

affected, by heavy applications of calcium sulfate in solution form. Wooster silt loam soil was influenced more strongly than any other of the soils leached."

It should be remembered that many of these tests were conducted with crops such as legumes that are frequently benefited by applications of gypsum, especially where the soil is low in sulfur. There is little evidence that turf grasses are actually benefited by applications of gypsum, except in very limited areas. Furthermore, gypsum has a tendency to encourage the growth of clover, which most greenkeepers and golfers regard as very objectionable. In some cases applications of sulfur have proved actually injurious. It is further shown by the results reported in the publication quoted above that gypsum has very little effect on the soil acidity; is of little consequence in releasing plant food; and in the amounts normally used, has little effect on the physical condition of the soil. In view of this situation any club considering the use of gypsum is strongly advised to try it out experimentally before spending money, which may be worse than wasted, in purchasing large quantities of the material.

Conditions Which Influence the Growth of Turf

By C. A. Tregillus

The study of soils and soil conditions and their effect upon turf growth; the study of grasses suited to varying conditions of soil and exposure; the study of fertilizers and their effect, and the study of chemicals for the control of pests and diseases, have within the last few years, greatly modified and regulated our methods of course maintenance. Greenkeeping is a development of the old art of gardening which, in those sections of the earth blessed with a suitable climate, has long reached a high stage of proficiency and has acquired results of outstanding merit. It must be remembered that while a great deal of credit is given to the climate and to the natural grass flora that lends itself to such practice, the early greenkeepers had evolved from custom and observation, a system on which rests the basis of modern golf course management. In recent years, due to the rapid expansion of the game of golf, the science and practice of greenkeeping has had to considerably widen its scope to embrace circumstances under which it was formerly thought impossible or at least uneconomical to grow and maintain grass of the quality demanded by the game. Extremes of climate and other natural phenomena bring up problems that are gradually being solved both by close study and analysis in the laboratory, and by trial and error in the experimental plot. This has been going on apace until there are very few regions left where it is not possible to produce at least a fair to medium turf.

Success in turf culture lies in thoroughly understanding the various influences, whether natural or artificially produced, that bear upon the life history of the grass plant and being able to eliminate or modify those that have an adverse effect and to promote those that are conducive to healthy development. It means that we should seek to acquaint ourselves as closely as possible with the intimate relation of the common circumstances under which turf will grow.

The early men possessed a vast amount of this information which, acquired by the long process of constant observation, and well served

apprenticeship, became practically an intuition and could meet most emergencies with simple but effective methods, even if they did not understand the underlying causes from a scientific viewpoint. Since that time however, a great change has taken place and we approach the study and practice of turf culture from quite a different angle. This is not a revolt against old-time methods as some old-timers are inclined to think, but an evolution that is bound to come as in all lines of endeavor. The spread of the game to new territories, the intrusion of diseases and pests hitherto unknown, the rising standard demanded by players and the immense sums now spent on course maintenance throughout the world, have all lifted the industry to a plane before undreamed of. To this end the up-to-date greenkeeper has to organize his information and regulate his methods as never before. He must be prepared to delve beneath the superficial symptoms of trouble in order that he may treat for permanent improvement, he must be able to cope with a wide diversity of weather and climate, be able to recognize the effects of weeds, diseases and other pests and know where to get reliable information concerning remedial measures—in short, he must keep himself informed of all the new developments related to his profession.

Of first importance and as a foundation for all other knowledge associated with his craft, the greenkeeper must possess a clear conception of the fundamental principles of plant growth, particularly as they refer to the grass family. Without this he cannot intelligently follow the technical and scientific discoveries, of which these present years are very fruitful, nor successfully evolve his own system of management. With this thought in mind it might be of interest to scan this field rather hurriedly and touch upon those points that show the related circumstances that affect the natural development of the grass plant.

It is necessary to know in the first instance that there are certain essentials for the growth and development of grass and without which we could get no results. These are, light, heat, air, food and water. While not entering into a long explanation of each, it might be well to tabulate the main features.

Light is essential because it is intimately associated with the green coloring in the leaves. Without this green matter the plant could not digest its food and build up its structure. It explains in part why heavily shaded greens are not healthy and also brings to our notice that some grasses need more light than others, hence those that can get along with less are the ones for the shady places.

Heat or warmth starts the plant functioning—puts the life processes under way. Grass has a liking for moderate temperature, above or below which it will become dormant or semi-dormant. We also notice that in these outside temperatures, disease may readily develop and do severe injury.

Air is a necessity because it contains life giving oxygen, essential to the plant and to the countless numbers of bacteria that are busy preparing food by working it into a condition to be absorbed by the plant roots.

The need for food of course is obvious in order to increase the plant structure. The various substances of mineral origin that the plant feeds upon are generally present in the soil, though not always in sufficiently available quantities to supply every need; those most

often deficient are nitrogen, phosphoric acid and potash. They are the chemicals that are supplied under the heading of fertilizers.

