**Letting Soil Organisms Do the Work for You**

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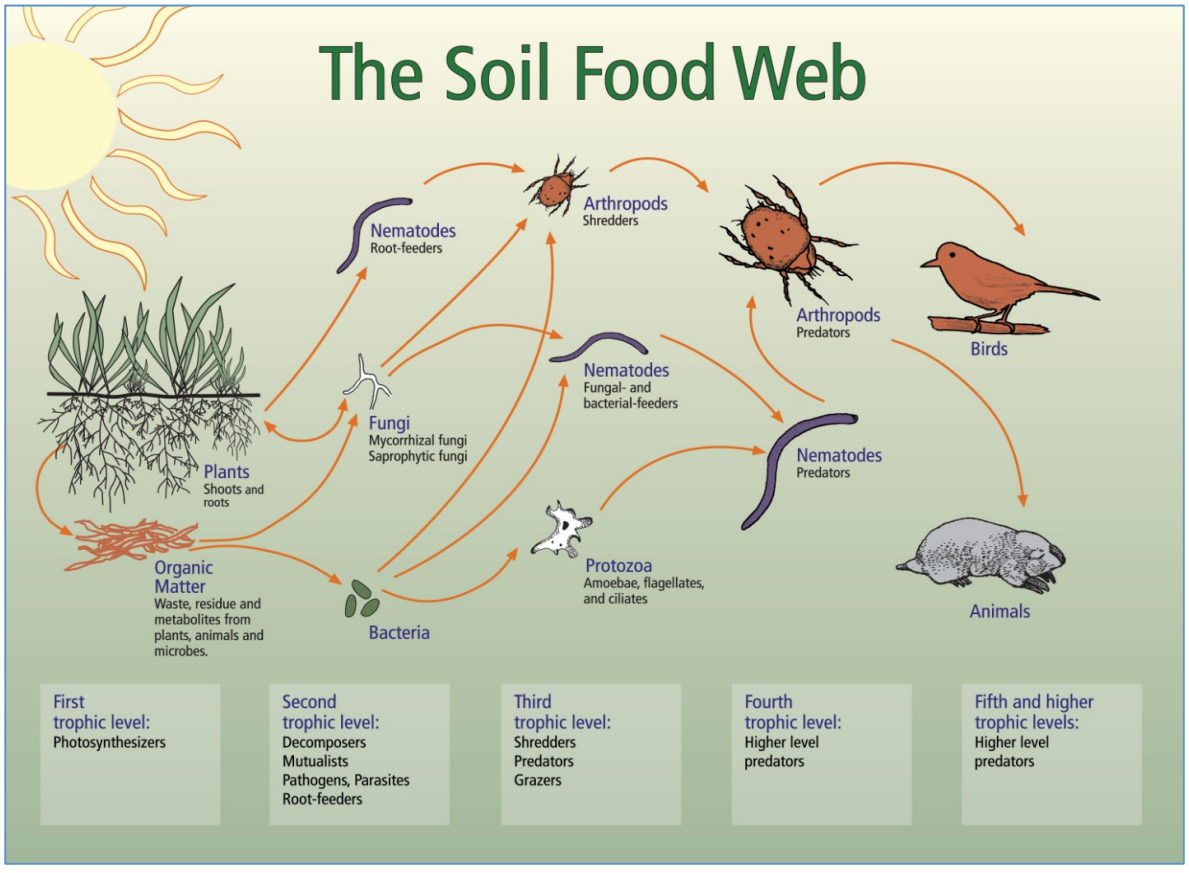
I recently took an amazing one-day class at Morris Arboretum: *The Life of Soil*, taught by Dr. Elaine Ingham, Chief Scientist at the Rodale Institute. Many of you feel that your eyes were opened to the importance of native plants and insects in a healthy terrestrial ecosystem by Doug Tallamy's book, *Bringing Nature Home*. Well, hearing Dr. Ingham speak about the incredible food web within the soil and the importance of fostering a healthy subterranean ecosystem was every bit as inspirational. Of interest to many gardeners will be how the balance of soil microorganisms affects the health and diversity of plant communities and how we can put bacteria and fungi to work for us fertilizing our plants and controlling weeds, diseases, and pests. Soil is one place where the good guys and gals really can win when given the chance.

**The Soil Food Web**

Soil is the most biologically diverse ecosystem on Earth. There are many groups of organisms that function in or near the soil at different levels of the food chain. In most forests and grasslands, several different organisms have processed every particle in the topsoil at various times. Together, these organisms enhance soil structure, store water and nutrients, decompose organic matter, and make nutrients available to plants. Each group is critical to maintaining a healthy balance of soil functions and should be encouraged in the home garden, but fungi and bacteria have immediate impacts on plant nutrition and health through their direct contact with roots on a cellular level.




http://soils.usda.gov/sqi/concepts/soil_biology/biology.html

The soil is full of nutrients necessary for plant growth, such as nitrogen, phosphorous, and potassium, but most of those nutrients are not in forms that are immediately available to plants. From the plants' perspective, most of these nutrients are being stored inside living or dead organisms as chemical compounds that are too complex for roots to absorb. Bacteria or fungi break these complex organic compounds down into soluble nutrients through decomposition and other processes. The incredible variety of microorganisms, each with its own metabolic process, creates a finely calibrated cycle that, in conjunction with soil pH, allows nutrients to be available when plants actually need them.

