CONTROL MEASURES FOR CITRUS BACTERIAL SPOT IN NURSERIES AND PACKINGHOUSES

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Additional index words. Swingle citrumelo, Xanthomonas campestris pv. citrulmo, defoliation, bactericidal copper sprays, disinfection of personnel and tools, fruit treatment, sodium-orthophenylphenenate.

Abstract. Citrus bacterial spot (CBS), caused by Xanthomonas campestris pv. citrulmo, produces unsightly blemishes on leaves and stems of nursery plants that may affect their market value. In simulated nurseries, Swingle citrumelo and ‘Ruby red’ grapefruit infected with X. c. citrulmo were treated with combinations of defoliation and sprays of copper ammonium complex (CAC) to control CBS. Also, Swingle citrumelo, budded with ‘Ruby red’ grapefruit, were treated likewise before and after unwrapping the buds. Removal of diseased leaves reduced disease to a low level but did not eradicate CBS on grapefruit or Swingle citrumelo. Bacteria from stem lesions on Swingle citrumelo infected new leaves. Biweekly CAC sprays reduced the recurrence of leaf infection but did not prevent new disease except on ‘Ruby red’ grapefruit budlings, where CAC-treated Swingle citrumelo rootstock stems were removed before unwrapping the bud. The effect of disinfection of personnel and equipment on spread of X. c. citrulmo in a nursery was demonstrated by handling or hedging diseased Swingle citrumelo and following the transmission of the disease to noninfested trees down the row. Rubbing wet, diseased leaves with gloves transmitted CBS to the end of 12 m rows of 44 plants. After contamination, surface treatments of gloves with Gallex 1027 and dilute chlorine bleach reduced the incidence of CBS on individual plants but not the transmission down the row. Hedging of diseased shoots did not transmit CBS. In fruit disinfection studies, a spray application of sodium-orthophenylphenenate for 30 sec on rotating brushes reduced the proportion of infested ‘Valencia’ orange fruit from 25/25 to 1/25 and bacterial populations of X. c. pv. citrulmo from 1.7 X 10^2 cfu/cm^2 to 0.1 cfu/cm^2 fruit surface.

Citrus bacterial spot (CBS), caused by Xanthomonas campestris pv. citrulmo Gabriel, has occurred in over 60 locations in Florida on 20 different cultivars, but is predominately found in nurseries and on the rootstock, Swingle citrumelo (Graham and Gottwald, 1990; Graham and Gottwald, 1991). This hybrid cultivar (Poncirus trifoliata (L.) Raf. × Citrus paradisi Macf.) and the parent trifoliolate orange are highly susceptible under nursery conditions (Graham and Gottwald, 1991; Graham et al., 1990); however, the incidence of CBS on these cultivars decreases when infected trees are transplanted to the grove (Gottwald and Graham, 1990; Gottwald et al., 1992). Citrus cultivars, such as grapefruit, are resistant to X. c. citrulmo based on artificial inoculations, but become infected to varying degrees under nursery conditions depending on the aggressiveness of the strain and nursery practices. Mechanical operations, such as leaf stripping, budding, sprouting, hedging and spraying create wounds on leaves and stems and opportunities for the bacteria to spread down nursery rows when plants are wet and bacteria are exuding from existing lesions (Egel et al., 1991; Gottwald and Graham, 1990; Timmer et al., 1991). Strains of X. c. citrulmo, even the least aggressive forms, are capable of infecting through wounds or stomatal openings when they are assisted by physical or water pressure on the leaf or stem surface (Gottwald and Graham, 1990; Gottwald et al., 1992; Graham and Gottwald, 1990). Only the most aggressive strains are capable of significant spread by wind-blown rain and infection through stomata without wounding (Gottwald and Graham, 1990; Gottwald et al., 1992; Gottwald et al., 1988; Graham and Gottwald, 1990). The aggressive strains have occurred infrequently in nurseries, so in most cases, we are dealing with weakly to moderately aggressive that are spread by mechanical means (Gottwald and Graham, 1990; Gottwald and Gottwald, 1990).

