



Diagnostic Facts

Diagnostic Services
Michigan State University



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Pine Wilt Disease

A Tale of an Insect-Nematode Partnership

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Introduction

Have you ever looked out your back window or while driving around your neighborhood and asked, “Wow, what happened to that pine tree? Last year, it seemed so healthy and now it’s dead.” If the answer to this initial question is “Yes,” this fact sheet is for you. It is possible the infected Austrian or Scotch pine may have suffered the wrath of the pinewood nematode.

Pinewood nematode (PWN), *Bursaphelenchus xylophilis*, is the cause of pine wilt, a disease of exotic pine species in Michigan as well as other locations in North America and the World. The nematode was first detected in Michigan in 1980 from a white pine growing in Kalkaska County. A year earlier, it was believed PWN was discovered for the first time in the U.S. in Missouri on Austrian and Scotch pines. Initially, we quickly blamed the Japanese for the problem because a visiting professor from Japan was responsible for the diagnosis in Missouri and many Japanese species of pines had died due to pine wilt earlier in the decade. The initial conclusion, of course, was that the nematode responsible for causing these symptoms had to be exotic. However, that assumption was wrong. A review of the literature revealed the nematode was found associated with fungi in downed timber in 1929 and appeared native to North America.

PWN is a plant-parasitic nematode but in comparison with other nematodes of this type, it is unusual because it is a parasite of the aboveground parts of the tree, is carried by an insect and does not enter the soil. The majority of plant-parasitic nematodes invade roots. However, PWN, like all other plant-parasitic nematodes, is microscopic. Nematodes are small animals and are capable of locomotion. Due to its ability to rapidly move through plant tissue, it is difficult for pine trees to defend. See below for more information regarding its success as a pathogen.



Infected Scotch Pine tree.

Symptoms

Pine wilt is typically a disease of mature pine trees, 20 or more years old. Our native pine species, white, red and jack, appear resistant or at least tolerant to this disease. It primarily affects Austrian and Scotch pines or any other exotic species. There are also a few reports of isolation of PWN from trees other than *Pinus* sp., including cedar, balsam fir, larch and spruce. By and large, this disease has received very little funding for research because it affects landscape more than forest trees in the U.S.

Initially, the needles of one branch may turn yellow and die. However, the symptoms spread quickly and within 3 to 4 months the entire tree may succumb. Trees die so quickly due to pine wilt, the needles do not form abscission layers and therefore remain attached to the branches. Only if the tree is highly exposed to wind will infected trees lose their needles.

The Insect Partner in Crime



White-spotted Sawyer. Credit: Terry Thormin

Pinewood nematodes are carried from tree to tree by beetles, principally sawyer beetles (*Monochamus* sp.). Other beetles may vector PWN for short distances but sawyers are the main culprits. Based on a survey of the Entomology museum at MSU, Michigan is home to at least 5 species of *Monochamus* with *M. scutellatus* (the white spotted sawyer) apparently the most common based solely on the number of specimens in the collection. Sawyer beetles are very skittish in their behaviors and the adults are not often seen.

Sawyers are rather large beetles in the insect family Cerambycidae, commonly named round-headed borers. Adult sawyers are attracted to dying or dead trees or freshly felled timber, including logs, for breeding. The bark must still be on the tree or log for the beetles to lay eggs (oviposit) and for the larvae (round-headed borers) to develop. The female gnaws an irregular hole through the bark (an oviposition pit) and inserts from one to six eggs. If a female harbors

nematodes, they exit her body at this time. The larvae feed for one to two months and eventually produce a U-shaped tunnel in the sapwood prior to pupation. The pupal chamber is located just beneath the outer bark. If PWN is present in the wood, they are attracted to chemicals released by the pupae and migrate to these chambers. After pupation, the adult emerges by chewing through the bark. However, prior to that event, PWN crawl into the breathing tubes of the insects (tracheae) by entering through the spiracles. A single adult can carry 100,000 or more nematodes. Two years are often required to complete the life cycle.

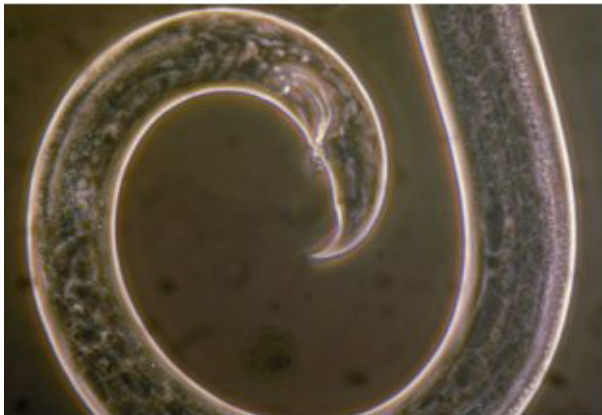
Upon emergence, an adult beetle locates a living host tree to feed on the bark of the young branches. This is typically referred to as maturation feeding because female sawyers require nourishment for their eggs to mature. During this feeding, PWN will leave the insects by crawling out of the spiracles, migrating to the tip of the abdomen and then onto the host. They enter the trees through the feeding wounds produced by the sawyers. If a pine tree becomes infected at this time, it is referred to primary transmission. Most cases of pine wilt are blamed on primary transmission but some evidence suggests this is erroneous. Secondary transmission is discussed in the next section.

