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Fire Blight Susceptibility of Apple Introductions and Selections[1]

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Abstract

Susceptibility of 68 cultivars and selections of apple (*Malus* x *domestica*) to *Erwinia amylovora* was determined by artificial inoculation of trees in the orchard. Ten vigorously growing shoots per tree were tip inoculated by injecting a 36-hr broth culture of a highly pathogenic local isolate. Lesion length was measured 3 mo after inoculation and expressed as a percentage of the current season's shoot length. Mean percentage ranged from 2 to 171%, indicating a wide range in levels of genetic susceptibility to fire blight. Old cultivars of European origin were generally highly susceptible cultivars of North American origin and genotypes selected for resistance to apple scab (*Venturia inaequalis*) were generally resistant.

Fire blight, incited by *Erwinia amylovora* (Burrill) Winslow et al., is a serious bacterial disease of apple (*Malus* x *domestica* Borkh). Control measures include chemical sprays, sanitation, good cultural practices, and the planting of resistant cultivars (1, 2, 4).

Although no cultivars are completely resistant, great differences in susceptibility exist. Several authors have reported susceptibility ratings of apple cultivars based on natural infection in the field (5, 7). Because initiation and development of the disease are influenced by factors including rootstock, soil water availability, aphid infestation, number and age of suckers, and weather before, during, and after bloom (2, 4), absence of infection over a few years cannot be considered conclusive evidence of genetic resistance (6). Artificial inoculation of shoots under controlled conditions has yielded data largely in agreement with field observations (2, 4).

This paper reports the results of artificial inoculation of shoots of 68 cultivars and selections of apple. Included were recent plant introductions, old North American cultivars, and recent selections from the Purdue-Rutgers-Illinois (PRI) Cooperative Apple Breeding Program. Most of the cultivars were either not included in previous studies or information is available only from field observation This information should be valuable to breeders and those involved in the collection and preservation of apple germplasm.

Materials and Methods

Single trees of 68 apple genotypes in a small orchard were used. Trees were on domestic seedling rootstock (seed parent: 'Delicious') and were 5-20 yr old. Trees were pruned heavily during the dormant season and fertilized by hand to stimulate shoot growth. Ten succulent shoots ca. 40 cm in length were flagged on each tree. The cultivars 'Alexander' and 'Calville Blanc' were included as susceptible checks. 'Priscilla,' 'Liberty,' and 'Britemac' served as resistant checks.

Erwinia amylovora was isolated from current season infections on 'Gros Bois' (PI 173981), 'NJ74,' and two seedlings highly susceptible to

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Table 1. Reaction of terminal shoots of apple to artificial inoculation with *Erwinia amylovora*.

Cultivar or Selection	Mean[a]
Highly Susceptible Cultivars[b]	
Antonovka Kamenitshka	171
Alexander	159
Cestra Belfer Kitajka	147
Bessemianke	113
Kitajka Zolotaja	110
Pepin Shafrannyi	106
Co-op 18[c]	103
Calville Blanc	99
Spencer Seedless	97
Charlamoff	96
Lura Ellis	95
Polly Eades	94
Cap of Liberty	93
Priol's Delicious	93
Susceptible Cultivars	
Pacific Gold	90
M2439	90
Wainwright	87
Ivette	87
Z74-5011-18	87
Jonafree[c]	85
Sinta	85
Wellington Bloomless	83
Co-op 16[c]	79
Shinko	77
Frumos de Voinesti	75
Ein Shemer	75
Coast Apple	74
Co-op 15[c]	73
Mislimka	72
Co-op 7[c]	72
Blushing Golden	64
Tasma Oz 10-9	64
Carola	62
Reine des Pommes	60
Champagne Reinette	60
Gjallen	57
Killand	57
Co-op 10[c]	55
Detroit Red	54
Crown Prince Rudolf	54
Intermediately Resistant Cultivars	
Kestrel	48
Mandan	47
Garrison	47
Peace Garden	46
Elita 20 Marculesti	45
Summer Treat	42
Worcester Pearmain	38
PI 312810	32
Resistant Cultivars	
Dakota	30
Clivia	30
Heyer #2	28
Prima[c]	28
Redfree[c]	26
Thorberg	25
Co-op 20[c]	23
Dukat	21
Co-op 12[c]	20
Goldjon	15
Auralia	14
NJ 136055	13
Paducah	13
Pohorka	13
Highly Resistant Cultivars	
Lyman's Large Summer	10
Priscilla[c]	7
PI 158586	5
PI 129155	3
Liberty[c]	3
Britemac	2
Standard Error	12

[a]Lesion length was expressed as a percentage of the current season's shoot growth.
[b]Cultivars and selections are grouped according to the classification system of Gardner *et al.* (1980).
[c]Cultivars and selections carrying the V_f gene for resistance to apple scab.

fire blight and grown in nutrient broth at 22C for 36 hours. The broth cultures containing 10^8-10^{10} cells/ml were combined and used directly as inoculum. A 26 gauge hypodermic needle was pushed through the stem at the base of the petiole of the youngest expanded leaf. The cavity thus formed near the shoot apex was filled with inoculum by injecting until drops appeared on both sides of the stem. Inoculations were performed in the morning on 7 June 1985. Lesion length and length of the current season's growth were recorded in mid-September after all lesions had ceased extending. Lesion length expressed as a percentage of the current season's growth was calculated for each shoot and mean percentage for each genotype was determined.

