

SOIL TEEMS WITH LIFE

By J. W. WHITE
Penn. State College

The soil, far from being sterile and lifeless, has millions of organisms to the gram

HOW many of us, do you suppose, really understand the true significance and nature of this universal thing we so familiarly refer to as the soil? So far as I am concerned my thirty years of intimate association with it has led to the conclusion that in reality the soil is the most profound and mysterious creation of nature.

Most of us think of the soil as an inanimate mass of ground rocks and minerals mixed with organic matter in various stages of decay. If this be true then you will be surprised to hear that in reality a fertile soil is the most animated thing known to man. One gram of such soil, about the quantity that could be held on the end of a jack knife, contains millions of living micro-organisms, minute one cell plants which are organized more or less into various groups or families each performing a fairly definite function in the role of soil fertility.

Nature of Soil Micro-organisms

The micro-organisms of the soil are divided into two groups including both the plant (flora) and animal fauna kingdoms. The plant kingdom includes algae, fungi and bacteria. The animal kingdom includes protozoa, nematodes, rotifers, earthworms and also other worms and insects. Our discussion at this time will be confined to the important microflora known as bacteria and will be discussed under the name bacteria, soil organisms or soil micro-organisms (visible only under a microscope).

Size and Weight of Micro-organisms

It takes 100 million bacteria to equal the weight of one small grain or crystal of cane sugar. The next time you dump several spoonfuls of sugar into your coffee, stop for a moment and single out a grain and see how small it is. Now that we have settled this matter of weight, what say you we find out the significance of such a figure as 100 million. Let us now place this one crystal of sugar on the pan of a delicate laboratory balance. Now let us assume that we can pick up these organisms from the soil, one by one, and each second place one upon the opposite

pan of the balance; it would require over 11 years working 8 hours a day and 6 days a week to transfer these 100 million bacteria to balance the grain of sugar. Pretty small, aren't they? But I forgot to say that during these 11 years the living bacteria would lose their water content, in which case it would require 460 million dry bacteria to equal the weight of this now famous grain of sugar!

Now we know the weight of these invisible plants, how about their dimensions? My answer is that many of them are less than one micron in length. But a micron also has no meaning to us. Let us again simplify matters. Take an ordinary filing card and see if you can really see its edge or width. Well, I will assume that you can, though I doubt it. A filing card is 250 microns thick. Many organisms are about one-half a micron in width or length. So it follows that 500 bacteria could stand, sit or lie side by side on the edge of your filing card; pretty small, aren't they?

Number of Organisms in Soils

The number of micro-organisms in a soil depends upon many factors. Energy material such as organic substances, including especially animal and green manures (crop residues), chemical and physical properties, all plan an important role in this respect. Normal field soils may vary from five to one hundred or more millions per gram (454 grams represent one pound).

Micro-organisms In Frozen Soils

A few years ago the writer was interested in determining the number of micro-organisms in our experimental greens which were made up of peat, sand and field soil. In January, 1934, when the soil was frozen to a depth of about 18 inches, samples were taken by means of a pick to a depth of 6 inches. The soil was thawed and

the number of organisms determined. The results were so astounding and unbelievable that the determination was repeated several times. We actually found over five billion per gram of soil. The writer took up the matter with a soil bacteriologist of note and learned that he classified them, for want of a better name, as pin point organisms, which were able to withstand the frozen conditions of this soil. Just how many of these extremely minute organisms would be required to equal the weight of a grain of sugar—I'll leave the answer to you.

Functions of Soil Micro-organisms

A great variety of functions are ascribed to the soil organisms. The most important is their ability to render plant-food both organic and inorganic, available for use of crops. One group may be busy enriching the soil with nitrogen by fixing nitrogen from the atmosphere; another, converting organic nitrogen into soluble nitrates while other groups are rendering available the insoluble minerals of the soil. Now these minute or microscopic plants, concerning which so little thought is given in regard to their vast importance, are extremely sensitive to soil changes, both physical and chemical, brought about by the farmer, the gardener and last, but by no means least, the greenkeeper.

The ideal soil conditions for the most beneficial effect of these invisible plants below the soil surface, is also the ideal condition for the growth of your turf grasses and vice versa. The soil must be well aerated, and supplied with a liberal amount of plant food of the proper ratio. Excess of water, physical packing of the soil surface by walking upon the greens when too wet shuts off the supply of oxygen and brings about at least temporary stagnation.

Under such adverse conditions compounds may be produced entirely different from those of a beneficial nature. In other words, anything that you may do to your green or fairway soil by design or otherwise that may prove beneficial to the soil micro-organisms will immediately benefit your turf. From this statement it follows that a study of the requirements of the soil micro-organisms becomes a new method of studying soil fertility.

For several years the writer and his associates have been studying the relationship between the activity of soil micro-organisms and the yields of crops on the

55-year-old soil fertility plots at Penn State. Studies just completed have proved conclusively that a close correlation exists between these two factors. This activity is measured by the rate of decay of cellulose (a form of organic matter) brought about on each of the 36 plots of these organisms.

