Two Fungal Diseases Spreading and Endangering Walnut Species:
Butternut Canker and Thousand Cankers Disease

Invasive fungal diseases and insects are assaulting hardwood tree species in our eastern forests. Although the insects receive more attention (they are more visible after all), scientists, foresters, and environmentalists are concerned that invasive fungi are endangering many hardwoods, with fungus-caused canker diseases the most destructive. Trees that produce mast—beechnuts, butternuts, walnuts, and acorns—which are food sources for many animals—are especially at risk. The most tragic example is the American chestnut, once the “queen of the eastern forests,” which has essentially been extirpated in the wild in its native range because of the canker disease chestnut blight.

Cankers are localized areas of fungal infection of tree bark and cambium on branches and stems. Numerous infections and subsequent coalescing of cankers will kill trees. Butternut canker and thousand cankers disease of black walnut are cankers affecting eastern hardwoods. Since its discovery in 1967, butternut canker has established itself throughout the native range of butternut in the East, killing up to 90% of the trees in some states. Since 1990, Northern Research Station (NRS) scientists have focused their attention on conservation of butternut and the search for disease resistance in this species. The discovery of thousand cankers disease (TCD) in Colorado in 2007 and its subsequent discovery in the eastern United States have led to predictions of disastrous losses of eastern black walnut trees. NRS scientists and university colleagues are investigating how the insect-pathogen complex causing this disease may build and spread within the East and assessing what resistance exists in black walnut to both the pathogen and the insect pest.
BUTTERNUT CANKER

Butternut canker is a disease that threatens the butternut tree (Juglans cinerea), also known as white walnut. It is mostly found in mixed hardwood forests, sometimes in groups but often as isolated individuals, from New Brunswick to North Carolina, and westward to Minnesota and Missouri. The nuts are important as a mast crop and are also used in baking. The wood looks similar to black walnut but is more easily worked for woodcarving, paneling, and furniture. The first chief of the Forest Service, Gifford Pinchot, paneled his library at Grey Towers with butternut wood. The trees are difficult to propagate and grow in plantations necessary for commercial production. However, butternut is highly valued as a yard tree or in small woodlots.

The fungus causing butternut canker (Ophiognomonia clavigignenti-juglandacearum, abbreviated as Oc-j) occurs all over North America and was first discovered in 1967 in Wisconsin. The canker has spread rapidly throughout the range of the butternut and is extremely virulent. Because of the host-tree's limited resistance, the fungus is believed to be of non-native origin. Survival of the butternut species is threatened and the severity of the disease has prompted the U.S. Forest Service to consider butternut a "species at risk." The fungus attacks other members of the walnut family, but butternut is the most susceptible native species.

Infection by this canker results in sunken, elliptical cankers on branches, stems, and buttress roots and dark brown, elliptical stains beneath the bark; these become large and girdle branches and twigs, then trunks or roots, which kills the tree.

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Investigating the biology of the fungus causing butternut canker has provided useful insights. The canker predominantly affects butternut, but naturally produced cankers have been found on other Juglans species, namely black walnut (J. nigra) and Japanese walnut (J. regia). Artificial inoculations have found that Oc-j colonizes and survives in the wood of several genera, including Carya (hickory), Corylus (hazelnut), Prunus (stone fruits), and Castanea (chestnut). This is evidence that the fungus may be surviving on other trees in a non-pathogenic state as a reservoir when butternuts are not present.

Finding insect vectors of butternut canker is another important activity of NRS scientists. Rain splash and wind have been shown to spread Oc-j conidiospores up to about 45 meters. For long-distance transport, the sticky spores can adhere to insects that then carry the spores to isolated butternut trees. A number of insects have been found capable of disseminating Oc-j conidia, and three beetle species were found able to carry viable conidia for up to 16 days. These potential vectors may explain how apparently isolated butternuts become infected, but more studies are needed on conditions and timing.

