African Journal of Biotechnology Vol. 9(6), pp. 834-841, 8 February, 2010
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB09.1625
ISSN 1684–5315 © 2010 Academic Journals

Full Length Research Paper

Investigations on pests, diseases and present early warning system of apple orchards in Isparta, Turkey

Gürsel Karaca, Ismail Karaca, Nejla Yardimci*, Ozan Demirözer, Baran Aslan and Handan Çulal Kiliç

Department of Plant Protection, Faculty of Agriculture, Süleyman Demirel University, 32260, Isparta/Turkey.

Accepted 18 January, 2010

As a result of three year surveys performed in the apple orchards in Isparta region, 19 pest species belonging to 4 orders were determined and it was found that the main pest was codling moth. Most of the predators and parasitoids were effective against aphids and they were mostly found in the orchards where selective pesticides were used. Apple scab and powdery mildew were the most common and important diseases. Biology of codling moth and apple scab in the region were investigated. By using the obtained data, proper application times were given and some recommendations regarding integrated pest management program in apple orchards, were summarized.

Key words: *Malus domestica*, pests, diseases, IPM.

INTRODUCTION

China, Russian Republic, Poland, United States and Turkey are the primary countries having extensive apple production areas. Turkey comes third in terms of apple production with 4.38% of the total production of the world (Anonymous, 2002a). Apples can be grown in almost all parts of the country and apple production constitutes 7% of total fruit areas and 19% of total fruit production. One-fifth (21.13%) of the total apple production of Türkiye is supplied from Isparta province (Anonymous, 2002b). Most of the apple orchards continue conventional production with older cultivars, however, number of orchards having dwarfing or semi-dwarfing rootstocks and new popular cultivars recently increase in the province.

As for all agricultural crops, plant protection problems such as pests and diseases are the major factors decreasing apple production. Codling moth, mites, aphids, scale insects, leafrollers, leafminers, jewel beetles and bark beetles are the main pests and apple scab, powdery mildew, cedar apple rust, brown rot, fire blight, collar rot and apple mosaic virus are the main diseases of apple trees (Blommers, 1994; Anonymous, 1999a). These pests and diseases, mainly codling moth and apple scab, cause economical losses in some orchards in Isparta region, time to time, according to the location, rootstock, cultivar and cultural practices. Chemical control is the primary method in use to suppress apple pests and diseases, due to its easy application and rapid effect. However, it is known that populations of beneficial organisms decrease and some insects and disease agents develop resistance against some pesticides as a result of improper and excessive applications (Jones, 1981). Recently, with the terms “organic agriculture”, “ecological agriculture” and “sustainable agriculture”, side effects of chemical control on human health and environment have taken more attention and integrated pest management (IPM), gained importance.

IPM studies started at the 70’s in Turkey and still continue for different crops (Zeki, 1998; Anonymous, 1999b, 2000; Uygun, 2001). Much of the work was on early warning system against codling moth and apple scab (Yürüt et al., 1988; Demir and Hepdurgun, 1988; Çevik and Kilinçer, 1999). In Isparta province, Plant Protection Bureau of the Ministry of Agriculture and Rural Affairs have studied this subject since 1996 (Atlamaz et al., 2007) and more than 20 portable electronic early warning devices were settled in different locations in the province. However, apple growers pronounce that they could not trust the system and apply fungicides more often.

The aims of the present research were to determine the

*Corresponding author. E-mail: nejyard@ziraat.sdu.edu.tr. Fax: + 90 246 237 16 93.

