Symptoms of and Treatments for Turf Diseases

In the following pages the various turf diseases will be discussed separately as regards symptoms, extent of injury, cause, and treatment. The first group of turf diseases considered are those caused by parasites. The second group includes the various nonparasitic diseases. It is of prime importance that the greenkeeper familiarize himself particularly with symptoms. Without correct diagnosis, no disease can be treated intelligently. A treatment successful with one disease often is of no value with another.

The problem of diagnosis is rendered difficult on account of the similarity between the symptoms of certain diseases. In many cases unusual environmental conditions so modify the customary symptoms that it may be difficult to recognize them merely from a printed description. The difficulty in such cases, however, is no greater than is experienced in identifying plants which may vary somewhat from the usual type of any species. Everyone knows that the symptoms of human diseases vary greatly from typical symptoms and that a physician has to make allowances for individual variations in making a diagnosis. Printed descriptions of any diseases, whether they be of human ailments or turf disorders, are merely guides which may lead to much confusion to some readers, but which in the hands of an intelligent reader may be made to serve a useful purpose. In spite of the similarity of many symptoms of turf diseases, the problem of distinguishing between them is by no means as difficult as it may appear. It should be borne in mind, however, that after turf has been dead for a few days it is often impossible for the expert as well as the beginner to determine what killed it, just as it is often impossible for the best physician to determine the cause of death if he examines a corpse several days after death and without any information as to the symptoms that preceded death. The greenkeeper who is on the alert has an advantage over the expert in diagnosing turf diseases, for he knows the past treatments of the turf which might have led to difficulties, and he is on the ground to observe all the developments of the injury from its earliest symptoms. Such information is of utmost importance in diagnosing certain ailments of turf, just as the various preliminary aches and pains of a patient help the physician in his diagnosis of human ailments. The specialist in turf disorders is too often handicapped in his diagnosis of certain turf ailments on golf courses due to the absence of anyone on the course who has been observant enough to notice early symptoms of a disease or due unfortunately in some instances to deliberate efforts to withhold important information. There are on the other hand many cases of turf diseases which still retain distinctive characteristics for weeks or even months after the damage occurred.

In the following pages there are presented descriptions of the more typical symptoms of a number of diseases with the hope that there will be sufficient detail to enable the observant greenkeeper to make his own diagnosis of the disorders that occur on his turf. If he can correctly and quickly diagnose these diseases, he may be in a position to promptly apply the remedies available for each disease, and he can avoid the aimless and costly methods, such as those practiced on many golf courses, of blindly applying fungicides for all browned turf.

In suggesting remedies for the various diseases care has been taken to include only such as have been proved to be effective. Wherever there are disease problems there are quack doctors and a never-ending propaganda for new wonder-cures. Golf clubs have spent many thousands of dollars within the past few years contributing toward the upkeep of this quackery. Doubtless many of them will continue much of this annual contribution. Most of the remedies suggested in this number of the Bulletin have been tested by carefully-checked experimental work as well as by practical tests on golf courses in many sections. In a few cases suggestions have been included that are based on many observations of promising results on golf courses even though they have not been subjected to the careful scientific tests, which may later prove them to be less valuable than assumed. It is frankly admitted that none of the remedies suggested will perform miracles. All of the remedies suggested require a certain amount of good judgment in applying them. Therefore it is only natural to expect that there will be those who claim that such and such a treatment will not work. The answer is that it has worked. Often a treatment is an utter failure, not due to any fault in the treatment, but due to faults of the individual who tries to apply it. Every effort has been made in this number of the Bulletin, even to the point of frequent repetition, to point out that even the best treatment will fail if improperly used, or if all other contributing factors in disease development are ignored or can not be modified.

Brownpatch

Symptoms.—Brownpatch (figures 6 and 23), commonly known also as "large brownpatch," occurs in irregularly-shaped browned areas, usually more or less circular, varying from 1 inch to 3 feet or more in diameter. The grass in the central portion of the affected area turns first dark and then gradually becomes a light brown. On the outer borders of the affected area there is usually a dark ring of more recently affected grass. In the early mornings the leaves in this ring are frequently observed to be intertwined with the mycelium of the causal fungus and hence the ring has been commonly referred to as the "smoke screen." The presence of this dark border or smoke screen indicates that the fungus is still actively attacking the grass and that the disease is spreading. Throughout the affected areas there are usually many blades of grass which have escaped infection. The relative proportion of blades that have been destroyed determines the color of the areas. If only a small number of the blades have been killed, a patch may still retain a green color with only a slight discoloration to mark the outlines of the diseased area. Light attacks of brownpatch are frequently overlooked; but unless some precautions are taken to check further development of the fungus, infection may spread to the other blades and result in distinctly browned, dead areas. In the late stages of the disease the injury from brownpatch may be confused with injuries from chemical burns, high salt concentration, unfavorable soil acidity, defective drainage, and with many other injuries that occur on turf.

Extent of Injury.—In severe cases browned areas may extend over the entire putting green and damage the turf to such an extent that it is necessary to replant the green. The fungus becomes active during periods of excessive heat and moisture and may continue to be active for several months in certain sections of the country.

Brownpatch has been reported as occurring in practically all parts of the United States and Canada, and in Great Britain, South Africa, Hawaii, and Japan. Its attacks are more serious in the southern section of the northern grass belt. Low-lying, pocketed putting greens or those surrounded by banks or trees are more often seriously affected than are greens located on higher areas exposed to winds.

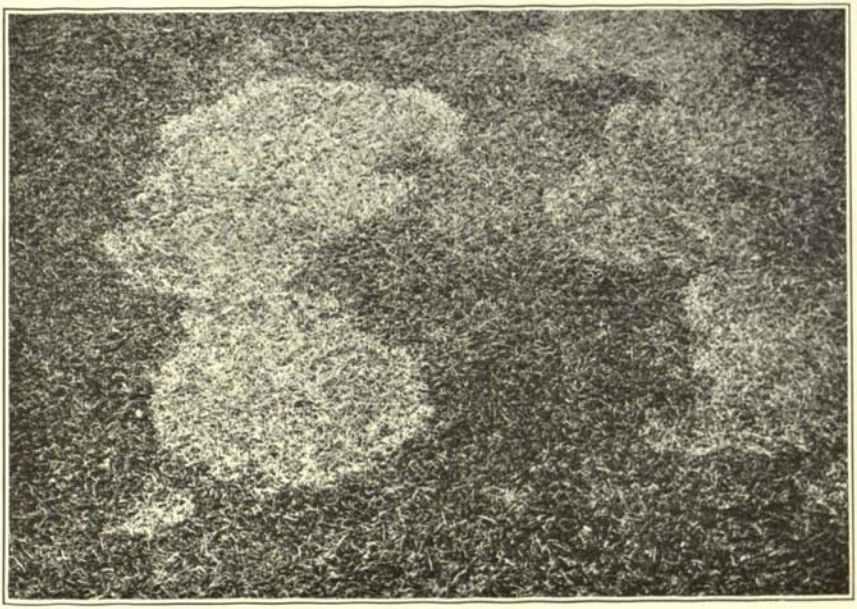


Figure 23.—Brownpatch caused by the fungus Rhizoctonia solani. The lighter areas of turf in the illustration have been injured by the fungus. The size of the patches varies from very small spots as seen in the lower left corner to 3 or more feet in diameter. The large patch on the left measures approximately 1 foot across and 2 feet long. The patches are often surrounded by a narrow band of darkened leaves which, with the photographic filters used, appear lighter in the illustration. This band is referred to as the "smoke screen." The disease may develop very quickly and unless treated promptly the grass may be killed in the patches

The disease occurs on the various species of Agrostis, being particularly destructive to colonial bent and redtop. It has been observed to attack ryegrass (*Lolium perenne* and *Lolium italicum*) and various species of bluegrass, including annual bluegrass (*Poa annua*), Kentucky bluegrass (*Poa pratensis*), rough-stalked bluegrass, (*Poa trivialis*), and Canada bluegrass (*Poa compressa*). It has attacked the fescues used in turf, including red fescue (*Festuca rubra*), Chewings fescue (*Festuca rubra* var. *fallax*), and sheep's fescue (*Festuca ovina*). It occurs also on Bermuda grass (*Cynodon dactylon*) and on carpet grass (*Axonopus compressus*). It has been observed to attack many of the common weeds of turf, such as yarrow (*Achillea millefolium*), pearlwort (*Sagina procumbens*), and clover (*Trifolium repens*). It has also been observed on many other grasses and weeds commonly found in turf, and it is likely that under favor-

able conditions it may attack, in varying degrees, practically all plants that are found in fine turf.

Cause.—Brownpatch is caused by the fungus *Rhizoctonia solani*, which is of world-wide distribution. This is the same fungus which causes serious diseases in potatoes and other crops. The fungus develops best in a temperature between 80 and 90 degrees Fahrenheit, and, as in the case of many other fungi, its development is encouraged by the presence of ample water; consequently brownpatch is most likely to develop during hot, humid periods. The fungus lives in the soil, and when climatic and soil conditions are favorable it grows above the surface of the soil and attacks the blades of the grass. The fungus penetrates the leaf usually through the stomata, or pores, distributed over the surface of the leaf, and rapidly spreads through all the leaf tissues. When a leaf blade is thoroughly invaded by the fungus the leaf turns dark and assumes a water-soaked appearance. When an affected leaf is exposed to sunlight or to drying winds it shrivels and turns brown, and all the invaded parts of the leaf die. Brownpatch is frequently described as spreading with alarming speed over a piece of turf. This apparent speed of development is due to the sudden collapse of affected grass blades which, although having been invaded by the fungus for several hours, may have remained turgid until the sun or wind had caused them to collapse (pages 91 to 97).

Treatment.—The control of brownpatch combines both precautionary and curative measures. As regards the former, the aim should be to check the growth of the causal fungus and to avoid the development of the soft, tender growth of grass so susceptible to the ravages of the disease (pages 105 to 114). Since the growth of the fungus is favored by an abundant supply of moisture both in the soil and on the blades of grass, care should be taken to provide adequate soil drainage and to dispense with water in excess of that required by the turf. Air pockets should also be avoided. Efforts should be directed toward producing a vigorous rather than a tender growth of grass by avoiding an excessive supply of nitrogen in the soil. Excessive soil acidity should likewise be avoided. Further, since there is a great range in the relative susceptibility of grasses to attacks by this fungus, the use of susceptible bent grasses should be avoided wherever resistant strains will serve satisfactorily (pages 102 to 104). There are many species or strains of grass highly resistant to brownpatch, but thus far no case of immunity has been established in spite of claims to the contrary. Removal of dew by early morning watering (pages 108 and 109) may under certain conditions reduce the frequency or severity of the disease. The common practice of poling, brushing, or the dragging of hose, rope, or similar equipment over putting greens in the early morning to remove dew may also prove of some benefit in reducing the disease under some conditions.

Curative measures, once turf is attacked, are found in the use of suitable fungicides, the purpose of which is to stop the spread of the causal organism. New leaves thus develop to replace those killed by the organism, healing the scars left in the turf by the disease. The first fungicide used successfully against brownpatch was Bordeaux mixture (figure 16), but due to the danger of the accumulation of copper in certain soils (pages 119 and 120), the use of Bordeaux mixture in the control of turf diseases has been largely abandoned. Safer

and more effective fungicides are the organic and the inorganic mercury compounds. Of these, corrosive sublimate has proved the most effective and economical (pages 120 to 124). Its rate and manner of application have been discussed on pages 124 to 132.

Dollarspot

Symptoms.—This disease (figures 6, 10, 17, 18, 19, and 24), commonly known as "small brownpatch" (page 89), occurs in spots on the turf ordinarily not larger than a silver dollar, as the name implies. They are usually regular in size and shape, although in severe

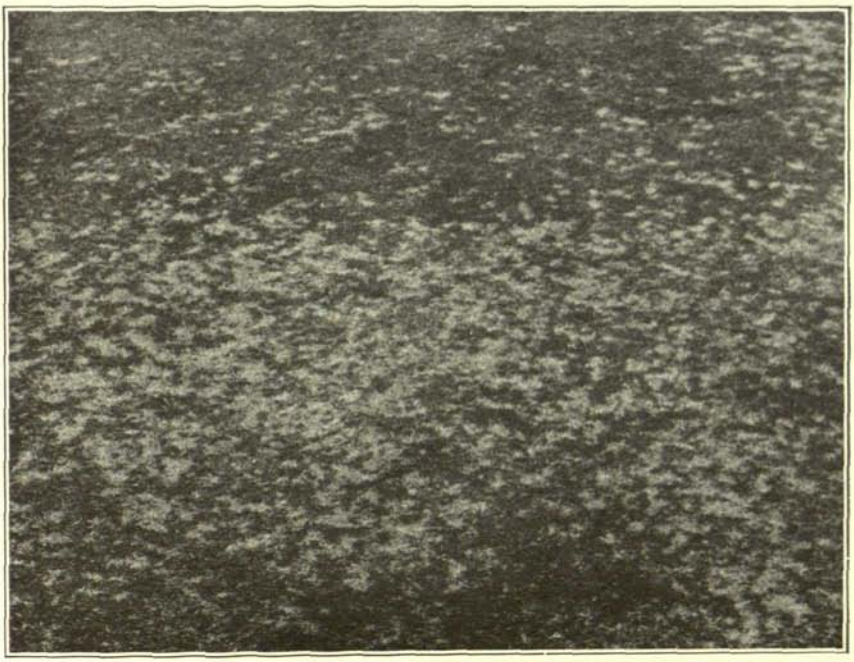


Figure 24—Dollarspot on Washington creeping bent turf caused by Rhizoctonia sp. Compare this with the lesions caused by brownpatch (figure 23). These spots are usually less than 2 inches in diameter. The leaves have a bleached appearance and the tips of newly-infected leaves are curled and shriveled. The leaves injured by snowmold fungus often have the same color as those injured by dollarspot but the patches of injured turf are much larger, and snowmold usually occurs in the winter or early spring while dollarspot occurs during the growing season. Control of dollarspot is effective with mercury compounds, particularly calomel (figures 17, 18 and 19). The diseased areas are usually scattered over the turf. In light cases only the top leaves are infected but in severe cases all the leaves may be killed. It may be confused with spotblight (figure 25) or snowmold (figures 26, 27, 28 and 29)

cases individual spots may be so close together as to merge and produce large, irregular areas of dead turf. In the early morning when the dew is still on the grass, tufts of the white mycelium of the causal fungus may be observed on the affected areas of turf. The fungus, which may have developed during the night in these areas, penetrates the blades of grass in a manner similar to that of the brownpatch fungus. The affected turf first appears dark and water-soaked. As

the sun and wind dry the grass, the mycelium dries and disappears and the blades of the affected grass shrivel, curl, and turn a bleached straw color, in contrast with the darker brown which usually develops in blades of grass affected with brownpatch or with spotblight. Dollarspot is occasionally confused with injuries caused by spotblight, snow-mold, burns from lumps of chemical, yellow tufts, and the injury caused by some insects, including cutworms and sod webworms.

Extent of Injury.—When there is a mild attack of dollarspot only the top blades of grass may be affected; after continued development of the fungus, however, the grass in the affected spots may be entirely destroyed. When the attacks are mild and damage occurs only on the surface growth, the turf quickly recovers if it is growing vigorously. When the disease is permitted to continue until the grass in the affected areas is destroyed, it may take many weeks and even months for the grass to spread into the dead areas sufficiently to cover the scars of the disease.

In northern sections the disease may occur at almost any season of the year from late spring to early fall; in the more southern regions it may occur at any time of the year. Dollarspot has been observed throughout most of the United States and Canada. The lack of authentic reports of its occurrence in other countries may be due to the failure of observers there to recognize the disease or to report it.

The disease occurs on a wide range of grasses and weeds, affecting practically all of the turf plants named as hosts for brownpatch. There are striking differences in the susceptibility of different species and strains of grass to this disease. Some of the bent grasses are particularly susceptible. Although there is great variability in the susceptibility of strains, it has been observed in general that, of the cultivated species of Agrostis, the creeping bents are more susceptible than other species. Of the commonly-used bent grasses, the Washington strain of creeping bent is the most susceptible. Some of the strains of velvet bent are decidedly resistant, whereas others are extremely susceptible. Colonial bent and redtop are fairly resistant.

Cause.—Dollarspot is a fungus disease caused by a species of Rhizoctonia, which in some respects is similar to the fungus causing brownpatch. The fungus lives in the soil and attacks the grass in a manner similar to brownpatch (pages 91 to 97). This fungus is generally more destructive at a somewhat lower temperature than is favorable for brownpatch. It, too, requires abundant moisture. An adequate supply of readily-available nitrogen, when other conditions are favorable, enables grass to quickly recover from an attack of the disease. Abundant sulphur and a decided deficiency of lime tend to encourage dollarspot on turf.

Treatment.—Dollarspot is readily controlled with mercury fungicides (pages 120 to 132). The common copper and sulphur combinations, frequently used as fungicides, are ineffective against this disease. Of all the mercury compounds that have thus far been tested, calomel has proved to be the most effective and economical. The disease is discouraged by the judicious use of fertilizer and water and by the use of resistant strains of grass (pages 102 to 104). In spite of the claims of immunity, none of the bent grasses so far tested have proved to be immune to this disease. The removal of dew from turf early in the morning may reduce somewhat the damage from this disease, as has been mentioned in the case of brownpatch.

Spotblight

Symptoms.—Spotblight (figure 25), which has been called Pythium disease, appears in the early morning as a circular spot of blackened grass glades intertwined with a cottony growth of mycelium of the causal fungus. Under the influence of sun and dry wind the mycelium dries and disappears and the dark blades of grass wither and usually turn a reddish-brown color. The individual diseased spots are usually not more than 2 inches in diameter, and new spots in many

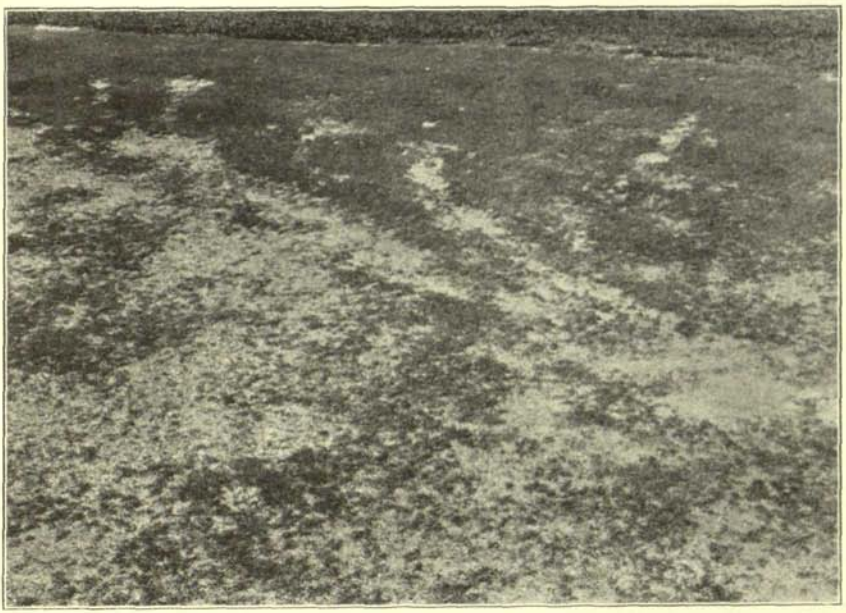


Figure 25—Spotlight caused by the fungus Pythium butleri. This disease develops rapidly when conditions of temperature and moisture are favorable. The damage here illustrated developed within a few days. Often serious attacks develop overnight. The fungus may kill large areas of turf when the small spots merge, as shown near the lower right corner of the figure. The individual spots are usually less than 2 or 3 inches in diameter and often occur in streaks, similar to those radiating from a point a little to the right of the center of this figure. Evidently the spores of the fungus, in the case here illustrated, were washed down from the edge of the green causing new infection along the course of the water. The spores may also be spread in streaks by mowers or other golf course equipment. These spots are often larger than those of dollarspot (figure 24), but instead of being a bleached color they are usually a reddish brown. This disease occurs in the hottest periods of the year in contrast with snowmold (figure 26), which occurs during the colder periods

respects resemble small spots of brownpatch in early stages. The spots of spotblight seldom occur individually but usually in groups which tend to form streaks, due apparently to the spread of the spores from an initial point of infection by means of running water or through distribution by the mower or by similar means. The reddish appearance and the tendency to spread in streaks have led to the designation of this disease in one locality as "blood streak." Spotblight may be confused with dollarspot, snowmold, burns from

lumps of chemicals, yellow tufts, and injuries from cutworm and sod webworm.

