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Resistance of Pear Cultivars in Oregon to Natural Fire Blight Infection

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Abstract

In April 1994, severe fire blight infection occurred in a planting of 119 pear cultivar/rootstock combinations. Infection varied from 0 to 59 strikes per tree. Of four replicate trees of each cultivar/rootstock combination, 34, 34, 34, 15, and 2 combinations had infection in 0, 1, 2, 3, and 4 trees, respectively. 'Jules d'Airolles' and 'Worden Seckel' on OH x F 333 had fire blight strikes in all trees, with an average of 6.7 and 5.0 strikes per tree, respectively. Over 80% of all fire blight strikes were visible by 9 May. Most of the highly infected cultivars were at full bloom between 16 and 20 April, the time that coincided with extreme risk weather conditions. While some of the noninfected cultivars were well past full bloom when risk was high and may have escaped infection, others were in full bloom and may possess genetic resistance.

Introduction

Fire blight, one of the most serious and destructive diseases of pear in the United States and in many other countries of the world (9, 10), is caused by the bacterium *Erwinia amylovora* (Burrill) Winslow et al. Many reports of resistance of pear cultivars to fire blight, which appeared in the late 1960's and 1970's (1, 2, 5, 6, 11, 12), included observations of natural infections in pear cultivars as well as studies using artificial inoculation.

A pear cultivar trial with 119 cultivar/rootstock combinations was established in 1990 at the Oregon State University Mid-Columbia Agricultural Research and Extension Center (MCAREC), Hood River. According to the Courgarblight model developed in Washington and used successfully in the Pacific Northwest for several years (8), the fire blight risk level during pear bloom in 1994 was extremely high from 18-21 April. Degree hours exceeded 500 for four consecutive days, and rain occurred on both 18 April and 21 April. Although streptomycin was applied on 20 April, considerable fire blight infection was observed in the cultivar planting in early May. Because there appeared to be considerable differences in the severity of fire blight among the cultivars, quantitative data were collected and are reported herein.

Materials and Methods

Trees were planted in 1990 at a distance of 2.4 m within rows and 4.9 m between rows. The planting is a randomized complete block with four replicate trees of each cultivar/rootstock combination. Trees were trained to the central leader system. Several cultivars were planted on more than one rootstock (Table 1). Standard fertilizer, herbicide, and pesticide practices were followed (7).

Beginning on 9 May 1994, the number of visible fire blight strikes in each tree was recorded, then infected tissue removed by cutting at least 46 cm below visible symptoms. After each cut, pruning tools were sterilized with a solution of 0.525% sodium hypochlorite. Fire blight strikes also were counted and removed on the following dates: 20 and 23 May, 8 and 24 June, and 6 and 29 July. The number of trees infected per four replicates and the total number of infections per infected tree are given in Table 1. The date of full bloom for each cultivar also was recorded. Our criteria for determination of full bloom were that the cultivar must have at least 90 and 98% of the flowers

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Table 1. Susceptibility of pear cultivars to natural fire blight infection in Hood River, Oregon, 1994.

