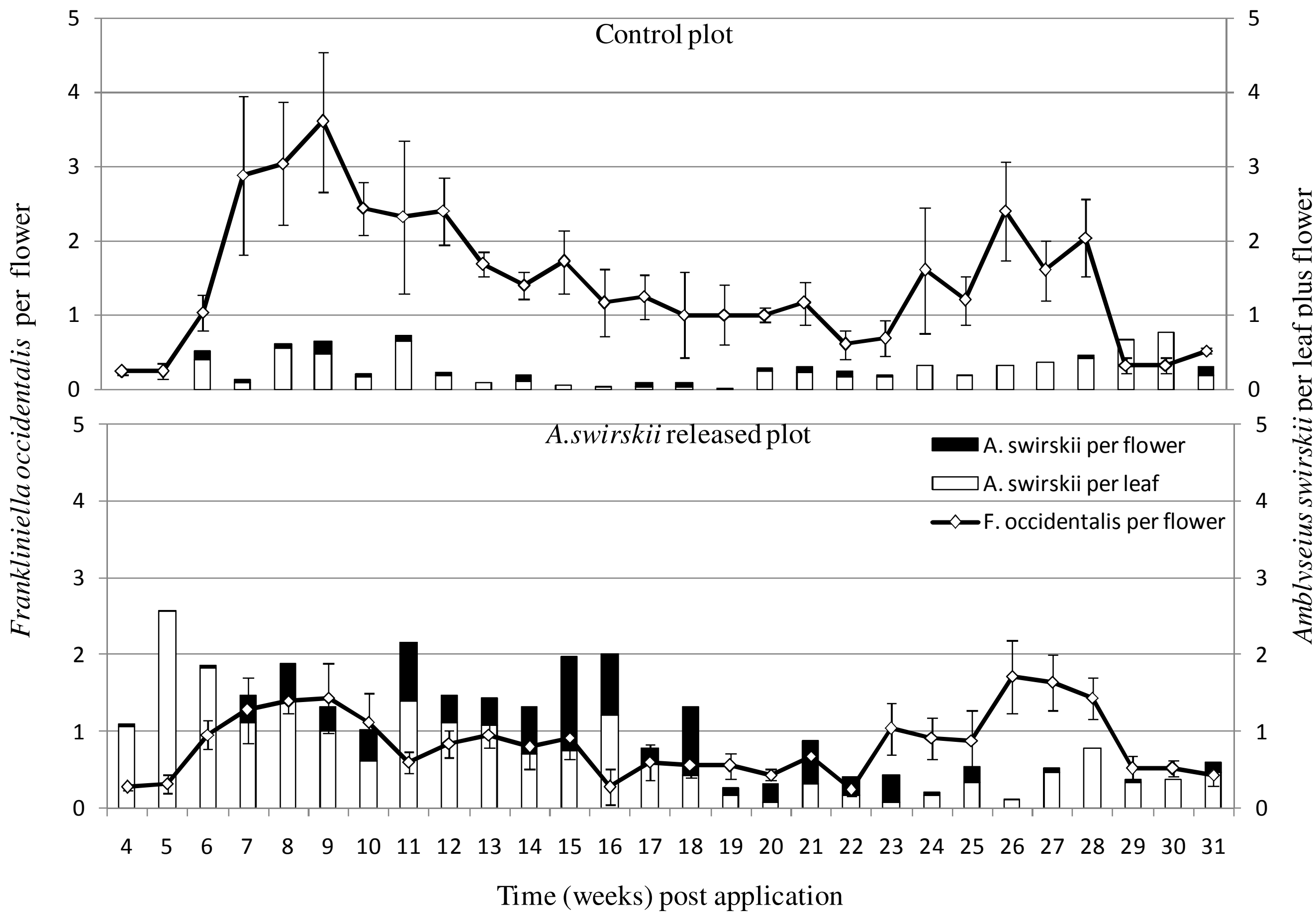

Figure 1. Mean (±SEM) number of *Frankliniella occidentalis* per flower in heated plastic tunnel plots with and without releases of predatory mite and mean *Amblyseius swirskii* per leaf plus flower.

