A main line serving four or five branches should be 3-inch pipe, except that if it is 2,000 feet long it should be the next size larger.

The main supply pipe may be 4-inch and will be sufficient for watering half the course at one time.

The Brown-Patch Disease of Turf: Its Nature and Control

By John Monteith, Jr.

With the increased attention given to development of better turf grasses and the demand for pure strains of the finer types on putting greens to replace mixtures of coarser grasses and clover, the damage caused by the brown-patch disease of turf in many sections of the country has become increasingly important. The disease has undoubtedly occurred throughout the country for many years, but formerly was overlooked or disregarded since there has always been a tendency to assume that grasses "naturally die out" to a certain extent during the summer months. Therefore little or no attention was given to these browned areas, for from previous experience it was known that just as "naturally" these scars would, in time, become green again, due frequently to an invasion of clover or another grass. Now that a single variety is desired to give a better putting surface, this grass alone must replace that injured by brown-patch, and methods have to be devised to check the disease and to aid the grass in its recovery. Many of the devices now used for control are well founded and under certain conditions beneficial, but many others are evidently based on little more than superstition or hearsay—about on a par with the old method of "bleeding" to control human diseases. It is apparent that the nature of the difficulty is widely misunderstood. As a result, the methods of combating it are largely ineffective. It is the purpose of this discussion to try to indicate how the disease works and to point out a few of the factors influencing its development with the hope that ultimately more intelligent methods may be used to control it.

Brown-patch has been known to occur on the fescues, redtop, Rhode Island bent, creeping bent, velvet bent, seaside bent, the ryegrasses, *Poa annua,* and *Poa trivialis,* but so far not on Bermuda grass or Kentucky bluegrass.

From the nature of the disease and the variety of circumstances under which it works, it is not expected that any single treatment will be found to prevent and cure all cases of brown-patch. Frequently some one announces a method which is claimed to forever settle the problem. As is to be expected, such a claim does not stand long, for while one method may be effective under certain conditions on one course it may be of little value when applied under the entirely different conditions found on another course. We can hope for adequate control only by recognizing the various factors which influence the disease and making due allowance for them when utilizing the various remedies which have been devised.

Injuries Confused With Brown-Patch

Before any general discussion of the disease itself is attempted, it may be well to point out various types of grass injury which are often confused with brown-patch. There are many unfavorable soil

conditions which at times cause turf to die or become discolored in patches; as, for instance, the following: too shallow soil where there is a large rock just beneath the surface; improper preparation of the soil before planting; poor drainage; an improperly sloped surface producing pockets where water collects readily and "drowns" the grass. There are also various insects which feed on the roots or leaves of grass, and these may weaken or even kill turf in irregular patches. Grass is often injured by chemicals, such as drops of oil from machinery and excessive use of copper in the form of Bordeaux mixture, and by fertilizers or composts improperly used. Any of these injuries, although confused by many persons, are usually readily distinguished from brown-patch by a careful observer. The discussion here given does not apply to the injuries mentioned above, but is limited to the diseases commonly referred to as "brown-patch."

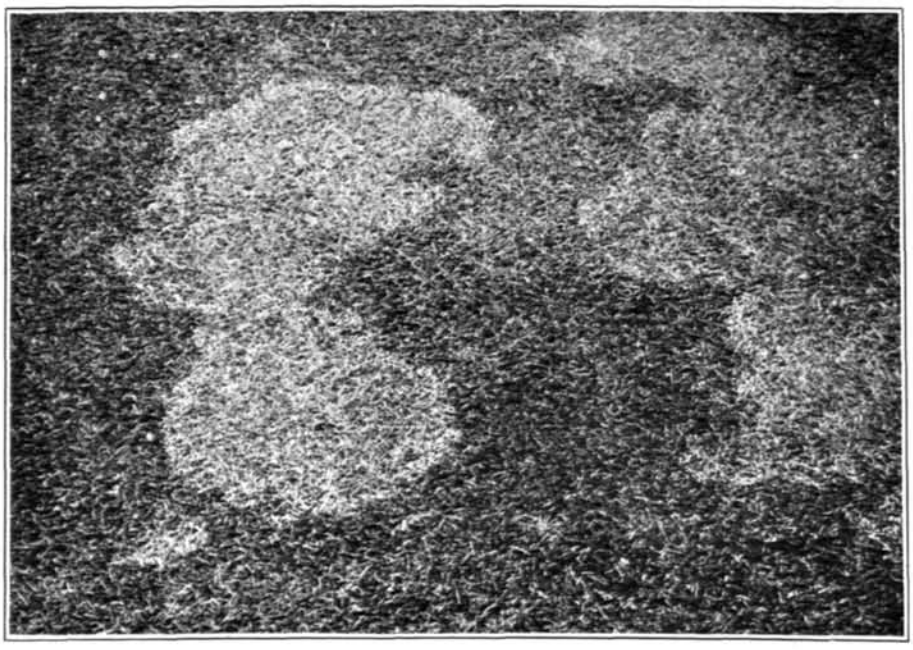

Fig. 1. Large brown-patch. This photograph was taken at the Arlington Turf Garden on the same day as that shown in Fig. 2. The brown, diseased turf appears light in the photograph contrasted with the dark color of the healthy green grass. The conspicuous area at left center was formed by two patches spreading outward until they joined. Each of these two patches was more than a foot in diameter.

Symptoms of the Diseases

There are two well-recognized types of brown-patch, but their differences are still often much confused. Large brown-patch is more prevalent in the southern section of the bent-grass area. It appears suddenly as large discolored areas which may be several feet across and which apparently develop overnight (Fig. 1). In the morning, before the grass is dry, the affected blades have a blackened appearance, as if scalded, and around the borders of the patch a fine cobweb-like growth may be seen spreading over the grass. As

soon as the sun is high enough to dry the green this so-called "cobweb" growth disappears and the discolored grass shrivels and dies, giving the patch the brown color from which it is named. In mild attacks a large percentage of blades escape injury and show up green throughout the browned area. The stems and runners are not killed except in very severe cases, and as a result the patch soon recovers its green color if conditions are made favorable.

