**////Title: Getting to the Root of Plant-Fungi Symbiosis**

**////Standfirst:**

An ancient relationship between plants and fungi could help us improve forestry and agriculture, while also responding to the challenges posed by climate change. These beneficial fungi, along with their bacteria helpers, help plants to grow bigger and healthier, and survive droughts. An international team of researchers has been investigating how these fungi and bacteria increase mineral availability for Scots pine and red pine seedlings through mineral weathering.

**////Main text:**

In the earth beneath our feet, an intimate relationship hundreds of millions of years old plays out. Some types of fungi are able to form mutually beneficial relationships with plants, by wrapping a thin structure around their roots and spreading finger-like projections into the surrounding soil.

The fungi help the plant to take up water and nutrients, and in return, the plant supplies the fungi with the sugars that they can’t easily obtain for themselves. This plant-fungi symbiosis helps plants survive adverse conditions, and can be particularly important during the vulnerable young stages in the plant’s life.

The roots of these plants, along with their fungal associates and some soil bacteria, have a powerful effect on their surrounding environment. Within the zone around the root system – called the ‘rhizosphere’ [rye-zoh-sphere] – complex interactions involving rock, soil, water, air, and living organisms occur that help to shape the ecosystem.

The symbiotic fungi help to break down minerals within the soil, releasing nutrients that are needed for plant growth. This process, known as ‘mineral weathering’, helps to improve the nutrition of the host plant, as plants cannot easily increase the weathering process themselves.

These growth-limiting nutrients come from silicates, which are minerals containing silicon and oxygen atoms bonded with metallic elements in various configurations. Silicate weathering is important for many natural cycles, soil formation, and nutrient supply for plants and whole ecosystems. The breakdown of silicate minerals also removes carbon dioxide from the atmosphere, and their interactions with microbes, fungi and plants increase the amount of carbon fixation. Therefore, this process could be utilised in the fight against climate change.

However, we still do not fully understand how the relationships between plants, fungi, and soil bacteria influence and are influenced by their surroundings. As such, research in this area is becoming increasingly important for ecosystem management and restoration, forestry, and agriculture.

Dr Zsuzsanna [Zhoo-zhaw-nah] Balogh-Brunstad [bah-log-brun-stad] from Hartwick College in New York state, and her international team of researchers, aimed to investigate the interactions between fungi, bacteria, and minerals in the rhizospheres of selected pine species.

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The symbiotic fungi along with helper bacteria coat mineral particles within the rhizosphere in a thin layer of densely packed cells and slime. This coating – called a ‘biofilm’ – is fundamental to enhancing mineral weathering and increasing nutrient uptake in plants. At the surface of the mineral, within the biofilm, acids and other substances help to break down the mineral surface, which can then be taken up by the fungi’s finger-like projections and delivered to the plant roots. The biofilm also prevents water reaching the surface of the mineral particle and washing away all the newly released nutrients.

Dr Balogh-Brunstad and her team developed a series of experiments to investigate the physical and chemical characteristics of the process occurring underneath the biofilm covering. Their model plant species were Scots pine and red pine. Both of these pine species are important commercial species grown for their useful timber.

The researchers hypothesised that the development of biofilms within the pine tree rhizosphere is enhanced when particular types of signalling molecules are low. By enhancing biofilm development, more mineral weathering is facilitated and smaller quantities of mineral nutrients are lost, meaning that more nutrients are delivered to the host plant. They suggest that the biofilm also helps to protect the nutrients released from the mineral particles.

Dr Balogh-Brunstad and the team used several types of symbiotic fungi and soil bacteria in their tests, covering their pine seedlings with the mixture and then growing them for nine months. They used high-powered microscopes and other advanced techniques to examine the minerals within the soil that the plants were growing in, and the roots of the plants themselves.

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To support their hypotheses, Dr Balogh-Brunstad and the team expected to see an increase in the amount of mineral nutrients released from the soils containing seedlings treated with symbiotic fungi and helper bacteria. They also expected these plants to grow larger and send more sugars down to their roots to feed their fungal associates.

Although their results did go some way in confirming their expectations, none of the Scots pine seedlings that were used as a control group – and therefore had no symbiotic fungi – survived until the end of the experiments. While this may suggest that the association of Scots pine with beneficial root fungi is needed for their survival rather than an enhancement, without this important control group the researchers had nothing to compare their treated seedlings’ growth with. By contrast, red pine seedlings were less affected by the presence or absence of fungal associates, suggesting a good baseline tolerance of low mineral availability in this species.

The results did suitably demonstrate that the increased mineral weathering benefit provided by the symbiotic fungi-helper bacteria biofilm was enhanced under low water availability. Thus, the fungal symbiosis could help plants cope with drier conditions.

Additionally, since acidic environments – like that found under the biofilm – is important to the weathering of certain minerals, the benefit provided by the fungal associates may be especially significant in soils with neutral or alkaline conditions.

With changing climate and water availability, the role of fungal associations in supporting plant growth may become increasingly important. Dr Balogh-Brunstad and her team suggest that further laboratory and field experiments should be designed to fully evaluate the effect of symbiotic fungi on plant growth in relation to watering regimes, soil types and conditions, and other environmental factors.

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This SciPod is a summary of the paper ‘Ectomycorrhizal Fungi and Mineral Interactions in the Rhizosphere of Scots and Red Pine Seedlings’, in *Soils*. [doi.org/10.3390/soils1010005](https://doi.org/10.3390/soils1010005)

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