THE UNIVERSITY OF ARIZONA
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# Phymatotrichopsis Root Rot in Pecan

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## What is Phymatotrichopsis root rot?

Phymatotrichopsis root rot (abbreviated as PRR) is commonly referred to as Cotton root rot, Phymatotrichum root rot, Texas root rot, or Ozonium root rot. This disease is caused by a soilborne fungus *Phymatotrichopsis omnivora* (abbreviated as PO) that attacks the roots of susceptible plants, causing sudden wilt and death. This pathogen has a wide host range and can attack more than 2,300 dicotyledonous (broadleaf) plant species including many ornamental and important agronomic crops (Lyda, 1978). In contrast, the fungus colonizes but does not kill monocotyledonous plants (grasses), which are highly tolerant or resistant to this pathogen. Phymatotrichopsis can be found in a wide range of soils, but is more prevalent in calcareous clay soils with a high pH range of 7.0 – 8.5. It is one of the most destructive fungal pathogens of pecan, pistachio, cotton, alfalfa, grape, fruit trees, shade trees, and ornamental plants like conifers. The economic losses attributable to this important disease are over hundreds of millions of dollars annually in the southwestern and south central United States (**www.cotton.org**).

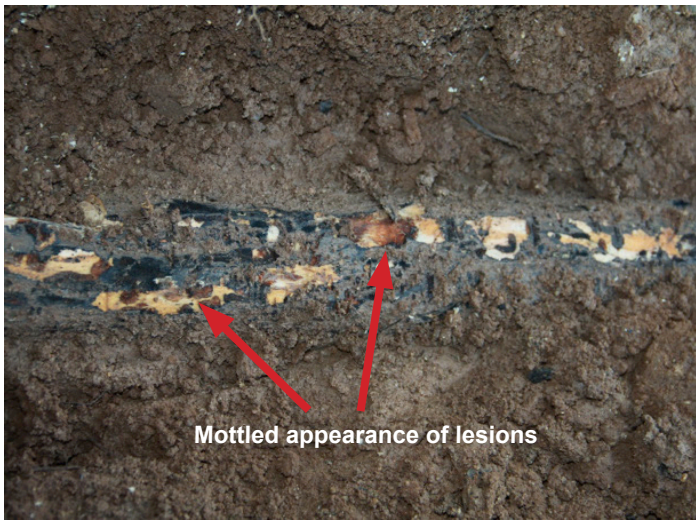



Figure 1. Outer layers removed to show mottled lesions on lateral roots of infected pecan trees.

## What is the PRR's economic impact on AZ pecan industry?

PRR is prevalent in all of major pecan production areas in Arizona. Average tree mortality due to this disease is thought to be greater than 10% annually. Consequently, the negative impact of PRR on AZ pecan industry is significant. For instance, in pecan growing areas where valuable resources (i.e., water, fertilizer, and labor) have been used to raise a young seedling transplant for 3 - 4 years, and sometimes even in trees of 12 years of age and older, the sudden loss due to root rot infection makes a waste of these high cost resources. The value of loss in new transplants indicated by farm managers are upwards to $2,000 per tree. In 2016, for Cochise County, it was reported that 600 immature trees in two separate locations died from this disease. This is an estimated $1.2 million dollar combined loss. Therefore, the need for researching economically viable methods in mitigating PRR's impact on tree mortality is critical and of high interest by a large number of perennial crop stakeholders.

## What does it look like?

Disease symptoms can occur from late April through November, but are most likely to occur from June to October when soil temperature is above 28°C (82°F). If the root system of a pecan tree is partially invaded by *P. omnivora* (Figure 1), this PO-infected tree may have a healthy asymptomatic appearance. However, overall vigor is less compared to non-infected healthy trees, especially in late April when pecan trees break buds and began their new flush of growth for the season. In southeastern Arizona, these PO-infected but asymptomatic trees often leaf out at least 2-weeks later than non-infected pecan trees (Figure 2). In some cases, where the majority of roots are destroyed by PO, the infected trees may wilt and die soon after emergence of new leaves (Figure 3). As summer temperature rises, trees with significant portions of their root systems compromised by PO

Figure 2. The pecan tree in the left panel is infected by PO and the one in the right panel is a healthy tree. The affected trees leafed out at least two weeks later than healthy trees.