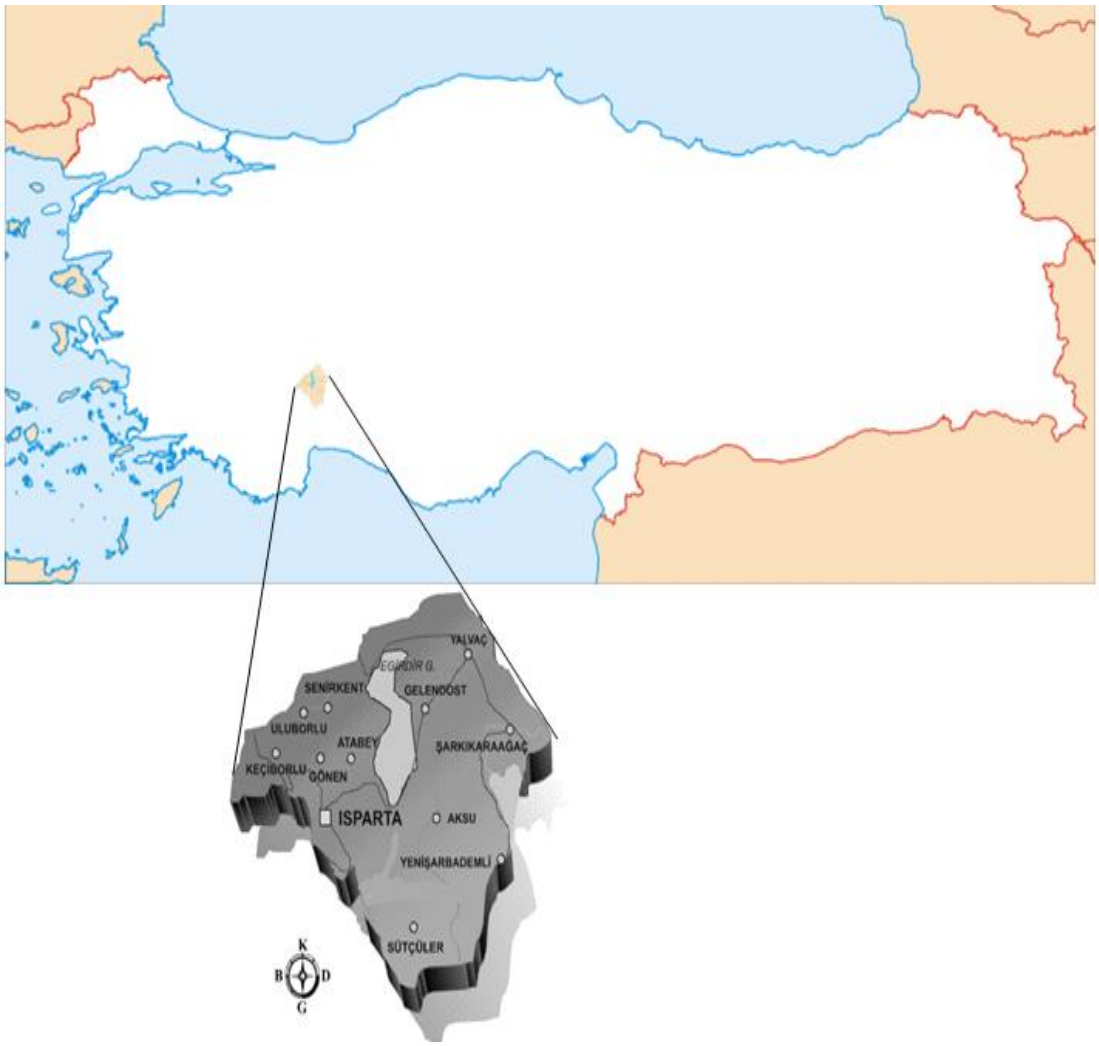

Figure 1. Map of Isparta province (Turkey).

present conditions of the apple orchards in Isparta region in terms of diseases, pests and beneficial insects; to investigate the biology of codling moth and apple scab and to evaluate the suitability of the early warning system presently used in the province.

MATERIALS AND METHODS

Survey studies

Surveys were performed in apple orchards selected randomly in different locations of the province during vegetation periods of 2001 - 2004 years and samples were taken (Figure 1). Pests, disease agents and natural enemies were determined. Biology of codling moth (*Cydia pomonella* L.) and that of apple scab (*Venturia inaequalis* (Cke.) Wint.) were investigated in selected orchards. Climatic conditions and phenology of apple trees were noted.

Randomly selected 50 trees from each orchard were examined in order to determine the pests and diseases. For sessile pests; leaves, twigs and fruits were sampled. Samples were brought to the laboratory and all pests on the whole surface of the tissue substrate were investigated under a stereomicroscope. Mobile pests and predators were sampled by the Steiner (1962) method. A collecting bag was held under a branch and the branch was struck strongly three times. To determine the diseases; roots, trunks, shoots, leaves and fruits of the randomly selected trees were examined for disease symptoms. Diseases which could be readily identified were noted. For others, plant parts showing typical disease symptoms were brought to the laboratory for identification. Plant samples showing virus and virus like symptoms were separately put in polyethylene bags, brought to the laboratory in ice boxes and kept at - 20°C.

