G A R D E N I N G S E R I E S

Colorado Master Gardener

MASTER GARDENER

The Living Soil

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Outline...

Soil Organisms Improve Garden Tilth

The soil is living ecosystem, although most living components are invisible to the naked eye. As soil microorganisms, insects and worms feed on organic matter (e.g. compost, manure, and many manufactured fertilizers and pesticides) nutrients become available for plant use. Their activity also significantly improves soil structure, reduces compaction and increases water and air movement.

Soil organisms do much of the work for gardeners of improving soil tilth (suitability of a soil to support plant growth, especially as it relates to ease of tillage, fitness for a seedbed, impedance to seedling emergence and root penetration) and making nutrients available to plants.

Encouraging their efforts is central to building a healthy fertile soil supportive to optimum plant growth. They require an environment that is damp (like a wrung out sponge, i.e. – near field capacity) but not soggy (has air – i.e.- aerobic), is between 50 to 90 degrees F, and hasorganic matter as a food source for bacteria and fungi from soil amendments (compost, crop residues) or mulch.

NOTE: **Mulch** refers to material placed on the soil surface. A mulch controls weeds, conserves water, moderates soil temperature and has a direct impact on soil microorganism activity. **Soil amendment** refers to materials mixed into the soil.

Creating a favorable environment for the living component of the soil accentuates plant growth and reduces maintenance. Soil organisms are favored by adding organic matter to the soil. Using organic mulch encourages these invisible friends by stabilizing soil moisture and temperature, and adding organic matter. Soil organism activity will be slowed in dry or overly wet soils. The long-term use of plastic under rock mulch discourages microorganism activity by reducing water and air movement and preventing the incorporation of organic matter.

Within the soil, organisms function within an ecological food web – the smaller becoming the food for the larger, cycling nutrients through the soil biomass. This soil food web provides for ongoing nutrient cycling and soil building and is the basis of healthy, living soil.

Types of Soil Organisms

Significant soil organisms include: 1) bacteria, 2) fungi, 3) protozoa, 4) nematodes, 5) arthropods, and 6) earthworms.

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Putting Knowledge to Work

Table 1. Living organisms in a typical soil. One cup of undisturbed native soil may contain the following.

Organism	Number
Bacteria	200 billion
Protozoa	20 million
Fungi	100,000 meters
Nematodes	100,000
Arthropods	50,000

Bacteria

A teaspoon of productive soil can contain from 100 million to 1 billion bacteria. Bacteria can be grouped as decomposers, mutualists, pathogens, or chemoautotrophs. Bacteria that improve soil quality feed on soil organisms, decompose organic matter, help keep nutrients in the root zone, enhance soil structure, compete with disease causing organisms, and filter and degrade pollutants in soil.

Species of bacteria that belong to the *Rhizobium* genus (mutualists – form mutually beneficial relationship with host) live on the roots of legumes (beans, peas, clover, locust trees, etc.) and convert nitrogen gas (N_2) into a form that the legume can use. When the leaves or roots of the legume decompose, nitrogen is released into the soil.

Beneficial bacteria can out-compete pathogenic bacteria in the soil.

The *Nitrosomonas* and *Nitrobacter* chemoautotrophs (obtain energy from nitrogen compounds) create nitrate in the soil.

Actinomycetes are a special group of decomposers that break down hard-to-decompose compounds in the soil and are active in Colorado's high pH soils. They are responsible for the earthy smell of healthy soil because they produce a compound called geosmin.

Fungi

Slightly larger than bacteria in diameter, fungi grow as long strands called hyphae (up to several yards long), pushing their way between soil particles, rocks and roots. Fungi can be grouped as decomposers, mutualists or pathogens. Fungi that improve soil quality decompose complex carbon compounds, improve accumulation of organic matter, retain nutrients in soil, bind soil particles into aggregates, function as food source in soil, compete with plant pathogens, and decompose certain types of pollution.

Mycorrhizae

Mycorrhizae are specific fungi forming a symbiotic association with roots. Found in most soils, they are very host specific (i.e., each plant species have specific species of mycorrhizae associates with it).

The Latin word *mycor* means fungus and *rhiza* is root. It refers to the tissue that forms when fungi and roots develop a mutually beneficial relationship. The mycorrhizae create filaments or threads that act like an extension of the root system—enlarging the surface-absorbing area of the roots by 100 to 1,000 times. This makes the roots of the plant much more effective in the uptake of nutrients and water. In exchange, the fungus receives essential sugars and compounds from the roots to fuel its own growth.

