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Ag is Life

Microbes and Soil Fertility

Directly or indirectly, the wastes of man and other animals, their bodies, and the tissues of plants are dumped onto or buried in the soil. Somehow they all disappear, transformed into the substances that constitute soil. It is the Microbes that mediate these changes - the conversion of organic matter into substances that provide the nutrient material for the plant world. Without microbial activity, life on earth would be gradually choked off.

Soil has been defined as "that region on the earth's crust where geology and biology meet". Few environments on earth provide so great a variety of microorganisms as fertile soil. Bacteria in soil exceed the population of all other groups of microbes in both numbers and kinds. Direct microscopic counts can be as high as billions per gram (there are over 900,000 grams in a ton). As many as millions per gram of actinomycetes are present in soils. These thread-like organisms produce the musty or earthy odor of freshly plowed fields. They degrade many complex chemicals and thus playa large role in soil fertility. Hundreds of mold species inhabit soil, most abundantly near the surface of loose soils where aerobic conditions favor them. Their numbers may approach a million per gram. Fungi decompose the major constituents of plants such as cellulose and lignin. Mold mycelia (their long chain growth) improves the physical structure of soil by binding fine soil particles to form water-stable aggregates.

The region where soil and roots make contact is called the rhizosphere. Its microbial population is much higher than root-free soil, and the difference is in both numbers and types. Bacteria predominate here and their growth is enhanced by nutritional substances released by the plant and in turn the plant is influenced by the products of microbial metabolism. Rhizosphere bacteria are much more physiologically active than those in non-root soils.

Studies have demonstrated that the rhizosphere has greater population of gram-negative, non-spore forming, rod shaped bacteria than free soil. These are mainly fluorescent pseudomonads (organisms which fluoresce under UV lights). Certain rhizosphere bacteria produce plant hormones. such as indole acidic acid, auxins and gibberellin-like materials.

In addition to the larger numbers of these special bacteria, the rhizosphere has a class of fungi called mycorrhizae which form intimate associations with plant roots. There are two main groups of these fungi: ectomycorrhizae which surround the root but usually do not penetrate the cells, and endomvcorrhizae which enter the root cells. Ecto forms are the most important in forests while endo forms are found in many nutrients. The mycorrhizae obtain organic nutrients from the plant and the plant benefits in return since they can absorb soil nutrients (especially phosphates and moisture) more easily.

In the soil there is a constant and complex cycling of organic and inorganic materials due to microbial activities. Nitrate nitrogen ($N0_3$) is the form of nitrogen most available to plants. Nitrogen in protein must be liberated by proteolysis (breakdown) into amino acids which are then either absorbed by plants or further broken downto liberate ammonia (deamination). This ammonia is then oxidized to nitrate (nitrification), This is one of the most important activities of autotrophic bacteria.

Some bacteria are able to use the nitrogen inthe air as a source. This is nitrogen-fixation and is carried out by two kinds of microbes: symbiotic, living in roots

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of legumes; and free-living. Chief among the free living are the Azotobacter, which are plentiful the rhizosphere. Free-living nitrogen-fixers may provide 20-50 lbs/acre/year, if conditions are ideal.

Organic carbon can be converted into carbon dioxide by decomposition of plant residues by microbes, chief1y bacteria and fungi. Sulfur like nitrogen and carbon passes through a cycle of transformation carried out by microbes. Sulfur, like nitrogen, cannot be used by plants in the elemental form. Itis oxidized to sulfate ($S0_4$) which is assimilated by plants for forming proteins. In some cases the sulfate serves to loosen hard soils and free calcium and magnesium from clay.

Phosphate is often bound into insoluble forms and can be liberated by several microbial actions. Chief among the bacteria of importance here are the f1uorescent pseudonerrads in the rhizosphere.

While this is only a brief outline of the roles microbes play in soil fertility, it should make it clear that microbes and their activities are essential for soil productivity. To consider soil-plant relationships we must consider the role of the microflora.

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