Soils in Relation to Golf Course Turf [1]

By J. G. Lipman

A sample of milk freshly drawn, when examined chemically or bacteriologically is found to possess certain definite characteristics. The number of bacteria in fresh milk is usually small and the species are easy to identify. When the milk is set aside and allowed to stand in a warm place a rapid change takes place not only in the kinds of bacteria that we find and their relative proportions but also in the number of bacteria present, and, under normal conditions, as we know, the milk turns sour. The souring is due largely to bacteria of one type which outgrow the other types of organisms that are normally found in milk; and the bacteriologist usually offers the explanation that milk is peculiarly suitable for the growth or multiplication of lactic acid bacteria. They outgrow any other bacteria under normal conditions.

We may apply this fact toward a better understanding of what happens in the average soil used in the growing of grass and of any other plants. We consider the soil as a culture medium, not only for invisible organisms but primarily for higher plants. We recognize from our experience and observation that certain types of plants occur prominently in one place or another. So we recognize certain forest growth, whether it is soft wood or hard wood, and associations of trees of different types. We recognize similar types and associations of plants in meadows, prairies, marshes, and other situations. It requires no special study to see that there is something in soil and climatic conditions that may favor one or another type of vegetation. The interest of the greenkeeper and of others concerned with grass culture and the management of grassland lies naturally in the conditions that would be specially favorable for the production of the plant or plants that are his immediate problem. It is therefore my intention to discuss the subject from that point of view.

We know in the first place that soils vary as to texture. Any careful observer knows that there are so-called light soils, so-called heavy soils, and soils that lie between the two. We know, also, that grass culture is difficult on certain types of soil, particularly the sandy loam soils. And we know that where the question of expense is a subordinate one, natural difficulties may be overcome. It is the problem of research to show how these natural difficulties may be overcome lest the average greenkeeper might throw up his hands and admit that the problem is beyond his power to solve. Now and then

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we come across people who are in the frame of mind of the policeman in New York who was taking a promotion examination some years ago. At that time I think there was a mad-dog scare, and the examiner had this question to put up, which seemed to be timely: "What are rabies, and what can you do about them?" The answer was, "Rabies are Jewish priests, and you can't do a damned thing about it." Such an attitude of mind on the part of the person responsible for the management of grasslands, including turf, is not of course a helpful one. It is the business of those who have been making a study of soils and other problems relating to turf culture to point out where difficulties may be met and how they may be overcome.

Let us say a few more words about soil texture. We understand by texture a condition of the soil determined by the size of the particles and the relative proportion of particles of different sizes, bearing in mind, of course, that no soil has particles of uniform size. In fact, the student of soils makes what he calls a mechanical analysis of the soil. He separates the particles of different sizes into fractions, and he will tell you that there is a measureable percentage of coarse sand, medium sand, fine sand, clay, silt, or other ingredients. This mechanical analysis will enable the soil specialist to interpret the characteristics of the particular soil and its relation to plant production.

The greenkeeper and others interested in the immediate problems of turf culture know that the texture of a soil will be a deciding factor in the type of growth and the rate of growth that may be expected. The differences in texture are expressed in differences in resulting growth through the factors of water, air, and heat. In other words, the differences in texture will influence conditions as they affect the passing of air in and out of the soil, the movement of moisture in the soil, and, within a certain range, the temperature of the soil. All of these factors in their turn affect the rate of root development and of top growth. They affect the solution and movement of plant food in the soil, and these are expressed again in the growth and various conditions surrounding growth. The problem of soil texture and its relation to the growth of turf has accordingly long been recognized as an important one, and we are beginning to see today how certain experimental work may be done which would be helpful in a practical way. I shall refer to that later.

Then, something may be said about what the Germans have called soil climate. When we speak of climate we mean the range of humidity, temperature, sunshine, and similar factors attending any particular location. When we think of soil climate, a term used in a more restricted sense, we bear in mind the same relations of soil temperature, the movement of air in and out of the soil, and the movement of moisture in the soil. Soil climate affects the activities of the invisible residents in the soil, the protozoa, fungi, bacteria, and other micro-organisms, and these create changes that influence plant growth. So again there is a connection between soil texture and soil climate and the ways and means of controlling or modifying soil climate that is of immediate and practical concern to persons interested in the production of turf.

