

Variability of Different Pear Hybrid Populations in Terms of Hybridization Performance and the Response to Fire Blight (*Erwinia amylovora*) Attack

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Abstract

The production of pear, which is one of the most important fruits in Turkey, was restricted by the occurrence of the fire blight disease. There isn't a certain chemical management against fire blight, although plant activators have been used, at present. It's very important to improve resistant varieties in terms of an integrated management of bacterial diseases. With this purpose, different crosses have been made between resistant cultigens and *P. communis* varieties that have good fruit characteristics. Besides, self-pollination and open pollination treatments have been carried out in parental plants. Pollen viability and germination ratio, fruit set ratio, total and mean seed number, seed germination ratio, the ratio of hybrid losses by root rot at early stage and the ratio of hybrid losses by natural fire blight infection were determined. The highest values of the properties such as pollen viability and germination ratio, fruit set ratio, mean and total seed number were obtained from the crosses with 'Kaiser Alexandre', 'Ankara', 'Akça', 'Conference' and 'Santa Maria' cultivars, in general. As a result of natural fire blight infection in Izmir-Turkey conditions, the resistance level of the hybrids from various combinations differed through the cultivars used for cross pollination, and it is very important to evaluate these hybrid pear populations through their response to fireblight disease in terms of obtaining new resistant cultivars and using these populations as disease resistant genetic resources in the future.

Keywords: pear, breeding, resistance, fruit set, seed number, germination

Introduction

Fire blight (*Erwinia amylovora*) is one of the most destructive diseases of pear in the world and effects apple, pear and the other species in the *Rosaceae* family (van der Zwet and Beer, 1995). Today, fire blight is spread almost all over the world where pear trees are grown. Fire blight was observed first in 1985 in Turkey. It occurs foremost in Central Anatolia but appears in all the regions of Turkey and causes severe losses (Momol *et al.*, 1992).

Fire blight is seriously harmful for *Pyrus communis* known as sweet pear. On the other hand, *P. ussuriensis* is the most resistant. *P. serotina* is less hardy than *P. ussuriensis* (Shay, *et al.*, 1962).

Although there is no certain solution for the disease, mechanical and chemical management can be performed. Biological methods have started to be used recently against the disease (Aysan *et al.*, 1999; Sobiczewski *et al.*, 1997). Improving resistant cultivars is one of the main objectives of integrated management of bacterial diseases. Using resistant cultivars, rootstocks and interstocks come into primary prominence in controlling fire blight disease (Bergamaschi *et al.*, 2006; Layne and Quamme, 1975).

Recently, investigations on breeding for disease resistance have gained acceleration, owing to the emphasis on human health and environment. Finding a market of organic agriculture products with high prices is another approach in improving disease resistant genotypes.

So far, a lot of breeding programs have been conducted in many countries by crossing cultivars that have different resistance levels to obtain resistant cultigens after artificial inoculations. Various simple and complex hybridization programmes have been used on fire blight resistance breeding of pear (Bergamaschi *et al.*, 2006; Durel *et al.*, 2004; Fischer and Mildenerger, 2000; Hevesi *et al.*, 2004; Hunter and Layne, 2004; Layne and Quamme, 1975; Ryugo, 1982; Sobiczewski *et al.*, 1997; Thibault, 1990). On this matter, it was stated that, it is possible to be successful by choosing resistant parents in disease resistance breeding (Layne and Quamme, 1975).

Taking into account the above mentioned explanations, a project supported by TÜBİTAK has started with the aim of obtaining resistant and high quality cultivars by crossing susceptible but qualified commercial cultivars grown in our country and worldwide to resistant commercial and local cultigens.

In the material derived from breeding programs, it takes a lot of time to determine resistance levels after natural infections in vivo, especially for the perennial plants like fruit trees. So, infections that naturally occur are of great importance. The response of genotypes to fire blight attack was assessed in natural conditions of infection (Layne and Quamme, 1975; Saygılı *et al.*, 1999; Sestras *et al.*, 2008).