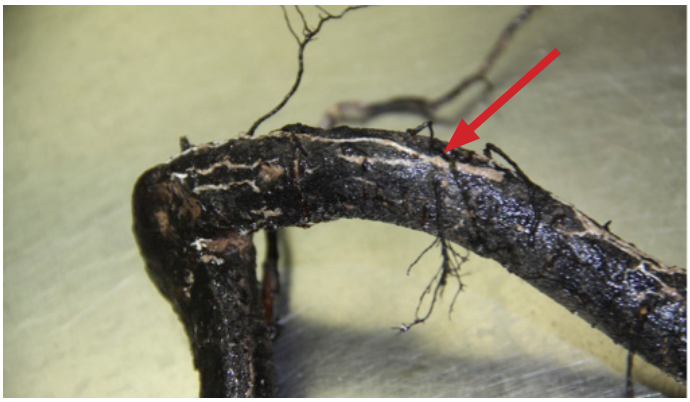
Figure 3. Trees with significant amount of roots destroyed produce new growth in the spring. Leaves wilt and die after bud break and blooming.

Figure 4. Infected pecan trees killed by PO. Dry, yellow leaves remain attached to the plant. (Photo credit: Joshua Sherman)

often wilt and die suddenly. Leaves will turn yellow or brown quickly and remain firmly attached to the tree, as if they are going dormant in the middle of summer (Figure 4). The reason for this sudden death is the inability of rotted roots to take up and translocate sufficient water to support the canopy. The term "flash" has been coined by some in pecan industry to describe this seeming overnight tree death. Other trees with PO infection, such as those in a residential setting, have been described by their owners: "It just died overnight". The affected trees may also become girdled at the soil line. Some PO-infected pecan trees at elevations above 4,500 feet can survive the hot summer conditions, but branch dieback with severe defoliation and significant yield reduction are often observed (Figure 5).

Additional symptoms observed in the roots of infected plants include: root bark that is decayed and brownish, and bronze colored wooly strands of the fungus are frequently visible on the root surface (Figure 6). These wooly strands, when viewed under a compound microscope will show the unique identifier

Figure 5. Defoliation, branch dieback, and root rot on a PO-affected pecan trees that survived the hot summer.



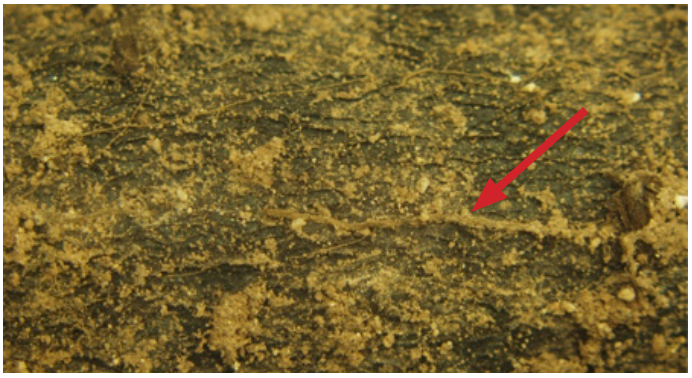


Figure 6. White to tan fungal strands (indicated by arrow) on the pecan root surface

