Cource: Rhizosphere Fauna (selective course)

Level one – Program Biotechnology

Title of Lecture number Five 18 /3/2020

THE LIVING SOIL Organisms and their Functions

By

Prof. Dr. Gad Hamada Hassan Rady

Plant Protection Department

Zoology Branch

THE LIVING SOIL: BACTERIA

Bacteria are tiny, one-celled organisms – generally 4/100,000 of an inch wide (1 µm) and somewhat longer in length.

Bacteria fall into four functional groups. Most are decomposers that consume simple carbon compounds, such as root exudates and fresh plant litter. By this process, bacteria convert energy in soil organic matter into forms useful to the rest of the organisms in the soil food web. A number of decomposers can break down pesticides and pollutants in soil.

A second group of bacteria are the *mutualists* that form partnerships with plants. The most well-known of these are the nitrogen-fixing bacteria. The third group of bacteria is the *pathogens*. Bacterial pathogens include *Xymomonas* and *Erwinia* species, and species of *Agrobacterium* that cause gall formation in plants. A fourth group, called *lithotrophs* or *chemoautotrophs*, obtains its energy from compounds of nitrogen, sulfur, iron or hydrogen instead of from carbon compounds. Some of these species are important to nitrogen cycling and degradation of pollutants.

WHAT DO BACTERIA DO?

Bacteria from all four groups perform important services related to water dynamics, nutrient cycling, and disease suppression. Some bacteria affect water movement by producing substances that help bind soil particles into small aggregates (those with diameters of 1/10,000-1/100 of an inch or 2-200μm). Stable aggregates improve water infiltration and the soil's water-holding ability. In a diverse bacterial community, many organisms will compete with disease-causing organisms in roots and on aboveground surfaces of plants.

A FEW IMPORTANT BACTERIA

Nitrogen-fixing bacteria form symbiotic associations with the roots of legumes like clover and lupine, and trees such as alder and locust. Visible nodules are created where bacteria infect a growing root hair (Figure 4).

Nitrifying bacteria change ammonium (NH_4^+) to nitrite (NO_2^-) then to nitrate (NO_3^-) – a preferred form of nitrogen for grasses and most row crops.

Denitrifying bacteria convert nitrate to nitrogen (N_2) or nitrous oxide (N_2O) gas. Denitrifiers are anaerobic, meaning they are active where oxygen is absent, such as in saturated soils or inside soil aggregates.

Actinomycetes are a large group of bacteria that grow as hyphae like fungi (Figure 3). They are responsible for the characteristically "earthy" smell of freshly turned, healthy soil.

THE LIVING SOIL: FUNGI

Fungi are microscopic cells that usually grow as long threads or strands called hyphae, which push their way between soil particles, roots, and rocks. Hyphae are usually only several thousandths of an inch (a few micrometers) in diameter. A single hyphae can span in length from a few cells to many yards. A few fungi, such as yeast, are single cells.

Fungi perform important services related to water dynamics, nutrient cycling, and disease suppression.

Along with bacteria, fungi are important as decomposers in the soil food web. They convert hard-to-digest organic material into forms that other organisms can use. Fungal hyphae physically bind soil particles together, creating stable aggregates that help increase water infiltration and soil water holding capacity.

Soil fungi can be grouped into three general functional groups based on how they get their energy.

- **Decomposers – saprophytic fungi – convert dead organic material into fungal biomass, carbon dioxide (CO2), and small molecules, such as organic acids.**
- **Mutualists – the mycorrhizal fungi – colonize plant roots. In exchange for carbon from the plant, mycorrhizal fungi help solubolize phosphorus and bring soil nutrients (phosphorus, nitrogen, micronutrients, and perhaps water) to the plant.**

- **endomycorrhizae that grow within the root cells and are commonly associated with grasses, row crops, vegetables, and shrubs. Arbuscular mycorrhizal (AM) fungi (Figure 4) are a type of endomycorrhizal fungi.**

- **fungi are commercially available and can be added to the soil at planting time.**

THE LIVING SOIL: PROTOZOA

Protozoa are single-celled animals that feed primarily on bacteria, but also eat other protozoa, soluble organic matter, and sometimes fungi.

Protozoa play an important role in mineralizing nutrients, making them available for use by plants and other soil organisms. Protozoa (and nematodes) have a lower concentration of nitrogen in their cells than the bacteria they eat.

Another role that protozoa play is in regulating bacteria populations. When they graze on bacteria, protozoa stimulate growth of the bacterial population (and, in turn, decomposition rates and soil aggregation.)

