JULY
1932
VOLUME VI
NUMBER VII

The NATIONAL GREENKEEPER

Official Organ of The National Association of Greenkeepers of America

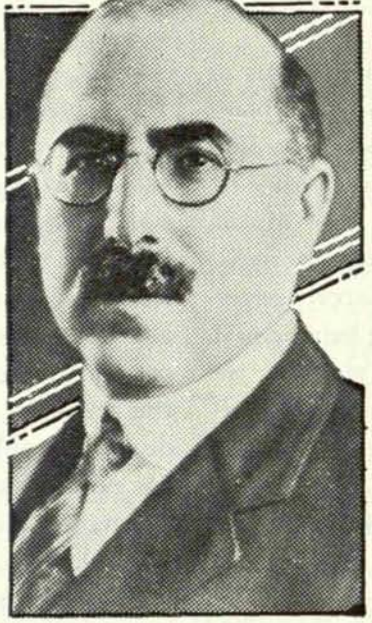
Bacteria In the Growing of Turf

By DR. J. G. LIPMAN,
Director of the New Jersey Agricultural Experiment Station, New Brunswick, N. J.

Read at the 6th Annual Educational Conference of the National Association of Greenkeepers of America, held at New York City, January 19-22.

SINCE the beginning of the present century, methods have been perfected for the growing of plants in water and sand culture. It is possible by these methods to grow normal plants in solutions, or in sand supplied with solutions, of known composition.

In such cultures, bacteria are not necessary. We may, therefore, say that *theoretically* bacteria are not essential for the production of grasses or of other plants. Practically, bacteria are essential. Even in water and sand cultures bacteria are not kept out, and the plant physiologist considers his pets in such cultures as sterile babies when they are not sterile.



Dr. Lipman, the author of this splendid article, has made an intensive study of the growing of fine turf and we offer here, to the readers of the NATIONAL GREENKEEPER, *the results of his experience.*

The greenkeeper may find some interest in the fact that, theoretically, turf grasses may be produced in a sterile medium, but what concerns him most is the question whether bacteria play any part in the growing of turf under his particular conditions. He wishes to know whether bacteria may be a help or an obstacle to him. If they may be made helpful, he wishes to know how he may so modify his practices as to get the greatest use out of bacteria toward attaining his goal. In so far as bacteria may be a detriment, he wishes to know how the damage done by them may be lessened or entirely eliminated.

The discussion which follows will deal, therefore, with bacteria and other micro-organisms as a positive and negative factor in the growing of turf.

The plants commonly used in greens are the specialized and selected representatives of their class. They are expected to thrive and to survive under conditions that would be fatal to most plants. Frequent and close cutting, the stimulation and overstimulation of root development, the compacting of the soil, and the frequently abnormal moisture, temperature and aeration conditions represent an environment that is not a normal one. It is evident that this abnormal environment would weaken, and ultimately destroy, the most hardy of the turf grasses except as special devices and treatments be used toward offsetting the weakening effects of the treatment that turf grasses are made to undergo. Such devices and treatments must reckon with the presence and activities of bacteria.

As we analyze the factors which, in one way or another, affect the growth and vigor of turf grasses, we find that some of the factors may be grouped under the head of environment, while other factors may be considered in connection with the food supply of plants. Among the factors which influence growing conditions in greens, that pertaining to the amount, character and distribution of organic matter is of major importance. As to the amount of organic matter, it directly affects the circulation of air and water in the soil, and, to some extent, its temperature. Everything being equal, the more organic matter there is in the soil, the greater will be the amount of water absorbed and held.

AMOUNT AND QUALITY OF ORGANIC MATTER

It is possible, therefore, to create a supply of organic matter so large as to interfere with optimum root development. The quality of the organic matter is also of direct significance in that its composition and its physical nature may favorably or unfavorably influence root growth and the activities of soil bacteria. The distribution of the organic matter is also to be considered as a factor of importance, since the amount of it at different depths of the soil and subsoil, control the circulation of water and air and, through these, the feeding of the plants.

Past and present studies of the root systems of grasses indicate that the soil zone from which plant roots draw their nourishment and water supply may be shallow or deep. Under some conditions, the plant roots are confined in a thin layer of soil. Under other conditions, the root zone may be measured by feet rather than inches. It is scarcely necessary to point out here that, everything being equal, the deeper the root zone, the more vigorous the plants and the greater their resistance to unfavorable changes in their soil and climatic environment.

