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Susceptibility of Common Rootstocks and Scions to Foliar Citrus Canker under Florida Conditions

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Citrus canker (*Xanthomonas citri* subsp. *citri*) has been introduced into Florida numerous times. The most recent eradication efforts were suspended in 2006 after a series of hurricanes in 2004 and 2005 spread the disease statewide. In central Florida, seedlings of 10 rootstocks and trees of 8 scion cultivars were evaluated for canker after being established for 9 to 18 months in a trial of nonbearing trees planted adjacent to young grapefruit trees that were highly infected with citrus canker. All rootstocks and scions were susceptible to foliar citrus canker to varying degrees. Rootstocks were ranked as predicted by the known susceptibility of the parental genotypes to citrus canker. Swingle citrumelo (trifoliate hybrid with grapefruit) was the most susceptible, followed by Carrizo and Kuharske citrange (trifoliate hybrid with sweet orange), and sour orange (pummelo parentage). Seedlings of X639, US812, and US897 (trifoliate hybrids of Cleopatra mandarin or Sunki) were moderately susceptible. Volkamer lemon, Cleopatra mandarin, and Kinkoji leaves were the least susceptible rootstocks. Within the scion varieties, 'Minneola' tangelo, 'Murcott' tangor, 'Valencia', 'Fallglo' tangerine, 'Sunburst' tangerine, and 'Orlando' tangelo exhibited low susceptibility. 'Ponkan' (mandarin hybrid) and 'Satsuma' mandarin were the least susceptible of the scion varieties.

Xanthomonas citri subsp. *citri*, the bacterial pathogen that causes Asiatic citrus canker, has been introduced into Florida numerous times since the first introduction in 1912 (Gottwald et al., 2002). The disease has been eradicated several times through tree removal, prohibitions against infected plant movement, and sanitation of both people and equipment (Stall and Civerolo, 1991). The most recent eradication efforts were suspended in 2006 after a series of hurricanes in 2004 and 2005 spread the disease statewide (Gottwald and Irey, 2007). Current rules under the Citrus Health Response Plan (CHRP) do not require removal of infected trees, allowing growers to develop their own citrus canker management plans based upon intended market for their fruit and the cultivar planted at each location.

Citrus canker is characterized by raised, rough lesions on fruit, foliage, and young stems of susceptible cultivars (Timmer et al., 1996). Lesions may be surrounded by an oily or water-soaked margin on leaves or fruit but not on twigs. The most critical period for infection of sweet oranges occurs when the stomates open as fruit reach 0.25 to 0.5 inches in diameter and become more tolerant when they exceed 1.5 inches. Grapefruit are susceptible to infection from 0.75 inches in diameter until full expansion of fruit. Infection through wounds can occur at any stage of leaf or fruit development. As the leaves, twigs, and fruit reach full expansion, resistance of tissues to bacterial infection greatly increases. Severe infections can cause defoliation, twig dieback, and fruit drop that may affect tree productivity. Blemished fruit are not acceptable for the fresh fruit market but can be processed into juice (Gottwald et al., 2002).

The bacterium multiplies in lesions and exudes out of infected tissues when free moisture is present. Windblown rain spreads the bacterium and allows it to gain entry into susceptible tissues via stomatal openings or wounds. Disruption of the cuticle caused by feeding of the Asian citrus leafminer (*Phyllocnistis citrella* Stainton) creates an entry way for water and bacteria into the leaf, thereby increasing bacterial infection, lesion development, and inoculum buildup (Gottwald et al., 1997). The bacterium can survive in lesions on woody branches of grapefruit up to several years under Florida conditions (Graham, unpublished observations). The duration and intensity of wind and rain determines the spread of the bacterium and incidence of disease within a given area. Windbreaks have been shown to be highly effective for reducing the spread and severity of canker by reducing wind speeds. Long-distance dispersal of *X. citri* subsp. *citri* up to 100 miles has been reported in association with hurricane events (Irey et al., 2006).

