FIA–FSP Forest Science Corner

Uncovering how trees compete for phosphorus as forests age

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Research uncovering how trees compete for phosphorus as forests age is being funded by the Forest Investment Account–Forest Science Program (FIA–FSP). Working with stands of mixed Douglas-fir and birch in the Southern Interior of British Columbia, researchers have identified the symbiotic root fungi involved in recycling phosphorus from forest soil and have also found signs that these fungi can suppress competing soil bacteria.

This work is being carried out by the Below-ground Ecosystem Group and the Forest and Mycorrhiza Ecology and Ecophysiology Research Group at the University of British Columbia.

Top photo: *Locations of phosphatase activity are marked for fine-scale sampling.*
Bottom photo: *Root window with enzyme imprinting paper in place.*

J. Sherstobitoff photo

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Background

Phosphorus is an essential nutrient that is needed to build DNA and store energy for plant growth. Plants obtain phosphorus by extracting it directly from soil minerals or by producing phosphatase enzymes to mobilize it from organic material in soil. Working with seedlings or small trees in the lab, scientists have shown that symbiotic root fungi (the ectomycorrhizal fungi or EMF) can mobilize phosphorus from organic material and transfer it to their host plants. Some EMF species appear to produce more phosphatase enzymes and mobilize organic phosphorus better than others, but the results are inconsistent. It is thought that some of this variability may be due to the production of phosphatase by bacteria associated with EMF. With dozens of species of EMF in a single forest stand, it is important to understand the roles they play in phosphorus extraction.

Studying how EMF extract organic phosphorus is challenging because of the difficulty in determining the species of fungal hyphae growing in soil, in associating these species with phosphorus mobilization, and in accounting for interactions between hyphae and soil bacteria. The goals of this study were to investigate whether ectomycorrhizal fungi act as gatekeepers of forest productivity through phosphatase production and organic phosphorus mobilization as trees age, and to determine if EMF hyphae affect the phosphatase activity of nearby soil bacteria.

Study process

To assess EMF phosphorus mobilization in the context of forest regeneration, forest stands of four ages were used: 3–6 years, 24–27 years, 55–60 years, and 88–100 years. Three replicates of each age class were located in the Interior Cedar–Hemlock (ICHmw2, ICHmw3, or ICHmk2) biogeoclimatic zone, regenerating after stand-replacing wildfire or clearcut harvesting (sites characterized by Twieg et al. 2007).

To identify EMF species associated with hot spots of phosphorus mobilization on the soil profile, an innovative imprinting technique was used. Soil profiles were accessed through plexiglass root windows installed at each stand. Phosphatase activity was visualized by pressing treated paper against a soil profile; the paper changed color where active phosphatase in the soil attached to it. The colored spots on the paper acted as a guide of where to take small, targeted soil samples that were then used to identify EMF species using a molecular fingerprinting technique.

To assess the effect of EMF on the phosphatase activity of nearby soil bacteria, sand-filled mesh bags of two opening sizes, one excluding roots and the other excluding roots and hyphae, were incubated in the F layer at one stand. Mesh sandbags act as a trap for EMF hyphae because EMF explore the nutrient-poor sand in the bags to a much greater extent than free-living (saprotrophic) fungi. Bacteria were isolated from the bags, identified to genus, and tested for phosphatase production.

...continued on page 16

Tree-symbiotic fungi are important

...continued from page 15

This targeted sampling detected EMF less often in hot spots than in low-enzyme areas in both the organic and mineral layers of all age classes, except for the oldest stands. In the organic layer of older stands, EMF were found more often in hot spots. Two species of EMF, *Amphenima* spp. and *Xerocomus* spp., were more likely to be present in microsites in older stands with high phosphatase activity. This study suggests that some EMF species associated with older trees, but not younger trees, play an active role in organic phosphorus mobilization.

Bacteria isolated from sandbags with trapped EMF hyphae produced significantly less phosphatase than bacteria isolated from hyphae-free bags. The reduction in phosphatase production by bacteria associated with EMF hyphae indicates that EMF may antagonize competing decomposers by selecting against bacteria with higher enzyme production. This antagonism may increase EMF access to organic phosphorus, which then can be translocated directly to the roots of host trees.

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