It is characteristic of grasses and practically every other form of plant life, that they take in their food in solution, so that all food elements must be dissolved in water before the grass plants can get them at all. Therefore we see that absence of moisture not only results in the plant drying out, but theoretically starves it.

It might be well also to consider the conditions of growth from an environmental point of view. While it is possible to grow a plant in a glass jar with just the necessary things already mentioned, it would not be robust or healthy. That is purely a laboratory method. In the ground there are other factors. There is the soil type most suitable for the free movement of moisture and food, and for the easy penetration of roots and air. This is the physical consideration and is associated with the texture of the topdressing material that is applied to the surface of the turf. There is the matter of food supply which deals with the fertilizers necessary to procure the best development. This is the chemical aspect. And thirdly, organic or biological requirements must not be overlooked, for without a sufficient amount of humus supplied by good compost or topdressing material there would be insufficient bacterial action, and an unsatisfactory texture to the surface soil. Compost, or its active essence, humus, is very vital to the well being of a close cut turf.

Again, in the production of a high-quality turf, there are other influences at work, which have a modifying effect upon continuous and healthy growth. There are those that come from natural causes, as climate, and related to that, seasonal growth, and also perhaps, disease might be classified here. There are those of artificial origin as, for instance, greenkeeping methods.

The influences that favor the fullest development of turf are worthy of mention because in the practice of course maintenance it is imperative that these conditions be assisted and methods so systematized as to bring about in an artificial way if possible, such a happy combination as would not be naturally provided.

A maritime or insular climate has for decades been considered the ideal in which to produce good lawns. The temperate coolness, and the moisture-laden breezes combine with the native grasses, to make a fine leaved, compact, hardwearing mat that suits the purposes of golfers so well. A salubrious climate is a very favorable influence.

A satisfactory soil texture has a marked effect. By the term satisfactory, we mean a soil of fairly loose, friable structure, that permits water to either go down or come up with comparative freedom; does not bake and crack in hot, dry weather, or become puddled when wet; does not dry out too readily. It also means one that has a sufficient amount of organic matter in it to regulate the food requirements of the plants.

Even with a favorable climate and with a soil of suitable texture it is impossible to develop and maintain satisfactory turf without an adequate and well balanced food supply. The importance of this factor should not be overlooked.

Looking at the situation from the reverse side of the picture, it is perhaps more illuminating to mention those conditions that retard rather than advance the development of turf for golfing purposes:

1. *Insufficient moisture*.—No doubt the most generally submitted reason for poor turf is dry weather, and it is a fact that except in

very favored sections, it is impossible to maintain a stand of closely clipped turf by depending upon the natural precipitation. Large sums of money are spent on water systems, not as a luxury but as a necessity, for without it the expenditure on seeds, fertilizers and grounds maintenance would be a useless waste. It is so obvious that it needs no comment.

2. *Starvation.*—Here is a very general cause for a large proportion of poor turf that is found throughout the country. This particularly refers to putting greens. Clubs are gradually becoming enlightened on this matter, are being more liberal with compost and fertilizers for their putting greens, but it appears that further missionary work must be done before replenishment of the food supply in the putting green soil is a universal practice. In discussion with committees on this point the answer is often given that funds will not permit, that enriching the soil brings attendant trouble as worms, disease, etc., but nevertheless, there is no gainsaying the fact that if we do not put into the greens at least as much as we take off, in the course of time there will be little or none to take off. The regular removal of grass clippings takes away from the turf a large quantity of real fertility, and besides, the close mowing limits the root range of the grass so that it is unable to feed as deeply as it would do if allowed a heavier top growth. Grass can be starved in two ways: by taking off all it produces, and by limiting its roots so that it has to find most of its food within a very narrow surface layer.

The only answer to this condition is to feed the top layer well and wisely. It requires care and close observation to do this properly, since by an injudicious hand, it is possible to do much damage. The turf, to do well, must have a balanced ration. It may have too much of one thing and not enough of another as some elements of fertility are easily conserved while others are lost. Composts vary in their fertilizing value and usually have to be augmented with chemical manures of one sort or another. It is in this field that special care must be exercised. The value of ammonium sulfate and ammonium phosphate are well established in greenkeeping practice. Many now use these forcing nitrogenous fertilizers and some are inclined to over-do it because of the excellent showing. The nitrogen contained in this type of fertilizer is only one of several food elements and in over-dosing with it an unbalanced condition is likely to be set up, and while the turf may present a very beautiful appearance, constitutionally it may be in very low health and unable to withstand sudden extremes in temperature or disease.

3. *Unsuitable soil texture.*—This might well stand next in importance as being responsible for an unhealthy stand of grass. There is no doubt but that one of the big considerations in the building of a golf course outside of the architectural features is to incorporate the right sort of soil into the putting greens. The right sort of soil has already been briefly described.

