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Our Soil Bacteria

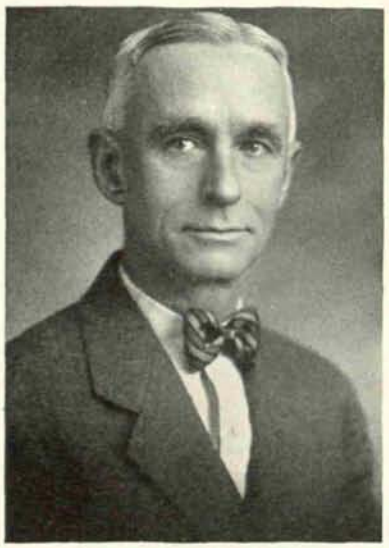
How they live and what they do for us

BY JAMES A. SMITH

IT IS difficult to tell a good story of the life of plants, many of whose members cannot be seen under the most powerful microscope. We know they do exist and are necessary to the maintenance of life upon this earth, so they concern us most vitally.

Ask an electrical engineer "What is Electricity" or a hydraulic engineer "What is Water" and they will both tell you that they do not know, still they apply their lives to getting the most out of what they know to be the working forces of each.

We recognize soil bacteria when it is possible for us to see them, know how they live, how they reproduce and comprehend what they do for us. Taken in their simplest form, and eliminating all types which are not of value to us, I advise that as early as possible you get interested in them.



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Mr. Smith is a recognized authority on soils. During the war he worked for the U. S. Dept. of Agriculture

It is necessary to remember three groups. First, those which produce Ammonia as the first step in breaking down organic matter. Second, those which add six atoms of Oxygen to the Ammonia to make Nitrous Acid and, lastly, those which add two atoms of Oxygen to the Nitrous Acid to make it Nitric Acid. This Nitric Acid combines with lime or some other base to make the Nitrates that are absolutely essential and necessary to plant life.

It seems to be human nature to give the smallest things the largest names and, unless you are particularly interested, I advise you to forget the names of these bacteria as early as possible. They are bound to be confusing. The first group are called Ammonifiers because they produce Ammonia. The second, Nitrosomonas because they produce Nitrous Acid from the Ammonia which is made by the first group. The third, Nitrobacter as they prepare the Nitric Acid which, combined with lime or one of the other bases in the soil, makes the finished product, a Nitrate. These three groups taken together are called the Nitrobacteria.

These Nitrobacteria are not "bugs" as many suppose but are the smallest form of plant life known. They are so small that it is possible for one billion of them to live in an ounce of good soil which of course must provide an ideal home. One healthy member may branch out and be the father or mother of seventeen million of offspring in twenty-four hours. The fact that they are a plant life, even though of a low form, creates the necessity for a balanced feeding practically the same as any higher form of plant life. What they produce is entirely through chemical ac-

tion and the types we have mentioned and which are the only ones we should be interested in, never vary their product. For centuries they have been making either Ammonia, Nitrous or Nitric Acid and will continue to do so until the end of time.

Bacteria Must Have Air

THEIR associates are not always of the best. If you insist upon their living in soil containing too much water, without air for an oxygen supply with which they may work, their enemies the Denitrifiers, who do not live in the presence of air, step in and commence to feed upon the Nitrates which they have produced. This parisitic action continues until they have broken down the entire product so laboriously made by the Nitrobacteria, returning it possibly to the air as free nitrogen which plant life cannot use. In this same unaerated soil may lurk the bacteria of cholera or typhoid fever ready to be leached out and carried into drinking water with serious effect on mankind. **Fresh air allowed to pass into the soil, at once destroys all but the desired bacterial life.**

There are five conditions necessary for the activity of Nitrobacteria in creating plant feedings as Nitrates.

1. The Presence of Food.
2. A Supply of Oxygen.
3. Moisture.
4. A Favorable Temperature.
5. Absence from Strong Sunlight.

The Presence of Foods—Nitrobacteria have but one food and that is the soil humus, an active form of organic matter. Any organic matter such as wood, straw, straw manure, decayed leaves, etc., exposed to the above conditions in the soil at once begins to decay. Manures, because of their straw and fibrous content very quickly disappear when worked into the soil. If soil humus is to be made from ordinary stable manures it should be put in the soil and kept under constant cultivation for at least three years before the maximum nitrate conditions should be expected. There should never be less than sixty tons of manure in a one acre compost area in order to get the most efficient top dressing.

A Supply of Oxygen—They must have air at all times, because from the air they obtain the oxygen with which to carry on their work. The moment air is denied them, they are at once compelled to stop production and the denitrifiers very likely begin operation.

Moisture—All chemical reactions must take place in the presence of moisture and, since their work is entirely chemical, a lack of moisture stops them. You are familiar with the old Seidletz Powder, the white paper containing tartaric acid, the blue paper bicarbonate of soda with Rochelle salts added as a laxative. They could be mixed dry without any chemical action taking place but the moment water was added they commenced a violent effervescence. So, moisture must always be present in order that there may be chemical action.

Due to the breaking down of organic matter, carbonic acid gas is given off. If sufficient moisture is present this gas will be absorbed, carbonic acid produced and this acid can be used in digesting out feedings which may be in the soil mixed with the soil humus and which can later be taken up by the plant.

A Favorable Temperature—A favorable temperature for the growth of the Nitrobacteria is always necessary. The moment the soil temperature gets below 45 deg. F. their action stops. They can keep up their plant feeding at a temperature as high as 110 deg. F. Above that they again stop. The bacteria of the soil are very similar to those of yeast our mothers used in making bread. When the yeast was raised at night it was sure to have been placed in a warm part of the room. If the temperature of the yeast during the night dropped below 45 deg. F. we had no bread the next day.

