Functions of the Microbial Population

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THE soil micro-organisms do not all function for the benefit of higher plants. The soil harbors a number of organisms which are causative agents of disease, either in plants or in animals. The number of plant pathogens which find a temporary or permanent habitat in the soil is quite large. Some organisms may be beneficial at one time and injurious at another.

The beneficial effects of various microbes may be conveniently discussed under the following three general topics: (1) changes brought about in the soil organic matter and its decomposition products, (2) fixation of atmospheric nitrogen, and (3) changes brought about in the soil mineral constituents.

One of the chief activities of micro-organisms is the decomposition of organic matter and the transformation of the composition products. By the term decomposition we have reference to those physical and chemical changes which organic materials undergo in changing into simple compounds by the action of the various soil organisms. Original organic matter, plant or animal residues, as such cannot be used by higher plants; but principally through the action of micro-organisms it becomes a valuable source of nutrients. All forms of soil organisms have something to do with the processes concerned with organic matter decomposition, but the bacteria, fungi, and actinomyces are the most important.

Rotting Produces End Products

In the rotting down of organic matter numerous simple end products are produced, the nature of which is to a large extent determined by the degree of soil aeration. In the presence of oxygen (sufficient aeration) the most important end products are ammonia, carbon dioxide, water, minerals, and energy in the form of heat. In the absence of sufficient oxygen (anaerobic conditions) the rate of decomposition is much slower and the chemical changes are less complete. Although some carbon dioxide, water and ammonia may be formed from complex organic materials under these conditions, most of the nitrogen, carbon, hydrogen, and oxygen are transformed into intermediate compounds, many of which are quite resistant to further decomposition. Many of these compounds have offensive odors and some may even be poisonous.

Ammonia Is By-Product

Ammonia is formed, as a by-product in the decomposition of organic nitrogenous compounds, by numerous soil organisms including fungi, actinomyces and bacteria. Thus the soil organisms responsible for producing ammonia nitrogen are widely distributed and are found in abundance in most soils. In other words, the organisms are there to function if soil conditions are made favorable. The process of ammonia production in soils by micro-organisms is of extreme importance not only because certain plants have the ability to use ammonia compounds directly but the production of ammonia is a necessary preliminary step to the production of nitrates from organic nitrogenous compounds.

The conversion of ammonia nitrogen into nitrate nitrogen is a process carried out by soil organisms. The fact that the nitrates produced in the soil are the principle of available nitrogen for most agricultural plants makes this a most important process. The process is apparently carried on largely by two specific groups of bacteria of which there are several species. Although seldom ever found in great abundance in any particular soil, fortunately they are widely distributed; they are present in every cultivated soil. Perhaps the two most important factors affecting the activity of the nitrate formers in soils and which can be controlled to a greater or less extent is the matter of drainage and soil acidity. They function best in a soil that is not strongly acid and one that is well aerated. It is obvious that the production of nitrates in the soil biologically does not increase the total supply of nitrogen in the soil; merely a change in the form of nitrogen.

Sulphur goes through a cycle somewhat similar to that of nitrogen. As organic matter decomposes sulphur is released and

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is eventually oxidized by certain specific groups of organisms to the sulphate form, a form which can be absorbed by higher plants.

There is an inexhaustible supply of nitrogen in the air in the free state which does not easily combine with other elements, yet certain groups of soil organisms have the ability to take that element out of the air and utilize it in the synthesis of their cells. The inert nitrogen in the air is thereby changed to a "fixed" form where it can be of use to higher plants. This process is known as "nitrogen fixation" and is accomplished largely by two groups of bacteria. One group functions independently of higher plants and the other group forms nodules and functions in association with certain plants known as legumes.

Changes In The Soil Mineral Constituents

In the decomposition of organic matter and in the synthesis of microbial cells there are numerous reactions involving the solubility of various soil mineral elements. Perhaps all mineral elements related to the growth of higher plants either as nutrients or "stimulants" are subjected to the action, in one way or another, of micro-organisms in the soil.

Some of the mineral elements and their compounds may serve certain bacteria as sources of energy, some of the minerals are assimilated by soil organisms, minerals may be released from their combination with organic compounds, soluble minerals may be changed to insoluble forms by oxidation processes, and an increase in the solubility of soil minerals may result from their interaction with organic and inorganic acids formed by the activities of micro-organisms.

These few statements serve to show that extensive and far-reaching chemical changes are produced in the mineral soil constituents through the various activities of soil micro-organisms. These organisms are the primary agents by which the insoluble and unavailable mineral elements are converted into forms in which the plant may use them.

It is not to be inferred that all microbial processes are beneficial; certain undesirable effects commonly observed may be grouped as follows: (1) the production of plant and animal diseases, (2) denitrification, and (3) competition with higher plants for available nutrients.

The first of these, the production of plant and animal disease, is usually of greatest concern. Denitrification is essentially the reverse of nitrate production. Ammonia or gaseous nitrogen is produced and the latter may escape into the atmosphere. This process is most apt to occur in poorly drained soils in the absence of air. Soluble nutrients taken up by micro-organisms are "tied up" in an unavailable form only temporarily. When these organisms die and their bodies decompose, the plant nutrients are again released in an available form.

The process involved in composting is based on biological principles. In composting an attempt is made to make conditions favorable for rapid decomposition. Composts are usually prepared from plant residues (sometimes animal residues are included) to which certain fertilizer salts are added and when kept at conditions of favorable moisture, aeration, and reaction the materials in the compost decomposes rapidly. The most important element of the fertilizer salts added is nitrogen in an available form; phosphorous and calcium (lime) are next in importance. The plant residues that are commonly composted are low in nitrogen and high in carbohydrate material. The breakdown of these carbohydrates releases considerable energy for the growth of micro-organisms.

Decomposition Speed Varies

The speed of decomposition in composts depends upon the nature of the composting materials, their chemical composition, the amount and nature of inorganic nutrients added, the moisture content of the compost, its aeration, and the temperature.

Since rotting is merely a process in which certain materials serve as food for micro-organisms, composting is an attempt to feed micro-organisms a balanced ration in order that they may function more efficiently. A ration for these organisms must contain (1) energy materials, (2) growth producing substances, and (3) certain essential minerals if they are to promote rapid decomposition. Plant residues serve as food and energy for the micro-organisms, nitrogen promotes their growth, lime, phosphorus, etc. supplies their mineral requirements. If these requirements are met and suitable conditions of moisture, temperature, and aeration are provided rapid decomposition occurs. It is thus evident that the principle involved in composting is that of meeting the growth requirements of the micro-organisms responsible for the decomposition processes.