Extent of Injury.—The disease usually is extremely disastrous to turf, resulting generally in the complete destruction of the grass in the affected areas. The causal fungus has been reported as scattered throughout the world. It has been reported causing damage to putting greens in practically all of the middle-western and eastern states. It is found only occasionally in the northern states. In the southern portion of the bent region it occurs most frequently during the summer months. The most serious damage occurs on poorly-drained greens. During the hot, wet periods of summer the putting greens which dry rapidly are less likely to be attacked. It is more likely to be destructive to new than to established turf, but under favorable conditions it will destroy turf of any age. Colonial bent and some strains of creeping bent and velvet bent are subject to severe attacks of spotblight. Other resistant strains may be damaged when conditions are unusually favorable for the development of the disease.

Cause.—Spotblight is caused by the fungus *Pythium butleri.* This fungus is one of a large number of closely-related fungi causing diseases and decay of a great many of our cultivated crops. It has been observed to attack a large number of grasses, cultivated plants, and weeds. It grows most rapidly when the temperature is around 90 to 95 degrees Fahrenheit. The disease does not become active unless there is an ample supply of moisture; consequently it develops only when the grass is wet. Therefore in periods of extremely hot weather when there is abundant rainfall or excessive humidity with heavy dews, it is likely to become serious, but it is quickly checked by a sudden drop in temperature or by a dry atmosphere. Overwatering in periods of great heat is likely to encourage the development of the disease.

Treatment.—No satisfactory control treatment has been developed for spotblight. Corrosive sublimate used as a spray has given some indication of checking the disease (pages 124 to 132 for rates and methods of application). Since water is an important factor in the development of this fungus it is important to use special care in avoiding excessive watering during periods when the temperature is high enough to encourage the development of spotblight (pages 108 and 109).

Snowmold

Symptoms.—Snowmold (figures 26, 27, 28, 29, and 53) appears first as a thick cottony growth of mycelium covering patches of turf. As the grass dries, irregular patches of grayish dead turf become apparent. These patches vary from an inch or so in diameter to several feet across and in their late stages resemble brownpatch. The disease occurs during fall, winter, or spring, but the causal fungus is most conspicuous and as a rule the disease is first noticed when the snow is melting. At times the injury is only superficial, affecting merely the top leaves of the turf, from which recovery is rapid. At other times the grass in the affected areas is completely destroyed, leaving bad scars requiring months for healing unless replaced with new turf. Snowmold may be confused with any of the turf injuries commonly referred to as winterkill, also with dead

patches of turf resulting from other causes which occurred during the preceding summer or fall.

Extent of Injury.—The causal fungus frequently attacks putting greens in the winter and early spring months during periods of thaws when the turf is kept moist with melting snow, fogs, or frequent rains. The disease is apt to be especially severe when a cover of snow has fallen on unfrozen ground. It has been observed in northern Europe and throughout the northern part of the United States and Canada. It has been reported as far south as Virginia.

The snowmold fungus attacks a large number of turf and cereal grasses. On golf courses it does greatest damage on the putting greens but occurs commonly also on fairways and tees. The disease is frequently most serious on putting greens in ravines or pockets and on those having a deep covering of snow for long periods. It may occur on any part of a putting green, but the injury is usually more severe on the poorly-drained areas than on the high areas.

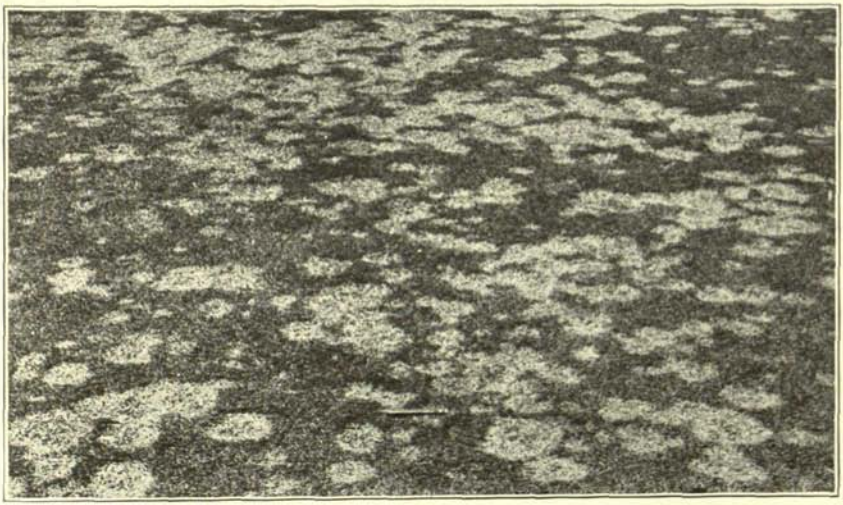


Figure 26—A severe attack of snowmold, caused by Fusarium nivali, on a susceptible strain of grass. The patches in the illustration are generally a foot or less in diameter (note full-sized pencil in foreground), but they may be much larger. The color of the grass in the patches is dirty gray, although some of the patches may have a pinkish cast after being exposed to the sun. The disease occurs in the winter or early spring usually when snow is present or is just melting. It is easily distinguished from dollarspot (figure 24), and spotblight (figure 25), which occur only in the growing season, by the larger size of the diseased areas it produces. The size of the diseased areas is often about the size of brownpatch (figure 23), but that disease occurs only in the warmer periods of the year. The use of susceptible varieties of grass should be avoided where the snowmold disease is apt to be serious

Red fescue and some of the strains of creeping bent appear to be particularly susceptible to snowmold. Of the common bents in use on putting greens, seaside creeping bent seems to be the most susceptible. The Columbia strain and others of a similar type, including one rather widely distributed under the name Inverness, have proved to be unusually susceptible to damage by snowmold.

Cause.—While the name snowmold is used to designate disease caused by a number of different fungi, as a general rule it applies to the disease caused by the fungus *Fusarium nivali*. Proof of the responsibility of this fungus for the disease on golf courses in the United States has been established. It has been recognized for many years as an important disease of grain in northern Europe, but has been definitely recognized as a golf course problem only within the past few years. Occasionally patches of snowmold are found in which the leaves of the injured grass have small black or brown bodies (sclerotia) scattered over them. These are resting bodies of fungi which, although associated with the snowmold injury, have not been proved to be the causal organisms. The common name snowmold is derived from the fact that the fungus, or mold, causing the injury grows under snow and even through snow. However, although the occurrence of the fungus is most generally associated with a covering of snow, such a covering is by no means an essential for the

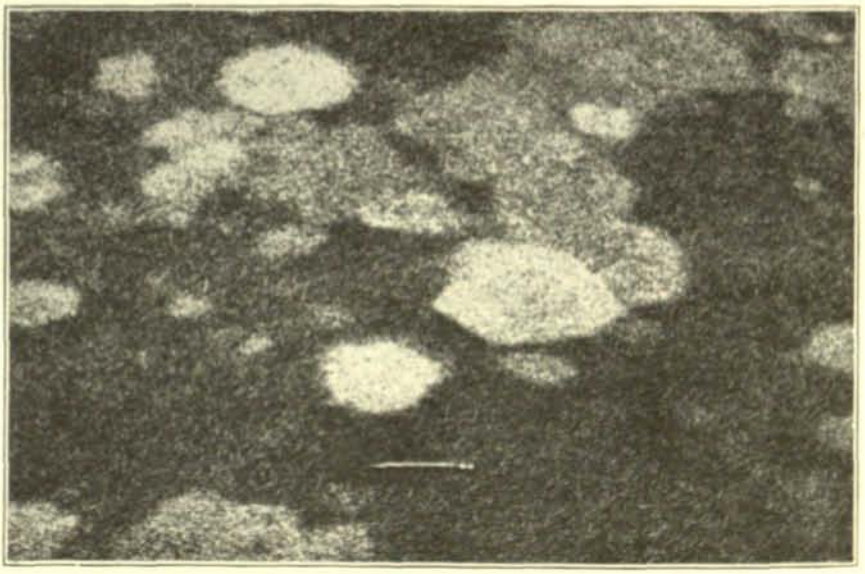


Figure 27.—The few lighter spots in this illustration are old patches of snowmold which have developed for a long period. The gray patches are newer and did not have time to become serious before being checked by an application of corrosive sublimate in the second week in January. The turf in these patches had begun to recover when the photograph was taken on April 3. The lighter, more seriously-diseased areas may need replanting

occurrence of the disease. Remaining dormant in the soil for most of the year, as soon as the temperature becomes low the fungus again becomes active.

Treatment.—As the susceptibility of any grass to injury from snowmold has been found to be increased by fertilization with excessive quantities of nitrogen in late fall, putting greens in the snowmold belt should be fertilized as little as possible after August. Since there is a decided difference in the susceptibility of grasses to this disease, the ability of a grass to withstand attacks of snowmold should be

given consideration in the choice of grass for putting greens in the snowmold belt (pages 102 to 104). On courses where the disease is likely to be particularly serious, the Columbia, Inverness, seaside, and similar strains of creeping bent, and also red fescue, should be avoided. It has been found also that a covering of straw, particularly when left on the turf late in the spring, tends to encourage the development of the disease (figure 53). The use of any covering which keeps the grass wet after the snow has melted and the grass has commenced growth should therefore be avoided. The removal of snow, the sweeping off of any debris or any mass of the fungus

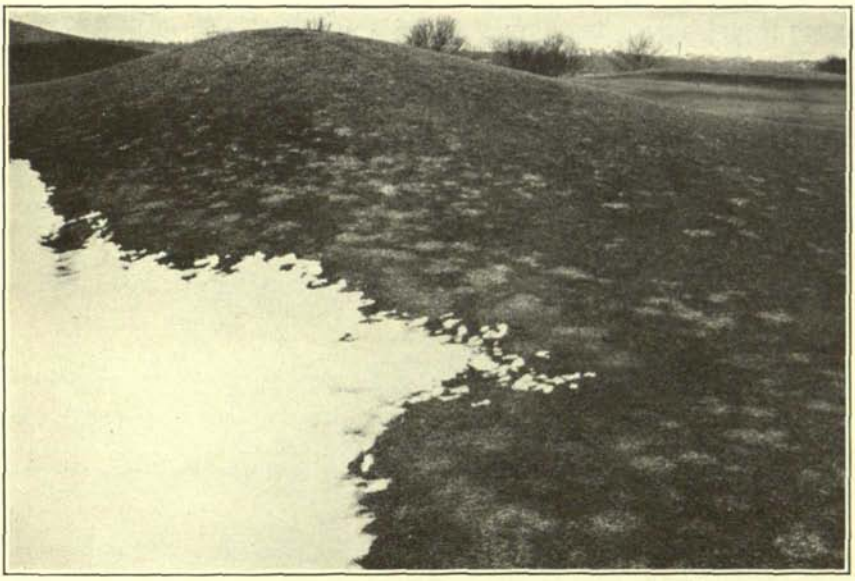


Figure 28—As the snow covering retreats with the advent of warm weather it often leaves behind the evidence of damage by the snowmold fungus. Snowmold has been confused with injury from standing water (figure 44). The mound in the picture is on the highest part of this course and there is no possibility of water standing on this slope. The mound serves as a trap for snow, and as the snow melts the fungus attacks the grass. Snowmold is often found on the highest areas on a putting green, but the damage it does there is usually not as serious as in the low places

remaining on the putting greens, and any other treatment tending to hasten the drying of the surface after the spring thaws begin, will in many instances tend to reduce late damage by snowmold.

In spite of all these precautions, however, snowmold is likely to develop under other favorable conditions. It is therefore well to treat the greens with one of the mercury fungicides (pages 120 to 132) before winter begins in order to avoid entirely attacks on the greens or at least to greatly reduce the severity of the attacks. Corrosive sublimate and calomel have proved to be entirely satisfactory for the control of the disease. These should be applied in late fall or early winter at the rate of from 2 to 5 ounces to 1,000 square feet. The lighter rate is usually sufficient where the above precautions are taken. In certain locations where environmental conditions seem

fall months to provide a green turf for winter play, failure to establish a uniform stand of turf with the first or second seeding, due to this ailment, may result in uneven turf throughout the season. Early cold periods retard growth in the later plantings to such an extent as to prevent the covering of scars left from the damping-off. In most cases the casual organism kills the seedling outright, although in some cases it destroys only part of the shoot of the plant and causes merely a checking of growth. It will thus be found that usually all the grass plants in an infected area are killed, while again in some cases a sufficient scattering of plants survive ultimately to develop a good turf. The disease may occur in the United States wherever new turf is seeded. It is most disastrous on putting greens that remain moist for long periods after rain or watering. It affects any of the grasses used for turf on golf courses.

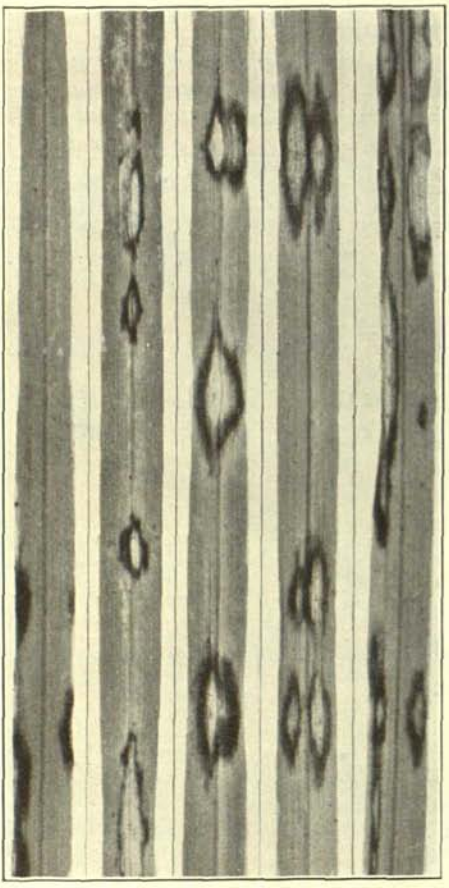


Figure 30—Leafspot on Kentucky bluegrass caused by the fungus Helminthosporium vagans. Magnified 3 times. The symmetrical disposition and paired arrangement of lesions resulting from infections occurring while the leaves were still folded, are illustrated in all the specimens except the one on the left. Compare the characteristics of these lesions with those of zonate eyespot (figure 32)

Cause.—The disease is caused by different species of Rhizoctonia, Pythium, Fusarium, and other fungi. These fungi may be present in the soil or seed, and under favorable conditions may spread through or over the upper layer of soil and from there penetrate the leaves or stems of the plants. The fungi attack the young plants near the surface of the ground and spread out from several infection centers. The growth of these fungi is favored by an ample supply of water near the surface of the ground, and their invasion of the seedling seems to be much more readily accomplished when the plant is in a soft, luxuriant condition brought about by improper fertilizing, watering, or other practices. An attack by fungi at this stage of growth quickly leads to withering and complete destruction of the plant, for the fungus readily spreads over the short distance required to involve the entire plant.

Treatment.—Much can be done to lessen the severity of the dis-

ease, or perhaps under favorable conditions eliminate it altogether, if, when establishing seedling turf, care is taken not to overwater or overfertilize (pages 108 and 110). Although treatment of seed with fungicide before seeding has controlled seedling diseases in some cases, it has not proved effective for damping-off of turf grasses.

Leafspot on Bluegrass

Symptoms.—The lesions produced by this disease (figure 30) are scattered over the leaves in small spots. At first they appear as tiny brown specks, enlarging until they may extend across the leaf. The

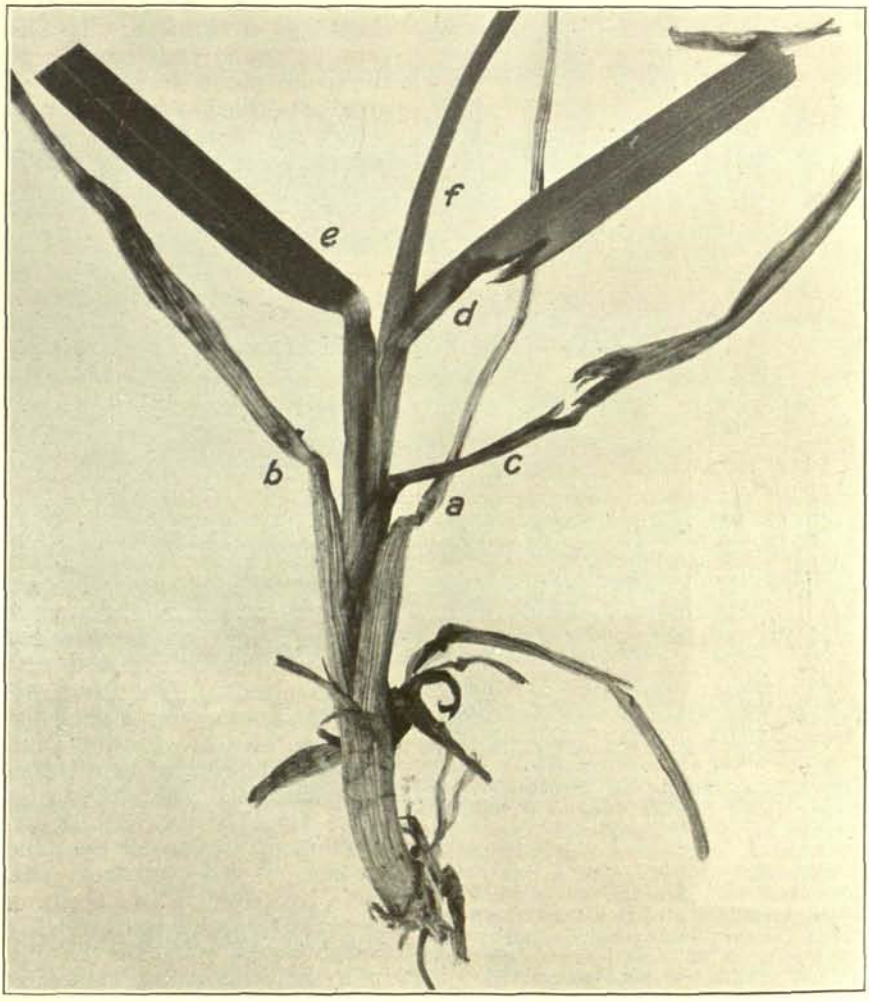


Figure 31—The footrot stage of the leafspot disease of Kentucky bluegrass shown in figure 30. Magnified 3 times. Characteristic of the disease is its progress upward along the stem of the plant. The three leaf blades a, b, and c have withered as a result of being interrupted by broad lesions near their respective bases, while a fourth, d, appears destined for a similar end with further enlargement of the one lesion present. Two other leaves, e and f, appear free of infection. Obtained from a closely-cut fairway at Washington, D. C., in April, 1929

tissue in the center of the spot dies, becoming straw-colored. Around the straw-colored area is a border varying in color from dark brown to black. When the lesions extend across the leaf they may cause the leaf to wither. In severe cases the whole leaf may become involved and the crown of the plant also may be invaded by the fungus, usually resulting in the death of the plant. The causal fungus is responsible also for symptoms commonly described as footrot (figure 31). In this latter case the whole leaf sheath is infected and becomes brown. The stem and the crown are also attacked and the plant dies. Usually footrot and leafspot occur simultaneously, resulting in areas of turf where a majority of the plants are dead. Most of the damage to the turf is due to the footrot stage of the disease. In such severe cases the leafspot stage may be overlooked and the injury confused with other diseases productive of dead areas.

