Managing Phytophthora Root Rot

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Phytophthora root rot (PRR) is a significant disease affecting a multitude of agricultural crops around the world. For Christmas tree producers it can be one of the most formidable diseases with the potential to cause tree mortality at any stage throughout a rotation (Photo 1). In addition, it can cause extensive mortality to conifer seedlings in bareroot nurseries (Photo 2). PRR can be caused by many different Phytophthora species that can vary by geographic region. These fungal-like, oomycete plant pathogens are often referred to as water molds because they are favored by saturated soils and produce swimming zoospores. PRR is a complex disease and is difficult to control once it has established in a production area. To minimize the impact of PRR on their operations, it is crucial for growers to understand this potentially devastating pathogen. Here, we review the pathogen's life cycle, factors that contribute to its development and spread, and potential management steps to mitigate PRR development. As with other diseases, a proactive integrated management approach will often lead to the best possible outcomes.

Photo 2 – *Phytophthora root in 2-0 bareroot stock nursery. Credit: Edward L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org*

Life Cycle:

The Phytophthora species which cause PRR are soil borne pathogens that can remain dormant for years as resting thick-walled spores called chlamydospores. These can remain idle in the soil or in previously infected root tissues. When conditions become favorable for disease development (i.e. warm, saturated soils), these dormant structures become active and develop sporangia. Sporangia can infect nearby tree roots themselves or they may produce and release mobile zoospores (Photo 3). Zoospores can easily move in water through saturated soils and are attracted to root tips where infections begin. Once a root is infected, Phytophthora begins to colonize tissues until it eventually spreads into the root crown. While additional periods of saturated soils will result in more sporulation and infections, saturated soils are not necessary for colonization of infected roots after the initial infection has occurred. Once the roots and trees have been killed, Phytophthora will resume its dormant phase (chlamydospores) until favorable conditions restart active infections.

Symptoms:

As Phytophthora colonizes a tree's root system, a number of above ground symptoms develop. This may include cankers, loss of apical growth, branch flagging, and needle chlorosis. As disease progression continues, the needles on infected trees can rapidly go from an off-colored yellowish (Photo 4) color to red/brown particularly with the onset of warmer ambient temperatures in the spring and summer (Photo 5). Once above-ground symptoms are observed, disease progression is usually advanced as internal vascular damage limits water and nutrient uptake and movement through the tree. Tree decline and death can happen rapidly. Spruce, pine, and fir trees can all be infected with PRR, however, susceptibility varies widely among fir species. For example, testing at Washington State University demonstrated that Fraser fir and noble fir are among the most susceptible species, while Nordmann and Turkish fir are among the most resistant (Photo 6).

While trees affected by PRR are typically associated with poorly drained areas and areas where in fields where water accumulates, accurate diagnosis is important. Some biotic and abiotic stressors can present similar symptoms. To confirm PRR, send a sample of symptomatic roots to a regional plant diagnostic lab. Trees that are not fully dead, but exhibiting symptoms are often the best samples to submit. Field testing can also be done to help confirm the presence of PRR. Use a knife to scrape away the outermost bark tissue near the root collar. Often PRR will exhibit a red to purple discoloration (flame) on cortical tissue as the disease progresses up the tree.

Management:

As with other diseases, PRR requires a conducive environment, a susceptible host, and the presence of the pathogen for it to develop in the field. Preventing PRR involves eliminating or removing one of those three factors to prevent disease development.

Prevent inoculum from entering field:

One of the best ways to deal with PRR is to prevent it from being introduced

Photo 1 – *Phytophthora root rot damage in field. Credit: Penn State Department of Plant Pathology & Environmental Microbiology Archives , Penn State University, Bugwood.org*

Photo 3 – *Sporangium filled with zoospores prior to release. Credit: Mary Ann Hansen, Virginia Polytechnic Institute and State University, Bugwood.org*

to your field in the first place. Common pathways of introduction include planting stock and irrigation water. Any surface water (e.g. pond or stream) can be a source of PRR. Growers who use these water sources for irrigation should consider testing them for the presence of Phytophthora and treating the water prior to application to fields (or finding other sources of water). Treatments of free chlorine at 2 to 4 parts per million for exposure time of 10 minutes have been shown to be successful in eliminating PRR species from water. In most instances, filtration is not an economically viable option to eliminate Phytophthora from irrigation water. Water sourced directly from wells is not a source of PRR.

Another common source of PRR introduction is from planting stock. When receiving planting stock, inspect transplants thoroughly, paying particular attention to the health of their roots systems. Do not plant transplants that exhibit any signs of disease, it is best to cull them without planting into field. Although it is possible to have transplants that are asymptomatic, but are infected with PRR a careful inspection of the seedlings prior to planting will help reduce the risk of introducing PRR into production fields.

For fields that have confirmed PRR, it is imperative to prevent further spread to non-affected areas. Make sure to not move soil or plant material from contaminated sites to other areas on the farm. Limit the movement of surface water from affected to non-affected areas. While dead trees should be cut and removed from fields, digging out diseased stumps and roots from the field will have limited value. It is more important to not disturb the soil in infected areas thereby increasing the chance of spreading infected soil. Soil can be inadvertently transferred on equipment (tractor tires) or by people (boots, shoes). Maintain ground cover

Photo 4 – *Concolor fir infected with Phytophthora root rot. Credit: Bill Lindberg MSU Extension*

Photo 5 – *Fraser fir trees infected with PRR. Credit: Bill Lindberg MSU Extension*

to prevent soil erosion from moving PRR-infested soil from one location to another.

Fungicides:

While fungicides are often used to help manage PRR on a number of ornamental nursery crops, there are several challenges relating to their use to manage PRR in Christmas tree plantations. Some of these include the spotty nature of where the disease occurs, the lack of solid information on the residual activity of fungicides, and the need for a better understanding on the timing and number of fungicide applications that are needed to limit disease development. When fungicides have been tested in Christmas tree plantations, applications are typically limited to one or two per year and data suggests that fungicide treatments are not very effective when conditions are favorable for disease development, such as after soils have been flooded. A product like Metalaxyl may be an option, but will not overcome poor cultural issues (wet soils) or aid trees that are already facing moderate to severe infection.

Photo 6 – *Differences in tree species susceptibility to phytophthora inoculation. Noble and Fraser species highly susceptible, Trojan, Turkish, and Nordman show resistance to PRR. Credit: Dr. Gary Chastagner Washington State University*

Change the environment:

Growers can work to mitigate the impacts of PRR by managing their sites

to be less conducive to pathogen spread and more favorable for vigorous planting stock. Avoiding poorly drained planting sites is an important key to minimizing the risk of PRR. Other management steps growers can take to improve marginal locations include increasing drainage (surface/subsurface tiles) or implementing a raised bed planting. Either strategy will reduce the time saturated soils exist and can help alleviate the spread of PRR within a field.

Change your tree species:

As noted earlier, Fraser fir is one of the most susceptible tree species to PRR. Current research is underway to obtain an understanding of the mechanism(s) of PRR resistance in other fir species, which may allow future tree breeding efforts to introduce these trait(s) into Fraser fir germplasm. In the meantime, grafting Fraser fir onto resistant rootstock, such as Momi fir has enabled growers in some areas to continue to grow Fraser fir in sites where PRR is present. Planting alternative species, such as Caanan fir which has moderate resistance to PRR is another option. (balsam, concolor, and spruces are also options) In some areas switching to other exotic fir species, such as Nordmann, Turkish, and Trojan firs might be a viable alternative. However, the potential use of some of these exotic species will be limited in the Great Lakes region because of their early bud break and potential of damage from late spring frosts.