BİTKİ KORUMA BÜLTENİ 2015, 56(2): 227 - 241
ISSN 0406-3597

Determination of reaction levels of some apple genetic resources in Turkey to Apple scab (*Venturia inaequalis* (Cke.) Wint.)

Suat KAYMAK[1] Mesut İŞÇİ[2] Şerif ÖZONGUN[2] Hülya ÖZGÖNEN[3]

ABSTRACT

Apple scab caused by *Venturia inaequalis* (Cke.) Wint. is a serious fungal disease of apple and it causes important economic loss in Turkey. Cultivating disease-resistant varieties seems to be an alternative method to chemical control. Therefore, susceptibility to apple scab of 304 apple cultivars and types were evaluated in the Apple Genetic Sources and Collection Garden in the Eğirdir Fruit Research Institute during 2005-2009. The purpose of the study was to identify scab-resistant cultivars among the apple varieties. The apple varieties were tested under natural infection conditions. During the study, fungicides were not applied in the trial. Experiments were established according to completely randomized block design with three replicates. Infection ratios were evaluated according to 0-4 scale, including, resistant (0-1% leaf infection), less sensitive (< 25% leaf infection), sensitive (25-50% leaf infection) and more sensitive (> 50% leaf infection). There were not differences between years significantly, it showed homogenous dispersion and there was a significant difference between varieties. Thirty two cultivars showed no sign of leaf symptoms and another 47 cultivars showed only slight leaf symptoms against apple scab pathogen. A hundred and eighteen cultivars were less sensitive, 84 varieties and types were assessed as sensitive, and 23 varieties and types were assessed as more sensitive. The highest disease ratios were determined with the varieties E40, Eden Spur and Elite as 69.61%, 67.88% and 65.09%, respectively.

Keywords: Apple, cultivars, disease severity, resistance, *Venturia inaequalis*

[1] General Directorate of Agricultural Research and Policies, 06170 Yenimahalle, Ankara, Turkey
[2] Directorate of Fruit Research Institute, 32500 Eğirdir, Isparta, Turkey
[3] Süleyman Demirel University, Faculty of Agriculture, 32260 Isparta, Turkey
Sorumlu yazar (Corresponding author) e-mail: skaymak@tagem.gov.tr
Alınış (Received): 14.03.2016, Kabul ediliş (Accepted): 20.06.2016

ÖZ

Türkiye'deki bazı elma genetik kaynaklarının Elma kara lekesi hastalığı (*Venturia inaequalis* (Cke.) Wint.)'na karşı reaksiyon seviyelerinin belirlenmesi

Elma karaleke hastalığı *Venturia inaequalis* (Cke.) Wint. elmanın önemli bir hastalığı olup, Türkiye'de önemli ekonomik kayıplara neden olmaktadır. Hastalığa dayanıklı çeşitlerin kullanılması kimyasal savaşa göre alternatif bir metot olarak görülmektedir. Bu yüzden 2005-2009 yılları arasında Meyvecilik Araştırma Enstitüsü Müdürlüğü elma genetik kaynakları parselinde bulunan 304 elma çeşit ve tipinin Elma Karaleke hastalığına karşı hassasiyetleri belirlenmiştir. Bu çalışmanın amacı, elma çeşitleri içerisinde karalekeye dayanıklı çeşitlerin belirlenmesidir. Elma çeşitleri doğal inokulasyon şartlarında denemeye alınmış, enfeksiyon boyunca hiçbir fungisit uygulanmamıştır. Çalışma tesadüf blokları deneme desenine göre 3 tekerrürlü olacak şekilde planlanmış, hastalık şiddeti 0-4 skalasına göre değerlendirilmiştir. Reaksiyon seviyeleri; dayanıklı (%0-1 yaprak enfeksiyonu), az hassas (< %25 yaprak enfeksiyonu), hassas (%25-50 yaprak enfeksiyonu) ve yüksek hassas (> %50 yaprak enfeksiyonu) olarak gruplandırılmıştır. Yıllar arasında istatistikî açıdan fark bulunmamış olup, homojen bir dağılım gösterdiği belirlenmiş ve çeşitler arasındaki fark ise çok önemli bulunmuştur ($P<0.01$). Otuz iki çeşitte hastalık belirtisi gözlenmezken (0), 47'sinde çok az enfeksiyon oluşmuş ve 118 adedi az hassas olarak belirlenmiştir. 84 adet çeşit ve tip ise hassas ve 23 çeşit ve tip yüksek hassas grup içinde yer almıştır. Hastalık şiddeti en yüksek sırasıyla E40, Eden Spur ve Elite çeşitlerinde %69.61, %67.88 ve %65.09 olarak hesaplanmıştır.