Extent of Injury.—This disease occurs on Kentucky bluegrass wherever grown in the United States. It may occur also on other species of bluegrass. The disease was first noticed in 1922, since which time seriously-damaged areas have been observed throughout the bluegrass section of the country. Leafspot on bluegrass is usually most severe in the spring, although it may cause damage throughout the growing season. It causes greatest damage in the footrot stage on the closest-clipped turf.

Cause.—The disease is caused by the fungus *Helminthosporium vagans*. The fungus is localized on the leaves but may spread over the whole sheath and stem in the footrot stage of the disease. Spores of the fungus are found on old lesions and are disseminated by wind and spattering water. These spores infect new areas when they fall on leaves of bluegrass. Such infection may take place throughout the growing season.

Treatment.—Cultural practices (pages 105 to 113) offer the best means found thus far for combating this disease. Fertilizing to stimulate the plants to produce new leaves, and the raising of mowers to allow longer leaves to develop during periods of activity of the disease, will encourage the development of stronger plants better able to withstand attacks. The footrot symptoms are rarely found on uncut bluegrass; and since footrot is the more serious type of the disease, the longer the grass is allowed to grow the better it can withstand the disease.

Zonate Eyespot

Symptoms.—The lesions occurring on leaves of grass from this disease (figures 11 and 32) are similar to those of leafspot on bluegrass in the early stages, except that they are usually much larger, due to the manner in which the causal organism spreads over the leaf. In each case the lesion is characterized by a bleached central area with a dark brown border. Where droplets of dew cling to the leaf, the fungus grows through the droplets and infects the leaf over the entire area covered by the droplet. Successive spreading of the fungus daily into new zones in the presence of dew gives rise to a zonation, which characterizes this lesion and renders it distinct from the lesions of other leafspots. The fungus may spread over an entire leaf, and in severe cases large areas of turf may be completely defoliated.

Extent of Injury.—The fungus causing the zonate eyespot disease

is not as restricted in the number of different grasses it attacks as is the fungus causing leafspot on bluegrass. It attacks 23 different species of grass, including Bermuda grass (*Cynodon dactylon*),

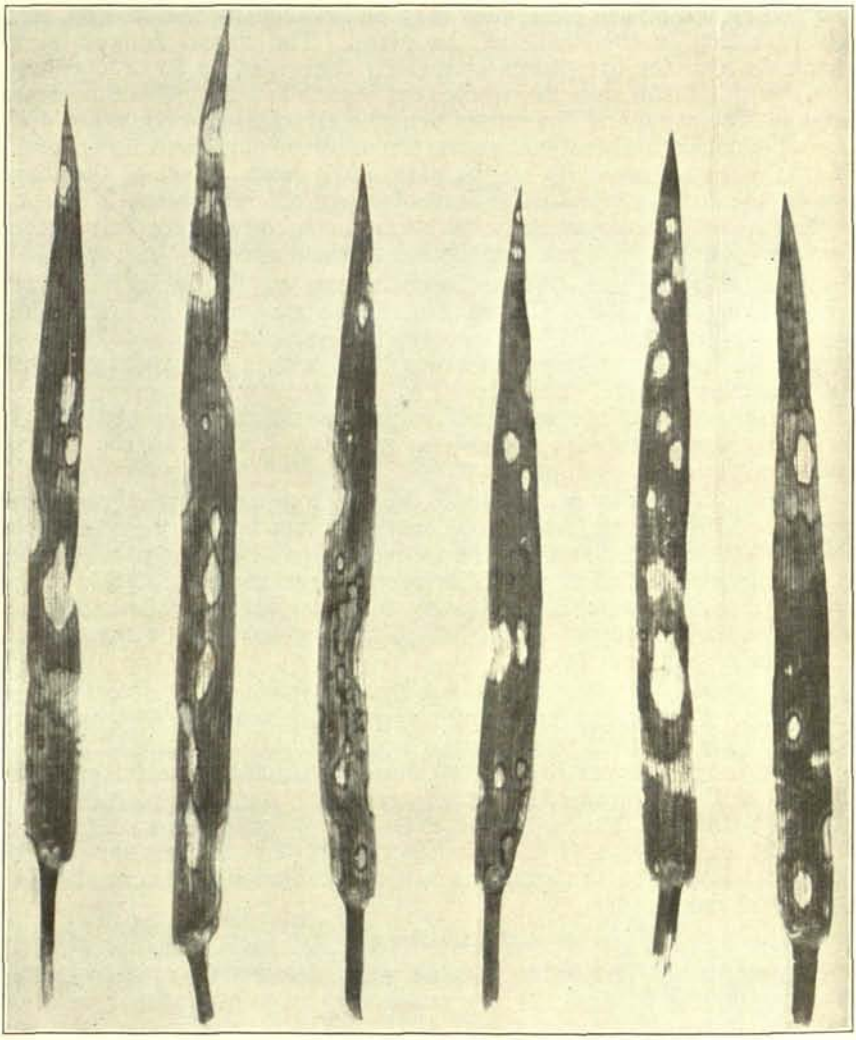


Figure 32—Zonate eyespot disease on Virginia creeping bent caused by the fungus, Helminthosporium giganteum. Advanced stages of the disease are shown about twice the natural size. The spots first appear as dark brown specks which spread to a diameter of from 1/16 to 1/8 inch. Then the center bleaches, leaving a straw-colored spot surrounded by a brown ring. When droplets of water occur on the spots the fungus grows into the water and attacks surrounding healthy areas of the leaf covered with water. It will be seen from the photograph that the disease has spread out into zones around the original eyespots, leaving large discolored blotches which in time dry out. Leaves generally affected, as those shown in the photograph, soon wither and die, resulting in thin, badly-discolored turf, as shown in figure 11. The lighter areas on the leaves are a bleached straw color and have a ring of dark brown around them. This characteristic gives the lesion the name eyespot

goose grass (*Eleusine indica*), wild ryegrass (*Elymus virginicus*), brome grass (*Bromus inermis*), quack grass (*Agropyron repens*), creeping bent (*Agrostis palustris*), and velvet bent (*Agrostis canina*). The disease was first noticed on Bermuda grass in Texas in 1911, and may cause severe damage on extensive areas of Bermuda grass in the South. Among the northern grasses, it is important economically only on the Virginia strain of creeping bent. Although it has been found on the Metropolitan strain of creeping bent, such occurrence has been only as a few scattered spots and never as an epidemic. In a few cases it may cause some damage to certain of the velvet bents; but in this respect it has not been economically important. The disease is worse during warm, wet seasons. Usually it does not damage Virginia creeping bent until August, continuing into September.

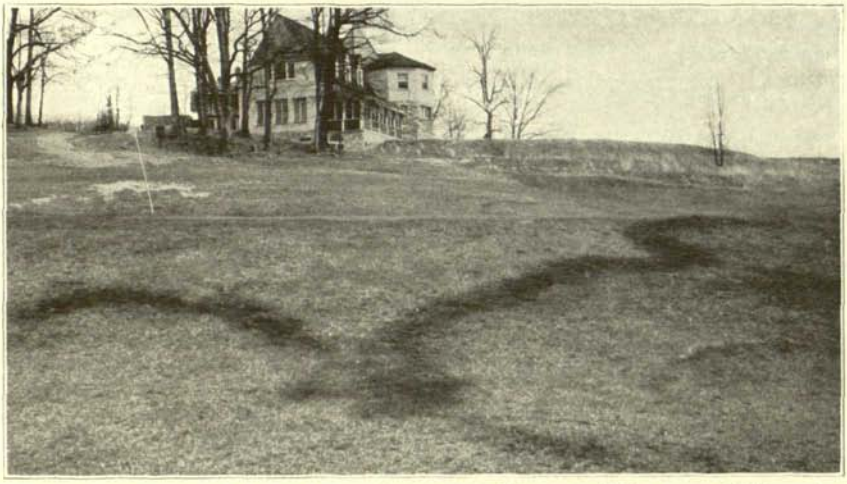


Figure 33—Portions of large fairy rings, caused by one of the several fairy-ring fungi. The photograph was taken in late winter on the approach of a putting green. Note the dark green grass in the stimulated area of the ring in contrast with the dormant grass surrounding it. Under favorable conditions mushrooms may develop in the ring (figure 35). In the spring and fall and during the winter the rings usually are dark green while during the summer months the grass is often injured and the rings are frequently marked by brown dead grass (figures 34 and 36)

Cause.—Zonate eyespot is caused by the fungus *Helminthosporium giganteum*. Infection occurs only in the presence of water. Heavy dews encourage its spread. When the lesions become old, spores of the fungus develop on the surface of the diseased spot. The spores are scattered by spattering water, by clippings, and by greenkeeping equipment.

Treatment.—The best control for zonate eyespot is to replant the turf with a resistant variety of grass (pages 102 to 104). The Virginia strain is the only one of the commonly-used creeping bents which is seriously affected; and since it is an undesirable strain in many respects it should be replaced with a better grass. Raising the mowers and allowing longer leaf growth will tend to help the plants withstand attacks of the disease (figure 11).

Fairy Ring

Symptoms.—Although there is much variation in size and shape of fairy rings in turf (figures 33, 34, and 35), they are, as a rule, distinct rings or semicircles several feet in diameter. The grass in the center of rings less than a foot in diameter may be injured, thus presenting an appearance somewhat similar to that of brownpatch. Grass in the encircled area of a ring 30 or more feet in diameter may show no effect of the causal organism. At times the growth of grass in such rings is stimulated and the affected turf is then of a darker green color, growing more luxuriantly than is the turf immediately

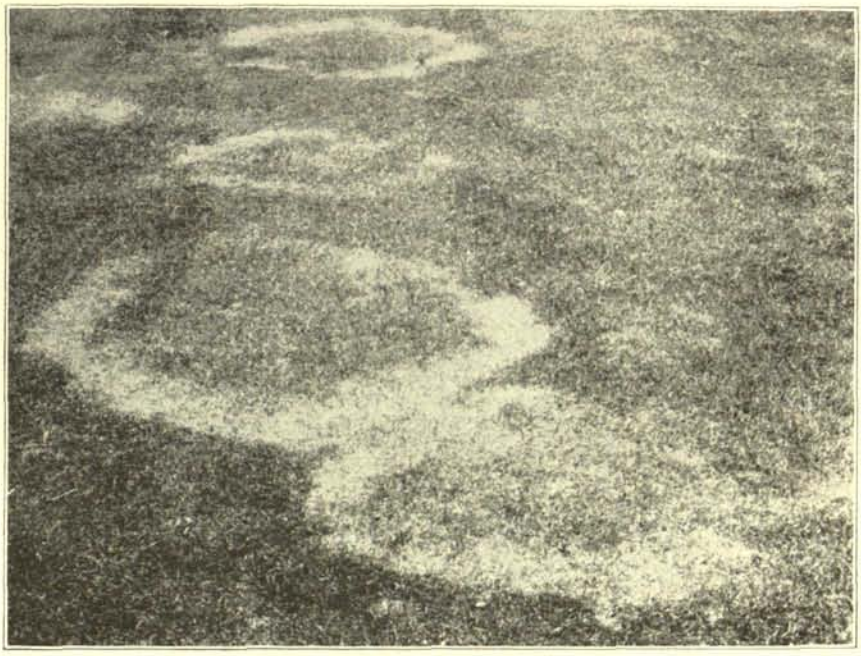


Figure 34—Fairy rings 1 to 4 feet in diameter on putting turf. These are commonly termed ringspot. They are sometimes confused with brownpatch (figure 23). As a rule the turf is injured only in narrow bands, forming the ring; but the turf within the ring is sometimes affected also, as is illustrated by the ring in the foreground. The photograph for this figure was made in midsummer, but this type of injury is usually most in evidence on putting green turf during late fall, winter, or early spring. Fairy rings on putting greens vary in size from less than a foot to more than 30 feet in diameter. The stage of stimulated growth, as in figure 33, is not often seen on putting greens, due probably to the greater stimulation of all the turf in these areas by more frequent fertilization

enclosed by the ring or that on the outside (figure 33). At other times the affected turf wilts, turns brown, and dies (figure 34). Frequently fairy rings several feet in diameter occur as distinct bands of dead grass or bare ground several inches across. On the outside and inside of the ring of dead grass there are often distinct rings of dark green grass growing more vigorously than the other grass nearby which is not affected by the fungus.

Extent of Injury.—Fairy rings are usually most abundant on fairways and in the rough. Large rings occasionally occur in the

putting greens, but as a rule the rings in putting greens are only from 1 to 4 feet in diameter. Fairy rings are usually present in the turf throughout the year. At times, however, they are masked by a vigorous growth of grass due to application of fertilizer or to decreased vigor of the fungus in the soil. Fairy rings on golf courses are usually regarded as interesting curiosities, but where they are numerous they are decidedly objectionable especially when they kill the grass and leave bare spots which make poor lies. On putting greens, fortunately, there are seldom found more than one or two on a single course. There are, however, records of courses where dozens or even hundreds of small fairy rings have developed on putting greens. These small rings are frequently referred to as ring-spots (figure 34). Fairy rings were recognized in Europe centuries ago, and they occur practically everywhere that turf grows. There

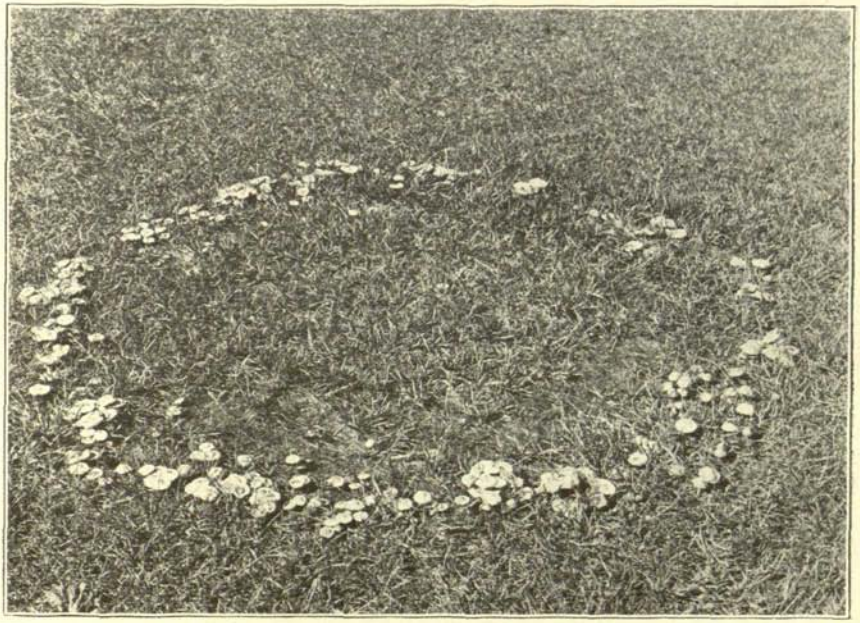


Figure 35.—A small fairy ring containing an unusually large number of mushrooms of the fungus, Marasmius oreades. Many years ago it was a belief that fairies danced around these circles and caused the mushrooms to grow. It is now known to be a concentric growth of a fungus from a central point (figure 36). There are many fungi that cause fairy rings in turf, the most common being the puffballs and the common edible mushroom.

are no species or varieties of grass that have shown any marked resistance to this type of injury.

Cause.—Fairy rings are caused by several different fungi which grow in the soil. The infestation gradually spreads outward from a central point, making an ever-widening circle. The mycelium of the fungus along the ring is tightly woven through the soil and around the roots of turf plants (figure 36). Through some effect of the fungus not yet thoroughly understood, the grass in the immediate vicinity of the fungus at certain seasons is stimulated as if well fer-

tilized. In dry periods the soil invaded by the fungus is dried and not easily moistened by showers or sprinkling, and the grass wilts and often dies along the central band where the fungus is present. Under favorable conditions the fungus sends up its fruiting structures to bear innumerable spores. These structures are commonly known as mushrooms, toadstools, or puffballs. Probably the most common fairy rings on golf courses are caused by *Agaricus campestris*, the common edible mushroom. At certain seasons the fairy rings are outlined with the white caps of this mushroom. In many cases the rings are caused by *Calvatia cyanthiformis*, which produces brownish puffballs often much larger than baseballs. These puffballs are frequently found distributed around the entire fairy ring. In other cases the rings are outlined with the small mushrooms of *Marasmius oreades* (figure 35). Among other fungi causing fairy

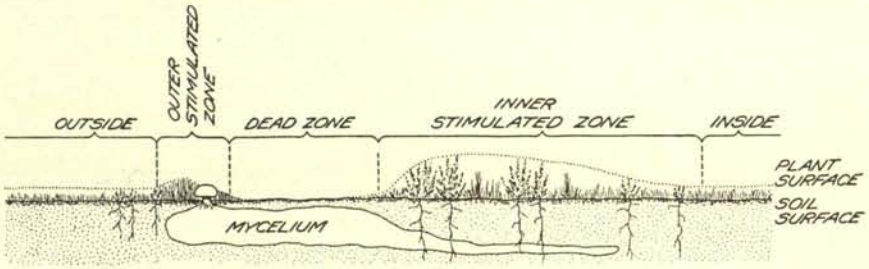


Figure 36.—Sketch of a section through a fairy ring. This section shows the area of soil occupied by the mycelium of the mushroom. Near the left, at the outer edge of the ring, the grass is stimulated. Just back of this is the dead zone, and back of this again is the reestablished growth on the inside of the ring. Its growth is stimulated by the organic matter left by the decay of the mycelium of the mushroom. Sketch taken from Journal of Agricultural Research, Volume XI, No. 5.

rings on golf courses are species of Lycoperdon, Naucoria, Hygrophorus, and Clitocybe.

Treatment.—Thus far there has been no satisfactory control remedy for fairy rings. Iron sulphate sprayed on the ground has been recommended. Forking of the affected areas and drenching with weak solutions of corrosive sublimate or other mercury fungicides have been reported as giving some control. On putting greens the use of the mercury treatments for brownpatch have been reported as providing some protection against fairy rings. Where a few rings occur in putting greens it is usually best to remove the sod in the affected area, take out the soil to a depth of 6 or 8 inches, and replace with new soil and sod. Where turf is well fertilized and properly watered the fairy rings are less conspicuous and cause less damage.

Smut

Symptoms.—Smuts occur on leaves, stems, or seed heads of grasses, usually as elongated, discolored streaks (figure 37). When grass is kept clipped for turf the disease is apparent as long black stripes on the leaves. In time the affected areas become somewhat swollen. Finally the pustules break, exposing masses of black soot-like powder consisting of the spores of the causal fungus. The fungus

works throughout a plant for a long time without killing it. One of the most conspicuous and perhaps the best-known example of smut is the common smut of corn, which often develops large pustules several inches in diameter which, when matured, liberate great clouds of black spores that fall as a black smudge. Smut may in some cases be confused with slime mold because of the dark-colored, dusty spore masses. The smut disease, however, is characterized by definite lesions on the leaves of infected plants.

