The European Journal of Plant Science and Biotechnology ©2013 Global Science Books

Integrated Pest Management of Protected Vegetable Cultivation in Turkey

Seral Yucel[1] • Mehmet Kececi[2] • Melike Yurtmen[1] • Raziye C. Yildiz[1] • Adem Ozarslandan[1] • Canan Can[3*]

[1] Biological Control Research Station, Kışla Cad., P.O. Box 21, 01321, Adana, Turkey
[2] Batı Akdeniz Agricultural Research Institute, P.O. Box 35, 07100 Antalya, Turkey
[3] University of Gaziantep, Department of Biology, 27310, Gaziantep, Turkey

Corresponding author: * can@gantep.edu.tr, canancan2000@hotmail.com

ABSTRACT

Protected vegetable cultivation is located mainly in the Aegean and Mediterranean regions having a 93% share within the total greenhouse area in Turkey. Among the major vegetable crops of the regions, tomato, pepper, eggplant and cucumber are the most preferred since they give farmers high income. Diseases and pests are the prime items restricting production in quality and quantity under protected conditions. Integrated pest management (IPM) programmes were initiated under protected cultivation areas such as Antalya, Mersin, Izmir and Mugla provinces in the 1990s, which aimed to adopt a reduced number of pesticide applications. Further activities were performed through field days and broadcasting services as well. Farmers were encouraged to reduce outcome costs and apply environmentally friendly practices including pesticides. The use of solarization practices dates backs to the 1980s in Turkey. It was first introduced to farmers by demonstration projects during 2000-2007 under protected conditions of the Mediterranean region. The use of natural enemies against pests on various crops and pesticides with low side effects to useful insect fauna were also examined. Farmers were trained about IPM applications by conducting field days. To extend IPM practices for the control of pests and diseases under protected vegetable cultivation areas, studies are still in progress in Turkey.

Keywords: IPM applications, protected vegetable crops, Turkey

CONTENTS

INTRODUCTION

Protected vegetable cultivation in Turkey, which is economically important both in domestic consumption and export facilities, is done in an around 56.348 ha area with 5.4 million tons of production (TÜİK 2010). Thus, disease and pest management have become one of the major restricting factors for protected vegetable cultivation in Turkey.

The protection of human health, the environment, ecosystems and biodiversity has recently been considered as important elements in the application of agricultural practices. Hence, it is vital that the agro-ecosystem and sustainable systems in agriculture be considered when deciding pest control methods. This can be achieved primarily by employing cultural methods in harmony with other alternatives to pesticides. In addition, all alternatives should be implemented in a compatible way, if necessary.

The first reasonable form of pest and disease control is chemical measures since the effect is instant. Farmers usually do not wait for pests to reach a certain population level (the economic threshold). Besides, they often accidentally mix pesticides with fungicides in protective chemical applications. Such incorrect applications have been proven to have a bad effect on human health, the environment, and disturb the natural balance which also induces resistance of the pest population (Delen *et al.* 2007). On the other hand, detection of pesticide residues that exceeds daily amounts for fresh products as determined by international organizations negatively affects domestic consumption and the export market. Thus, studies aiming to integrate pest and

Received: 13 October, 2011. Accepted: 20 April, 2012.

Invited Mini-Review

disease control by applying less pesticides and alternative control measures have been fostered in Turkey.

Noteworthy studies on integrated pest control started with cotton in 1970 (Yasarakinci 2009). Following this, several projects were conducted on grapes, olive, cherry, pistachio, apple, hazelnut, citrus, wheat, potato, maize and sunflower. In addition to these crops, research on vegetables and ornamental plants grown under protected conditions was carried out in cooperation with research institutes and broadcasting organizations of The Ministry of Agriculture and the universities. Moreover, a project titled 'A national network assembles for integrated pest management (IPM) in Turkey' was funded by FAO/UNDP during 1994-1996. Through this project, technical guidelines for IPM were agreed upon and put into use by researchers, farmers, educational and broadcasting staff of The Ministry of Agriculture (Bulut 1995; Yücel *et al*. 2002).

Alternative applications to chemical control such as mechanical and physical measures, biological control, biotechnical methods and the use of resistant and/or tolerant varieties were specified in the guidelines. Chemical control is not recommended to control diseases, pests and weeds if their management is available through alternative control methods. When chemical control is a must, specific pesticides have to be suggested in order to minimize adverse effects on natural enemies, humans and the environment. In such a case, the criterion is based on the minimum use of such chemicals, and the most efficient dose in a proper device on the time when the populations of natural enemies are low. Chemicals should also be applied in a technically correct way. The pesticides in the guidelines were determined according to international criteria and to the active ingredients accepted for integrated control programs. Furthermore, the pesticides containing high residual risk factors were excluded in the technical guidelines of IPM (Yücel *et al*. 2011).

IPM applications of protected tomato cultivation in Antalya, Mersin, Izmir and Mugla provinces of Turkey have already been adopted by growers starting at the end of 1990. Decade-long comparisons were made between IPM-implemented and -nonimplemented greenhouses. Production cost was estimated through control expenses and the number of pesticide applications as a portion of the total cost. The reduced expenses in greenhouses where IPM was applied and where the number of pesticide applications was reduced by half were taken into consideration. Thus, practicing IPM in greenhouses provides an opportunity to use less pesticides, resulting in environmentally friendly products. In addition, the application of IPM could reduce control expenses, which in turn could compensate economic losses (Yücel *et al*. 2002).

