Severity of Fire Blight on Apple Cultivars and Strains in Michigan

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ABSTRACT

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During the 1991 growing season, 84 apple (*Malus domestica*) cultivars and strains in an experimental planting were evaluated in July and again in September for susceptibility to fire blight; a standard rating system was used. All cultivars were infected, but the severity of the disease varied significantly among cultivars. Among cultivars currently planted in Michigan, Jonathan, Rome, Idared, Braeburn, and Fuji were very susceptible; Golden Delicious, Gala, and Jonagold were moderately susceptible; Granny Smith, Empire, and McIntosh were intermediate; and Red Delicious and Liberty were moderately resistant. Correlation of lesion length data for 16 cultivars tested in New York State and USDA severity scores for naturally infected trees in Michigan was $r = 0.67$ ($P = 0.004$). Planting intermediate to moderately resistant rather than very susceptible cultivars is likely the best means of controlling fire blight in areas infested with streptomycin-resistant strains of *Erwinia amylovora*.

Fire blight, caused by *Erwinia amylovora* (Burrill) Winslow et al, is increasing in importance on apple (*Malus domestica* Borkh.) in Michigan. Many new plantings of apple cultivars on dwarfing rootstocks are susceptible to fire blight. Fire blight infections on dwarf apple trees can quickly result in severe reductions in the fruit-bearing capacity, because lesions need only extend a comparatively short distance to penetrate the scaffold limbs and trunk. Many high density orchards contain trees propagated on M.26, a dwarfing rootstock that is highly susceptible to fire blight (5). Even minor infections in trees propagated on this rootstock have been associated with outbreaks of fire blight in the root system.

Because the apple industry in Michigan used rootstocks and cultivars with increased host susceptibility to fire blight, more emphasis was placed on preventing infection by spraying with the antibiotic streptomycin. Recently, strains of the fire blight pathogen with high resistance to streptomycin were detected in some Michigan orchards (4; A. L. Jones, *unpublished data*). Clearly, greater emphasis needs to be placed on fire blight control measures that decrease reliance on antibiotic sprays.

In the spring and summer of 1991, there was an unusually severe epidemic of fire blight in a two-county area surrounding the Southwest Michigan Research and Extension Center near the city of Benton Harbor, where an extensive planting of apple cultivars and strains was located. In this paper, we report our observations on the severity of fire blight on the cultivars and strains in this planting.

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MATERIALS AND METHODS

The severity of fire blight on each tree in the apple cultivar planting was rated in July and again in September with a USDA scoring system (10,11). Severity was based on the following scale: 10, 0%; 9, 1–3%; 8, 4–6%; 7, 7–12%; 6, 13–25%; 5, 26–50%; 4, 51–75%; 3, 76–88%; 2, 89–99%; 1, 100% of the tree with fire blight. All ratings were made by the same observer. Severity values were then converted to a five-step scale developed by H. S. Aldwinckle, New York State Agricultural Experiment Station, Cornell University, Geneva, for classifying the susceptibility (or resistance) of apple to fire blight in the Germplasm Resources Information Network (GRIN) data base. The ratings (and cultivar standards for each category) in the GRIN system were 1, very resistant (Novole); 2, moderately resistant (Delicious, Liberty); 3, intermediate (Empire, McIntosh); 4, moderately susceptible (Golden Delicious); and 5, very susceptible (Jonathan). The USDA scores for 11 September 1992 of 9.7–8.5, 8.4–6.6, 6.5–5.1, and 5.0–0 were given GRIN scores of 2, 3, 4, and 5, respectively. None of the cultivars or strains was rated as very resistant on the GRIN scale.

The cultivars and strains, all propagated on M.7a or M.7 EMLA rootstocks, were obtained from commercial nurseries and planted in the spring of 1988 or 1989. The trees were trickle-irrigated as needed for preventing drought stress. Each tree was fertilized in the spring before the onset of growth with 28 g of actual nitrogen per year of tree age. For comparison, strains of each major cultivar, such as Delicious, were grouped together in the planting. Trees of single cultivars were grouped according to harvest and bloom dates. There were four trees of each cultivar planted in two tree plots. The two plots were randomized within the appropriate cultivar grouping. The trees were planted at a spacing of 5 m within rows that were 6 m apart.

Data were statistically analyzed with the one-way analysis of variance procedure available through MSTAT-C (MSTAT, Michigan State University, East Lansing, MI); variance among trees within cultivars was the error term. Separation of means with Tukey's test and standard error of the mean for each cultivar were computed with subprograms within MSTAT-C.

