MICRO-ORGANISMS OF THE SOIL

NAGA Address

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A MICRO-ORGANISM is an organism the details of which can not be seen by the naked eye. This does not mean that the eye can not see the mass-growth of a micro-organism. You have all seen moldy bread—the fungal mass being made up of great numbers of roots, branches holding spores and other details much too small for the human eye. Algae, the green scums of ponds, are about the same size. As we go down the scale, there are the yeasts and lastly, but not least, the bacteria, the smallest things in the plant kingdom.

How small are bacteria? A bacterium of average size has to be magnified 500 times if you are to see it easily; on other bacteria higher magnifications of 1,000 or even 2,000 are used.

Small size is no handicap to bacteria—what they lack in size they make up in numbers. One investigator took samples of soil from grass land and found 90,000 microscopic insects and mites in a square yard of soil one foot deep, and 150 million microscopic one-cell animals; at the same time one-half a teaspoonful of that same soil contained 6 million bacteria.

Micro-organisms, like the grass on the turf, must have food, moisture, and proper temperature. As long as these are present, they grow and increase rapidly in numbers until some factor puts on the brakes. Usually, it is lack of food. In ordinary soil, available food materials are not so abundant, and there is keen competition between the various types of micro-organisms and higher plants. Bacteria being so small, have a big advantage in the matter of food. In a compost pile great activity takes place, especially if the materials used in the pile are succulent and easily decomposed.

How Bacteria Decompose Organics

The question might be raised as to how do bacteria feed upon organic materials and decompose them? Being only one-celled, they must get their food by absorption. This requires that the food material be in solution. But if it is not in solution, if it is a solid substance, it may be made soluble by the action of enzymes, or digestive fluids which the cells excrete. When plants are plowed under and begin to die, the bacteria begin to multiply, secrete their enzymes and break down the complex compounds into simple ones.

Sugars, Starches Are First to Go

The first of the carbonaceous materials broken down by the bacteria would be the soluble portion—sugars and starches. After they are gone, the same bacteria or others or combinations of micro-organisms, attack the pentosans (a gummy material), cellulose and lastly the lignin, reducing them to carbon dioxide through various steps. Simultaneous with the destruction of the carbonaceous substances, there is a breaking down of the complex protein compounds to ammonia and CO_2; therefore, the theoretical ultimate end of the organic matter in a compost pile is NH_3 and CO_2. Most of the CO_2 escapes into the air, the NH_3 is absorbed by soil, organic colloids and by any undecomposed organic matter. A rapidly decomposing pile of horse manure often gives off large quantities of NH_3, plant food going into the air to be carried away and brought down by rain on someone else's land. A small amount of soil will hold a tremendous amount of NH_3 efficiently. In fact it is so efficient that we have difficulty in the laboratory getting out of soil as much NH_3 as we have just put in, so tightly does it hold on to it.

This NH_3 and CO_2 is food for certain bacteria, and strange as it may seem, the bacteria, in using the NH_3 and CO_2 in their growth, oxidize the NH_3 to nitrite (a rank poison to most green plants) but it is not troublesome except in special cases of waterlogging because it is at once oxidized by another group of bacteria to nitrate. Now soil does not hold nitrate very well, it is very easily leached out, comes to the surface quickly with drying out of the soil, and is frequently lost in surface run-off; provided, of course, that there is nitrate there to be lost. In the case of ordinary sod, one has little to fear in this respect because of the low amount of nitrate.

The nature and chemical composition of organic materials greatly affect the rates of decomposition. It is well known that grass clippings, cottonseed meal and the like, decompose quickly and that straw, peat and such are very slowly broken down. Therefore, we choose the materials to be added to the soil which will best suit our purposes.

Straw Is Poor in Nitrogen

In all studies on the process of decomposition, one fact stands out. It is that materials having more than 1.7% nitrogen will show an excess amount of it over that needed by the bacteria involved in the process; that materials having less than 1.7% nitrogen do not release any of it upon decomposition, all the nitrogen being required for food by the micro-organisms. For instance, straw contains less than 1.7% nitrogen, usually about 0.6%. Its decomposition is slow for two reasons; the material is rather resistant and there is not enough nitrogen for the micro-organisms. The latter can be overcome by adding nitrogen, which hastens the process. This is best done in compost piles. A farmer may ruin his intended crop by plowing under a considerable amount of straw. The straw may decompose but in so doing, the soluble nitrogen of the soil has been used by the bacteria and it is therefore tied up. The NO_3 may be liberated slowly, but in the meantime, the crop has lacked nitrogen and shows the characteristic pale color of nitrogen starvation.