COMMON DISEASES IN GREENHOUSE-GROWN VEGETABLES

The most common diseases of greenhouse-grown vegetables in Turkey are grey mold (*Botrytis cinerea* Pers.), late blight of tomato [*Phytophthora infestans* (Mont.De Bary)], cucurbit downy mildew (*Pseudoperonospora cubensis* Berk. and Curt.), wilting and root rot diseases (*Fusarium* spp., *Verticillium* spp., *Rhizoctonia solani* Kühn, *Phytophthora* spp., *Pythium* spp., *Alternaria* spp., *Sclerotinia* spp., *Pyrenochaeta lycopersici* R.Schn.&Gerl.), white mold [*Sclerotinia sclerotiorum* (Lib) De Bary], cucurbit powdery mildew [*Erysiphe cichoracearum* (D.C.)], [*Sphaerotheca fuliginea* (Schlech) Polacci], powdery mildew of Solanaceae [*Leveillula taurica* (Lev.) Arn. syn. *Oidiopsis sicula*], tomato leaf mold [*Fulvia fulva* (Cke.) Ciferri, early leaf blight of tomato and eggplant (*Alternaria solani* Ell. and Mart.)], tomato stem necrosis [*Pseudomonas* spp. and *Erwinia* spp.], tomato bacterial wilt [*Clavibacter michiganensis* subsp. *michiganensis* (Smith Davis et al.)], tomato bacterial speck disease [*Pseudomonas syringae* pv. *tomato* (van Hall)], pepper bacterial speck disease [*Xanthomonas vesicatoria* (*Doidge*) Vauterin, Hoste, Kersters & Swings)] angular leaf spot of cucumber [*Pseudomonas syringae* pv. *lachrymans* (Smith & Bryan) Young, Dye], *Alfalfa mosaic alfamovirus* (AMV), *Cucumber mosaic cucumovirus* (CMV), *Potato X potexvirus* (PVX), *Potato Y potyvirus* (PVY), *Squash mosaic comovirus* (SqMV), *Tobacco mosaic tobamovirus* (TMV), *Tomato yellow leaf curl bigeminivirus* (TYLCV), *Tomato spotted wilt tospovirus* (TSWV), *Tomato mosaic tobamovirus* (ToMV), *Tomato black ring virus* (TBRV), *Tomato ringspot virus* (ToRSV), *Watermelon mosaic 1 potyvirus* (WMV–1) and *Zucchini yellow mosaic potyvirus* (ZYMV) (Yilmaz and Davis 1985; Yilmaz *et al.* 1998; Yorganci *et al*. 1994; Yücel 1994; Yucel *et al*. 2008; Tokgönül 1995; Ulubilir and Yabaş 1996; Saygılı *et al*. 2008; Baysal *et al*. 2009; Tok and Kurt 2009; Karaca and Guncan 2009; Celik *et al*. 2009; Celik and Gocmen 2009; Ozdemir 2009).

CONTROL METHODS OF GREENHOUSE-GROWN VEGETABLE DISEASES

All of the control methods for greenhouse grown vegetables are evaluated in terms of IPM requirements while priority is given to cultural methods to grow healthy plants so that plant resistance to pest and diseases can be achieved. In the case of pest and disease contamination, despite cultural measures, the control procedures which are physical, biotechnical and biological control methods and that have a minimal effect on human health and the environment should be given priority. In case pest and disease intensity is still high and can not be prevented even though the above mentioned procedures are implemented, chemical control must be applied to prevent crop loss (Saygılı *et al*. 2008).

Cultural measures

Important yield losses occur when cultural practices are ignored in plant disease control. Educational studies on IPM applications broadcasted to farmers mainly focus on several cultural practices (Yigit and Dikilitas 2007; Saygılı *et al*. 2008; Yücel *et al*. 2011):

1. Planting materials should be healthy (pathogen-free) and certified.
2. Pest and disease resistant and/or tolerant varieties should be used.
3. Dense planting should be avoided so as not to prevent air circulation among plants.
4. Air ventilation should be optimized in greenhouses to prevent raising temperature and relative humidity.
5. Fertilization and care requirements should be balanced to result in healthy plant grow, and excessive nitrogen application must be prevented.
6. Greenhouse soil should be enriched with organic matter, and compost or farm manure should be applied in poor and porous soil.
7. Water accumulation around roots must be prevented and if possible drip irrigation should be preferred.
8. Diseased or retarded in growth or plants must be uprooted and eradicated from the greenhouses. Before the activities, hands should be washed with soap and water, and smoking should be avoided.
9. Weeds should be removed at regular intervals.
10. Single crop should be planted to avoid inter-crop contamination of diseases.
11. Pruning utensils should be frequently disinfected with sodium hypochlorite.
12. Copper applications for diseases should be conducted after trimming plants.
13. Crop rotation should be applied in greenhouses with high disease prevalence.
14. Fruits should not be wet during harvest.
15. Plant debris should be removed from the growing areas after harvest.