Identification of the pests and disease agents

Samples of plants seemed to be damaged were examined in the laboratory. The damage type and pest causing the damage was then identified. Arthropods in pre-adult period were transferred to culture boxes and identified after becoming adults. Plant samples were kept under laboratory conditions and checked daily and emerging adults and natural enemies were determined. Adult samples were included to the collection and kept in EMIT (Entomological Museum of Isparta, Türkiye). Coccinellid predators

Table 1. Pests found in the apple orchards in Isparta province.

Orders	Pest species	Common name
Acarina	*Tetranychus urticae*	Twospottedspider mite
	Panonychus ulmi	European red mite
Coleoptera	*Scolytus mali*	Larger shothole borer
	Capnodis sp.	Flat-headed borer
Homoptera	*Aphis pomi*	Green apple aphid
	Dysaphis plantaginea	Rosy apple aphid
	Dysaphis devecta	Rosy leaf-curling aphid
	Eriosoma lanigerum	Woolly apple aphid
	Parthenolecanium corni	European Fruit Lecanium
	Eulecanium tiliae	
	Quadraspidiotus perniciosus	San jose scale
	Lepidosaphes ulmi	Oystershell Scale
Lepidoptera	*Cydia pomonella*	Codling moth
	Archips rosana	Rose Tortrix
	Phyllonorycter gerasimowi	
	Euproctis chrysorrhoea	Browntail moth
	Leucoptera scitella	pear leaf blister moth
	Stigmella malella	Apple Pygmy
	Yponomeuta melinellus	Apple Ermine

were identified by Prof. Dr. Nedim Uygun (Çukurova University, Faculty of Agriculture, Plant Protection Department, Adana) and parasitoids by Assoc. Prof. Dr. George Japoshvili (Süleyman Demirel University, Faculty of Agriculture, Plant Protection Department, Isparta).

Diseases were identified according to the symptoms on the plants. For the symptoms that could not be identified, diseased plant samples were cut into small pieces and incubated on WA (Water agar) and PDA (Potato dextrose agar) plates after surface sterilization with 1% NaOCl for a few minutes. Fungal or bacterial agents were transferred to new plates for identification after 4 - 5 days incubation at 22 - 25°C. Identifications were made according to the cultural and morphological characteristics of the agents (Barnett and Hunter, 1998; Schaad, 1980). DAS-ELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) test was applied to all samples showing virus or virus-like symptoms (Clark and Adams, 1977) and identification kits of Agdia Company (Elkhart, USA) were used. Absorbance values of alkaline phosphatase were measured at 405 nm with a microplate reader (EL X 800 Universal Microplate, Bio-Tek Instruments, Inc.B-2610 Wilrijk, Belgium). Samples with absorbance values exceeding 2.0 after subtraction of the background were considered to be positive (Stellmach, 1985). DAS-ELISA positive samples were later inoculated onto herbaceous test plants.

Determination of the biology of codling moth and apple scab

Biology and seasonal development of codling moth and apple scab were investigated in two orchards, one in Eğirdir and the other in Central district. Surveys were performed weekly in spring, summer and autumn and monthly in winter. Pheromone traps were placed in the orchards and trap bands were wrapped around the trunks of apple trees, before adults of codling moth emerged. Traps and 100 apple fruits in every orchard were controlled every week for codling moth adults and eggs.

Leaves and fruits that fell to the ground in autumn were gathered and kept in wire cages in two orchards. In spring, a few microscopic slides with vaseline were hung over the cages and also to trees. Slides were controlled under microscope every week. First release of spores causing primary infections and the end of spore period were determined. Meteorological data were obtained both by the electronic early warning devices settled by the Plant Protection Bureau of the Ministry of Agriculture and Rural Affairs (recording data per 12 min) and by electronic meteorological data recorder settled by us (recording data per hour).

RESULTS AND DISCUSSION

With this research, pests and disease agents affecting quality and quantity of apple crop in Isparta region and their natural enemies were determined.

Pests of apples grown in Isparta region

As a result of surveys performed between 2001 - 2004, 19 pest species belonging to 4 orders were determined (Table 1). Among these codling moth, mites were observed in all orchards examined. Apple leaf roller, San jose scale and leaf miners were pests frequently found in some locations. Apple ermine moth, aphids and coccids were rarely observed in some orchards but reach economical threshold time to time. *Scolytus mali* and *Capnodis*

Table 2. Predator and parasite species found in apple orchards in Isparta province and their hosts.

