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Branching Out
from the Canadian Forest Service - Laurentian Forestry Centre

Forest Genomics: Reacting to Diseases

When observing a tree, one is tempted to believe that it relies on its environment and is unfazed by forest pests. The truth is that trees, just like the pathogens that attack them, have evolved over the centuries. Thanks to the work carried out in forest genomics, Canadian Forest Service (CFS) researchers have a greater understanding of the dynamics involved in these perpetual changes, more specifically with regards to certain diseases such as white pine blister rust and poplar leaf rust.

Trees: masters of immobility?

When facing a pathogen, trees deploy basic resistance mechanisms. These mechanisms are non-specific and help trees protect themselves against most pathogens present in their environment. This resistance also limits the spread of the disease. In conifers, this can be achieved through the secretion of a substance (resin, for example) that prevents the pathogen from reaching the healthy wood.

Certain pathogens have evolved and are now able to short-circuit basic defences; this is referred to as a specific interaction. After its immune response has been by-passed, the host tree detects and sacrifices the live cells in the infected area, thereby killing not only its own cells, but also those of the pathogen. As pathogens are highly selective, some are able to avoid being recognized by their host. They then multiply, forcing the tree to develop new detection strategies. Over the course of evolution, a number of virulence factors and resistance factors have appeared in the genomes of pathogens and of their hosts, respectively.

Since resistance factors are relevant to genetic improvement programs, CFS researchers screen the genomes of trees and pathogens to identify resistance and virulence factors. White pine blister rust and poplar leaf rust are two of the diseases their work focuses on.


Photo: NRCan

White pine blister: fruiting bodies on bark.

The myth of eternal immunity

White pine blister rust, which is caused by the exotic fungus *Cronartium ribicola*, has been present in North America since the early 20th century. This pathogenic fungus spends a part of its lifecycle on *Ribes* (black currant, currant and gooseberry) before attacking and killing white pines. In 2008, a drop in the immunity of black currant was observed in Connecticut (USA). In 2011 and 2013, a new aggressive strain of *Cronartium ribicola* was sampled and observed in black currant fields in Quebec, the Maritimes and several north-eastern states in the US.

Canada

Ben Lomond | Consort | Coronet | Crusader

Virulence test of the new strain *Cronartium ribicola* performed on different black currant cultivars (NRCan). The cultivars Consort, Coronet and Crusader were selected in the late 1930s by researchers from Agriculture Canada (now Agriculture and Agri-Food Canada) because they were immune to white pine blister rust. Photos: NRCan

Using laboratory tests, CFS researchers proved that all black currant plants descending from the cultivar Consort that are currently available on the market had lost their immunity. According to genetic tests, this new strain of rust is the result of a new mutation or genetic recombination of a North American strain of the fungus rather than a new disease introduction.

Since the 1950s, the CFS has implemented genetic improvement programs that have led to the introduction of resistance to white pine blister rust in pines. Due to the constant evolution of pathogens, research on the resistance of pines and black currants must go on.

In a rush to head off rust

Poplar is a fast-growing tree species used by the forest and bioenergy industries. It is also being used increasingly in phytoremediation (the use of plants to restore sites that have been disturbed). The pathogenic fungus *Melampsora larici-populina* is responsible for poplar leaf rust and is threatening poplar trees, which could lead to a significant reduction in the volume of wood produced.

Poplar leaf infected by poplar leaf rust.

As part of their genetic baggage, poplars have a certain level of resistance to this rust. However, this resistance is often specific to a particular strain of the pathogen and it is often short-lived as it can quickly be evaded by the pathogenic fungus, which brings in new virulence factors.

Thanks to genomics, researchers have identified 26 resistance-related genes that are associated with various types of rust. This discovery could help produce poplars with increased, long-lasting resistance to the fungus causing poplar leaf rust.

Influential work

Scientific knowledge evolves along with the interactions between trees and pathogens. Research needs in forest genomics are increasing with regards to bioinformatics capabilities, qualified staff and financing. Furthermore, resistance must become one of the targets of genetic improvement programs.

Monitoring the evolution of pathogens will make it possible to identify new strains of the two diseases discussed in the present text in a timely manner. The goal is to decrease the impact of the damage they cause as this damage could lead to significant financial losses for the forest industry, increase greenhouse gas emissions and hinder Canada's commercial relationships.

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