Anahtar kelimeler: Elma, çeşit, hastalık şiddeti, dayanıklılık, *Venturia inaequalis*

INTRODUCTION

Apple has a wide distribution in the world and can be grown in different ecological conditions. Today, 80.822.520 tonnes of apples were produced worldwide. Turkey is the third leading producer, accounting for 3.128.450 tonnes of world production (Faostat 2015). Pome fruit production in Turkey accounts for 24% per year of total fruit production and apple production is accounted for 84% in pome fruits (Department of Agriculture 2003).

Apple scab is the main disease of apple and it causes 70% reduction in yield as well as leads to loss of 30-60% reducing the market value (Agrios 1997, Türkoğlu 1978).

A large number of pesticides with different active ingredients are applied against various pests and diseases at the beginning of the vegetation period until the harvest in apple orchards. The number of active ingredients licensed in Turkey is 30 for codling moth and 58 for apple scab (RPPP 2014), which reflects the high number of pesticides used in apple orchards.

Pesticides are applied 20-25 times against apple diseases and pests by apple producers in a season in Eğirdir location of Turkey. Apple producers consistently apply fungicides to protect the trees against apple scab infections during the time of late rainy spring (Boyraz et al. 2005). Because of intensive fungicide use against apple scab, efficacy of fungicides gradually decreased, therefore the use of different preparations with different modes of action became necessary (De Waard et al. 1993).

Fungicide applications increase production costs and constituted risk in terms of both environment and human health. This situation causes great economic losses in apple production.

To reduce fungicide usage it is necessary to develop or use disease-resistant varieties. Therefore, using traditional breeding methods, disease resistance genes in wild apples have been tried to be transferred to culture variations for many years (Mac Hardy 1996). Different types of apples have been identified having resistance genes to the disease. Fischer and Fischer (1999) have continually evaluated old and new fruit varieties, including their own breeding material, for disease resistance. Lateur and Populer (1994) conducted a project for screening old varieties for disease resistance in Belgium, where nine cultivars were recommended for growing or breeding. The Russian cultivar 'Antonovka' (Va gene) has been included as a scab resistant parent in breeding for a long time (Visser et al. 1974). The Russian apple R 12740-7A (*Malus pumila*) was also recognised as a source of resistance to apple scab (Dayton et al. 1953).

There are over 450 local apples varieties in Turkey and many of them are susceptible to apple scab. It is necessary to preserve genetic diversity and work should be done by characterization of the collected genetic resources to use in breeding and improvement of new varieties with highest yield and quality, resistant to apple scab and post-harvest diseases. In this study, it was aimed to determine the resistance levels of genetic sources of 304 varieties and types of apples in the Apple Genetic Sources and Collection Garden in the Eğirdir Fruit Research Institute against apple scab under field conditions and to introduce new breeding materials to apple breeders.

MATERIALS AND METHODS

Three hundred and four apple varieties and types grafted on MM 106 rootstock were used in Eğirdir Fruit Research Institute, Republic of Turkey, Ministry of Food, Agriculture and Livestock. Experiments were conducted in between the years 2005-2009. Apple varieties and types were grown at 4x2 m plots in 2001. Completely randomized design with 3 replicates 1 tree in each, was used in the trial.

Experiments were conducted under natural infection conditions. Infection formation following perithecium maturation and ascospore flight was determined

via electronic prediction device (Lufft) and were evaluated in apple plantations which observed the disease in previous years. No fungicide applications were done against disease during the experiment (Didelot et al. 2007).

Disease evaluation

Assessments were done after the leaves reached to maximum size and the development of disease was completed. One hundred leaves were collected randomly in the four directions of the tree crown and at the level of size and following scale was used for each replication for evaluation (Table 1). Disease severity (%) was calculated using Townsend-Heuberger formula (Unterstenhöfer 1963).

Table 1. Scale used for the evaluation of apple scab (Anonim 1996).