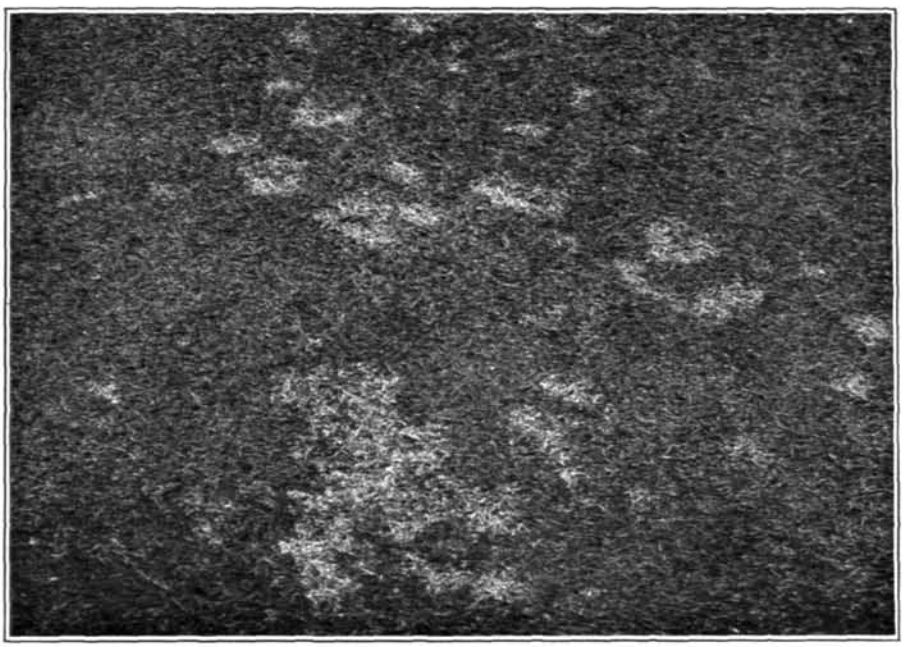

Fig. 2. Small brown-patch or "dollar spot." Notice the numerous definite spots an inch or two in diameter, contrasted with the spreading character of large brown-patch shown in Fig. 1. Figs. 1 and 2 are photographed at approximately the same magnification.

Small patch is generally limited to about the size of a silver dollar, from which it has been commonly referred to as "dollar spot." Like the large patch, it appears suddenly, and overnight the turf may develop a conspicuous "moth-eaten" appearance (Fig. 2) caused by numerous small browned spots. With this type the grass is usually killed to the ground; none of the blades escape; and the dead grass has a lighter, more bleached appearance than is found in the large patch. In certain cases several patches of the small type may develop so close together that they coalesce and give the appearance of the large patch. Similarly, under certain conditions, large brown-patch may start to develop and be checked before it spreads more than an inch or so in diameter. In such cases one may easily be mistaken for the other, although in instances where they both occur at the same time, as illustrated in Figs. 1 and 2, they are readily distinguished.

So-Called "Causes" of Brown-Patch

Brown-patch has been attributed to a large number of causes; some have no connection with the trouble, while many, although in themselves not the cause, have a direct bearing on its development.

The "weather" is always a convenient alibi for failure of any crop, and, as might be expected, has been most blamed for brown-patch. Under this designation have been included high temperature, excessive rain, heavy dews, high humidity, and cloudy periods. Some of these weather conditions, as will be shown later, no doubt exert a marked influence on the development of the disease, but none of them alone can cause this particular type of injury. Soil conditions of various kinds are frequently blamed, especially excessive soil moisture due to poor drainage. Spiders are sometimes supposed to produce the patches by forming webs which kill the grass. This idea came, no doubt, from confusing harmless cobwebs with the fine colorless threads of the fungus which is actually the cause of the disease. Various fertilizers and composts are often supposed to cause brown-patch. There are numerous other theories which have been presented and passed on from one greenkeeper to another with very little substantial evidence to support them. The fact that some of these so-called "causes" actually do exert a secondary influence by favoring growth of the fungus producing the disease may explain much of the confusion which has obscured the actual source of injury.

The Disease Caused by a Fungus

Brown-patch is produced by a fungus which penetrates and kills the grass leaves. For the benefit of those who are not familiar with plant diseases produced by fungi, a brief explanation will be given to enable them to better understand brown-patch and the various factors influencing its development and control.

A fungus is one of the lower forms of plant life, which does not possess the green coloring material found in the common higher plants. Since this green coloring material enables plants to utilize sunlight in the manufacture of certain foods, fungi are unable to manufacture these foods and must therefore depend on other plant or animal tissue for their supply. They are most commonly referred to as molds or mildews, and are found on all kinds of organic matter in moist places, particularly in the shade. A common example of a fungus is the edible mushroom. Commercial mushroom beds are prepared in dark, damp cellars where fungous "spawn" is planted in beds of stable manure. From this "spawn" is developed a growth of very fine cobweb-like threads (mycelium) which ramifies through the manure and serves much the same purpose as the roots and branches of our higher plants. After some weeks' growth of this mycelium, the fungus develops fruiting bodies, commonly referred to as mushrooms. If one leaves a mature mushroom in a damp place on a piece of paper, he will find after a few hours that there is a dark dust-like deposit on the paper. This powder comes from the gills on the under side of the mushroom cap, and consists of millions of very small "spores," which serve as seeds to distribute and propagate the fungus.

As in the case of the higher plants, there are thousands of species of fungi. A few of these, like some of the mushrooms and toadstools, can be readily distinguished, but in a large majority of cases their differences can be determined only by use of a microscope. Many fungi are decidedly limited in their distribution and food requirements. Some forms, such as the mushroom fungus, depend entirely on dead organic matter for their food, while others may penetrate

living organisms, where they are able to feed and ultimately destroy the invaded tissue. It is this latter type which produces disease in plants. The most familiar of these are the various rusts, smuts, mildews, blights, and similar diseases which have been known for many years. They are caused by various fungi which are, as a rule, very closely limited as to the plant they may attack. Unless one is mindful of the presence of these many distinct fungi, he is apt to mistake a harmless one for a dangerous one, and vice versa. As an example of this confusion, some greenkeepers have observed a fungus (mold) growing over their compost pile and, thinking it was the same as that causing brown-patch, have hesitated to use the compost lest they thereby infect the turf. The fungus, or perhaps many fungi, which they observed on the compost pile, were no doubt the usual ones causing decay and entirely incapable of injuring any living plant. This was pointed out in an article in THE BULLETIN for May, 1926, page 119.