In this research, controlled hybridizations have been performed between susceptible and resistant pear genotypes. Pollen viability and germination ratio, fruit set ratio, total and mean seed number, seed germination ratio, the ratio of hybrid losses by root rot at an early stage and the ratio of hybrid losses due to natural fire blight infection were detected.

Materials and methods

In the current study that was conducted during 2007-2009, hybridization treatments were performed at Ege University Ödemiş Vocational Training School and Atatürk Central Horticultural Research Institute. Pollen was obtained from Atatürk Central Horticultural Research Institute, Ege University Faculty of Agriculture Department of Horticulture, Ege University Ödemiş Vocational Training School, collection gardens of S.S. Bademli Arboriculture Cooperation and North Carolina State University Department of Horticultural Science Mountain Horticultural Crops Research and Extension Center.

'Akça', 'Mustafa Bey', 'Santa Maria' and 'Williams' (Bartlett) cultivars that have high market values as high fruit qualities, but, susceptible to fire blight (Aysan *et al.*, 1999; Çıtır and Mırık, 1999; Momol *et al.*, 1992; Öden, 1999; Sobiczewski *et al.*, 1997; van Der Zwet and Beer, 1991) as well as 'Magness' cultivar that is listed as resistant-middle resistant to disease, but, could not be used as pollinator because it can not produce viable pollens (Honty *et al.*, 2006; McGraw, 2006), were used as maternal parents in this research. As for pollinators, 'Ankara', 'Cleveland Select', 'Conference', 'Dancer', 'Kaiser Alexandre', 'Kieffer', 'Limon', 'Moonglow' cultivars that are listed as resistant-middle resistant to *E. amylovora* (Aysan *et al.*, 1999; Bell *et al.*, 2005; Çıtır and Mırık, 1999; Honty *et al.*, 2006; Momol *et al.*, 1992; Sobiczewski *et al.*, 1997; van Der Zwet and Beer, 1991) and local cultigens with desirable traits as 'Bursa', 'Güz', 'Taş', 'Ekşi', 'Pamuk Akçası' (Ünal *et al.*, 1998) were used. Hybridizations were done between cultivars that bloom in the same period as susceptible x susceptible, susceptible x resistant, resistant x susceptible and resistant x resistant combinations (Rosati *et al.*, 2002).

Pollen, which was used for hybridization studies was provided from the balloon stage buds of the parents, chosen as pollinators (Layne and Quamme, 1975).

Pollen viability was determined by using TTC and IKI staining tests (Misirli *et al.*, 2006).

To state the pollen germination ratio of cultigens, germination medium containing 1% agar, 10% sucrose and 0.01% boric acid (Franco-Mora *et al.*, 2005; Hiratsuka and Zhang, 2002) was tested in the first year of the experiment, but pollen could not be germinated. Thus, the other years, the hanging drop method containing 20% sucrose was used (Jefferies, 1977). The viability and germination tests were done as three replicates for three years. Data were evaluated through the SPSS statistical program.

In terms of hybridization studies, 3 flowers per cluster were emasculated by removing petals and anthers. One day after emasculation, pistils were pollinated (Layne and Quamme, 1975). As for self-pollination, pink bud stage buds were isolated. For open pollination, buds on the shoots were counted and labelled. In every combination, almost 500 buds were emasculated. These treatments were carried out for three consecutive years. Fruit set ratio for each combination was determined 40 days after pollination.

Ripened fruits were harvested; obtained seeds were washed and dried, separately. The seeds were treated with a fungicide before stratification. Seeds were stratified at 2-4°C for 90 days. Seeds of 2007 and 2008 crosses were transplanted to vials containing peat and the ability of the seeds to germinate was evaluated. Then, they were transmitted to a media consisting of sand, manure and soil (Layne and Quamme, 1975). The seeds which were obtained from crosses in 2009 are still in stratification. So, some of the combinations were not evaluated in the previous years.