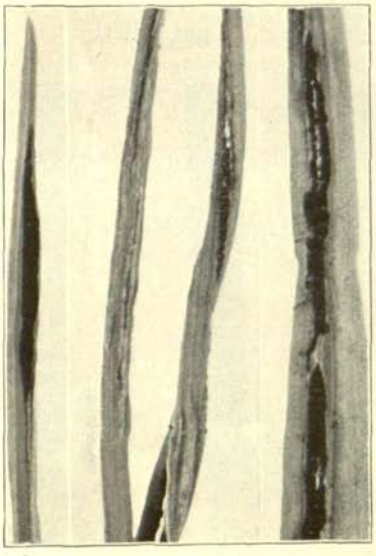


Figure 37.—Smut on Kentucky bluegrass caused by the fungus Ustilago striaeformis. The elongated pustules of black sootlike spores are apparent on each of these leaves. The characteristic twisting of the leaf blades affected by this fungus is shown in the second leaf from the right. The plant is dwarfed and the leaves yellow due to the systemic invasion by the fungus. The disease may cause extensive damage to turf by weakening and stunting the plants.

Extent of Injury.—Like the corn smut, a great many of the grass smuts attack the flowers and greatly decrease the yield of seed. Fields of colonial bent producing seed have been reported badly damaged by smut. In turf, smut fungi are capable of doing far more damage than are rust fungi. The plants which are attacked are stunted in growth. The disease may occur at any time of the growing season, but is most apparent in the spring. It occurs throughout the United States. On golf courses smut has been found on Kentucky bluegrass and in isolated cases on creeping bent. In the spring one frequently finds areas of Kentucky bluegrass in which a large proportion of the plants are affected by this disease. No one has determined as yet just how much of the loss of bluegrass turf during the summer may be traced directly or indirectly to the weakening of the plants by the systemic invasion of this fungus. It is indeed probable that future observations will reveal that this disease is a far more serious turf pest than is commonly surmised.

Cause.—The common smuts are caused by a group of fungi somewhat similar to the rusts in that many of them are confined closely to definite species or groups of grasses. The smut on golf grasses is commonly caused by *Ustilago striaeformis*, although other species of smut fungi may cause the disease on the many grasses growing wild in the rough and along roadsides. The disease is called systemic, meaning that it grows throughout the entire plant, so that one frequently finds an individual plant of Kentucky bluegrass with every leaf striped with smut, whereas surrounding plants are entirely free from an attack even though the leaves from the diseased and healthy plants are intertwined and in close contact at numerous points. The diseased plant is usually dwarfed and yellowish in color and the leaves oftentimes are badly distorted even before any of the streaks of smut are in evidence.

No satisfactory treatment is known for smut on turf grasses.

Rust

Symptoms.—Rust first appears on the blades or stems of grass as small yellowish specks (figure 38). These gradually develop into well-defined yellowish or reddish pustules circular or elongated in shape becoming dark brown or black as they grow older. These pustules liberate dustlike spores, reddish or dark brown in color, which, like the numerous small pustules, have a fairly close resemblance to rust of iron, a fact which probably led to the common use of the name of rust for this type of disease.

Extent of Injury.—The rust fungi as a rule do not kill the leaves

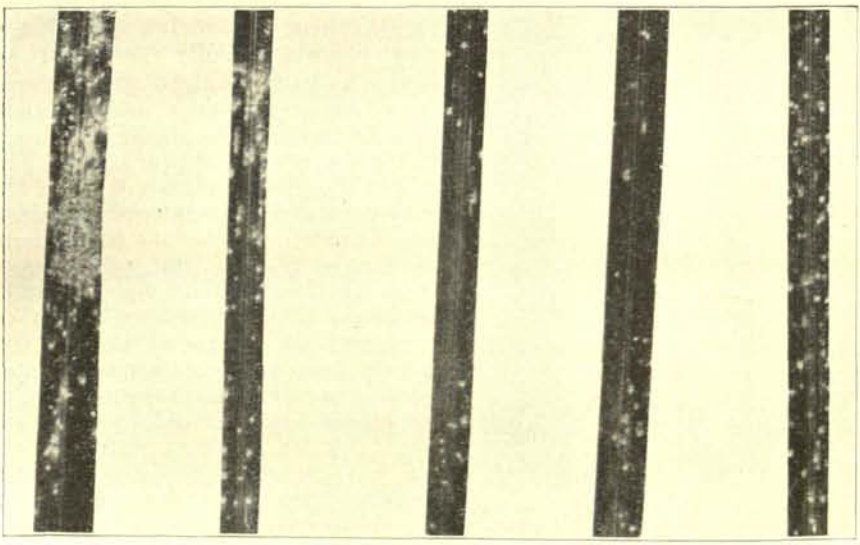


Figure 38.—Leaves of Kentucky bluegrass infected by one of the group of fungi causing leaf rust. The light spots on the leaves are the reddish pustules containing the spores of the fungus. Rust is the most important disease of the cereal grasses, but although frequently abundant on turf grasses it is not at present regarded as a serious golf-turf pest. Although a few leaves may be seriously damaged, the damage to the turf as a whole is usually slight.

on which they are found. They damage the plant by robbing it of some of its food supply and consequently cut down the yield of seed. Rust is usually evident during the early summer, but may occur at any time during the summer and fall. It is most severe in wet seasons. Although it is a serious factor in grain fields, it is usually of little consequence on turf grasses except where these are being grown for purposes of seed production. Under golf course conditions, therefore, although blades of grass are occasionally found badly spotted with rust, aside from a slight discoloration no harm is done and no treatment is necessary. It occurs on golf courses most frequently on Kentucky bluegrass, and may attack this grass wherever it is grown.

Cause.—The word "rust" is often erroneously applied to any condition of turf characterized by a scattering of browned leaves tending to give a more or less rusty appearance. As applied to plant diseases,

the word is more or less confined to diseases caused by a definite group of fungi. The well-known destructive rusts of cereals are examples of this type of disease. Most of the common grasses are attacked by one or more different species of rust fungi. Most of these fungi are restricted rather closely to definite species of host plants, as are also the fungi of the genus Helminthosporium, which cause the common leafspots of grasses. In some cases different strains of a single species of rust fungus may affect a large variety of plants. Varieties of the common species of grain rust (*Puccinia graminis*) affect not only wheat, barley, oats, and other cultivated grains, but also Kentucky bluegrass and other common turf grasses. Many other species of Puccinia, as well as species of Uromyces, are also found on the grasses in golf course turf.

No treatment is known for rust on turf grasses.

Mildew

Symptoms.—This disease (figure 39), commonly known as powdery mildew, appears on the surface of blades of grass as a thin,

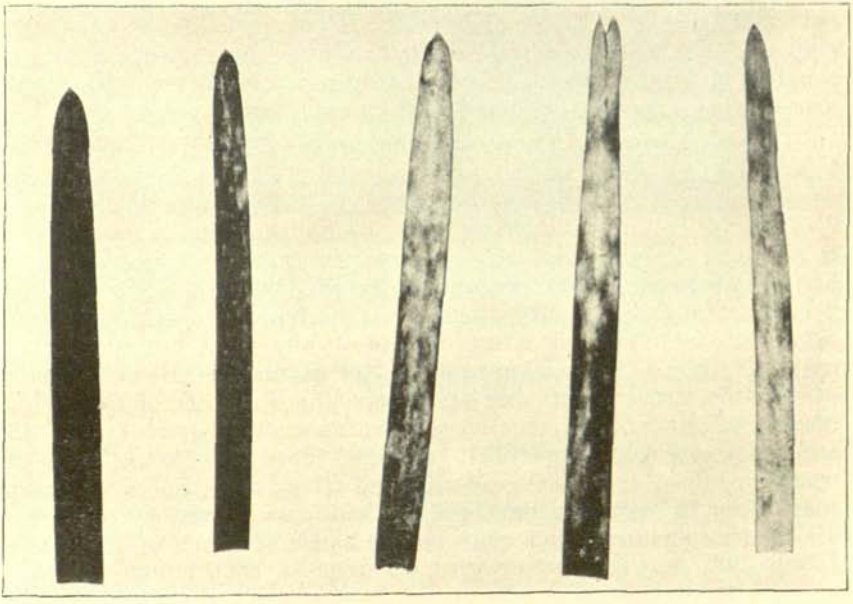


Figure 39.—Mildew caused by the fungus Erysiphe graminis on leaves of Kentucky bluegrass. The two leaves at the left are newly infested whereas the three at the right are well covered by the white, powdery growth of the fungus. This type of mildew is common on many wild and cultivated plants. It is not regarded as a serious pest of golf turf, although occurring frequently.

white, powdery growth, in many respects resembling the mold growing on the surface of old shoes or similar articles left in moist places. Heavily-infested turf has the general appearance of having been dusted with flour. If the mildew is wiped off the surface, the blade of grass usually will be found to be green and apparently uninjured

by the fungus. The older leaves, when covered with mildew, turn yellow or brown and dry out prematurely. Bluegrass turf occasionally is heavily infested with this fungus, particularly in the late fall months.

Extent of Injury.—The general distribution of the fungus may cause some concern to those not acquainted with it, but it will be found that except for the somewhat unsightly appearance no harm is done and the fungus will ultimately disappear.

Cause.—The mildew that occurs on golf turf is usually caused by the fungus *Erysiphe graminis.* This is one of a group of fungi which causes the same type of disease on a great variety of plants both cultivated and wild, the most common of which are the powdery mildews of lilac, grape, and rose.

Treatment.—When troublesome on turf the disease can be checked by lightly dusting or spraying with finely-powdered sulphur.

Miscellaneous Parasitic Diseases

In addition to the foregoing, there are many grass diseases which have been reported from time to time but which as yet have not been observed to cause enough damage to be economically important on golf courses except in a few isolated cases. These diseases may be common on wild grasses in roughs, pastures, or along roadsides, but usually they cause no serious losses in such places.

The grasses which are most common on golf courses are subject to attacks by a group of fungi which penetrate the leaves mainly and usually cause limited lesions described as leafspot, netblotch, stripe, eyespot, footrot, and spotblotch, depending on the characteristic form in which the lesion occurs. The fungi causing them are closely related and belong to the Helminthosporium group. There are a large number of fungi belonging to this group, and many of them are soil organisms which do not cause disease on any plant but spend their entire lifetime on the dead organic matter in the soil. However, many of them do attack plants and are responsible for some of the serious diseases of grasses, as in the cases of leafspot of bluegrass (page 146) and zonate eyespot (page 147). Some of these fungi attack only one species while others are less specific and attack many species. Fescue may often be seriously damaged by leafspots caused by species of Helminthosporium, which may be the cause of much of the loss of fescue turf during the summer. In general, each fungus causes a characteristic type of lesion on its particular host.

Several unimportant diseases occur as spots on leaves or stems, differing in characteristics depending on the causal fungus. Some of the most common of these are *Septoria graminum, Aschochyta graminicola,* and *Cercospora graminis.*

Many of the diseases of golf grasses are caused by the same fungi or by fungi closely related to those that cause disease on grains and agricultural grasses. Ergot caused by *Claviceps purpurea* occurs on the seed heads of many of the grasses. Anthracnose and takeall, caused by *Colletotricum cereale* and *Ophiobolus graminus,* respectively, are footrot types of diseases which occur commonly on grains

At certain times large numbers of individuals of the same species grow together and develop dense masses which soon break up into innumerable small spores. This massing for spore formation is the only stage at which slime molds are discernible on turf. In direct sunlight the masses may quickly dry and shrivel; otherwise they may retain their form until spores are mature, when the entire mass breaks apart and the spores are blown or washed away.

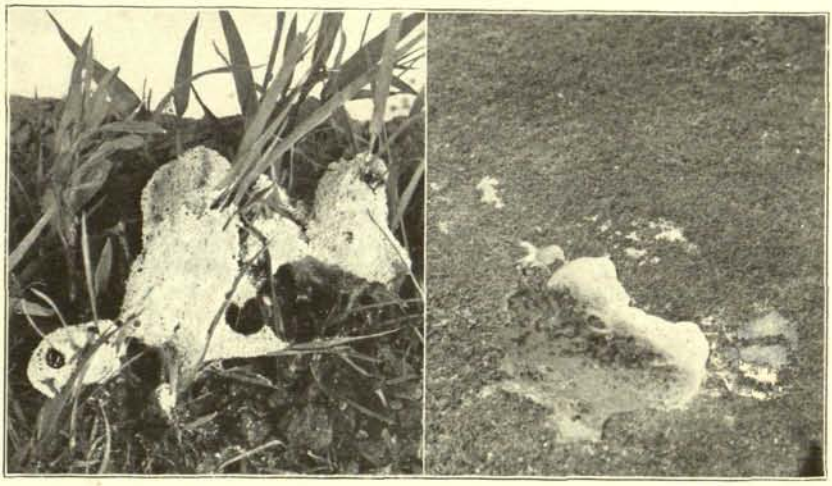


Figure 42.—Slime mold, two varieties of Fuligo septica, occurring on grass. On the left is a slime mold on grass in the rough, growing over the stems and leaves of the plants. It does not directly attack the grass. On the right is a slime mold occurring on turf. This organism appeared during a warm wet period in the summer and developed for two days, after which a hard crust was formed. When the crust broke down a mass of sooty spores was released which discolored the surrounding grass. This type of slime mold can be picked up easily from the turf when it is in the crustlike stage.

Treatment.—Where only small spore bodies are produced, it is usually best to ignore them until they turn black, when they can be washed away with ordinary sprinkling. Large masses, such as seen in the illustration, occur only occasionally, and these can be picked from the turf by hand.

Scald

Scald is a popular name applied in a general way to several different types of injury, chiefly nonparasitic. The term is used to apply to almost any type of browning of turf which appears to be scalded. Under the term scald greenkeepers frequently include injuries caused by salt concentration, chemicals, excessive water, excessive acidity, drought, and by many other agencies. In many cases the term is used loosely to include brownpatch and other fungus diseases as well as insect injuries, and almost any type of dead turf the cause of which is unknown or not recognized. As scald has been used to designate almost any type of turf injury occurring during the summer, winterkill has been used loosely to include all types of winter injuries.

and grasses. Under certain conditions these fungi may contribute largely toward loss of golf course turf.

Any of the fungi occasionally occurring on the wild grasses adjacent to the golf course may attack the turf grasses if conditions become favorable. A Sclerotium disease occurring frequently in damp meadows and in stands of wild grasses is caused by *Sclerotium rhizodes*. The most common host of this fungus is bluejoint grass, but it may also occur on turf grasses.

Occasionally injuries on turf, apparently caused by fungi and other parasitic organisms, are found on golf courses, but their true causes have not as yet been established. An injury appearing as a pink mold has occasionally been observed on velvet bent turf. Nematodes and a certain bacterium have been observed in abundance in such turf, but their relation to the injury has not been determined.

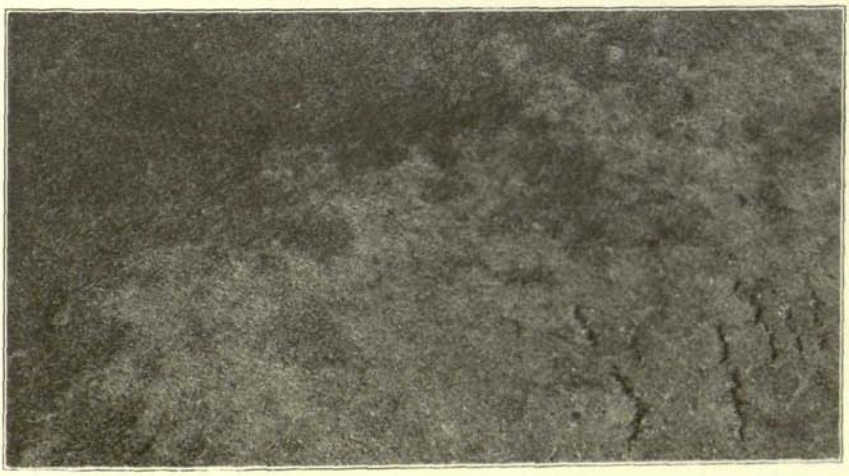


Figure 40.—Black or green scum on turf caused by growth of algae. Such a growth frequently develops on turf that has been killed or weakened by diseases. The scum is at first green, but when the surface of the turf dries the algae at the surface of the scum die and turn black. Later when there is sufficient moisture the algae resume growth and the scum gets thicker until a heavy crust is formed. This crust may get so thick that it smothers the grass. New shoots are unable to penetrate the crust and the turf can not heal. In the illustration the crust in the lower right corner has been lifted with a knife to show how it completely covers the dead turf.

Many of the uncommon diseases may occur on turf only in rare cases and may not come to the attention of the greenkeeper. At any time, however, one of these relatively unimportant diseases may become troublesome without warning and require new methods of culture and control. There are undoubtedly many other turf parasites which have not as yet been recognized as the cause of diseases. Furthermore, some of the injuries now supposed to be due to nonparasitic causes may upon further study prove to be due to some parasitic organism.

Black or Green Scum

Symptoms.—The scum usually appears first as a thin green covering on bare spots of ground or mats of dead turf. It thickens gradu-

ally, usually turning darker. Later it develops into a tough, parchmentlike coating, which may become as thick as heavy paper (figures 40 and 41). When wet it feels soft and slimy; when dry it feels hard and stiff and frequently cracks and curls up. When it becomes heavy it usually makes such a dense covering that new shoots of grass beneath are smothered and prevented from developing. As a consequence, large areas covered with the scum are apt to remain bare for long periods, due to the inability of new grass to penetrate the covering. This scum may be confused with a crust resulting from a concentration of salts on the surface. In the latter case, however, the color is usually white or gray.

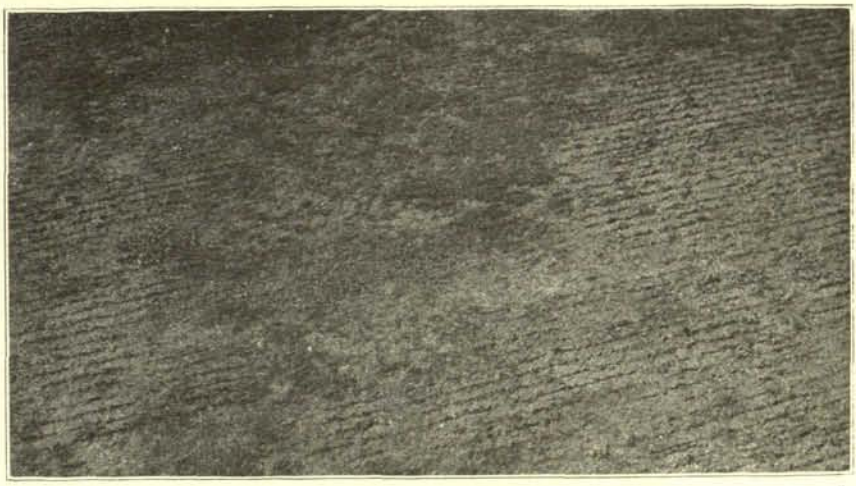


Figure 41.—Treatment of black scum. The hard crust, which is also shown in figure 40, may be eliminated by raking. The crust in this illustration has been raked in one direction with an iron rake. It should be raked in several directions until the crust is loose, and the material may then be removed. When the grass is badly damaged the turf may need replanting.

Extent of Injury.—The algae causing black or green scum occur in practically every climate and the scum is likely to be found on any golf course. Under certain favorable conditions they may develop even on sand greens, but are usually troublesome only where competing with turf on putting greens or where present in drinking water or bodies of water on the course, in which cases the odor from the decomposing algae is objectionable.

Cause.—Scum is a growth of algae (small, single-celled or filamentous green plants) occurring in water and moist places. Algae are common in lakes, ponds, or sluggish streams, frequently rising to the surface to form green scums. They find conditions favorable for development on soil kept well watered, particularly if there is an abundance of decomposing organic matter rich in nitrogen. In the absence of a vigorous turf they grow together to form dense mats.

