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Pine wilt disease

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The pine wilt disease is caused by a microscopic nematode, *Bursaphelenchus xylophilus*, sometimes known as the pinewood nematode. It is transmitted in Missouri by a long-horned beetle vector, *Monochamus carolinensis*. It was isolated and identified as a serious disease problem in the State Extension Diagnostic Laboratory in the Plant Pathology Department of the University of Missouri in 1979.

The nematode was reported in the United States in 1931 in logs of longleaf pine, yet it was not recognized as a pathogen of pines. The disease has been of great concern in Japan since the early 1900's, and Japanese investigators have studied the disease intensively.

Since its identification in 1979, the disease has been found in at least 36 states in the U.S., including all states east of the Mississippi River, and several provinces in southern Canada. The widespread distribution of the pinewood nematode suggests that it may be endemic to North America, not an imported pest.

Symptoms

Pine wilt disease can affect pine trees of all ages, but it is generally seen in older non-vigorous trees. Pines affected by the disease die relatively fast. Once infected, a tree will progressively turn light gray-green, to yellow-green to yellow-brown in a period of three to six weeks. Eventually, all needles turn brown and adhere on the tree as the tree dies. The browning of the needles may develop uniformly over the entire tree or may progress from individual branches or sections. The end results are dead trees.



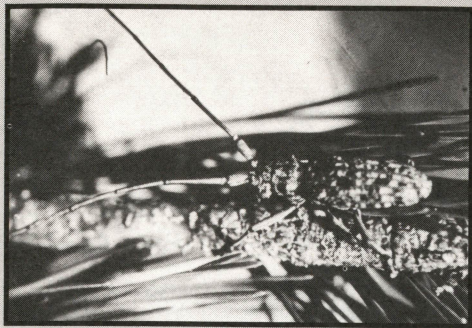
Infested trees first turn light gray-green, then yellow-green and finally yellow-brown in three to six weeks. Pine wilt disease usually affects older non-vigorous trees. Wilt damaged trees have brittle twigs and decreased resin flow.

Trees often die from mid-summer to late fall or from late winter to late spring. The rapid death contrasts with the slow decline associated with fungus diseases such as Brown spot or Diplodia blight, or by unfavorable environmental conditions.

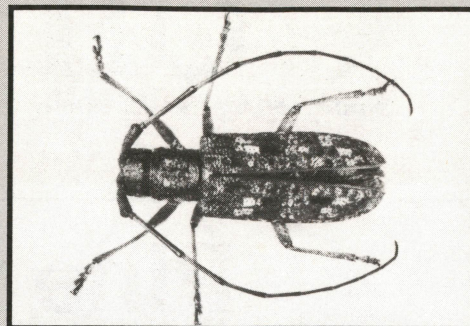
Pine wilt disease symptoms are characterized by cessation of resin flow and decrease in sapwood moisture. This may come about because of colonization by huge numbers of the nematodes in the resin ducts. The decreased resin flow results in dry or brittle twigs. In comparison, winter injured trees, which show needle browning, will have green flexible branches and normal resin flow.

Dead pines often retain most of their needles for six to twelve months, depending upon age, time of death, and location. Trees that die in the spring generally shed their needles in the autumn, whereas those that die in the summer/fall period shed needles during the following summer.

Nematodes can be detected more easily during the summer/fall period because of higher populations in the infested trees.



In North America six species of long-horned beetles (genus *Monochamus*) carry the pine-wood nematode disease.



Adult beetle (*Monochamus carolinensis*). Scotch and Austrian pines are most susceptible.

A long-horned beetle feeds on the bark of young branches. Those feeding wounds allow pine-wood nematodes to enter, infecting the tree.

Tree Hosts

In recent years, the pine wilt disease has become a serious problem of Scotch pine grown in plantations or as ornamental trees. Other pine species introduced from outside North America, such as Austrian pine, are also highly susceptible to the disease. Most pine infestations have occurred in landscape plantings, but the nematode has also been introduced into windbreaks, Christmas tree nurseries and recreational plantings.

At least 27 species of *Pinus* (pine), one species each of *Abies* (Balsam) and *Pseudotsuga* (Fir) and two each of *Cedrus* (Cedar), *Larix* (Larch), and *Picea*, (spruce) are known hosts of the pinewood nematode in the United States. It appears that most native pines (jack, red, shortleaf, white, etc) and other conifers, such as spruce, cedar or fir are relatively unthreatened in their native habitats.

In the Great Plains, the pinewood nematode has been found in Scotch, Japanese black, Austrian, eastern white and loblolly pines.

Field tests conducted in Missouri indicate that Scotch pine is highly susceptible to pine wilt disease, while shortleaf, jack, and eastern white pines are resistant.