Mean seed number per fruit was determined in 20 fruits. Mean seed number and total seed number in each combination were detected for three years, but, germination ratio was detected for 2007 and 2008 combinations.

Root rot occurred due to fungal infections such as *Verticillium*, *Fusarium*, *Rhizoctonia* at an early stage (in 1 month after germination) in hybrid population. Plant losses were determined according to hybrid combination for first two years.

The fire blight attack occurred intensively during the 2008-2009 period. The frequency attack of the hybrids was (F %) determined. The frequency attack was calculated according to Sestras *et al.* (2007). The estimation of fire blight level was done, either for no attack or complete scorching and death due to hybrid population in the juvenile stage (6-12 months old plants).

Results and discussion

There was a statistical difference according to years and cultigens in terms of pollen viability and germination. For IKI pollen viability test, the highest values were obtained in 2009, followed by 2008 and 2007, respectively. In TTC test, the highest viability ratio was determined in 2008, 2009 had the second and 2007 had the last statistical level. Pollen germination was evaluated for 2008 and 2009

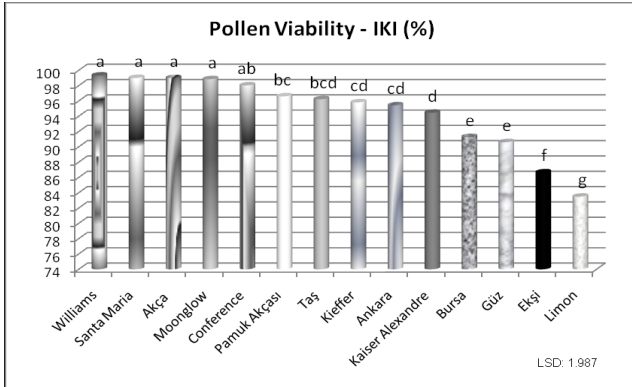


Fig. 1. Pollen viability ratio of pear cultigens in IKI test

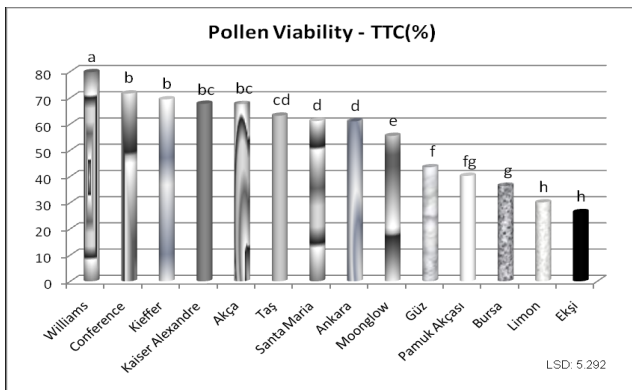


Fig. 2. Pollen viability ratio of pear cultigens in TTC test

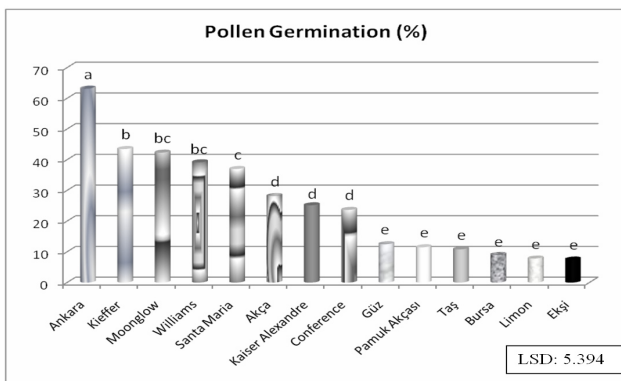


Fig. 3. Pollen germination ratio of pear cultigens

years, because of the unsuitable method of the first year, and 2008 and 2009 followed each other, respectively.