4. *Improper drainage.*—Soil texture and drainage are very closely allied and to derive the best results, the latter must be thoroughly understood. Insufficient drainage makes the soil wet, waterlogged and cold. Air is as necessary to the roots of the grass and to the soil organisms as it is to the leaves and stems, but it cannot descend if the ground is already filled up solidly with water. The water used by the plant is that which clings as a film around the

soil particles, not the water that occupies the spaces between. The water table should be kept well below the root range. The amount of artificial underdrainage needed depends upon the soil texture and the location of the part to be drained. Drainage in the fullest sense of the term involves the movement of the water within the soil and on the surface of the soil as well as the movements of the air currents above.

5. *Location a vital factor.*—There are putting greens that have never been right and have not held a good turf because they were put in the wrong place. Due attention to the other circumstances already mentioned may lessen the importance of location.

6. *Poor methods.*—By no means the least important factor to be considered is the human element—greenkeeping methods—and how they affect the natural development of grass. Mis-management in this particular may result in poor greens, even though other circumstances are quite satisfactory.

Success in greenkeeping lies in keeping as nearly as possible to a healthy balance between all these influences, by a close study of the life habits of the grass plants both when growing unhampered and when subjected to close culture. Appreciating this we may regulate our methods so as to assist the natural inclinations where they suit the golfer's purpose and bear down as lightly as possible where they do not fit so well.

Many of the common golf grasses are naturally of the tall-growing sort, extending their stems, leaves and flower heads a couple of feet or more into the air, and, likewise, penetrating with their roots a fair distance into the ground. On the other hand there are familiar grasses that prefer to lay their stems flat upon the ground in a prostrate fashion, and send small roots out at each joint, being somewhat of a shallow feeder. It can, therefore, be readily seen that the surgical operation of cutting off all but a fraction of an inch of the top growth is much more severe for the tall than for the low plant, not only because of the shortening of the stem, but also on account of the danger of scalping, since tall growing species usually develop noticeable crowns. There seems to be a great deal of adaptability among such forms, and they will conform to a remarkable degree to the treatment of mowing, and, since the absence of top growth prohibits root depth, will make up for the deficiency by producing a multitude of small surface feeding roots, taking on the form, in a loose way of speaking, of the low-growing types. The particular point brought to light here is that the tall grasses lend themselves to considerable modification of their natural habits, though it should be remembered that they can not be expected to retain their full vigor and robustness when changes are carried to extremes. The most practicable way of handling this circumstance is the adoption of low-growing types for putting green turf as has been done in the case of creeping bent.

Another prominent habit to be observed is that of the seasonal periods of growth activity. There are times of the year when growth is vigorous and times when it lags. The slowing down may be due partly to inherent characteristics and partly to a response to surrounding conditions, such as the drying out of the ground and excessive heat or cold. It is possible by the use of stimulating fertilizers and much water to induce the grass to keep up its springtime

energy, and continue green and lush right through the summer till the last moment in autumn, or winter, when the growth stops altogether. It is very doubtful if such practice is at all wise. Turf that has been over-stimulated is not in good shape to weather the troublesome times of midsummer with its fungous menace or meet the sudden onslaught of winter. Observation tends to show that the time to feed a green is that period when it can, by reason of weather and inherent habit, make the most active and ready use of the nourishment. Fertilizing right through the year is possible, but must be done with extreme care.

The natural hardiness of certain strains and their ability to withstand cold weather, winter kill and summer scald, better than other varieties is very noticeable among the various grasses found on the golf course, whether of native origin or introduced. Immunity from disease is another variable character. Consideration of these factors and selection with them in mind has had a great deal to do with the development of our best turf grasses for the golf course.

QUESTIONS AND ANSWERS

All questions sent to the Green Section will be answered in a letter to the writer as promptly as possible. The more interesting of these questions, with concise answers, will appear in this column each month. If your experience leads you to disagree with any answer given in this column, it is your privilege and duty to write to the Green Section.

While most of the answers are of general application, please bear in mind that each recommendation is intended specifically for the locality designated at the end of the question.

1. Brown-patch fungus affects leaves.—Why is it that, if brown-patch spores live in soil, the brown-patch attack starts at the tips of the grass and not at its roots? (Massachusetts.)

ANSWER.—Your question as to why the disease affects the blades of grass when the fungus lives in the soil is one which is frequently asked. Just why this happens we do not know. It is not an uncommon thing for a fungus to attack the leaves of a plant and not injure the roots. Similar conditions exist in human pathology. The organisms causing some of our skin diseases, for instance, do not affect parts of the body other than the skin.

2. Winter killing: probably snow-mold.—I am sending you under separate cover a sample of fungus. This sample has been taken from a green lying high and dry. Two-thirds of the green is affected and the grass seems to be dead. We had 30 inches of snow in the early part of December, which disappeared on January 6th, and it was then I noticed the fungus. I do not think this can be snow-mold as I saw this fungus in the winter of 1926 and 1927 before the snow came. (British Columbia.)

ANSWER.—From your description we suspect that the injury was due to some fungus, probably of the snow-mold type. The fact that you found the same type of injury even in the absence of snow does not necessarily rule it out of consideration. "Snow-mold" is a common name used to designate one or more of the fungi injuring plants at a very low temperature. The moist conditions provided by a