Scale	Disease definition
0	No spot
1	Up to 5 spots with less than 5 mm
2	Up to 5 spots greater than 5 mm or more than 5 spots with less than 5 mm
3	More than 5 spots greater than 5 mm
4	More than half of the leaf covered with spots

According to disease severity rates, resistance levels were grouped (Table 2) as: 0–1% resistant; less than 25% less sensitive; between 25–50% sensitive, more than 50% more sensitive (Pauwels and Keulemans 2000).

RESULTS AND DISCUSSION

In the study, variations among 304 apple cultivars were determined, regarding their reactions against apple scab disease, under natural inoculation conditions during 2005, 2006, 2008 and 2009.

Homogeneity tests were carried out for the annual integration of percent values of disease severity during the study. It was concluded that disease severity showed homogenous distribution among years. However, there were some differences in the disease severity values of some species among years. On the other hand, differences between cultivars were found highly significant. So the results were evaluated using the average values of the years. It was thought that these kinds of differences were caused by the increasing inoculum densities in the orchard.

Distribution of apple varieties/types regarding to their reaction levels were determined (Table 2). According to the results of this study no indication of infection was observed in 32 cultivars (0), very low infection was seen in 47 (> %1) and 118 were determined as less sensitive, while 84 cultivars were included in sensitive and 23 cultivars in more sensitive groups (Table 2, 3, 4, 5 and 6).

Table 2. Reaction levels and groups according to disease severity (%) of apple varieties/types.

Group	Numbers of Cultivars	Reaction level
0 (No infection)	32	Resistant
1 (Disease severity between 0-1%)	47	Resistant
2 (Disease severity <25%)	118	Less sensitive
3 (Disease severity between 25-50%)	84	Sensitive
4 (Disease severity >50%)	23	More sensitive

Table 3. Symptomless apple varieties/types in the gene source according to the observations in the vegetation periods of 2005-2009 years

No	CV name	No	CV name	No	CV name
1	King Lucious	12	220887 (3-5)	23	Prima
2	Gelendost	13	546 E	24	Santana
3	Korella	14	A15	25	Wealthy
4	Piraziz	15	A76	26	Süs Elması
5	Topaz	16	Priscilla	27	Tatlı Elma (2492)
6	Reçel Elması (2506)	17	32 E 1	28	Juliet
7	Bey Elması (2477)	18	32 E 2	29	Cidagut
8	Redfree	19	42-Ko-1 (Yayla Pınarı)	30	Demir (2486)
9	Cincik (2471)	20	529 J	31	Vista Bella
10	Reinette Tardiva	21	A25	32	Early Red
11	Priam	22	A31		

Table 4. Apple varieties/types with disease severity rates between 0.1-1% in the gene source according to the observations in the vegetation periods of 2005-2009 years

No	CV name	No	CV name	No	CV name
1	Col.22	17	180887(5-4)	33	21
2	Tatlı Elma (2511)	18	2438	34	Batum
3	Söğüt Elma (2480)	19	60	35	14
4	Mektep Elması (2565)	20	61	36	11
5	Elma (2582)	21	82	37	Portakal
6	Laz Emaası (2507)	22	62-1	38	504 J
7	Champion	23	47	39	473 E
8	Belle Fleo Jello	24	37	40	496 E
9	180887(5-1)	25	41	41	542 E
10	Kalkan Delen	26	81	42	Sinap
11	180887(5-2)	27	2328	43	4
12	220887	28	2334	44	Şeker
13	220887(1-2)	29	2411	45	42 E 2 (Ankara Güzeli)
14	220887(1-1)	30	72	46	YB 3
15	Vinesap	31	65	47	Aksu 4
16	130887(2-3)	32	29		

Table 5. Apple varieties/types with disease severity rates between 1.1-5% in the gene source according to the observations in the vegetation periods of 2005-2009 years

No	CV name	No	CV name	No	CV name
1	Red Bird Early	14	Şeker Elması (2551)	27	383 E
2	Yaz Elması (2563)	15	Sarı Elma	28	Gürcü
3	Grimes Golden	16	Demir (2562)	29	1
4	Amasya (Uludağ)	17	Demir (2514)	30	18
5	Amasya 41	18	Hüryemez	31	42 E 4 (Mayhoş Yıldızkıran)
6	Amasya	19	Rosa De Benauge		
7	Amasya 21	20	Reine De Renettes	32	42 E 3 (Hanım Teni)
8	Col.27	21	230887(1-2)	33	42 E 1 (Dalda Bir)
9	Amasya 9	22	240887(1-2)	34	Amasya 37
10	Amasya 40	23	130887	35	YB 1
11	Amasya 50	24	56	36	Orak 2
12	Amasya 20	25	19	37	Inebolu
13	York Imperial	26	32	38	180887(1-1)