The PWN Saga

Upon entering the host through a wound, the nematodes migrate to the resin canals of their hosts. They typically kill these cells rendering them ineffective. This, of course, is extremely detrimental to the host because resin is critical for the tree's defense. Beetles, including sawyers and many others, are attracted to trees with reduced or no flow of resin because the oleoresin often kills young larvae by preventing them from feeding. Therefore, sawyer beetles are attracted to trees infected with PWN, bringing the vector to the nematode. It's an effective partnership for the two organisms.

In theory, pine trees infected with PWN kill themselves. In a defensive response, they attempt to wall off the nematodes by killing the cells in their vicinities (hypersensitive response). While the hypersensitive response is effective against fungi, it fails against PWN because of the nematode's mobility. By the time the host responds and kills the cells, the nematodes have moved to new locations triggering a whole series of these defensive responses. It is highly unusual for plant-parasitic nematodes to kill their hosts but, in the case of pine wilt, the infected tree kills itself.

PWN does not feed entirely on host cells. If introduced to trees during primary transmission, they do feed on epithelial cells and resin ducts resulting in vascular disruption. However, when introduced during secondary transmission, they feed upon fungi. Secondary transmission, which apparently is more common than primary transmission, occurs when the nematodes invade freshly cut softwood or dead and dying conifers when sawyer beetles lay eggs. Upon cross section, trees visited by sawyer beetles (and other beetles) often have a bluish or grayish stain to the wood. This bluish color is caused by a blue-stain fungus (*Ceratocystis* sp.) and is fed upon by the nematodes. All plant-parasitic nematodes need living host tissue to feed upon to grow and reproduce but PWN can survive for long periods in dead trees because they use the fungi as sustenance. It is for precisely this reason, dead trees should be removed from premises as rapidly as possible. They serve as nematode reservoirs and as long as bark remains on their surfaces, they are quite attractive to sawyer beetles.



Pine wood nematode and the damage caused to a pine tree.

(Photos: USDA Forest Service - UGA1442034/J.J. Witcosky; USDA Forest Service/UGA4387005/L.D. Dwinell).



Blue stain fungus colonizing pine wood. (Courtesy P. Donald)

Management

As mentioned, trees infected with PWN should be felled and the wood destroyed as soon as possible. Trunks should also be removed. If the softwood is to be used for burning in fireplaces, etc., the bark should be removed or avoid harvesting the wood when sawyer beetles are laying eggs (July-September). Reports indicate PWN can persist in trees for up to 20 years, in some cases without symptom expression.

There are no cures for pine wilt once a susceptible tree becomes infested with PWN. Therefore, the principle strategy is one of prevention (avoidance). The most effective method is to avoid planting non-native pine species in areas where the average summer temperature exceeds 20°C (68°F). Where these non-native pines already exist, care should be taken to water and fertilize them properly especially during periods of drought. Many studies have indicated a positive correlation between temperature and trees exhibiting pine wilt. The higher the average temperature, the greater the number of infected trees. Since nematodes are cold-blooded animals, higher temperatures favor faster generation times, so they increase in numbers much more rapidly within their hosts. It is important to remember that evidence seems to suggest that transmission of PWN is more likely to occur during secondary than primary transmission. Since sawyer beetles are attracted to dead or dying conifers, it is imperative trees are kept healthy to minimize infection.

While there is still no cure once a tree is infested with PWN, systemic injections of pines with abamectin (Avid™) has been demonstrated to reduce the incidence of pine wilt. Trees are injected in the spring with small quantities of this material and if PWN is transmitted after the injection, these nematodes are paralyzed and usually die. For best results, applications of abamectin should be repeated every spring. However, even with an injection, there is no guarantee a tree will not succumb to pine wilt. Abamectin will fail if a tree is already infested with PWN. This is most likely due to the fact it cannot move within the tree because the nematodes destroy the resin canals. Contact your local landscape specialist regarding abamectin.

Conclusion

Exotic species of pine are extremely susceptible to pine wilt disease. Homeowners should be familiar with the trees growing on their property and care should be taken to keep trees as vigorous as possible. Hot, dry summers (average temperatures over 75°F and rainfall less than an inch over any 30-day period) favor disease development and expression. Infected trees should be removed from premises and destroyed as quickly as possible. Valuable trees can be protected with injections of abamectin or even sprayed with insecticides if feasible.

Proper diagnosis involves collecting a sample of wood and submission of the sample to a Nematode Diagnostic Laboratory for isolation and identification of PWN, the pathogen responsible for pine wilt. A sample should consist of branches that are showing symptoms and are at least 1 inch in diameter. Branches can be cut into 6 to 8 inch pieces for ease of packaging and shipping. If the tree has already been cut down, a wedge from the trunk may also be submitted. In Michigan, samples can be sent to Diagnostic Services at MSU. See our website for information and submittal forms. Questions can be addressed to Fred Warner (517-432-1333) or Angela Tenney (517-353-8563).

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