Soil Germs—

Their Role In Composts and Special Fertilizers

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PRODUCTIVITY of our soils is directly affected by the activities of the innumerable soil organisms. Many of these organisms cannot be seen with the naked eye, yet they take part in a great variety of fundamental activities. They perform an indispensable service in keeping certain plant nutrient elements in circulation. In the absence of these germs, the surface of soils under natural conditions would soon become covered with a great mass of undecomposed plant and animal residues; life would soon cease because the essential elements would quickly become exhausted.

The original concept of the soil population as being predominately bacterial has been modified in recent years to include also numerous groups of fungi, actinomyces, protozoa, algae, and many small animals. A general knowledge of the nature of soil organisms is of considerable interest and of extreme importance because it is to these tiny living things we owe the continued development of higher plants.

Bacteria are usually regarded as the simplest and smallest forms of life known. The numbers of bacteria present in soils are extremely variable since so many conditions affect their growth and since they can multiply in numbers with such extreme rapidity. A new individual may be formed in less than 20 minutes, thus permitting sudden fluctuations in numbers with the ever-changing environment. It has been found that the numbers may range from 1 to 4 billion per gram of soil and it is not unlikely that the total live weight of bacterial substance, per acre-seven-inches of soil, exceeds 1,000 lbs. in good soils.

Soil bacteria may be divided broadly into two large groups based on their food and energy requirements: (1) those which can obtain their energy from the oxidation of inorganic elements, their

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carbon from carbon dioxide, and their nitrogen and other minerals from inorganic compounds; (2) those which obtain their energy and carbon from organic substances.

Those bacteria which obtain their energy and carbon from organic substances may be subdivided into two groups: (1) the nitrogen fixing bacteria (those that gather atmospheric nitrogen), and (2) those that require fixed nitrogen. There are two groups of nitrogen fixing bacteria; the members of one group grow and function in the association with legume plants, and members of the other group are able to gather and fix nitrogen in soils in the absence of higher plants.

Fungi are all devoid of chlorophyl and obtain their food and energy from the soil organic matter or from other forms of life with which they may be associated. They respond especially well to aeration and can make extensive growth only under aerobic conditions. They make a vigorous growth in either acid, neutral or alkaline soils; many fungi are favored by the more acid soil conditions.

The number of fungi ordinarily found per gram of soil is usually between 8,000 and over 1,000,000. This would probably be the equivalent of from 1,000 to 1,500 lbs. per acre (7 inches deep) of living substance. It is observed, therefore, that fungi may be out-numbered by bacteria but the fungi present a much greater mass of growth per unit volume of soil, due, of course, to their much greater size.

Actinomyces may be looked upon as occupying a position, from the morphological point of view, between that of the bacteria and fungi. They resemble bacteria in that they are unicellular and are about the same size in cross section. They resemble the filamentous fungi in that they produce a very extensive, unicellular and profusely branched filamentous network.

Sensitive to Acidity Changes

For the most part, actinomyces are aerobic and in comparison to most soil organisms they are more sensitive to changes in soil acidity. They function best in soils at about the neutral point as far as soil acidity is concerned. They perform a very important function in soils by breaking down organic matter and setting free the nutrients it contains.

These organisms are present in great abundance in soil; the numbers may run as high as 36 million per gram of soil.

In actual weight of live substance per acre they excel bacteria but as a rule will not equal that of fungi tissue.

The chlorophyl-bearing microscopic plants are called algae. They are universally distributed in the surface layers of soil wherever moisture and light are available. Algae obtain nitrogen and minerals from the soil while carbon is derived from CO_2 of the atmosphere. They utilize the energy of the sun so long as they have free access to light. Below the soil surface, in the absence of light, they act in a manner similar to fungi in that they live at the expense of the soil organic matter. Algae may thus live and function much like higher plants or they may perform like the lower forms of plant life.

Algae are most abundant in the upper soil horizons where environmental conditions are most favorable for their development. The number may run as high as 10,000 or more per gram of soil with a total live weight of perhaps 800 lbs. per acre-7-inches of soil.

The development of algae in the soil results in increasing the supply of organic matter and in transforming, temporarily, soluble forms of nitrogen and mineral elements into organic or insoluble forms. Furthermore, they may aid in the decomposition of organic material and they exert a solvent action on rocks and minerals.

The protozoa are generally accepted as being the simplest form of life belonging to the animal group. They are all microscopic in size and unicellular but larger than bacteria and more complex in their activities. Soils may contain up to 1,000,000 or more of these organisms per gram of soil with a total live weight of two or three hundred pounds per acre.

Protozoa depend on the organic matter as a source of food; certain groups may feed on bacteria. Granting that they may feed on bacteria then their effect will be either beneficial or harmful depending upon whether they consume beneficial or pathogenic bacteria.

Nematodes are sometimes called eel worms; they are round or spindle-shaped and usually with a pointed posterior end. Most of them are microscopic in size, seldom large enough to be readily seen with the naked eye. Billions of them are found in each acre of soil. Some of them feed on decaying organic matter, some feed on earthworms, bacteria, protozoa, etc., and others infest the roots of higher plants, passing a part of their life cycle imbedded therein, causing a great deal

of damage to certain crops, especially the vegetable crops.

The activities of all mematodes are not harmful to the growth of higher plants. They aid in bringing about an intimate mixture of the mineral and organic matter and in breaking down organic matter. They may improve soil aeration in heavy soils.

