

Friends of the Fir

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Ectomycorrhizal communities of the Pinaceae family and *Abies balsamea* insights into their characterization and host interactions.

The Pinaceae family consists of cone-bearing trees with needle-like leaves. Some common examples include spruce, fir, pine, and larches. Members of the Pinaceae almost exclusively associate with ectomycorrhizal fungi (EMF), and no endo or arbuscular mycorrhizal fungi are known to associate with balsam fir. Fossil evidence supports the development of a symbiotic relationship between Pinaceae members and EMF more than 156 million years ago. (figure 1)

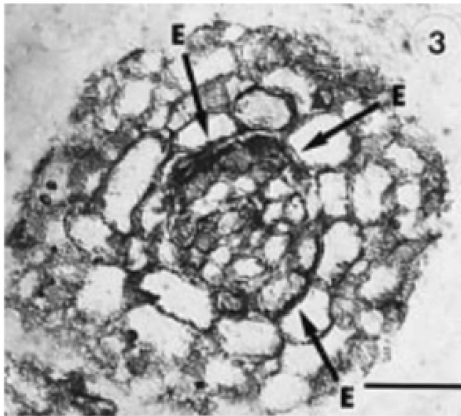


Fig 1. Fossil evidence of Hartig net structure in a *Pinus Spp* root, the Hartig net serves as a biological interface allowing exchange of nutrients and sugars.

– that’s one long lasting friendship! While molecular data supports EMF diverged from white and brown rot saprotrophic ancestors as far back as the origins of the Pinaceae 140–180 million years ago. (figure 2)

The balsam fir (*Abies balsamea*) is known to associate with EMF from at least 14 different genera¹⁷. Technically referred to as mutualistic symbiosis, both organisms benefit from the relationship. Trees see increased access to key nutrients like phosphorus and nitrogen, as the fungi possess enzymes to degrade complex organic material, while host trees supply

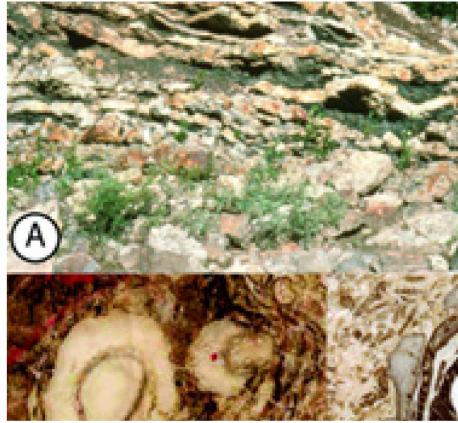


Fig 2. (A) Princeton Chert outcrop in southern BC where EMF associated fossil was located. (B) Fern rhizome (C) *Pinus Spp.* Cone.

the fungal network with carbohydrates in the form of sugars produced via photosynthesis⁴. EMF associations can increase access to soil water⁵, confer resistance to pathogens^{14,15}, and improve tolerance to environmental stresses such as drought⁶ or freezing⁷.

The ability of EMF to liberate nitrogen from soil organic matter and contribute to bio-geochemical processes that aid in nutrient acquisition are perhaps one of their most well acknowledged benefits^{8,9}. However, EMF can uptake and translocate a variety of key nutritional elements to the host, from macronutrients like phosphorus, potassium, and calcium, to micronutrients like zinc, copper, and manganese¹⁰. An important consideration for a tree species often found thriving on marginal land!

When looking the history of utilizing EMF in containerized nursery settings and the field, research has shown a mixed bag of results, yielding no significant differences in performance or outplanting survival at times, but also successes showing significant improvements. Inoculation of containerized Scots pine with EMF for example has been shown to increase nutritional uptake, increasing height by 61%, dry root weight by 123%, and needle dry weight by 149% after 1.5 years of cultivation¹¹. However, a recent study on Norway spruce reported no improvement inoculated nursery stock seedling

height or stem diameter after 2 years of containerized growth, and no significant difference after 3 years of post-transplant field growth¹². Successful EMF inoculation depends heavily on the fungal species used and host species. Older commercial products have traditionally used “generalist” EMF species which associate with a broad range of hosts, or species that weren’t locally adapted or suitable for a region potentially contributing to failure or even raising ecological concern. Recent research has shown these EMF-host associations are often highly specialized, particularly for balsam fir^{16,17}.

Large scale nursery holding corporations have recently invested in the development of commercial products from mycosymbionts of conifers and other trees to improve seedling performance, and results demonstrating significant improvements within the Pinaceae family and across other tree types continue to emerge. Researchers in China recently found significant improvements in the performance of container grown hazel seedlings using isolated locally adapted EMF demonstrating the remaining potential of the field as a research area.

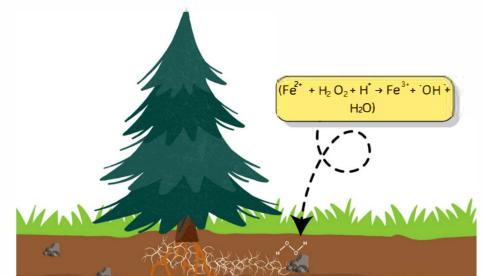


Fig 3. Fenton Chemistry exhibited by some EMF makes iron available to plants¹⁰.