Results

Wide variation in fire blight infection was observed among the cultivars and selections tested (Table 1). Using the classification system of Gardner, *et al.* (6), cultivars ranged from highly susceptible to highly resistant. Several cultivars of Eastern European origin, including 'Alexander,' 'Antonovka Kamenitshka,' 'Cestra Belfer Kitajka,' 'Bessemianke,' 'Kitajka Zolotaja,' 'Pepin Shafrannyi,' 'Calville Blanc,' and 'Charlamoff' were extremely susceptible. Other cultivars of European origin, including 'Priol's Delicious,' 'M2439,' 'Ivette,' 'Z74-5011-18,' 'Frumos de Voinesti,' 'Mislimka,' 'Tasma Oz 10-9,' 'Carola,' 'Reine des Pommes,' 'Champagne Reinette,' and 'Crown Prince Rudolf' were susceptible. Other introductions from Europe including 'Pohorka.' 'Auralia,' 'Goldjon,' 'Dukat,' 'Clivia,' and 'Worcester Pearmain' exhibited a fairly high level of resistance. Recent introductions from North American breeding programs, including 'Britemac,' 'Paducah,' and the scab-resistant genotypes 'Liberty,' 'Priscilla,' 'Redfree,' 'Prima,' 'Co-op 12,' and 'Co-op 20' were highly resistant or resistant. Other scab-resistant selections, notably 'Co-op 18,' 'Co-op 16,' and 'Jonafree' were susceptible to fire blight. The ranking of check cultivars was in the expected order.

Discussion

All apple cultivars tested were susceptible to *E amylovora* in the sense that infection occurred after inoculation with a massive dose, although the data indicate large differences in susceptibility. These data cannot be compared directly with ratings of blight severity under natural conditions, as such ratings are influenced by many uncontrolled factors. The data represent the potential of the genotypes tested to be damaged by fire blight under field conditions highly favorable for the disease.

The high degree of susceptibility of the European introductions was expected. As fire blight has not yet become established in Eastern Europe, there has been no selection. neither natural nor artificial, for resistance to the pathogen (8).

The level of resistance in the scab-resistant selections produced by the PRI Cooperative Program is encouraging. Selection was based on fruit quality and resistance to apple scab. Information on fire blight resistance was based solely on field observation. It is possible that fire blight resistance was transmitted fortuitously along with scab resistance from *M. floribunda* (1), but that 'Co-op 18,' 'Co-op 16,' and 'Jonafree' were not so fortunate.

The results of the present study are largely in agreement with the results of previous studies (2, 3. 4, 5, 6, 7), with one notable exception. 'Antonovka Kamenitshka,' the most susceptible cultivar in our study, was found to be highly resistant by Gardner *et al.* (6). It is likely that we are dealing with two different cultivars with the same name.

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Current Status of Several Japanese Apple Cultivars

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Abstract

Apple breeding programs in Japan have resulted in the introduction of such cultivars as Mutsu, Fuji, and Akane to the U.S., Canada, and Europe. Many of the more recent Japanese introductions have not been evaluated outside their home country, and their potential for commercial development elsewhere is unknown. Descriptions of some of these new apple cultivars, obtained in Japan during informational tours of tree fruit research stations and commercial and nursery growers, may be of value to those who have an interest in obtaining material for possible introduction.

This article updates our evaluation of new apple cultivars and planting trends in Japan and follows the report by Yoshida and Mink of more than 10 years ago (2). The information reported was obtained during a three-week tour of tree fruit research stations in northern Honshu in September-October 1985 by the senior author[2], a two-week visit to Japan in 1984 by the second author and also through subsequent correspondence with breeders and nurserymen in Japan and the United States. Some of the cultivar descriptions are condensed from Japanese nursery catalogs[3].

A brief historical perspective of apple cultivar development and the apple industry in Japan has been presented by Yoshida and Mink (1, 2). The first apple cultivars imported into Japan from the United States in 1871 included 'Baldwin,' 'Ben Davis,' 'Jonathan,' 'Ralls Janet' and 71 others. 'Delicious,' 'McIntosh,' 'Golden Delicious,'

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