Actively growing plants require a liberal supply of the element carbon. This is obtained from one of the air gases known as carbon dioxide. It is well to remember that approximately 50 per cent of the dry weight of grasses, and of other plants, is represented by the element carbon, the element which makes up all but a small portion of the entire weight of coal or charcoal. There is only about .03 per cent of carbon dioxide in moisture-free air. Areas on which vegetation is flourishing draw heavily and repeatedly on this relatively small supply.

Had it not been for the constant movement of air above the land surface, the gases overlying any area on which forests, cultivated crops, or grasses grow vigorously would become depleted of their carbon dioxide supply to a point where plant growth would be checked. It is fortunate that there is not only the circulation of air, but also the replenishment of carbon dioxide from the soil itself. As will be noted later, bacteria play a significant role in the maintenance of a reasonably constant supply of carbon dioxide in the atmosphere.

Actively developing plant tissues contain only 5 to 10 per cent of dry matter. The rest of it is water. Without an adequate water supply, the growth of both roots and tops is retarded. It is not merely a question of the amount of water supplied by rain or artificially, but also of the circulation of water in the soil, its ability to lift water from lower depths, and its ability to allow water to move downward and laterally.

Together with water supply, we must consider air supply, for, insofar as the space not occupied by soil particles or roots is filled with water, it is not occupied by air or vice versa. When the soil is saturated and water stands at the surface, there is no air in it except for the small amounts of air gases dissolved in the water itself.

WATER AND AIR IN PORE SPACES

When the soil is dry, the empty space, or so-called *pore* space, is occupied by air. For the best growth of plants, there must be an optimum relation between water and air in the pore space. Growing roots take something out of the soil water and something out of the soil air. The latter must move about freely enough to prevent such changes in the composition of the soil air as would be inimical to the activities of soil bacteria. When such inimical or unfavorable conditions arise, substances more or less poisonous to the plants may be formed. Furthermore, the upsetting of normal conditions in the relation between soil moisture and soil air would also disturb the desirable balance among the various groups of soil micro-organisms.

Types of bacteria, fungi, protozoa and algae objectionable to the greenkeeper might, under such conditions, become unduly prominent. They might interfere with the functioning of the roots of turf grasses and of the kinds of bacteria that are important in providing for a satisfactory supply of certain plant ingredients.

The plant food capital of the soil represents a certain turnover, in a sense analogous to the turnover of the commodities on the merchant's shelves. There is, however, an essential difference in that the merchant must replenish his supplies from the stock of the wholesaler or manufacturer. In the soil, available plant food is both manufactured and dispensed, so that there is a more or less constant transformation of raw materials into finished products that plants can use, and there is also a transformation into material made unavailable. Such material may be worked over again, in a sense like scrap iron that is reworked into steel. The manufacturing process in the soil is carried on largely by bacteria and other micro-organisms.

It happens that one of the plant nutrients prominent in promoting growth of the tops and roots of plants is nitrogen. This plant nutrient is of particular importance in the growing of turf. Nearly all of the nitrogen in soils is present in combination with carbon, hydrogen, sulphur and other elements in the so-called organic matter. This, as is well known, consists of residues of plants, the cells of micro-organisms and of the remains of insects, worms and other soil-inhabiting organisms.

SOIL NITROGEN IS LOCKED UP

MORE of the soil nitrogen is locked up in these organic materials. They must be broken down and the nitrogen released in the form of ammonia and nitrates. Bacteria and other soil micro-organisms are the living agency on which we depend for the breaking down of the soil organic matter and for the manufacturing of ammonia, nitrates, sulphates, phosphates and of other essential plant nutrients. We should also remember that the extent and intensity of the biological activities in the soil is determined by the amount and composition of the organic matter, the environmental conditions relating to water, air supply and temperature, and soil treatment which involves applications of chemical fertilizers, lime, composts and other materials.

Everything else being equal, the warmer the soil the more favorable the conditions as to water and air supply, the greater the number of soil bacteria, the more intense their multiplication and activities and the greater the rate of plant growth.

