What advances have today's researchers made?

OFRI's genetics researchers have found families of pure eastern white pine that have some resistance to blister rust at low rates of infection. However, where blister rust infection rates are moderate to high, trees in these families perform similarly to wild eastern white pine (not well).

Himalayan white pine (*Pinus wallichiana* A.B. Jacks.) is one of the most resistant five-needle pines, and researchers have successfully crossed and backcrossed this pine with eastern white pine. The second and third generations are 75 to 87.5 percent eastern white pine but are much more successful than the pure pine at surviving blister rust infection.

Himalayan white pine does not grow and survive well in northern Ontario climates. However, researchers use backcrossing to increase the proportion of eastern white pine in hybrids and thus increase their genetic ability to withstand harsher climates.

Hybrids may grow better, too. According to older studies in milder climates in southern Ontario, some first-generation hybrids have outperformed pure eastern white pine in tree height, diameter at breast height, and wood-specific gravity by ages 20 to 40.

Researchers are continuing to conduct advanced-generation backcrossing of eastern white pine hybrids with Himalayan and other white pines and screening seedlings for blister rust resistance. They are also field-testing hybrids' ability to adapt to a range of Ontario conditions and to resist varying levels of blister rust. To date, new trials have been established in Huntsville, Kemptville, Midhurst, Thunder Bay, and Sault Ste. Marie.

For more information about breeding blister rust resistant white pine, contact:

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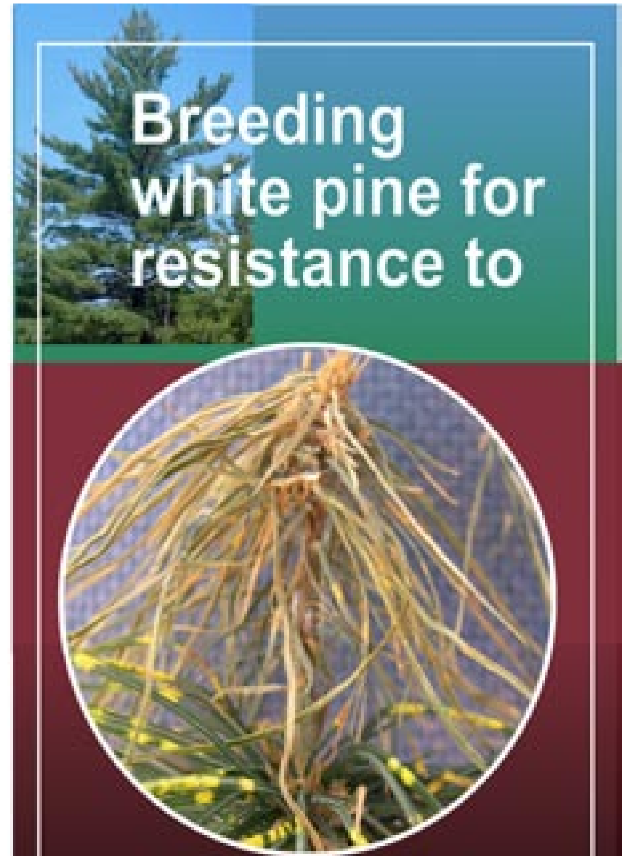

Breeding white pine for resistance to blister rust

Eastern white pine (*Pinus strobus* L.) and interspecific hybridization

Genetics Research Program

Ontario

Ministry of Natural Resources

Ontario Forest Research Institute

The arrival of blister rust

White pine blister rust is caused by an invasive alien fungus called *Cronartium ribicola* J.C Fisch. This fungus arrived in North America around the turn of the 20th century, courtesy of infected seedlings shipped from Europe.

This disease spread quickly to every five-needle pine species on the continent, with devastating consequences. Over the past century, it has contributed to a dramatic decrease in white pine regeneration, which coupled with historic over-harvesting has greatly reduced this species across its range.

The search for a cure

Soon after blister rust arrived, foresters and researchers began to search for a solution to the growing pandemic. They had varying success with options such as trying to eradicate *Ribes* (currants and gooseberries, the alternate hosts of *C. ribicola*), applying fungicides, and using silvicultural techniques, such as pruning lower branches to reduce infection. The disease persisted, and control costs soared, particularly where infection rates were high.

OFRI geneticist Carl Heimburger was among the pioneers in developing white pines with blister rust resistance. As early as the 1940s, he was selecting survivors from heavily infected white pine stands and using traditional plant breeding to produce trees with some resistance.

He also bred eastern white pine with some Eurasian white pine species, which coevolved with blister rust and can fend off this disease. His work led to the development of many white pine crosses (including interspecific hybrids) that had varying degrees of resistance.

Today's efforts to breed more resistant white pine

OFRI genetics researchers are continuing to improve white pine and interspecific hybrids for blister rust resistance, adaptation, growth, and wood quality. Their two complementary approaches:

1. Breeding selected eastern white pine trees to build up genetic resistance. This approach is slow, as pure eastern white pine has little resistance. The resulting trees do have relatively stronger genetic resistance than wild trees but do not have enough to withstand heavy blister rust infection.

2. Breeding selected eastern white pine trees with related Eurasian pine trees (interspecific hybridization) to introduce genetic resistance and then crossing the hybrids back to eastern white pine for several cycles. The resulting trees will be more than 93 percent eastern white pine, with the rest of the genome from a resistant Eurasian pine.

Breeding usually occurs between May and June, depending on variations in local climate. Researchers pollinate white pine trees by:

1. Covering female flowers (strobili) in breeding bags shortly before ripening to prevent pollination by other nearby white pines
2. When strobili are receptive, pumping pollen from a selected tree into the breeding bags
3. Removing breeding bags when the strobili scales are closed (no longer receptive to pollen)

Many uncovered female strobili are fertilized by windblown pollen, providing another source of seed for testing. Seed cones from controlled and open-pollinations are harvested between August and September of the following year.

Screening trees for resistance

Researchers use seeds from both controlled- and open-pollinated white pine to produce potentially resistant seedlings in OFRI's greenhouses. Screening for resistance involves:

1. Inoculating seedlings with blister rust spores (at rates of more than 6,000 spores per square centimetre) under conditions that are optimal for infection
2. Monitoring seedlings for infection and survival
3. Propagating surviving trees by taking cuttings and rooting them, to allow archiving, field testing, and breeding the next generation