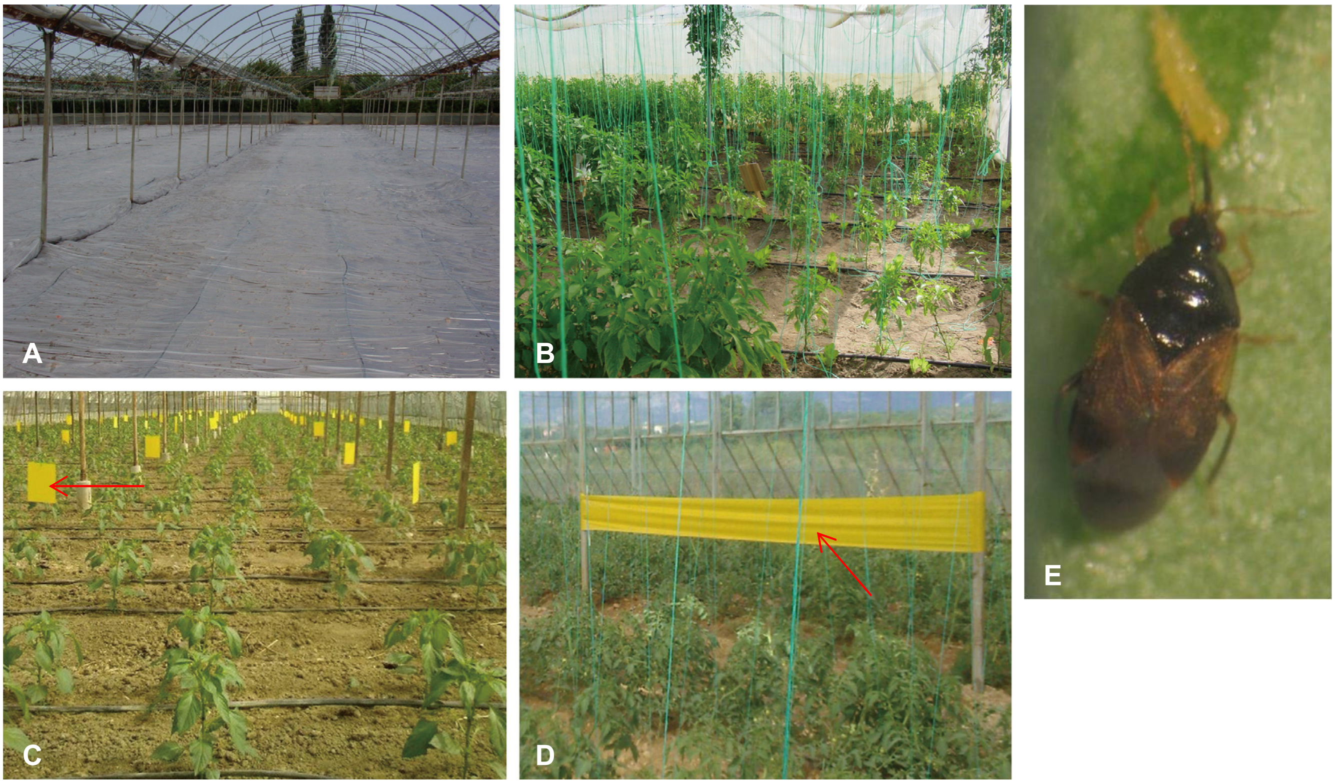

Fig. 1 (**A**) Soil solarization. (**B**) Solarization treated and untreated parcels (indicated with an arrow). (**C-D**) Yellow sticky traps (red arrows) in greenhouses. (**E**) *Orius laevigatus* adult.

Physical control

Heating soil with sun rays (solarization) is performed by covering the damp soil with a layer of transparent plastic for about 4-8 weeks during summer time (July-August) while no plant is present in the greenhouses. Solarization could be effective to a certain degree when it is applied alone or in combination with a low dosage of registered fumigants, biocontrol agents and organic amendments associated with disease contamination status of greenhouse soil (Katan 1987; Gamliel and Stapleton 1993; Yucel *et al* 2007a).

Solarization in Turkey was first applied in 1982 through research projects conducted in Eastern Mediterranean region (**Fig**. **1A-B**). Various variable studies were, then, conducted on vegetables grown under protected conditions in the region (Yücel and Çınar 1989; Erkilic *et al*. 1994; Aysan *et al*. 1995; Yucel 1995). In addition, demonstration projects funded by World Bank and UNIDO with the participation of plant protection research institutes, universities and agricultural extension services establishing alternative methods to methyl bromide were successfully completed during 2000-2007. The results of these projects, solarization alone, solarization+low dose fumigant and solarization+biofumigation applications, are being recommended for greenhouse-grown vegetables in the Eastern Mediterranean region. In addition, *Trichoderma* spp. is added to planting material mix to establish antagonist fungi colonization. The results have also revealed that by applying solarization, soil-borne fungal and bacterial diseases as well as nematodes can be controlled in vegetables grown under protected conditions in the Mediterranean and Aegean regions of Turkey (Aysan *et al.* 1995; Çınar and Aysan 1995; Benlioglu *et al*. 2005; Sogut and Elekcioglu 2007; Yılmaz *et al*. 2007; Yucel *et al*. 2007b; İmriz *et al.* 2011; Yıldız and Çınar 2011).

Biological control

In greenhouses, where climatic conditions are controlled, there are registered commercial forms of antagonistic organisms (*Bacillus* spp., *Pseudomonas* spp., *Trichoderma* spp., *Streptomyces lydicus*) recommended against such diseases as powdery mildew, grey mold, downy mildew and seedling damping off. Their efficiency varies in accordance with IPM applied greenhouse conditions (Bora and Özaktan 1998). Cucumber seedlings applied with a biological preparation containing *Trichoderma harzianum* rifai KRL AG2 were planted to solarised soil, and root rot diseases caused by *Rhizoctonia solani* and *Fusarium solani* were contollled by 59.6% (Yücel *et al*. 2008). Similarly, *Trichoderma harzianum* and *Glomus mosseae* applications in pepper against root rot diseases (*Fusarium oxysporum* and *Rhizoctonia solani*) were reported to be effective (Arıcı *et al.* 2011).

Furthermore, studies on the use of plant growth promoters and essential oils against plant pathogens have been conducted for vegetable cultivation grown under protected conditions (Sahin *et al*. 2000; Soylu *et al*. 2003 a, 2003b; Altinok 2007; Soylu *et al*. 2010).

Chemical control

As soon as the first symptoms are appeared in the greenhouse, registered pesticide for the crop-pest combination is applied accordingly. However, in the case of downy mildew of tomato and cucurbits, chemical control can be conducted when downy mildew symptoms in neighboring greenhouses appeared and the conditions are appropriate for the disease development. Thus, chemical control measures must be applied at the minimal effective dose by considering the population of natural enemies (Yücel *et al*. 2002). A demonstration experiment carried out during 2000-2003 reported a pesticide use reduction from 27 to 15 in IPM conducted greenhouses, which could double farmers' profit (Ekmekci *et al*. 2002). In case of viruses, insect-vectored agents should be specially handled in order to protect the crop from transmission. Chemical control should be applied without taking into account of the insect's economical threshold in case of vectoring to a plant-virus.

