GROWING KNOWLEDGE

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Progress towards effective *Phytophthora* root rot control

Phytophthora root rot caused by *P. cinnamomi* (wilting plant, left) and *Phytophthora* leaf spot caused by *P. syringae* (right), both occurring at the same nursery. These two diseases require different approaches for management. BY JERRY WEILAND U.S. DEPARTMENT OF AGRICULTURE AGRICULTURAL RESEARCH SERVICE

Research shows *Phythopthora* root rot, leaf spot require different approaches for management

BY JERRY E. WEILAND AND CAROLYN F. SCAGEL

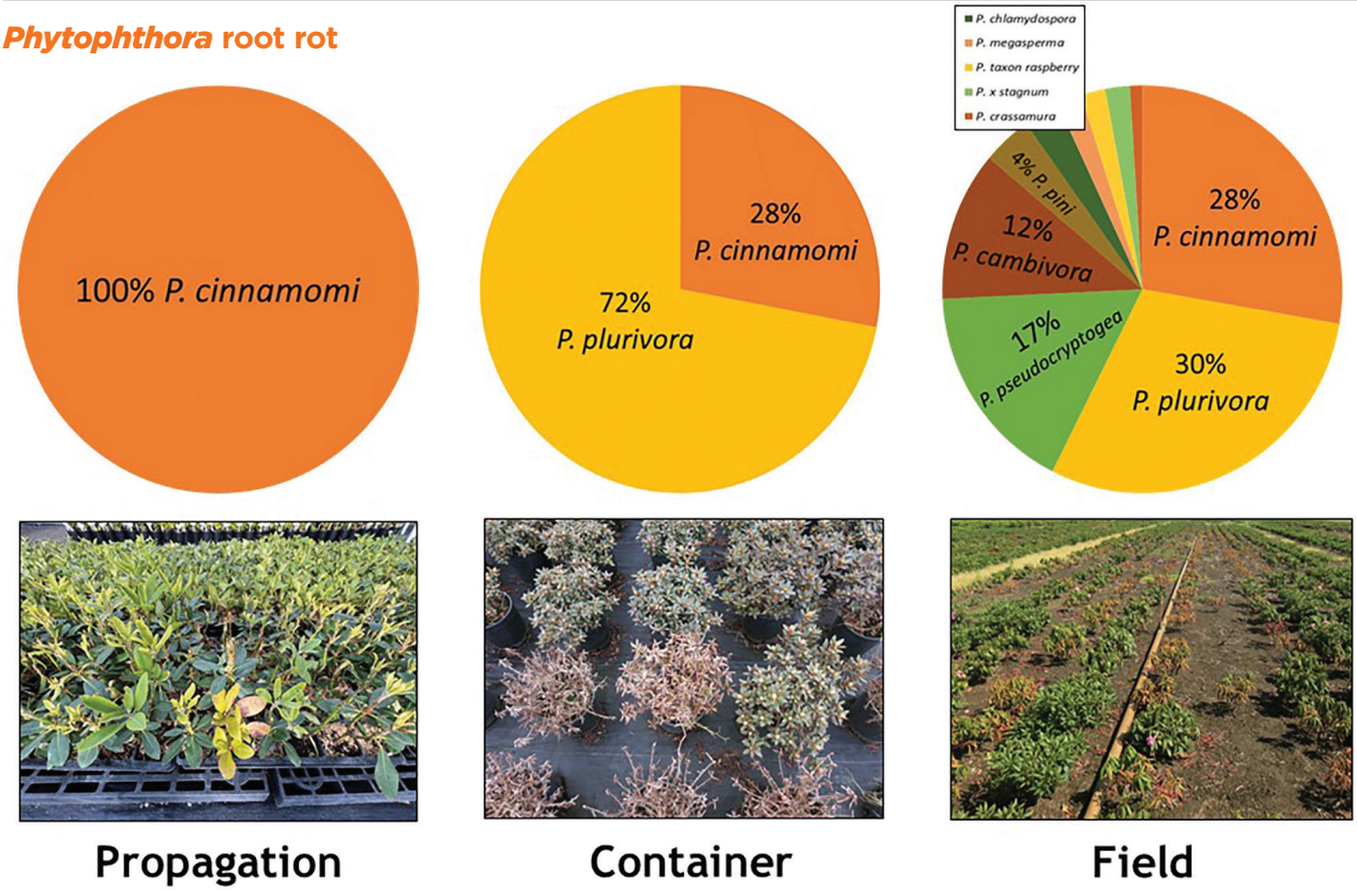
IT'S BEEN 10 YEARS since our research team started receiving funds from the Floriculture and Nursery Research Initiative (FNRI) to study soilborne diseases for the nursery industry. Based on Oregon Association of Nursery's research priorities, we chose to study *Phytophthora* root rot because it is one of the most common diseases of nursery plants nationwide.