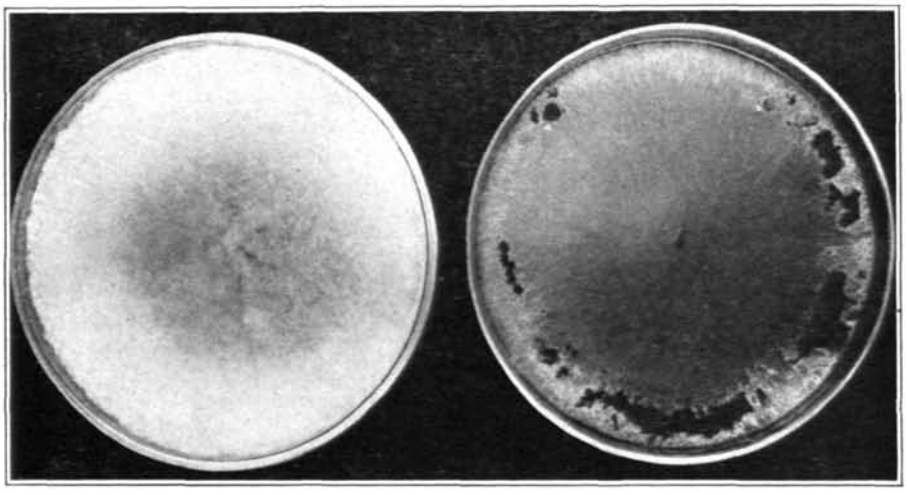

Fig. 3. Pure cultures of the fungi causing small (left) and large brown-patch (right). These circular glass dishes contain a thin layer of sterilized food material over which the fungus (mold) has been allowed to grow. Notice the "fluffy" growth of the small brown-patch fungus on the left compared with the more spreading habit of growth shown by the fine threads (mycelium) of the large brown-patch fungus in the other dish. The black masses shown near the edge of the plate on the right are "sclerotia" (see Fig. 4).

Experimental Proof of the Cause

When a fungus attacks a plant, it is possible to examine, under a microscope, a section of the part affected and see the threads of mycelium growing through it. It is usually possible to isolate this fungus from the diseased plant and grow it in culture free from the plant. These cultures are obtained by preparing a gelatin-like material (culture medium) containing certain foods needed by the fungus, sterilizing it in a covered glass tube or plate, and placing on it a section of the diseased plant. The fungus causing the disease then grows out from the plant tissue on to the culture medium. Pieces of this fungus may then be transferred to other tubes or glass plates containing sterilized medium and allowed to develop there

quite free from any other living organism. Such a growth is shown in Fig. 3 and is referred to as a "pure culture."

Pure cultures of fungi may be kept alive for many years simply by transferring them occasionally to new tubes of culture media. This makes it possible to study them independent of the host plant and obtain much information which helps in understanding their behavior under a variety of conditions. Fig. 4 shows an enlargement of the fungus causing large brown-patch as it grows in pure culture on sterilized artificial medium.

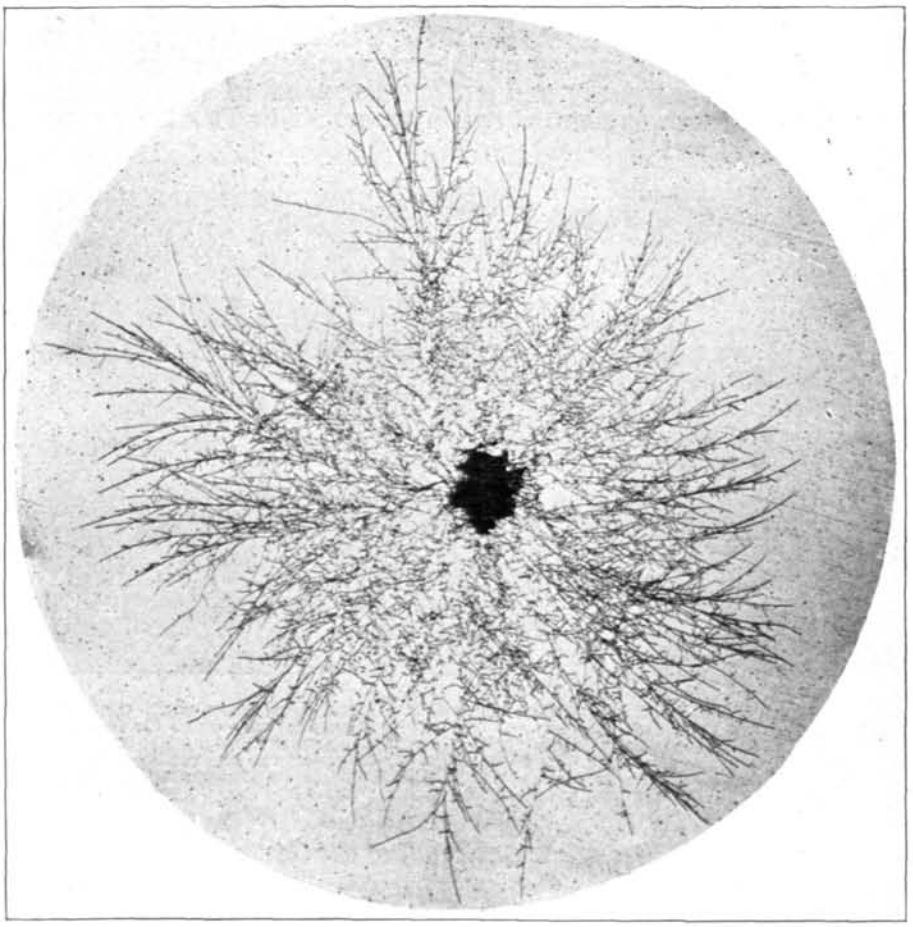

Fig. 4. Large brown-patch fungus growing on culture medium (magnified 10 times the actual size). This shows the fine thread-like mycelium growing out from the black sclerotium in the center. Sclerotia (see Fig. 3) serve to perpetuate the fungus through periods of drought or other unfavorable weather conditions which are likely to kill the delicate mycelium. Like seeds of higher plants, they send out new shoots as soon as conditions are again favorable.