Treatment.—Algae can be controlled in reservoirs, water hazards, or other bodies of water by adding copper sulphate at the rate of 1 pound to one million gallons of water. Excessive quantities of this

chemical may prove toxic to certain species of fish and to vegetation. The use of water heavily infested with algae for watering greens may hasten somewhat the formation of scums of algae on putting greens. Algae, however, are so generally distributed that they are likely to infest greens whenever conditions are favorable even though the water supply itself is entirely free from algae.

Any treatment of putting greens which will prevent the loss of turf will prevent the development of scums, since these seldom develop seriously in turf unless the grass has been injured. When scums begin to form they can often be checked or actually destroyed by a spray distributing corrosive sublimate at the rate of 1 ounce to 1,000 square feet. When heavy scums develop they should be broken by disking, spiking, or raking the surface until the crust is well broken (figure 41), after which the putting green should be topdressed with a sandy loam compost. Since algae grow in water or where there is ample moisture, it is important to water putting greens as little as necessary wherever algae are becoming troublesome. Frequent light watering which keeps the surface soil soaked will encourage the growth of algae (pages 108 and 109).

Slime Mold

Symptoms.—Different species of slime molds produce different types and forms of spore-forming masses, but all have many common characteristics. Some species of Physarum commonly appear as small, elongated, capsulelike spore masses growing upright from the surface of leaves of grass, clover, or weeds. So small are they that dozens or even hundreds may be found on a single blade of grass. At first they are steel-gray, later black. They are often so numerous that patches of grass several feet in diameter seem to be entirely covered with a steel-gray dust. Such patches later have the appearance of being well dusted with soot. The spores of other slime molds, particularly varieties of *Fuligo septica*, instead of being produced in myriads of small capsules, occur in single large masses several inches across; these are shown in figure 42. At first they are white, yellowish, or gray, but soon turn dark, and later the entire mass is black. In still other cases the mold appears first as thin, white, yellow, or gray layers of a slimy, pastelike substance, usually of irregular form and with a rough, wavy surface. These layers quickly change shape and build up to form the completed mass, which is usually gray or yellowish in color.

Extent of Injury.—Usually the slime molds are not troublesome on golf courses even though they may excite alarm because of the strangeness of their appearance and the denseness of their mass. Sometimes they cover the turf so completely that one naturally expects to find that the grass beneath will be quickly killed. As a rule, however, they cause no injury to the turf, and after the spores have matured, which seldom takes more than two days, they can be easily washed away, and the grass will continue to grow as if nothing had happened. The molds occur on turf most commonly in warm weather when there is ample water.

Cause.—The slime molds are fungi which normally grow in soil or decaying organic matter where there is a good supply of moisture.

At certain times large numbers of individuals of the same species grow together and develop dense masses which soon break up into innumerable small spores. This massing for spore formation is the only stage at which slime molds are discernible on turf. In direct sunlight the masses may quickly dry and shrivel; otherwise they may retain their form until spores are mature, when the entire mass breaks apart and the spores are blown or washed away.

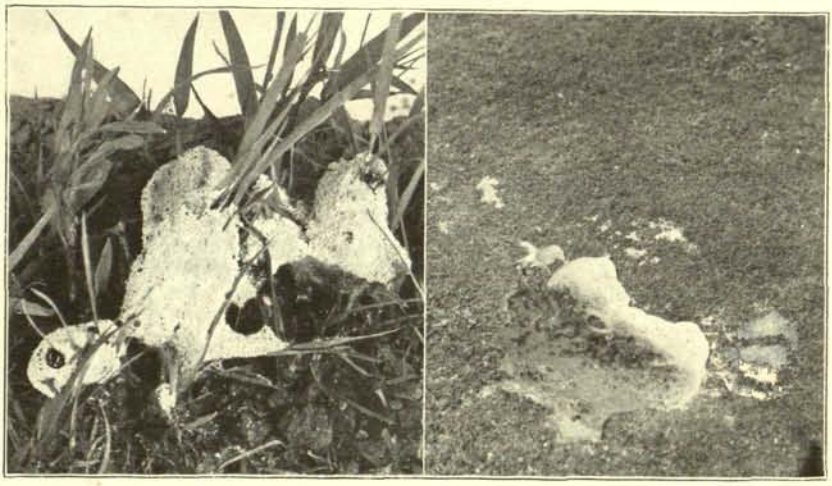


Figure 42.—Slime mold, two varieties of Fuligo septica, occurring on grass. On the left is a slime mold on grass in the rough, growing over the stems and leaves of the plants. It does not directly attack the grass. On the right is a slime mold occurring on turf. This organism appeared during a warm wet period in the summer and developed for two days, after which a hard crust was formed. When the crust broke down a mass of sooty spores was released which discolored the surrounding grass. This type of slime mold can be picked up easily from the turf when it is in the crustlike stage.

Treatment.—Where only small spore bodies are produced, it is usually best to ignore them until they turn black, when they can be washed away with ordinary sprinkling. Large masses, such as seen in the illustration, occur only occasionally, and these can be picked from the turf by hand.

Scald

Scald is a popular name applied in a general way to several different types of injury, chiefly nonparasitic. The term is used to apply to almost any type of browning of turf which appears to be scalded. Under the term scald greenkeepers frequently include injuries caused by salt concentration, chemicals, excessive water, excessive acidity, drought, and by many other agencies. In many cases the term is used loosely to include brownpatch and other fungus diseases as well as insect injuries, and almost any type of dead turf the cause of which is unknown or not recognized. As scald has been used to designate almost any type of turf injury occurring during the summer, winterkill has been used loosely to include all types of winter injuries.

It has been suggested that the heat of the sun on bright days in the summer may raise the temperature of the water in the soil to such an extent that actual scalding occurs; it is improbable, however, that the temperature of the water in the soil ever reaches a point that would cause injury to plants. True scalding of plants—that is, injury from actual exposure to water of high temperature—has not been sufficiently studied to determine whether such injury actually occurs on turf.

Winterkill

Winterkill is a term that has been applied to injuries to turf that occur during the late fall, winter, or early spring (figure 43). The term has been used to designate a number of winter injuries the causes of which have not been understood, just as many summer injuries of turf have been designated in a general way as scald. In

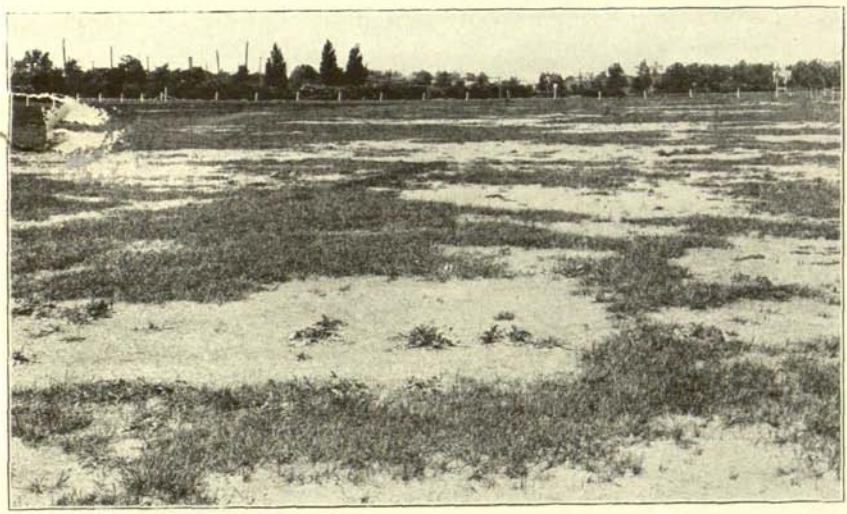


Figure 43.—Winter injury in a public park in Minnesota. This loss of turf was probably due to a combination of factors including poor drainage, a late spring cold wave, and possibly some snowmold.

some sections of the country injuries from certain causes are attributed to winterkill while in other sections injuries from quite unrelated causes are also called winterkill. The loose use of the term to include any type of injury that occurs during the cold periods of the year has led to some confusion. The important causes of injuries that have been referred to as winterkill are frost, snowmold, poor drainage, and drying of turf by long-continued, cold, dry winds.

Injury from Poor Drainage

Symptoms.—Turf is frequently injured by excessive water in the soil due to poor drainage. In such cases it usually becomes thin and is likely to become easily invaded by certain weeds. Turf on poorly-drained areas is apt to turn brown during hot weather and develop

symptoms commonly referred to as scald; during the winter such injury is frequently designated as winterkill (figure 44). The areas of turf injured by poor drainage are usually large and irregularly-

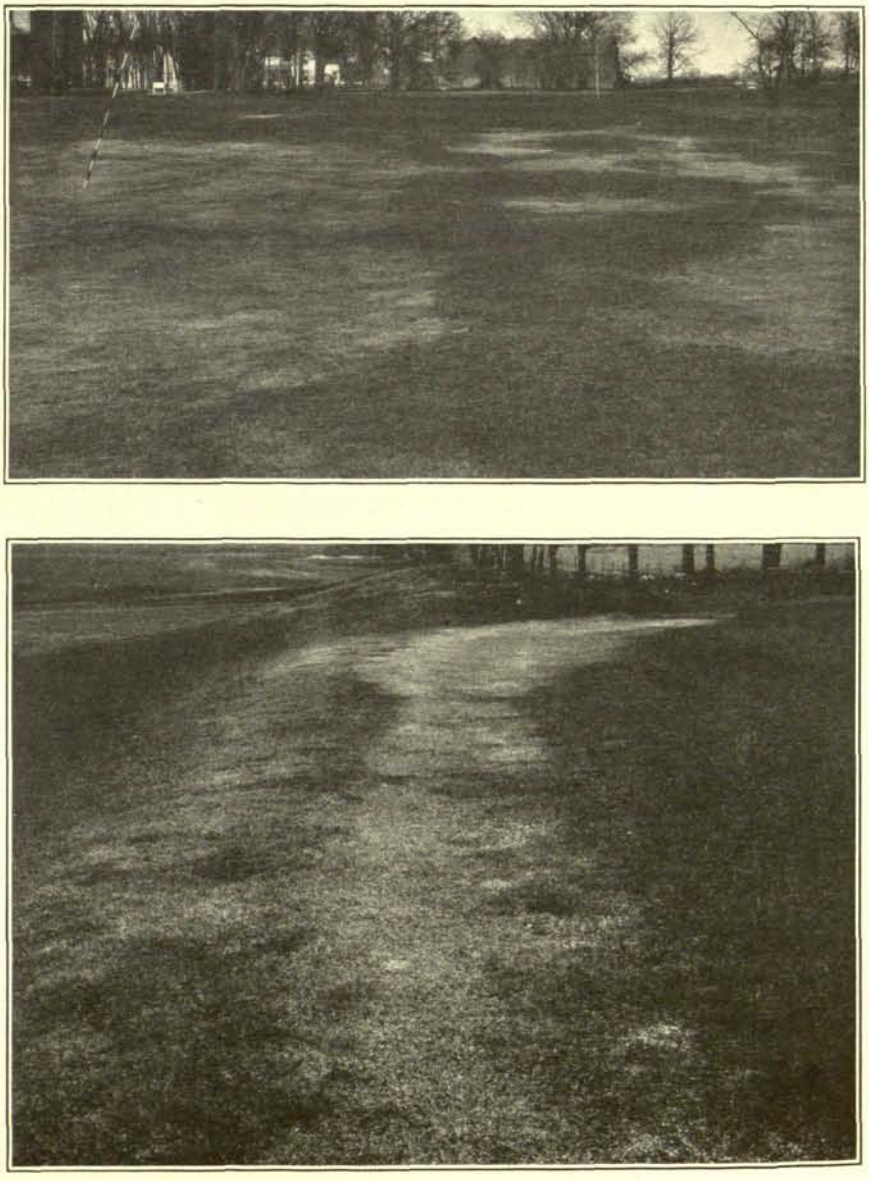


Figure 44.—Injury caused by poor surface drainage during the winter and early spring. In the upper view the surface drainage was completely ignored when the putting green was built. Water standing in the low areas when the snow was melting killed the grass. In the lower view a ridge across the entire green served as a dam interfering with surface drainage. When the underdrainage is rendered ineffective by the frozen soil, surface drainage is very important in removing water from melting snow or from rainfall.

shaped with the greatest damage in the central portion and the injury gradually tapering toward the outer edges of the areas. The grass first becomes yellow and has an unthrifty appearance, later becoming brown as the leaves die. In winter the areas of dead turf resulting from poor surface drainage are characteristically browned or bleached.

In summer injury caused by poor drainage may be confused with high salt concentration, unfavorable soil acidity, and chemical burns, when careless watering has washed large amounts of chemical treatments into the low places on a putting green, and in winter it may be confused with that of snowmold and the drying of windswept areas.

Extent of Injury.—Poor soil drainage occurs most frequently in heavy soils. The areas of turf that are injured may be only a foot or two across or they may extend to include several acres. Often the turf continues to live on poorly-drained areas but the growth is weak and unthrifty and rendered more susceptible to other injuries.

Faulty surface drainage may also cause loss of turf. This may occur during the summer when water from heavy rains collects from surrounding higher areas. Damage from poor surface drainage is most common in the winter and early spring. In mild cases of the injury developing at that season a sufficiently large portion of the affected grass recovers to produce a thick turf as soon as sufficient growth is produced in the spring. On the other hand, in many cases most of the affected area is killed. The damage may occur wherever the ground remains frozen for a long period, but its greatest severity is in the northern tier of states. The seeded putting greens seem to be slightly more susceptible than those planted with stolons of the common varieties of creeping bents.

Cause.—Defective drainage may occur as poor soil drainage or as poor surface drainage. When either type occurs during the growing season, the air is displaced from the soil around the roots of the plants and if this condition continues long the grass is drowned. In cases of the common type of injury from poor surface drainage that occur in winter and early spring, the water covers the stolons and leaves of the turf when the ground is frozen and the grass is killed even though the roots may not be affected by excessive water.

Poor soil drainage often is caused by heavy soil which holds water for long periods after rains or artificial watering. Putting greens that are constructed in low places where the water table is close to the surface may also suffer from poor drainage. There seems to be an erroneous general opinion among those in charge of golf courses that poor-drainage problems arise only in low areas. As a matter of fact, many of the most serious cases of loss of turf due to poor drainage on golf courses occur on high land or on steep hillsides. It is usually recognized that low areas are in need of tile drainage, and it is provided. Hillsides, however, or other high areas needing drainage, are more often neglected, and the poorness of the turf in such places is naturally attributed to some other cause. Shelves of clay, hardpan, or rock a few inches or feet below the surface soil may extend close to the surface in a fairway or at the edge of a tee or putting green. Underground water running across these shelves

may seep out upon the surface soil at the edges of the shelves and keep large areas of turf thoroughly soaked for weeks after heavy rains.

Damage from poor surface drainage in winter usually occurs in low pockets where water stands on turf, but it may also occur on higher ground where water from melting snow has accumulated due to the temporary blocking of drainage by mounds of snow or ice. Low areas of turf in which water does not remain long during the months when there is no frost in the ground may be covered with injurious pools of water when surface water is unable to escape through the frozen ground. If water remains on poorly-drained areas for long periods during the late winter and early spring the grass is likely to be killed. A mere covering of turf with ice, as is the case with the so-called ice storms, does not injure turf, even though the sheet of ice remains for many weeks. There are also numerous cases where turf has been flooded and covered with ice for skating rinks or in natural freshets without any apparent damage to the grass beneath. The damage seems to be due to the smothering or drowning of grass which is covered by water and possibly a thin layer of transparent ice. Grass at the bottom of these shallow pools of water, due to the protection they provide against low air temperature during the night, seems to start growth earlier than grass in the open and is thereby weakened. Moreover, the grass blades are also able to absorb sufficient heat from the sun penetrating the thin ice and water to stimulate growth even when the temperature of the air to which grass in the open is exposed may be well below the freezing point. Snowmold may also contribute to the loss of grass weakened by this covering.

Treatment.—The solution of poor-drainage problems simply involves the installation of an adequate drainage system (pages 106 and 107). There are many systems which are available, but the modern tile drainage is generally regarded as the most satisfactory for golf course use. The best time to determine whether a part of the golf course is in need of drainage is after the spring thaw. At that time it will be found that some portions of the course remain wet and soggy weeks after all frost has thawed from the ground and long after other parts of the course are dry and in good playing condition. Some putting greens present special drainage problems, which can not be handled adequately with the usual tile drainage. For example, where seepage threatens a green there should be provided protection by the laying of a tile drain deep enough to intercept seepage water from the elevations. To make certain of intercepting all of the seepage water, the tile should be placed so as to catch the water before it reaches the green, and the trench should be filled with cinders and rocks to within 8 inches of the surface.

Injury in winter and early spring can be avoided by adequate surface drainage, also by opening drainage channels through any drifts of snow which may block the escape from the turf of water from melting snow. In severe cases resodding of the dead areas is sometimes necessary.

Injury from Moisture Deficiency

Symptoms.—Absence of sufficient soil moisture during the growing season causes blades of grass to wilt and assume a bluish or slate

color. If the grass is watered when it is in this condition it often recovers, but when the moisture deficiency continues the grass dies and becomes brown (figure 45). Even in winter, when the ground

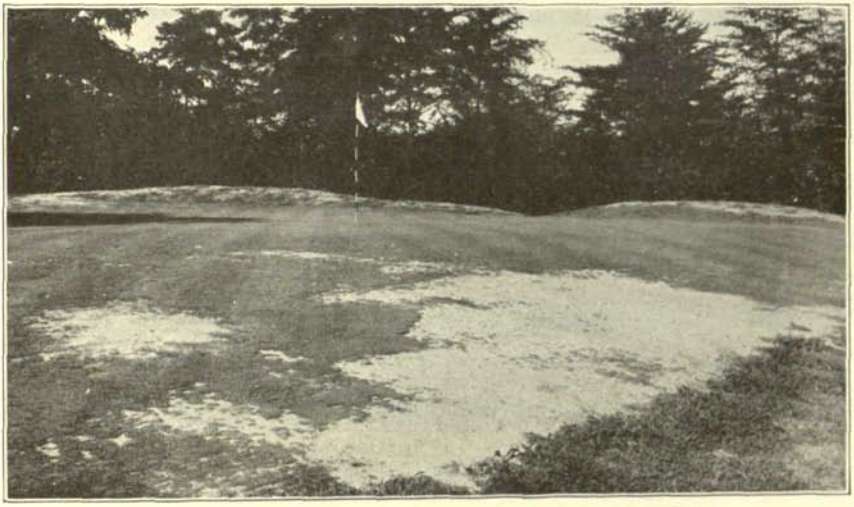


Figure 45.—Damage caused by drying of turf due to insufficient water on the elevations of a putting green. A mat of turf had developed on these elevations which served as a thatched roof in shedding water. As a consequence most of the water which fell as short heavy showers or which was applied in rapid watering ran over the surface of the mat and was prevented from penetrating the soil. A similar shedding of water may occur without a mat wherever physical conditions of the soil are unfavorable or where soil has become excessively dry. Areas such as these should be given more water than the depressions and must be watered by hand in some cases. These areas should also be raked frequently to prevent development of a mat.

is not covered with snow, knolls and ridges may become injured by cold, dry winds enduring for long periods of time, and indeed large areas of a putting green may be so affected (figure 46). Such drying of the soil has by some been erroneously attributed to the inability of the turf to withstand low temperatures. Grass suffering from moisture deficiency when the ground is frozen is affected gradually and finally turns a light-brown color.

Extent of Injury.—The injury may occur in small, limited areas, or it may extend over a large part of a putting green. It occurs often around the edges of a putting green or on knolls or ridges. Any grasses grown on putting greens may be injured by deficiency of moisture. The injury may appear at any time of the year.