We come again to the question of the supply of plant food. In turf culture, the demands made on the soil are very much greater than the demands normally made by crops under field conditions. Some recent investigations of soils, if they do not tend to modify some of the older views, at least raise a question. One hundred years ago progressive farmers believed that plants lived on decayed vegetable matter. Then the pendulum swung the other way, and the experts thought that the only thing of importance in the feeding of plants was the mineral matter in solution in the soil, the solid particles not being absorbed by the roots. But one or two papers which have appeared in the last two or three months make it appear that certain soil materials need not actually be in solution provided the particles are small enough. It is, however, really a matter of relative size, since solution is the division of fragments of material into very small pieces so that they are scattered through the liquid, becoming invisible, as in a solution of salt or of sugar. The salt or the sugar is there, but the particles are invisible, being sufficiently small to find their way readily into the roots of the plants.

We recognize that the soil moisture is at best a very dilute solution. If I may use an analogy, a person would have to eat many bowls of soup to get a square meal. Since with plants the food is taken by the roots out of solution, and that solution is at best a weak solution, then a relatively large amount of it must be absorbed, or the material in solution must be taken out rather quickly, if it is to provide for vigorous and uninterrupted growth. We are thus forced to see that the ability of the soil or the material in the soil to pass into solution (the rate at which material in the soil becomes soluble) determines the rate of growth of the plant. Therefore texture, so-called soil climate, seasonal conditions, rainfall, temperature, and the like will influence the rate of feeding of crops; and these factors, again, we can modily by artificial treatment, a matter which I shall discuss presently.

Of all things, we must remember that turf culture represents culture under an artificial environment. Conditions are very exacting. The cutting, the trampling, the intensified feeding, and the modifying of the culture medium (the soil) as a result of this treatment, create an artificial condition which, as far as field conditions go, is an abnormal condition. When we cut turf we prune the tops of the grass plants, and, as with the pruning of apple or peach trees, the cutting must temporarily check the gowth of the plant. When the cutting is continued and is severe enough we are apt to discover that certain kinds of plants are unable to stand such treatment and consequently disappear. Very interesting studies are now being made on the subject—in England, particularly at the University of Cambridge, under the direction of Dr. Wood; in Wales, at the college of agriculture at Aberystwyth, under the direction of Prof. Stapledon; and in Ireland, at Dublin, under the direction of Prof. Drew. The experiments of these men lay considerable emphasis on what the close cutting of turf is doing, in the first place to the reserve of food in the roots and in the second place to the resistance of the plants to disease. These investigations are placing the whole question of turf culture before us in a new light.

Let me go back to some of the earlier experiments of Prof. Sommerville, of the School of Rural Economy of Oxford University, out of which he developed a process of grassland treatment that he referred to as fertilizing for meat. He began these experiments some twenty-odd years ago, when he was located in Scotland. He recognized that pastures, or grasslands, vary in their ability to support live stock. Some will maintain (or carry, as the term goes) a larger number of animals on a given area than others. Grasslands differ in their carrying capacity. It has been known, of course, that the carrying capacity may be increased by manure. Prof. Sommerville devoted himself to the study of the effect of slag on the growth of grass. This particular type of slag, basic slag, is a by-product in the manufacture of iron or steel from iron ore that contains a relatively large amount of phosphorus. In this country our iron ores are not sufficiently high in phosphorus to call for the use of the process that is being employed in Europe, where they have high-phosphorus ores. I think the only instance in the United States is the ore used by the Tennessee Coal and Iron Company, which produces thousands of tons of basic slag relatively high in phosphorus. These European basis slags are now less highly phosphatic than they were fifteen or twenty years ago. On account of modifications in the manufacturing process, the present-day basic slag is not as valuable for fertilizer purposes as it was formerly, but there is still a good deal of it on the market. The slag is ground to a fine powder and scattered on the grassland, furnishing a material containing from 14 to 20 per cent of phosphoric acid and a considerable proportion of lime.

Prof. Sommerville found in his work that where he scattered this slag on the grassland white clover became prominent, and because the white clover appeared in greater abundance the soil became richer in nitrogen, gathered from the air by the bacteria in the roots of the clover. By using basic slag he met two problems; he supplied phosphorus, which is necessary for the making of bone and meat, and he supplied nitrogen from the air by encouraging the growth of clover. When his experiments were well under way it was recognized how the treatment with basic slag changes the botanical picture of grasslands by modifying the competition. We saw more clearly then, and we see it still more clearly today, how by certain treatment of grasslands, whether they be greens or other areas of turf, we can modify the botanical picture.

Experiments now in progress in England to which I refer have approached the subject from a different point of view. Very often the experimenters are interested in the carrying capacity of their grasslands and the composition of the grasses they cut as regards value for the feeding of live stock; but they nevertheless furnish information which we could very well apply to the immediate problems that the country club or golf association has to consider.