Pieces of the fungus from a pure culture put on a plant will, under favorable conditions, attack the plant and produce the same disease symptoms found originally. Such a process is called "artificial inoculation" and is used to prove that the fungus isolated is actually the cause of the disease. The artificially inoculated plant

is examined for the disease, the organism is again isolated from an infected part, and is then compared with the original isolation. This method of isolation, artificial inoculation and reisolation of the organism, is used in both animal and plant pathology to test the disease-producing possibilities of an organism. A result of this process is illustrated in Fig. 5 which shows a box of grass inoculated with both the large and small types of brown-patch.

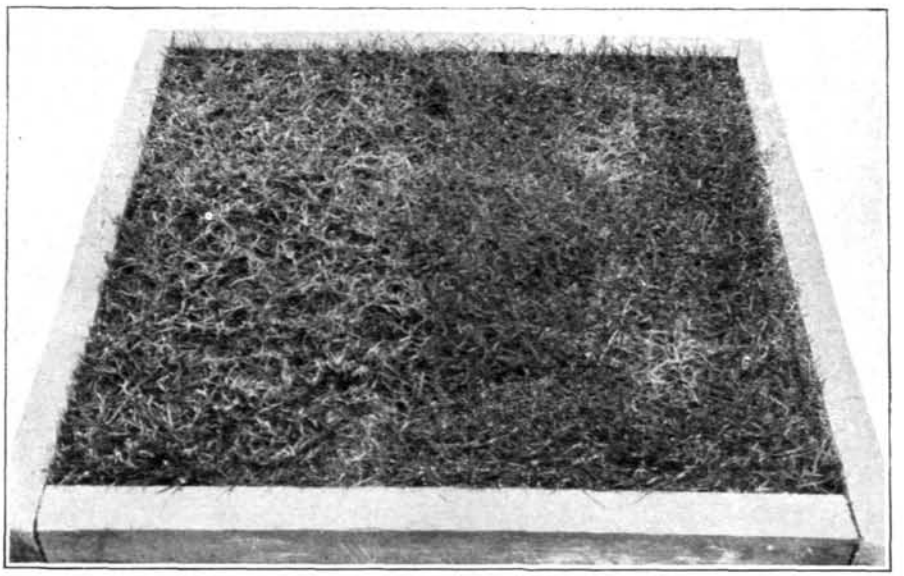

Fig. 5. Creeping bent artificially inoculated with the brown-patch fungi in greenhouse experimental work. .Pieces of small brown-patch fungus were taken from a dish, such as that shown in Fig. 3, and placed on the above box of grass in two places at the right. Similar pieces of large brown-patch fungus were placed in corresponding positions at the left, after which the box was placed in a moist enclosure where "dew" settled on the grass. The pieces of fungus placed on the turf immediately started growth and infected the grass blades. When the large brown-patch fungus, spreading from the two inoculated points on the left, had covered half the turf, the box was removed to a drier atmosphere. As soon as the dew evaporated the affected grass blades shrivelled and turned brown, as shown by the light areas in the picture. .These inoculations were made at the same time. Note, however, the limited development in the case of "dollar spot" contrasted with the extended area affected by large brown-patch. Compare this with the disease as it occurs naturally (see Figs. 1 and 2).

The Disease as Influenced by Environment

Since a fungus is a plant, it is influenced by certain environmental factors much the same as are the higher plants. It is well known that certain plants, such as corn, grow best at comparatively high temperatures, whereas others, such as many of our early spring plants, are unable to grow during the hot summer period. Fungi show a similar response to temperature. The organism causing large brown-patch grows best at fairly high temperatures, as shown in Fig. 6, and therefore this disease becomes serious only in periods of hot weather.

In the same way, some plants require plenty of moisture, while others survive with very little water. As a rule, fungi require plenty of moisture, and because their mycelium is so delicate they are usually extremely sensitive to drying out or to strong sunlight. For this reason molds or mildews are most common in moist, shaded

places; and this, in the case of brown-patch, accounts for the severity of an attack during periods of cloudy weather and heavy dews.

Acidity of the soil has a direct influence on the growth of many fungi. This is illustrated in Fig. 7, which shows its effect on the growth of the large brown-patch fungus on artificial medium. It would be well to compare this figure with the table given in the article by H. L. Westover on the "Effects of Certain Fertilizers on Soil Acidity, Quality of Turf, and Weed Control" on page 269 of the December, 1925, number of THE BULLETIN. In his table Mr. Westover gives the effect on acidity of the soil produced by various fertilizers as indicated by pH measurement of acidity, which is the same measurement as that used in the cultures shown in Fig. 7.

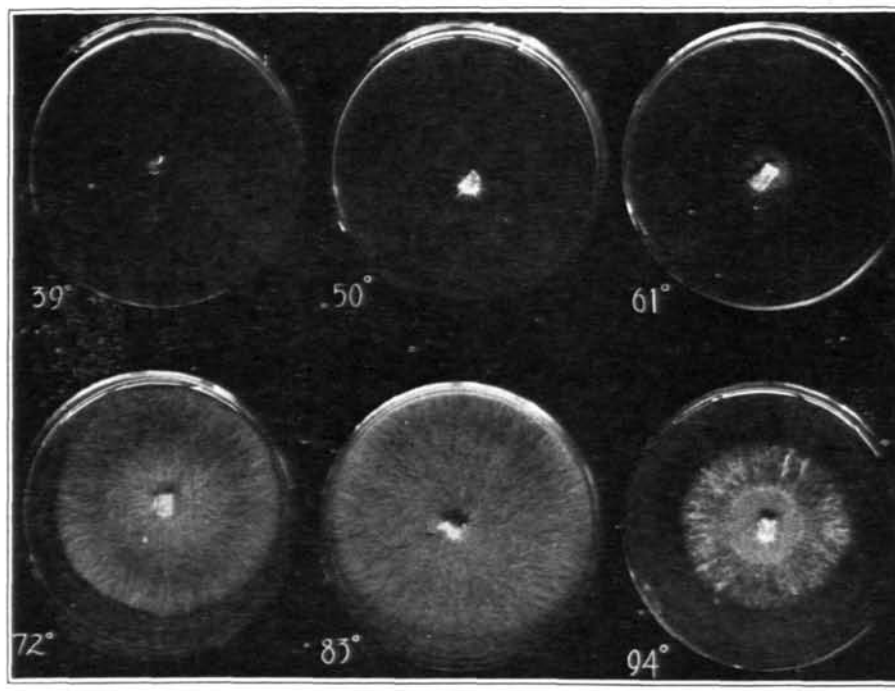

Fig. 6. The effect of temperature on growth of the large brown-patch fungus. In each of these glass dishes was placed an equal amount of food (culture medium) for the fungus. A piece of material on which the fungus was growing was then placed in the center of the dish, after which each was kept constantly at the temperatures indicated (Fahrenheit). Notice that no growth occurred at 39° and very little at 50° and 61°. The most rapid growth was at 83°. In applying this to field conditions it should be remembered that the fungus usually develops during the night; so these temperatures are to be considered in terms of night averages rather than maximum day temperatures.