This symbiotic relationship can significantly improve root growth, nutrient absorption (specifically phosphorus and iron) and general plant growth. With a more efficient rooting system, the plant becomes more proficient in water uptake giving the plant more resilience to drought and increased hardiness in dry weather. It enhances the plant's own ability to tolerate environmental stress and reduces post-planting stress (transplant shock). Plants with mycorrhizae may need less fertilizer and may have fewer soil-born diseases.

A by-product of mycorrhizal activity is the production of **glomalin**, a primary compound that improves soil tilth. In simple terms, glomalin glues the tiny clay particles together into larger aggregates increasing the amount of large pore space, which in turn creates an ideal environment for roots. For additional details refer to U.S. Department of Agriculture Web site at www.ars.usda.gov/is/AR/archive/sep02/soil0902.htm.

Two types of mycorrhizae occur. Plants with **ectomycorrhizae** have short, swollen, frequently branched roots usually devoid of root hairs. This type grows almost exclusively on trees. Plants with **endomycorrhizae** show no visible

signs. Endomycorrhizae have been isolated from over 80 percent of higher plant species. Since they are very host specific, additional research work is needed for practical application.

Growth of mycorrhizal fungi is favored by the same good soil properties that support plant growth. If soil conditions favor mycorrhizal establishment, they are probably already active.

Mycorrhizal cocktails are sometimes incorporated in planting or post planting care of trees and landscape plants. In research studies, results are variable. Over time, additional research will help clarify what procedures result in improved plant health and vigor.

Protoza

Protozoa are larger than fungi and primarily eat bacteria. The bacteria contain more nitrogen than the protozoa can utilize and some ammonium (NH_4) is released to plants and other bacteria when protozoa eat bacteria. As protozoa consume bacteria the bacteria population is stimulated, increasing the number of bacteria in soil. This in turn increases decomposition rates and soil aggregation from the higher bacteria numbers. Protozoa also prevent some pathogens from establishing on plants and function as a food source for nematodes in the soil food web.

Nematodes

Larger than protozoa at a 1/500 of an inch in diameter and 1/20 of an inch in length, most nematodes are beneficial, only some are plant root-feeders. There are groups that feed on bacteria, fungi, other nematodes, a variety of organisms (omnivores), and plant roots.

Nematodes help release ammonium in the same way protozoa do. At low numbers, grazing nematodes stimulate bacteria, fungi and root numbers/growth. At higher densities, nematodes will diminish the numbers/growth of their prey. Nematodes will distribute bacteria and fungi through the soil as they move about. Predatory nematodes can consume root-feeding nematodes or prevent their access to roots.

Nematodes live in water films in the large pore spaces in soil and are more resistant to dry conditions than bacteria.

Arthropods

These organisms have jointed legs, no backbone and are covered with an exoskeleton. They range in size from microscopic (like all of the above) to several inches in length. Most live near the soil surface or in the upper three inches.

They are grouped as *shredders* (millipedes, sowbugs, etc.), *predators* (spiders, scorpions, pseudoscorpions, centipedes, predatory mites, ants and beetles), *herbivores* (symphylans, root-maggots, etc.), and *fungalfeeders* (springtails and turtle mites).

Most soil-dwelling arthropods (not all live in soil) eat fungi, worms, or other arthropods). Arthropods improve soil quality by creating structure through burrowing and fecal pellets, controlling disease-causing organisms, stimulating microbial activity, enhancing decomposition via shredding organic matter and mixing soil, and regulating healthy soil food web populations.

Earthworms

See fact sheet 7.721, *Earthworms* for more information.

Ways to Encourage Beneficial Soil Organisms

- Avoid unnecessary roto-tilling or cultivation, as it will destroy the delicate mycorrhizal web and the natural soil structure. Use mulches for weed control.
- Amend the soil with composts or other organic materials as a food source for soil organisms.
- Water-logged soils will be harmful to beneficial soil organisms. Avoid over irrigation.
- Avoid unwarranted use of phosphate fertilizers.
- Some fungicides, insecticides and herbicides are harmful to various types of soil organisms. Avoid unwarranted pesticide applications.
- Soil organism activity may be reduced due to dry soil conditions that are common in the fall and winter.
- Use organic mulches to help reduce soil compaction forces, lower soil oxygen levels needed by beneficial soil organism and roots.

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