RESULTS AND DISCUSSION

We tried to avoid some of the problems associated with assessing the susceptibility of cultivars under natural conditions (2). All trees were propagated on a similar rootstock, they differed in age by only 1 yr, and they were grown together at one site with some replication to avoid obscure differences in soil type and topography within the site. There was, however, variation between trees in the numbers of blooms produced. A few apple cultivars and strains did not bloom and, thus, were omitted from the analysis.

Predictions from a computerized blossom blight model (MARYBLYT) and observations of symptom development in commercial orchards near the experimental cultivar site indicated that temperature and moisture conditions were highly favorable for blossom infections from 9 to 15 May (6). Conditions were also exceptionally favorable for secondary spread of fire blight to late bloom and shoots. Under these favorable conditions, the severity of the disease varied significantly among cultivars and strains, and all were infected with fire blight to some degree (Table 1).

The susceptibility or resistance of well known cultivars was generally in the same order as reported from previous field observations (1). For example, rating scores for Delicious and Nured Winesap were high, indicating moderate resistance, whereas scores for Jonathan,

Table 1. Severity of fire blight on 2- and 3-yr-old apple trees on M.7a or M.7 EMLA rootstocks at the Southwest Michigan Research and Extension Center after an unusually severe epidemic in 1991

Cultivar	Bloom date[w]	Severity scores and standard errors for 84 cultivars[x] 17 July	11 September	GRIN code number[y]
Red Chief (Campbell) Delicious	29 April	10.0 ± 0.00 a[z]	9.7 ± 0.25 a	2
Nured Delicious	30 April	9.7 ± 0.25 ab	9.5 ± 0.29 ab	2
Starkrimson Delicious	30 April	9.5 ± 0.50 abc	9.5 ± 0.50 ab	2
Liberty	8 May	9.7 ± 0.25 ab	9.2 ± 0.48 abc	2
Keepsake	1 May	9.7 ± 0.25 ab	9.2 ± 0.25 abc	2
Nured Winesap	10 May	9.5 ± 0.29 abc	9.2 ± 0.25 abc	2
Early Red One Delicious	4 May	9.2 ± 0.48 abcd	9.2 ± 0.48 abc	2
Top Spur Delicious	3 May	9.2 ± 0.00 abcd	9.2 ± 0.50 abc	2
Cascade Spur Delicious	1 May	9.2 ± 0.25 abcd	9.2 ± 0.25 abc	2
Lurared	10 May	9.2 ± 0.25 abcd	8.7 ± 0.48 abcd	2
Melrose	9 May	9.0 ± 0.41 abcde	8.5 ± 0.50 abcde	2
Starkspur Ultra Stripe Delicious	29 April	9.0 ± 0.71 abcde	8.5 ± 0.87 abcde	2
Starkspur Supreme Red Delicious	30 April	8.7 ± 0.48 abcde	8.5 ± 0.65 abcde	2
Starkspur Compact Red Delicious	29 April	8.7 ± 0.63 abcde	8.5 ± 0.65 abcde	2
Red Max	7 May	9.2 ± 0.75 abcd	8.2 ± 1.18 abcdef	3
Empire	3 May	8.7 ± 0.25 abcde	8.2 ± 0.48 abcdef	3
Ace Delicious	29 April	8.7 ± 0.48 abcde	8.0 ± 0.71 abcdefg	3
Scarlet Spur Delicious	30 April	8.7 ± 0.63 abcde	8.0 ± 0.82 abcdefg	3
Jonamac	3 May	8.2 ± 0.48 abcdefg	8.0 ± 0.58 abcdefg	3