COMMON PESTS IN GREENHOUSE GROWN VEGETABLES

Harmful species in protected vegetable cultivation were determined according to the frame of IPM Project and to the other survey researches. The most common pests of greenhouse grown vegetables in Turkey were determined as whiteflies [*Bemisia tabaci* (Genn.), *Trialeurodes vaporariorum* (Westw.)], leaf miner [*Liriomyza trifolii* (Burgess)], aphids [*Myzus persicae* (Sulz.), *Aphis gossypii* Glov.], thrips [*Thrips tabaci* Lind., *Frankliniella occidentalis* Pergande], carmine spider mite [*Tetranychus cinnabarinus* (Boisd.)], tomato leaf miner [*Tuta absoluta* (Meyrick)], cotton leafworm [*Spodoptera littoralis* (Boisd.)] and cotton bollworm [*Heliothis armigera* (Hübn.)] (Ulubilir and Yabaş 1996; Yaşarakıncı and Hıncal 1997, 1999; Bulut and Gocmen 2000; Keçeci *et al.* 2007; Kilic 2010; Erler *et al.* 2010). Western flower thrips and cotton whitefly were common in all seasons whereas cotton leafworm and cotton bollworm populations were detected at the beginning of the growing season, intensively (within October-November), and carmen spider mite was observed at the end of the season as well (within April-May) (Ulubilir and Yabas 1996; Yaşarakıncı and Hıncal 1997; Keçeci *et al.* 2007).

Meloidogyne arenaria, *M. incognita* and *M. javanica* were reported to be root-knot nematodes of vegetable crops with the economic importance in different regions of Turkey in some studies (Sogut and Elekcioglu 2000; Mennan and Ecevit 2001; Devran and Sogut 2009; Ozarslandan and Elekcioglu 2010; Devran and Sogut 2011). On the other hand, *M. incognita* race 2 and *M. javanica* race 1 were observed in vegetable crops from the East Mediterranean (e.g. Adana and Mersin provinces) and the Black Sea (e.g. Samsun province) regions of Turkey (Sogut and Elekcioglu 2000; Mennan and Ecevit 2001). In addition, *M. incognita* race 2 and 6, *M. javanica* race 1, *M. arenaria* race 2 and 3 were recorded in vegetable crops from the West Mediterranean region of Turkey (Devran and Sogut 2011).

GREENHOUSE GROWN VEGETABLES PESTS CONTROL METHODS

The ultimate goal of pest control depends upon basic implementations of IPM. These are cultural measures (screening open spaces of air ventilations, control of weeds that could be the host of pests, etc.), biotechnical control (use of visual sticky traps and pheromone traps), biological control (augmentative releases of biological control agents, enhancement of natural enemies) and chemical control (use of specific pesticides having no negative effect on natural enemies, considering economic damage threshold, etc.). These methods can be implemented alone or in combination to control pests in greenhouses. However, it is essential that an appropriate IPM program using a minimal level of chemical control is to be applied (Yaşarakıncı *et al*. 1996).

Cultural measures

In order to prevent insect movement into the greenhouse and protect the cultivation, insect-proof nets are required particularly during the sensitive seedling and on-going stages. Special care should be given to close all the spaces in the greenhouse such as airing, doors, etc. The ventilation of primitive-greenhouses is realized through side surfaces. The use of insect net was not widely used since insect-proof nets significantly limited this kind of ventilation in greenhouses. However, *T. absoluta* was first detected in 2009 and became a major pest in tomato cultivation in Turkey, which in turn increased the tendency of using insect-proof nets by producers. Furthermore, the use of nets has lately been achieved 100% in advanced greenhouses by improving the standards (Tüzel *et al.* 2010).

Excess use of nitrogenous manure in the greenhouses, on the other hand, should be avoided. It is widely accepted that plants with extra nitrogen are given preference to the insects to feed and lay down the eggs comparing to the less nitrogenous ones. Plants with high nitrogen concentration can increase the insect populations (Civelek and Önder 2002).

Cultural practices against nematodes are cited as follows.

Seedlings and the irrigation water should be free from nematodes. In addition, getting rid of the plants after harvesting, plowing the soil by upside-down in order to decrease the nematode populations, the use of resistant cultivars is recommended. The gene called *Mi* against root-rot nematodes in tomatoes enable resistance to *M. incognita*, *M. arenaria*, and *M. javanica* species and is widely applied. However, *Mi* gene cannot preserve the resistance when the temperature overs 28°C (Devran *et al.* 2010).

Special care should also be given to use grafted seedlings which have recently been widely used for tomatoes and eggplants in Turkey.

Biotechnical control

There has been a great number of research on the efficiency of visual sticky traps against some pests. Yellow sticky traps were reported to be effective on whitefly (Ulubilir *et al.* 1996; Durmusoglu *et al.* 2009a, 2009b), blue sticky traps on thrips (Kazak *et al.* 2009). In placing the visual sticky pest traps to 10-15 cm over the plants by 1 for each 50-100 m^2 for monitoring the pests in the protected production, right after the time of transplanting seedlings are recommended (**Fig. 1C-D**). Following the determination of the first adult flight, 1 trap for each 10 m^2 is appropriate for mass trapping (Yücel *et al*. 2002, 2011). Visual sticky pest traps were not commonly used in the early years of IPM practices. In recent years, nevertheless, they have been used in all of the advanced and 80% of the conventional greenhouses (Tüzel *et al*. 2010).

Determining the existence of *T. absoluta* in the greenhouses is crucial, hence *T. absoluta* originating from South America is also incorporated into the IPM programme. For this purpose, pheromone traps (1 trap/day) is placed for monitoring. When the presence of the pest is detected, mass trapping should be transferred to 2-4 water trap/da (Keçeci 2010).

Biological control

Although the studies initiated earlier in order to investigate the possibilities of biological control measures against vegetable pests such as *Macrolophus caliginosus* and *Encarsia formosa* against whiteflies (Yasarakinci and Hincal 1999, 2001), *Phytoseiulus persimilis* against *T. cinnabarinus* (Kazak *et al*. 1992, 1997, 2000; Akyazı and Ecevit 2009) and *Diglyphus isaea* against leafminers (Ulubilir and Sekeroglu 1997; Yaşarakıncı and Hıncal 1997), *Orius laevigatus* against *F. occidentalis* (Keçeci 2005), they were actually started at the beginning of 2000s. In the early stages of biological control, it was only applied for pepper cultivation. *Eretmocerus mundus* and *Amblyseius swirskii* against whiteflies, *O. laevigatus* (**Fig. 1E**) and *A. swirskii* against thrips, *Aphidius colemani* against aphids and *P. persimilis* against Carmine spider mite were successfully used as the biological control agents against the major pests of the pepper cultivation.

