Rooted Resilience: The Power of Keeping a Living Root In the Ground As Long As Possible

The Principle of Keeping a Living Root in the Ground as Long as Possible

Keeping a living root in the ground as long as possible has numerous benefits for soil and plant health. It maintains soil structure, supports a living, photosynthesizing plant above ground, and cycles carbon into the soil. Roots and microbes (fungi, bacteria, nematodes, etc.) have a symbiotic relationship, where roots feed about 50% of sugars to microbes, and microbes provide essential nutrients to plants. This process, where plants transfer carbon to soil through roots, helps build soil carbon.

What Are the Basic Structures of a Plant?

Plants are hugely unique, and many species have wildly diverse characteristics that contribute to the biodiversity of an ecosystem. However, many plant species share three common characteristics: leaves, stems, and roots. The leaves capture solar energy and absorb carbon dioxide from the atmosphere to activate photosynthesis and produce sugar. The stem takes part in transpiration by conducting water and nutrients through the vasculature toward the leaves. Sugars travel down the vasculature to enter the roots. The roots uptake and exude metabolites that are necessary for photosynthesis and cellular respiration.

Getting to the Root of It All

Roots help to build carbon in the soil. Carbon (sourced from CO_2) is used to build sugar in the leaves, and some of it (about 50%) is transported through the stem and exuded through the roots. The microbes in the soil use the exuded sugars for their own metabolism and accumulate nutrients to exchange with the roots. The longer a plant root stays in the ground, the more microbes can benefit, grow, and expand to find more nutrients from the soil.

What Are Root Exudates?

Root exudates are organic compounds that can be simple sugars, organic acids, or amino acids. Roots send out these signals (exudates) to the soil, microbes respond to these signals, and in exchange for sugar, the microbes bring whatever nutrient was “requested” by the plant.
There are multiple advantages to producing exudates:

- Attract nitrogen-fixing bacteria
- Facilitate communication with other plants
- Attract microbes that help defend plant roots from invaders

Imagine a Pizza Delivery Service

Root exudates behave a lot like a pizza delivery service. For example, you call a store to order a pizza, and they begin to assemble your order. A delivery person picks up the pizza from the store and brings it to your door. You pay the delivery person and enjoy your pizza. Now take a look at the root exudates: roots send exudates into the rhizosphere, and microbes send off into the soil to gather nutrients. The microbes take up nutrients from the soil and deliver them to the root. Finally, the roots exchange their exuded sugars for nutrients. This comparison makes it easier to understand the dynamics of root communication with microbes.

Why Keep a Living Root in the Soil?

When roots develop in the soil, they create complex webs with the microbes in the soil to:

- Maintain Structure
  - Roots grow deep into the soil to access nutrients and water. As a plant seed matures and develops roots, it is establishing itself into the composition of the soil, which is integral in maintaining the soil structure. The root builds physical connections with microbes in the soil. If the living root is pulled out of the ground, the soil structure is disrupted and those connections are severed.
- Support a Living Plant Above Soil
  - The roots not only provide nutrients and water through transpiration, they also provide tensile strength to the plant. They can tether themselves into the ground to protect them from rain and wind above ground. Additionally, the leaves of the plant need crucial metabolites from the soil to photosynthesize, and they gain these from the roots shipping them up the plant body.
- Cycle Carbon
  - Carbon is one of the most essential elements involved in photosynthesis and cellular respiration. Plants take carbon dioxide from the atmosphere and convert it to simple sugars through photosynthesis. In exchange for other metabolites, carbon in the form of sugar is exuded from the roots to be exchanged with other nutrients. About 50% of sugars produced by plants feed microbes so that they can bring necessary metabolites to the roots to be taken up by the plant.

What Are the Benefits of Keeping a Living Root in the Soil Over Winter?

- Keeps nutrients from leaching out of the soil
- Provides erosion control
- Provides grazing material for livestock
- Provides litter for weed control