Perhaps the most important group of the larger animals inhabiting the soil is the common earthworm. They prefer a moist environment with an abundance of organic matter and a plentiful supply of available calcium. They are found only sparingly in acid sandy soils low in organic matter. Obviously, figures indicating numbers are merely suggestive. The numbers per acre-plowed-layer may range from a few hundred or even less to more than a million. It has been estimated that between 200 and 1,000 lbs. of earthworms are present in an acre of soil.

It is believed that in some soils these organisms may pass several tons of soil through their bodies annually and in so doing bring about an increased availability of plant nutrients. Considerable soil mixing is accomplished as a result of their action. Holes left in the soil aid in increasing soil aeration and drainage. Frequently earthworms bring considerable quantities of soil from the lower soil layers to the surface which is very objectionable in the soil of golf greens. This frequently occurs where such soils have received heavy applications of organic fertilizers.

Other groups of the larger animals inhabit the soil, namely: rodents, ants, snails, spiders, mites, millipedes and centipedes. Some of these organisms may spend all and others only a part of their life cycle in the soil. Although soils may be directly benefited by their activities, it is obvious that they may prove unfavorable under certain conditions.

Soil organisms, in general, have the same nutritional requirements as higher forms of life. For their growth and synthesis they all require supplies of energy in addition to the several essential elements including carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, calcium and others. With the exception of algae all the important soil microbes are devoid of chlorophyl and must obtain their energy either from the oxidation of simple inorganic substances or from complex organic substances as is

the case with most bacteria, all the fungi, and protozoa.

Certain groups of bacteria have the ability to utilize the free nitrogen of the air and build it into their protoplasm, thereby increasing the soil's supply of combined nitrogen. Other soil organisms must get their nitrogen from complex organic substances or from simple inorganic compounds. They obtain their other necessary mineral elements from the soil minerals.

The environmental conditions, including the physical and chemical composition of the soil, determine the nature of the microbial population at any given time in the soil. In general, the fertile heavy soils rich in organic matter contain many more microbes than light soils poor in organic matter.

The optimum temperatures for most soil microbes are considerably higher, as a rule, than those which prevail in the soil, even in summer. Consequently it may be assumed that micro-organisms never reach their highest level of activity in soil and they thus utilize only a part of the potential energy sources. For the majority of the soil organisms the optimum temperature is about 35° C. Within a rather narrow range the rate of biological

reactions increases two to three times for each increase in temperature of 10° C. up to their optimum temperature.

The optimum amount of water for most soil organisms is between 50 and 70% of the water-holding-capacity of the soil or about the same as for most higher plants. Growth will take place at higher and lower moisture contents than the values given; they have the ability to withstand rather wide extremes in both soil moisture and temperature, thus insuring their wide distribution in soils in spite of periodic changes in the environment.

The degree of acidity or alkalinity of the soil is of particular importance in influencing the activities and relative abundance of the different groups of soil organisms. In general, the optimum range in acidity for the majority of the soil population is essentially the same as for most higher plants.

The development and activities of soil organisms are greatly affected by the concentration and rate of supply of gases (particularly oxygen, carbon dioxide, and nitrogen) in the soil environment. A well aerated soil is usually in a good sanitary condition while a poorly aerated soil favors undesirable biological and chemical reactions. Soil aeration is to a large extent governed by fluctuations in soil moisture.

The addition of mineral elements to the soil may influence the soil population in several ways. They may stimulate the growth of higher plants, giving greater plant residues, thereby increasing the available supply, resulting in increased microbial activities. In a general way, soil micro-organisms respond favorably to the applications of ordinary fertilizer salts. However, the action of the various mineral salts depends on the nature of the salt, type of soil, and the nature of the organism concerned. Salts of copper, mercury, lead, arsenic are very toxic to most beneficial biological soil reactions.

Direct sunlight is highly injurious to most forms of soil micro-organisms; many are instantly killed when exposed directly to the sun. Diffused daylight appears to have an inhibiting effect on most bacterial processes although having little effect on the growth of fungi. The growth of algae, however, is stimulated by the presence of diffused daylight but direct sunlight appears to be detrimental.

Of the various factors affecting soil organisms in humid regions the influence of organic matter is one of the most important. Since organic matter is the

source of food and energy for the majority of soil organisms, obviously those soils well supplied with organic matter are capable of supporting a more dense population than those low in organic matter. Organic matter may exert indirect effects on the nature of the soil population through its effect on the physical and chemical condition of the soil.

(*To be concluded in August GOLFDOM*)

Hoare Takes In Open From Wheel-Chair

WILLIE HOARE got a great kick out of a newspaper error at Fort Worth during the Open. Willie was identified in an item as a "former British Open Champion."

Willie motored to Fort Worth from Chicago, with his pal Chick Jansky, who is conducting special golf promotion work for Wilson Sporting Goods Co., at the wheel.

Although compelled to go the rounds in a wheel chair there wasn't much Willie missed at this Open. He continues to have a livelier interest in golf affairs after several years of invalidism than many of the boys who are in A-1 physical condition.

Ryder Cup Squad to Play Jones' Challenge Team

THE Ryder Cup team, which never got to play against a British team, due to the war, will cross clubs with a team captained and selected by Bob Jones on August 22 and 23 at the Detroit Golf club. Proceeds of the matches will go to the USO. Sponsor of the event is the PGA.

The Ryder Cup squad is, of course, already formally in existence. Walter Hagen is honorary captain; the team members are Picard, Nelson, Runyan, Snead, Horton Smith, Metz, Hines, Guldahl, McSpaden and Ghezzi.

Bob Jones is captain of the challenging team of Wood, Little, Sarazen, Heafner, Bulla, Demaret, Dudley, Hogan, and Shute.