Cause.—The damage on ridges of a putting green or on surrounding elevations may be due to improper watering. In some cases on areas only slightly raised a mat of turf may be so dense as to shed water much as is done by a thatched roof. Water is thus prevented from entering the soil, and as soon as the top layer of turf dries the grass wilts. Wilting also occurs in small limited areas where for some reason the soil has become very parched and hard. These areas may be but a few inches in diameter. The drying of such areas may

be due to an old fairy-ring type of fungus growth in the soil which prevents penetration of water (figure 36). This may be the case even though all indications of the presence of the ring have for a time disappeared. The injury may also be due to faulty construction, pockets of stiff clay being left in the soil as a result of insufficient mixing. The clay in such pockets may harden and cause trouble. Excessive drying of the surface soil may also occur where buried layers of sand, peat, or other materials prevent the normal rise of capillary water from the soil below.

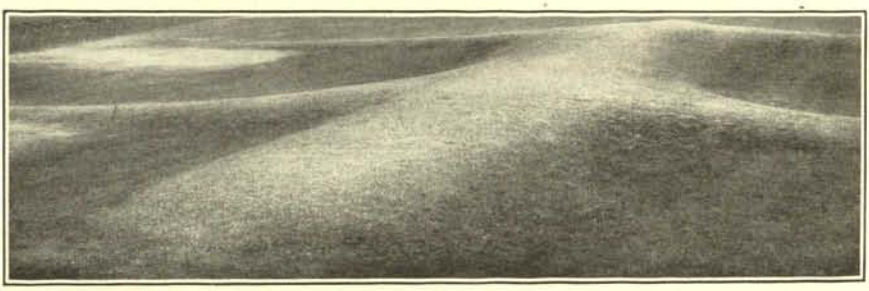


Figure 46.—On this putting green a mound was built in imitation of one of the Indian mounds commonly found in certain sections of the country. Wind keeps the snow swept from the mound so that throughout the winter the grass is exposed to cold, dry winds resulting in the light-brown color in the bare areas as contrasted with the dark green where the turf was protected by a blanket of snow. The photograph shows the lighter appearance of the grass along the crest of the mound. This type of injury seldom amounts to more than a slight delay in early spring growth. More serious injury over winter is caused by defective surface drainage. A low area in the upper left of the picture may be seen badly damaged by excess water.

Treatment.—A person watering a putting green is apt to forget that the elevations should receive more water than the low places, since the runoff collects in the low places, leaving the elevations dry (pages 108 and 109). The watering of elevations should therefore be continued for a longer period so that more water can be absorbed. Wilting can be prevented by care in watering and the removal of any cause which may prevent the penetration of water into the soil. Elevations on a putting green should be watered by hand, if necessary. It is good practice to cut out plugs of turf after watering, so as to ascertain whether or not sufficient water has penetrated.

If an impervious mat of turf has developed, this may be removed by spiking the turf thoroughly with large spikes and then topdressing with a good sandy loam, working the topdressing into the spike holes (pages 111 and 112). The more material that can be worked into the layer of turf, the more quickly will the turf recover. Large dead areas resulting from pockets of hard soil may be helped also by spiking; if the areas are small, the soil can be removed and replaced with soil of a good texture. The same treatment may be given to soil where the injury is due to the activity of fungi.

As a preventive of drying of turf during the winter the covering of putting greens with straw has at times past been attempted. This practice has now been largely abandoned due to the consequent and more serious injury from the snowmold fungus (figure 53). A better

protective measure is to construct barriers or fences to hold the snow and to deflect sweeping winds.

Injury from Faulty Soil Texture

Symptoms.—Where soil texture is faulty, turf will become thin and easily dominated by weeds. Although under favorable weather conditions grass may thrive even though the soil texture is faulty, during periods of hot, dry weather large irregular areas of damaged

Figure 47.—Injurious layers may be formed on a putting green by the improper use of topdressing materials. The six clearly-defined layers of soil were formed in as many seasons of topdressing. A highly-plastic soil was used for topdressing purposes throughout the growing season and each winter a heavy dressing of sand was applied. Satisfactory results would have been attained had the soil and the sand been mixed for use during the growing season.

putting green turf may result from faulty soil texture. The soil becomes hard and baked and the grass gradually dies. Young plants seem unable to force their way up through the hard top crust of the soil.

Extent of Injury.—The injury caused by faulty soil texture occurs generally on many golf courses in this country. Often putting greens become too hard to control even a well-played pitch shot and golfers demand that the putting green be softened. This is often done by excessive watering, which may cause the turf to die. This type of injury is very common.

Cause.—Faulty soil texture prevents the grass from growing vigorously because the soil becomes too hard. The root system becomes restricted, the soil dries too rapidly and water is unable to penetrate through the soil. In such cases also, excessive rainfall or artificial watering followed by periods of drought is likely to encourage injury to turf. A clay soil when wet commonly becomes puddled by the trampling of players or workmen or by machinery. Putting greens are often puddled by players trampling on greens during the period when frost is leaving the ground. When puddled clay soil dries it becomes extremely hard and requires frequent watering to soften it enough for play. This excessive watering further adds to the difficulty of maintaining the covering of grass. In some cases layers of distinctly different materials have been added to putting greens (figure 47), and as the successive layers are covered deeper by topdressing material they interfere with the natural capillary movement of water through the soil and also prevent the normal development of roots. Even though the physical condition of the surface layer of soil may be satisfactory it may, in some instances,

be too shallow to support a good turf throughout the season. Large rocks, layers of clay, or similar substances close to the surface may result in patches of poor turf during the summer months.

Treatment.—When the physical condition of a clay or silt soil is responsible for poor turf the most effective remedy is to strip off the turf and improve the soil by thoroughly mixing with it sufficient sand and organic material to reduce its tendency to puddle. Where this treatment is impractical it is advisable to topdress frequently and heavily with soil of a satisfactory composition. On large areas even this latter treatment may not be feasible, and in such cases the installation of adequate drainage and the judicious use of water may greatly reduce the damage (pages 105 to 114). Some clubs, particularly in the northern section of the country, close their courses during spring thaws to prevent puddling of soil on greens.

Injury from Chemical Deficiencies in Soil

Symptoms.—Large areas of a putting green, or even the entire surface, may become yellow or otherwise discolored. Often turf fails to respond to applications of the customary fertilizers or shows little or no improvement after treatments with fungicides. It may retain its unkempt appearance for several weeks, then gradually resume its normal color. Injury from chemical deficiency may be confused with injuries from salt concentration, unfavorable acidity, faulty soil texture, and grubs.

Extent of Injury.—Chemical deficiency in soil may occur everywhere that turf is grown and on any grass. It may occur on putting greens and on fairways and tees. It is most common on putting greens because the grass is forced to grow more vigorously there and the necessary chemical elements are removed with the grass clippings in large quantities. Deficiencies of nitrogen, phosphorus, and potash are very common on golf courses and many cases of calcium and magnesium deficiencies have been observed. Deficiency of other necessary elements is less common, since in most soils there is a sufficient supply of elements to meet the needs of the plants.

Cause.—Injury of this type may be due to a lack of one or more of the important plant foods in the soil. All growing plants require a sufficient quantity of several different elements, including carbon, hydrogen, oxygen, nitrogen, calcium, magnesium, potassium, phosphorus, sulphur, iron, manganese, and copper. Though the soil may have an abundance of all these elements with but a single exception, the lack of any one may be the cause of a weak growth of turf. Most soils are naturally abundantly supplied with the majority of these elements, and in practically every soil may be found at least traces of all. To obtain satisfactory turf on most soils it is necessary to supply only water and the common fertilizers, which contain nitrogen, phosphorus, and potash, since these are the elements which a plant uses in larger quantities. In many instances, however, the removal of other necessary elements through grass clippings, together with the leaching by rains and artificial watering, make it necessary to replenish them. Calcium and magnesium are most frequently needed to furnish turf with a balanced diet, and may be supplied in the form

of lime. Soils also often become deficient in iron, resulting in a general yellowing or bleaching of the grass.

Deficiencies in some elements may further be caused by excess of others, thus upsetting the chemical balance in the soil and tying up one or more elements in insoluble combinations (pages 97 to 99). Iron deficiencies, to which velvet bent seems particularly sensitive, are sometimes caused by the excessive use of fertilizers high in phosphorus.

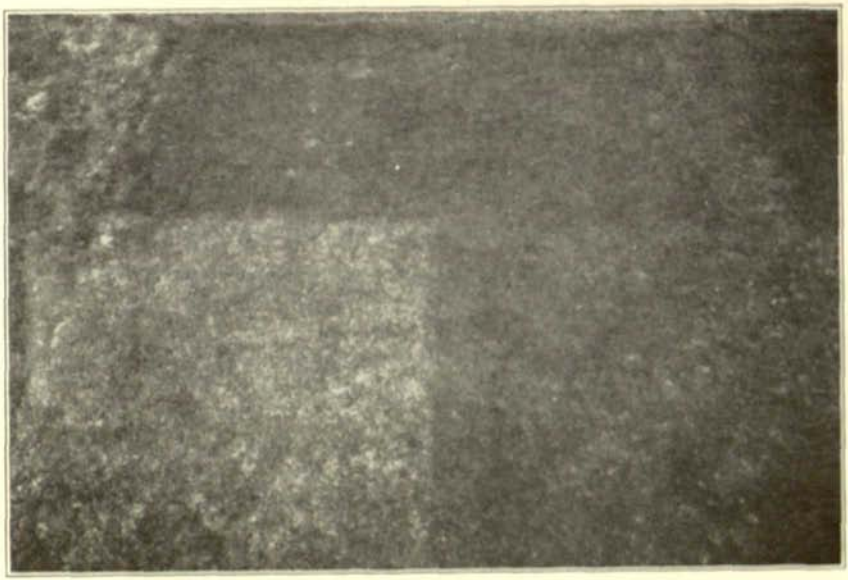


Figure 48.—An example of correcting a chemical deficiency in soil. Turf can often be improved by application of iron sulphate. The three dark, healthy plots shown in this illustration were treated with iron sulphate while the light, unhealthy plot in the lower left corner did not receive any treatment. The grass in this last plot was yellow and unthrifty and clearly showed evidence of an iron deficiency.

On some soils, particularly some of the sandy soils of the southeastern United States, there is a deficiency of manganese, and turf on such soil is greatly benefited by the addition of some manganese salt, usually manganese sulphate. It has been found that some muck soils are deficient in copper, when the growth of plants is greatly stimulated by very light applications of copper sulphate.

These and other chemical deficiencies occur in soils from time to time and result in weakened turf. They can easily be corrected by the addition of small amounts or traces of the element that is deficient or by correcting certain conditions in the soil which would liberate to plants certain of the elements which may be so chemically tied up as to be unavailable.

In explaining turf problems on the basis of chemical deficiencies it should be remembered that most soils are abundantly supplied with all of the elements except the three common fertilizing elements and lime.

Treatment.—When grass begins to appear yellow and unthrifty the first attempts to correct deficiencies should start with an application of nitrogen in some quickly-available form, as nitrogen is most generally the element that limits the growth of grass (pages 110 and 111). When nitrogen fails to give proper response it is well next to consider the possibility of the lime shortage. Next one should make sure that ample phosphorus and potash are present before turning to iron and the other elements for relief. Iron may be supplied to the soil in the form of iron sulphate, the usual rate of application being from 1 to 3 pounds to 1,000 square feet (figure 48).

Injury from Salt Concentration

Symptoms.—Grass growing on soil in which the salt concentration becomes excessive turns dark, withers, and dies much as though suffering from drought (figures 49 and 50). Along the borders of affected areas there may be a band of weakened turf where the con-

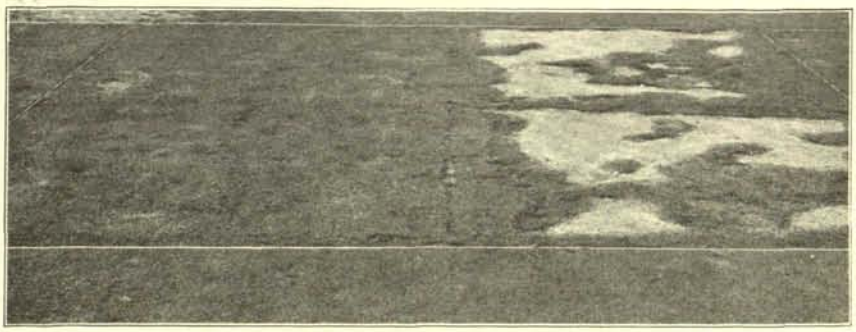


Figure 49.—Turf injured by high concentration of salt in the soil (see also figure 50). An incrustation of salts frequently forms on the surface of the soil in these dead patches. The turf in the damaged plots on the right is growing on pure clay and the healthy turf on the left is growing on similar clay to which organic matter has been added. All of the plots were given similar heavy rates of fertilizer and had similar cultural treatment. Organic matter in soil tends to decrease the effect of excessive salt concentration.

centration is not sufficient to kill all the roots; however, as the salts concentrate, more roots are killed and the dead and weakened areas keep gradually extending. Some time after the damage has been done the grass may recover along the borders where only part of the roots have been killed. At such times the affected areas may be clearly defined and show no signs of weakened grass along the borders.

Extent of Injury.—Salt concentration usually affects large areas, but in some cases the damage is localized and affects only small spots a few inches across. Loss of turf from this cause usually occurs during periods when there is rapid evaporation from the soil due to the more rapid movement of soil moisture to the surface and the consequent concentration of salts carried up by the soil water. When areas in which grass has been killed by excessive salts are reseeded the seedlings fail to emerge from the soil or are killed soon after they come through. Frequently there is a band of new grass around the edges of the reseeded areas when the center fails to show any seedlings.

Cause.—Injury to plants from excessive salt concentration is due to the inability of roots to withstand more than a certain amount of salts dissolved in the soil water. All soil water contains some salts in solution. When water moves upward through the soil by capillary action as the surface layer becomes drier, it brings with it additional salts in solution. When the water evaporates from the surface it leaves behind the salts it held in solution, and as more and more water is evaporated the surface of the soil is left with an increasing amount of soluble salts. This action is similar to that which is commonly observed when a glass of water containing table salt or some other soluble salt is permitted to evaporate; the solution becomes increasingly concentrated until finally the dry salt is left behind on the glass.

Figure 50.—Bermuda turf injured by high concentration of common salt. The soil on which this turf was planted was pumped in from a salt-water lagoon two years before the photograph was taken. Such a condition is difficult to correct and emphasizes the need for carefully selecting the materials to be used in the construction of golf courses. Where circumstances permit of little choice, as in the above case, every effort should be made to remove such toxic substances from the soil or to neutralize them.

Common table salt is often the cause of concentration injury to turf, especially along the seacoast where sea water has left a deposit of salt in the soil (figure 50). There are numerous ways in which this salt is unknowingly applied to golf course turf even on inland courses. For instance, manure may contain some rock salt, and mixtures of fertilizers may leave a residue of common salt in the soil. There are, however, many other salts beside the common table salt which may cause injury to turf when they become too concentrated, among which are many of the salts contained in commercial fertilizers and manures. Grass can stand relatively large amounts of some salts, whereas others in comparatively small quantities are toxic. Copper salts even when used in small amounts, as in the case of Bordeaux mixture used to control brownpatch (figure 20), have resulted in sufficient concentration in some soils to cause death of the turf.

Concentration develops when there is a large loss of water and diminishes when there is ample rainfall or artificial irrigation. When soils are well drained so that excessive salts leach away rapidly there is little likelihood of damage. Turf on light sandy soils is therefore less likely to be affected by this injury than that on heavy soils. An abundance of organic matter in the soil also reduces the danger of salt-concentration damage.

Treatment.—Loss of turf from salt concentration can be avoided by using no more soluble salts than are needed for proper turf maintenance (pages 105 to 114). Adequate tile drainage should be provided wherever this injury appears. In certain types of soil a system of shallow mole drains with adequate outlets may be effective in helping to rid the surface soil of an excess of salts. On heavy soils the tiles should be close together and not more than 2 feet deep. Heavy soils should be further improved by adding sand and organic matter. Heavy watering to leach excess salts will check the damage, especially where there is good tile drainage. When small areas on putting greens have been killed by this means it is usually best to remove the soil and replace with some fresh soil which is not likely to contain too much salt.

Injury from Chemicals

Symptoms.—Grass is often injured or killed by excessive or careless applications of concentrated chemicals. Injury may also occur from some chemicals that have accumulated in the soil from repeated applications. When grass is directly burned by chemicals it first turns dark and later becomes yellow, and finally brown (figure 51). Grass which is injured from chemicals that have accumulated in the soil becomes yellow and later dies and turns brown. The injury often occurs in definite areas where chemical solutions have been slopped on the turf or where dry chemicals have been spilled. Uneven or excessive applications of chemicals may discolor or kill large areas of turf in more or less regularly-placed spots (pages 124 to 132). A common example is the occurrence of narrow streaks marking the outlets of a distributor used in applying fertilizer. Another example is that of the fairly regularly-spaced semicircular browned areas marking the injury from fertilizers or other chemicals broadcast by hand. When lumps of chemical are present in materials applied to turf, small definitely-limited spots of dead grass are found scattered about in the turf which are often confused with dollarspot and spotblight.

Turf is often killed by droplets of oil or gasoline which drip from mowers or other golf course equipment. The oil coats the blades of the grass and gives them a blackened appearance which is very similar to the early stages of spotblight, dollarspot, or brownpatch. Often extensive areas of turf on putting greens and fairways are dotted with spots killed by oil. Often they occur in a line where the oil has dripped from a single point on a mower.

When excessive amounts of chemicals are applied to turf the grass is often rendered extremely susceptible to injury from bruising. The injury from chemicals is often confused with injuries caused by unfavorable soil acidity, salt concentration, and some cases of poor

drainage. When direct burning of the turf occurs it may be confused with wilting of the grass due to moisture deficiency.

Extent of Injury.—Injury from chemicals may occur in small portions of a putting green or it may occur on large areas of greens or fairways. Careless spilling of chemicals usually occurs in small areas but when excessive applications are made whole putting greens or fairways may be burned. Injury from chemicals which have accumulated in the soil also vary in the amount of turf affected. Usually the low areas are more seriously affected because greater amounts of the chemical accumulate there due to the washing of chemicals by rains and watering from the higher areas. Turf is more

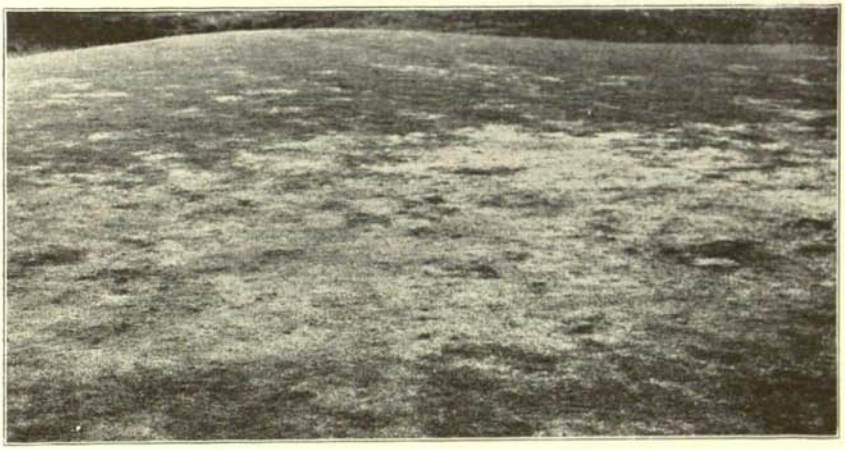


Figure 51.—An example of chemical injury in putting green turf. In this instance the damage was caused by the improper application of an organic mercury fungicide used in an effort to prevent brownpatch.

susceptible to injury from chemicals in the hot weather. Rates of application that could be safely used in the spring and fall can not be used in the summer. There are wide differences in the susceptibility to chemical burn among the different species or strains of grass used on golf courses. Creeping bent as a rule is less susceptible than other grasses but some strains of them, such as the Washington, are rather susceptible. Velvet bent is usually susceptible to chemical burn.