Host insect	Predator	Parasite
Lepidosaphes ulmi	*Rhyzobius lophantae*	*Aphis prochlia*
Eulecanium tiliae	*Exocomus quadripustulatus*	-
Aphis pomi	*Coccinella septempunctata* *Adalia bipunctata*	*Lipolexis grail's* *Pachyneuron aphidis*
Dysaphis plantaginea	*Coccinella septempunctata* *Harmonia quadripunctata* *Episyphus balteatus* *Scaeva albomaculata* *Forficula auricularia*	*Aphidius matricariae* *Ephedrus persicae*
Dysaphis devecta	*Adalia bipunctata* *Adalia decempunctata* *Adalia fasciatopunctata* *Harmonia quadripunctata* *Propylae quatuordecimpunctata* *Scymnus bivulnerus* *Metasyrphus corollae*	*Aphidius matricariae* *Ephedrus persicae* *Ephedrus* sp.
Eriosoma lanigerum	-	*Aphelinus mali*

species were mostly found in old and neglected orchards.

Diseases of apples grown in Isparta region

It was determined that the most common and important disease in apple orchards in Isparta province was apple scab and that it could cause significant losses if it was not controlled. In the first year of the study, it was found that the disease rate was very high (72% on leaves, 100% on fruits) in an orchard in Eğirdir district, with susceptible Red delicious cultivar, where no pesticide application was performed. All fruits were small and distorted and had scab lesions. This showed that chemical control is inevitable especially in orchards with susceptible cultivars.

Powdery mildew, damaging young shoots at the beginning of the growing period, was also determined in all survey areas. Most of the commonly grown cultivars (red delicious and golden delicious) were susceptible to the disease. Cedar-apple rust and brown rot were seldom observed. Root and collar rot disease caused by *Phytophthora* species was found on young trees with susceptible MM106 rootstock, in a few orchards with high soil water level. Fire blight disease is common on pear trees, but it was also found on some susceptible apple trees (Granny Smith, Gala) in Eğirdir district. *Agrobacterium tumefaciens*, the agent of crown gall disease was isolated from a sample sent from a nursery in Atabey district.

During surveys, virus symptoms such as severe chlorosis, curling and mosaic on leaves of especially Golden and Granny Smith cultivars in some orchards from different districts were observed. A total of 138 samples taken from those trees were serologically tested by DAS-ELISA and it was determined that 41 of them were infected with apple mosaic virus (ApMV).

Natural enemies at the apple orchards in Isparta region

Most of the predators were Coccinellidae individuals and they were effective on aphids. In addition to predators, 7 parasitoid species belonging to 3 families were determined (Table 2). Most of these were also effective on *Dysaphis* and *Aphis* species. Predators and parasitoids were mostly found in the orchards where selective pesticides were used.

Biologies of codling moth and apple scab in Isparta region

Previous observations gave the opinion that there was a problem in pesticide application periods. For this reason, climatic data and the biology of codling moth and apple scab were determined. Moth numbers and pesticide application warnings, according to the computer based forecasting and warning system used by the government and proper dates found in the study were shown on the graphics (Figures 2 - 4). Moth flight started on 13th, 12th and 14th of May in 2002, 2003 and 2004, respectively. Warnings made by the government were on 31st of May, 18th of June and 8th of July in 2002, 28th of May, 16th of June, 9th of July and 3rd of August in 2003 and 6th of June, 25th of June, 18th of July and 7th of August in 2004.