The highest and the lowest pollen viability ratio were found in ‘Williams’ (99.3%) and ‘Limon’ (83.5%) varieties respectively in IKI (Fig. 1). For the TTC test, pollen viability ranged from 79.8% (Williams) to 26.4% (Ekşi) (Fig. 2).

As for a general evaluation, pollen viability of local types except ‘Taş’, was detected as lower than of the other cultivars.

In comparing pollen germination ratio, variation range was detected between 7.5% (Ekşi) and 63.2% (Ankara) during two years (Fig. 3).

Fruit set ratio for female parents ranged between 4.9% (Magness) and 21.6% (Santa Maria). For ‘Akça’ hybridiza-

tions, ‘Kaiser Alexandre’ (37.8%), ‘Conference’ (35.3%) and ‘Ankara’ (31.8%) cultivars appear as the best pollinators. Conversely, ‘Limon’ (2.2%) and ‘Ekşi’ (1.7%) cultivars had the last orders for fruit set ratio. In the ‘Magness’ cultivar, the highest fruit set ratio was determined in ‘Santa Maria’ (18.6%) and ‘Ankara’ (15.8%) pollinators. No fruits could be obtained in the combinations that ‘Ekşi’ and ‘Pamuk Akçası’ used as pollinators and self-pollination treatment. For ‘Santa Maria’ cultivar, ‘Cleveland Select’ and ‘Ankara’ combinations had the best results with fruit set higher than 37%. On the contrary, ‘Santa Maria’ x ‘Limon’ combination (7.7%) and self-pollination treatment (0.0%) were the worst. As for ‘Williams’ cultivar, ‘Akça’ and ‘Conference’ combinations resulted 38.3% and 32.9% fruit set, respectively, but, ‘Limon’ (1.4%) and self-pollination treatment (0.0%) had the last orders (Tab. 1). Confirming these results, it is stated that fruit set percentage of over 20% is an acceptable level in fruit species (Nyéki and Soltész, 2003). For a general evaluation, ‘Ankara’, ‘Kaiser Alexandre’, ‘Santa Maria’, ‘Akça’ and ‘Conference’ pollinators, that have high fruit set ratios, exhibited good performances in terms of pollen viability and germination tests, whereas, ‘Pamuk Akçası’, ‘Bursa’, ‘Ekşi’ and ‘Limon’ had lower values for the three investigated properties.

Mean seed number was the highest in ‘Santa Maria’ (3.2) and the lowest in ‘Akça’ (2.5) for general evaluation. When it comes to different ‘Akça’ combinations, ‘Akça’ x ‘Kaiser Alexandre’ ranked the first (4.1), but, ‘Akça’ x ‘Pamuk Akçası’ (1.0) the last row. In comparing pollinators for ‘Magness’ cultivar, the mean seed numbers of ‘Akça’ (5.0), ‘Ankara’ (4.6) ‘Conference’ and ‘Santa Maria’ (4.3) were higher than the others. Similar to the ‘Akça’ cultivar, the highest fruit set values were obtained from these cultivars in ‘Magness’, too. Similarly, ‘Bursa’ (0.7) replaced to the last row as in fruit set ratio. In the evaluation of ‘Santa Maria’, ‘Santa Maria’ x ‘Conference’ (7.6) was the best combination in terms of mean seed number, but, ‘Dancer’ (0.6) was on the last row. Lastly, in ‘Williams’, the highest mean seed numbers were found in ‘Kaiser Alexandre’ (6.1) and ‘Conference’ (5.6) cultivars, respectively. ‘Limon’ cultivar had a lower seed number with 0.1. As it was seen in Tab. 1, both fruit set ratio and mean seed number of ‘Kaiser Alexandre’, ‘Akça’, ‘Ankara’, ‘Conference’, ‘Santa Maria’ pollinators was high (Tab. 1).