Biology and Disease Cycle

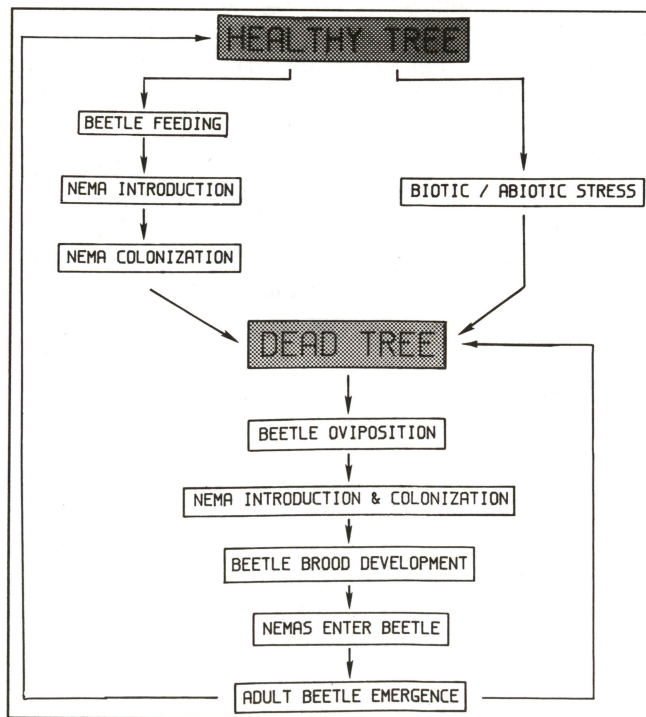
The pine wilt disease cycle begins when the pinewood nematode is introduced into healthy, uninfested trees through the feeding wounds of long-horned beetles in the genus *Monochamus*. Worldwide, nine species of *Monochamus* are known to carry pinewood nematodes. Six of these species occur in North America, and two, *M. carolinensis* and *M. titillator*, occur in Missouri. Both species are known vectors of the pinewood nematode.

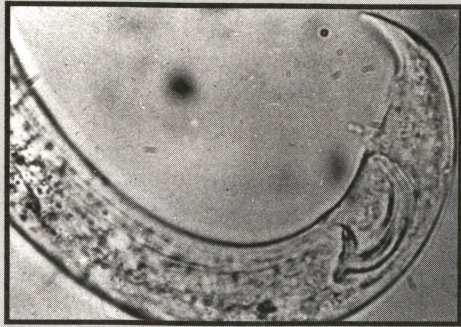
Monochamus beetles are wood borers. The beetle's immature stages develop beneath the bark and within the woody tissues of dying pines and recently cut pine

logs. Adult beetles are attracted to these stressed hosts where they mate and oviposit (lay eggs). Newly-formed adult beetles emerge after completion of their immature stages. They move to healthy pines to feed on the young bark of shoots and branches.

If the beetle is carrying pinewood nematodes, the tree may become infested as nematodes move from the body of the beetle, through the feeding wound, and into the tree. Once within a susceptible host tree, the nematode population builds rapidly and is involved in the death of the tree.

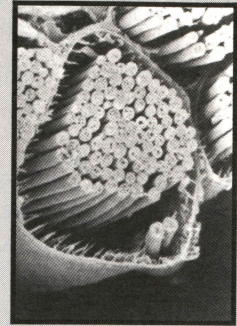
Within 4 to 8 weeks, infested pines exhibit reduced oleoresin flow and diminished transpiration. Susceptible trees often die within three months of infestation. While dying the tree becomes attractive for *Monochamus* oviposition, and the disease cycle begins again.





Experts use the curved, pointed abdominal tip and nearby anchor-shaped spicule (reproductive organ) to positively identify the adult male pinewood nematode. This pathogen causes pine wilt disease.

As many as 100,000 nematodes can inhabit the long-horned beetle's tracheae. They spread once the beetles feed on the tree. Dying trees attract more beetles, repeating the disease cycle. To control remove infested trees before adult beetles emerge in May. See the "Diagnosis" paragraph.



Nematodes in beetle's tracheae.

Within a newly infested host, the nematode population reproduces rapidly and colonizes the xylem tissue throughout the tree. During the reproductive phase, the nematode feeds on fungi, principally the blue stain fungi associated with dying pines. It develops through four larval stages before becoming an adult. Following the death of the host tree, nematode development switches to a dispersal phase.

The mechanisms that control this switch is poorly understood, but this behavior may be triggered by the deterioration of the food source as the infested tree dies and the decay process begins.

During this phase, the nematode molts from a second stage reproductive larvae to a third stage dispersal larvae. The fourth larval stage is a non-feeding stage called the dauer larvae. It is this stage that moves into the newly-formed adult beetles prior to the beetles' emergence from the tree. The nematode dauer larvae inhabit the beetle's tracheae, where they remain during transport to a new tree. Individual adult beetles may be nematode-free or may carry as many as 100,000 dauer larvae; nematode densities from 1,000 to 10,000 per beetle are most common.

Diagnosis

For positive diagnosis, obtain a portion of branch near its attachment to the main trunk or a wedge of wood from the lower trunk. If the tree has recently died, obtain a cylinder sample from the lower trunk for assay to confirm the pine wilt disease. Keep the sample moist with damp paper and enclose it in a plastic bag. Send the sample to the State Extension Plant Pathology Diagnostic Laboratory, 3-22 Agriculture Building, University of Missouri, Columbia, MO 65211.

Control

Once pine trees are positively identified as having the pine wilt disease, it is important to destroy them

before the annual activities of the beetle vectors begin. Infested trees should be removed and the wood destroyed. Do not store pines killed by the disease for firewood. The dead wood will provide a source of nematodes and a habitat for the beetle vectors.

Monochamus adults may emerge from wilt-killed trees in early May. Therefore, all infested trees should be removed and destroyed well before May 1.

Control measures are not justified in forest situations. In established landscape plantings, windbreaks, and Christmas tree plantings, destroy recently infested trees by cutting and burning. This will destroy the breeding habitats of the beetle vectors and kill larvae and pupae of the beetles before they emerge.

Avoid conditions that cause stress to trees. If possible, reduce known fungus diseases of the needles and twigs with appropriate fungicides. Other insect pests should also be controlled, if possible, to avoid stressing trees and attracting vectors.

In high value areas, keep trees well pruned of dead and diseased branches. Watering pines during dry periods may reduce chances of infestation. Planting conifer species other than Scotch or Austrian pines for shade trees or windbreaks is recommended.

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