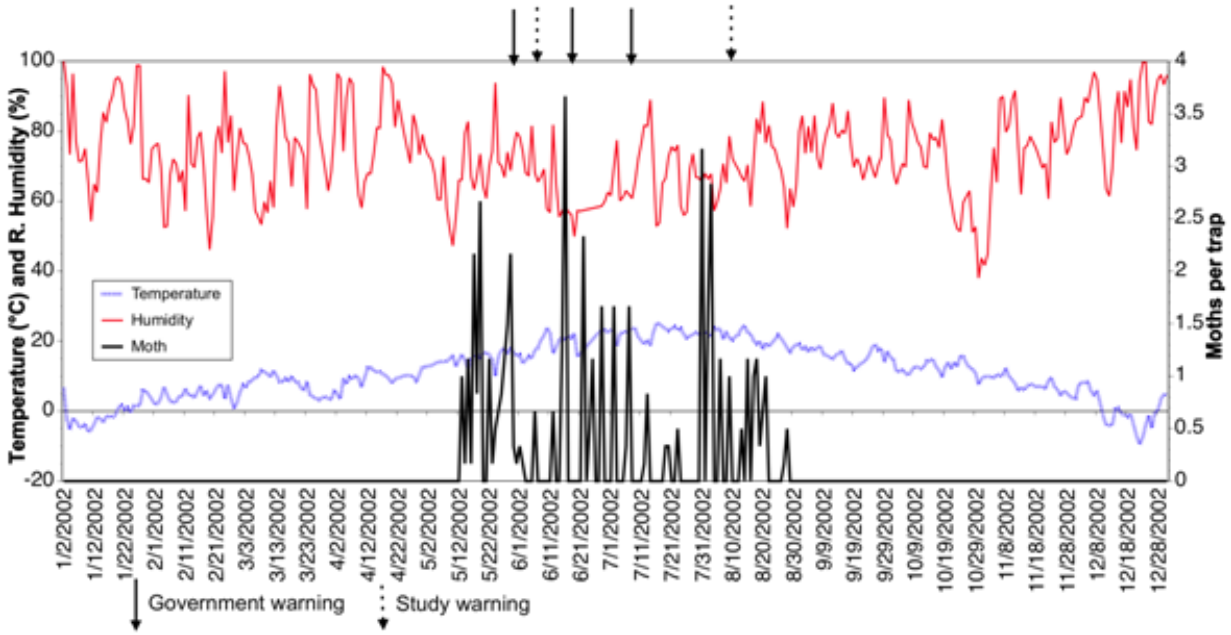

Figure 2. Temperature, relative humidity and population dynamics of codling moth in 2002.

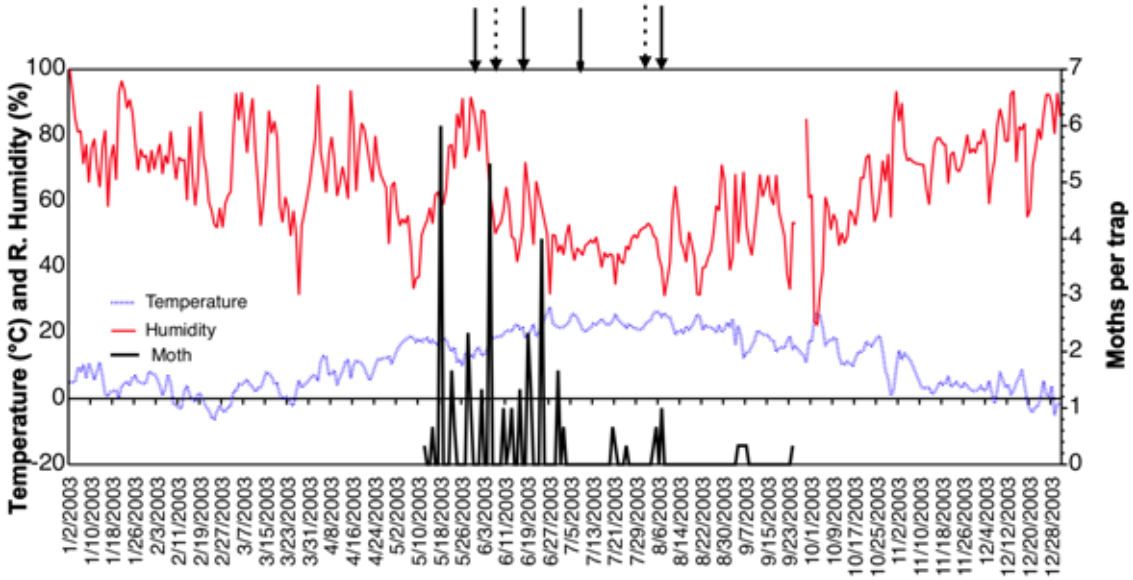

Figure 3. Temperature, relative humidity and population dynamics of codling moth in 2003.