Fungi, like green plants, are influenced by the food materials available; for that reason, brown-patch may be affected by the kind and amount of certain fertilizers used on greens. This relationship in the development of turf diseases has not been thoroughly studied as yet. There are many other conditions of soil and environment which may exert some influence on the growth of fungi; but thus far these are not understood in the case of brown-patch.

All these factors not only exert a direct influence on the development of the fungus, but also have a bearing on the development of

the host plant. For example, a high temperature is favorable to the development of the fungus and at the same time less favorable to grass of the bent or fescue type. Such a condition which weakens the grass and stimulates the fungus naturally increases the likelihood of a disease attack. On the other hand, the fungus requires

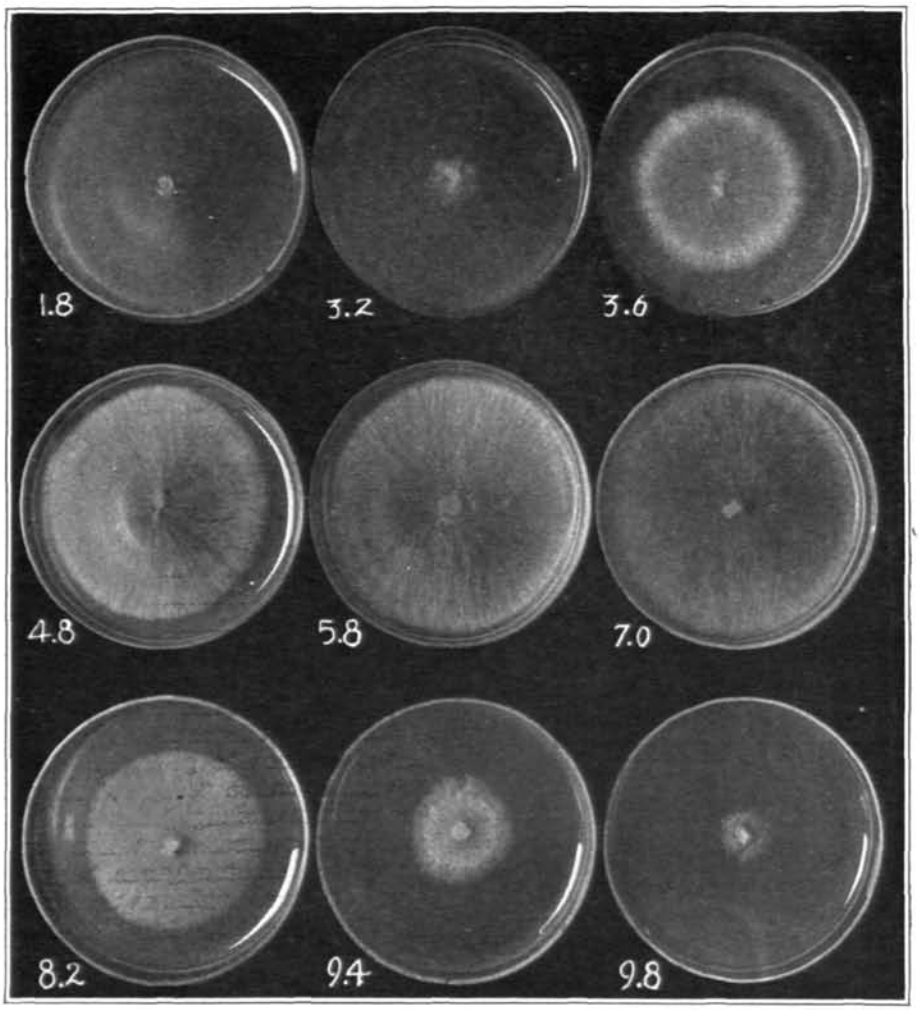

Fig. 7. Showing the effect of acidity on the growth of large brown-patch fungus. These nine dishes all had equal amounts of the same culture medium, were started at the same time, and grown under identical conditions; the only difference being that of acidity, indicated by the pH figures beneath the dishes. A pH of 7.0 (right on center row) is neutral. The greater the acidity the smaller the figure below 7.0; those above 7.0 are alkaline. Notice that the most rapid growth was on the slightly acid or neutral plates. Adding lime to acid soil tends to bring the reaction up toward 7.0 but does not raise it above that point.

much more moisture than does grass; so even if the temperature is favorable to the fungus and unfavorable to the grass, the disease may not appear, due to insufficient moisture for the fungus. In a similar way many other factors may balance one against another to influence the occurrence or severity of an attack of brown-patch. For this reason no hard and fast rule can be laid down as to when to ex-

pect an attack nor how to completely prevent one. It is not difficult to see that hot weather, heavy dews, cloudy weather, or other weather conditions which have been regarded as the "cause" of brown-patch, do not in themselves actually cause the disease, although they unquestionably have a decided influence on the real source of the disease—the fungus. When these factors are well understood and analyzed there will no doubt be devised some method for greens management that will greatly reduce the prevalence and severity of brown-patch.

To fully understand the disease it is essential that one get the conception of two separate plants, the grass and the fungus, each affected by a great many conditions which when balanced in certain ways give the fungus a decided advantage and permit the disease to develop, whereas at other times the balance is thrown in favor of the grass and the fungus is practically harmless.

Development of the Disease

Under conditions favorable for the development of the disease, the fungus grows up over the grass blades and spreads rapidly from one blade to another. The fine thread-like mycelium grows over the surface of the leaf until it reaches one of the pores, through which the grass "breathes." When it reaches one of these pores (stomata) the mycelium enlarges somewhat and fine branches of the fungus push through the opening into the leaf. When it has thus penetrated the grass it grows through and between the cells which make up the leaf tissue. This invasion is illustrated in the drawing shown in Fig. 8. The fungus absorbs food from these grass cells and grows rapidly until the blade is filled with the parasitic mycelium. At this stage the grass blade has a scalded, darkened appearance, but may show no sign of shrivelling. A blade in this condition does not last long, however, and as soon as the sun strikes it and the dew has evaporated it shrivels and turns brown. Most of the blades over a large area may be affected; and in this way the familiar brown patches are produced. It is a common experience to go out on the greens before the dew has dried, during the so-called "cobweb" stage of attack, and find a fine network of mycelium among grass blades that show the first blackened symptoms of the disease. When the dew disappears this mycelium vanishes, the infected grass begins to shrivel, and finally there is the brown, dead area which is the final symptom of the disease.