Cultivar	Rootstock	Date of full bloom[y]	Trees infected (%)[z]	Number strikes per infected tree	
				Range	Mean
Jules d'Airolles	OH x F 333	17	100	2-15	6.7
Worden Seckel	OH x F 333	18	100	2-8	5.0
Red pear 6-67	OH x F 333	20	75	6-36	17.7
Best Ever (OSU 2-301)	OH x F 97	17	75	4-40	16.7
Dr. Jules Guyot	OH x F 333	18	75	6-34	15.7
Red Spot	OH x F 333	18	75	14-18	15.3
Canal Red	OH x F 333	19	75	10-12	11.0
Eldorado	OH x F 333	18	75	3-18	8.0
Autumn Red	OH x F 333	18	75	1-10	5.0
Butirra Rosata Morettini	OH x F 333	14	75	1-6	3.7
Stark Super Red (Mock)	OH x F 97	19	75	2-7	3.7
Collins d'Anjou	OH x F 333	18	75	1-8	3.3
Red Angelo	OH x F 333	18	75	2-5	3.3
Rosired Bartlett	OH x F 333	18	75	1-6	3.3
Rubjyat	OH x F 333	18	75	2-5	3.3
New Century (Shinseiki)	OH x F 333	15	75	1-3	2.0
Olympic (A Ri Rang)	OH x F 333	14	75	1-1	1.0
California	OH x F 333	18	50	2-59	30.5
Glou-Morceau	OH x F 333	17	50	10-32	21.0
Sensation Red Bartlett	OH x F 333	16	50	1-35	18.0
Placer	OH x F 333	18	50	6-20	13.0
Concorde	OH x F 333	18	50	5-19	12.0
Concorde	OH x F 97	18	50	4-18	11.0
Vermont Beauty	OH x F 333	17	50	2-19	10.5
Scarlett Red Comice (Fowler)	Betulaefolia	18	50	1-14	7.5
Max Red Bartlett	OH x F 333	20	50	4-8	6.0
Butirra Precoce Morettini	OH x F 333	15	50	4-7	5.5
Duchesse de Brissac	OH x F 333	18	50	3-6	4.5
Flemish Beauty (IRP 164-1)	OH x F 97	16	50	3-6	4.5
IRP 24-1-2	Betulaefolia	18	50	4-5	4.5
Packham's Triumph (IRP 142-1)	OH x F 97	17	50	1-8	4.5
Swiss Bartlett (IRP 21-1)	Betulaefolia	18	50	1-8	4.5
Red Bartlett (Stark's)	OH x F 333	20	50	2-6	4.0
Bartlett (IRP 20-1)	Betulaefolia	18	50	1-6	3.5
Columbia Red d'Anjou	OH x F 333	16	50	2-4	3.0
Spartlett	OH x F 97	19	50	2-4	3.0
Conference	OH x F 333	18	50	2-3	2.5
IRP 44-1	Betulaefolia	18	50	1-4	2.5
IRP 45-1	Betulaefolia	18	50	1-4	2.5
Pound	OH x F 333	16	50	1-4	2.5
Twentieth Century (Nijiseiki)	OH x F 333	16	50	1-4	2.5
Comice	BA29C	19	50	1-3	2.0
Gorham	OH x F 333	18	50	2-2	2.0
Harrow Delight	OH x F 333	17	50	1-3	2.0
Harvest Queen	OH x F 333	18	50	2-2	2.0
IRP 24-1-2	Bartlett	18	50	1-3	2.0
Packham's Triumph (IRP 30-1)	OH x F 97	18	50	1-2	1.5

Table 1. (Continued).

Cultivar	Rootstock	Date of full bloom[y]	Trees infected (%)[z]	Number strikes per infected tree	
				Range	Mean
Red Bartlett (California)	OH x F 333	17	50	1-2	1.5
Ang x Dom H35-39	OH x F 97	19	50	1-1	1.0
Comice	OH x F 40	18	50	1-1	1.0
IRP 43-1	Betulaefolia	18	50	1-1	1.0
Fame	OH x F 333	19	25	50	50.0
Bosc	OH x F 40	19	25	21	21.0
Fondante d'Autumn	OH x F 333	17	25	18	18.0
D'Anjou (russeted)	OH x F 333	14	25	14	14.0
Doyenne d'Hiver	OH x F 333	16	25	7	7.0
IRP 2-1	Betulaefolia	17	25	7	7.0
Lacock 6	OH x F 333	17	25	7	7.0
IRP 2-1	Bartlett	17	25	5	5.0
Bartlett (IRP 22-1)	Betulaefolia	18	25	4	4.0
Red d'Anjou (Gebhard)	OH x F 333	16	25	4	4.0
Bosc	Bartlett	19	25	3	3.0
Capitol	OH x F 333	12	25	3	3.0
Cascade	OH x F 333	18	25	3	3.0
Ang x Dom 1-3 EH	OH x F 97	17	25	2	2.0
Devoe	OH x F 333	16	25	2	2.0
Duchesse de Angouleme	OH x F 333	17	25	2	2.0
French Bartlett (IRP 42-1)	Betulaefolia	18	25	2	2.0
Hosui	OH x F 333	16	25	2	2.0
MCP-1	OH x F 97	17	25	2	2.0
Shin Li	OH x F 97	13	25	2	2.0
Swiss Bartlett (IRP 21-1)	Bartlett	18	25	2	2.0
Abate Fetel	OH x F 97	17	25	1	1.0
Bartlett (IRP 20-1)	Bartlett	18	25	1	1.0
Bartlett (IRP 22-1)	Bartlett	18	25	1	1.0
Belmont	OH x F 333	17	25	I	1.0
Bosc	OH x F 97	19	25	1	1.0
Cal 8-46	OH x F 333	15	25	1	1.0
Comice	OH x F 97	17	25	1	1.0
Dabney	OH x F 333	16	25	1	1.0
French Bartlett (IRP 42-1)	Bartlett	18	25	I	1.0
Hoskins	OH x F 333	19	25	1	1.0
Lincoln	Bartlett	17	25	1	1.0
Red Silk	Bartlett	17	25	1	1.0
US 56112-146	OH x F 97	17	25	I	1.0
B.P. Morettini (Fowler)	Winter Nelis	18	0	0	0.0
Bantam	OH x F 333	15	0	0	0.0
Bartlett (IRP 3-1)	Bartlett	18	0	0	0.0
Bartlett (IRP 3-1)	Betulaefolia	18	0	0	0.0
Bileu	OH x F 333	18	0	0	0.0
Blanquilla	OH x F 97	13	0	0	0.0
Bosc	OH x F I8	19	0	0	0.0
Bradford (IRP 133-1)	OH x F 97	17	0	0	0.0
Bronze Beauty Bosc	OH x F 333	18	0	0	0.0
Comice	Bartlett	19	0	0	0.0