Total seed number of hybrid fruits in ‘Magness’ and ‘Akça’ was detected as 3458 and 8167, respectively. ‘Akça’ cultivar had the highest total seed number with the same combinations that highest fruit set ratios obtained. These combinations were ‘Kaiser Alexandre’ (1312) and ‘Conference’ (1256). The lowest total seed number was with ‘Pamuk Akçası’ (10) combination. In ‘Magness’ cultivar, this value ranged from 2 (Bursa) to 686 (Ankara). As for ‘Santa Maria’, ‘Ankara’ (1194) and ‘Akça’ (1037) combinations distributed the best total seed number, whereas, ‘Limon’ (60) and ‘Dancer’ (5) combinations possessed the lowest seed. In ‘Williams’, it was seen to be 1581 and 6

Tab. 1. Investigated properties of the hybrid combinations

Combination	Fruit set ratio (%)	Mean seed number	Total seed number	Mean		
				Seed germination ratio (%)	The ratio of hybrid losses by root rot at early stage (%)	The ratio of hybrid losses by natural fire blight infection (%)
'Akça' x 'Ankara'	31.8	2.5	1126	0.0	-	-
'Akça' x 'Bursa'	7.0	1.4	191	5.3	0.0	100.0
'Akça' x 'Conference'	35.3	2.7	1256	11.9	18.5	49.1
'Akça' x 'Ekşi'	1.7	1.5	11	0.0	-	-
'Akça' x 'Güz'	6.0	1.8	88	30.0	0.0	0.0
'Akça' x 'Kaiser Alexandre'	37.8	4.1	1312	10.0	0.0	64.2
'Akça' x 'Kieffer'	20.8	2.2	751	5.2	33.3	75.0
'Akça' x 'Limon'	2.2	1.8	16	0.0	-	-
'Akça' x 'Moonglow'	21.1	2.2	254	10.0	0.0	0.0
'Akça' x 'Pamuk Akçası'	2.6	1.0	10	0.0	-	-
'Akça' x 'Santa Maria'	22.8	2.9	619	4.4	10.0	71.2
'Akça' x 'Taş'	18.6	2.2	381	8.6	20.0	50.0
'Akça' x 'Williams'	28.7	2.6	415	5.5	8.7	19.1
'Akça' Self-Pollination	2.6	3.9	40	0.0	-	-
'Akça' Open Pollination	19.2	4.1	1697	20.6	1.7	48.0
'Akça' General	17.2	2.5	8167	7.4	9.2	47.6
'Magness' x 'Akça'	7.1	5.0	576	66.7	25.1	31.6
'Magness' x 'Ankara'	15.8	4.6	686	50.0	2.1	29.1
'Magness' x 'Bursa'	0.7	0.7	2	0.0	-	-
'Magness' x 'Conference'	6.30	4.3	170		In stratification	
'Magness' x 'Ekşi'	0.0	-	-	-	-	-
'Magness' x 'Güz'	1.9	1.6	103	31.6	3.3	34.5
'Magness' x 'Kaiser Alexandre'	8.4	4.1	132		In stratification	
'Magness' x 'Kieffer'	7.5	3.0	530	36.9	0.0	53.5
'Magness' x 'Limon'	2.8	2.0	111	37.8	9.5	29.0
'Magness' x 'Moonglow'	1.3	0.8	3		In stratification	
'Magness' x 'Pamuk Akçası'	0.0	-	-	-	-	-
'Magness' x 'Santa Maria'	18.6	4.3	337	87.2	34.0	45.4
'Magness' x 'Taş'	6.5	3.9	407	37.9	3.9	42.3
'Magness' x 'Williams'	0.5	3.0	15	66.7	70.0	100.0
'Magness' Self-Pollination	0.0	-	-	-	-	-
'Magness' Open Pollination	0.7	2.9	386	59.4	11.4	63.9
'Magness' General	4.9	3.1	3458	47.4	17.7	47.7
'Santa Maria' x 'Akça'	33.4	2.9	1037	61.1	23.6	91.7
'Santa Maria' x 'Ankara'	37.3	5.7	1194		In stratification	
'Santa Maria' x 'Bursa'	17.9	1.1	125	45.4	14.3	96.7
'Santa Maria' x 'Cleveland Select'	37.7	3.7	162	46.9	13.2	90.9
'Santa Maria' x 'Conference'	32.4	7.6	274		In stratification	
'Santa Maria' x 'Dancer'	14.9	0.6	5	40.0	50.0	100.0
'Santa Maria' x 'Güz'	11.0	1.2	107	57.5	30.0	57.0
'Santa Maria' x 'Kaiser Alexandre'	24.0	6.0	773		In stratification	
'Santa Maria' x 'Kieffer'	10.3	2.0	479	43.6	37.9	53.6
'Santa Maria' x 'Limon'	7.7	1.5	60	30.0	5.6	76.5
'Santa Maria' x 'Moonglow'	31.3	3.1	492	81.5	0.0	100.0
'Santa Maria' x 'Taş'	22.5	2.5	702	56.9	29.7	51.3
'Santa Maria' x 'Williams'	20.9	2.7	246	84.2	8.7	30.7
'Santa Maria' Self-Pollination	0.0	-	-	-	-	-
'Santa Maria' Open Pollination	23.1	4.3	416	54.9	15.4	53.2

