Response of Apple Scions on Size-Controlling Rootstocks to Inoculation by *Erwinia amylovora*

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ABSTRACT

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Controlled inoculation studies in the field at the Harrow Research Station in southwestern Ontario during two successive seasons showed that the size-controlling apple rootstocks M26, MM106, and MM111 did not greatly influence the fire blight susceptibility of several popular scions grafted onto them. The interaction between scion cultivar and rootstock was not large enough to overcome the strong influence of the cultivar on the fire blight susceptibility of young trees.

Apple rootstocks influence tree size and form, flowering, fruiting, hardiness, and leaf fall (6). The susceptibility of the scion to fire blight appears to be affected by the rootstock (8); according to a number of reports, the rootstock apparently influences natural infection of apple scions (5,8–10). Aldwinckle et al (3) and Bonn (4) reported on the susceptibility of apple scions on different rootstocks, as determined by a controlled inoculation technique that reduces the problems associated with relying on natural infection for disease reaction. This paper reports further results with that technique.

MATERIALS AND METHODS

Young trees involving nine popular cultivars grafted onto either two or three size-controlling rootstocks were obtained from a local nursery in the early spring, heeled into a soil and peat mixture in a nursery-stock barn, and planted in the field nursery at the Harrow Research Station in southwestern Ontario on 3 May 1977. Five trees of each scion cultivar/rootstock combination were planted about 30 cm apart in the nursery. Each tree was pruned to a height of 1 m and maintained in a vigorously growing condition.

Freeze-dried isolates of *Erwinia amylovora* (Burrill) Winslow et al obtained from diseased tissue of local apple and pear trees were reconstituted in sterile distilled water and plated out on nutrient agar and a selective medium (7) for verification of viability and colony morphology. Pathogenicity of the isolates was checked by injecting bacterial suspensions into greenhouse-grown Bartlett pear seedlings. *E. amylovora* isolates E2005P, E2017P, E4003P, and E3001A were grown on yeast-dextrose-carbonate agar slants at 28 C for 48 hr and then were suspended in sterile distilled water, the suspension being adjusted to approximately 5×10^8 cells per milliliter, measured turbidimetrically. The suspensions of each *E. amylovora* isolate were pooled in equal proportions. On 12 July 1977, several shoots (approximately 30 cm long) of each tree were injected subepidermally with 20 μl of the inoculum using a Hamilton 700 series syringe equipped with a 26-gauge hypodermic needle and automatic dispensing unit (Hamilton Company, Reno, NV).

Disease progression, measured by the total length of shoot affected by visible fire blight lesions, was recorded on 23 August 1977. Internal necrosis, denoted by reddish-brown discoloration of the vascular system, was measured similarly. The experiment was repeated in 1978 on the same apple trees using the same isolates of *E. amylovora*. All fire blight lesions had been pruned out in the fall of 1977, and the trees had no symptoms before inoculation on 21 June 1978; observations were recorded on 26 July 1978. The requirement for equal shoot growth in 1977 and 1978 resulted in a different inoculation date each year. Data were subjected to analysis of variance. Individual *t* tests were used to establish the significance of differences among the means of scion/rootstock combinations, mean scion effects, and mean rootstock effects.

RESULTS

Generally, fire blight in the Harrow area on both apples and pears was more severe in 1978 than in 1977 because of mild temperatures and frequent precipitation.

A summary of the data on lesion extension for 1977 and 1978 is presented in Table 1 and that for internal necrosis, in Table 2. The analysis of variance of the data indicated that an interaction had occurred between rootstock and scion cultivar in both years. The interaction was most evident among the cultivars Cortland, Lodi, and McIntosh in 1977 and the cultivar Golden Delicious in

Table 1. Effect of scion/rootstock combinations on extension of fire blight lesions in apple shoots