Two Types of Brown-Patch

Large brown-patch is caused by a strain of the fungus which has been known for many years as a serious disease of potatoes. Dr. C. V. Piper several years ago identified it with this potato fungus, known scientifically as *Rhizoctonia solani.* The threads of its mycelium are at first colorless, but gradually develop a light brown color and at times grow together in compact knotted masses, forming dark brown or black mats which are known as "sclerotia." These are shown in pure culture in Fig. 3. The mycelium grows very rapidly over the surface of the soil or turf, and under favorable conditions may soon cover a large area, in which it kills a high percentage of the leaves. In most cases it skips a number of blades, so that there is a scattering of green within the browned area. Ordi-

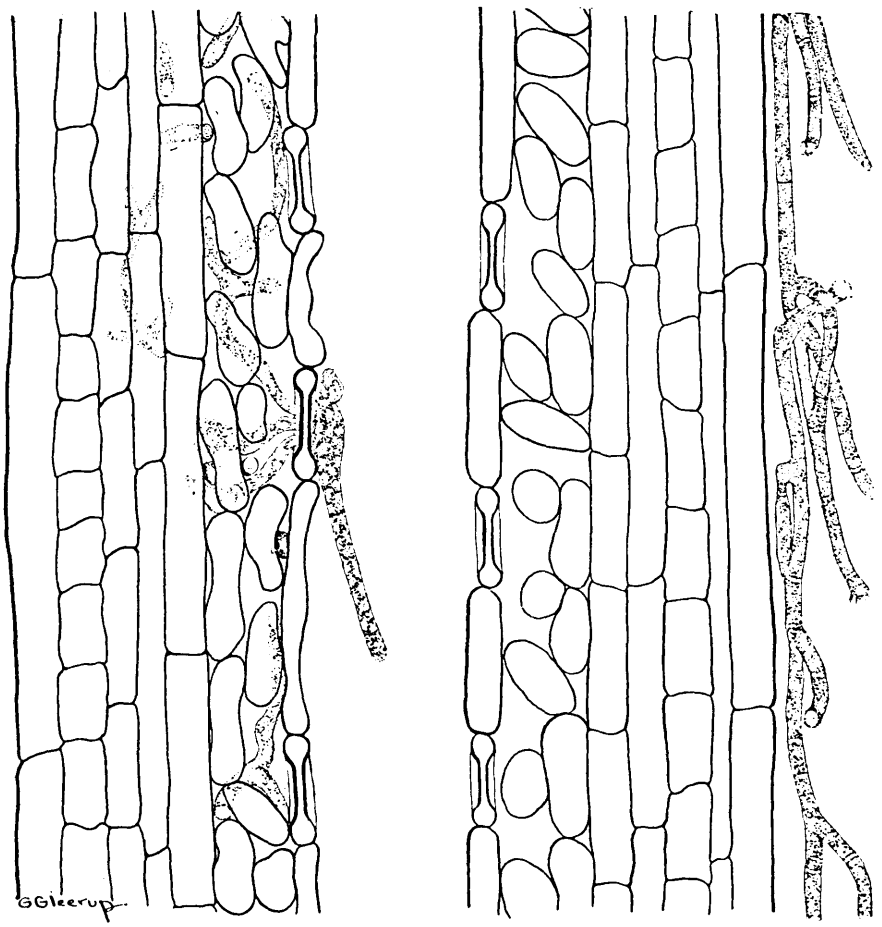

Fig. 8. Sketch showing the large brown-patch fungus growing on grass (magnified 375 time). This drawing was made, with the aid of a microscope, from very thin sections cut lengthwise through leaves of grass over which the fungus was growing. The cells making up the grass blade are simply outlined, whereas the tubular thread-like mycelium of the fungus is represented as dark stippled strands in the drawing. On the right is shown a healthy grass blade with the fungus still entirely on the outside. In the case of the blade at the left the fungus has penetrated through one of the "pores" in the epidermis (skin) and has spread among the cells of the leaf. By comparing the individual cells of this leaf with those of the healthy blade at the right it will be seen that some cells of the former are beginning to collapse; especially noticeable is the case of the cell just above the point where the fungus entered the leaf. After a leaf is thus invaded by the fungus, the cells gradually break down, causing the leaf to shrivel and turn brown. When the fungus has penetrated a blade as here shown, no control measure is known which will restore that leaf. Methods for control are based on checking the development of the fungus and following this by stimulating the grass to replace injured leaves with new ones. As the sections are magnified about 375 times, the actual size of each of the sections represented was approximately 1/250 of an inch thick and 1/88 of an inch long.

narily it attacks only the leaves and does not injure the stems or the buds on these stems, although in severe cases even these may be attacked and the turf is then "killed out" in the affected patches. Fortunately, however, the stems usually escape injury and are therefore left to produce new leaves to replace those killed by the fungus. This makes it possible to treat the green after an attack, and by stimulating a rapid growth the scar can be quickly obliterated by new blades shooting up from the uninjured buds along the stem.

Small brown-patch is due to a distinctly different species of Rhizoctonia. This fungus has a white mycelium with a much more "fluffy" growth. It does not produce the same type of hard, black sclerotia as does the one described above. It is shown in Fig. 3 in pure culture compared with the one causing large brown-patch. The area affected by this small brown-patch fungus is limited, but the injury, although it covers only a small piece of turf, is severe. Usually every blade in the patch and frequently even the buds and stems are killed. Fortunately this more severe injury is restricted in area, and the spot is ordinarily not more than an inch or two across, as shown in Fig. 2. The killed leaves have a more bleached appearance than do those affected in large brown-patch.