Whitefly has been considered to be the main pest in biological control applications on tomato, after several years of biological control implementations on peppers. Biological control of the whiteflies was done by combining of three agents; *M. caliginosus*, *E. formosa* and *E. mundus.* After the introduction of *T. absoluta*, the aspect on biological control was revised since it became the major pest of tomato production in Turkey. The new approaches on biological control of tomato pests were employed using *Nesidiocoris tenuis* feeding with both pre-adult period of whitefly and eggs and larvae of *T. absoluta* in system. The studies related to assessing alternative and native biocontrol agents against

T. absoluta were also carried out. Additionally, *E. mundus* is also being used for controlling whiteflies. *D. isaea* has been released in greenhouses for controlling leafminers. Mostly, the pests are easily controlled by the naturally occurrence of parasitoid species such as *D. isaea*, *D. crassinervis*, *Neochrysocharis formosa*, *Chrysonotomyia chlorogaster*, *Hemiptarsenus* sp., etc. in the IPM conducted greenhouses (Ulubilir and Yabaş 1996; Yaşarakıncı and Hıncal 1997; Keçeci *et al*. 2008).

Biological control research involves not only to determine the efficacy of the biological control agent, but also for improving their current efficiency. The predatory mite *A. swirskii* was successful to control *F. occidentalis* by artificially adding pine (*Pinus brutia*) pollen to the plants before their flowering period to provide an alternate food source for predator (Kutuk *et al.* 2011).

Biological control is applied only at a rate of 1% on the total protected cultivation areas of Turkey. However, it is intended to reach double-digit numbers of this rate in the forthcoming 5–10 years. On the other hand, practicing biological control for the other species such as strawberry, cucumber and eggplant is very limited.

Chemical control

When the pest population is over the economic thresholds although alternative control measures are applied, the use of chemical control is fatal. In this case, pesticides should be appropriate for the IPM programs in terms of international criteria. In case of root-knot nematodes control, applications should be done before transplanting the seedlings into the greenhouse. Otherwise, it is applied through the transplantation or just right after this process.

CONCLUSION

Protected vegetable cultivation areas are mainly located in the Aegean and Mediterranean regions of Turkey. However IPM applications are not used in a widespread manner in all the greenhouses. To enhance IPM applications, the following suggestions should be considered in protected cultivation greenhouses in Turkey:

1. Most of the protected cultivation is conducted in the plastic cover type greenhouses that are not appropriate for airing and side heights. Such greenhouses cannot sufficiently prevent pests and diseases to enter and epidemics occur in high humid and temperatures. These factors should be taken into account in planning of new greenhouses.
2. IPM applications should be advertised through media to increase consumer demand. The producers and consumers should be trained about the side effects of overdose pesticide and fertilizer use on the environment and soil.
3. The farmers do not have a habit of recording the applications in greenhouses; hence they should be trained on this issue.
4. Legal arrangements and sanctions for pesticide sellers and farmers engaged in illicit practice should be determined by the Ministry.
5. A certificate should be given to IPM applied crops, and the price of such crops should be higher than those of conventionally produced. The certificates to the producers should be given by the Ministry or any other authorized agent.
6. IPM practicing farmers should also establish an association.
7. An upper committee on IPM theme established under the Ministry should be authorized to materialize the action plan.
8. Research data obtained at Universities and Research Institutes should be transferred to broadcasting and extension service staff, and information flow should be fastened.
9. As the part of inspecting issue of control department, samples have to be taken from IPM applied greenhouses as certain intervals to be analyzed and out coming results should be shared by public.

Broadcasting IPM is one of the main goals of agriculture in Turkey in order to protect the environment and human health. Thus, sustainable research and training activities for the growers and consumers supported by the Government are in progress.

ACKNOWLEDGEMENTS

The authors thank Dr. Jaime A. Teixeira da Silva for improvements to English grammar.

REFERENCES

*In Turkish

Akyazı R, Ecevit O (2009) The effectiveness of predator mite *Phytoseiulus persimilis* Athias-Henriot (Acarina: Phytoseiidae) for controlling important spider mite species *Tetranychus cinnabarinus* Boisduval (Acarina: Tetranychidae) in protected cucumbers in Samsun. *Anadolu Journal of Agricultural Sciences* **24 (3)**, 147-157*

Altinok H (2007) Induction of systemic resistance in eggplant against Fusarium wilt disease in polytunnel conditions. *Journal Turkish Phytopathology* **36 (1-3)**, 21-30

Arıcı E, Gümüş E, Özgönen H (2011) The effect of *Trichoderma harzianum* and *Glomus mosseae* on *Fusarium oxysporum* and *Rhizoctonia solani* on pepper. In: *Proceedings of the 4th Plant Protection Congress of Turkey*, 28-30 June, K. Maraş, Turkey p 485*

Aysan Y, Sarı N, Erkılıç A, Çınar Ö, Abak K (1995) Effect of soil solarization and resistant variety use on disease development and yield of tomato bacterial speck disease. In: *7th Turkish Phytopathology Congress*, 26-29 September, 1995, Adana, Turkey pp 418-422*

Baysal O, İkten H, Polat İ, Gümrükçü E, Ünlü A, Yiğit F (2009) Molecular diagnosis and race diversity of *Fusarium oxysporum* species in protected tomato cultivation fields in west mediterreanean region. In: *Proceedings of the 3rd Plant Protection Congress of Turkey*, 15-18 July, Van, Turkey, p 183*

Benlioglu S, Boz O, Yildiz A, Kaskavalci G, Benlioglu K (2005) Alternative soil solarization treatments for the control of soilborne diseases and weeds of strawberry in the western Anatolia of Turkey. *Journal of Phytopathology* **153**, 423-430