These experiments, of immediate interest here, particularly those of Prof. Stapledon at Aberystwyth, in Wales, have to do with the selection and breeding of grasses more resistant to close grazing. He approached the problem from the grazing standpoint. Close grazing is very much like close cutting. Whether the cutting is done by an animal or a tool is immaterial. On cricket fields, lawns, and greens, where there is frequent cutting, the green tissue is not allowed to develop in any great mass, and this must weaken the plant. But there are some types of grasses that will resist this treatment or will stand it much better than others; and one of Prof. Stapledon's objectives is to develop, by breeding, types of grasses that will stand cutting, or pruning, much better than the grasses commonly available. He is making some very interesting progress; and I think those who care to follow the subject will find much of general as well as immediate interest in looking over some of the bulletins that are now being published by the college of agriculture of the University of Wales. He has also developed types of grasses which are more nutritious and more valuable for animal husbandry. But I wish to lay particular emphasis on the point that it is possible to develop (and the development is now taking place) grasses that will stand the artificial environment much better than those we have available at present.

Just a word about the treatment to which I have referred and how this treatment affects the problems of your organization. What are these artificial conditions as we see them? We say, in the first place, that we feed heavily. In so doing we create a soil solution which is more concentrated than we normally find in the field or even in the garden. In other words, we have a richer medium, a richer solution, from which the roots draw their nourishment. In the second place, because we are partial to certain types of grasses we try to create an environment which will peculiarly favor these grasses; but in doing so we encounter problems of soil acidity which are very much in the foreground at present. We do not recognize as clearly that this treatment, this intensification of the feeding of plants, also develops competitive factors in the soil which we do not see. We know something about the problem of earthworms; but we do not understand about larvae of soil-infesting insects as they develop under these conditions; nor do we understand about the change in the picture of the organisms in the soil because of this artificial or intensive treatment; neither do we fully understand, even though we are thinking a great deal about it, just what this artificial and intensive feeding is doing to the susceptibility of the plants to disease, or their resistance to disease. Here again we might have a problem in plant breeding where types of grasses might be developed which are normally more resistant to disease under these artificial conditions.

The greenkeeper in the older days (and these are not so far back of us) was inclined to depend on empirical methods for accomplishing results. Just as in the older days farmers often kept live stock in order to have the waste material for maintaining the fertility of the soil, so the greenkeeper, depending on empirical methods which have been tried for a long time and proved to be more or less satisfactory, has used compost. What is compost? Fifty years ago everybody knew what compost was, even people living in the cities. It was a common commodity. Many of us would not know what compost is. As the term is generally understood, it refers to a mixture of soil and decaying vegetable or animal matter. Usually it is vegetable matter. We take soil and add to it this refuse material and let the process of decay and fermentation take place in it; that is, the billions of bacteria present cause fermentation, which in turn splits up the vegetable or animal matter and increases the proportion of it that is readily available as plant food. Thus we produce a mixture of materials that will supply plant food and, at the same time, a large number of bacteria. When we apply bacteria we inoculate the soil, just as in the making of bread we apply yeast to a mixture of flour, water, and sugar in order to inoculate it, or as in the making of acidophilus milk we apply a culture of the acidophilus organism in order to induce a particular type of fermentation.

A compost is rich in bacteria and other micro-organisms. When we apply composts to soil we supply not only plant food but also millions of invisible organisms which cause fermentation. The insoluble material partly passes into solution and favors the intensive feeding of the crop. We provide the material, and also the living machinery, which will change this material and put it into circulation. Beyond that, when we add compost we add a product which will lighten the soil, opening it up and permitting better circulation of air and water and altogether improving the texture and the chemical and biological conditions of the soil. That is why the empirical practice is so satisfactory. But because of our changing economic, labor, raw material, and other conditions we recognize the limitations of compost more clearly than we did five or ten years ago. We recognize that when we add compost to the soil we add something that is not always desirable. It may be weed seeds, by which we create competition between the grass and the types of plants that are not wanted. We may introduce certain fungi which cause disease. And then there is the question of supply and demand. For these reasons we have in recent years turned to other methods of maintaining a relatively high concentration of the soil solution for the intensive feeding of grass plants under the conditions of severe pruning to which they are subjected. We are often very much perplexed when we begin to use these chemicals. They have been the cause of much satisfaction and much sorrow, as many of you no doubt know.

The other day I was reading *College Humor*. That is not always funny, but this particular story, I thought, had some merit. It was about a young father who was expecting an increase in the family. He was pacing up and down the corridor of the hospital in great agitation. The house physician, by way of encouraging him, said, "Cheer up, old man, we have never lost a father." Just then the nurse poked her head out of the room and announced triplets. And that is the time they lost their first father. Very often the greenkeeper comes near having heart failure because he applies some of these new chemical fertilizers and then finds himself with a serious situation on his hands, either because he was not properly informed as to the method of their use or because the materials were not suited to his particular conditions.