Table 1. (Continued).

Cultivar	Rootstock	Date of full bloom[y]	Trees infected (%)[z]	Number strikes per infected tree	
				Range	Mean
Comice	OH x F 333	18	0	0	0.0
Comice (Crimson Gem)	OH x F 333	18	0	0	0.0
Dana Hovey	OH x F 333	17	0	0	0.0
Dawn	OH x F 333	17	0	0	0.0
Fukui Bosc	OH x F 333	18	0	0	0.0
Gaspard	OH x F 333	15	0	0	0.0
IRP 23-1-3	Bartlett	18	0	0	0.0
IRP 23-1-3	Betulaefolia	18	0	0	0.0
IRP 43-1	Bartlett	18	0	0	0.0
IRP 44-1	Bartlett	18	0	0	0.0
IRP 45-1	Bartlett	18	0	0	0.0
Karr Bosc	OH x F 333	18	0	0	0.0
Magness	OH x F 333	18	0	0	0.0
Magness 3866E	OH x F 333	17	0	0	0.0
Maxine	OH x F 333	18	0	0	0.0
Missouri 83	OH x F 333	16	0	0	0.0
Moonglow	OH x F 333	16	0	0	0.0
Mount Adams Bosc	OH x F 333	19	0	0	0.0
Passe Crassane (IRP 31-1)	OH x F 97	17	0	0	0.0
Passe Crassane Rouge (IRP 32-1)	OH x F 97	17	0	0	0.0
Shinko	OH x F 333	13	0	0	0.0
Tsu-Li (IRP 166-1)	OH x F 97	11	0	0	0.0
US 65003-023	OH x F 97	17	0	0	0.0
Waite	OH x F 333	17	0	0	0.0

[y]April.
[z]Based on four replicate trees. Disease data are based on evaluations from 9 May through 29 July.

open on the north and south sides of the tree, respectively.

Results and Discussion

Over 80% of all fire blight strikes were visible by 9 May, the first date of removal of infected tissue. Of the 119 cultivar/rootstock combinations, 34 had no fire blight strikes in any of the four replicate trees (Table 1). Another 34 combinations had only one tree with fire blight infection. Two trees were infected in 34 combinations, including 'California,' 'Glou-Morceau,' and 'Sensation Red Bartlett' on OH x F 333, all with more than 18 strikes per infected tree. Three of the four trees were infected in 15 cultivar/rootstock combinations, including Red pear 6-67, 'Dr. Jules Guyot,' and 'Red Spot' on OH x F 333 and 'Best Ever' on OH x F 97, all of which had more than 15 strikes per infected tree. Two cultivars, 'Jules d'Airolles' and 'Worden Seckel' on OH x F 333 had fire blight strikes in all trees and an average of 6.7 and 5.0 strikes per tree, respectively. All trees of these two cultivars had to be removed in 1994.

Although each study on pear cultivar resistance includes many cultivars not tested in other rankings, some common cultivars often appear. 'California' and 'Glou-Morceau,' which were susceptible in our trial, also are considered susceptible by others (10). Cultivars with no fire blight in our trial and also listed as resistant by others include 'Bantam' (10), 'Dawn' (1), 'Magness' (1), 'Maxine' (1, 6), 'Moonglow' (1), 'Shinko' (3), and 'Waite' (1). Resistance of a few cultivars differed from previous reports. 'Eldorado,' which we found susceptible, was considered resistant by Aldwinckle and van

Table 2. Fire blight severity on IRP clones with Bartlett and *Betulaefolia* rootstocks.