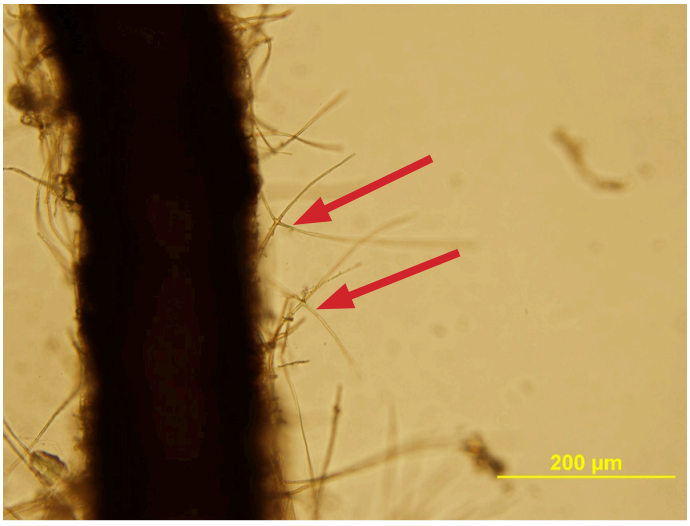



Figure 7. Cruciform hyphae (indicated by arrow) on the fungal strand

for PO: cruciform hyphae (Figure 7). Cushion-like sclerotia or resting bodies about the size of a pinhead (1-2 mm in diameter), initially light tan in color but later dark and warty, can be found on the root surface. A spore mat may sometimes appear on the soil surface during periods of high moisture. These mats, which can range from 2 to 16 inches in diameter, are first snow-white and cottony, then later turn tan and powdery (Figure 8). The spore mats are evidence of the fungal presence, but currently, spores are thought to have no function in the survival, infection, or spread of the PO fungus.

Figure 8. Spore mat on the moist soil surface during the summer monsoon season

## What can it be confused with?

Verticillium wilt, sudden wilt, and root rot due to excessive moisture in waterlogged soil can often be mistaken for PO infected trees.

## What should I look for?

PRR often occurs in patches within a pecan orchard (Figure 9). These patches often are circular, but may be irregular in overall shape. These areas gradually enlarge in subsequent years as the fungus grows through the soil and moves from plant to plant. Infested areas may advance 5 to 30 feet per year. New orchards established in old cotton or alfalfa fields are especially vulnerable (Figure 10). In early spring, look for trees with delayed leaf development; during summer, look for wilted or dead trees with dry leaves firmly attached; in the fall, look for trees with thinner canopy and defoliation; during periods of high moisture, and look for presence of a spore mat on the soil surface. The roots of trees with symptoms should be dug up and examined for the presence of white to tan fungal strands on the root surface (Figure 6). These roots can be dug up and sent to the Plant Disease Diagnostic Laboratory at the University of Arizona for confirmation. The Plant Disease Diagnostic Form should be completed and included with the sample. Refer to instructions on preparing samples and completing the form. This form is available at: https://cals.arizona.edu/azpdn/sites/cals.arizona.edu.azpdn/files/docs/PDDL_form.pdf

## How does the disease occur in my farm?

The PO fungus persists almost indefinitely, primarily in the top 2 to 6 feet of soil. It produces two distinctive survival structures: 1) sclerotia, which function much like seeds, surviving for years in the soil as deep as 12 feet; and 2) fungal strands, root-like strands (rhizomorphs) that grow through the soil until they contact susceptible plant roots. Strands surround a root and grow toward the soil surface. The fungus reproduces rapidly around the hypocotyl just below the soil surface, producing a

Figure 9. Aerial view of disease foci pecan orchards infested with root rot.

Figure 10. Aerial view of young pecan orchards with severe tree loss and damage due to root rot.

white cottony mycelial growth. Below this mycelium, the bark is destroyed, and the fungus fills the vascular tissue of the tree. Following death of the tree, sclerotia form in the strands to complete their life cycle.

## How does it spread?

Locally, the pathogen can spread directly to adjacent plants by fungal strands that grow through the soil. However, it does not spread readily from one field to another, unless present on the roots of infected transplanted trees or through the movement of soil or plant debris from infected to clean fields.

## Where is it now?

The disease is limited to the southwestern and south central United States. In Arizona, it is found across the southern portion of the state. Highly prone areas include the flood plains and certain tributaries of the Gila, Santa Cruz, San Pedro, Colorado and Salt Rivers.

## How can I protect my pecan orchard from Phymatotrichopsis root rot?

There are no effective control methods. Resistance is not available in common rootstocks. An integrated approach may help reduce the occurrence and severity of this disease.