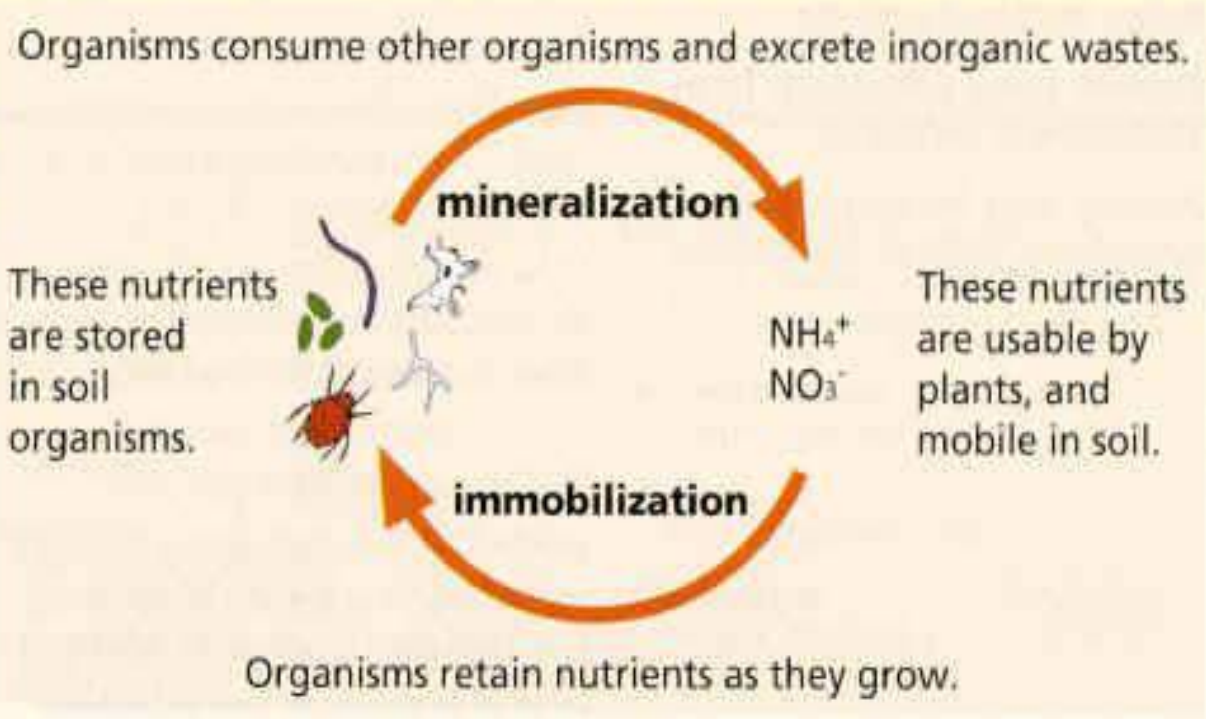
Protozoa are also an important food source for other soil organisms and help to suppress disease by competing with or feeding on pathogens.

WHAT DO PROTOZOA DO?

What Are Mineralization and Immobilization?

Soil nutrients generally occur in two forms: inorganic compounds dissolved in water or attached to minerals, and organic compounds part of living organisms and dead organic matter. Bacteria, fungi, nematodes, protozoa, and arthropods are always transforming nutrients between these two forms.

When they consume inorganic compounds to construct cells, enzymes, and other organic compounds needed to grow, they are said to be "immobilizing" nutrients. When organisms excrete inorganic waste compounds, they are said to be "mineralizing" nutrients.



NEMATODES AND PROTOZOA

Protozoa and bacterial-feeding nematodes compete for their common food resource: bacteria. Some soils have high numbers of either nematodes or protozoa, but not both. The significance of this difference to plants is not known. Both groups consume bacteria and release NH_4^+.

THE LIVING SOIL: NEMATODES

Nematodes are non-segmented worms typically 1/500 of an inch (50 μm) in diameter and 1/20 of an inch (1 mm) in length.

Free-living nematodes can be divided into four broad groups based on their diet. *Bacterial-feeders* consume bacteria. *Fungal-feeders* feed by puncturing the cell wall of fungi and sucking out the internal contents.

Predatory nematodes eat all types of nematodes and protozoa. They eat smaller organisms whole, or attach themselves to the cuticle of larger nematodes, scraping away until the prey's internal body parts can be extracted. Omnivores eat a variety of organisms or may have a different diet at each life stage. Root-feeders are plant parasites, and thus are not free-living in the soil.

WHAT DO NEMATODES DO?

Nutrient cycling. Like protozoa, nematodes are important in mineralizing, or releasing, nutrients in plant available forms. When nematodes eat bacteria or fungi, ammonium (NH_4^+) is released because bacteria and fungi contain much more nitrogen than the nematodes require.

Grazing. At low nematode densities, feeding by nematodes stimulates the growth rate of prey populations.

Dispersal of microbes. Nematodes help distribute bacteria and fungi through the soil and along roots by carrying live and dormant microbes on their surfaces and in their digestive systems.

Food source. Nematodes are food for higher level predators, including predatory nematodes, soil micro arthropods, and soil insects. They are also parasitized by bacteria and fungi.

Disease suppression and development. Some nematodes cause disease. Others consume disease causing organisms, such as root-feeding nematodes, or prevent their access to roots. These may be potential biocontrol agents.