Bora T, Özaktan H (1998) *Biological Control of Plant Diseases*, Aegean University Press, İzmir, Turkey, 205 pp*

Bulut H (1995) IPM Programmes in Turkey. General Directorate for Agricultural Researches, 29 pp

Bulut E, Göçmen H (2000) Pest and their natural enemies on greenhouse vegetables in Antalya. *IOBC/WPRS Bulletin* **23 (1)**, 33-38

Çalışkan F, Kamberoğlu MA (2009) Identification of *Zucchini yellow mosaic virus* (ZYMV) isolates and search of possible using of plant activators in ZYMV control. *Proceedings of the 3rd Plant Protection Congress of Turkey*, 15-18 July, Van, Turkey, p 168*

Çelik N, Göçmen M (2009) Assignation of *Potato Y potyvirus* (PVY) strains and virus diseases facing in protected pepper cultivation in Antalya region. In: *Proceedings of the 3rd Plant Protection Congress of Turkey*, 15-18 July, Van, Turkey, p 253*

Çelik N, Güneş S, Özalp R, Çelik İ (2009) Assignation of resistant lines to *Tobacco mosaic tobamovirus* (TMV) and *potato Y potyvirus* in protected pepper cultivation. In: *Proceedings of the 3rd Plant Protection Congress of Turkey*, 15-18 July, Van, Turkey, p 254*

Civelek HS, Önder F (2002) Investigation on effect of nitrogenous fertilizers against biological stage and morphological characters of leaf miners (Diptera: Agromyzidae). *Derim Journal* **19 (1)**, 46-55*

Çınar Ö, Aysan Y (1995) Research on the effect of soil solarization on the survival of bacterial spot (*Xanthomonas campestris* pv *vesicatoria*) tomato and the using of antagonist for biological control. In: *7th Turkish Phytopathology Congress*, 26-29 September, 1995, Adana, Turkey, pp 423-428*

Delen N, Yıldız M, Kınay P, Yıldız F, Hantal M (2007) Susceptibily decrease, its importance and precaution measures of diesases against fungicides. *Congress and Exhibition Announcement of Agricultural Pesticides*, pp 223-234*

Devran Z, Sogut MA (2009) Distribution and identification of root-knot nematodes from Turkey. *Journal of Nematology* **41 (2)**, 128-133

Devran Z, Sogut MA, Mutlu N (2010) Response of tomato rootstocks with the Mi resistance gene to *Meloidogyne incognita* race 2 at different soil temperatures. *Phytopathologia Mediterranea* **49 (1)**, 11-17

Devran Z, Sogut MA (2011) Characterizing races of *Meloidogyne incognita, M. javanica* and *M. arenaria* in the West Mediterranean region of Turkey. *Crop Protection* **30**, 451-455

Durmuşoğlu E, Karsavuran Y, Kaya M (2009a) Efficiency of different hue yellow sticky traps to whitefly under greenhouse. *Turkish Journal of Entomology* **33 (1)**, 13-21*

Durmusoglu E, Salaman M, Civelek H S, Hatipoglu A, Balci H (2009b) Effect of various hues of yellow as sticky trap color on leafminers in cucumber growing greenhouses. *Turkish Journal of Entomology* **33 (3)**, 163-170*

Ekmekçi U, Yücel S, Yurtmen M, Karataş A, Özarslandan A, Aksoy E (2002) *Research, Practice and Education Project on Protected Vegetable Cultivation in the Eastern Mediterranean Region*, Progress Report, BK/96/04/08/101, 14 pp*

Erkilic A, Cinar O, Aysan Y (1994) Effects of soil solarization and chemical methods on bacterial speck (*Pseudomonas syringae* pv. *tomato*) on tomato. In: *9th Congress of the Mediterranean Phytopathological Union*, 18-24 September, Kuşadası, Aydın, Turkey, pp 397-399

Erler F, Can M, Erdogan M, Ates AO, Pradier T (2010) New record of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on greenhouse-grown tomato in Southwestern Turkey (Antalya). *Journal of Entomological Science* **45 (4)**, 392-393

Gamliel A, Stapleton JJ (1993) Effect of soil amendment with chicken compost or ammonium phosphate and solarization on pathogen control, rhizosphere microorganisms and lettuce growth. *Plant Disease* **77**, 886-891

İmriz G, Aysan Y, Çınar Ö (2011) Determination of survival of *Pseudomonas corrugata* and *Pseudomonas cichorii* in infested soil and plant debris and effect of soil solarization on these pathogens' populations. In: *Proceedings of the 4th Plant Protection Congress of Turkey*, 28-30 June, Kahramanmaraş, Turkey, p 333*

Katan J (1987) Soil solarization. In: Chet I (Ed) *Innovative Approaches to Plant Disease Control*, Wiley, New York, pp 77-105

Kazak C, Çölkesen T, Zaman K, Şekeroglu E (1992) Effect of predator mite, *Phytoseiulus persimilis* A.-H. (Acarina: Phytoseiidae), on *Tetranychus cinnabarinus* (Acarina: Tetranychidae) in greenhouse grown strawberry (*Fragaria vesca*). Turkey. In: *2nd Turkish Entomology Congress*, 28–31 January, Ankara, Turkey, pp 145-155*

Kazak C, Colkesen T, Karut K, Sekeroglu E (1997) Biological control of *Tetranychus cinnabarinus* by *Phytoseiulus persimilis* on greenhouse grown cucumber. *IOBC/WPRS Bulletin* **20 (4)**, 215-220

Kazak C, Karut K, Sekeroglu E (2000) The population dynamics and predation of Hatay strain of *Phytoseiulus persimilis* (Athias-Henriot) (Acari: Phytoseiidae) on the prey *Tetranychus cinnabarinus* Boisduval (Acari: Tetranychidae); effects of different initial prey and predator ratios on greenhouse cucumbers. *IOBC/WPRS Bulletin* **23 (1)**, 195-200