Tab. 1. Investigated properties of the hybrid combinations (Continuous)

Combination	Fruit set ratio (%)	Mean seed number	Total seed number	Seed germination ratio (%)	The ratio of hybrid losses by root rot at early stage (%)	The ratio of hybrid losses by natural fire blight infection (%)
'Santa Maria' General	21.6	3.2	6072	54.7	20.8	72.9
'Williams' x 'Akça'	38.3	4.2	479	57.8	6.6	51.5
'Williams' x 'Ankara'	19.8	4.8	1581	64.0	7.2	16.3
'Williams' x 'Bursa'	8.5	2.3	107	78.1	12.7	59.7
'Williams' x 'Cleveland Select'	7.7	2.7	9	55.6	40.0	100.0
'Williams' x 'Conference'	32.9	5.6	933	23.1	3.1	40.2
'Williams' x 'Dancer'	26.1	0.5	53	56.6	23.3	60.9
'Williams' x 'Ekşi'	18.0	0.6	34	52.9	27.8	84.6
'Williams' x 'Güz'	4.5	1.2	160	66.1	6.5	46.2
'Williams' x 'Kaiser Alexandre'	17.2	6.1	637	41.9	11.4	72.6
'Williams' x 'Kieffer'	17.9	3.2	532	66.1	19.9	55.8
'Williams' x 'Limon'	1.4	0.1	19	42.1	0.0	75.0
'Williams' x 'Moonglow'	19.3	5.1	620	41.9	11.5	82.6
'Williams' x 'Pamuk Akçası'	24.4	0.9	6	50.0	33.3	50.0
'Williams' x 'Santa Maria'	9.9	4.0	422	23.5	19.2	63.2
'Williams' x 'Taş'	20.3	4.0	833	62.7	7.7	55.2
'Williams' SSelf-Pollination	0.0	-	-	-	-	-
'Williams' Open Pollination	16.4	3.6	872	45.0	11.6	53.0
'Williams' General	16.6	3.0	7297	51.7	15.1	60.4
TOTAL	15.1	2.9	24994	40.3	15.7	57.2

seeds in 'Ankara' and 'Pamuk Akçası' combinations (Tab. 1). Generally, the higher fruit set brought along the higher total seed number for combinations.