Table 6. Mean disease severity rates (%) of apple varieties and types according to the observations in the vegetation periods of 2005-2009 years

No	CV name	Disease severity (%)	No	CV name	Disease severity (%)	No	CV name	Disease severity (%)
1	Ranna Çervena Ptitsa	5,25	64	Granny Smith Spur	20,48	127	Oregon Spur	37,73
2	240887 (1-2)	5,32	65	Gümüşhane	20,6	128	Yaz Tavşanbaşı	38,63
3	Amasya 9	5,43	66	Astragan Rouge	21	129	Gallia Beauty	38,7
4	180887 (1-1)	5,59	67	10	21,23	130	Pancarlık	39,09
5	1	5,68	68	Rize Demir	21,33	131	Kırmızı Elma (2552)-1	39,35
6	56	5,85	69	Paşa Elması	21,54	132	68	39,54
7	Yaz Elması (2563)	5,86	70	Elma(2590)	22,11	133	Lutz Golden	39,72
8	73	6,44	71	Mollie's Delicious	22,28	134	Golden Sel-B	40,74
9	Ciğit	6,5	72	Scarlet Staymared	22,34	135	Stark Spur Golden	41,61
10	180887 (2-1)	6,63	73	Close	22,39	136	El-23035 (Amasya)	41,88
11	51	7	74	Amasya23	22,67	137	Arlet	42,24
12	210887 (2-1)	8,04	75	371 E	23,13	138	Amasya 532	42,47
13	Demir	8,04	76	Gürcü	23,18	139	Ferik	42,82
14	S.Early Stripe	8,36	77	Harım	23,56	140	Melrose	43,07
15	66	8,36	78	Winter Banana	23,99	141	Petek (2577)	43,37
16	Stark	9,21	79	55	24,19	142	9	43,37
17	42-A-1 (Yaz Elması)	9,84	80	Topred	24,25	143	Golden Sel B	43,46
18	Red Spur	10,17	81	2329	25,13	144	Amasya 351	43,63
19	372 E	10,52	82	250887 (1-10)	25,33	145	Auwil Spur	43,79
20	Kış Elması (2590)	10,53	83	57	25,47	146	Dbl. Red Delicious	43,81
21	180887 (4-4)	10,75	84	17	25,48	147	Samsun	44,08
22	Yaz Elması(2384)	10,78	85	Karanfil (2570)	25,67	148	Petevrek Elması (2566)	44,94

Table 6. Mean disease severity rates (%) of apple varieties and types according to the observations in the vegetation periods of 2005-2009 years (continued)