Since 1986, fruit shipped from groves within quarantine areas for citrus canker, caused by X. campestris pv. citri, have been treated with chlorine or sodium-orthophenylphenenate (SOPP) to disinfect the fruit in packinghouses (Anonymous, 1987). In a previous test of quarantine treatments for citrus fruit (Brown and Schubert, 1987), SOPP was the most effective disinfectant against another pathovar of X. campestris. Since CBS was discovered in 1984, treatments were prescribed for fruit shipped from all citrus groves in Florida until the disease was deregulated in 1990 by the USDA Animal Plant Health Inspection Service (APHIS) (Graham and Gottwald, 1991). In spite of the lifting of this state-wide quarantine, California and Arizona still require treatments for all fruit shipped to their markets (R. Gaskalla, personal communication).

CBS continues to occur in Florida nurseries and causes unsightly blemishes on leaves and stems of nursery plants that may affect their market value (unpublished observations). Thus, means of eradication or control of CBS in the nursery are desirable. Treatments with defoliants and copper bactericides for control of citrus canker (Muraro, 1989; Timmer, 1988) have been used for eradication of the aggressive strain of X. c. citrulmo in Florida (Gottwald and Graham, 1990). Therefore, various combinations of defoliation and sprays of a copper bactericide on rootstocks and scions were tested under simulated nursery conditions for control of CBS. Secondly, means of reducing mechanical spread of CBS by disinfection of personnel and tools were investigated. Thirdly, since fruit treatments for citrus
canker and CBS are required, a treatment with SOPP was evaluated.

**Materials and Methods**

*Control with defoliation and copper bactericide in the nursery.* Experiments were conducted at a 6 ha quarantine facility at the Agricultural Research and Education Center in Hastings, FL. The facility was designed for containment of *X. c. citrumelo* in a location remote from the principal citrus production areas in Florida.

The first experiment was in a simulated nursery bed with 44 plants located in 22 rows at a spacing of 10 cm within the row and 30 cm between the rows. There were 12 rows of 3-yr-old Swingle citrumelo seedlings (ca. 1 m ht.) and 10 rows of 3-yr-old ‘Ruby red’ grapefruit (*C. paradisi*) budded on Swingle citrumelo (ca. 0.75 m ht.).

Inoculum of strain Fl (DPI X84-3048) of *X. c. citrumelo* was prepared by growing the bacterium for 3 days on nutrient-glucose agar and washing the plate with 0.075 M phosphate buffer (pH 7.0). The bacterial suspension was adjusted to ca. 10^6 cfu/ml and mixed with an abrasive, Carbunrum, to serve as a wounding agent. On 24 June 1989, bacteria were mechanically rubbed onto the upper and lower surface of leaves on each plant with leather gloves soaked in the suspension. Three weeks later, plants were cut to leave the single stem with the most lesions present on the leaves. The incidence of diseased leaves was ca. 0.60 to 0.70 (no. diseased leaves over the total no. of leaves per plant). On 21 July 1989, 5 randomly-selected rows of the ‘Ruby red’ grapefruit and 6 rows of Swingle citrumelo were mechanically defoliated which removed all diseased leaves. The defoliated plants were sprayed immediately with copper ammonium complex (CAC) (Copper-Count-N, 8% metallic copper, Mineral Research and Development Corp., Charlotte, NC) at 7.9 ml/liter and the nondefoliated plants left unsprayed. Sprays were applied to run-off by back-pack sprayer and were repeated biweekly for the next 3 months. At 14, 54, 84, and 112 days after inoculation, disease assessments were made by estimating the disease incidence for each of the 44 plants in a row. The area under the disease progress curve (AUDPC) based on disease incidence for the 4 disease assessments was calculated for each plant. The mean AUDPC’s for all of the plants in each replicated row were used for comparisons among disease control treatments (no control and defoliation/CAC spray) and cultivars (Swingle citrumelo and ‘Ruby red’ grapefruit) using the GLM procedure (SAS Institute, Inc., Cary, NC) and Student-Newman-Keul’s multiple range test.

A second experiment in 1989 was conducted on 2-yr-old Swingle *citrulmelo* seedlings (ca. 1 m in ht.) planted in a split plot design with each plot containing 15 subplots of 10 plants. Main plots received no spray or CAC spray as before at a biweekly interval beginning at the same time as a defoliation treatment. Main plots were located 6 m apart to minimize the effects of spray drift on nonsprayed controls. Within each plot, plants were inoculated with strain Fl as before on 4 May 1989 and disease incidence assessed on 17 May 1989, which ranged from 0.82 to 0.94. At 14 days after inoculation, the following treatments were randomly applied to 5 replicate subplots each: (1) nontreated control; (2) defoliation of the Swingle citrumelo; (3) defoliation, budding with ‘Ruby red’ grapefruit, and removal of the Swingle *citrulmelo* top before unwrapping the bud. Disease was assessed on the Swingle *citrulmelo* seedlings or the ‘Ruby red’ grapefruit scions at 14, 53, 89, and 125 days after inoculation and comparisons of AUDPC’s among treatments were made as before.