interaction was detected (F = 1,303; df = 27,216; P = 0.154).The absence of the treatment-by-time interaction was presumably similar *F. occidentalis* densities in the predatory mite release plot compared to the control plot at the end of trial. The percentage suppression of *F. occidentalis* in release plot compared to that one control plot was 60; 54.10; 74.14; 65 in week 9, 10, 11 and 12, respectively. *F. occidentalis* populations in the predatory mite release plot remained very low from the beginning to the end of the study (Figure 1). This low thrips population level coincided with the successful establishment of *A. swirskii* on the pepper plants from the beginning of the study in the release plot. The predatory mite effectively produced long-term thrips control (Figure 1). In the control plot, the thrips populations began to increase rapidly in week 6. In week 9, the populations attained a peak level of 3.60 active stages per flower on average. This value exceeds the action threshold of 3 thrips per flower (Anonymous, 2002). This peak represents a typical trend for autumn populations. The thrips population level then decreased to 2.40 thrips per flower in week 12, after which a steadily decline in population occurred. The number of thrips per flower averaged 1 to 1.5 during weeks 13 to 23, which is a typical trend for winter populations (Figure 1). Thrips populations showed a minor increase in week 24, but they declined in week 27 due to the presence of naturally occurring *Orius* species in the flowers. *Orius* first appeared in week 27 in both control and predatory mite release plots. Predatory bugs appeared late in the experiment. Nevertheless, the thrips were eliminated from the control plot, and the experiment ended with a similar number of thrips in both plots.

Unheated plastic tunnels

F. occidentalis densities in the release plot were again significantly lower than those in the control plot (F = 12.526; df = 1, 8; P = 0.008). In addition, the effect of time (F = 6.077; df = 7, 56; P = 0.000) and the treatment x time interaction (F = 3,349; df = 7, 56; P = 0.005) were both significant. Thrips populations remained nearly constant at a level of approximately one thrips per flower from the beginning to the end of the study in release plots, whereas they increased continually in the control plot (Figure 2). The percentage suppression of *F.*

