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, actinomycetes, 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

*GSA Convention Address.
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.

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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 CO₂ 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 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 nematodes 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

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**WHITE GRUB CONTROL**

White grubs, or the larvae of the May or June beetle, are a menace to fine turf. Grubs of the green June beetle do damage too, but are more difficult to control because they work deeper in the soil. In eastern regions, grubs of the Oriental, Garden, Asiatic, and Japanese beetle do similar damage. All can be controlled by applying acid lead arsenate, commonly called lead arsenate.

When any of these beetles occur in sufficient numbers, resulting grubs will damage grass, unless enough lead arsenate is applied to kill the young grubs. On new seedings lead arsenate should be applied and worked into soil before seeding. This treatment may retard, but will not prevent germination. Apply at 5 to 10 pounds per 1,000 square feet, which is 200 to 400 pounds per acre.

Since lead arsenate is an exceedingly fluffy, fine powder, a carrier is needed to insure even distribution. Besides being the best carrier for applying lead arsenate, Milorganite is the ideal source of nitrogen for new seedings. Use 30 to 50 pounds per 1,000 square feet. (1,200 to 2,000 pounds per acre). Simply mix the lead arsenate with it and scatter evenly over the area. Then apply 20% grade superphosphate at 10 pounds per 1,000 square feet (400 pounds per acre); scratch all three into surface and sow seed. The Milorganite and phosphate insure quick development of uniform turf.

Milorganite is the ideal carrier for applying lead arsenate to established turf, also. From 3 to 5 pounds Milorganite are needed for each pound lead arsenate used. Where infestation is light, 5 pounds lead arsenate per 1,000 square feet (200 pounds per acre) is enough; but from 10 to 15 pounds (400 to 600 pounds per acre) is needed for heavy infestation.

While lead arsenate may be applied at any time when there is no frost in the ground, early August treatments seem most effective for killing newly hatched grubs, particularly in the Japanese beetle belt. It gets the small grubs before they appreciably injure the turf.

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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

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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.