Etiology, Epidemiology, and Management of Hyphoderma Gummosis

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Hyphoderma gummosis is a relatively new disease of lemon trees in the central valley and coastal production areas of California. The causal pathogen *Hyphoderma sambuci* is a fungus in the Basidiomycota that invades woody tissues through wounds.

Branches and tree trunks may become rapidly colonized, leading to tree wilting, dieback, and ultimately tree death. During late stages of disease development, extensive gumming is often observed, and a thin layer of cream- to salmon- colored fruiting bodies is produced on the surface of branches and tree trunks. Fruiting bodies produce the sexual spores (i.e., basidiospores) that are wind-disseminated and can cause new infections.

Our monitoring over several years indicated that viable fruiting bodies, as assessed by basidiospore production, in affected orchards in Tulare County are found commonly starting February/March. By early-June, with the onset of hot, dry summer weather, most fruiting bodies are no longer viable.

Our genetic studies indicated that the outcrossing *H. sambuci* has a bifactorial mating system with two loci determining compatibility. We found multiple alleles for each of these loci. The genetic background of fruiting bodies from trees within a small area in the orchard was diverse.

This indicated that (1) the pathogen population is highly heterogeneous, (2) the disease is disseminated by basidio-spores, (3) multiple introductions of the pathogen are generally responsible for disease epidemics, and (4) new infective dikaryons capable of producing new fruiting bodies can be readily established. The highly heterogeneous population structure of *H. sambuci* was confirmed using random amplified polymorphic DNAs. This is an indication of sexual recombination and that basidiospore dissemination is most likely the only mechanism of pathogen dispersal.

Hyphoderma gummosis has been found in the field only on lemons, stone fruit, and native woody plants. To define the citrus host range of *H. sambuci*, we conducted several inoculation studies with potted plants of different citrus species and varieties in the greenhouse. Using several inoculum concentrations (200 to 4000 basidiospores/inoculation site) and two inoculation methods, we previously found that the fungus was pathogenic to several citrus varieties other than lemon, including Valencia and Navel orange, Bears lime, Murcott, mandarin, grapefruit, as well as pineapple sweet orange.

These experiments were repeated in 2007. Plants (4-5 plants per variety) with stems ca. 0.5 inch in diameter were cut ca. 20 inch above the soil line and inoculated with basidiospores. After ten weeks, plants were rated for dieback. Samples were taken ca. 0.5 inch below the cross-cut inoculation site and plated out on agar.

Dieback was found on all cultivars except for Eureka lemon, and the highest incidence of dieback was observed on Navel, Valencia, and pineapple sweet orange. The pathogen was re-isolated from woody tissues with the highest incidence from Murcott (100%), pineapple sweet orange (100%), mandarin (100%), Valencia orange (87.5%), and Navel orange (50%). Lower incidences of recovery were obtained for lemon (40%), lime (30%), and grapefruit (20%).
Thus, similar to our previous studies, *H. sambuci* was found to be pathogenic and possibly more virulent to several citrus species and varieties other than lemon. Host-specificity of the pathogen in the field, however, may depend on the type of wound or environmental factors that were not considered in our greenhouse studies. For example, the occurrence of the disease only on lemon in the field may reflect the fact that lemons are more often affected by freeze damage that creates entryways for the pathogen.

Hyphoderma gummosis is very difficult to manage. There are no curative treatments available, and orchard sanitation that includes the removal of diseased branches and severely affected trees is the only option once the disease is established. Thus, management of Hyphoderma gummosis is mainly based on preventative measures that include pruning during the drier time of the year when fruiting bodies are not viable, inoculum levels in the orchard are lower, and when environmental conditions are less favorable for basidiospore germination and the establishment of new infections (i.e., do not prune prior to rainfall).

In our previous studies on disease management we found that, although highly toxic in vitro, fungicides (i.e., azoxystrobin, pyraclostrobin, boscalid, and propiconazole) were not effective as pruning wound treatments to prevent the colonization of host tissues by *H. sambuci*. Preventative treatments with the biocontrol agents *Trichoderma viride* and *T. harzianum*, however, resulted in a significant reduction of wound colonization.

We are currently working with Wilbur-Ellis and BioWorks on registration of PlantShield (commercial formulation of *T. harzianum*) on citrus. PlantShield will have to be applied immediately after pruning or trunk/branch injuries before infections occur. BioWorks has obtained exemption from food tolerance for the product in California (40CFR180.1201) and will provide toxicity data against non-target pests such as bees. Handling procedures for worker safety will be as for other Class 3 pesticides in California. Currently, we are preparing a label for registration specifically against Hyphoderma gummosis. The proposed label will read: Apply 3-5 oz of product per 100 gal of water and apply at 400 gal/A directly to recent injuries (e.g., pruning wounds, cold injuries).

**Figure 1.** Citrus host range studies of *Hyphoderma gummosis* in the greenhouse. A. Cross-cut inoculation (one of two inoculation methods used) with basidiospores applied onto the transverse cut surface that was covered with parafilm and taped (arrow). Early dieback is shown (arrowhead). B. Extensive dieback of an inoculated shoot. In re-isolations, the fungus was recovered from the advancing margin (arrow).