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Observations on the Susceptibility of Japanese Apple Cultivars and Rootstock Selections to Fire Blight[1]

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Abstract

Apple cultivars and rootstocks were evaluated for susceptibility to fire blight following controlled inoculation with *Erwinia amylovora*. Most of the x Japanese apple cultivars tested were susceptible to fire blight, but 'Himekami' was intermediate. Most of the x Morioka rootstock selections and the x Cornell University rootstock selections tested had levels of resistance similar to, or greater than, that of Malling 7 (M.7).

Introduction

Fire blight is a serious bacterial disease of apple and pears caused by *Erwinia amylovora* (Burr.) Winslow, et al. Fire blight has been reported on apple in North America, Europe, New Zealand, and in the Near East (20). A new strain of *E. amylovora* was recently isolated from Asian pear in Japan (4). The pathogen was identified as *E. amylovora* biovar 4 which is distinct from *E. amylovora* bv. 1, 2 and 3 isolated in countries outside of Japan (13). This strain was found to be pathogenic to some apple cultivars following artificial inoculation (4). However, there have been no reports of natural infection of apples in Japan.

Many apple cultivars bred in Japan are being examined for commercial potential in the United States. 'Fuji' and 'Mutsu' have become popular in the U.S., and new cultivars such as 'Sansa' and 'Sensyu' (synonym of 'Senshu') are considered promising in several regions (9, 17). Although many apple cultivars have been evaluated for susceptibility to fire blight (1, 2, 3, 12, 14), few Japanese cultivars have been tested.

The susceptibility of rootstocks to fire blight is also a serious problem. Severe damage or whole tree mortality is likely on susceptible rootstocks. Resistant rootstocks have been selected at Cornell University (7). Ten Morioka rootstock selections from the cross of *Malus prunifolia* x Malling 9 were selected based on dwarfing ability and ease of propagation at the Apple Research Center, National Institute of Fruit Tree Science in Japan (5). Five rootstocks from this research center were named: JM1, JM7, and JM8 in 1996; JM2 and JM5 in 1997 (19). They have been not examined for susceptibility to fire blight.

We report here results of controlled inoculations of apple cultivars and rootstocks introduced from Japan and Cornell University rootstock selections.

Materials and Methods

Scion-wood was obtained from the New York State Agricultural Experiment Station, Cornell University, Geneva; Plant Genetic Resources Unit, National Clonal Germplasm Repository, Geneva; Center of Plant Health, Sidney, B.C.; and the University of Massachusetts, Amherst, Mass. Scion-wood was budded or grafted on seedling rootstocks in the greenhouse. Succulent shoots of each plant were used for inoculation.

E. amylovora strain Ea 273 isolated from apple in New York was used in the experiment. Broth cultures were started from a single colony from a freshly revived

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Table 1. Reaction of terminal shoots of Malus genotypes to artificial inoculation with *Erwinia amylovora* (Experiment 1).

Genotype	Replication	Shoot Length (mm)	Lesion Length (mm)		Percent shoot length blighted[z]	
CG.007	5	101	0	a	0	a
CG.41	6	117	0	a	0	a
CG.210	3	103	0	a	0	a
G.11	8	113	0	a	0	a
M. Prunifolia	3	142	0	a	0	a
CG.189	6	107	1	a	1	a
Morioka 10	3	108	1	a	1	a
M. sieboldii	6	127	8	ab	6	ab
Himekami	6	176	24	abc	13	abc
JM2	2	101	32	abc	32	bcd
JM1	13	167	47	abcd	34	bcd
M.7	8	127	45	abcd	35	cd
Akane	6	147	64	bcdef	49	de
Jonagold	4	154	82	cdefg	51	de
Mutsu	9	100	53	abcde	53	de
Fuji	4	144	71	cdef	55	de
Golden Delicious	4	115	79	cdefg	66	e
Jonathan	8	142	113	efg	76	ef
M.26	3	83	62	bcdef	78	ef
Sansa	7	149	125	fg	86	f
Ralls Janet	3	143	133	g	94	f
Orin	6	103	103	defg	100	f
Sensyu	2	130	130	g	100	f

[z]Percent shoot lengths blighted followed by same letter did not differ significantly (P=0.05) according to Duncan's multiple range test on arc-sin transformation data.