Marshall McIntosh	30 April	8.2 ± 0.48 abcdefg	8.0 ± 0.58 abcdefg	3
Sturdeespur Delicious	8 May	8.5 ± 0.96 abcdef	7.7 ± 1.11 abcdefgh	3
Freedom	10 May	8.0 ± 0.58 abcdefgh	7.7 ± 0.75 abcdefgh	3
Macspur	6 May	8.0 ± 0.91 abcdefgh	7.7 ± 1.11 abcdefgh	3
Lysgolden	12 May	9.2 ± 0.48 abcd	7.5 ± 1.04 abcdefghi	3
Dixi Red Delicious	29 April	8.5 ± 0.29 abcdef	7.5 ± 0.29 abcdefghi	3
Regent	10 May	8.0 ± 0.91 abcdefgh	7.2 ± 1.11 abcdefghij	3
Prima	5 May	7.7 ± 0.75 abcdefgh	7.2 ± 1.18 abcdefghij	3
Classic Delicious	6 May	8.5 ± 0.50 abcdef	7.0 ± 0.41 abcdefghij	3
Dana Red Delicious	4 May	8.2 ± 0.48 abcdefg	7.0 ± 0.82 abcdefghij	3
Lustre Elstar	10 May	8.0 ± 0.41 abcdefgh	7.0 ± 0.71 abcdefghij	3
Scarlet Gala	10 May	8.0 ± 0.41 abcdefgh	7.0 ± 0.41 abcdefghij	3
Swiss Gormet (Arlet)	10 May	7.7 ± 0.25 abcdefgh	7.0 ± 0.71 abcdefghij	3
Stamared	10 May	7.7 ± 0.25 abcdefgh	7.0 ± 0.41 abcdefghij	3
Ozark Gold	12 May	7.7 ± 0.48 abcdefgh	7.0 ± 0.41 abcdefghij	3
Pioneer Mac	8 May	7.5 ± 0.87 abcdefghi	7.0 ± 1.16 abcdefghij	3
Mor Spur Mac	8 May	7.5 ± 0.96 abcdefghi	7.0 ± 0.91 abcdefghij	3
Akane	9 May	8.0 ± 0.41 abcdefgh	6.7 ± 0.48 abcdefghijk	3
Red Winesap	12 May	8.0 ± 0.41 abcdefgh	6.7 ± 0.25 abcdefghijk	3
S165	5 May	8.0 ± 0.41 abcdefgh	6.7 ± 0.48 abcdefghijk	3
Gold Spur	10 May	7.7 ± 0.85 abcdefgh	6.7 ± 1.03 abcdefghijk	3
Perfect Spur Criterion	8 May	7.5 ± 0.50 abcdefghi	6.7 ± 0.25 abcdefghijk	3
Red Chief (Mercier) Delicious	30 April	7.5 ± 0.87 abcdefghi	6.7 ± 1.11 abcdefghijk	3
Granny Smith	12 May	7.0 ± 0.00 abcdefghij	6.7 ± 0.25 abcdefghijk	3
Summer Treat	10 May	8.2 ± 0.25 abcdefg	6.5 ± 0.29 abcdefghijk	4
Red Fuji	10 May	8.0 ± 0.41 abcdefgh	6.5 ± 0.29 abcdefghijk	4
Smoothee	10 May	7.2 ± 0.48 abcdefghij	6.5 ± 0.29 abcdefghijk	4
Stark Gala	10 May	7.2 ± 0.25 abcdefghij	6.5 ± 0.29 abcdefghijk	4
Mutsu	10 May	7.0 ± 0.41 abcdefghij	6.2 ± 0.63 abcdefghijk	4
Red Cort	7 May	6.7 ± 1.38 abcdefghij	6.2 ± 1.65 abcdefghijk	4
Golden Delicious	10 May	6.7 ± 0.75 abcdefghij	6.2 ± 0.63 abcdefghijk	4
Honeygold	10 May	7.2 ± 1.11 abcdefghij	6.0 ± 1.58 abcdefghijk	4
Imperial Gala	10 May	7.2 ± 0.25 abcdefghij	6.0 ± 0.41 abcdefghijk	4
Super Chief Red Delicious	5 May	6.7 ± 0.50 abcdefghij	6.0 ± 0.91 abcdefghijk	4
Fulford Gala	10 May	7.2 ± 1.03 abcdefghij	5.7 ± 1.03 abcdefghijk	4
Royal Gala	10 May	7.0 ± 0.41 abcdefghij	5.7 ± 0.50 abcdefghijk	4
Virginiagold	12 May	6.5 ± 1.32 abcdefghij	5.7 ± 1.38 abcdefghijk	4
Staybrite	11 May	7.5 ± 0.96 abcdefghi	5.5 ± 0.87 abcdefghijk	4
Red Fuji 4	9 May	6.5 ± 0.29 abcdefghij	5.5 ± 0.65 abcdefghijk	4
Jonagold	10 May	6.2 ± 0.25 abcdefghij	5.5 ± 0.29 abcdefghijk	4
Blushing Golden	10 May	7.5 ± 1.04 abcdefghi	5.2 ± 1.65 abcdefghijk	4
Spur Gala Go Red	11 May	7.0 ± 0.91 abcdefghij	5.0 ± 1.83 abcdefghijk	5
Red Fuji Nagano	12 May	6.7 ± 0.75 abcdefghij	5.0 ± 1.08 abcdefghijk	5
Nicobel Jonagold	10 May	5.2 ± 0.25 cdefghij	5.0 ± 0.00 abcdefghijk	5