I have always thought that sanding of greens, where this top dressing was not protected by good turf, was a bad practice. Upon hot days the heat of the exposed sand was almost sure to bring the temperature above 110 deg. F. at which point at least all bacteria close to the surface suffered severely, not to mention the increased evaporation from the green.

Some soils are in their natural construction much warmer than others or become warmer because of exposure to the sun in a protected place. A warm soil, because of its earlier bac-

terial activities and feedings, always produces the first good turf.

In the fall with a temperature drop to below 45 deg. the development of plant life stops. In the spring as soon as soil warms to 45 deg. or more our Nitrobacteria again become active and our turf starts growing.

Absence from Strong Sunlight—In the presence of strong sunlight we have no active bacteria. It is an old custom to hang disease infected bedding in strong sunlight to kill any traces of bacteria which it might carry. The same holds good of our soil bacteria.

Nature has been very careful in providing a home for it in our soil humus not only because it provides it with food but because of the assured darkness which it requires. From this, the reason for the more rapid growth of turf at night-time, due to darkness, is at once apparent. During the night even the bacteria close to the surface are active.

Throughout the process of the decay of soil humus by these organisms, certain very important acids are formed. If they are acting in black humus a Humic Acid is produced and if in a brown humus an Ulmic Acid. The Humic Acid will combine with soil particles with which the soil humus is mixed, producing Humates which is the natural source, without chemical fertilization, of our potash and phosphorous feedings. The action of the Ulmic Acid in the soil while similar to that of Humic Acid is not quite so pronounced.

Going over the five conditions mentioned above, with your turf problems in mind, you may gather some clue as to the possible correction of some of your soil conditions which are not producing the greatest number of these active Nitrobacteria. A hard surface green or fairway, deficient in soil humus, would prevent the passage of moisture and air to your Nitrobacteria and consequently their power to produce feedings would be suppressed. Equally aggravating would be the activities of the Denitrifying bacteria which can exist only under these adverse conditions.

Two Text Books on Bacteria

THERE are two text books, easily understood which I believe should be in the hands of every greenkeeper as a nucleus for a practical library. "Soils: Their Properties and Management" by Lyon, Fippin and Buckman is one and Lipman's "Bacteria in Relation to Country Life" is the other. Both of these books are easily understood and make very interesting reading. If you are interested I think the editor of the NATIONAL GREENKEEPER will be glad to tell you about them.

Concerning soil conditions as affecting Nitrobacteria the first mentioned volume produces a table showing the number of bacteria found on farms in widely separated states. I recall counts made on two Kansas farms. The soil drawn was taken to a depth of thirty inches. The first sample was a loam, rich in soil humus. It was stated that 53,596,060 Nitrobacteria was found in each gram of soil, one gram equaling about one twenty-eighth of an ounce.

On another Kansas farm with thin top soil and a gumbo sub-soil but 78,534 Nitrobacteria were found in each gram. This latter number I imagine very nearly represents the active bacterial count that might be expected in the top six inches of many of our hard greens.

I recently made a physical examination of the top eight inches of the soil of a green which had never been successful. The top one and one-half inches had a good humus content and must have been selected with care. The turf rootage extended to this depth. The next four inches was a very dark soil which must have been hauled to the green and spread over the original contours to a depth of four inches. It proved to be almost entirely deficient in soil humus and it was almost impossible to get water into it. It was a true home for everything but the really necessary Nitrobacteria. Strangely, the original soil upon which this green was built and which was taken five and one-half inches below the surface of the green, was far superior to the other two soils in every respect.

Do not make the mistake of thinking that all black soil is rich in soil humus. But little of it is. Years ago it may have contained an active humus but now what was once an active humus has been completely digested by the Nitrobacteria, becoming wholly inactive, leaving nothing in the soil on which they can live.

It is truly a gumbo soil rich only in carbon. Keep away from dark soils for that reason. They are dangerous. **All soil humus is organic matter but all organic matter in the soil is not soil humus.**

Never build a green without adding an ample amount of lime mixed in your construction. As our soil bacteria create Nitric Acid there must be some base, such as lime, in the soil with which it may combine to make a nitrate suitable for plant feedings.

There is little doubt but that our Nitrobacteria are still fairly active in many of our greens heavily acidulated through the use of Ammonium Sulphate. Our lack of feedings on such greens may be due to the fact that the Sulphuric Acid additions from Ammonium Sulphate have used up all the lime or similar basic salts present in the soil of the green and there no longer remains one of these bases which can take up the Nitric Acid produced by the bacteria and make it into Nitrate feedings. The amount of lime which would be used would not be sufficient to cause detrimental turf conditions.

If your construction is such that your soil bacteria have sufficient moisture and air to a depth of five inches, you are having but little trouble with your greens. If the count of your Nitrobacteria is small, because of firm and hard packed soils in your greens, no artificial feedings which you may apply can permanently revive them. A beaten path, has in the soil but few Nitrobacteria. It is a natural home of the Denitrifiers.

Excellent Standard

THE NATIONAL GREENKEEPER
Cleveland, Ohio

Gentlemen:

I have been Green committee chairman at the Hammond Country Club for five years and have been an interested reader of your magazine since its first publication, and wish to congratulate you on the excellent standard you have maintained.

Please mail me a copy of the ABC of Turf Culture for which I am enclosing my check for three dollars.

Yours very truly,

(Signed) E. Spraker, Chairman Green Committee,
Hammond Country Club, Hammond, Louisiana