23	J/5/4/59 Bel.	11,04	86	Stayman's Winesap	25,69	149	Gloster	45,05
24	Canada Renette	11,06	87	130887 (3-4)	26,25	150	Tokat-2	45,36
25	220887 (3-2)	11,71	88	Karapınar Elması	28,01	151	24 M 31	45,54
26	42-E-7 (Yıldızkıran)	11,76	89	67	28,13	152	Mor Spur	45,68
27	180887	12	90	Yenice	28,34	153	Anglyska Zelena	45,84
28	E 71	12,19	91	50	28,94	154	Zlatna Prevuzhodna	45,91
29	Elma (2523)	12,54	92	Ayvania	29,27	155	Niğde İngiliz	45,95
30	Lodi Early Golden	13,51	93	34	29,67	156	42-C-5 (Yaz Amasya)	46,3
31	210887 (1-4)	13,53	94	35	29,72	157	Red Jonathan	46,41
32	Beyaz Elma (2575)	13,6	95	63-8-2	29,73	158	Tokat-3	46,99
33	63	13,71	96	78	29,84	159	Karasakı	47,07
34	Yenişehir Çöğür A.	15,48	97	170887(2-5)	29,85	160	Pozmer 20	47,58
35	Susuz Elma (2500)	15,5	98	Calville Rouge Datan	30,66	161	Ed Gould Golden	48,65
36	Elstar	15,56	99	Sah Elması (2600)	30,92	162	Tokat-4	48,96
37	20	15,97	100	Gelin Elması (2475)	31,95	163	Jonagold	49,11
38	Yaz Elması (2484)	16,08	101	180887 (5-1)	31,97	164	Yellow Spur	49,38
39	Karpuz	16,18	102	Chesapeak	32,06	165	G Smothee	51,06
40	62-2	16,24	103	E 42	32,29	166	Cooper 4	52,67
41	42-E-6 (Kaba Elma)	16,41	104	Gemlik-2 Çöğür A.	33,07	167	Sandık	52,69
42	6	16,93	105	385 E	33,22	168	Mutsu	53,11
43	Calviller Rouge Del.	17,09	106	Gemlik-3 Çöğür A.	33,39	169	Starkrimson	54,39
44	Sarıgöbek	17,12	107	48	33,52	170	Tavşanbaşı (2531)	54,53
45	190887 (1-4)	17,64	108	49	33,59	171	Dbl. Red Stayman	54,58
46	210887 (1-2)	17,8	109	18	33,79	172	Hi- Early	54,77
47	42-C-3(Tatlı Tavşanbaşı)	17,82	110	Kırmızı Elma (2552)-2	34	173	Sivanor Elması (2601)	55,82
48	Calville Rouge Del.	17,96	111	Renna Cernava	34,29	174	Ervin Spur	56,24
49	190887 (3-2)	17,97	112	12	34,33	175	Wayne Spur	56,57
50	Göbek (2455)	18,02	113	Candır	34,73	176	Güztavşanbaşı	56,98
51	23	18,25	114	Democrat	35,31	177	McIntosh	58,4
52	Granny Smith	18,28	115	392 E	35,37	178	Cooper 900	59,95
53	Tokat-1	18,42	116	2331	35,5	179	Cooper 7 Sb-2	60,96
54	Yaz Elması (2482)	18,46	117	Black Stayman	35,73	180	Mayhoş Tavşanbaşı	62,51
55	384 E	18,59	118	Chasapoke	35,98	181	Kadir-Hatice (2602)	62,54
56	13	18,82	119	Summerred	36,14	182	Sky Spur	63,24
57	E 45	18,88	120	Spartan	36,26	183	Dlatro Prevuzhodna	63,79
58	Daldatek	19,13	121	Altınok Elması (2490)	36,34	184	2332	64,41
59	Amasya 38	19,25	122	33	36,63	185	Elite	65,09
60	42-Bs-5 (Almila)	19,35	123	Mahsusa Elması (2478)	36,66	186	Eden Spur	67,88
61	52	19,63	124	38	36,94	187	E 40	69,61
62	200887 (1-9)	19,88	125	24	37,57			
63	Oltu Elması (2594)	19,89	126	Rome Beauty	37,68			

Some local varieties and types showed disease severity less than 1%. Maximum disease severity was found on E40, Eden Spur, Elite, and 2332 varieties, respectively as 69.61, 67.88, 65.09, and 64.41%.

The mean disease severity levels were changed between varieties and types. Among the most known varieties, the disease severities were 54.39% for Starkrimson, 53.11% for Mutsu, 49.11% for Jonagold, 41.61% for Stark Spur Golden, 37.68% for Rome Beauty, and 18.28% for Grany Smith, respectively. According to the electronic estimation warning device (Lufft), the first ascospore discharge occurred on 02.04.2005, 03.04.2006 and 08.04.2009.

When the meteorological data of April-August (2005) following the bud break were considered (Table 7), total precipitation amount was found 145.6 mm and the number of rainy days was 20. Regarding 2006, precipitation amount was 151.9 mm, and the number of rainy days was 38. Increasing number of rainy days in 2006 explains the increase in infection.

According to the meteorological data of 2007, weather was rainless during the susceptible periods for the disease, and infection could be avoided. Therefore, disease evaluation could not be done. The number of rainy days was 21 from April to August, and total precipitation amount was only 38.8 mm. Importance of rain in the formation of infections was evident.

In 2008, total precipitation amount for the same period was 57.5 mm, and the number of rainy days was 27. Infection was formed, and infection warning was issued 6 times according to the early warning device.

Table 7. The numbers of rainy days and rainfall (mm) from April to August in 2005-2009 years.