Proper application dates obtained by this study were 8th of June and 11th of August in 2002, 8th of June and 31st of July in 2003 and 9th of June, 1st of July and 9th of August in 2004. Number and dates of applications were different from each other, since warnings made by the government were based on the simulation model prepared according to the relation of the biology of the pest in another country (Germany) and meteorological data, while moth flight dates in the region were taken into account in this study.

Similarly, meteorological data, spore release and warnings made by the government for apple scab were evaluated together. Biology of apple scab and warnings made by the government for the disease were shown together for 3 years (Table 3). It was determined that ascospore release which cause primary infections of scab started at the beginning of April and lasted 4 - 7 weeks according to the climate. Spore discharge stop in rainy and cold days and continue again in warmer period. If leaves emerge and they are exposed to release ascospores, primary infections initiate. Sometimes phenology

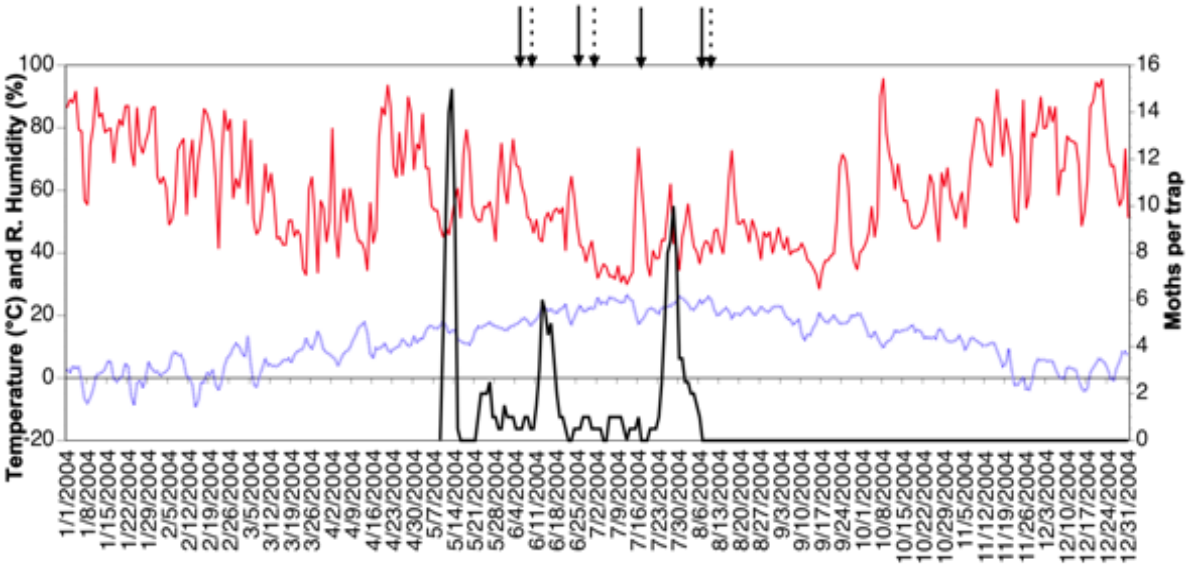

Figure 4. Temperature, relative humidity and population dynamics of codling moth in 2004.

Table 3. Fungicide application warnings made by the government against apple scab and biology of the disease in 2001 - 2003.

Dates	Warnings	Biology of apple scab
2001		
March 23rd	1. warning	
March 30th	2. warning	
April 3-9th		Start of ascospore release
April 12th	3. warning	
April 24th		End of ascospore release
May 1st		First scab lesions on the leaves, formation of conidia
May 7th	4. warning	
May 15th	5. warning	
2002		
March 14th	1. warning	
March 22nd	2. warning	
April 6th	3. warning	
April 7-14th		Start of ascospore release
April 17th	4. warning	
May 2nd	5. warning	
May 5th		End of ascospore release, first scab lesions on the leaves, formation of conidia
May 14th	6. warning	
May 24th	7. warning	
May 31st	8. warning	
2003		
April 3rd	1. warning	Start of ascospore release
April 19th	2. warning	
April 29th	3. warning	
May 3rd	4. warning	
May 22nd		First scab lesions on the leaves, formation of conidia
May 29th		End of ascospore release
June 2nd	5. warning	