Soil organic matter which contains too large a proportion of carbon does not favor a large supply of ammonia and nitrates to growing plants. In a soil of this character, bacteria actively compete with the higher plants and interfere with the growth of the latter insofar as the supply of available nitrogen is concerned. The ammonia and nitrates of the soil solution are so rapidly taken up by bacteria and changed back into unavailable organic matter as to deprive plant roots of a sufficient supply of this important plant nutrient. To a lesser extent, this will apply also to sulphate, phosphates, lime and magnesia. The greenkeeper, if he is successful, so tunes up the biological machinery in the soil as to create optimum growing conditions for the plants in which he is interested.

SUPPLY OF WATER IS IMPORTANT

IN THE light of the above, it may properly be asked how our practice may be so established as to give us the best greens under any given set of conditions. We realize that, from the standpoint of environment, turf grasses must be well supplied, but not over supplied, with water. We know that in many greens drainage conditions are far from satisfactory. An examination of the plant roots will show that they do not penetrate deeply enough, nor are they more or less symmetrically distributed.

The fault may lie in the texture of the soil and subsoil. In that case, artificial drainage must be provided for. Otherwise the use of chemical fertilizers may hinder rather than favor normal and vigorous root development. The greenkeeper must bear in mind that, in applying chemical fertilizers, he enriches the soil solution which bathes the plant roots. He may make this solution so rich as to corrode the root hairs and the fine rootlets. He may also swing the biological balance in the soil toward types of bacteria and fungi that would be detrimental rather than helpful.

In his anxiety to maintain a sufficient supply of organic matter, he may resort to the use of peat, which has valuable as well as objectionable characteristics. It is true that any organic matter, including peat, will open up heavy soil and make loose sandy soil more compact. It will increase the water-holding power of the soil and improve the circulation of air in fine-textured material. At the same time, the organic matter of peat is not readily usable as a source of food for bacteria. Hence, peat is less desirable than good compost for stimulating soil bacterial activities.

There is another factor in the use of composts that should not be overlooked. In one sense, good compost is like yeast, in that it inoculates the soil, supplies it with billions of bacteria and sets up fermentation of soil organic matter that results in liberating a more adequate supply of available plant nutrients.

SOIL INOCULATION NEEDS STUDY

THE question of soil inoculation for greens is one that has not received much study. It is not necessary to use composts for the purpose. It is conceivable that, in the course of time, we shall be able to develop artificial inoculants that could be applied to greens as a means of accomplishing the various improvements that an active soil bacterial flora may make possible.

The greenkeeper must remember that, when he uses sulphate of ammonia, urea, nitrate of soda or various mixed chemical fertilizers, he supplies raw material containing an important and essential constituent of plant food. The stimulus which soluble nitrogen salts furnish to turf grasses is nothing short of striking. It may be over done, as we all know. But, whatever the kinds and amounts of these nitrogen salts that may be used for stimulating root development and top growth, we should not forget that bacteria, also, are stimulated by having these substances placed at their disposal. Being so stimulated, they effect a whole chain of transformations and changes that become evident in the rate of growth of the plants themselves.

In following the best fertilizer practice that he knows of, the greenkeeper may use too large quantities of chemicals. He may use too little. He may apply too much at a time, and he may fail in making a uniform distribution of these materials. He may overlook the fact that the various chemicals employed may tend to make the soil more acid or less acid; that he may deepen the root zone or make it more shallow. He knows, or should know, that over-emphasis has been laid in the past on the desirability of using such chemicals as would make the soil strongly acid. In consequence, there are many greens where lime or other materials possessing the same corrective action is needed. But, there are different kinds of lime and there are differences as to the amounts of lime that need to be used in establishing optimum conditions in the soil both for the bacteria and the plants.

A uniform procedure cannot be recommended because conditions afield are not uniform. The best we can do is to acquaint ourselves with certain fundamental facts which hold true under all conditions. If these fundamental facts are well understood, practice may be so adjusted as to meet the needs of any particular place and time. Out of his own experience and observations, the greenkeeper has much to draw upon. If he will supplement his own fund of knowledge with technical information readily to be had from technicians and soil specialists, he will be on the way toward defining a practice for himself that will give him both results and satisfaction.