lyophilized culture. Inoculum consisted of 20-hr-old cultures grown in Kado 523 broth (10) at 25±3°C and contained ~ 10^{10} colony-forming units per milliliter. The preparation of inoculum and inoculations were based on Aldwinckle and Preczewski (2). A 0.46-mm diameter (26-gauge) hypodermic needle was inserted through the stem just above the youngest unfolded leaf. Sufficient inoculum was introduced to fill the wound after inoculation. In the first experiment, 23 genotypes were inoculated on 29 June 1995. Two to thirteen replicates of each cultivar were used for experiment 1. The length of visible fire blight lesions and of current season's shoot growth were recorded on 21 August 1995, after all lesions had ceased to extend as determined by the formation of a determinate margin between diseased and healthy tissue. The mean of maximum temperatures during the experiment was 28.1°C with a mean minimum temperature of 16.8°C. In experiment 2, 15 genotypes were inoculated on 20 July 1995. Two to seven replicates of each cultivar were used for experiment 2. Lesion length and total shoot length were measured on 22 September 1995. The mean of maximum temperature during the experiment was 25.9°C with a mean minimum temperature of 14.1 °C. The percentage of the current season's shoot length that was necrotic was calculated. The length of fire blight lesions and the percentage of shoot length blighted after arc-sin transformation for normality were separated by Duncan's multiple range test.

Table 2. Reaction of terminal shoots of Malus genotypes to artificial inoculation with *Erwinia amylovora* (Experiment 2).

Genotype	Replication	Shoot Length (mm)	Lesion Length (mm)		Percent shoot length blighted[z]	
CG.007	3	108	0	a	0	a
G.11	2	100	3	a	3	ab
CG.41	3	133	9	ab	7	abc
JM2	7	125	10	ab	8	abc
M.7	3	129	29	abc	23	abc
Homei Tsugaru	2	60	16	abc	27	bc
JM7	4	174	47	bc	27	bc
CG.210	3	80	24	abc	30	bc
CG.120	5	76	26	abc	34	bc
Sensyu	3	114	59	c	52	c

[z]Percent shoot lengths blighted followed by same letter did not differ significantly (P=0,05) according to Duncan's multiple range test on arc·sin transformation data.

Results and Discussion

The length of fire blight lesions and the percentage of shoot length blighted on 12 apple cultivars and 14 rootstock selections were determined in the greenhouse (Table 1 and Table 2).

In both experiments Cornell-Geneva (CG.) 007 and Geneva (G.) 11 had the shortest lesion length, M.7 was intermediate, and 'Sensyu' was very susceptible. The reaction of CG.210 was variable. In experiment 1, no lesions developed on inoculated CG.210, but in experiment 2, the reaction of CG.210 was similar to M. 7

In experiment 1, the Geneva selections, *M. prunifolia*, Morioka 10 and *M. sieboldii* had shorter lesion lengths than M.7, but these differences were not statistically significant. However, the percent shoot length blighted was significantly less than M.7 (Table 1). 'Himekami', JM2 and JM1 showed resistance similar to M.7. 'Akane', 'Jonagold', 'Mutsu', 'Fuji', and 'Golden Delicious' had lower percent shoot length blighted than 'Sensyu'. 'Jonathan', M.26, 'Sansa', 'Ralls Janet', and 'Orin' were highly susceptible to fire blight.

Fire blight lesions in experiment 2 developed less (0 to 52% shoot length blighted) (Table 2) than in experiment 1 (0 to 100% shoot length blighted) (Table 1). Plant material was less vigorous in experiment 2. It is well known that active and vigorous growth favors initiation of infection by *Erwinia amylovora* and subsequent development of fire blight (18), the less vigorous plant material in experiment 2 may have led to low susceptibility. CG.007, G.11, CG.41 and JM2 had shorter lesion lengths than M.7. CG.007 and G.11 had less shoot length blighted than

Table 3. General classification of fire blight susceptibility of Malus genotypes

Susceptibility class	Genotype
Highly susceptible	Jonathon, Orin, RallsJanet, Sansa, Sensyu, M.26
Susceptible	Akane, Fuji, Golden Delicious, Jonagold, Mutsu
Intermediate	Himekami, JM1, JM2, M.7
Intermediate to resistant	CG.210
Highly resistant	CG.007, CG.41, CG.189, G.11, Morioka 10, M.prunifolia, M.sieboldii

'Sensyu'. 'Homei Tsugaru', JM7, CG.210 and CG.120 and 'Sensyu' had a higher percentage of shoot length blighted than CG.007. 'Sensyu' had the greatest lesion length blighted in both experiments. The difference in susceptibility to *E. amylovora* between experiment 1 and experiment 2 shows the environmental effects and the need for replicating tests.