Year	April		May		June		July		August	
	TNRD*	Rainfall (mm)	TNRD	Rainfall (mm)	TNRD	Rainfall (mm)	TNRD	Rainfall (mm)	TNRD	Rainfall (mm)
2005	9	14,3	5	9,7	2	10,2	1	14,1	4	35,6
2006	11	17,2	12	20	10	11,9	3	2,1	2	33,3
2007	5	12,3	6	5	6	6,1	1	7,3	3	8,1
2008	10	23,8	8	14,9	4	2,6	1	3,8	4	12,4
2009	10	52,6	11	93,5	8	15,1	8	8,8	3	0,7

*TNRD: The number of rainy days

In 2009, weather conditions were highly suitable for the formation of infection, and apple scab was epidemic. Total precipitation amount was 161.2 mm, and the number of rainy days was 29 only for April, May and June. Even the total of the three months was higher than the total values of other years.

In the present study, resistance levels of our gene sources presenting 304 varieties and types of apples against apple scab under field conditions were determined. 79 cultivars and types found to be resistant and could be evaluated for further studies as a resistance gene source.

Using resistant varieties is the most efficient way of controlling the disease and reduction of pesticide applications. Therefore, several apple scab resistance gene were identified from wild apples and these genes were attempted to introduce into cultivated apple by classical breeding methods. Although there are 11 host genes (Va, Vb, Vbj, Vd, Vf, Vg, Vh2, Vh4, Vh8, Vm and Vr2) related with the resistance, 8 of them had mentioned as being primarily responsible for host resistance against apple scab (Janick and Moore 1996).

The varieties having an Avr gene are described as resistant. When the apple varieties containing the Avr gene were inoculated with the pathogen *V. inaequalis*, no symptoms were observed on them. Therefore, several apple scab resistance genes isolated from wild apples were identified, and were inoculated into cultivated apples by classical growing methods. Another study on apple scab showed 17 resistance genes for the disease (Jha et al. 2009, Bus et al. 2011). Vf gene identified from *Malus floribunda* 821 is the most commonly used apple scab resistance gene (Gessler et al. 2006). Using this gene as donor, many species resistant to apple scab disease had been successfully developed in breeding programs for 50 years (Bus et al. 2005). Prima was the first commercial apple species with Vf resistance gene (Blazek et al. 1999). Two new races of the pathogen which are able to overcome the resistance of the cultivars with Vf resistance gene were found, and named as 6 and 7 numbered races (Hemmat et al. 2002). In this study, no disease indication was determined in, Coper 44, Cooper 43, Enterprise, Priam, Prima, Priscilla and Red Free apple species, which were known to have Vf resistance gene, during experiment period; and therefore, it was concluded that 6 and 7 numbered races of the pathogen were not yet spread in the region (Afugan et al. 2004).

Pathogenicity of each species changes depending on its host. So far, various resistant races have appeared in many regions in the world; therefore, the studies on the determination of resistant species to the pathogen in Turkey should be given priority. The races of apple scab in the region where commercial apple orchards were established should be determined, and the breeding programme should be created to these races using resistant apple varieties. Xu et al. (2008) determined the population variation of apple scab isolates from Asia and Europe.

Considering the fact that pesticide use in Turkey increased by 45.29% in 2002 compared to 1979 (Delen et al. 2004), importance of the use of resistant cultivars became clearer. Reducing losses in apple production caused by the disease with the preference of cultivars more resistant to apple scab disease will contribute to regional and national economy. Development of the resistant cultivars will reduce pesticide use in apple production, which will both decrease production costs and protect human health and environment (Delen and Ozbek 1994).

Turkey has a great potential for organic farming compared to many other countries because of its unpolluted nature and climatic conditions. Today, organic farming has become more common both in Turkey and in the world with the increasing consciousness for human health and environment (Aksoy 1999). The total organic

apple production for 2006 was 28.393 tonnes, while it increased to 37.291 tonnes in 2013 (Ataseven and Guneş 2006, Atasay et al. 2013). There are very limited numbers of licensed pesticides that could be used in chemical control against apple scab in organic production. This situation makes the preference of resistant varieties necessary. The resistant varieties that emerged in this study should be preferred for organic production.

Akçay et al. (2009) determined Braeburn, Clear Red, Golden Delicious, Granny Smith, Jonagold, Jonagored, Red Chief and Royal Gala as prominent cultivars in their study on the adaptation of apple cultivars. However, none of these were found to be resistant; therefore, producers should be careful regarding the use of protective pesticides in the orchards planted with these apple cultivars. Inoculum density is always higher in the orchards consisting of mixed cultivars.