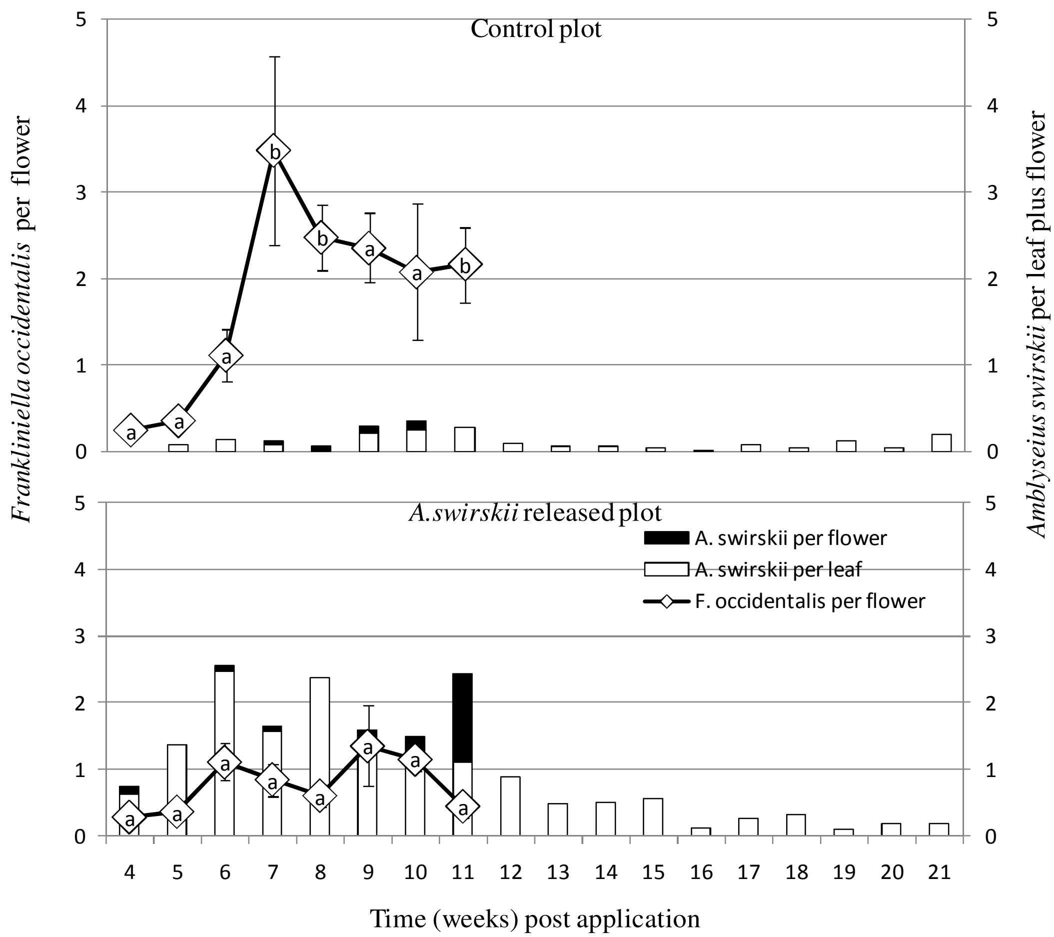

Figure 2. Mean (±SEM) number of *Frankliniella occidentalis* per flower in unheated plastic tunnel plots with and without releases of predatory mite and mean *Amblyseius swirskii* per leaf plus flower. Values of *Frankliniella occidentalis* per flower indicated by different letters are significantly different at P≤ 0.05 (Student's t-test).

occidentalis in release plot compared to that one control plot was 75.86; 75.80; 42.37; 44.23; 79.62 in week 7, 8, 9, 10 and 11, respectively. In the release plots, *A. swirskii* populations increased substantially from the beginning of the trial and peaked in week 6 with more than 2.5 predatory mites per leaf plus flower (Figure 2). The predatory mites declined steadily from week 12 to 21 on the pepper leaves. However, the mites never became extremely scarce. Some individuals were recorded in all of the periodic samples. Furthermore, the pepper plants did not have enough flowers (Figure 2). In the unheated plastic tunnel, greater variation in day/night temperature retarded the emergence of new flowers from week 12 to 21. During those weeks, nighttime temperatures dropped to 5.4°C and occasionally to 1.17°C.

DISCUSSION

In the heated plastic tunnels, *F. occidentalis* populations of less than 2 per flower throughout the experiments in the release plots coincided with an increase in predatory mite density. This finding shows that *A. swirskii* is a highly effective predator of *F. occidentalis* in sweet pepper for single mite releases in the eastern Mediterranean region of Turkey (Figure 1). This result agrees with the finding by van Houten et al. (2005) that releases of *A. swirskii* (30 mites per plant) allowed successful establishment of mite populations and effective control of thrips on greenhouse-grown sweet pepper. Likewise, Arthurs et al. (2010) found that *A. swirskii* was an effective predator and consistently held populations of *Scirtothrips dorsalis* Hood below 1 per terminal leaf on peppers grown in a greenhouse and in the field. In the control plot of the current study, *F. occidentalis* population level decreased to 2.40 thrips per flower in week 12, after which a steadily decline in population occurred throughout the winter months (Figure 1). It is difficult to ascribe this decline in thrips density to winter conditions alone, part of this decline could result from *A. swirskii* entered unavoidably the control plot. Moreover, this thrips population level is very close to that reported by Kececi (2005), who found a low level of 1 to 3 thrips per flower in a control plot from late January to the beginning of March. In the release plots in that study, *Orius levigatus* successfully controlled *F. occidentalis* on greenhouse peppers in the Antalya province of Turkey. A population trend of this kind is typical of this thrips species under natural conditions in the region. Atakan and Uygur (2005) found that mean numbers of *F. occidentalis* (females plus males) were <1 adult per sample in winter months on most weed species in the eastern Mediterranean region of Turkey. On the other hand, Toapanta et al. (1996, 2001) suggested that development of thrips is slower at cool temperatures. One generation was completed in approximately 30 to 40 days during the winter in northern Florida.