(continued on next page)

[w] Date when 80% of the flowers were open was determined from daily observations during bloom.
[x] Final USDA rating scores were based on the following scale: 10 = 0%, 9 = 1–3%; 8 = 4–6%; 7 = 7–12%; 6 = 13–25%; 5 = 26–50%; 4 = 51–75%; 3 = 76–88%; 2 = 89–99%; and 1 = 100% of the tree blighted. Data are mean rating scores for four trees followed by the standard error of the mean.
[y] Germplasm Resources Information Network (GRIN) data base codes (and cultivar standards for each category) were 1 = very resistant (Novole); 2 = moderately resistant (Delicious, Liberty); 3 = intermediate (Empire, McInotsh); 4 = moderately susceptible (Golden Delicious); and 5 = very susceptible (Jonathan).
[z] Cultivar means within a column followed by the same letter do not differ significantly according to Tukey's test ($P = 0.05$).

Table 1. (*continued from preceding page*)

Cultivar	Bloom date[w]	Severity scores and standard errors for 84 cultivars[x]		GRIN code number[y]
		17 July	11 September	
Spigold	14 May	5.2 ± 0.50 cdefghij	4.7 ± 0.50 abcdefghijk	5
EarliJon	12 May	6.5 ± 0.50 abcdefghij	4.5 ± 0.96 bcdefghijk	5
Fuji	7 May	5.5 ± 0.65 bcdefghij	4.5 ± 0.29 bcdefghijk	5
Northwest Greening	10 May	5.5 ± 0.65 bcdefghij	4.5 ± 0.50 bcdefghijk	5
Ultra Red Jonathan	6 May	5.2 ± 0.48 cdefghij	4.5 ± 0.29 bcdefghijk	5
Berts Special	9 May	5.0 ± 1.08 defghij	4.5 ± 0.87 bcdefghijk	5
Prime Gold	10 May	5.0 ± 0.41 defghij	4.5 ± 0.29 bcdefghijk	5
Double Red Jonathan	10 May	6.7 ± 1.60 abcdefghij	4.2 ± 1.80 cdefghijk	5
Braeburn	9 May	5.7 ± 0.63 abcdefghij	4.0 ± 0.41 defghijk	5
Geneva Early	10 May	5.2 ± 0.63 cdefghij	4.0 ± 0.71 defghijk	5
Super Jon	9 May	4.7 ± 0.85 efghij	4.0 ± 0.41 defghijk	5
Earligold	5 May	5.5 ± 0.97 bcefghij	3.7 ± 0.86 defghijk	5
Jonnee	9 May	4.7 ± 0.85 efghij	3.5 ± 0.48 efghijk	5
Idared	2 May	5.7 ± 1.49 abcdefghij	3.5 ± 1.19 efghijk	5
Starkspur Law Rome	10 May	4.7 ± 0.50 efghij	3.2 ± 0.25 fghijk	5
Jonafree	10 May	3.2 ± 0.25 ij	3.2 ± 0.25 fghijk	5
Red Yorking	12 May	3.7 ± 1.03 hij	3.0 ± 0.58 ghijk	5
Nittany	12 May	4.0 ± 0.82 ghij	2.7 ± 0.48 hijk	5
Early Spur Rome	8 May	4.2 ± 0.63 fghij	2.5 ± 0.65 ijk	5
Ginger Gold	10 May	5.0 ± 0.71 bcdefghij	2.2 ± 0.63 jk	5
Nured Jon	9 May	3.0 ± 0.41 j	1.7 ± 0.50 k	5

Idared, and Rome were low, indicating they were very susceptible to fire blight.

Some currently popular cultivars, such as Braeburn, Idared, Starkspur Law Rome, Early Spur Rome, and several strains of Jonathan, including Jonnee, were rated as very susceptible to blight. Other very susceptible cultivars included Ginger Gold, Nittany, Red Yorking, and Earligold. Although Delicious was one of the parents of Fuji (Ralls Janet × Delicious), Fuji and strains of Fuji (Red Fuji, Red Fuji 4, and Red Fuji Nagano) were rated as very susceptible to moderately susceptible, whereas most strains of Delicious were rated as moderately resistant. Strains of the cultivars Gala, Elstar (Lustre), and Golden Delicious, a parent of Gala and Elstar, were moderately susceptible to intermediate (Elstar) in reaction to blight. Among the cultivars resistant to apple scab, Liberty was moderately resistant, Freedom and Prima were intermediate, whereas Jonafree was very susceptible to fire blight. This ranking was expected according to previous reports of artificial inoculations to shoots (3), but the ranking for Jonafree was much lower than reported for a field trial in North Carolina (9).