*Disinfestation of personnel and tools in the nursery.* For this experiment, there were 22 rows of 44 four-yr-old Swingle *citrulmelo* seedlings planted in the same configuration as the first experiment above with 11 rows maintained as multiple stems (ca. 1 m in ht.) for the treatments with hedges and 11 rows cut to single stems for the treatments with gloves. On 6 July 1990, the first 4 seedlings in each row were inoculated with strain Fl as before to obtain a disease incidence of 0.85 to 0.95 after 4 weeks. On the morning of 14 Aug. 1990, the following treatments were applied to wet plants in each of 5 rows: (1) handling diseased seedlings with gloves and then handling noninfected seedlings down the row; (2) handling the first 4 infected seedlings, and the next 4 noninfected seedlings; that at point in the row and at 4-seedling intervals thereafter, gloves were dipped in a 1.85% solution of Gallex 1027 (Galloway Chemical Div., Largo, FL) and then a 20% solution of chlorine bleach and the excess was rung out; (3) cut through infected seedlings with an electric hedger and then along the row; (4) hedge through 4 infected seedlings, then the next 4 noninfected seedlings; disinfect the hedger at that point and at 4-seedling intervals thereafter by spraying the cutting edges with Gallex and bleach as before; (4) one row of single-stemmed or multiple-stemmed seedlings were left as inoculated controls and not treated with gloves and hedges, respectively. Disease incidence was evaluated at 28, 42, and 63 days after treatment as before. Disease gradients away from the inoculated trees within each row were linearized by a modified Gregory model (ln(y/1-y) where y = disease incidence vs. ln x, where x is distance down the row from the source trees) (Gottwald and Graham, 1990). The means of slopes of the gradient for each treatment were calculated and compared among treatments using GLM and Student-Newman-Keul’s multiple range test.

*Disinfestation of fruit.* Fruit of ‘Valencia’ orange (*C. sinensis* (L.) Osb.) was harvested from the USDA-ARS Whitmore Foundation Farm in Leesburg on 3 Mar. 1991 and transported to the USDA Quarantine Laboratory in Plymouth, FL. On 4 Mar. 1991, 25 fruit were placed on a stainless-steel rack and sprayed to run-off with a suspension of strain Fl of *X. c. citrumelo* containing 10^6 cfu/ml. The fruit were allowed to dry for 1 hr in a well-ventilated, shaded location. The fruit surface was then swabbed with a cotton-tipped applicator soaked in phosphate buffer within a previously marked 17.2 cm^2 circular area across the equator of the fruit. The swab was placed in a vial containing 2 ml of buffer, sonicated for 30 sec, and the vial was placed on a shaker for 30 min to dislodge the bacteria from the swab. Dilutions of the suspension were plated on a selective agar medium containing kusagamycin-cephalexin-chlorothalonil (Graham et al., 1990). The population of bacteria on the fruit was expressed as cfu/cm^2 of fruit surface.

For evaluation of the disinfestation treatments, 25 fruit were sprayed with a bacterial suspension prepared as before and sodium orthophenylphenate (SOPP, FMC Corp., Lakeland, FL) was applied as a 2% formulated solution. Fruit were placed on 30.5-cm-wide polyethylene brushes (30 wraps per 30.5 cm) rotating at 90 rpm that were saturated with the SOPP solution. Fruit were sprayed with

SOPP solution for 30 sec on the rotating brushes and then immediately moved onto rotating rollers to rinse for 20 sec with sterile-distilled water. To determine the effect of washing without disinfectant, infested fruit were washed on brushes wetted with sterile-distilled water for 30 sec and rinsed with the same for 20 sec. Fruit were immediately removed from the rollers and placed on a stainless-steel rack to air-dry. After drying, individual fruit were swabbed as before.