We also focused on the disease as it affects *Rhododendron* because the Pacific Northwest is the top producer of this valuable ornamental shrub ($13 million/year). Since 2013, we have collaborated with other scientists to better understand this troublesome disease, including Johanna Del Castillo-Munera (University of California-Davis), Carla Garzon (Delaware Valley University), Nik Grunwald (United States Department of Agriculture-Agricultural Research Service), Jay Pscheidt (Oregon State University), and Luisa Santamaria (OSU). Here are some of our most important findings.

Main causes of *Phytophthora* root rot of rhododendron

Our first task was to determine which *Phytophthora* species were causing root rot of rhododendron in the PNW.

A 1974 survey indicated that *P. cinnamomi* was the main culprit in our region, with losses averaging 10–15%. However, a lot has changed since then, and nurseries may be dealing with new species that weren't around 50 years ago. Indeed, more recent surveys show that there are about 20 different *Phytophthora* species causing leaf spots, cankers, and root



Rhododendrons are exposed to an increasing number of Phytophthora species as they move from propagation into container and field systems. As a result, container and field systems generally suffer more losses from Phytophthora root rot. BY JERRY WEILAND U.S. DEPARTMENT OF AGRICULTURE AGRICULTURAL RESEARCH SERVICE

rot on many of Oregon's most important nursery crops.

Nevertheless, it still wasn't clear which species were causing root rot on *Rhododendron*, and we also wanted to know if disease control had improved since the 1970s, when few *Phytophthora*-specific fungicides were available.

To answer these questions, we evaluated root rot at seven PNW rhododendron nurseries and collected samples to identify the *Phytophthora* species involved.

Our survey found that root rot is still a serious problem for the rhododendron industry, causing up to 41% in inventory losses per year (average 15%), with damage generally being least on cuttings in propagation facilities, intermediate in container-grown plants, and worst in the field. The increase in root rot corresponds to an increasing number of *Phytophthora* species as plants move through the production cycle (see chart above). This is because propagation facilities generally start with clean materials, while plants in container and field systems are increasingly exposed to *Phytophthora* from contaminated pots, gravel, irrigation water, potting media, and field soil.

Our survey also found that *P. plurivora* and *P. cinnamomi* are now the top two species causing root rot in most rhododendron nurseries, with *P. plurivora* (44% of samples) replacing *P. cinnamomi* (29% of samples) as the #1 species in our region.

Phytophthora plurivora is a relatively newly-discovered species that may have been introduced into the U.S. as early as the 1960s. It is unique in that it produces inoculum that spreads both above and belowground. It causes leaf spots, cankers, and root rot.

On the other hand, *P. cinnamomi* is restricted almost completely belowground where it mainly causes root rot. This difference in biology allows *P. plurivora* to spread more easily than *P. cinnamomi,* and has led to it becoming one of the most important *Phytophthora* species in nurseries worldwide.

Fungicide resistance hampers control

While conducting the survey, growers mentioned that *Phytophthora* root rot was increasingly difficult to control, and that fungicides weren't always effective at preventing the disease.

Based on this information, we tested *Phytophthora* isolates from the survey for resistance to two popular fungicides, mefenoxam (e.g., Subdue MAXX®) and phosphorous acid (e.g., Alude™).

While all *P. cinnamomi* isolates and many *P. plurivora* isolates were sensitive to both fungicides, isolates of *P. plurivora* at four nurseries had developed resistance to one or both products. In fact, 90% of the *P. plurivora* isolates at one nursery were resistant to phosphorous acid, which explained why that grower had difficulty controlling root rot.