of the apple trees does not fit spore development. For example, in 2003, ascospore discharge started on 3rd of April in the research area, but bud break occurred on 17th of April and leaves became ready for infection on 28th of April. So, infections likely took place between April 22nd and 28th, probably on 26th of April after the rainy period during April 23rd and 25th. Thus, first scab lesions were observed on 22nd of May in this orchard. As it is known that lesions became visible within 9 - 17 days after infection depending on the temperature, infections should not occur in this orchard before 5th of May (Jones and Aldwinckle, 1991). Similarly, first lesions were observed on 1st of May in 2001 and 5th of May in 2002, so infections should occur at the beginning of April. It was already determined that ascospore discharge started on 3rd of April in 2001 and 7th of April in 2002. According to the computer based forecasting and warning system used by the government, first warning against scab was on 23rd of March and the second one was on 30th of March in 2001. It is obvious that the first warning was unnecessary because ascospore discharge had not started yet in the research area. Since ascospore discharge started on 7th of April and first lesions were observed on 5th of May in 2002, first and second announces for fungicide applications on 14th and 22nd of March were again unnecessary. First fungicide application should better be made with the third announce of early warning system which was on 6th of April. Ascospore discharge and warning announce coincided in 2003, but first two announces were again unnecessary because apple trees in the research area were not suitable for infection because their leaves did not emerged. National forecasting and warning system used for apple scab based on Mills criteria related with temperature, relative humidity and wetting period. However, it was determined that the amount of rain or dew necessary to wet the leaves on the ground and photoperiod was very important for the pseudothecia to become mature and discharge ascospores, while the wetness of the leaves on the trees was important only for ascospore germination and infection (O'Leary and Sutton, 1986; Aylor and Sutton, 1992; Rossi et al., 2003). In consequence, warnings made by the government are very useful for seconder infections, but fungicide applications done only according to the warnings may be unnecessary for some orchards. Variations on the phenology depending on the location and cultivar should be taken into consideration and spore flight should better be observed by using slides with vaseline at least for each orchard representing different locations and cultivars. If prophylactic fungicide applications against primary infections are made on time, amount of inoculum needed for secondary infections will be less and number of fungicide applications will also be less and maybe there will be no need for further applications especially in the orchards with resistant cultivars.

It was clearly observed in this study that resistance was very important regarding apple diseases. In the research orchard, rate of fruits with scab lesions was 73% on a susceptible cultivar (red delicious), while that of resistant cultivar (Granny Smith) was 12% in 2003. A typical example about the same subject is that *Phytophthora* collar rot disease existed as a problem only in the orchards with MM-106 rootstocks. Thus, rootstock and cultivar selection should be made with great care in new orchards (Anonymous, 1999a; Biggs and Ellis, 2008).

Effects of cultural applications in orchards against diseases are also very important. It is known that primary infections of apple scab was caused by ascospores formed in the pseudothecia on the leaves fallen to the ground in the previous year. So, there is a correlation between the number of infected leaves and pseudothecia on them and the rate of primary infections (Gadoury and MacHardy, 1986; Fiaccadori, 1993). If the infected leaves were plowed under soil, amount of primary inoculum will be diminished. In one of the research orchards, a similar application done by the grower decreased the rate of fruit spots to 16% in 2003. In some countries, urea applications immediately before or after leaf drop were recommended. This application causes an increase in epiphytic fungi and bacteria on the leaves and thus decreases the number of pseudothecia (Biggs and Ellis, 2008).

Conclusion

It is known that the number of pesticide applications decreased after the use of early warning system (Atlamaz et al., 2007). However, as a result of this study, it was found that early warning model prepared in another country and using only meteorological data was not efficient for all orchards in our region. Especially at the beginning, these meteorological data should be used in connection with the biology of the key pest and disease agent. After long term investigations on the biology of the pests, disease agents and meteorological data, simulation models may be prepared and used in early warning systems. Spore release periods for diseases and emergence of adult individuals for pests, phenology of the trees and meteorological conditions in the location should be taken into consideration for pesticide applications.

REFERENCES

Anonymous (1999a). Integrated Pest Management for Apples and Pears. Second Edition. University of California, Agriculture and Natural Resources Publication: 3340, California, USA.

Anonymous (1999b). Bağ Entegre Mücadele Teknik Talimati. T.C. Tarim ve Köyişleri Bakanliği, Tarimsal Araştirmalar Genel Müdürlüğü, Ankara.

Anonymous (2000). Patates Entegre Mücadele Teknik Talimati. T.C. Tarim ve Köyişleri Bakanliği, Tarimsal Araştirmalar Genel Müdürlüğü, Ankara.

