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Impact of Different Preplant Cultural Treatments on Survival of *Phytophthora nicotianae* in Soil

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ABSTRACT

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During the life of a citrus planting, the population of *Phytophthora* pathogens can build to significant levels in orchard soil. A study was initiated to examine the impact of some nonchemical cultural practices on survival of *P. nicotianae*, the most prevalent *Phytophthora* sp. in Arizona citrus groves, in soil formerly planted to citrus. In three trials over a 3-year period, *P. nicotianae* could not be detected at a depth of 10 cm after soil naturally infested with the pathogen was subjected to a dry summer fallow period of at least 31 days in the desert southwest region of Arizona. The mean temperature of soil at this depth during these trials ranged from 37 to 39°C. Furthermore, in two of these trials, after summer dry fallow periods of 38 and 45 days, the pathogen could not be detected at a depth of 15 to 20 cm and was detected in only one of 19 soil samples at a depth of 25 to 30 cm. In comparison, the pathogen was recovered from a high proportion of soil samples subjected to a dry winter fallow period or maintained in the greenhouse and planted with a seedling of citrus, alfalfa, or irrigated without the presence of any plant, where mean temperature of soil ranged from 15 to 30°C. In regions with a hot and dry summer climate, a dry summer fallow treatment of soil after removal of an existing citrus planting and before establishment of a new grove could provide a rapid and relatively inexpensive means of lowering the population of *P. nicotianae* to virtually nondetectable levels to at least a depth of 30 cm.

Phytophthora gummosis and root rot is an economically important disease of citrus trees (7). The cited causal agents of this disease in the United States are *Phytophthora citrophthora* (R.E. Sm. & E.H. Sm.) Leonian and *P. nicotianae* Breda de Haan (syn. *P. parasitica*). Both oomycete pathogens are cited as important citrus pathogens in Arizona (16) and California (8), whereas *P. nicotianae* alone is the primary pathogen on citrus in Florida (26) and Texas (24). Although both pathogens are present in Arizona citrus groves, *P. nicotianae* is much more prevalent than *P. citrophthora* (16).

Infection of citrus tissue usually occurs by zoospores, which are released from sporangia in the presence of free water (25). In addition to soil moisture, disease development and severity within a citrus planting can be affected by rootstock (17), seasonal differences in rootstock susceptibility to *P. citrophthora* and *P. nicotianae* (10,11), and soil temperature (12,13). Disease management within infected citrus plantings is achieved by avoiding overirrigation (27), facilitating soil drainage (27), and using systemic fungicides such as fosetyl-Al (Aliette, Bayer CropSciences, Research Triangle Park, NC) and mefenoxam (Ridomil Gold, Syngenta Crop Protection, Inc., Greensboro, NC) (25).

During the life of a citrus planting, the population of *Phytophthora* pathogens can build to significant levels in orchard soil. When this orchard is removed and replanted, the residual population of *Phytophthora* remaining in soil can infect the new trees, resulting in suppressed growth and possible tree death, delayed onset of commercial fruit yields, and long-term decrease in yield and tree growth compared to trees growing in the absence of the pathogen. Utilization of fallow periods with or without a cover crop or soil fumigation are potential means of reducing the population of *Phytophthora*, so that newly planted trees can grow without the deleterious influence of these organisms.

In Arizona, several different methods are used by growers to prepare land for replanting of citrus trees. One approach involves total removal of old trees, including as many roots as possible, followed by rapid replanting without any additional treatment of soil. An alternative approach is to treat soil after tree and root removal with a soil fumigant such as metam sodium before replanting the orchard. Additional practices include leaving the soil fallow or planting the former orchard site to alfalfa (*Medicago sativa* L.) for 1 to 3 years before replanting with citrus. It is unknown how these different cultural practices affect the final population of *Phytophthora* present in soil prior to establishment of another citrus planting. The objective of this research was to examine the impact of different nonchemical cultural practices on survival of *P. nicotianae*, the most prevalent *Phytophthora* sp. in Arizona citrus groves, in soil formerly planted to citrus (16).

MATERIALS AND METHODS

Survival of *P. nicotianae* in citrus orchard soil. For each of the five experiments described below, a 15-liter capacity container was filled with a sandy loam soil collected from within the drip line of each of 8 (experiment 1), 9 (experiment 2), or 10 (experiments 3 to 5) different trees within a mature lemon (*Citrus limon* (L.) N.L. Burm.) grove at least 20 years old in Yuma, AZ. The soil sample from each tree was thoroughly mixed and tested for the presence of *P. nicotianae* by adding 500 cm^3 of soil into a container (13 cm wide × 23 cm long × 7 cm deep), then placing two ripe but green-colored unblemished pear fruit on the surface of the soil. Sufficient water was added to establish a 1- to 2-cm layer of free water at the soil surface. After incubation at 26°C for 48 h, the fruits were removed from the soil, washed in water, and incubated for an additional 48 to 96 h at 26°C. Firm brown lesions developed on pear fruits invaded by *P. nicotianae*. To confirm the identity of the pathogen, a small piece of tissue from the advancing margin of one or more lesions per pear fruit was placed on corn meal agar amended with pimaricin, ampicillin, rifampicin, and pentachloronitrobenzene (PARP) (5) and observed for mycelial growth characteristics of *P. nicotianae*.

Four 1-liter subsamples of soil from each bulk sample collected from a citrus tree became samples of soil subjected to one of the following cultural conditions: (i) planted with a *Citrus volkameriana* Tan. & Pasq. seedling, maintained in the greenhouse, and irrigated as needed; (ii) planted with an alfalfa seedling, maintained in the greenhouse, and irrigated as needed; (iii) maintained in the greenhouse and irrigated at the same time as soil containing citrus or alfalfa plants; and (iv) soil maintained outside without irrigation in full sun within a 1-liter capacity container composed of white plastic (11 cm diameter × 13 cm deep) placed in the field so that the upper lip was 1 cm higher than the surrounding soil surface and the soil within the container. In all but experiment 1, a 7-liter

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