The susceptibility of the genotypes to fire blight is based on the results of experiment 1 and experiment 2, and summarized in Table 3. Most rootstocks were considered to have levels of resistance similar to, or greater than, that of M.7. Most of the x Japanese apple cultivars tested were susceptible to fire blight, but 'Himekami' was classified as intermediate. There was not sufficient data to reliably classify 'Homei Tsugaru', JM7, and CG.120.

'Himekami' was derived from a cross between 'Fuji' and 'Jonathan' (21). Both parents are considered to be susceptible. Previous studies have indicated that resistance to fire blight is polygenically controlled with dominant additive gene effects (8, 11). Further experiments are needed to confirm the resistance level of 'Himekami'.

This report was limited to strain Ea 273, the normal "wild" type endemic in New York. Since differential susceptibility of *Malus* species to strains of *E. amylovora* has been reported (15, 16), it will be necessary to examine the susceptibility of these apple varieties and rootstocks to different strains of *E. amylovora*.

The new rootstocks developed at Cornell University by Cummins and Aldwinckle have been reported to be resistant to fire blight (7). Our study confirmed that the rootstock selections from Cornell University were more resistant to fire blight than M.7. The Morioka rootstock selections were resistant or intermediate in resistance to fire blight. This resistance may have been transmitted from *M. prunifolia*. Rootstocks from both the Cornell University and the Morioka Station can be useful as rootstocks and as sources of fire blight resistance for future breeding.

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Rootstock and Scion Affect Cold Injury of Young Pecan Trees

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Abstract

An exceptionally early Autumn freeze on 8 and 9 October 2000 injured young pecan trees [Carya illinoinensis (Wangenh.) C. Koch]. There was less injury to current season's growth on 'Kanza' than on 'Mohawk', 'Mount' and 'Creek'. Trees on rootstocks of 'Peruque', 'Giles', 'Colby', 'Apache', and native seedlings from Stillwater, Okla. and Brunswick, Mo. were among the least injured by the fall freeze. Trees on 'Starking Hardy Giant' and natives from Chetopa, Kans. were the most severely injured by the freeze. Cold hardiness imparted to the scion by the rootstock was not closely related to the climate at

Introduction

Cold injury of pecan is a frequent problem. One form occurs in the Autumn before trees have acclimated to cold temperatures (3, 9, 14), another form during winter usually after trees have met their chilling requirement (1, 7, 13, 16), and another in the spring when damage is done to buds or developing shoots (4, 5, 12). A cultivar or rootstock resistant to one type of cold injury is not necessarily resistant to all types of cold injury. For instance, 'Pawnee' is resistant to both fall and mid winter cold injury, but is among the first cultivars to break bud in the spring, and therefore is highly susceptible to spring freeze damage. Cultivar and rootstock dramatically affect cold injury (1, 2, 3, 7, 11, 13, 16). During a freezing event it is common to find certain cultivars uninjured while others are severely damaged or killed (11), and certain rootstocks impart sufficient cold hardiness for a cultivar to escape injury on one rootstock genotype while being killed on another (2). This emphasizes the importance of selecting the correct cultivars and rootstocks for each production area.

Pecan cold hardiness is largely based on the effects of cold on field plantings. Controlled freezing tests have generally been unsuccessful (8). Substantial information has been amassed on the cold hardiness of older cultivars, but little is known about recently released cultivars. Also, little information is available concerning how the rootstock affects cold hardiness of the scion. Hinrichs (2) reported that cold fall temperatures killed 1-year-old 'Stuart's-cions on certain rootstocks, while similar 'Stuart' scions on other rootstocks were not injured. Low Autumn temperatures damaged more 4-year-old 'Wichita' and 'Choctaw' trees on 'Riverside' rootstock

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