**Results**

**Control with defoliation and copper bactericide in the nursery.** At 28 days after inoculation with *X. c. citrumelo*, incidence of CBS on 'Ruby red' grapefruit and Swingle citrumelo leaves ranged from 0.55 to 0.74 (Table 1). With no further treatment, disease incidence decreased to 0.26 on both cultivars by 112 days after inoculation. Defoliation and biweekly CAC sprays, reduced disease incidence to 0.02 or less on grapefruit and 0.04 or less on Swingle citrumelo and maintained the disease incidence at those levels through 112 days. The reduction in area under the disease progress curve (AUDPC) by defoliation/CAC spray treatment was more pronounced but not significantly greater for grapefruit than for Swingle citrumelo (Table 1).

Similar results were obtained in the second experiment, i.e., disease incidence decreased from 0.82 to 0.39 for untreated Swingle citrumelo seedlings by 125 days (Table 2). Biweekly sprays of CAC reduced disease incidence somewhat by 89 days as reflected by a significantly lower AUDPC. Defoliation alone greatly reduced disease incidence and the associated AUDPC, and in combination with biweekly CAC sprays, the disease incidence and AUDPC were even lower but not significantly so. The appearance of lesions on new leaves of the defoliated stems was often associated with the presence of lesions on the adjacent stem.

Grapefruit budded onto Swingle citrumelo rootstock that had been defoliated but not sprayed had a very low incidence of disease (0.001). Again, lesions occurred where rootstocks with stem lesions were present before the bud was unwrapped. If the rootstock was sprayed with CAC before unwrapping, the budding remained free of disease.

**Table 1. Reduction in disease incidence and area under the disease progress curve (AUDPC) by defoliation and copper bactericide treatment of 2-yr-old Swingle citrumelo (SC) and 'Ruby red' grapefruit (RRG) trees infected with citrus bacterial spot in Hastings, FL in 1989.**

<table>
<thead>
<tr>
<th>Days after inoculation</th>
<th>SC</th>
<th>RRG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28</td>
<td>54</td>
</tr>
<tr>
<td>RRG-untreated</td>
<td>0.71</td>
<td>0.49</td>
</tr>
<tr>
<td>RRG-defol/CAC</td>
<td>0.74</td>
<td>0.02</td>
</tr>
<tr>
<td>SC-untreated</td>
<td>0.63</td>
<td>0.43</td>
</tr>
<tr>
<td>SC-defol/CAC</td>
<td>0.55</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 2. Reduction in disease incidence and area under the disease progress curve (AUDPC) by combinations of defoliation and copper bactericide treatments of 2-yr-old Swingle citrumelo seedlings infected with citrus bacterial spot that were either not budded or budded with 'Ruby red' grapefruit in Hastings, FL in 1989.

<table>
<thead>
<tr>
<th>Days after inoculation</th>
<th>SC</th>
<th>RRG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47</td>
<td>54</td>
</tr>
<tr>
<td>No CAC/untreated</td>
<td>0.82</td>
<td>0.46</td>
</tr>
<tr>
<td>CAC/untreated</td>
<td>0.94</td>
<td>0.42</td>
</tr>
<tr>
<td>No CAC/defol</td>
<td>0.88</td>
<td>0.015</td>
</tr>
<tr>
<td>CAC/defol</td>
<td>0.88</td>
<td>0.011</td>
</tr>
<tr>
<td>No CAC/defol/bud</td>
<td>0.92</td>
<td>0.00</td>
</tr>
<tr>
<td>CAC/defol/bud</td>
<td>0.92</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Disinfestation of personnel and tools in the nursery. After handling of wet, infected Swingle citrumelo (disease incidence = 0.94 to 0.96) with gloves, CBS was readily transmitted to the next 4 seedlings down the row. In rows where single-stemmed seedlings were not handled, only a few diseased leaves were observed on the next 4 seedlings in the row and no disease was observed down the row. When gloves were not disinfested, the disease was transmitted 12 m to the end of the row of 44 plants. The disease incidence was 0.15 on the first set of plants handled beyond the inoculated plants and 0.04 on the next set of plants. The disease incidence steadily decreased on each succeeding set of 4 plants to 0.006 at the end of the row. When gloves were disinfested with Gallex and bleach, the bacterium was still transmitted to the end of the row but disease incidence along the row was lower compared to rows handled with nontreated gloves. When disease gradients away from the inoculated source trees were fitted to a logistic model, the slopes of the linearized curves did not differ between non-disinfested and disinfested glove treatments, but were significantly different from the shallower gradient in the untreated rows where there was no disease spread (Fig. 1a).