	Lesion length (%)		
Scion/rootstock	**1977**	**1978**	**2-yr average**
Quinte/MM106	14.3 a[y]	25.6 a[y]	20.0 a[z]
Red Delicious/M26	22.6 ab	19.6 a	21.1 a
Quinte/M26	14.5 a	40.1 bc	27.3 a
Red Delicious/MM106	29.5 abcd	31.3 ab	30.4 ab
Red Delicious/MM111	27.2 abc	48.9 c	38.1 ab
Golden Delicious/MM111	33.9 abcde	60.6 d	47.3 b
Golden Delicious/MM106	52.5 cdefg	80.9 e	66.7 c
Cortland/M26	44.2 bcdef	99.7 f	72.0 cd
Golden Delicious/M26	52.9 cdefg	99.6 f	76.3 cde
Lodi/M26	54.8 defg	100.0 f	77.4 cdef
Northern Spy/MM106	66.2 fgh	91.4 ef	78.8 cedfg
McIntosh/M26	60.1 efg	99.3 f	79.7 cedfg
Idared/MM111	72.1 ghi	93.0 ef	82.6 cdefgh
Cortland/MM106	76.3 ghij	91.3 ef	83.8 cdefgh
Northern Spy/M26	87.7 hij	91.5 ef	89.6 defgh
Idared/MM106	88.9 hij	92.2 ef	90.6 defgh
McIntosh/MM106	88.0 hij	97.8 f	92.9 efgh
Idared/M26	90.1 hij	96.2 f	93.2 efgh
Tydeman's Red/M26	89.0 hij	98.0 f	93.5 efgh
Lodi/MM106	90.0 hij	99.9 f	95.0 efgh
Cortland/MM111	99.7 ij	94.6 f	97.2 fgh
McIntosh/MM111	99.3 ij	96.9 f	98.1 gh
Tydeman's Red/MM106	100.0 j	100.0 f	100.0 h

[y]Means of replicates of each scion/rootstock combination. Numbers in columns followed by the same letter do not differ significantly ($P = 0.05$) in a comparison using individual *t* tests.
[z]Arithmetic mean of 1977 and 1978 means; differences in the values of n for each year have been accounted for in performing *t* tests.

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1978. The interaction was less evident when the data for 1977 and 1978 were combined.

A positive correlation between lesion extension and internal necrosis existed in both 1977 ($r = 0.96$, $n = 23$, $P = 0.01$) and 1978 ($r = 0.99$, $n = 23$, $P = 0.01$). In many cases, the internal necrosis limited to the vascular region extended further in the shoots than the visible lesion did; this was especially evident in cultivars with resistance to lesion extension, eg, Red Delicious, Quinte, and Golden Delicious.

Differential cultivar susceptibility to fire blight was evident in both 1977 and 1978 (Table 3). Quinte and Red Delicious were resistant, Golden Delicious was moderately resistant, and the others were susceptible. Tydeman's Red was highly susceptible in both years, with lesions extending to 96.8% of the inoculated shoot length.

Analysis of the rootstock effect on cultivar reaction to *E. amylovora* indicated that scions were least susceptible on M26 in 1977 but more susceptible on this rootstock in 1978 (Table 4). No differences were noted between MM106 and MM111. When data were combined in the 2-yr average, no differences were noted among the three rootstocks in their effect on scion susceptibility to fire blight, as determined by both external lesion and internal necrosis symptoms.

Table 2. Effect of scion/rootstock combinations on extension of internal necrosis of vascular system caused by *Erwinia amylovora*

	Internal necrosis (%)		
Scion/rootstock	**1977**	**1978**	**2-yr average**
Red Delicious/M26	24.8 a[y]	21.2 a[y]	23.0 a[z]
Red Delicious/MM106	42.0 abc	35.4 b	38.7 ab
Quinte/M26	40.3 ab	45.7 bc	43.0 b
Quinte/MM106	51.7 bcd	38.5 b	45.1 b
Red Delicious/MM111	50.1 bcd	51.5 cd	50.8 b
Golden Delicious/MM111	42.0 abc	61.3 d	51.7 b
Golden Delicious/MM106	63.4 bcdef	81.0 e	72.2 c
Lodi/M26	55.8 bcde	100.0 f	77.9 cd
Cortland/M26	57.6 bcde	100.0 f	78.8 cde
Golden Delicious/M26	58.9 bcde	99.6 f	79.3 cdef
Northern Spy/MM106	68.2 cdefg	91.6 ef	79.9 cdef
McIntosh/M26	62.6 bcdef	100.0 f	81.3 cdefg
Idared/MM111	72.3 defgh	93.0 ef	82.7 cdefg
Cortland/MM106	79.4 efghi	91.3 ef	85.4 cdefg
Northern Spy/M26	88.4 fghi	92.9 ef	90.7 cdefg
Idared/M26	90.1 ghi	96.6 f	93.4 defg
Idared/MM106	95.5 hi	91.5 ef	93.5 defg
McIntosh/MM106	88.0 fghi	100.0 f	94.0 defg
Lodi/MM106	89.6 ghi	99.9 f	94.8 defg
Tydeman's Red/M26	93.7 ghi	98.4 f	96.1 defg
Cortland/MM111	99.7 i	96.0 f	97.9 efg
McIntosh/MM111	100.0 i	97.2 f	98.6 fg
Tydeman's Red/MM106	100.0 i	100.0 f	100.0 g

[y]Means of replicates of each scion/rootstock combination. Numbers in columns followed by the same letter do not differ significantly ($P = 0.05$) in a comparison using individual t tests.
[z]Arithmetic mean of 1977 and 1978 means; differences in the values of n for each year have been accounted for in performing t tests.