Cause.—Direct burning of turf is due to the inability of the grass to withstand concentrated chemicals on its leaves or roots. Often solutions of chemicals are applied to turf which in themselves are not concentrated enough to cause burning but when left on the leaves become more concentrated as the water evaporates. Chemicals that are applied dry absorb water from the soil and grass leaves and cause injury when the solution is too concentrated. The burning from some chemicals is due to the absorption of water from the cells of the plants while in the case of other chemicals it may be due to the poisoning of the cell contents by the chemicals. Accumulation of chemicals in the soil affects the plants by restricting the root systems.

In such cases single treatments do not harm the plants but if the chemicals are of the type that do not leach out of the soil, repeated applications increase the amount of chemical in the soil until the roots are injured. Copper compounds accumulate in the soil in that manner and many putting greens have been damaged by copper poisoning where Bordeaux mixture was applied for the control of brown-patch (page 120).

Treatment.—Much burning of turf by chemicals can be avoided by washing the chemicals from the leaves with judicious watering. Applications of chemical fertilizers and fungicides should always be watered immediately except in the case of small amounts of corrosive sublimate (½ ounce or less to 1,000 square feet) which are to be left on the leaves to check the spread of disease. When turf is watered after the application of chemicals it is important that it be done properly. The water should not be applied in a heavy stream directed downward to the turf as that washes the chemical into the low areas where it concentrates and injures the turf. The stream of water should be directed upward so that it falls gently to the turf. When it is noticed that grass, which has been treated recently with a chemical, is becoming dark in color it is important to water immediately even if the turf had been watered after the treatment had been applied. Abundant and prompt watering either prevents a great deal or burning of turf or lessens the injury materially. When the injury is due to accumulation of chemical in the soil it may be necessary to remove the poisoned soil and replace with fresh soil. Injury from oil is best eliminated by careful oiling and greasing of equipment and by careful inspection of all parts that may contain excess oil or grease. When turf has been injured by chemicals, further applications of fertilizers or fungicides should be avoided since the injury is only aggravated by the additional chemicals.

Injury from Unfavorable Soil Acidity

Symptoms.—In the summer the grass turns yellowish and generally becomes unthrifty and fails to respond to applications of sulphate of ammonia or other quickly-available forms of nitrogen. Irregular areas of the turf turn brown and die and the ground becomes hard and dry (figure 52). The symptoms of this type of injury are much the same as those produced by accumulation of different kinds of chemical poisons and by salt concentration. The injury may also be confused with that caused by faulty soil texture, some instances of poor drainage, or chemical deficiency, or it may occur in combination with injuries from those causes.

Extent of Injury.—This type of injury is very common on putting greens. The soil from which greens are built is often acid and certain practices on golf courses tend to increase the acidity. The continued use of certain chemicals, such as sulphate of ammonia, may lead to an injurious acid condition. Injury from acid condition in the soil is more common during the hot periods of the summer. It may occur in small areas on the green, but usually the affected areas are extensive and the grass may be injured so severely that it is necessary to resod.

Cause.—When soil becomes too acid or too alkaline plants can not survive. Some thrive best in an acid soil; others in neutral or slightly alkaline soil. All plants, however, are able to grow in a fairly wide range of soil acidity in spite of any preference. On the other hand, regardless of whether a plant grows better in an alkaline or an acid soil, it is unable to survive beyond a certain degree of acidity or alkalinity. The limits beyond which the plant can not survive are not definite, as there is some variation due to difference in soil make-up, moisture present, temperature, and many other factors. The acidity of the soil is constantly changing within a fairly narrow range even without the addition of chemicals. Therefore at both the acid and alkaline limits of growth for any one plant there are fairly wide ranges of soil conditions in which the plant may not only survive but in which it can actually grow well under favorable climatic conditions. In such soil conditions a plant may seemingly be entirely healthy under favorable weather conditions but be badly injured or killed when weather conditions are unfavorable.

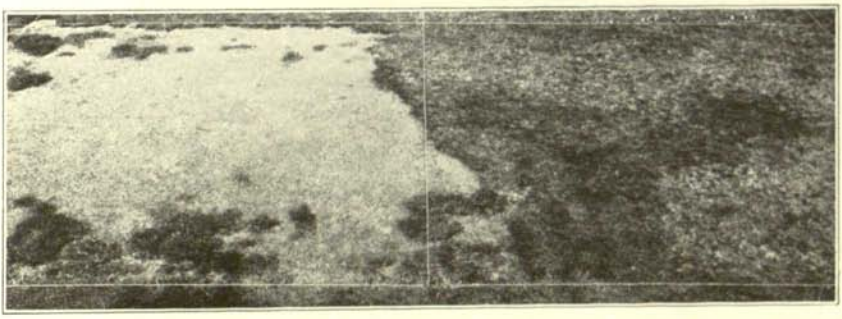


Figure 52.—Injury from unfavorable soil acidity. The soil in the plot on the left had a pH value of 4, while that on the right had a pH value of 6. The excessive acidity in the plot on the left was created by use of sulphuric acid before planting. The plots were planted at the same time and with the Washington strain of creeping bent. They were planted in the spring and the photograph was taken in August. It is evident that the plot on the left with a pH value of 4 is too acid for the growth of creeping bent on this soil.

Bent grasses have commonly been regarded as acid-tolerant plants. Although the common species of bent grass (Agrostis) are capable of growing in soil too acid for the best development of many other plants, it is well known that these grasses will grow well even in an alkaline soil. When soil becomes too acid, bent grass may grow rapidly enough to produce a satisfactory turf during the cooler seasons but will not survive the hot periods of midsummer.

Treatment.—Excessive soil acidity is readily corrected by the addition of lime (page 106). During the summer when the symptoms of this injury are first apparent and when a quick change in acidity is desirable it is best to use hydrated or builders' lime. When immediate change of acidity is not important, ground limestone or air-slaked lime is preferred. In using hydrated lime it should be remembered that lime in this form should not be applied to turf within several days of an application of fertilizers containing ammonia.

Injury from Shading

Symptoms.—Grass in heavily-shaded areas often turns a yellowish and bleached color and the leaves and stems elongate. When shade is suddenly removed to expose this grass to direct sunlight it usually quickly dries and turns brown. If it has been shaded for too long a period death will result. Shading by trees has been blamed for much damaged turf, probably because putting greens that are built among trees and are heavily shaded, are harder to keep healthy. On the other hand there are times when turf seems to be greatly improved where it is exposed to partial shade. Damage from shade of trees is usually an indirect one, that is, it encourages a more succulent growth which is more easily attacked by various parasitic diseases and is more susceptible to chemical injury, bruises, and similar types of injury. Areas heavily shaded also frequently suffer from poor air drainage.

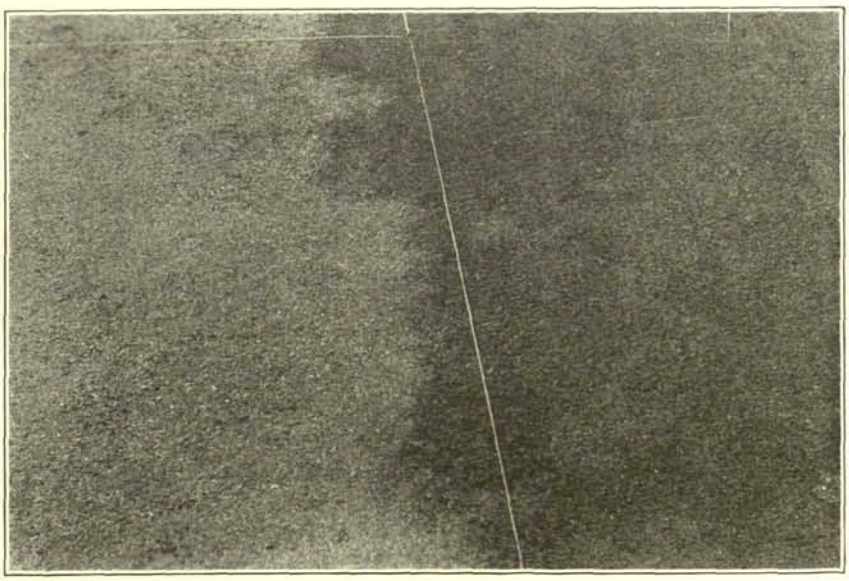


Figure 53.—Effect of a straw covering of turf on the development of snowmold in Minnesota. A layer of straw a few inches thick covered the turf at the left of the white line during the winter, while the turf at the right had no covering. The straw was removed as soon as the snow melted in the spring. The shade provided by the straw encouraged the development of the snowmold fungus, which killed most of the covered turf but which did no harm to the uncovered area.

Extent of Injury.—Shading may injure turf slightly or severely, depending on the length of time that the shading has continued. It occurs at any time during the growing season but the most serious injuries occur during the warmer periods of the summer. Strains of creeping bent and fairway grasses are usually less severely injured than are colonial bent and strains of velvet bent.

Cause.—Some types of tee markers, coils of hose, or other equipment used on a golf course, left on the turf too long at one time, frequently result in dead patches of turf which necessitate resodding or

reseeding. Clippings scattered too thickly about the approaches often shade and smother the grass beneath and result in yellow or dead patches of turf. Heavy layers of topdressing, particularly in hot weather, may shade the grass sufficiently to weaken it so as to kill it or make it an easy victim of attacks of various disease organisms. Heavy coatings of straw or similar material put on a green with the view to protecting the grass from the cold and left there when the grass starts to grow have frequently resulted in killing large areas of turf. Crab grass or other weeds when permitted to grow large enough to provide a dense shade will prevent the rays of sunlight from reaching the finer grasses beneath and so weaken them that when the weed is removed most of the finer grass which has survived under the dense shade of the weed is killed as soon as it is suddenly exposed to the drying effect of the sunlight and winds.

In any of the above cases the damage may be due to the direct effect of shading the grass or to the indirect effect of encouraging a fungus growth. In many instances a cover on grass provides ideal conditions of moisture and shade for the encouragement of fungi. If temperature and other conditions are favorable for the growth of any parasitic fungus that may be present in the shaded area, the grass which is weakened by the heavy shade quickly succumbs to an attack by the fungus (figure 53).

Treatment.—When turf has been injured by shading it recovers slowly. Prevention of the injury is the best means of control. At no time should equipment or materials be allowed to remain on turf for long periods of time. In cases where disease has become active in the shaded grass, a fungicide should be applied. Injury which is apparently associated with heavy shading by trees may be reduced by thinning out the underbrush and branches of trees in a manner similar to that described for air drainage (page 108). Judicious pruning often accomplishes the desired effect better than the ruthless destruction of trees, such as is too often experienced on golf courses wherever shading has been suspected as the cause of injured turf.

Injury from Matted Turf

Symptoms.—Putting greens often have poor putting qualities due to the development of a spongy mat of grass sometimes ¾ to 1 inch thick (figure 54). Footprints do not readily disappear when this condition is present and the putting surface becomes uneven. The condition is further aggravated by the development of a grain, in which the leaves of grass lie flat and grow in one direction.

Extent of Injury.—Matted turf occurs most frequently in some of the creeping bents, Bermuda grass, and, in a few cases, in colonial bent. It does not occur in seeded putting greens as often as in those planted with stolons, and, in the latter, there are differences in tendencies to form thick mats, depending on the strain of grass that is used.

Cause.—The greatest injury resulting from the matted condition is due to what is commonly termed smothering, the exact causes of which are not fully understood. One assumption is that the top, or growing layer, loses contact with the soil, due to the inability of the roots to penetrate the thick layer of dead and dying turf. Partial proof of this is that often the turf can be stripped from the soil with

comparative ease using only the fingers. It is possible that the density of the mat of leaves and stolons encourages such a vigorous development of fungi that they become parasitic and penetrate the plants, causing them to die. Severe cases of brownpatch frequently

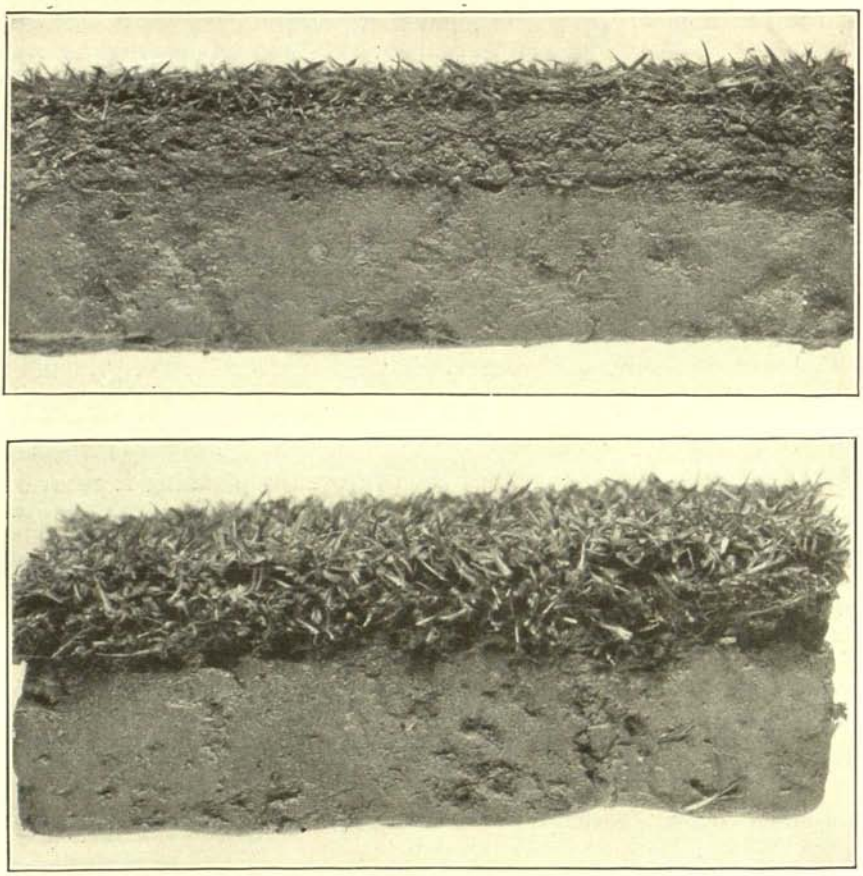


Figure 54.—Matting effect of neglect of topdressing. These two illustrations are cross-sections of turf of the same strain of creeping bent, both planted at the same time. The upper was properly topdressed and shows the ability of the turf and the soil to combine to produce a true putting surface. In the lower view, topdressing had been neglected, contact with the soil was lost, and the turf was spongy and in a condition liable to be susceptible to still other injuries. In attempting to correct such a condition care must be used to avoid the application of a heavy topdressing liable to bury the mat of turf and thus produce a layer of undecomposed organic matter. Before any topdressing is applied, the turf should be raked and cut repeatedly, with the removal of all excess leaves and stolons, until contact with the soil is regained.

occur in heavily-matted turf, under which conditions the disease is extremely difficult to check.

Treatment.—Matting of turf can be prevented by raking or brushing and then cutting the excess leaves and stolons, and then applying topdressing (pages 111 and 112). It is dangerous to apply a heavy

topdressing to a mat without first removing the excess leaves and stolons, as the topdressing will not penetrate the turf but will bury the mat, forming a layer of organic matter which may cause damage by interfering with the capillary rise and fall of water in the soil. Continuation of topdressing in such a manner builds up a series of injurious layers several inches thick. The turf should always be kept in close contact with the soil by a judicious system of raking or brushing and by cutting in several directions before topdressing.

Bruising

Symptoms.—Turf is often crushed by trampling, by falling golf balls, and by machinery. Bruised turf first appears blackened and gradually dies and turns brown. Usually the injuries are clearly confined to the definite areas which have been damaged. In some

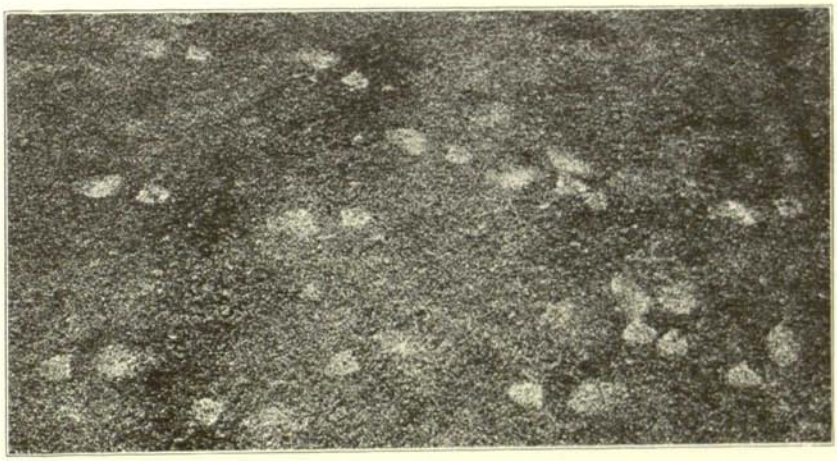


Figure 55.—Injury to turf from walking on a putting green at a time when the grass is particularly susceptible to bruising. This injury occurred when the grass was walked on while a heavy frost lay on the leaves. A few hours later, however, when the frost had begun to melt, no injury resulted from walking on this turf.

instances the footprints of players or large animals are clearly outlined in dead turf (figure 55). The tracks of the wheels of automobiles are frequently observed as definite streaks of browned grass running across long stretches of green turf. The edges of putting greens are often marked with browned areas where rollers of the putting-green mowers have slipped and bruised the turf as they were being turned. Portions of a putting green, especially near the cup, are frequently badly bruised by the trampling of players and caddies. Although clearly-defined bruise marks are easily distinguished, it is probable that a great many of the bruises that occur at times when grass is less susceptible to bruising result in only slight browning of indefinite areas that may easily be confused with diseases or other injuries.

Extent of Injury.—Even though some bruised areas may be injured only temporarily, in many instances the grass is killed in large

areas. At the Arlington turf garden in the summer of 1932 a large dog walked across the garden and its tracks could easily be traced in dead turf across the entire garden. When walking across the garden the dog stepped on several different species and strains of grasses as well as several areas under different chemical treatments. The uniform browning of the dog's footprints in the various plots demonstrated that the matter of susceptibility to this particular type of injury did not vary with different grasses or treatments. In the cases of bruising of frozen turf or many of the bruises that occur during the summer there have been striking examples of varying susceptibility among the common turf grasses. Such grasses as Bermuda grass or some strains of creeping bent are much more resistant to bruising than is velvet bent, for instance.

Cause.—Thus far it is not definitely known just what factors contribute to make grass more susceptible to bruises at one time than at others. It has been observed that during certain periods of excessive heat and humidity grass becomes more tender and is likely to be bruised and show the footprints of players or the scars of machines. In other cases the same type of bruising has been observed in hot weather when grass is beginning to suffer from lack of water. Similar injury is very apt to occur in late fall, winter, or early spring, when the top of the turf is frozen. In the case of bruises on frozen grasses it has been repeatedly observed that human or animal footprints as well as wheel tracks are clearly marked with browned turf when the grass is bruised under a certain condition of freezing, whereas during much of the time when grass is well frozen players or machines can go over the turf repeatedly without any apparent harm. It is probable that there are many different factors which combine to make turf particularly susceptible to bruising. It is no uncommon experience to find that light trucks carrying compost or equipment can be driven over fairway turf day after day with no apparent harm, when suddenly the same truck will leave a definite track of dead grass wherever it has been on turf during the course of a single day or part of a day. Likewise putting-green mowers may be turned day after day on the edges of the green without harm, when suddenly the injury will develop without any apparent difference in the handling of the machine. It has also been noted many times that on greens used regularly there suddenly appear the definite footprints of players who apparently walked across the greens when the grass in some way was particularly susceptible to bruises.