In general, decomposer bacteria consume simple organic complexes such as root exudates, animal waste, or non-woody "green" plant residue like leaves or stems. Millions of these short-lived bacteria dwell in the immediate root zone (rhizosphere), where they have ready access to green materials and, in turn, excrete highly soluble forms of nutrients. When these "good" bacteria proliferate, they cover root surfaces and crowd out many pathogens. Decomposer fungi, on the other hand, prefer more complex organic compounds, like humus and woody "brown" plant residue. These fibrous, long-lived fungi can stretch outside a single plant's rhizosphere and, in doing so, ferry nutrients between plants. They also help stabilize soil aggregates and form humus for long-term storage of nutrients. Another, very important group of fungi, the mychorrhizal fungi, colonize some roots and exchange nutrients they derive from organic matter for carbon from the plants.

**Plant Succession, Soil Disturbance, and Weeds**

You probably know something about plant succession: grasslands are succeeded by shrub/scrub communities, and shrub/scrub communities are succeeded by forests. But before any plants can get established on bare soils at all, the soil has to have been populated by microorganisms that solubilize nutrients. Bacteria move in to bare soil first, followed by fungi and other microorganisms. Weed and annuals that thrive on highly soluble bacterial excretions are the earliest plants on disturbed soil. As the fungal biomass gains on and eventually surpasses the bacterial biomass, the plant colonies change according to the prevalent forms of nutrients excreted. After weeds come grasses and non-weedy annuals, then herbaceous perennials, followed by shrubs and, finally, trees. In old-growth forests, the fungal mass is upwards of 100 times the bacterial mass. At each stage of succession, the balance of fungi and bacteria has influenced the predominant form of nutrients available, which in turn drives the plant community.

**What This Means to You**

Every time we disturb the soil, we are undoing the lifework of millions of soil organisms by killing many of them outright, breaking up the soil structure they have created, and exposing to erosion the nutrients they have generated. This makes soil disturbance a sort of reverse succession. The more severe the disturbance, the farther we drive plant communities back along the line of succession. Bulldozing away topsoil dooms future homeowners to the nearly bare parent mineral material favored by weeds. Even routine tilling perpetuates regression toward the bacteria-dominated soils preferred by weeds. So, the less we disturb soil, the more we encourage the soil organisms that foster the plants most of us want to grow: vegetables, herbaceous perennials, shrubs, and trees.

Without the balanced biological processes of a diverse soil food web, soil pH alone determines the chemical availability of nutrients regardless of the type of plant community present or the individual

plants' actual needs. Because soil pH is easily quantified, however, many gardeners control nutrient availability through soil amendments based upon soil test results. These amendments do not provide a long-term solution to nutrient availability and typically must be made once at least a year. Standard soil tests do not account for microbial activity, either, so some of the amendments may not be necessary or effective. We can break this dependency on artificial amendments by fostering a healthy, diverse soil ecosystem.

**Compost and Compost Extract**

I always knew that composting was great. It reduces the amount of waste that goes to landfills, provides nutrients for plants, and improves soil structure and water retention by adding organic material. Until taking the class at Morris Arboretum, however, I never thought of the living organisms that compost adds to the soil. The same organisms that convert food and yard waste to compost are necessary parts of a healthy soil food web, and compost can provide soil with inocula of those organisms. Multiple studies have shown that soils with restored biology are more productive and have fewer weeds that soils managed with conventional amendments, fertilizers, and herbicides.

By adjusting the proportion of green and brown materials in your compost, you can influence the type of organisms it contains. Most soils already have enough active or dormant bacteria, so most of the materials going into your compost should be brown food for fungi. Using a variety of brown materials from different plant species will encourage a wider variety of desirable inocula. A good ratio of compost materials for this purpose is three parts woody (brown), two parts green, and one part high-nitrogen. High nitrogen materials like animal waste help kick-start the decomposing process. Finished compost should be applied to the soil surface, not tilled in. I suggest scratching up the soil surface a bit before applying the compost in order to increase the contact area. If you want to get the beneficial organisms down into the root zone faster or if you do not want to apply a layer of compost in an established planting, you can inoculate your soil by applying compost extract. Compost extract is made by agitating compost vigorously in water to dislodge the microorganisms. As the extract flows down into the soil, the organisms will attach themselves to roots or soil particles.

By restoring the proper balance of fungi, bacteria, and other organisms to you soil, you can enjoy a healthier, more productive garden. All you will need to do to maintain this functioning ecosystem is ensure a steady supply of organic material for the microorganism to decompose. This can be as simple as using the mulching attachment on your lawnmower or topdressing ornamental beds with compost, mulch, or leaf mold. In general, you should mimic a natural ecosystem by applying the same type of organic material as the plants that you are growing (i.e., herbaceous/green, woody, or a combination thereof).

**For More Information**

Soil biology is a complicated and fascinating science, and I have simply sketched out some of the basic principles applicable to the home garden. If you're interested in learning more, I suggest starting with the Natural Resources Conservation website at http://soils.usda.gov/sqi/concepts/soil_biology/biology.html . I also posted some information about soils and composting on my webpage at www.marcmradell.com.

Happy gardening, and go native!