Breeding for resistance to butternut canker is probably the most important aspect of NRS research for fighting butternut canker. Beginning in the 1990s, healthy butternut trees were being found despite growing in close proximity to diseased trees. Numerous surveys by forest agencies as well as contacts from private individuals recorded a number of potentially resistant butternut trees throughout the range. These trees offer some hope of finding resistance to butternut canker within the natural population. Starting in 1995, Dr. Dan Ostry and Dr. Darrell Skilling of St. Paul, MN (now both retired), Melanie Moore of St. Paul, and Paula Pijut, Keith Woeste, and Jim McKenna of the Hardwood Tree Improvement and Regeneration Center (HTIRC) at Purdue University (West Lafayette, IN) have been deeply involved in research on butternut canker. They have collected large samples of possibly resistant butternuts, grafted these into rootstocks, and planted these into orchards in many different locales and environmental conditions. These trees include an experimental station at Rosemount, MN; the Oconto River Seed Orchard on the Chequamegon-Nicolet National Forest in Wisconsin; the HTIRC at Purdue University; and several Ministry of Natural Resources locations in Ontario, Canada. Butternuts at these sites are used in inoculation studies or allowed to become infected naturally. Survivors can then be used for further breeding. Asian butternuts do show resistance to Oc-j and are being used in hybridization efforts.
During the search for resistant trees, an unusual appearance was discovered among many of the healthier trees. A large proportion of the healthier, possibly resistant, butternuts had distinctive bark that was darker than the typical light gray with deeper gray furrows. At first glance, it was easy to mistake these for black walnut trees and there was a correlation found between tree health and bark characteristics. Preliminary molecular studies of leaf samples from this population are underway to determine if there is any relationship between bark type and disease resistance. If this is indeed the case, the process of selecting resistant trees will be much more efficient. Other studies on bark chemistry have shown a possible correlation between canker resistance and chemical inhibition of conidial germination, which could be developed as a screening tool for finding resistance.

THOUSAND CANKERS DISEASE

Thousand cankers disease (TCD) is the newest “invasive” disease complex confronting western forests. Black walnut is a eastern tree that produces wood so highly desirable for furniture and cabinet making that it has been planted all over the United States. In the East, the tree grows in forests and in the countryside, often along fence rows; it is also grown in plantations as an investment. It is allelopathic, meaning that it produces phytochemicals that hinder the growth of other plants near its roots. Unfortunately, in the West, black walnut was planted in the native range of Arizona walnut (J. major) in Arizona, New Mexico, and southern Nevada, which has a deadwood. It has become infected with the walnut twig beetle (Pityophthorus juglandis), which has historically lived on Arizona walnut and perhaps on southern California walnut (J. californica). The walnut twig beetle carries with it the fungus Geosmithia morbida, which causes small cankers beneath the bark of the branches and stems of walnut trees. These numerous small cankers, which give the disease its common name, kill infected trees by restricting water flow, which typically lasts 2 to 4 years of infection. The fungus was described as new to science in 2010. Thus, this new disease complex has expanded its geographic range and was able to reach new host species with no co-evolved resistance, acting as a nonnative pest of black walnut in North America and now also in Europe.

Since the 1990s, black walnut trees have been planted in the West where they share native and nonnative habitats. In 2003, evidence of the walnut twig beetle in the San Francisco Bay area was linked to the presence of the TCD beetle and fungus complex. The disease is now present in the western United States and continues to spread into the native range of black walnut. In 2010, it was found in Tennessee, followed by Virgina and Pennsylvania in 2011 (in Maryland and Ohio. In 2012, both the beetle and fungus were found in black walnut in Oregon. In 2014, it was found in California, and in 2015, it was found in New York and New York. The disease is now established in nine western states and continues to spread into the native range of black walnut. In 2010, it was found in Tennessee; in 2011, in Virginia and Pennsylvania; and in 2012 in Maryland and Ohio. In 2013, both the beetle and fungus were found in black walnut in Minnesota. In northern Italy, in 2014 the fungus was reported on a weevil species that emerged from infested black walnut in Italy, although TCD symptoms and the beetle were not present. The TCD beetle has since been found in northern Italy in 2016, and TCD symptoms have been reported in northern Italy in 2017. Beetle reproduction is affected by different cultivars of black walnut and other Juglans species, offering hope for sources of resistance.