In the unheated plastic tunnels, *F. occidentalis* in the release plots were also maintained by *A. swirskii* throughout the experiments at a level of fewer than 2 per flower. This result shows that *A. swirskii* reproduced and persisted in the more challenging environment of unheated plastic tunnels (that is, greater variation in day/night temperatures). The predatory mite remained present until 21 weeks after release, despite the fact that the emergence of new flowers was retarded (Figure 2). Optimum temperatures for vegetative growth for greenhouse peppers are between 21 to 26℃. However, fruit set is determined by the 24 h mean temperature and by the difference between day and night temperatures. The optimum night temperature for flowering and fruit setting is 14 to 18℃ (Yılmaz et al., 2009b). *A. swirskii* was able to tolerate variable temperatures in our tests. This tolerance likely exists because the predator is native to the Mediterranean (Swirski and Amitai, 1982; Moraes de et al., 2004). An additional explanation of the predator's successful persistence is that peppers contain leaf domatia, minute pockets at the intersections of the midrib and the lateral veins, which can protect phytoseiid mites against adverse environmental conditions and against cannibalism (Ferreira et al. 2008). Lee and Gillespie (2010) suggested that the effects of temperature on population growth of *A. swirskii* may not be of concern to biological control programs that focus on *F. occidentalis* because the temperature responses of *A. swirskii* and *F. occidentalis* are quite similar.

As a conclusion, *A. swirskii* is a highly effective control agent of western flower thrips on sweet pepper in the region represented by the study. Moreover, *A. swirskii* can be released preventively when the crop is flowering and remains present in the crop throughout the entire growing season, even when the population density of the thrips is very low. In the eastern Mediterranean region of Turkey, pepper growers who are considering releases of this predatory mite in plastic tunnels may find *A. swirskii* useful as a new control agent.

ACKNOWLEDGMENTS

We thank R. T. Villanueva of Texas AgriLIFE Extension for reviewing the manuscript.

REFERENCES

Anonymous (2002). Integrated pest management in protected cultivation of vegetables. Ministry of Agriculture and Rural Affairs, General Directorate of Agricultural Research, Ankara, Turkey. (In Turkish.)

Anonymous (2003). Agricultural structure and production. State institute of statistics, Prime ministry, Republic of Turkey, Ankara, Turkey. (In Turkish.)

Atakan E, Uygur S (2005) Winter and spring abundance of *Frankliniella* spp. *Thrips tabaci* Lindeman (Thysan., Thripidae) on weed host plants in Turkey. J. Appl. Entomol., 129: 17-26.

Bulut E, Gocmen H (2000) Pests and their natural enemies on greenhouse vegetables in Antalya. IOBC/WPRS Bull., 20(3): 33-37.

Ferreira JAM, Eshuis B, Janssen A, Sabelis MW (2008). Domatia reduce larval cannibalism in predatory mites. Ecol. Entomol., 33: 374-379.

Kececi M (2005). Using possibilities of polifag predator *Orius* spp. (Hemiptera: Anthocoridae) against greenhouse pests. Ph.D. Thesis, Ankara University Press, Ankara, Turkey (In Turkish.)

Kececi M, Ceylan S, Kahveci L, Ulker Y, Toprakci N (2007). Studies on greenhouse pests and their population fluctuation on greenhouse peppers in Antalya province of Turkey. Proceedings of II National Plant Protection Congress; 27–29 Agoust, Isparta, Turkey (In Turkish).

Laznik Ž, Trdan S (2008) Enthomopathogenic and entomoparasitic nematodes as biological control agents of thrips. Acta Phytopathologica et Entomologica Hungarica 43(2): 317-322.

Lee HS, Gillespie DR (2011) Life tables and development of *Amblyseius swirskii* (Acari: Phytoseiidae) at different temperatures. Experi. Appl. Acarol., 53: 17-27.