Introducing resistant varieties is costly and takes time. Therefore, evaluation of the genes that aid in the resistance are critical and currently progressing, thanks to the discovery and isolation of resistance genes.

In conclusion, changes in response to apple scab infection on 304 apple cultivars were examined, and great variations were determined in this study. Many promising candidates were identified for further investigations, and used in breeding programme as source of resistance to apple scab (Kaçal and Yıldırım 2011, Kaymak et al. 2013). There are apple species that could be used genetically in breeding programs. The risk of resistance being overcome by a new race of scab can be very high, particularly when resistant varieties are cultivated as monocultures. Considering the fact that pathogen constantly creates new races, breeding programs to obtain new apple cultivars bearing resistance gene (Vf, Va, Vr, Vb, etc.) are needed. The best planting strategy is to mix varieties with resistance from different genetic sources.

As a result of the selective pressure on the pathogen, from increased pesticide use, new apple cultivars could potentially lack adequate resistance to the pathogen. However, considerable efforts are being made to develop novel genes that would provide resistance against the pathogen.

REFERENCES

Afugan M.R., Goodwin P.H. and Hunter D.M. 2004. Linkage of Vfa4 in *Malus domestica* and *Malus floribunda* with Vf Resistance to the Apple Scab Pathogen *Venturia inaequalis*. Plant Pathology, 53 (4), 461-467.

Agrios G.N. 1997. Plant Pathology (Fourth Edition). ISBNO-12-044564-6, California, USA. 619.

Akçay M.E., Doğan A., Burak M., Yaşasın A.S. and Öz F. 2009. Adaptation Studies of Some Apple Varieties at Marmara Region. Research Journal of Agricultural Science, 2 (2), 65-71.

Aksoy U. 1999. Advances in Ecological Agriculture. Ecological Agriculture, Association of Ecological Agriculture Organization, İzmir/Turkey. 30-35.

Anonim 1996. Zirai Mücadele Standart İlaç Deneme Metotları. Tarım ve Köyişleri Bakanlığı Tarımsal Araştırmalar Genel Müdürlüğü, Ankara, 183 s.

Ataseven Y. ve Güneş E. 2006. The Production of Processed Organic Agricultural Products and Development in Its Trade in Turkey. Journal of Agricultural Faculty of Uludağ University, 22 (2), 25-33.

Atasoy A., İşçi M. ve Uçgun K. 2013. Basic Factors Affecting Success in Organic Apple Growing. Proceeding in 5th Turkish Symposium on Organic Agriculture, p 40-46, Samsun.

Blazek J., Syrovatko P., Reznicek V. and Kloutvorava J. 1999. Inheritance of Apple Scab Resistance *Venturia ineaqualis* Cke. Wint. Controlled by the Vf Gene as Indicated After Inoculation. Acta Universitetis Agriculturae et Silviculturae Mendelianae Brunensis, 47, 97-105.

Boyraz N., Kaymak S. and Yigit F. 2005. General Evaluation of Applications Chemical Control of Apple Growers in Eğirdir County. Selçuk University Journal of Agricultural Faculty, 19 (36), 37-51.

Bus V.G., Laurens F.F., Van De Weg W.E., Rusholme R.L., Rikkerink E.H. and Plummer K.M. 2005. The Vh8 Locus of A New Gene-for-Gene Interaction Between *Venturia inaequalis* and The Wild Apple *Malus sieversii* is Closely Linked to the Vh2 Locus in *Malus pumila* R12740-7A. The New Phytologist, 166 (3), 1035-1049.

Bus V.G.M., Rikkerink E.H.A., Caffier V., Durel C.E. and Plummer K.M. 2011. Revision of the Nomenclature of the Differential Host-Pathogen Interactions of *Venturia inaequalis* and *Malus*. Phytopathology, 49, 391-413.

Dayton D.F., Shay J.R. and Hough L.F. 1953. Apple Scab Resistance from R12740–7A, A Russian Apple. Proc. American Society of Horticulture Science, 62, 334–340.

Delen N. and Özbek T. 1994. Roles in Environmental Pollution of Pesticides. Ege University, Journal of Faculty of Science Seri B Annex, 16, 67-75.

Delen N., Durmuşoğlu N., Güncan A., Güngör N., Turgut C. and Burçak A. 2004. Pesticide Use in Turkey, Residue and Sensitivity Decrease in Organisms Problems. In: Proceedings of Sixth Technical Congress on Agricultural Engineering in Turkey Ankara/Turkey pp 1-21.