So, although both fungicides are effective for *P. cinnamomi*, they may not work at nurseries where *P. plurivora* has developed resistance (see photo on Page 43). This situation illustrates why it is important to not rely on fungicides alone for disease control and why growers should alternate with more than one or two different fungicide chemistries over time.

Drenches vs. foliar sprays

We also tested whether disease control depends upon where the fungicides

A mefenoxam soil drench did not prevent root rot caused by a fungicide resistant isolate of *P. plurivora* (yellow plant, foreground), but was effective against root rot caused by *P. cinnamomi* (healthy plant, background right). BY JERRY WEILAND U.S. DEPARTMENT OF AGRICULTURE AGRICULTURAL RESEARCH SERVICE

are applied to the plant.

Both mefenoxam and phosphorus acid are systemic, and some growers apply these fungicides as a foliar spray to protect against leaf- and stem-infecting *Phytophthora* species such as *P. syringae* and *P. ramorum*, hoping that the systemic activity will also protect against root rot (see photo on Page 41). But does this actually work? Unfortunately, no.

Our research showed that soil drenches are much more effective at reducing root rot than foliar sprays. It is therefore better to put fungicides where the plant needs the most protection: on the leaves for *Phytophthora* leaf spots and on the roots for *Phytophthora* root rot.

The impact of nitrogen fertilization

Fertilization is often used to produce larger, quality plants more quickly. We therefore wanted to see how nitrogen (N) application influences root rot in a study evaluating three levels of ammonium sulfate (none, low, and high).

Generally, increasing the amount of N applications caused root rot to get worse. Although lower levels of N reduced the number of visibly diseased plants, it also led to plants becoming stunted and chlorotic, and could increase the risk for selling apparently healthy plants with low levels of infection. Growers should therefore focus on a balanced approach, being cautious not to overfertilize, as this makes plants more susceptible to several diseases, not just *Phytophthora* root rot.

Climate change affects *Phytophthora* biology

Climate change is having an effect on nursery production in the Willamette Valley, with hotter and drier summers and more unpredictably cold or wet winters. We therefore conducted experiments to determine how temperature and soil moisture influence *Phytophthora* biology and control.

Our studies showed that *P. cinnamomi* and *P. plurivora* are adapted to a broad range of temperatures, growing best at temperatures near 80 F. *Phytophthora plurivora*, however, sporulates better at cooler temperatures (50-70 F) than *P. cinnamomi* (60-80 F), which may give it »

an advantage for causing disease in spring and fall. We also found that temperature influences how well fungicides inhibit the growth of *Phytophthora* isolates in the laboratory. But additional experiments are needed to determine how this relates to disease control.

Because *Phytophthora* root rot is frequently associated with overwatering and wet soil, we tested whether we could reduce disease by growing newly infected plants under drier conditions.

Unfortunately, plants grown with less water developed just as much disease as those grown in consistently moist soil. Counterintuitively, root rot actually became severe under dry conditions because the newly infected roots slowly lost their ability to take up water.

This, in turn, caused soil moisture to rise and resulted in a slightly wetter environment that was more conducive for root rot. So, once infection has occurred, there is little that can be done to manage the disease by reducing irrigation. Instead, focus disease control efforts on preventing infection from occurring in the first place by avoiding situations where plants are overwatered or sit in puddles for any length of time.

Future directions

In summary, our research has shown that there are two main species of *Phytophthora* causing root rot of rhododendron, *P. plurivora* and *P. cinnamomi*. This is important, because these two species differ in their biology and adaptability to different environments (affecting their ability to cause disease) as well as their sensitivity to fungicides and other disease control measures (affecting disease control). Disease control strategies that were developed for *P. cinnamomi* back in the 1970s–1990s may not work as well for other *Phytophthora* species such as *P. plurivora*.

Our next step will be to evaluate new fungicide chemistries to see if they are effective against mefenoxam- and phosphorous acid-resistant *Phytophthora* isolates. We will also be expanding our *Phytophthora* root rot survey to include other plants important to the nursery industry. This will allow us to identify other *Phytophthora* species constraining nursery production and will help us develop disease control methods that are effective for a broader range of nursery plant species.

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