One thing which, I notice, is receiving a good deal of discussion at meetings like this, is the question of soil acidity. Fundamentally the problem is very simple. We are maintaining artificial conditions so as to grow a type of grass which is suitable for the cricket field, lawn, or green, and we do not want any more competition for this particular species of grass than we can help having. The soil investigator and the plant physiologist have this to tell us: "If you maintain your soil at a certain pH, then white clover or bluegrass will have to stay out." In other words, you favor bent grasses in the competition, and they win out, just as in the bottle of milk the milk sugar favors the development of the lactic acid bacteria. When the experimental work was started in Washington some experts claimed that sulphate of ammonia and other ammonium salts would increase the acidity of the soil and give the bent grasses a chance to crowd out everything else. They would win out because they would be favored. I had my misgivings when I heard this, for although I recognized that the practice was sound at the beginning, there were certain dangers that should have been understood and anticipated.

We had a similar situation with our potato growers in New Jersey. As you probably know, potato growers are troubled by various diseases, and among them a fungus which causes scab. The potatoes may be so scabby as to be practically unsalable. This fact has been under investigation for many years, and it was shown that the scab fungus would not thrive in a soil that is acid beyond a certain point. Dr. Wheeler, whom I see in the audience, when he was director of the Rhode Island Experiment Station, was a pioneer in showing the relation of the acidity of soil to the development of scab on potatoes. On the strength of that many enthusiasts said, "Let us use sulphur, ground brimstone, and apply it to the soil for certain bacteria that eat this brimstone and change it into sulphuric acid. Thus we will stop the potato scab." This was done accordingly. But the enthusiasts forgot that the conditions in the soil do not remain unchanged. It would be helpful if in the treatment of soil we could create a permanent condition, as when we place a chair in a permanent place. But conditions in the soil change all the time. A good many greenkeepers are in the position of the man in New England who prayed for a barrel of sugar and a barrel of flour and a barrel of oatmeal and a barrel of pepper, and then decided that he was asking for too much pepper. Too much acid!

I am told that Dr. Monteith reported yesterday on the use of lime. Two or three years ago, if anyone recommended to a greenkeeper the use of lime he would have been accused of heresy. The common attitude is usually expressed as follows: "We do not want lime. It will bring weeds and crab grass. It would be foolish to use it." But here we started with a fact and an assumption perfectly sound, that by maintaining the acidity of the soil at a certain point we could create conditions which are peculiarly favorable for the bent grasses and thus enable them to win out in the competition. But we forgot that we could increase the soil acidity to a point where we destroyed even the bent grasses. In some of our experimental work years ago we sterilized the soil by means of sulphur. We used two tons of brimstone to the acre; but we made the soil so acid that it became entirely barren. Nothing would grow on it, because it was too sour. We could use sulphate of ammonia or nitrate of ammonia or urea and continue long enough to make the soil sour to the point of being barren. But before we should have reached that point the plant would have become weakened and its ability to resist disease diminished. And then we would consider a lot of new diseases. The plant pathologist often finds much satisfaction in the discovering of a new disease. I remember overhearing two medical students refer to "a most beautiful case of cancer." With them it was a professional interest. Similarly the plant pathologist experiences professional pride when he discovers brown-patch or other plant diseases. But at the same time he will tell you, and will be the first to tell you, that certain diseases appear or become troublesome only when the resistance of the plant is weakened. He will tell you that artificial soil conditions often weaken the resistance to disease. There is the severe pruning, the using up of the reserve of the food in the roots, the concentrated solution, the over-stimulating of growth; and all these conditions do weaken the resistance of the plant.

We are in a fair way to modify our treatment as regards the use of chemicals. We have recognized that (to use the chemical term) we might have a pH that is too low—a soil that is too sour even for bent grass. There is the danger of becoming over-enthusiastic and over-dosing the soil with lime. We are then just as bad off as we were before. The greenkeeper is inclined to become discouraged and say, "What shall I do? This is a most peculiar situation. I add sulphate of ammonia, and then lime, and then a little more sulphate of ammonia. It seems as if I were operating a chemical laboratory; and the operation is too complicated to suit me."

If we are to produce the results that we are expected to produce we might just as well recognize what the fundamental facts and relations are. For this, technical talent is necessary. It is not very expensive these days. That is what specialists are for.