Hedging through the multiple-stemmed Swingle citrumelo did not readily transmit the bacterium to the next 4 seedlings down the row compared to the row that did not receive the hedging treatment where some natural disease spread apparently occurred. Thus, the effect of disinfestation of the hedges could not be evaluated because the disease gradient for the nonhedged treatments were significantly steeper than where hedging treatments were applied (Fig. 1b).

**Disinfestation of fruit.** *X. c. pv. citrumelo* was recovered from all fruit that were sprayed and left untreated (Table 3). The bacterial concentrations on the fruit surface varied from 46 to 9418 cfu/cm². Washing the inoculated fruit with water alone reduced the number of fruit with detectable bacteria to 13 of 25. The recoverable number of bacteria decreased from a mean of 1711 cfu/cm² on untreated fruit to 12 cfu/cm² on the washed fruit. Treatment with SOPP reduced the incidence of fruit with detectable bacteria to 1 out of 25 and less than one bacterium/cm² fruit surface.

**Table 3. Reduction in disease incidence and area under the disease progress curve (AUDPC) by SOPP treatment of 2-yr-old Swingle citrumelo seedlings infected with citrus bacterial spot in Hastings, FL in 1989.**

<table>
<thead>
<tr>
<th>Days after inoculation</th>
<th>SC</th>
<th>RRG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>99</td>
<td>171</td>
</tr>
<tr>
<td>No SOPP</td>
<td>0.74</td>
<td>0.00</td>
</tr>
<tr>
<td>SOPP</td>
<td>0.25</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Discussion

Control measures applied to simulated nursery situations were effective for reduction of CBS to a low level but usually did not eradicate the disease. CBS was eliminated by treating Swingle citrumelo by mechanical defoliation and biweekly sprays of CAC before removing the rootstock stem and unwrapping the 'Ruby red' grapefruit bud. Without copper sprays, bacteria from stem lesions apparently infested the wrapped buds even though the rootstock was removed before unwrapping. Likewise, stripping diseased leaves from the Swingle citrumelo rootstock greatly reduced but did not eliminate CBS because bacteria from stem lesions infected new leaves that sprouted after defoliation. The reinfection of leaves was reduced but not prevented by CAC sprays. Isolations of X. c. citrumelo from stem lesions on Swingle citrumelo at the end of the growing season and even after overwintering in the field, confirmed that stem lesions act as a source of inoculum for months unless infected rootstock stems are removed.

Defoliation and Cu sprays did not eliminate CBS on resistant 'Ruby red' grapefruit. This demonstrates the difficulty in eradication of a bacterium, even on a resistant cultivar, without removing all of the affected shoot tissue. Likewise, defoliation of citrus canker-infected trees with the defoliating chemical, diquat, did not eradicate the disease in citrus groves on the west coast of Florida (Graham and Gottwald, 1991). Although diquat kills angular, green stem tissue that harbors most of the stem lesions on trees recently infected with citrus canker, larger stem tissues on trees infected for more than one season will not be killed (Muraro, 1989). On mature trees, X. c. citri may survive in bark tissue in the absence of disease and remain protected from conditions such as low temperatures that can be lethal to the bacterium in leaves (Goto, 1972).

By handling wet, infected plants with gloves, we demonstrated that X. c. citrumelo was easily spread to noninfected plants in nursery rows. A similar mode of spread has been identified in direct-seeded tomato fields infested with X. campestris pv. vesicatoria in South Florida (Pohronezny et al., 1990). Disinfestation of the hands of workers that thinned the seedlings greatly reduced spread of bacterial spot on tomato plants in rows, especially when the plants were dry in the afternoon. Gloves are routinely worn by citrus nursery workers to protect their hands from thorns on rootstock cultivars. Unfortunately, leather gloves very effectively soaked-up the bacteria and were difficult to disinfect even after repeated treatment with Gallex and chlorine bleach solutions that are mild enough to be used next to the skin. Disinfestation of gloves after handling of every 4 trees did not reduce disease spread down the row, but treatments somewhat reduced the incidence of the disease compared to handling with nontreated gloves. If the plants had been handled in the afternoon when dry instead of when wet in the morning, the transmission might have been reduced (Pohronezny et al., 1990).