Kazak C, Karut K,Chu Ch, Arslan A (2009) *Frankliniella occidentalis* capture on blue and yellow sticky traps treated with floral compound mixture thrips attractant (Thrips-Lure) in greenhouses. Integrated control in protected crops, Mediterranean climate. *IOBC/WPRS Bulletin* **49**, 167-170

Keçeci M (2010) Tomato leaf miner [*Tuta absoluta* (Meyrick) (Lepidoptera Gelechiidae)]. *Voice of Agriculture Journal* **26**, 9-12*

Keçeci M (2005) Using possibilities of polyphag predator, *Orius* spp. (Hemiptera: Anthocoridae) against greenhouse vegetable pests. Ankara University. Graduate School of Natural and Applied Sciences, Department of Plant Protection, PhD thesis 99 pp*

Keçeci M, Ceylan S, Kahveci L, Ülker Y, Topakcı N (2007) Investigation on harmful species on protected pepper cultivation and their population density in Antalya Province. In: *Proceedings of the 2nd Plant Protection Congress of Turkey*, 27-29 August, Isparta, Turkey, p 216*

Keçeci M, Tepe S, Tekşam İ (2008) Research on population development of leaf miner [*Liriomyza trifolii* (Burgess)] that is a pest of tomato and bean grown under protected condition in Antalya province, and its parasitoids. *Derim Journal* **25 (2)**, 13-23*

Kilic T (2010) First record of *Tuta absoluta* in Turkey. *Phytoparasitica* **38 (3)**, 243

Kutuk H, Yigit A (2011) Pre-establishment of *Amblyseius swirskii* (Athias-Henriot) (Acari: Phytoseiidae) using *Pinus brutia* (Ten.) (Pinales: Pinaceae) pollen for thrips (Thysanoptera: Thripidae) control in greenhouse peppers. *International Journal of Acarology* **37 (1)**, 95-101

Mennan S, Ecevit O (2001) Race determination on some populations of *Meloidogyne incognita* (Kofoid & White, 1991) (Nemata: Heteroderidae) obtained from Bafra and Çarsamba plains (Turkey). *Turkish Journal of Entomology* **25**, 33-39

Ozarslandan A, Elekcioglu IH (2010) Identification of the root-knot nematode species (*Meloidogyne* spp.) (Nemata: Meloidogynidae) collected from different parts of Turkey by moleculer and morphological methods *Turkish Journal of Entomology* **34 (3)**, 323-335

Özdemir S (2009) Identification of viruses in greenhouse-grown tomato production in Mugla province and determination present condition of ToRSV on seeds. *Proceedings of the 3th Plant Protection Congress of Turkey,*15-18 July, Van, Turkey p 220*

Sahin F, Kotan R, Demirci E, Miller SA (2000) Effects of Actigard and antagonists in biological control of bacterial spot disease on tomato and pepper. *Atatürk University Journal of the Agricultural Faculty* **31 (1)**, 11-16

Saygılı H, Şahin F, Aysan Y (2008) *Bacterial Plant Diseases*, Meta Press, İzmir, 317 pp*

Soylu S, Baysal O, Soylu EM (2003a) Induction of diseases resistance by the plant activator acibenzolar-S-methyl (ASM), against bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*) in tomato seedlings. *Plant Science* **165**, 1069-1075

Soylu EM, Soylu S, Baysal O (2003b) Induction of diseases resistance and antioxidant enzymes by acibenzolar-S-methyl bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*) in tomato. *Journal of Plant Pathology* **85 (3)**, 175-181

Soylu EM, Kurt S, Soylu S (2010) *In vitro* and *in vivo* antifungal activities of the essential oils of various plants against tomato grey mould disease agent *Botrytis cinerea*. *International Journal of Food Microbiology* **143**, 183-189

Sogut MA, Elekcioglu IH (2000) Determination of *Meloidogyne* spp. Goeldi, 1892 (Nemata: Heteroderidae) species races found in vegetable growing areas of the Mediterranean region of Turkey. *Turkish Journal of Entomology* **24**, 33-40

Sogut MA, Elekcioglu IH (2007) Methyl bromide alternatives for controlling *Meloidogyne incognita* in pepper cultivars in the Eastern Mediterranean region of Turkey. *Turkish Journal of Agriculture and Forestry* **31**, 31-40

Tokgönül S (1995) Bacterial diseases of tomato plants grow in greenhouses in the Mediterranean region of Turkey. In: *7th Turkish Phytopathology Congress*, 26-29 September, 1995, Adana, Turkey, pp 402-406*

Tok FM, Kurt S (2009) Isolation and identification of *Fusarium oxysporum* f.sp. *radicis-cucumerinum* from greenhouse cucumber growing areas of Mediterranean region. In: *Proceedings of the 3rd Plant Protection Congress of Turkey*, 15-18 July, Van, Turkey, p 186

TÜİK (2010) Turkish Statistical Institute, Ankara. Available online: www.tuik.gov.tr

Tüzel Y, Öztekin GB, Karaman İ (2010) Producer feature of the modern and conventional greenhouse enterprises of Serik district. *Agean University Agriculture Faculty Journal* **47 (3)**, 223-230*

Ulubilir A, Yabaş C (1996) Determination of detrimental and useful fauna of vegetables grown under protected conditions in the Mediterranean region. *Turkish Journal of Entomology* **20 (3)**, 217-228*

Ulubilir A, Yabaş C, Yiğit A (1996) Effect of yellow sticky trap and mass tarp on control of leaf miner, *Liriomyza trifolii* Burgess (Diptera: Agromyzidae), a pest of vegetables grown uder protected conditions. *Plant Protection Bulletin* **36 (3-4)**, 143-150*

Ulubilir A, Sekeroglu E (1997) Biological control of *Liriomyza trifolii* by *Diglyphus isaea* on unheated greenhouse tomatoes in Adana, Turkey. *Bulletin OILB/SROP* **20 (4)**, 232-235

Yasarakinci N, Hincal P (1999) The development of pest populations and their beneficials over different growing periods in tomato greenhouses in the Aegean Region of Turkey. *Acta Horticulturae (ISHS)* **491**, 469-474