In contrast to straw, legume green manure crops, soybeans, cowpeas, vetch, etc., when plowed under, decompose rapidly. This is due to less resistant nature of the material and to the nitrogen content which is usually around 3.5%. This is an excess over the needs of the micro-population, the NH_3 and finally the NO_3 becomes available for crops.

The relationship of carbon to nitrogen is called the C/N ratio and is an important thing to know about a soil. The greater the proportion of nitrogen to carbon in a soil or compost, the greater will be the excess of nitrogen over the needs of the bacteria, resulting in either an accumulation of nitrate or nitrate available for plants.

At this time we might briefly discuss the growing of legumes. The early Roman observers recognized the value of growing legumes and exhorted the farmers to grow more of them. Much has been learned since those times but we are still recommending the growing of legumes. We now know that part of the beneficial effect of legumes is due to bacteria which invade the rootlets and cause a nodule to form. In this nodule, the bacterium lives and multiplies at the expense of the plant as far as minerals and sugar are concerned and in payment gives the plant nitrogen compounds which it forms from the nitrogen of the air. Obviously this enables the legume to grow on soil poor in nitrogen and to build up the nitrogen in that soil through the decomposition of its roots. This building-up process can go on provided the NO_3 in the soil remains low, otherwise the legume uses the NO_3 and the symbiosis between the plant and the bacteria is discontinued and no further benefit from the growth of the legume is accrued. Each group of legumes must have its own particular bacteria for best results. Sometimes nodules are formed by unsuited bacteria, but these are false alarms, often proving detrimental to the plant. To forestall this, it is becoming more and more the custom to inoculate the seed of legumes with the proper culture of bacteria. There are about forty commercial concerns making and selling such inoculation. It is one of the duties of the Division of Soil Microbiology in the United States Department of Agriculture, to test cultures from all sources to see if the bacteria are alive and capable of forming normal nodules.

No "Cultures" Are Available

We frequently get requests for information about cultures to put on grass, corn, wheat, potatoes and most any other crop. I wish to state emphatically that there are no cultures of bacteria which will form nodules on the roots of non-legumes nor are there any cultures known to help those plants in any other way. Our tests, as well as those made in other laboratories, have failed to find any beneficial bacteria for plants other than legumes.

Perhaps I should have brought up the question of soil acidity before now, for it is quite important to know whether a soil is alkaline, neutral or acid. Before a western audience, one would have to dwell upon the alkaline conditions, but I dare say that the eastern half of the country is not troubled with alkali. The millions of years of leaching by rain has washed out the alkali and left the acid. In small amounts, acid is not considered harmful for most plants. Legumes do well, but with increasing acidity, they are among the first plants to suffer, both the bacteria and the legume seem to be paralyzed. Kentucky bluegrass is tough and can stand considerable acid. But this can be overdone. If the soil is very acid, the old roots of the grass do not decompose, nitrates are formed slowly, and the whole situation is one of stagnation.

Decomposition Checked by Acid Soil

In our studies upon the decomposition of green manures, we used a neutral and an acid soil. Decomposition in the neutral soil was rapid and complete. In the acid soil, however, although decomposition started out like in the neutral soil, the activity slowed up sooner and the decomposition was not so complete. By adding limestone to some of the acid soil without any green manure, the numbers and activities of the micro-organisms in the soil were increased due to the more favorable reaction. This, of course, would tend to deplete the organic matter in the soil if no other organic matter were added. There was an increase in NO_3 and an apparent increase in fertility. It is more apparent than real, for by adding limestone, we have unlocked the storehouse of organic matter and made part of it available.

Recently an article appeared in a British journal advocating the use of potassium permanganate on turf. It was said to decompose organic matter in the soil and to oxidize the nitrogen to nitrates. This resulted in an increase yield of grass clippings and made the grass greener. No details of the experiment were given and one wonders whether that is good advice—to destroy the organic matter. Certainly the treatment would not be applicable to all conditions. Perhaps it is just the thing for them to do.