The germination of seeds is of great importance from the point of obtaining hybrid plants in breeding programs. Accordingly, seed germination was the lowest (7.4%) in the 'Akça' cultivar, because of it is one of the early ripening pear cultivars. Thus, seeds cannot ripen when the fruits are matured. Other female cultivars had more than 45% seed germination, in general. When the hybrid combinations were investigated for each cultivar, in the 'Akça' cultivar the maximum seed germination ratios was observed in 'Akça' x 'Güz' combination (30.0%) and open pollination treatment (20.6%). On the contrary, in combinations pollinated with 'Ankara', 'Ekşi', 'Limon', 'Pamuk Akçası' and self-pollination treatment, any seed germination was not detected. In 'Magness' cultivar, 'Magness' x 'Santa Maria' combination (87.2%) showed the best value, but in 'Bursa' pollinator no germination could be determined. 'Santa Maria', 'Williams' (84.2%) and 'Moonglow' (81.5%) combinations ended up with the highest seed germination values. 'Santa Maria' x 'Limon' combination (30.0%) replaced the last row. As for 'Williams' cultivar, 'Bursa' (78.1%) and 'Güz' (66.1%) cultigens had the highest seed germination ratios, despite their low fruit set values (Tab. 1). The lowest germination was obtained from 'Williams' x 'Conference' (23.1%) combination. As reported earlier (Lewandowski and Zurawicz, 2009), the differences occurred according to hybrid combinations related to seed germination.

Plant losses in the growing stage are serious problems in breeding programs. On this matter, a great majority of hybrid losses due to root rot was observed at an early growing stage. Taking into account female parents, maximum losses were observed in the 'Santa Maria' cultivar (20.8%), while 'Akça' lost the minimum (9.2%). In the evaluation of different crosses, 33.3% of 'Akça' x 'Kieffer' hybrids died because of root rot. On the other hand, there were no hybrid losses in 'Bursa', 'Güz', 'Kaiser Alexandre' and 'Moonglow' combinations of 'Akça'. In the 'Magness' x 'Williams' combination 70.0% of the germinated hybrids were lost after root rot infections, when no losses were detected in 'Kieffer' crosses. In the 'Santa Maria' cultivar, the combination with 'Dancer' (50.0%) placed on the first row on hybrid losses, when 'Moonglow' (0.0%) combination was the best. Lastly, in the 'Williams' cultivar, 'Cleveland Select' combination (40.0%) showed the highest hybrid losses but, 'Limon' (0.0%) and 'Conference' (3.1%) combinations lost minimum of hybrid (Tab. 1).

Fire blight, which is the most destructive disease for pear cultivars, appeared in 2008-2009 growing period. The response of the pear genotypes obtained from different crosses to fire blight attack was evaluated visually in natural conditions of infection. Therefore, a great majority of plant losses occurred in F₁ hybrid population which grew by means of their own roots. For instance, the ratio of losses through natural infection was the highest in 'Santa Maria' (72.9%) and 'Williams' (60.4%) female parents. In the evaluation related to different crosses, all the hybrids were lost in the 'Akça' x 'Bursa' combination. Additionally,

75% of 'Akça' x 'Kieffer', 71.2% of 'Akça' x 'Santa Maria' hybrids was killed by *Erwinia amylovora* infection. No losses were detected in 'Akça' x 'Güz' and 'Akça' x 'Moonglow' combinations. Natural infection gave rise to the death of all hybrids in 'Magness' x 'Williams', too. On the contrary, 'Limon' (29.0%) and 'Ankara' (29.1%) combinations had the lowest hybrid loss. For the 'Santa Maria' cultivar, all the hybrids were lost in 'Dancer' and 'Moonglow' combinations. Besides, infection resulted in the death of more than 90% of hybrids in 'Akça', 'Bursa' and 'Cleveland Select' combinations. Minimum loss was detected in 'Santa Maria' x 'Williams' combination with the ratio of 30.7%. All of the hybrids belong to 'Williams' x 'Cleveland Select' combination were lost. In 'Ekşi' and 'Moonglow' combinations of 'Williams', more than 80% hybrids were infected and died. 'Williams' x 'Ankara' (16.3%) combination displayed minimum hybrid loss in case of natural fire blight infection (Tab. 1).