I wanted to refer to some experimental work that we should be justified in undertaking. But speaking as a specialist I am tempted to tell a story that I have told before. It is a good story and will bear repeating. One of my former students, who is interested in golf courses on Long Island, came in to see me several weeks ago, and, as former students will do, came to give me some information; but out of consideration for my feelings he would not put it as boldly as all that. He said, "Doctor, I came in to ask you a question. What is the difference between a specialist and a philosopher?" Of course I knew that he was there with something on his mind, and I was ready to absorb it. He said, "A specialist has to do with a narrow field of human knowledge, a few things or one thing. A philosopher covers the whole field of human knowledge. The field of human knowledge is increasing all the time. We are finding out facts and establishing new principles, and the body of knowledge is growing very fast. A specialist must confine himself to a smaller and smaller fraction of this great body of knowledge. As time goes on he knows more and more about less and less. That is a specialist. The philosopher, on the other hand, because he must deal with the whole field of human knowledge, knows less and less about more and more." Then he looked at me in a benign way and continued, "I am coming to the point. To carry this to a logical conclusion it would seem that ultimately the specialist will know everything about nothing and the philosopher will know nothing about everything."

And so, whatever the fate of these specialists and technical men may be, we have to depend on them, and we call them in where their peculiar type of knowledge may help us. We might just as well face it—and your association recognizes it—that because of the peculiar conditions that we are trying to maintain, because of the peculiar technical problems that we are creating, we must furnish expert advice for the men in charge of the turf maintenance problems on our golf courses, and place these men in a position where they can get in touch with persons who can answer questions which they themselves are not in a position to answer.

I have perhaps taken undue advantage of you in discussing the problem at so great a length. But before I close I should like to refer to a few matters which we might profitably bear in mind, and these are matters pertaining to investigations that we might carry on to clear up a lot of questions that we do not now fully understand. In the first place, because there is a wide range in soil texture between a course, let us say, at Atlantic City, and some courses in northern New Jersey where the soil is very heavy, we might think that theoretically it would be very convenient if we could standardize the soil texture of greens. The cost might not be prohibitive. For instance, if we could standardize a mixture consisting of definite proportions of medium sand, fine sand, silt, and clay, and then also, under the given climatic conditions, standardize the supply of water and chemical plant food, we should have very simple conditions for the men in charge of the greens to deal with. That is a theoretical conception. There is, however, a practical side to it, in that after we carry on certain preliminary studies we could, within reasonable expense, establish certain important conditions, certain important facts, as to the best texture that would allow us to maintain under our particular conditions the best type of grass or turf. I think that is one phase of study that would be profitable.

We could find a great deal of helpful information if we knew what the use of different kinds of chemicals, different amounts of chemicals, different proportions of chemicals, would do to the rate of flow of material into the soil solution, the rate of the spread of the roots, the rate of creating a food reserve in the root system, and the rate of passage of the food into the top of the plant. We should profit greatly if we could look into the soil and see what is happening to the bacteria, the fungi, the protozoa, the earthworms, and the soil-infesting insects as we modify these conditions and particularly the nature of the solution in the soil. We know very little about it. We also know very little about the effect that certain fungicides, whether they be compounds of arsenic or compounds of copper, have in modifying the living machinery of the soil to which I referred some moments ago—the bacteria that are responsible for fermentation and stimulation of the flow of soluble food into the soil solution. And along with this we should study the relation of this treatment to disease resistance, hardiness, trampling, and weeds. Our bent grasses are of primary interest here. How is their existence modified by these treatments, especially the chemical and bacteriological changes in the soil?

Perhaps I should stop here. But I am tempted to add that I am very hopeful that the work you have already undertaken in the Midwest, Canada, and the East, in providing more definite information on the technical phases of your problem, will give you very satisfactory results, and that within a short time, within a year or two, the man at the front, the greenkeeper who has to bear the burden of management, will find this burden considerably lessened.

Roadside trees.—Oak trees, of which there are species native to nearly all parts of the country, are more generally used for roadside planting than any other kind of tree. Maples are next in importance for a large part of the country, but as the most-used species are not well adapted for the purpose, the selection must be carefully made.

For the cooler dry regions the most promising trees are the green ash, common locust, hackberry, thornless honey-locust, and poplars, with boxelder, willows, and poplars for the extremes of cold and drought. In warm, dry climates the eucalyptus, or gums, the palms, the Jerusalem thorn, and the mesquite are good.

Only thrifty, vigorous trees, with healthy foliage, look well on country roads. To secure this type for any location it is usually best to select native varieties, although trees from localities with similar growing conditions are frequently satisfactory.