DISCUSSION

Several scion/rootstock combinations were significantly different in either 1977 or 1978, but the interactions were relatively weak and only Golden Delicious appeared in the 2-yr average as differentially affected in susceptibility by the rootstocks MM106 and MM111. Scion/rootstock interactions appeared to be relatively unimportant in our study, despite evidence to the contrary elsewhere (9). Rootstock M26 has been shown to induce fire blight susceptibility in the scion cultivar (3,5,8), but we could not confirm this.

Response of the apple cultivar to fire blight is well documented (1,2,11), and our data support earlier observations.

Table 3. Reaction of apple cultivars to infection by *Erwinia amylovora*

	Lesion length (%)			Internal necrosis (%)		
Cultivar	**1977**	**1978**	**2-yr average**	**1977**	**1978**	**2-yr average**
Quinte	14.4 a[x]	33.0 a[y]	23.7 a[z]	46.0 ab[x]	42.1 a[y]	44.1 a[z]
Red Delicious	26.4 a	33.2 a	29.8 a	38.9 a	36.1 a	37.5 a
Golden Delicious	46.6 b	80.3 b	63.4 b	54.8 b	80.6 b	67.7 b
Cortland	73.4 c	95.2 c	84.3 c	78.9 c	95.8 c	87.4 c
Northern Spy	77.0 c	91.5 c	84.3 c	78.3 c	92.2 c	85.3 c
Lodi	72.2 c	99.9 c	86.1 c	72.7 c	99.9 c	86.3 c
Idared	83.7 cd	93.8 c	88.8 cd	86.0 cd	93.7 c	89.9 cd
McIntosh	82.5 cd	98.0 c	90.3 cd	83.6 cd	99.1 c	91.4 cd
Tydeman's Red	94.5 d	99.0 c	96.8 d	96.8 d	99.2 c	98.0 d

[x]Means of either 30 or 45 replicates of each cultivar. Numbers in columns followed by the same letter do not differ significantly ($P = 0.05$) in a comparison using individual t tests.
[y]Means of either 70 or 105 replicates of each cultivar. Numbers in columns followed by the same letter do not differ significantly ($P = 0.05$) in a comparison using individual t tests.
[z]Arithmetic mean of 1977 and 1978 means; differences in the values of n for each year have been accounted for in performing t tests.

Table 4. Reaction of scions on apple rootstocks to infection by *Erwinia amylovora*

	Lesion length (%)			Internal necrosis (%)		
Rootstock	**1977**	**1978**	**2-yr average**	**1977**	**1978**	**2-yr average**
M26	57.3 a[x]	82.7 b[y]	70.0 a[z]	63.6 a[x]	83.8 b[y]	73.7 a[z]
MM111	66.4 b	78.8 ab	72.6 a	72.8 b	79.8 a	76.3 a
MM106	67.3 b	79.0 a	73.2 a	75.3 b	81.0 ab	78.2 a

[x]Means of either 225 (MM111) or 405 replicates of each rootstock. Numbers in columns followed by the same letter do not differ significantly ($P = 0.05$) in a comparison using individual t tests.
[y]Means of either 525 (MM111) or 945 replicates of each rootstock. Numbers in columns followed by the same letter do not differ significantly ($P = 0.05$) in a comparison using individual t tests.
[z]Arithmetic mean of 1977 and 1978 means; differences in the values for n for each year have been accounted for in performing t tests.

Quinte and Red Delicious were resistant and Golden Delicious was moderately resistant to infection; the other six cultivars showed very little resistance. Rootstocks M26, MM106, and MM111 had no influence on the overall ranking of scion cultivars to fire blight infection. There were slight differences among scions on different rootstocks within the same year but no significant differences in the 2-yr averages.

The interaction of scion cultivar and rootstock, at least in our limited range of combinations, does not appear to be as important as previously suggested by an analysis of 1 yr of data (4). Interactions do occur but are relatively weak and appear to be overshadowed by seasonal effects. The genetic susceptibility of the cultivar and the environment appear to be more important than rootstock effects in determining fire blight response of apple shoots to *E. amylovora* inoculation.

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