Department of Agriculture 2003. Agricultural Structure and Production 2003. DİE Press, Ankara/Turkey.

De Waard M.A., Georgopoulos S.G., Hollomon D.W., Ishii H., Leroux P. and Schwinn F.J. 1993. Chemical Control of Plant Diseases: Problems and Progress. Annual Review of Phytopathology, 31, 403-421.

Didelot F., Brun L. and Parisi L. 2007. Effects of Cultivar Mixtures on Scab Control in Apple Orchards. Plant Pathology, 56 (6), 1014-1022.

Faostat 2015. Retrieved 2015, July 30 from http://faostat.fao.org.

Fischer M. and Fischer C. 1999. Evaluation of *Malus* Species and Cultivars at the Fruit Genebank Dresden-Pillnitz and Its Use for Apple Resistance Breeding. Genetic Resources and Crop Evolution, 46 (3), 235-241.

Gessler C., Patocchi A., Sansavini S., Tartarini S. and Gianfranceschi L. 2006. *Venturia inaequalis* Resistance in Apple. Critical Rewiews in Plant Sciences, 25 (6), 473-503.

Hemmat M., Brown S.K. and Weeden N.F. 2002. Tagging and Mapping Scab Resistance Genes from R1270 7A Apple. Journal of the American Society for Horticultural Science, 127, 365-370.

Janick J. and Moore J.N. 1996. Fruit Breeding. Vol I. Tree and Tropical Fruits. John Wiley and Sons, Inc., New York, USA, 1-77 pp.

Jha G., Thakur K. and Thakur P. 2009. The *Venturia* Apple Pathosystem: Pathogenicity Mechanisms and Plant Defense Responses. Journal of Biomedicine and Biotechnology, doi:10.1155/2009/680160.

Kaçal E. and Yıldırım F.A. 2011. Development of Apple Variety Breeding for Scab Resistance. Derim Dergisi, 28 (2), 14-26.

Kaymak S., Kaçal E. and Öztürk Y. 2013. Screening Breeding Apple Progenies with Vf Apple Scab *Venturia inaequalis* Cke. Wint. Disease Resistance Gene Specific Molecular Markers. Integrated Protection of Fruit Crops IOBC-WPRS Bulletin, 91, 361-365.

Lateur M. and Populer C. 1994. Screening Fruit Tree Genetic Resources in Belgium for Disease Resistance and Other Desirable Characters. In: Schmidt H. and Kellerhals M. eds, Progress in Temperate Fruit Breeding. Kluwer Academic Press, 425–431 pp.

Mac Hardy W.E. 1996. Apple Scab. Biology, Epidemiology, and Management. American Psychopathological Society Press, St Paul, Minnesota.

Pauwels E. and Keulemans J. 2000. Breeding for Scab Resistance in Apple: Evaluation of Resistance in the Greenhouse and in the Field. Acta Horticulturae doi:10.17660/ActaHortic.2000.525.75.

RPPP 2014. Registered Plant Protection Products, Hasad Publication, ISBN 978-975-8377-91-6, İstanbul/Turkey. 154, 187, 188

Türkoğlu K. 1978. Karaleke *Venturia inaequalis* Cke. Wint. Epidemisinin Önceden Saptanması ve Hastalığın Eradikasyonu Üzerine Araştırmalar. [Detection of the Apple Scab *Venturia inaequalis* MCA. Wint. Epidemic and the Research on the Rradication of the Disease]. Retrived 2015 January 01 from Food, Agriculture and Livestock Ministry Izmir Regional Directorate of Plant Protection Research Institute Research Service, No: 030-465.

Unterstenhöfer G. 1963. The Basic Principles of Crop Protection Field trials. Pflanzenschutz-Nachricten, Bayer, pp 155-56.

Visser T., Verhaegh J.J. and de Vries D.P. 1974. Resistance to Scab *Venturia inaequalis* and Mildew *Podosphaera leucotricha* and Fruiting Properties of the Offspring of the Apple Cultivar Antonovka. Euphytica, 23 (2), 353-364.

Xu X., Yang J., Thakur V., Roberts A. and Barbara D.J. 2008. Population Variation of Apple Scab *Venturia inaequalis* Isolates from Asia and Europe. Plant Disease, 92 (2), 247-252.