Anonymous (2002a). FAO Production Yearbook 2002. FAO, Rome, Italy.

Anonymous (2002b). Tarimsal Yapi ve Üretim 2002, DİE Yayinlari,

Ankara.
Atlamaz A, Zeki C, Uludağ A (2007). The importance of forecasting and warning systems in implementation of integrated pest management in apple orchards in Turkey. OEPP/EPPO Bulletin, 37: 295-299.
Aylor DE, Sutton TB (1992). Release of *Venturia inaeaualis* ascospores during unsteady rain: Relationship to spore transport and deposition. Phytopathology, 82: 532-540.
Barnett HL, Hunter BB (1998). Illustrated Genera of Imperfect Fungi. Fourth Edition. APS Press, Inc., St. Paul, Minnesota, p. 218.
Biggs AR, Ellis MA (2008). http://www.caf.wvu.edu/Kearneyville/ organic-apple.html (December, 2008)
Blommers LHM (1994). Integrated pest management in European apple orchards. Ann. Rev. Entomol. 39: 213-241.
Clark MF, Adams AN (1977). Characteristic of microplate method of enzyme linked immunosorbent assay for the detection of plant viruses. J. Gen. Virol. 34: 475-483.
Çevik T, Kilinçer N (1999). Elma içkurdu (Cydia pomonella L.)'nun biyolojik ve biyoteknik savaşiminda Euro-Bugoff modelinin kullanilmasi. Türkiye 4. Biyolojik Mücadele Kongresi. Bildiriler: 285-294. 26-29 Ocak 1999, Adana.
Demir ST, Hepdurgun B (1988). Elma Karalekesi (*Venturia inaequalis* (Cke.) Wint.) savaşiminda tahmin ve uyari sisteminin uygulanmasi. V. Türkiye Fitopatoloji Kongresi. Bildiri Özetleri: 117. 18-21 Ekim 1988, Antalya.
Fiaccadori R (1993). Quantification of inoculum potential in Venturia inaequalis control. Acta Hort. 347: 133-142.
Gadoury DM, MacHardy WE (1986). Forecasting ascospore dose of *Venturia inaequalis* in commercial apple orchards. Phytopathology, 76: 112-118.
Jones AL (1981). Fungicide resistance: Past experience with benomyl and dodine and future concerns with sterol inhibitors. Plant Dis. 65: 990-992.
Jones AL, Aldwinckle HS (eds.) (1991). Compendium of Apple and Pear Diseases. APS Press, St. Paul, Minnesota.
O'Leary AL, Sutton TB (1986). The influence of temperature and moisture on the quantitative production of pseudothecia of *Venturia inaeaualis*. Phytopathology, 76: 199-204.
Rossi V, Giosue S, Bugiani R (2003). Influence of air temperature on the release of ascospores of *Venturia inaequalis*. J. Phytopathol. 151: 50-58.
Schaad NW (ed.) (1980). Laboratory Guide for Identification of Plant Pathogenic Bacteria. APS Press, Inc., St. Paul, Minnesota.
Steiner H (1962). Metoden Zur Untersuchungedes Population Dynamik in Obstanlagen. Entomophaga, 7(3): 207-214.
Stellmach G (1985). Elisa testing of grapevine rootings reared from nepovirus-infected mother plants forced to rapid growth. Phytopathol. Med. 24: 123-124.
Uygun N (ed.) (2001). Türkiye Turunçgil Bahçelerinde Entegre Mücadele. TARP Türkiye Tarimsal Araştirma Projesi Yayinlari, TÜBİTAK Matbaasi, Ankara.
Yürüt HA, Coşkun H, Benlioğlu K, Gürer M (1988). Elma ağaçlarinda zarar yapan elma karalekesi (*Venturia inaequalis* (Cke.) Wint.) hastaliğinin mücadelesinde tahmin ve uyari sisteminin geliştirilmesi ve uygulanmasi üzerinde araştirmalar. V. Türkiye Fitopatoloji Kongresi. Bildiri Özetleri: 116. 18-21 Ekim 1988, Antalya.
Zeki C (1998). Elma Bahçelerinde Entegre Mücadele Teknik Talimati. T.C. Tarim ve Köyişleri Bakanliği, Tarimsal Araştirmalar Genel Müdürlüğü, Ankara.