Soil Bacteria

useful in studying processes of organic matter formation and decomposition

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Soil bacteria are useful in studying the basic chemical processes that occur in all living organisms.

One such process now being investigated is the conversion of sugar into fats or fatty acids. The chemical reactions involved in fatty acid synthesis—build up—are not well understood, largely due to the fact that it has not been possible to obtain from animal or plant tissues the soluble enzymes that cause these reactions.

It is difficult to study such reactions with living cells because many other reactions are occurring simultaneously. Only by separating the enzymes causing fatty acid synthesis from all the other processes that occur in the living cell can the individual chemical reactions be studied successfully.

This has been done using a bacterium called *Clostridium kluyveri.* This organism specializes in the formation of the lower fatty acids containing four to seven carbon atoms from simpler substances containing two or three carbon atoms. By growing the bacteria on a fairly large scale, then drying the cells and extracting them with water, it has been possible to obtain soluble enzymes that are responsible for these reactions. It has been found that the conversion of the two-carbon compounds, ethyl alcohol and acetic acid, to the four-carbon fatty acid, butyric acid, is a very complex process requiring at least five different enzymes and probably more.

Soil Microörganisms

Formation of organic matter is largely due to photosynthetic plants whereas the decomposition of organic matter is due mainly to the action of microörganisms.

There are many different kinds of microörganisms required in the decomposition of organic matter because of the variety of compounds to be decomposed and the variety of environmental conditions that exist in the soil and elsewhere.

Microörganisms tend to be somewhat specialized with respect to the particular organic compounds that they can utilize for growth. Some grow best with one type of organic compound, some with another. For example, there are bacteria that require cellulose as a nutrient and are unable to utilize simple sugars or amino acids, whereas other bacteria utilize sugar and amino acids very readily and are entirely unable to attack cellulose.

Similar specialization exists with respect to the environmental requirements of microörganisms. Some require oxygen, whereas others are killed by oxygen; some prefer a strongly acid environment whereas others only develop well under alkaline conditions; some grow only at low temperatures whereas others require temperatures above 50° C.

The decomposition of several types of organic and inorganic compounds has been studied to find what microörganisms are responsible for these processes, the conditions most favorable for their action, the nature of the chemical reaction produced, and the role of the organisms in soil processes.

Methane Formation

One process studied in some detail is the formation of methane, commonly called marsh gas..

Methane is produced by bacteria in large amounts in nature, especially in marshes, lake beds, and soils that have been saturated continuously with water over a period of time.

Methane also is produced in the digestive tracts of cattle, sheep and other ruminants. Although the quantity of methane formed depends upon the nature of the feed and other factors, about 10% of the food eaten by a cow is converted into methane. This corresponds to a formation of about 100 to 200 liters of methane per cow per day.

Natural gas consists largely of methane. It is probable that a considerable part of the natural gas that we now use for fuel was formed by bacteria from plant residues in past ages.

Methane-producing bacteria are anaerobic organisms—that is, they are able to grow only in the absence of free oxygen. This is the reason that they are almost always found in a water-saturated environment rich in decaying organic materials. Water helps to exclude oxygen, and the various aerobic bacteria present in decaying organic materials rapidly use up any oxygen that may be available, thus making conditions favorable for the methane-producing organisms.

Complex organic compounds such as sugar and cellulose which are important constituents of plants are not attacked directly by methane-forming bacteria. The more complex compounds must first be partially decomposed by other bacteria to give simpler substances like alcohol, acetic acid and carbon dioxide. These compounds are then converted to methane by the special types of bacteria. This occurs very rapidly under favorable conditions.

Denitrifying Bacteria

There are other bacteria that sometimes cause a loss of nitrogen from the soil.

These denitrifying bacteria are universally present in soils but only cause nitrogen losses under special conditions.

Like most other bacteria, denitrifiers require organic compounds as food. When they are supplied with organic materials such as plant residues and oxygen, they develop readily and decompose the organic compounds without causing any loss of nitrogen.

When nitrate is present and oxygen is lacking, the nitrate and organic compounds interact in such a way as to convert nitrate—a common constituent of soils and fertilizers—to nitrogen gas which cannot be used by most plants. Even a relatively small concentration of oxygen, not more than one tenth that of normal air, largely prevents this loss of nitrogen. For this reason denitrification does not occur to a large extent in light textured, well-aerated soils unless excessive amounts of organic matter are added to them.

Still other bacteria have been found that are responsible for the formation of ammonia from various nitrogen containing organic compounds such as amino acids and uric acid. Uric acid is the main nitrogenous excretory product of chickens and other birds. It can not be used directly by plants but must first be converted to ammonia. This occurs very rapidly under the influence of an anaerobic bacterium known as *Clostridium acidi-urici* that is widely distributed in soils. This bacterium can only grow on uric acid or a few closely related compounds.

Soil microörganisms are sometimes useful for studying problems not immediately connected with soil fertility. For example, several soil microörganisms have been found to produce antibiotic substances such as penicillin and streptomycin that are capable of preventing the development of other microbes and are therefore used in the treatment of diseases.

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