Only 'Akça' x 'Güz' and 'Akça' x 'Moonglow' combinations have not presented symptoms of attack. 'Akça' x 'Williams', 'Magness' x 'Ankara', 'Magness' x 'Limon', 'Santa Maria' x 'Williams', 'Williams' x 'Ankara', 'Williams' x 'Conference', 'Williams' x 'Güz' combinations had lower plant losses from natural fire blight infection. Accordingly, the remarked parents could be used for further breeding programs. Since natural infection is of great importance in terms of defining resistance of genotypes to the pathogen (Layne and Quamme, 1975; Saygılı et al., 1999; Sestras et al., 2008), the observations obtained from this research are of great importance.

The ratio of hybrid losses due to fire blight attack differed according to the hybrid combinations in the current study. Confirming this, in the other investigation on the response of the pear genotypes, variation limits for the attack degree on trees were estimated between 0% ("No attack") and 100.0% ("Complete scorching - trees death"). Out of all genotypes, 75 of them, representing 20.5% were registered with "No attack", while 96 of them, representing 26.3% were extremely sensitive, so, the trees died in the fire blight attack (Sestras et al., 2008).

Although, 'Moonglow', 'Dancer', and 'Cleveland Select' (Bell et al., 2005; Honty et al., 2006) cultivars stated as resistant to fire blight, natural infection caused serious losses in some combinations of these cultivars. Similarly, Sestras et al. (2008) reported that some cultivars known as resistant were defined as susceptible to fire blight attack in Cluj-Napoca conditions; for example 'Old Home' was registered with AD% = 37.5 and 'Moonglow' with AD% = 54.2. On the hand, the 'Williams' cultivar is known as susceptible (Aysan et al., 1999; van Der Zwet and Beer, 1991) to fire blight, but, in some combinations of this cultivar, the survived hybrid ratio was high after natural infection, in our investigation. These data are parallel to the results obtained by Sestras et al. (2008). They explained that, a certain inconstancy of the cultivars reaction to *Erwinia* attack was noticed, as some are known as resistant or toler-

ant being susceptible or the contrary. 'Williams' considered highly susceptible was included in the no attack class. The same class encompassed 'Williams Bovey', while 'Williams Precoce Morettini's' trees were completely killed.

Observations in relation to fire blight carried out in the first year recorded 1477 and the second year 3637 hybrids in 63 combinations including different crosses and open pollination. A total of 678 of them survived from the first, and 2600 from the second year. The resistance level of the hybrids from various combinations differed among the cultivars used for cross pollination. In another research concerning the testing of 85 hybrids differences detected between crosses in terms of the degree of resistance. Because of these variations, a stable resistance level could not be detected for any of the species. It was observed that, resistance could not be transferred optimally in highly resistant x highly susceptible or highly resistant x highly resistant hybrid combinations. On the contrary, when two medium resistant parents combined, a maximum resistance level could be obtained (van Der Zwet et al., 1974).

Conclusions

Pollen viability and germination ratio, fruit set ratio, mean and total seed number, seed germination ratio, losses by root rot and natural fire blight infection changed through the hybrid combinations. The highest values of the characters such as pollen viability and germination ratio, fruit set ratio, mean and total seed number were obtained from the crosses with 'Kaiser Alexandre', 'Ankara', 'Akça', 'Conference' and 'Santa Maria' cultivars, in general. This situation is important to obtain a large hybrid population in breeding programs.

As a result of natural fire blight infection in the İzmir-Turkey conditions, the resistance level of the hybrids from various combinations differed among the cultivars used for cross pollination. No attack was identified in combinations such as 'Akça' x 'Güz' and 'Akça' x 'Moonglow'. Additionally, 'Akça' x 'Williams', 'Magness' x 'Ankara', 'Magness' x 'Limon', 'Santa Maria' x 'Williams', 'Williams' x 'Ankara', 'Williams' x 'Conference', 'Williams' x 'Güz' combinations had lower plant losses.

In this sense, the evaluation of hybrid population under natural fire blight infection is very important from the point of view of early selection in breeding projects. The detailed investigations must be maintained on this matter.

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