Yasarakinci N (2009) *A Chronicle of IPM in Turkey*, IPMnet NEWS October/ November 174

Yaşarakıncı N, Hıncal P, Öz S, Filiz N, Çınarlı İ, Ertekin N, Demir G, Fidan Ü, Taşdelen P, Tokaç A, Saltabaş M (1996) Integrated Pest Management applications of tomatoes grown under protected conditions in the Aegean region of Turkey. In: *3rd Turkish Entomology Congress*, 24-28 September, Ankara, Turkey pp 98-108*

Yaşarakıncı N, Hıncal P (1997) The research on determining the pests and their beneficial insects, their population densities on the tomato, cucumber, pepper, and lettuce glasshouses in İzmir. *Plant Protection Bulletin* **37 (1-2)**, 79-89*

Yaşarakıncı N, Hıncal P (2001) Studies on population development of *Macrolophus caliginosus* (Wagner) (Heteroptera; Miridae) and its preys found in vegetables grown under protected conditions in Izmir province. In: *6th National Greenhouse Congress*, 3-5 September, Fethiye-Muğla, Turkey, pp 167-172*

Yıldız HN, Çınar Ö (2011) Effect of soil solarization on *Pseudomonas viridiflava* tomato pith necrosis agent. In: *Proceedings of the 4th Plant Protection Congress of Turkey*, 28-30 June, Kahramanmaraş, Turkey, p 330*

Yılmaz S, Ünlü M, Göçmen M, Mutlu K, Aydınsakir F, Fırat M, Kuzgun MA, Celikyurt B, Celik S (2007) Phase out of methyl bromide for soil fumigation in protected horticulture and cut flower production in Turkey. *Final Report*, Antalya, Turkey, Kutlu Avcı Ofset, 155 pp*

Yılmaz MA, Baloğlu S, Özaslan M (1998) *Plant Virus Diseases*, Lecture Notes, Cukurova University Agriculture Faculty, C-128 pp*

Yilmaz MA, Davis RF (1985) Identification of viruses infecting vegetable crops along Mediterranean sea coast in Turkey *The Journal of Turkish Phytopathology* **14 (1)**, 1-8

Yiğit F, Dikilitaş M (2007) Status of integrated pest management and their possible application in greenhouses in Fethiye District. In: *Proceedings of the 2nd Plant Protection Congress of Turkey*, 27-29 August, Isparta, p 333*

Yoldaş Z (1995) Research on efficiency of *Encarsia formosa* (Gahan) (Hymenoptera, Aphelinidae) on *Bemisia tabaci* Genn. (Homoptera, Aleyrodidae), a pest of cucumbers grown under protected conditions. *Turkish Journal of Entomology* **19 (2)**, 95-100*

Yorganci U, Erkan S, Ozaktan H, Eser B (1994) Detection of agents of viral and bacterial diseases in seeds of pepper, tomato, eggplant, cucumber and their inactivation ways. In: *9th Congress of the Mediterranean Phytopathological Union*, Kusadasi-Aydin, Turkey, pp 37-39

Yucel S (1995) A study on soil solarization and combined with fumigant application to control of Phytophthora Crown Blight (*Phytophthora capsici* Leonian) on peppers in the East Mediterranean region of Turkey. *Crop Protection* **14 (8)**, 653-655

Yucel S, Elekcioglu IH, Can C, Sogut MA, Ozarslandan A (2007a) Alternative treatments to methyl bromide in the Eastern Mediterranean region of Turkey. *Turkish Journal of Agriculture and Forestry* **31 (1)**, 47-53

Yucel S, Ozarslandan A, Colak A, Ay T, Can C (2007b) Effect of solarization and fumigant applications on soilborne pathogens and root-knot nematodes in greenhouse grown tomato in Turkey. *Phytoparasitica* **35 (5)**, 450-456

Yucel S, Can C, Yurtmen M, Cetinkaya-Yildiz R, Aysan Y (2008) Tomato pathology in Turkey. *The European Journal of Plant Science and Biotechnology* **2 (1)**, 38-47

Yurtmen M, Guldur ME, Yilmaz MA (1999) Tomato spotted wilt virus in Icel province of Turkey. *Petria* **9**, 343-344

Yücel S, Çınar A (1989) Studies on the effect of soil antagonists and application of soil solarization against to Fusarium wilt disease (*Fusarium oxysporum* Schleht. f.sp. *lycopersici* (Sacc.) Snyd. and Hans.) of tomatoes. *Turkish Journal of Agriculture and Forestry* **13**, 1372-1393*

Yücel S (1994) Survey studies on fungal diseases of covered vegetable areas in Mediterranean region. *Plant Protection Bulletin* **34 (1-2)**, 23-34*

Yücel S, Ulubilir A, Yaşarakıncı N, Keçeci M, Ekmekçi U, Demir G, Altın A, Fidan Ü, Tokgönül S, Uçkan A, Üstün N, Çalı S, Ulutaş E, Mısırlıoğlu B, Yurtmen M, Uludağ A, Ülke G, Aksoy E (2002) *Integrated Pest Management Directions for Protected Vegetable Production*, Agricultural Research General Directorate, Plant Protection Office, Ankara, 141 pp*

Yücel S, Ay T, Çolak A (2008) Effect of *Trichoderma harzianum* rifai KRL AG2 to control root rot disease (*Rhizoctonia solani*, *Fusarium solani*) of cucumber in protected crops. *Plant Protection Bulletin* **48 (2)**, 41-47*

Yücel S, Keçeci M, Ünlü A, Kılıç T, Aşkın A, Erdoğan P, Ozan S, Ekmekçi U, Öğüt E, Özdemir S, Aydın H, Yurtmen M, Üstün N, Devran Z, Karataş A, Mısırlıoğlu B, Karahan A, Toktay H,Velioğlu S, Kütük H, Erdoğan C, Aksoy E, Caner Ö, Duran H (2011) *Integrated Pest Management Directions for Protected Vegetable Production*, Agricultural Research General Directorate, Plant Protection Office, Ankara, 163 pp*