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In 2012, NRS researcher Robert Venette began work with scientists at the Pacific Southwest Research Station of the U.S. Forest Service and at University of Minnesota, University of Missouri, and Purdue University, to better understand the threat that walnut twig beetle poses to black walnut and closely related Juglans species. They studied cold tolerance of walnut twig beetle, the flight capacity of beetles, and the quality of different Juglans species for beetle reproduction and found that cold winter temperatures may cause substantial mortality of walnut twig beetle in portions of Minnesota, Wisconsin, Minnesota, South Dakota, and Iowa. In most places where black walnut grows, though, walnut twig beetle could survive the winter. Walnut twig beetle do not appear to be strong fliers; most fly less than a quarter mile in their lifetime. These results confirm the significance of moisture movement of infested wood products to the long-distance movement of beetles. Beetle reproduction is affected by different cultivars of black walnut and other Juglans species, offering hope for sources of resistance.

In 2013, NRS scientist Jennifer Juzwik will work with the Animal and Plant Health Inspection Service (USDA APHIS) and Virginia Tech collaborators to better understand the threat that walnut twig beetle poses to black walnut and closely related Juglans species. They studied cold tolerance of walnut twig beetle, the flight capacity of beetles, and the quality of different Juglans species for beetle reproduction and found that cold winter temperatures may cause substantial mortality of walnut twig beetle in portions of Minnesota, Wisconsin, Minnesota, South Dakota, and Iowa. In most places where black walnut grows, though, walnut twig beetle could survive the winter. Walnut twig beetle do not appear to be strong fliers; most fly less than a quarter mile in their lifetime. These results confirm the significance of moisture movement of infested wood products to the long-distance movement of beetles. Beetle reproduction is affected by different cultivars of black walnut and other Juglans species, offering hope for sources of resistance.

Black walnut showing early symptoms of thousand cankers disease in Tennessee. Photo by Jennifer Juzwik, U.S. Forest Service.
Jennifer Juzwik is a research plant pathologist in the “Restoration and Conservation of Rural and Urban Forests” unit in St. Paul, MN. She received her PhD from the University of Minnesota, MS from Colorado State University, and BS from Farmington State College, West Virginia. The etiology, epidemiology, and management of hardwood tree diseases, most recently thousand cankers disease, have dominated her research career.

James McKenna is a biologist at the Hardwood Tree Improvement and Regeneration Center (HTIRC) in West Lafayette, IN. He has a BS in plant biology from the University of California.

Melanie Moore is a biological science technician at St. Paul, MN, who frequently published with Mike Ostry (retired). She recently received her MS from the University of Minnesota and is working with Jennifer Juzwik.

Paula M. Pijut is a research plant physiologist with the HTIRC in West Lafayette, IN. She received her PhD in horticulture from The Ohio State University, a MS in horticulture from Murray State University, and a BS in medical technology from Maryville College of the Sacred Heart. Paula has worked for the USDA Forest Service since 1989 and joined the HTIRC in 2001. Paula’s research program focuses on forest tree biotechnology and vegetative propagation for tree improvement and conservation.

Keith E. Venette is a research geneticist for the HTIRC since 1999. His interests include the genetics and breeding of hardwood trees, especially few handpicks such as walnut, oak, and black cherry. He earned both MS and PhD degrees from the University of California, Davis; the BS in biology was from the University of Florida.
Vegetative propagation (rooted cuttings) and in vitro culture (micropropagation) methods are important in conserving and producing clones of possibly resistant butternut or black walnut trees selected or genetically improved for canker resistance. Paula Pijut at the HTIRC has developed methods for vegetative propagation by rooted cuttings by using carefully controlled conditions. Propagation of 5- and 6-year-old butternut trees by hardwood and softwood cuttings has been successful and rooted cuttings overwintered in cold-storage had high survival and good growth when field-planted the following year. In vitro propagation of shoot tips of black walnut produces a large volume of genetically identical material in a reasonably short period of time. This material can then be used in research on adventitious root formation in black walnut, which is a limiting factor in in vitro propagation. By using a fog system, black walnut softwood cuttings from juvenile seedlings were successfully rooted at rates as high as 71%. These clonal propagation methods developed at HTIRC are a necessary tool for tree breeders and foresters and for conservation efforts, especially because of butternut canker and thousand cankers disease.

References:

Additional References


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