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Breeding *Erwinia amylovora* Tolerant F_1 Hybrid Pear: Selection of Promising Hybrid Pear Genotypes

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ABSTRACT

Plant breeding for resistance to stress factors has become extremely important with the development of new agricultural policies which decrease or prohibit the use of pesticides in agricultural production. The variety number of pear is inadequate, which has high-resistance to fire blight and fruit quality parameters are superior in the World. Laying out the garden with resistant rootstocks and varieties to fire blight is significant because the disease factor could reach to plants in all conditions. When the factor reaches the plant, main struggle occurs in the criterion of plants response. In this study, 15 pear genotypes, which were obtained as a result of different hybridization combinations, were evaluated with their two-year data. Hopeful genotypes were chosen with the weighted ranking method and total scores of genotypes were varied between 425 and 910. As a result of the method formed by the parameters which bring the commercial value of the genotypes to the forefront, 6 genotypes (II-15-61, II-27-21, II-15-75, II-18-21, I-12-3, II-33-34) have been found to have the potential of being registrable and they were transferred to the advanced observation parcels. Superior 6 genotypes, considered to registration, could contribute to pear cultivation.

1. Introduction

Fire blight, caused by *Erwinia amylovora* is the most devastating disease of pear. Disease effects all upper and lower organs such as flowers, shoots, roots and branches of host plants and kills whole plant (Van der zwet and Beer, 1995). Pear cultivars which have commercial value are displays high susceptibility to fire blight. This situation is limiting pear production quantity and threatens pear cultivation. In order to optimize the pear production, great importance should be implemented to fighting against to fire blight, There is no certain management application against the disease and chemicals used for fire blight are harmfull to environment, animal and human health. The lack of effective solution to the disease and the shift of the consuming tendency towards organic products lead to the usage of resistant rootstocks and varieties in controlling the disease (Bergamaschi et al., 2006). Due to the polygenic nature of fire blight resistance and the complexity of its mechanism, controlled hybridization is generally used in breeding programs (Bell et al., 2005). The susceptibility level of pear genotypes to *E. amylovora* obtained by hybridization is determined by artificial inoculations (Bergamaschi et al., 2006).

Breeding of resistance to fire blight started with the introduction of the Chinese sand pear to the Western America (Hedrick et al., 1921). The pear varieties such as ‘Garber’, ‘Kieffer’ and ‘Le Conte’ obtained from hybridizations are more resistant to fire blight than the other varieties. However, the fruit quality parameters of those varieties are not good. After the introduction of those varieties, breeding pear genotypes that are tolerant to fire blight and have superior fruit characteristics were initiated (Ryugo, 1982; Hunter, 1993; Durel et al., 2004; Malnoy et al., 2005; Evrenosoglu et al., 2010; Djennane et al., 2011).

Canadian researchers developed three varieties namely, ‘Harrow Queen’, ‘Harrow Delight’ and ‘Harrow Sweet’, which had good fruit quality and also resistant to fire blight disease, by hybridizing the disease-resistant species *Pyrus communis*, *P.*

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ussuriensis and *P. pyrifolia* selections with *P. communis* which has good fruit properties (Hunter, 1993). 'AC Harrow Delicious' and 'HW606' pear verieties were developed and when they were compared to 'Williams' and 'Dr. Jules Guyot', it was seen that these varieties have improved tolerance to fire blight disease (Hunter and Layne, 2004). ISF-FO 80-104-72 hybrid which is resistant to fire blight and having good fruit quality was obtained from 'Coscia' x 'Dr. Guyot' hybridization (Rosati et al., 2002).

A great majority of pear varieties in Turkey are highly susceptible to fire blight. Breeding projects have been initiated in order to obtain varieties which are resistant to fire blight and have superior fruit characteristics, and the studies are ongoing (Evrenosoğlu et al., 2010; Öztürk et al., 2011).

In this study, 15 pear genotypes and 2 having high commercial value cultivars ('Williams' and 'Santa Maria') were chosen as a reference were examined. Fruits belonging to those cultivars and genotypes were assessed by weighted ranking method to determine the superior ones (Calıskan and Polat, 2008; Ozturk and Demirsoy, 2013).

2. Materials and Methods

2.1. Materials

The study was carried out using 15 F_1 hybrid pear plants which are located in the experimental fields of Eskisehir Osmangazi University, Faculty of Agriculture in the years of 2014 and 2015. Hybrid plants were obtained from projects TOVAG 106O719 and TOVAG 110O938 initiated in order to develop new pear varieties which are resistant to fire blight and have superior fruit characteristics.

