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Soil: A Feeding Frenzy

"In the garden the door is always open into the holy—growth, birth, death." —May Sarton



Predatory nematode eating a fungi-eating nematode

Soil is more than just dirt. In healthy soil an entire ecosystem of micro-organisms (bacteria, fungi, protozoa and nematodes) brings nutrients to plants at their roots. Plants need 60 to 80 different nutrients to be healthy and grow properly, and they actually—and amazingly!—orchestrate this swarm of microbes to bring them exactly what they need.

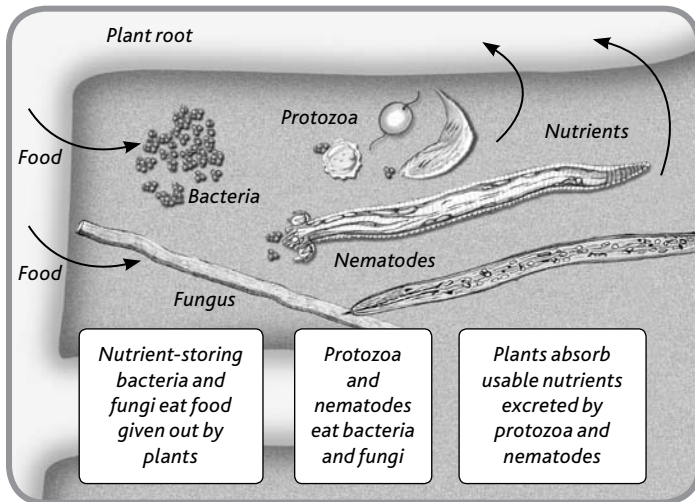
How? Recall that plants photosynthesize—they use the energy from sunlight to produce sugars. A plant sends 60 percent of these sugars down to its roots. A sixth of that is used to feed the roots while the rest is exuded from the root walls in the form of specific sugars, carbohydrates or proteins (converted by the plant) to feed microbes—in fact, to feed the exact types of microbes that will provide the nutrients the plant needs at that time. (The soil ecosystem also feeds and protects plants via their leaf and needle surfaces.)

If a plant requires nitrogen, it will exude food that will support many common soil bacteria. If the plant requires calcium, it will exude food to support fungi, which carry crystallized calcium. These bacteria and fungi will cluster against the root wall, absorbing the goodies the plant is feeding them and storing

the nutrients the plant desires. A constantly shifting mix of microbes competes for exudates at the root zone. The mix of microbes changes through the season as the plant alters what it exudes to satisfy its changing nutritional needs. At any one time a few hundred species of microbes will be active. Healthy soil will support tens of thousands of species of microbes, allowing the right ones to be available when needed. (Microbes become dormant when the conditions aren't right for their species—e.g., too hot, cold or dry—and are able to wake up and become active when conditions are right.)

Bacteria and fungi are like a stocked pantry right next to the roots, keeping nutrients from washing out of the soil and always at the ready for the plants. Bacteria and fungi produce substances that help them stick to each other and to other surfaces so they themselves won't wash away!

Bacteria and fungi are needed to store nutrients for plants. Protozoa and nematodes are needed to then release those nutrients and make them available for plants. Many of the bacteria and fungi clustered at the root wall or on the leaf surface get eaten by protozoa and nematodes. The protozoa and nematodes digest the minerals and nutrients into forms the plants can use and then excrete them (poop them out). The metabolism of protozoa and nematodes actually chelates



Plants and soil microbes work together to feed each other

minerals—bonds each ion to a protein—thus making the minerals much easier for plants to absorb. The plants then absorb the usable nutrients through their root walls and leaf surfaces.

Roots don't make digestive enzymes that would break nutrients down into forms that they can use, so they need the microbes to do this for them.

MICROBES PROTECT PLANTS

Within a few millimetres ($\frac{1}{10}$ of an inch) of a plant's root wall, a boisterous feeding frenzy is going on! (See the drawing in the colour pages.) The same kind of thing happens on leaf surfaces. The microbes are so thick along the roots and on the leaves of a plant in a healthy soil ecosystem that harmful bacteria or fungi have a hard time coming close. Many of the beneficial bacteria and fungi also produce substances that deter harmful bacteria and fungi. A healthy soil ecosystem not only feeds plants, it protects them from disease! Powdery mildew (botrytis), for example, is a common fungal disease on plants, covering the leaves with a white powder. Using actively aerated compost tea sprays, rich with soil microbes, scientists and farmers have found that they can reduce powdery mildew. (See Chapter 9, "Making Compost," for more on compost tea.)



Leaf surface greatly magnified under an electron microscope. Fungi, bacteria and other microbes are so thick on it, harmful diseases and pests can't get to the leaf. (Courtesy of Elaine Ingham, Soil Foodweb, Inc.)