Control of Brown-Patch

Readers of this article will of course be interested chiefly in a discussion of the disease from the standpoint of control. Control methods, if they are to be made effective over any considerable range of conditions, must naturally be based on some understanding of the cause of injury and factors affecting its development. Many greenkeepers think they have solved the whole problem of brown-patch because their greens have been comparativetly free from the trouble. As a matter of fact they may have had little to do with preventing the disease, for conditions on their particular course may be naturally unfavorable for the disease whereas conditions on a near-by course may be extremely favorable. Also a certain method of treatment may actually prevent the disease in one case, but due to other conditions it may be much less effective on another course.

Control measures may be classified into three groups, which are, in the order of importance, cultural methods, resistant varieties, and chemicals.

Cultural Methods

Under cultural principles will be included the various details involved in the construction and maintenance of greens. As far as known, no single practice can be advocated which will completely control this disease. However, it is obvious that certain modifications in construction and management of putting greens will decidedly lessen the severity of attacks by brown-patch. These modifications are based on considerations of the various factors involved in creating conditions as favorable as possible for the growth of grass and as unfavorable as possible for the growth of the fungus parasitic on the grass.

It is self-evident that the first consideration should be given to creating proper soil conditions in building the green, for no subsequent treatment will quite compensate for original deficiencies in construction. This is not meant to imply that the most expensive plan is the best, for in many cases much better soil conditions are produced by the simple processes of plowing and pulverizing the soil than by some of the most expensive methods used in certain freak schemes for green construction. From the standpoint of brown-patch control, one of the most important soil conditions to be considered is that of drainage. Since grass is weakened and the activities of the fungus increased by excessive water it is apparent that poor drainage will increase the severity of the disease. Judged from

any standpoint, a green should be well drained; but this again does not necessarily mean an expensive drainage system, for many greens are located where there is adequate natural drainage. It is often assumed that because a green is located on high ground the soil is well drained. This is not always the case, for poorly drained greens are sometimes found even on a hillside. By careful observation after watering or during rainy weather, it is usually not difficult to discover defective drainage. Another flaw in the construction which often encourages brown-patch is the disregard for adequate air circulation. As pointed out previously, the fungus is usually encouraged by heavy dew, especially when it falls early and lasts late into the morning. Many greens are so situated that the prevailing winds do not have access to the grass, and as a result dew has every opportunity to settle early in the evening and remain there until the sun dries the grass late the following morning. Frequently a breeze comes up during the night, which effectively removes dew from exposed greens, whereas sheltered greens remain wet. These latter are usually most subject to brown-patch. Often this difficulty can not be remedied owing to the contour of the land; but in a large number of cases a few channels cut through the confining underbrush would provide adequate ventilation whenever there was any air movement. In this connection reference is invited to the article, "Air Pockets and Brown-Patch," on page 180 of THE BULLETIN for August, 1925.

Another construction flaw which is occasionally found is that of slope as affecting temperature. The temperature influence on development of the disease is one which can be rarely modified. In some cases, however, it is worth consideration, especially if other factors are unfavorable. A slope toward the west which gets the full force of the afternoon sun would naturally retain more heat during the night, the time when brown-patch develops. Such faulty construction is well demonstrated on a green near Washington, D. C. The course is well managed and little bothered with brown-patch except for this one green with a southwest pitch located on a hillside where it is banked with a heavy growth of trees and thick underbrush both above and below it. Since the slope was rather steep, it was naturally assumed that drainage need not be considered. As a matter of fact, considerable water drains out from the wooded slope above on to the green and keeps it entirely too wet much of the time. The heavy growth of trees and underbrush at each end establishes a pocket of "dead air," and consequently dew settles there many times when nearby greens are perfectly dry due to air currents. The pitch toward the southwest insures full utilization of the heat of the sun, and as a result when night comes that green has a big reserve of heat, an abundance of moisture, and no air circulation to help reduce either. Thus ideal conditions have been created for the fungus and miserable conditions for the grass. In this particular case the green could be moved a few yards back without materially affecting the play, a few channels might be cut through the underbrush which would in no way detract from the beauty of the course, and drainage could easily be provided for the water running from the woods above, and thereby an environment would be created which, although perhaps not ideal, certainly would enormously decrease the injury from brown-patch.

Provided proper attention has been paid to construction, there are several points which should be considered in managing greens to reduce brown-patch injury. Chief of these is the proper use of water. Greens should not receive too much water, especially during periods recognized by most greenkeepers as "brown-patch weather." It is especially important that heavy watering should not be done late in the day if there is a possibility that the night will be warm and quiet, for under such circumstances conditions would be ideal for the development of the disease throughout the night. It is this consideration which no doubt contributes to the success of early morning watering in the cases where it has proved successful in controlling the disease. By avoiding the practice of afternoon or evening watering and adopting the morning watering plan, the grass remains dry later in the night and the fungus is thereby given a shorter time to develop. Early morning watering also has the advantage of washing the dew from the grass blades, making the turf dry more rapidly. The use of bamboo poles, rubber hose, or similar devices to sweep the dew from grass early in the morning hastens drying of the turf and under certain conditions may be of value in checking the disease. It is apparent that a general recommendation of early morning watering to control brown-patch may be overdone, for there are times when the greens already have too much water in them, so that further watering would tend to increase the injury. In such cases the dew would no doubt be more wisely removed by some process of sweeping as above mentioned.

Another matter to be considered is that of fertilizing. Grass should be kept in a good healthy condition, which, however, does not necessarily mean a rank growth. Mowing should not be checked in case of a severe attack of the disease, but extra care should be taken to remove all the clippings from the green.

Resistant Varieties

The method of controlling brown-patch which appears to hold the most promise is that of the development of strains which are able to resist attacks of the disease. At present there are two strains of creeping bent which are outstanding in this quality. These are the well known "Washington" and "Metropolitan" strains. It should be understood that they are not *immune* to brown-patch, nor is it likely that any strain under every condition will prove wholly immune. They do, however, show a decided resistance when grown under favorable conditions. These strains, especially the "Washington," have in the last few years provoked a great deal of discussion and have perhaps received more abuse and praise than any other strains of grass used for putting greens. Much of this has been caused by over-enthusiastic claims and exaggerated expectations. It should be remembered that all strains of bent are new as compared with our other cultivated plants. It would certainly be remarkable if, in the short history of bent strains, a *perfect* grass had been developed. Nevertheless those two have sufficient merit to justify their use even without the stamp of "perfection." In the course of the next decade it is probable that many better strains of bent will be developed in different localities. Indeed it would be surprising to find a single strain which would prove best for every soil type and climatic condition throughout the country. It is more likely that

one strain will prove the favorite in sections such as St. Louis, for instance, while another strain will be found best for clubs in New England. There are some strains now on the market which are advertised as "immune to brown-patch." Such a claim may possibly in time be substantiated, but as a rule it is either a deliberate attempt at deception or is based on total ignorance of the disease. To claim that a strain is "immune" to brown-patch simply because on the few courses where used it has never had the disease is about as safe as to claim that a man is "immune" to pneumonia because of the convincing fact that he has never been known to have it. Such strains