Often serious damage also occurs when turf is trampled by players after chemical applications which have not been well watered into the soil. Footprints have produced distinct injury to areas receiving certain fertilizers or chemicals, whereas no injury whatever developed when the same persons making the footprints stepped across the line onto other plots receiving different treatments.

Treatment.—When turf has been killed by bruising it may be necessary to replace the dead sod. Less severe injuries may recover slowly if the bruising is discontinued. When grass is susceptible to injury from bruising, the putting-green cup should be moved frequently to avoid continued trampling by players. Whenever turf shows evidences of bruising it should be promptly and liberally watered.

Scalping

Scalping is usually easily identified because of the more or less regular appearance of the affected areas. Where the injured areas are not definite they may be mistaken for other types of injury. There have been cases where treatments with expensive fungicides have been made to turf which actually had suffered from scalping. Small elevated areas in turf are frequently scalped by the mowers. In other cases carelessness in setting the mowers results in too close cutting of the turf on one side of the mower. When grass is allowed to grow too long and the mowers are then set down low the turf becomes brown and it may take a few days or several weeks for a new growth to cover up the brown stubble left after the turf has been scalped. Scalping injuries by mowers can be avoided by proper grading, regular cutting, and care in setting the bed knives of the mowers.

Injury from Frost

Symptoms.—Grass in turf is sometimes injured by frost. Freezing of plants may kill only the leaves and parts of stems or it may destroy the tissue of the crowns and roots. In some cases the injury

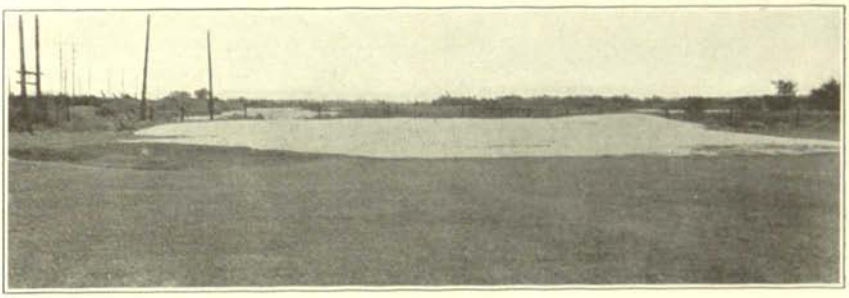


Figure 56.—Even in the South severe injury from frost is liable to occur. An extensive area of Bermuda is here seen destroyed by cold temperature. Such injury is often found near the northern limits of the Bermuda grass area. Low temperature in winter is the limiting factor that prevents the spread of Bermuda into the northern section of the country.

by freezing is an indirect result of the heaving of the plants from the ground, breaking the roots, and leaving the plants exposed to drying winds, with no adequate contact with the ground for securing moisture. Another common type of frost injury on northern grasses is that of the killing of grass by late freezes in the spring when the grass has already started to grow. In early spring annual bluegrass (*Poa annua*) is likely to grow rapidly in the early warm periods and develop a soft, lush growth which is greatly damaged by a sudden and decided drop in temperature. This type of injury results in large irregular patches of dead grass which are often confused with the injury from poor drainage, snowmold, or the drying of turf exposed to cold, dry winds. Seedling growth in spring may be injured by late freezes, which may kill the young plants directly or by heaving them from the ground.

Extent of Injury.—There is a group of grasses commonly referred to as southern grasses which are prevented from spreading into the North because of their inability to withstand severe winter weather.

The most common example is Bermuda grass, which is turned brown by frost early in the season due to the injury to the top leaves of the turf. As the cold weather continues the injury extends closer to the ground level and finally all of the aboveground growth appears brown. On close examination, however, it will be found that even though the turf looks entirely brown, when the sheaths of the leaves are stripped away the stems of grass still remain green and are ready to resume growth as soon as the temperature is favorable. In the

Figure 57.—Yellow tufts occur on turf as small yellow spots. These spots consist of groups of yellow leaves that originate from a single node on a stolon. They can be easily removed from the turf by grasping the tufts of leaves. In the illustration the tufts are lying on the turf at the points from which they were lifted. Yellow tufts give the turf an unsightly appearance but do no harm other than make the turf slightly bumpy in serious cases. These growths are more frequent on young turf than on old turf but may occur on turf of any age.

extreme southern part of the country frost injury on Bermuda grass is only temporary, but in the northern section of the southern grass belt there are likely to be large areas of Bermuda grass killed during severe winters (figure 56). The common northern grasses, such as the bents and Kentucky bluegrass, under ordinary conditions can stand extremely low temperatures without suffering. Extreme damage is most likely to occur where soil conditions are unfavorable and also where the grass has been cut too close, as on putting greens.

Treatment.—Frost injury can be reduced in some cases by providing artificial protection during the winter months. Putting greens in the northern part of the Bermuda grass range are sometimes protected with a mulch of straw, pine needles, or similar covering during the cold months, while the players use temporary or winter greens. Since most northern turf grasses are able to withstand extreme cold

they need no artificial protection. Some putting greens and other turf exposed to the sweep of drying winds are protected by branches of trees or snow fences, which break the force of the wind and collect snow for a protective covering. Since coverings of any kind on northern turf tend to encourage snowmold (figure 53) they should be avoided except where they are especially needed as protection from sweeping winds, and they should always be removed as early as possible in the spring.

Yellow Tufts

Symptoms.—Yellow tufts occur in turf as yellow circular spots ¼ to 1 inch in diameter. On putting greens these are often mistaken

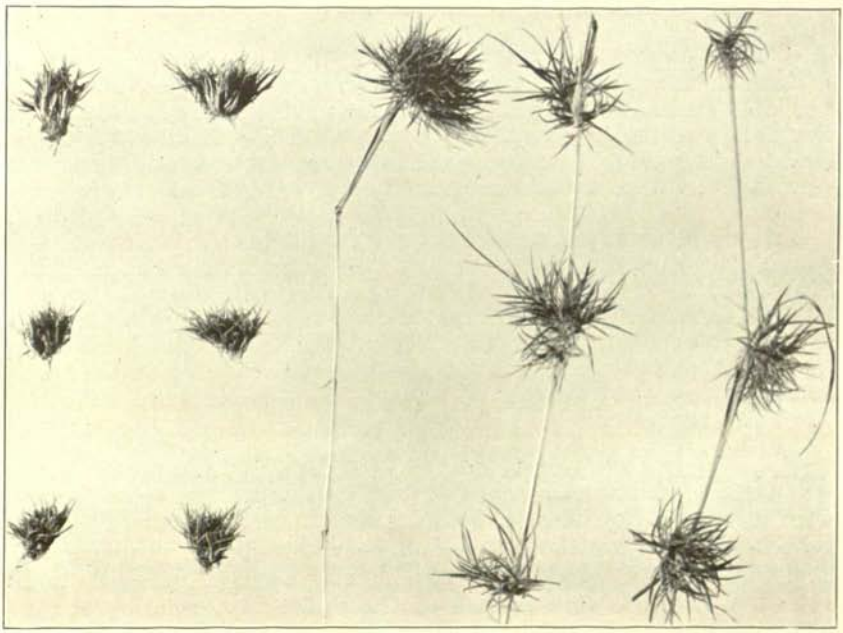


Figure 58.—Yellow tufts of velvet bent removed from sod and from nursery stock. On the left are bunches of leaves and stems each of which originated from a single node in putting green turf. At the right is a group of stolons from the nursery which bear tufts at the nodes and clearly show the origin of the leaves.

for dollarspot. In the case of yellow tufts, however, it will be found that the yellowed grass can usually be picked out of the turf, when a close examination will show that the tuft consists of a mass of fine leaves originating from a central point (figures 57 and 58). The yellow color, moreover, persists and the grass does not turn brown or dry as it does in the case of dollarspot or spotblight.

Extent of Injury.—Although unsightly, these tufts cause no permanent injury to turf. Appearing from time to time, they may be in evidence for several months consecutively and then rapidly disappear. They are usually most common in the fall and early spring,

but are frequently found throughout the year. They occur in various grasses but are most common in bent turf, being particularly so in some strains of velvet and creeping bent. They are frequently found in nursery rows, particularly in velvet bent, but there they are not objectionable. They are especially abundant in turf only a year or so old, usually becoming less common as the turf ages. On the other hand they are not altogether uncommon on turf ten or more years old.

Cause.—Although various explanations have been made as to the cause of yellow tufts, the real cause remains unknown. A similar tufted growth occurs on many trees and shrubs, where it has been traced to injuries resulting from some mechanical factor or from the invasions of parasitic organisms, particularly bacteria.

No remedy has as yet been devised for this ailment of turf.

Injury from Lightning

Occasionally turf is struck with lightning and the grass is scorched and killed in much the manner that trees and other plants are injured. The area affected by lightning may be several feet in diameter and is usually irregular in outline with forked projections of injured turf extending outward from the central area. The grass in the center of the affected area is blackened and immediately killed and soon dries. The injury gradually decreases toward the outside border of the area, where the grass may not show injuries immediately but may turn brown in a day or so and give the impression of a disease spreading rapidly from the center. Areas of turf struck by lightning, which are not at once recognized as such, often cause much alarm due to the suddenness of the attack and the apparent rapidity in the spread of a supposedly new disease. The turf near the center of such areas has to be replanted.

Injury from Insects

In many instances damage caused by insects has been confused with that caused by disease, with the result that expensive fungicides have been applied without apparent benefit when the proper insecticide would have produced results. Insect damage will not be discussed in detail in this number of the Bulletin. Attention is called to the matter here merely to warn readers that the role of insects in turf disorders must receive due consideration when a diagnosis of any injury to turf is called for (figure 59).

There are several kinds of grubs which live beneath the surface of the soil and feed on grass roots, thereby destroying the plant's means of obtaining both food and water. These grubs are the larval stages of such insects as the Japanese beetle, May beetle, June beetle, and Oriental beetle. The damage caused by grubs is frequently confused with fungus diseases or with many of the other injuries to turf described in this number of the Bulletin. When sufficiently numerous these grubs cut off the entire root system of the grass a trifle below the surface of the soil, and the grass withers and dies in much the same manner as occurs when the root system is destroyed by excessive concentration of acids, salts, or chemical poisons. Injuries to turf from this type of insect can, however, be readily distinguished from other turf injuries by the ease with which the in-

jured turf can be lifted from the soil like a loose carpet, exposing the grubs beneath, due to the fact that the root system has been severed from the aboveground parts of the plant.

On southern golf courses much turf is killed by mole crickets. These insects feed on roots of plants and are able to destroy large areas of turf. The insects burrow through the soil leaving many passageways behind them, above which the grass may die due to injury to the root system. Although patches of dead turf resulting from mole crickets feeding may be confused with various turf diseases (figure 59), they can usually be easily identified by the evidences of the burrowing of these insects.

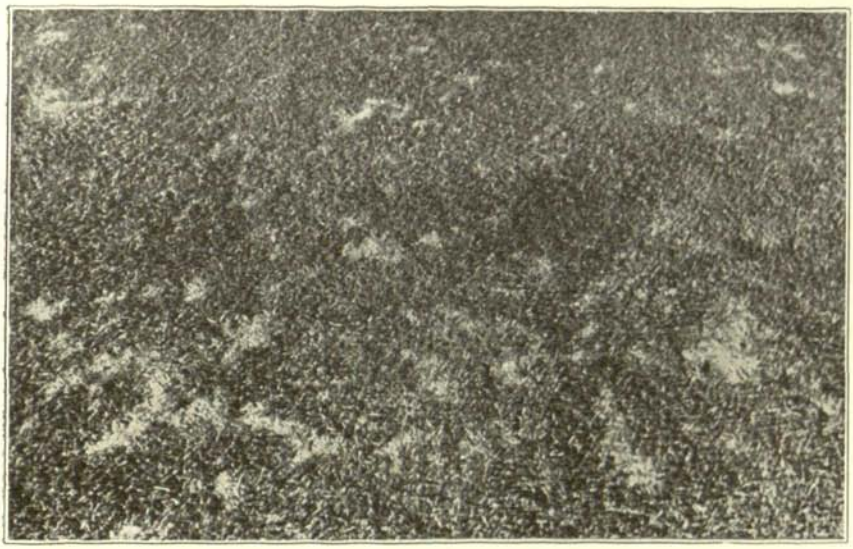


Figure 59.—Injury to turf caused by mole crickets on a southern golf course. This injury may easily be confused with dollarspot or spotblight (compare with figures 24 and 25). These figures illustrate the ease with which insect injuries can be mistaken for fungus diseases by anyone who is not familiar with both types of injury. Often expensive fungicides are applied to turf that is injured by insects without effect, when an insecticide would eliminate the cause of the injury. Insect injuries can usually be recognized by the presence of the insects themselves or evidences of their other activities, such as by burrowing or making of nests.

Other grubs, including the cutworms and army worms, eat the blades of grass instead of the roots. They usually cut the grass close to the ground, producing bare or browned spots sometimes confused with dollarspot and spotblight. Injury produced by this type of insect has much the same effect on turf as scalping with mowers. Such insect damage can readily be distinguished from disease on close examination, since in the case of diseased spots the affected leaves remain while in the case of insect damage the affected leaves have been removed, leaving scalped areas appearing brown on account of the color of the short brown stubble or of the ground beneath the spots where the worms have been working.

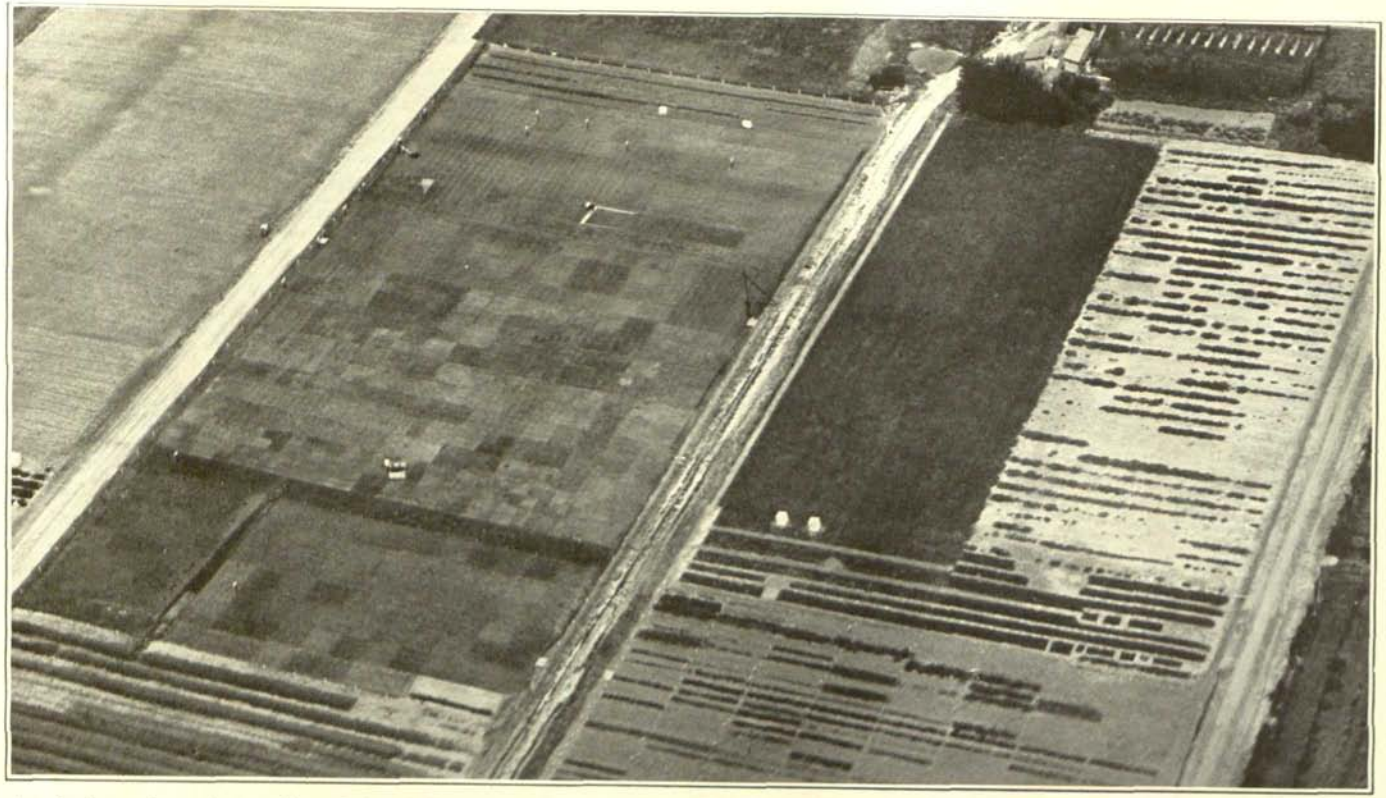
Injury caused by webworms is also often confused with dollarspot or spotblight. In some cases where the webworms make nests just below the surface of the ground there is a yellowing or browning of the surrounding grass which, particularly in the case of velvet bent, is easily confused with dollarspot. In other cases, where the nests are made at the surface of the ground, the accumulation of browned grass employed in the construction of the nests together with the destruction of a large proportion of the green blades, produce an appearance which, in a general way, is not unlike that produced by excessive soil acidity, moisture deficiency, and other injuries. The activity of webworms can be readily detected by a close examination of the turf, since a large proportion of the blades of grass will be found cut close to the surface of the ground well below the level of the bed knife of the mower. With still closer inspection the webworms themselves can usually be found, or at least their nests, which are constructed from grass clippings bound together with a fine web.

The chinchbug feeding on grass near the surface of the soil causes it to turn brown, and colonies of these bugs produce browned areas of turf commonly confused with brownpatch. It has been reported as one of the common pests of Bermuda grass throughout the South. More recent observations, however, have indicated that much of the damage which has been attributed to chinchbugs has in reality been cases of fungus diseases, particularly brownpatch.

Ants frequently destroy grass in the vicinity of their nests or in pathways between their nests and feeding grounds. These clearly-defined areas, usually close to their nests, are seldom confused with disease, except possibly if not observed until several days after all evidences of the ant hills have been removed.

Treatment.—Insects are controlled by treatments entirely different from those used for fungus diseases or other injuries. In the case of insects which feed on the root system of grass, the pests may be checked by poisoning the soil with arsenate of lead. This treatment, however, is ineffective with insects which feed above the ground level on the blades of grass. With these latter, arsenate of lead may be used effectively if sprayed or dusted on the blades and left there long enough to permit the insects to feed upon the poisoned grass. Poison baits also are effective with insects which come to the surface to feed. Certain materials such as kerosene emulsion, carbon bisulphide, and pyrethrum extracts, if properly applied, will destroy most insects which are sufficiently close to the surface of the ground to come within the reach of the material when applied, regardless of the feeding habit of the insect.

Ample fertilization of grass will produce a vigorous turf which is more capable of withstanding injury from root-feeding grubs. Wherever practicable, turf damaged by grubs should be rolled and watered sufficiently to provide moisture for the shallow root system left above the zone in which the grubs have been feeding.



An airplane view of a portion of the Arlington Experiment Farm of the United States Department of Agriculture, showing the turf garden at the left center (between the two roads). On this garden most of the experimental work on turf disease control has been conducted. Some of the disease-treatment plots are evident in the checkerboard effect. The garden is located near the Potomac River just across from Washington, D. C.

If I supply you a thought you may remember it and you may not. But if I can make you think a thought for yourself, I have indeed added to your stature.

Elbert Hubbard.