When citrus canker becomes well established in a given area, the primary means of disease management include: 1) the use of less susceptible cultivars, 2) planting of windbreaks to reduce wind speed within a citrus block, 3) protection of fruit with copper sprays at approximately 21-d intervals during early infection period, and 4) control of citrus leafminer insects to minimize wounding of leaves (Graham and Dewdney, 2012).

Commercially grown cultivars in Florida are susceptible to citrus canker to varying degrees. Grapefruit cultivars are most highly susceptible followed by early season sweet oranges, which are moderately susceptible. 'Hamlin' and 'Navels' are the most common early cultivars planted in Florida for processed and fresh market, respectively. Mid-season orange cultivars are substantially less susceptible than 'Hamlin' and late season 'Valencia' orange and most mandarin hybrids (tangerines, tangors, and tangelos) are even less susceptible than mid-season cultivars (Gottwald et al., 2002; Graham, 2001).

The purpose of this report was to quantitatively assess the

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susceptibility of young nonbearing trees of several scion cultivars as well as widely used rootstocks to compare their behavior under Florida conditions with that in other subtropical citrus production areas.

Materials and Methods

The trial was located in the Mid-Florida Foundation grove near Winter Garden, Orange Co., FL. The trial was initially established for evaluation of the reaction of citrus scions and rootstocks to an experimental herbicide. Due to the close proximity of citrus canker inoculum from the initial planting of highly susceptible 'Flame' grapefruit, subsequent plantings provided an opportunity to observe susceptibility of other commonly grown scions and rootstocks under Florida conditions. In May 2010, 164 one-year-old 'Flame' grapefruit trees on Swingle citrumelo were obtained from a commercial nursery and planted in four adjacent rows (Table 1). In Oct. 2010, one-year-old seedlings of 10 commercial rootstocks were planted in six rows to the west of the 'Flame' grapefruit. In Mar. 2011, eight scion varieties on different rootstocks were planted east of the 'Flame' grapefruit. Each rootstock seedling type or scion/rootstock selection was grouped together in three adjacent rows. Thus, the grapefruit planting was situated in the middle of the trial area with the rootstocks planted to the west and the scions to the east. All trees were within 160 ft from the grapefruit planting.

All trees were irrigated with microsprinklers and grown under standard production practices consisting of fertigation applications and management programs to control pests and diseases, including copper applications to suppress citrus canker, and soil applications of imidacloprid for citrus leafminer and psyllid control.

In Nov. 2011, after the rootstock seedlings were in the field for 13 months old and scion trees were in the field for 8 months, all plants were rated visually to determine the percentage canker-infected leaves for approximately 100 randomly selected leaves per tree. Foliar canker incidence data were analyzed using the GLM procedure in SAS and mean separation among scion and rootstock cultivars was performed using Student Newman-Keuls test at $P < 0.05$.

Results

Rootstock susceptibility. All observed rootstocks in this trial were susceptible to citrus canker but there were differing degrees of susceptibility. Swingle citrumelo was more susceptible than any of the other rootstocks based on the incidence of canker on leaves (Table 2). The moderately susceptible rootstocks, based on statistical differences were Carrizo citrange, Kuharske citrange, sour orange, X639, and US-812. Susceptible rootstocks included US-897, Volkamer lemon, and Cleopatra mandarin. Kinkoji was the least susceptible cultivar among the rootstocks tested.

Scion susceptibility. Among the scion cultivars, 'Minneola'

Table 1. List of scions, rootstocks and planting dates for each group of cultivars.