IRP clone[y]	No. strikes/infected tree	
	Bartlett	*Betulaefolia*
2-1	5.0	7.0
20-1	1.0	3.5
21-1	2.0	4.5
22-1	1.0	4.0
23-1-3	0.0	0.0
24-1-2	2.0	4.5
3-1	0.0	0.0
42-1	1.0	2.0
43-1	0.0	1.0
44-1	0.0	2.5
45-1	0.0	2.5
Mean[z]	1.1	2.9

[y]All IRP designations are clones of Bartlett.
[z]Means are significantly different at P = 0.00.

der Zwet (1). 'Dana Hovey' and 'Passe Crassane' were free of infection in our study but susceptible in other studies (10).

Considerable variability occurred among replicates. For example, the four 'Fame' replicates had 0, 0, 0, and 50 strikes per tree. Although many of the more severely infected trees were in the same general area of the orchard, highly infected trees were seldom adjacent to one another. The pattern in the orchard showed a general "band" running in an east-west direction and may be related to spread of inoculum by the prevailing west wind.

In this and other plantings at MCAREC, trees on OH x F 18 appeared most resistant while the same cultivars on OH x F 40 appeared most susceptible. For example, 'Comice,' 'Bosc,' and 'Golden Russet Bose' on OH x F 40 had means of 1.0, 21.0, and 2.4 strikes per infected tree, respectively. These cultivars on OH x F 18 were free of infection. Also, nine of the eleven IRP cultivars on 'Bartlett' seedling rootstock were more resistant than when the cultivars were on *Pyrus betulaefolia* rootstock (Table 2). The rootstock difference was highly significant (P = 0.01) according to a paired "t" test. We have observed that cultivars on OH x F 18 and OH x F 40 are similar in vigor. However, *P. betulaefolia* is considered a very vigorous rootstock (4). For many years, vigorous growth has been associated with fire blight infection (10).

Most of the highly infected cultivars were at full bloom between 16 and 20 April, the time that coincided with extreme risk weather conditions. Cultivars showing no infection were at full bloom over a wide time period of 11 to 19 April. Thus, while some of these noninfected cultivars were well past full bloom when risk was high and may have escaped infection, others were in full bloom and may possess genetic resistance. Because of the diversity of bloom dates of the cultivars in this trial, caution must be used when evaluating the results. The study is most valuable in sorting out highly susceptible cultivars since those without blight may be resistant but also may have escaped infection.

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Rootstock Effects on Growth and Fruiting of a Spur-Type and a Standard Strain of 'Delicious' Over Eighteen Years

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Abstract

'Red Prince,' a standard strain and 'Redchief' (Campbell strain), a spur-type strain of 'Delicious' apple were grown on several rootstock/interstock combinations for 18 years. The dwarfs were Malling 9 (M.9), M.26, M.9/Malling Merton 106 (MM.106), and M.9/M M.111. The semi-dwarfs were M.7, MM.106, and MM.111. Five three-tree replications were used. In-row spacing was varied from 1.8 to 5.5 m depending on the scion/interstock/rootstock combination; between-row spacing was 6.1 m throughout the experiment. Tree survival ranged from a high of 100% for five combinations to as low as 13% for both 'Delicious' strains on MM.106. In the dwarf group, trees of both strains on M.26 were the largest, those on M.9/MM.111 were intermediate, and those on M.9 and M.9/MM.106 were the smallest. The greatest numbers of rootsuckers were on trees on M.9/MM.111 and M.7. Crop density tended to be higher with 'Redchief' than 'Red Prince' and higher in the dwarf than semi-dwarf group. With both 'Redchief' and 'Red Prince,' cumulative per-tree yields were greater on M.26 than on M.9 or M.9/MM.111. Trees of 'Redchief' on the three semi-dwarf rootstocks yielded similarly; 'Red Prince' trees on MM.111 out-yielded trees on M.7. With both strains, trees on M.9 and M.9/MM106 tended to have higher cumulative yield efficiencies than those on M.26 or M.9/MM.111. Cumulative yields (T/ha) for both strains were highest for trees on M.26 compared to all other rootstocks. Cumulative yields for the three semi-dwarf rootstocks differed little with either scion.

Introduction

Most apple growers utilize clonally propagated, size-controlling rootstocks. Genetic dwarfing is the main choice for controlling tree size and productivity because the degree of tree size restriction possible by pruning and training is quite limited, and growth control chemicals are largely unavailable.

Rootstock evaluation studies have been published in many parts of the world. Some of these have been preliminary in nature, often providing data for five years up to a rather common maximum of 10 years. Although these reports are informative, there is also the need for long-term experiments for 15 or more years. Because of the great precocity of the very dwarfing rootstocks, yield data over only a 5-10 year period may tend to bias conclusions in their favor, while in longer term studies, less precocious stocks might

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