Now you may ask, what is one to do? If the soil is too acid, there is not enough micro-biological activity, nitrification is slow, organic matter tends to accumulate and conditions are poor for plant growth. On the other hand, if the soil is neutral or slightly alkaline, just the reverse takes place—great activity of the microbes resulting in a decomposition of the organic matter and production of NO_3. Our advice naturally would be to take the middle course and in your specialized conditions of golf greens, to slow up the decomposition of organic matter by using those materials which are very resistant and mixing in only certain amounts of the more easily decomposable materials. The resistant material will absorb considerable quantities of NH_3 like a sponge, and will release it later as it is needed. By this technique, the danger of an abundant supply nitrate followed by a scant supply is partially avoided. I need not dwell upon the harmful effects of adding a large amount of nitrogenous easily decomposable fertilizer to a soil. The amounts of nitrate produced often prove detrimental by stimulating a rapid growth.

What would be the effect on the micropopulation of treating turf for fungous diseases? This question can only be answered in specific cases, involving the nature of the fungicide, the amount of it used, whether its effect is accumulative and the nature of the soil. In general, the microbes in the soil and their activities would not be harmed unless the turf was injured. Here, again, organic matter comes into the lime-light. Its capacity to absorb poisons is as great as its capacity to absorb nutrients. You may know this as the buffering effect of organic matter, for that is what it is called.

Poisons Affect Plants Differently

Let us illustrate this buffering effect by soil from the cotton-growing regions on the Coastal Plain and the Piedmont Plateau. In certain cases along the Coastal Plain, the soil is very sandy and contains very little organic matter. Dusting the cotton with calcium arsenate to control the boll weevil has made the soil unfit for cowpeas following the cotton.

But on other soil, only a short distance away, containing some clay and some organic matter, several times as much calcium arsenate was applied without harmful effect. Again in the original district of the Japanese beetle infestation in New Jersey, it was the practice to add 1500 lbs. of lead arsenate to the rich loam soil to kill the beetles. This enormous amount was too much for certain plants, as might well be expected. The micro-organisms,

Experts in charge of growing fine golf turf, in attendance at short course session at University of Minnesota, check to see just what may be growing in the locks of Mike Sanko, vice-pres. Minn. Assn. of Greenkeepers. Those checking are (l. to r.): Victor Larson, Minneapolis GC; Leonard Bloomquist, Superior; Herb Graffis, editor of GOLFDOM; and Prof. L. S. Dickinson, Massachusetts States college.

however, did not seem to be put out of commission as evidenced by the good growth of plants which would tolerate the arsenate. I have been told that 900 lbs. of lead arsenate per acre has been used on golf greens without interference with the turf. If added before seeding, the growth of the grass was rather slow at first. If added to establish the turf, the grass was greener and more sturdy than without the arsenate. Nevertheless, we are not advocating such indiscriminate use of lead arsenate on golf greens—we have merely used this as an illustration to show the buffering effect of clay and organic matter and by analogy reach the conclusion that beneficial soil microbes, if protected by organic matter, can take plenty of poison. It is quite possible that certain groups of microbes would be killed by rather weak poisons, but what do we care about a few millions? Often the soil would be better off without them.

The killing off of some of the micro-population occurs naturally at times. Several droughts have been known to kill off more than half the microbes in soil. With rain, the survivors become very active, decompose the dead ones and with a production of nitrate, you then have the striking green growth of grass and other plants after a long dry spell. In a short time, however, re-inoculation occurs from dust in the air, brought, perhaps, from another part of the country and conditions revert to normal.

So in the applications of fungicides, if part of the micro-population is killed, most of the useful ones most probably would still be alive and able to carry on the micro-biological processes in the soil, viz., the breakdown of complex organic substances into simple forms and preparation of these for the use of green plants.

A PHILADELPHIA district golf authority notes what he considers a bad tendency in golf, that of making youngsters and women beginners feel that they have to have caddies.

He says that when these players are on the course during light traffic they should be encouraged to ease into the game at the lowest possible expense. He charges that in some cases caddymasters who get a percentage of caddie fees as salary are responsible for practically forcing caddies on the tyros, or embarrassing them to the degree they keep away from golf.

MALE members of the Carquinez GC at Giant, Calif., are taxed a dime every time they wear spiked shoes in the club's dining room. Proceeds go to the women's golf committee. The club also has a lively team competition; the Dutch vs. Irish.