Messelink G, Van Steenpaal S, van Wensveen W (2005) *Typhlodromips swirskii* (Athias-Henriot) (Acari: Phytoseiidae): a new predator for thrips control in greenhouse cucumber. IOBC/WPRS Bulletin 28: 183-186.

Moraes de GJ, McMurtry JA, Denmark HA, Campos, CB (2004) A Revised Catalogue of the Mite Family Phytoseiidae. Zootaxa 434: 1-494.

Nomikou M, Janssen A, Schraag R, Sabelis MW (2001) Phytoseiid predators as potential biological control agents for *Bemisia tabaci*. Experim. Appl. Acarol., 25: 270-290.

Overmeer WPJ (1985) Rearing and handling. In: Helle W, Sabelis MW (eds) Spider mites, their biology, natural enemies and control. Elsevier, Amsterdam, pp. 161-170.

Ramakers PMJ (1990) Manipulation of phytoseiid thrips predators in the absence of thrips. IOBC/WPRS Bull., 13: 169-172.

Swirski E, Amitai S (1982) Notes on the predacious mites (Acarina: Phytoseidae) from Turkey, with description of the male of *Phtytoseius echinus* Wainstein and Arutunian. Israel J. Entomol., 17: 55-62.

Teich Y (1966) Mites of the family of Phytoseiidae as predators of the tobacco whitefly, *Bemisia tabaci* Gennadius. Israel J. Agric. Res, 16: 141-142.

Toapanta M, Funderburk J E, Beshear R J, Olson SM, Mack TP (1996) Abundance of *Frankliniella* spp. (Thysanoptera: Thripidae) on winter and spring host plants. Environ. Entomol., 25: 793-800.

Toapanta M, Funderburk JE, Chellemi D (2001) Development of *Frankliniella* species (Thysanoptera: Thripidae) in relation to microclimate temperatures in vetch. J. Entomol. Sci., 36: 426-437.

Trdan S, Žnidarčič D, Vidrih M (2007) Control of *Frankliniella occidentalis* on greenhouse-grown cucumbers : an efficacy comparison of foliar application of *Steinernema feltiae* and spraying with abamectin. Russian J. Nematol., 15(1): 25-34.

Tunc I, Gocmen H (1994). New greenhouse pests, *Polyphagotarsonemus latus* and *Frankliniella occidentalis* in Turkey. FAO Plant Prot. Bull., 42: 218-220.

Ulubilir A, Yabas C (1996) Determination of pests and natural enemies on vegetables in Protected Cultivation in Mediterranean Region of Turkey. Turk. J. Entomol., 20: 217-228 (In Turkish).

Ulubilir A, Yasarakinci N, Kececi M (1999) Report of Integrated Pest Management, Applied and Education Project in Protected Cultivation of Vegetables. Annual Report of the Plant Protection Research Institute, Adana, Turkey. (In Turkish.)

Van Houten YM, Ostlie ML, Hoogerbrugge H, Bolckmans K (2005). Biological control of western flower thrips on sweet pepper using the predatory mites *Amblyseius cucumeris, Iphiseius degenerans, A. andersoni and A. swirskii*. IOBC/WPRS Bull., 28: 283-286.

Yılmaz S, Celik I, Zengin S, Fırat A (2009a). Tohum fide ve cesit secimi. In: Yılmaz S, Celik I, Zengin S, Aktas A, Teksam I, Devran Z, Arı N, Gocmen M, Fırat A (eds.) Örtüaltı biber yetiştiriciliği. Kutlu Avcı Ofset Form Baskı, Antalya, Turkey, pp. 49-58 (In Turkish).

Yılmaz S, Celik I, Zengin S, Gocmen M, Aktas A (2009b). Cevresel faktorler ve sera yapıları. In: Yılmaz S, Celik I, Zengin S, Aktas A, Teksam I, Devran Z, Arı N, Gocmen M, Fırat A (eds.) Örtüaltı biber yetiştiriciliği. Kutlu Avcı Ofset Form Baskı, Antalya, Turkey. pp. 11-28 (In Turkish).