For new plantings, the best strategy is to avoid establishing orchards on land known to be infested with the fungus, especially former cotton or alfalfa fields with a history of PO. PO can also survive on roots of native vegetation, such as mesquite, without causing any disease, so if you are clearing mesquite land for a new orchard and have the proper irrigation method installed, the area may be pre-planted with susceptible cotton or alfalfa as an indicator crop. If no symptoms develop on these indicator crops, the land is relatively safe for establishing a new orchard.

For existing infected pecan orchards, no effective control is available for PRR disease. However, the disease may be mitigated to a significant degree or prevented from spreading to healthy trees by using a combination of the following approaches:

1. Early detection of the disease is key to effective control with fungicide and cultural practices. It is important to scout your orchards diligently for the presence of new pests and unusual disease symptoms. Make sure you are familiar with common diseases so you can accurately identify symptoms. Any suspect tree should be removed or treated immediately or monitored for continued symptoms and removed as soon as the presence of PO is confirmed.
2. Addition of organic amendments and fertilizers can significantly reduce disease severity by lowering the alkalinity of the soil. Acidifying the soil around susceptible trees with sulfur may help delay or prevent root rot infection. Wheat, oats and other cereal crops are effective in delaying infection and reducing disease incidence when incorporated into the soil in the spring. Certain forms of nitrogen, such as anhydrous ammonia and ammonium sulfate, have been reported to kill sclerotia, thus reducing the incidence of root rot (Neal and Collins, 1936; Lyda, 1978; Rush and Lyda, 1982). Field trials are needed to determine whether a combination of sulfur, humate fertilizer, natural compost, and fungicide could save or revive PO-infected trees.
3. Planting resistant plants as a barrier around an infected area may help to contain the fungus and reduce the spread of the fungus as the resistant plants do not harbor the pathogen in their roots. Grain crops such as sorghum, barley, corn, wheat, oat, rye, and millet are typically used. Other resistant plant species include all grass species, black currant, strawberry, bamboo, crepe myrtle, holly, evergreen

honeysuckle, eucalyptus, cedar (juniper), Japanese red pine, cedar-elm, live oak, southern magnolia, and weeping mulberry. Of course, this may be very limited due to water availability and capital resources.

4. Although there is no effective fungicide program to control PRR in pecan, the compound flutriafol has been shown to be highly effective in controlling the fungus of cotton and grape. In Arizona pecan, flutriafol is registered as Rhyme (FMC Corporation) for the control of foliar fungal diseases on pecan such as powdery mildew and scab. While the current Rhyme label does not explicitly state its efficacy for controlling Phymatotrichopsis root rot, field research trials are ongoing to find the best application method, rate and frequency. Some research has shown that foliar application of flutriafol can delay senescence and dormancy, since triazole fungicides have been shown to affect plant hormone balance (Fletcher et al., 2000). It is important to follow label instructions when applying this fungicide.

## Concluding Remarks

Although PRR issue has become top concern on the priority list of AZ pecan growers, disease management can be very difficult, costly, and has not been effective to date. Effective management should focus on early detection so that infected trees have less amount of root damages and are able to respond to treatment. Without the ability to accurately locate the advancing fungus, management measures initiated behind the leading edge of the disease center would be ineffective; whereas, management options implemented beyond the advancing fungus could result in unnecessary loss of healthy trees. An accurate method of determining infected asymptomatic trees needs to be devised before reliable disease management can be implemented with maximum effectiveness.

Currently, information is limited regarding the effectiveness and the economic benefit of current PRR management practices. Research is needed to answer the following questions that address the management of PRR in Southeastern Arizona: How far PO spreads beyond symptomatic trees into infected, asymptomatic trees? What are the spatial spread pattern? What is the annual rate of tree mortality in a typical PO-infested orchard? What are the major environmental and agronomic factors contributing to epidemics in Southeastern Arizona? To what extent infected transplants has spread PRR between orchards? Is fungicide treatment effective in killing the fungus, thus helping to improve the health and productivity of an infected tree? Is application of organic matter beneficial? How diverse are PO populations in Southeastern Arizona? Are there some rootstocks tolerant to the infection by PO? What is the status of rootstock resistance in Arizona? Research projects to address these questions will help to provide a strong basis for integrated control of PRR in Arizona pecans.

## Resources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