2.2. Methods

2.2.1. Evaluation for fire blight susceptibility

The susceptibility levels of hybrid plants were defined by artificial inoculations. In the artificial inoculation, 7 *Erwinia amylovora* isolates with a very high virulence level were used, as it is defined in the pathogenicity tests in apple and pear shoots. The hybrids were tested twice with a suspension of equal volumes of these isolates when they reached the appropriate size. Susceptibility of the shoots to fire blight was calculated according to the formula shown below (1).

$$\text{Variety Susceptibility} = \frac{\text{Length of the Infected Part (cm)}}{\text{Total Length of Shoot (cm)}} \text{x}100 \qquad (1)$$

Length of the infected part of the shoots was measured at the end of 8 weeks and then the arithmetic mean of the two values was taken and the VS value was calculated for each hybrid. Susceptibility values were calculated according to the table performed by Thibault et al (1987) and susceptibility characters and classes of hybrids were detected by scoring "A"-"E" susceptibility levels (Table 1). 15 hybrid pear genotypes were evaluated out of which 6 hybrids were included in class A, 3 hybrids in class B, 6 hybrids in class C (Evrenosoglu et al., 2010).

Table 1

Evaluation of susceptibility through artificial inoculation (Thibault et al., 1987)

Variety Susceptibility Value	% 0-10	% 11-20	% 21-40	% 41-60	% 61-100
Susceptibility Class	A	B	C	D	E
Susceptibility Character	Very low susceptibility	Low susceptibility	Moderate susceptibility	High susceptibility	Very high susceptibility

2.2.2. Determine superior hybrid genotypes

In the study, weighted ranking method was used in order to determine the superior genotypes. For this purpose, the breeder defines the selection criteria and gives those criteria the relative points based on the significance level. The total score belonging to each genotype is determined with this revealed scoring system. (Calıskan and Polat, 2008).

While determining the score, in addition to the properties obtained with the measurement (susceptibility level of hybrids to fire blight, fruit size, length/diameter ratio, soluble solids content, harvest time and fruit firmness), sensorial properties (eating quality, fruit attractiveness, stone

cell status of fruit and rustiness) which are detected by 5 panelists, were added to weighted ranking method (Table 2). International pear identification documents were used in selection of the criteria used in the weighted ranking table and in setting the reference values of the criteria (UPOV, 2000). All these parameters were evaluated with the 2-year data.

Table 2

Parameters, relative scores, class values and scores of the characteristics of hybrid pear genotypes based on modified weighted ranking method (UPOV, 2000)

Parameter	Relative Scores	Class Values and Scores of the Charecteristics	
Fire Blight Resistance	20	Slightly susceptible	10
		Less susceptible	8
		Mid-susceptible	5
		Susceptible	3
		Very susceptible	1
Eating Quality	15	Very good	10
		Good	7
		Middle	4
		Bad	1
Fruit Attractiveness	15	Very good	10
		Good	7
		Middle	4
		Bad	1
Harvest Time	10	Late > 01.09	10
		Middle 01.08-01.09	4
		Early < 01.08	7
Fruit Size	10	Very big (> 220g)	10
		Big (175-220g)	8
		Middle (130-175g)	5
		Small (75-140g)	3
		Very small (< 75g)	1
Length/Diameter	10	Very long	10
		Long	8
		Middle	5
		Short	3
		Very short	1
Soluble Solids Content	5	High (> % 13.75)	10
		Middle (% 10 - 13.75)	7
		Low (< % 10)	3
Stone Cell Status of Fruit	5	Few	10
		Middle	5
		Lot	1
Fruit Firmness	5	Very firm (>11 kg/cm^2)	1
		Firm (8-11 kg/cm^2)	10
		Middle (6-8 kg/cm^2)	7
		Soft (<6 kg/cm^2)	4
Rustiness	5	Very few	10
		Few	7
		Middle	4
		Lot	1

3. Results and Discussion

Breeding new pear genotypes that will establish a market presence in the World, requires to supply the requests of the consumers in every sense. For this purpose, the sensorial characteristics have been added to the measured properties and it has been tried to determine the superior genotypes by subjecting all the genotypes to the weighted ranking method and the result are given in Table 3.