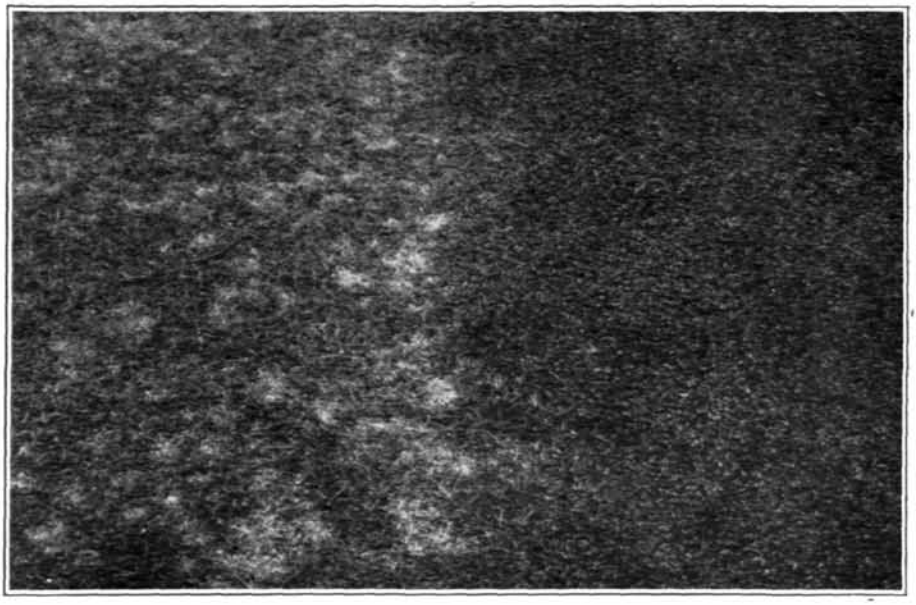

Fig. 9. Photograph showing difference in resistance of strains of creeping bent to small brown-patch. On the right is the Metropolitan strain, which is highly resistant, and at the time the photograph was taken it was entirely free from the disease. On the left, immediately adjoining, is a very susceptible strain badly spotted with brown-patch. Both plots were planted at the same time and have received identical treatment since planting. The economy of the use of resistant strains is obvious.

must prove their worth through at least three seasons, and in tests beside other grasses where brown-patch is prevalent, before they may be wisely branded "immune." Until other strains have been developed and adequately tested, the Washington and Metropolitan head the list of strains resistant to brown-patch. The resistance of the Metropolitan strain is shown in Fig. 9.

Chemicals

There are times when, due to climatic conditions over which we have no control, brown-patch will develop in spite of all precautions such as those indicated above. On such occasions certain chemicals may be used to kill the fungus or at least to check its spread over the turf. Numerous fungicides which are used against plant diseases in several fields of agriculture have been tested for control of brown-

patch. One of the most common groups of spray used against fruit diseases is that containing some form of sulfur. This group has, so far, not been satisfactory against turf diseases, due to the tendency of sulfur to injure grass. Another group of sprays is based on some form of copper compound. The most common of this group is Bordeaux mixture, either in the liquid or powder form. This mixture has proved effective in controlling the large brown-patch but is of little or no value when used against the small patch. There is also danger of an accumulation of copper in the soil, which, after excessive applications, appears toxic to grass and may produce an injury as serious as the disease itself. The most effective groups of chemicals so far tested are those composed of some combination of mercury. These results have been reported in detail in previous articles in THE BULLETIN and have been summarized in the October, 1925, number, page 219. From these tests it appears that mercury in several organic or inorganic forms is efficacious in checking the disease. The period of protection varies considerably, apparently due to some soil or climatic conditions which we so far do not understand. Some cases have been reported where the protection afforded turf lasts only a couple of days, while in others it has lasted several weeks. During the period of midsummer, when the disease is worst, these compounds, unfortunately, give their shortest period of protection. Other chemicals have been tested but have proved of little value or have not been tested under sufficiently varying conditions to justify any general conclusions.

While much has been learned about brown-patch and methods of control within the last few years, there is still much to be done. The experimental work will be continued during the summer chiefly along lines leading to control, and will be reported in THE BULLETIN as soon as results with any treatment are sufficiently promising to justify any general trials.

New Member Clubs of the Green Section

Stoughton Country Club, Stoughton, Wis.; Huron Hills Golf Club, Ann Arbor, Mich.; Granville Inn and Golf Course, Granville, Ohio; Shamokin Valley Country Club, Shamokin, Pa.; Black Hawk Hills Country Club, Rock Island, Ill.; Great Chebeaque Golf Club, Boston, Mass.; Hillcrest Country Club, Kansas City, Mo.; Oyster Harbor Country Club, Osterville, Mass.; Corning Country Club, Corning, N. Y.; Opequon Golf Club, Martinsburg, W. Va.; Haverhill Country Club, Haverhill, Mass.; Cedar Rapids Country Club, Cedar Rapids, Iowa; McMinnville Golf and Country Club, McMinnville, Oreg.; Skaneateles Country Club, Skaneateles, N. Y.; Mr. R. S. Burlingame, Syracuse, N. Y.; Meadow Brook Country Club, New Haven, Conn.; Picatinny Arsenal Golf Club, Dover, N. J.; Forest Lake Country Club, Pontiac, Mich.; Superior Golf Club, Minneapolis, Minn.; Seneca Falls Country Club, Seneca Falls, N. Y.; Orinda Country Club, Berkeley, Calif.; Nippersink Lodge Assn., Genoa City, Wis.; Mission Hills Country Club, Kansas City, Mo.; Dublin Road Golf Club, Columbus, Ohio; Bloomington Country Club, Bloomington, Ill.; Scenic Highlands Golf Club, Babson Park, Fla.; Country Club of Geneseo, Geneseo, N. Y.