Hedging was previously implicated in the transmission of the moderately aggressive strain of X. c. citrumelo on large, densely-foliated 'Ruby red' grapefruit in a commercial nursery (Gottwald and Graham, 1990). Hedging was not an effective means of transmitting CBS on Swingle citrumelo seedlings maintained as a hedge. Thus, we could not test the efficacy of disinfestation of the hedgers. The lack of spread by the hedgers may have been due to insufficient diseased-foliage surface to contaminate the cutting surface with the bacterium for transmission down the row. Also, the aggressive strain may not colonize wounded foliage on Swingle citrumelo as readily as the moderately aggressive strains on grapefruit observed in commercial nurseries. Moderately aggressive strains of X. c. citrumelo are specific to grapefruit varieties but are less aggressive

![Fig. 1. Gradients of citrus bacterial spot on Swingle citrumelo that developed after spread of Xanthomonas campestris pv. citrumelo by infested gloves (a) or hedgers (b) in nursery rows and the effect of disinfestation of personnel and tools with Gallex 1027 and 20% chlorine bleach after handling diseased plants, gloves treated with disinfestants; 4) multiple-stemmed shoots, no hedging treatment; 5) mul](image-url)
on Swingle citrumelo (Egel et al., 1991; Graham et al., 1990; Graham and Gottwald, 1990). In a recent outbreak, we observed substantial leaf-spotting and stem necrosis on ‘Henderson’ and ‘Flame’ red grapefruit budlings that were exposed to the moderately aggressive strain from adjacent rows of lightly-infected Swingle citrumelo (unpublished observations). In some cases, infected stems of grapefruit budlings were severely weakened by necrosis and broke off at the base.

Currently, Florida citrus packinghouses are required to surface-disinfest all fruit shipped from citrus canker quarantine areas in the state (Anonymous, 1987). As previously shown with the surrogate, X. campesstris pv. vesicatoria (Brown and Schubert, 1987), SOPP added during the washing of the fruit was very effective in reducing the number of viable bacteria on the fruit surface to a low level if not in eradicating X. c. citrumelo. Brown and Schubert (1987) discussed the advantages of adding the disinfectant during the washing process as the physical action of the brushes disrupt and remove surface organic matter that improves the exposure of the fruit to the disinfectant. We found that the washing alone removed over 99% of the bacteria but did not possess the eradicant action of SOPP. Brown and Schubert (1987) also demonstrated that treatments of SOPP applied during a 30 sec period were as effective as longer exposures, and therefore would not disrupt the orderly flow of fruit through the packinghouse. Also, SOPP is a proven fungicide (Eckert and Sommer, 1967) and could be used for the dual purpose of decay control and bacterial eradication.

Based on current knowledge, fruit treatment for X. c. citrumelo is unnecessary for several reasons. CBS has never been found on commercial citrus fruit cultivars, only on the rootstock cultivar ‘Flying Dragon’ trifoliate orange in a nursery (Gottwald et al., 1988). Fruit cultivars develop a resistant reaction when the fruit rind is artificially inoculated with X. c. citrumelo (Graham et al., 1992). The bacterium does not survive in the lesions more than 30 to 60 days and, therefore, are not present on the fruit at harvest (Graham et al., 1992).

Abstract. Inoculations of citrus rootstocks with chlamydospores of P. parasitica in the greenhouse produced the most fibrous root rot on sweet orange (SwO), sour orange (SO), Carrizo citrange (CC), and Cleopatra mandarin (CM), less on Volkamer lemon (VL) and least on trifoliate orange (TO) and Swingle citrumelo (SC). Propagule densities from rootstock seedlings grown in pots of infested soil were greatest on SwO and SO, less on CM, and least on TO and SC. The effects of inoculum density and metalaxyl treatment were evaluated in a pot test on SwO, SO, and SC budded with ‘Pineapple’ sweet orange. Inoculation of SC with P. parasitica produced little root rot and had no effect on growth. Fungicide treatment did not affect growth of trees on this rootstock. On SwO and SO, root rot increased and growth decreased as inoculum density increased. Metalaxyl treatment reduced root rot and increased growth of trees on these 2 rootstocks. In field rootstock trials

**RELATIONSHIP OF CITRUS ROOTSTOCK TO PHYTOPHTHORA ROOT ROT AND POPULATIONS OF PHYTOPHTHORA PARASITICA**

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Additional index words.


**Literature Cited**