Table 3
Scores of hybrid pear genotypes in terms of properties according to Modified Weighted Rating Method

Genotype	Disease Resistance	Harvest Time	Eating Quality	Fruit Attractiveness	Fruit Size	Length/Diameter	Soluble Solids Content	Stone Cell Status of Fruit	Fruit Firmness	Rustiness	Total
II-15-61 (Magness x Santa Maria)	160	100	150	150	100	80	50	50	50	20	910
II-27-21 (Williams x Akça)	100	70	150	150	50	80	35	50	35	35	755
II-15-75 (Magness x Santa Maria)	200	40	105	60	100	100	50	25	50	20	750
II-18-21 (Magness x Open Pollination)	200	40	105	105	80	50	35	50	35	35	735
I-12-3 (Akça x Open Pollination)	200	40	150	60	30	80	35	50	50	35	730
II-33-34 (Williams x Open Pollination)	100	70	105	150	50	80	50	25	50	35	715
Santa Maria	60	30	150	105	100	80	35	50	50	35	695
Williams	60	100	105	105	50	80	50	50	50	20	670
I-12-34 (Akça x Open Pollination)	160	70	150	60	30	50	50	50	20	20	660
II-11-73 (Kieffer x Santa Maria)	100	100	105	60	80	50	50	25	50	35	655
II-27-31 (Williams x Akça)	100	70	105	105	80	50	35	25	50	35	655
II-15-17 (Magness x Santa Maria)	100	30	150	105	50	50	50	25	35	20	615
II-27-137 (Williams x Akça)	100	30	105	105	80	50	50	25	35	20	600
II-16-4 (Magness x Taş)	160	30	105	105	30	50	35	25	35	20	595
I-34-4 (Williams x Akça)	200	70	60	15	30	50	35	25	50	20	555
II-11-20 (Kieffer x Santa Maria)	200	100	15	15	30	50	35	25	50	20	540
II-26-174 (Santa Maria x Open Pollination)	200	30	60	15	10	30	50	5	20	5	425

As a result of the modified weighted ranking method, the total point varied between 425 and 910 (Table 3). 'Santa Maria' (695 points) got the highest point among the commercial varieties included into the weighted ranking, used as a reference. This study carried out within the breeding program so hybrids which got higher point than 'Santa Maria' are considered as a candidate to become a new variety.

In the wake of the modified weighted ranking method, the total score is varied between 425-910 ranges. Among the commercial varieties used as a reference and included in the weighted ranking, 'Santa Maria' (695 points) got the highest score among varieties. In this study, hybrids which score higher than 'Santa Maria' variety are seen as candidates to become a new variety. In terms of total points, evaluations of the fruits of the hybrids remaining between 'Williams' and 'Santa Maria' varieties (670-695) will be continued and those with lower points than the 'Williams' variety (670) will be eliminated.

In consequence of the method formed by the parameters which bring the commercial value of the genotypes to the forefront, 6 genotypes (II-15-61, II-27-21, II-15-75, II-18-21, I-12-3, II-33-34) have been found to have the potential of being registrable. As the new candidate of cultivar, the fruits which belong to some hybrids having the potential are seen in Figure 1.