Effect of Soil Acidity

As the soil becomes acid as the result of excessive and continuous applications of such a material as sulfate of ammonia, rapid changes take place resulting in greatly decreased numbers of beneficial micro-organisms and their activity. Unless this very undesirable soil condition is checked with moderate applications of lime, preferably limestone, the soil will become sterile, under which conditions your turf grasses will cease to thrive.

In order to emphasize the effect of acidity upon the number of soil micro-organisms, perhaps it will be of interest to you if I bring to your attention the results of an experiment conducted by the author and his associates dealing with the subject under discussion. As a means of studying the effect of soil acidity upon various soil properties a series of small field plots were treated with different amounts of sulfur, including also two plots which received no sulfur but were limed.

Studies of each plot soil at the end of two years brought to light some valuable information concerning the changes that had taken place as the result of varied degrees of soil acidity. After completion of these studies a portion of each acid plot soil was treated with lime in amounts sufficient to overcome the excess of acidity. This gave us an opportunity to determine both the effects of acidity and the value of lime in restoring the soils to their original condition. The table on this page shows what happened to the soil micro-organisms of the various plots.

Soil Micro-organisms per Gram of Soil

Plot No.	—Unlimed—		—Limed—	
	pH	Millions of Micro- organisms	pH	Millions of Micro- organisms
1	*7.4	85	7.4	85
2	*7.1	72	7.1	72
3	6.0	66	7.2	68
4	4.5	38	6.8	68
5	3.8	15	6.7	64
6	3.2	2	6.3	116

*Above two soils were limed in the field.

This summary brings out clearly the destructive effect of soil acidity upon soil micro-organisms and also the value of lime in overcoming the sad plight of these acid soils. Soils of plots 5 and 6 supported no vegetation in the field and plot number 4 permitted only a scattered growth of native vegetation. The greatly increased number of micro-organisms of the plot 6 soil after liming (from 2 to 116 millions) is due to the fact that on this extremely acid soil there remained more energy material which was rendered available when lime was applied.

I have purposely confined this article to a discussion of the living matter of the soil with the hope that its true significance may impress you as it has me, and if I have been successful then you too will realize that the soil is an exceedingly complex and mysterious body of matter, extremely sensitive to the changes we bring about within it each day. When failure comes then, let us blame ourselves and not the soil.

Exchange of Club Information Is Profiting Westchester County Clubs

CLUBS in Westchester County (New York) have been exchanging menus, wine lists, data on course labor wages, caddie fees, locker-prices, etc., with such good effect that the suggestion comes for an extension of such circulation of facts and figures concerning golf club operation.

A professional who has had considerable close-up association with all departments of club operation, related to a member of GOLFDOM's staff numerous incidents of profit from the Westchester practice. Not enough of this sort of work is done by sectional golf associations, according to his observation. He is right.

Exchange of bulletins issued by the various sectional associations undoubtedly would give wide and helpful circulation to ideas that the various sections have found valuable.

THOUSANDS DISTRIBUTED

GROUP GOLF INSTRUCTION
SHEET NO. 1 SUPPLIED BY PROFESSIONAL GOLFERS ASSN. OF AMERICA

During the entire range of left hand with the fourth finger of right hand

Tip of thumb and base of first finger should be on a horizontal line as near as possible

Tip of thumb and base of first finger should be on a horizontal line as near as possible

These fits hold with left hand

RIGHT

LEFT

Tip of right hand comes and supports left thumb position

GROUP GOLF INSTRUCTION
SHEET NO. 2 SUPPLIED BY PROFESSIONAL GOLFERS ASSN. OF AMERICA

No. 1. In this position the hands are placed in the address position. The club is held in a vertical position as near as possible to the center of the club head.

No. 2. As the club is placed in the address position, the hands should be on a horizontal line as near as possible to the center of the club head.

No. 3. In this position the hands are placed in the address position. The club is held in a vertical position as near as possible to the center of the club head.

No. 4. Open the hands and feet in the address position. The club is held in a vertical position as near as possible to the center of the club head.

No. 5. The club is placed in the address position. The hands are placed in the address position. The club is held in a vertical position as near as possible to the center of the club head.

Swing weight will fall on back in the address of all shots. This is essential in maintaining the balance of the body during the great back and forth.

GROUP GOLF INSTRUCTION
SHEET NO. 3 SUPPLIED BY PROFESSIONAL GOLFERS ASSN. OF AMERICA

No. 1. Address. Right club is raised. Club is held in a vertical position as near as possible to the center of the club head.

No. 2. The backswing originates in the left side. Swing weight should fall on the left side. The club is held in a vertical position as near as possible to the center of the club head.

No. 3. Top of backswing. Club is horizontal position and pointing directly at the ball. The club is held in a vertical position as near as possible to the center of the club head.

No. 4. Following swing with left hand on the ground as support. Club is held in a vertical position as near as possible to the center of the club head.

Swing weight will fall on back in the address of all shots. This is essential in maintaining the balance of the body during the great back and forth.

These three lessons sheets have been supplied free in any required quantity for high school or other public golf class instruction as part of the PRO-motion plan. The lessons were originated by Elmer Biggs and Art Andrews for highly successful use in group teaching at Peoria (Ill.) high school. Sheets in the above group constitute the first series and were worked out by PGA publicity committee, Frank Sprogel, chairman. More than 50,000 of the sheets have been applied for.