When we compared our observations with results from New York that were obtained by needle-inoculated shoots in the field (3), two cultivars exhibited greater susceptibility than expected under orchard conditions (Fig. 1). Northwest Greening and Prime Gold were judged resistant on the basis of shoot inoculations in New York (3) but were judged very susceptible in southwestern Michigan on the basis of the severity of natural infections observed on trees in this study. Because the inoculations were carried out with a single strain, there is a possibility that these cultivars are differentially susceptible to strains of *E. amylovora* (7,8).

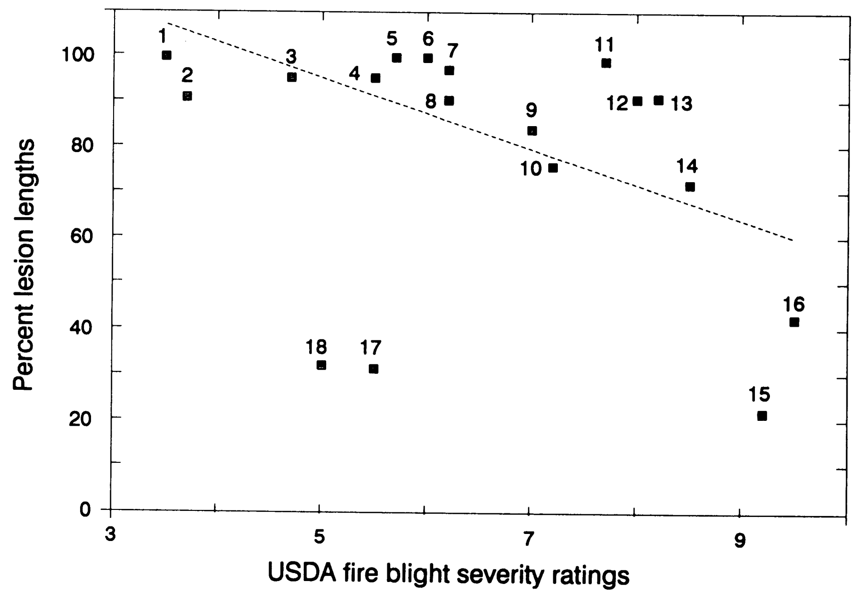

Fig. 1. Relationship between the percentage of the current season's shoot length that was necrotic after artificial inoculation with *Erwinia amylovora* in New York (3) and USDA severity scores for fire blight on naturally infected trees in southwestern Michigan. Numbered data points represent cultivars: 1 = Idared, 2 = Jonnee, 3 = Spigold, 4 = Jonagold, 5 = Virginiagold, 6 = Honeygold, 7 = Mutsu, 8 = Golden Delicious, 9 = Ozark Gold, 10 = Prima, 11 = Macspur, 12 = Jonamac, 13 = Empire, 14 = Melrose, 15 = Liberty, 16 = Starkrimson Delicious, 17 = Northwest Greening, and 18 = Prime Gold. The calculated regression line $Y = -8.25X + 139.39$, in which X is the USDA fire blight severity rating and Y is the percentage of lesion lengths, did not include points 17 and 18.

Correlation between the percentage of lesion lengths for 16 cultivars in New York (3) and USDA severity scores was $r = 0.67$ ($P = 0.004$) when the two cultivars mentioned above were omitted from the analysis. Some mean ratings were occasionally skewed toward more susceptible than expected when one or more cankers on the central leader resulted in the death of the upper part of the tree.

Fire blight was devastating in southwestern Michigan in 1991 on Jonathan and Rome apple trees. In some orchards, streptomycin was not a control option because of the presence of streptomycin-resistant *E. amylovora* (4). The lack of alternative chemical control procedures underscores the need for cultivars resistant to fire blight. Although strains of

Delicious predominated on the list of cultivars and strains with moderate resistance to fire blight, there was also a selection of commercially acceptable cultivars, including Empire and McIntosh strains in the intermediate category. Planting of cultivars with intermediate to moderate resistance should reduce losses from this disease. Selecting for cultivars with moderate to very high resistance to fire blight should increase in importance as chemical control becomes more difficult because of the prevalence of streptomycin-resistant strains of *E. amylovora*.

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