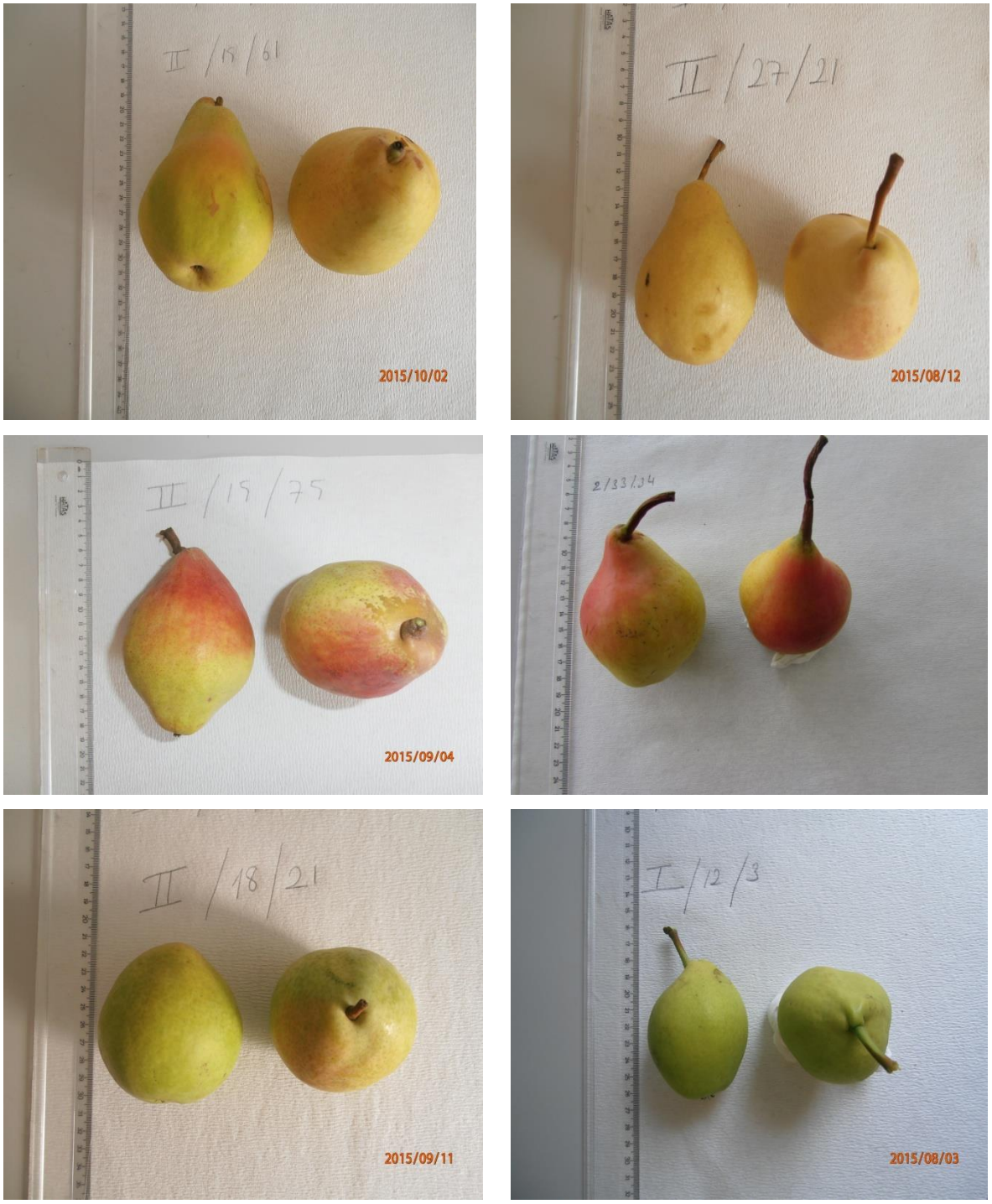

Figure 1
Fruits of some hybrids with registration potential

There are many studies in which the superior genotypes have been determined related to the pears by using the weighted ranking method previously. In a study done on the determination of the most suitable variety for Marmara Region, 11 varieties were subjected to the tests of suitability to the region and to the weighted ranking method in terms of 7 criteria and 4 cultivars were seen as hopeful (Akcay et al., 2009). The hybrids obtained within the scope of the project which Akdeniz University and Eğirdir Fruit Growing Research Institute have carried out together to develop the hybrid varieties resistant to fire blight, were sorted with the weighted ranking by using 7 parameters, and 73 genotypes considered hopeful were transferred to advanced observation parcel (Ozturk et al., 2011). In a study that carried out in the Northern Anatolia with 98 pear genotypes in order

to detect the hopeful pears, 6 characteristics were determined for weighted ranking and 14 genotypes were found hopeful (Ozturk and Demirsoy, 2013).

4. Conclusions

Fire blight is a disease which is hard to control and has hazardous effects. Although control precautions are taken to prevent the disease, the fire blight is widely seen in every region in which the pear growing is carried out. It's the fact that susceptibility of the tradable pear varieties to the disease threatens the pear growing. The fact that no effective solution has been found yet against the disease, chemicals used for fire blight are harmfull to environment, animal and human health, export products are sent back from the customs due to the residue and the tendency of consumers moves to organic products lead to the usage of resistant rootstocks and varieties in controlling the disease. It is thought that the disease related problems shall be reduced substantially by developing the resistant varieties in struggling with fire blight. In the present study, 6 genotypes (II-15-61, II-27-21, II-15-75, II-18-21, I-12-3, II-33-34) got high point from the weighted ranking method and were transferred to the advanced observation parcels. It is thought that superior 6 genotypes, considered to registration, could contribute to pear cultivation by being registered after the evaluation stage.

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