Cultivar group	Cultivar[z]	Spacing (in-row/between rows)	Planting date
Grapefruit (total trees 164)	'Flame' on Swingle	10 ft × 20 ft	12 May 2010
Rootstocks (48 trees per rootstock, 6 rows)	Carrizo citrange, Cleopatra mandarin, Kinkoji, Kuharske citrange, sour orange, Swingle citrumelo, Volkamer lemon, US-812 (Sunki × TF), US-897 (Cleo × TF), X639 (Cleo × TF)	5 ft × 20 ft	22 Oct. 2010
Scions (48 trees per cultivar, 8 rows)	'Fallglo' on Swingle, 'Minneola' tangelo on sour orange, 'Murcott' on Smooth Flat Seville, 'Orlando' tangelo on Cleopatra, 'Ponkan' on Kuharske, and 'Satsuma' on Cleo, Sunburst on Kinkoji, 'Valencia' on Smooth Flat Seville	8 ft × 20 ft	21 Mar. 2011

[z]TF = trifoliate.

Table 2. Incidence of leaves with citrus canker on rootstock cultivars and susceptibility.

Rootstock[z]	Foliar canker incidence (%)[y]	Susceptibility rating
Swingle citrumelo (GF × TF)	87.3 a	highly susceptible
Kuharske citrange	64.2 b	moderately susceptible
Sour orange	63.6 b	moderately susceptible
Carrizo citrange	63.6 b	moderately susceptible
X639 (Cleo × TF)	62.8 b	moderately susceptible
US-812 (Sunki × TF)	58.5 b	moderately susceptible
US-897 (Cleo × TF)	48.0 c	susceptible
Volkamer lemon	39.3 cd	susceptible
Cleopatra mandarin	37.9 cd	susceptible
Kinkoji	29.9 d	susceptible

[z]TF = trifoliate; GF = grapefruit

[y]Values followed by the same letters within a column are not significantly different at $P < 0.05$ according to Student Newman-Keuls multiple range test.

Table 3. Incidence of leaves with citrus canker on scion cultivars and rating of their susceptibility.

Specialty	Foliar canker incidence (%)[z]	Susceptibility rating
'Minneola' tangelo	27.469 a	less susceptible
'Murcott'	27.000 a	less susceptible
'Valencia'	24.688 a	less susceptible
'Fallglo'	19.656 a	less susceptible
'Sunburst'	19.563 a	less susceptible
'Orlando' tangelo	19.250 a	less susceptible
'Ponkan'	7.677 b	tolerant
'Satsuma'	3.323 b	tolerant

[z]Values followed by the same letters within a column are not significantly different at $P < 0.05$ according to Student Newman-Keuls multiple range test.

tangelo, 'Murcott' tangor, 'Valencia' orange, 'Fallglo' tangerine, 'Sunburst' tangerine, and 'Orlando' tangelo had statistically similar incidence of foliar canker levels (Table 3). 'Ponkan' and 'Satsuma' mandarins were less susceptible than the former group of scion cultivars.

Discussion

The foliar canker susceptibility of rootstocks observed in our trial is consistent with known susceptibility of the parents to citrus canker (Gottwald et al., 1993, 2002; Graham, 1990). Swingle citrumelo, a trifoliate orange hybrid with highly susceptible grapefruit, is the most susceptible to canker. Carrizo and Kuharske citrange, which are sweet orange hybrids with trifoliate orange, sour orange a natural mandarin/pummelo hybrid, X639, a cross between Cleopatra mandarin and trifoliate, and US-812, a cross of Sunki mandarin with trifoliate, exhibited moderate susceptibility to canker as expected for crosses with somewhat susceptible parents (Gottwald et al., 1993; Graham, 1990). US-897, another hybrid of Cleopatra mandarin with trifoliate, Volkamer lemon, and Cleopatra mandarin are less susceptible than the preceding group of rootstocks, and Kinkoji, another probable mandarin/pummelo hybrid, is the least susceptible to citrus canker.

The scion cultivars 'Valencia' orange and mandarin hybrids 'Minneola' tangelo, 'Orlando' tangelo, 'Murcott' tangor, 'Fallglo', and 'Sunburst' tangerine are less susceptible and 'Ponkan' and 'Satsuma' mandarins tolerant, which is the experience with these scion cultivars elsewhere in Florida and in Brazilian citrus groves (Graham, 2001; Graham and Dewdney, 2012).

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