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Winter Injury of Turf

By John Monteith, Jr.

Winter injury of turf has for several years been the subject of much debate among greenkeepers and others interested in turf maintenance. As is customary in such general discussions there has been evident an attitude of insistence that all such damage is due to a single cause. One group maintains that winter injury of northern grasses is nothing more than poor drainage and so sure has it been of this conclusion that all other theories or observations have been discredited and classed as nonsense. Another group maintains that there is a fungus or mold which kills the grass as the snow melts and that poor drainage has nothing whatever to do with winter injury. There have been other explanations presented and as dogmatically supported. In reality the opposing factions may all be right in their conclusions, for their own local conditions, but each has been equally wrong in insisting that his pet "cause" was the only one which should be considered. This article is an attempt, not to explain all cases of winter injury, but to summarize the present information available on the principal types of these important golf course problems. Those who choose to think of winter injury as due to one cause, no doubt will regard this discussion as an attempt to complicate matters by substituting separate explanations for our hitherto single "winter-killing." The fact remains that Nature has not so simplified matters for the convenience of the greenkeeper and that unless we distinguish between them we are unable to intelligently guard against the damage, for it is obvious that control measures must vary according to the cause of the injury.

It frequently happens that more than one type of winter killing is found on the same green and there may be an overlapping which renders a positive diagnosis extremely difficult or impossible. On the other hand, a consideration of causes and symptoms, as will be pointed out later, should make it possible for even the most casual observer to distinguish between them. No attempt will be made at any general evaluation for, although one type may be more widely distributed than another, the relative importance will vary with the locality; as an example, the "most important" type of injury in New England, Minnesota and Canada may never occur in Virginia or other southern districts.

In looking over the published references of winter injury to turf, one is frequently unable to determine to what the writer had reference, but in many cases the type of damage is quite apparent from its description. We have reports from Canada, New England and many of our northern states of a spotted condition which in some respects resembles large brown-patch. Somewhat farther south there is a belt where the injury reported is almost invariably associated with depressions in which water collects and freezes. Still farther south neither of these types appears to be troublesome but in that section the problem is largely one connected with the freezing of Bermuda or other southern grasses. In the Gulf States and California there is a spotting which is described as practically identical with brown-patch. There are occasionally complaints of other damage occurring on turf during the winter months but usually the

descriptions of these have been vague or apparently confused with one or more of the above.

The well recognized types of winter injury which will be discussed here are for convenience grouped according to their causes; namely, those due to freezing, both on new seedings and on established turf; those due to poor drainage or ice sheets; and those on northern courses due to fungi. The "brown-patch" of the southern states and California, damage due to tramping on grass when it is first frozen or during a period of alternate freezing and thawing, and various others that have been reported should also be considered. They will be omitted, however, chiefly because of our present limited information, or because of the restricted or sporadic occurrence of those of minor importance.

Freezing Injuries to Southern Grasses

In considering any winter injury one naturally first questions what portions of the loss may be attributed solely to freezing. Paradoxical though it may sound, the most serious injuries to golf course grasses due to freezing occur in the south.

Most of the native southern plants are extremely sensitive to low temperatures. This applies also to the grasses and many, such as Bermuda grass, are killed to the ground by the first heavy frost. As a rule this injury is only seasonal, for the roots are not killed and there is complete recovery with the return of warm weather. In their northern range, however, freezing may entirely destroy large areas of such grasses, in either new plantings or old, established turf.

On courses where it is desirable to keep the greens in play throughout the winter, the problem is one of providing a succession of grasses for the different seasons; Bermuda grass for summer and a cold-resistant grass for winter, one replacing the other with the least possible interruption of play. It is customary to seed rye grass, redtop or other northern species directly on the Bermuda grass in early fall. When the summer turf is checked by the cold the new seedlings are ready to take its place and provide a good playing sod for the winter months. Again in spring when it becomes too warm for these northern grasses, the Bermuda will appear and replace them. This method is so well established as to hardly call for discussion here. However, it necessitates an annual seeding of the greens and has other undesirable features. It appears probable that in the not distant future this method will be replaced by that of using perennial grasses for both the summer and winter turf. *Poa bulbosa* has shown much promise in combination with Bermuda grass particularly for fairways. Each of these grasses is perennial but with entirely different temperature requirements for growth. As one develops the other becomes dormant, but is not killed; each being ready to reappear and replace the other grass as the seasons change.

The problem of maintaining Bermuda grass on greens in the latitude approaching its northern limits is a somewhat more difficult problem. In this section, where fall seeding for winter turf is not practiced and where no attempt is made to have the greens in condition for winter use, there is the danger that Bermuda and other southern grasses will be killed by exposure to low temperatures. There have been cases reported where a covering of straw has proved effective in protecting such grass during the months when it is dor-

mant. This practice has been condemned because of the apparently harmful results obtained in covering greens with straw in the northern states, especially in the vicinity of Minneapolis. However, since the injury there is chiefly due to an entirely different cause it appears unwise to question this practice on the basis of harmful consequences in the north. On the other hand, there is some question as to whether the necessity for such a covering does not indicate that the wrong grass is being used for greens. Our northern turf grasses, particularly bent, are frequently found to flourish much farther south than was formerly supposed to be possible. With better methods of maintenance during the hot summer months, particularly in checking the ravages of brown-patch, it is likely that many clubs in such districts could well afford to convert their putting greens to bent rather than worry about the loss of Bermuda turf during the winter months. Another possible means for avoiding this annual loss is by the selection of strains of Bermuda grass more resistant to cold. In most of our cultivated crops there are varieties which are much more resistant to low temperatures. The same variation is likely to occur in any of our turf grasses, although little effort has been devoted to such improvements.

Freezing Injuries to Northern Grasses

Most of our best northern turf grasses are extremely resistant to cold. Some of those used in golf course mixtures disappear during the winter but their loss is usually of little importance. The cases are indeed rare where a well established sod of northern grass is killed by simply being exposed to low temperatures.

One frequently finds that new seedings which made a good start in the fall are completely destroyed during the winter months, apparently due entirely to freezing. As is the case in many crops, low temperatures harmless to older plants are disastrous to seedlings which have not become sufficiently well established. This loss can usually be avoided by earlier planting, but where this is impractical the customary procedure is to take a chance on late planting and to rely on reseeding early next spring wherever the stand has been destroyed or thinned by winter exposure.

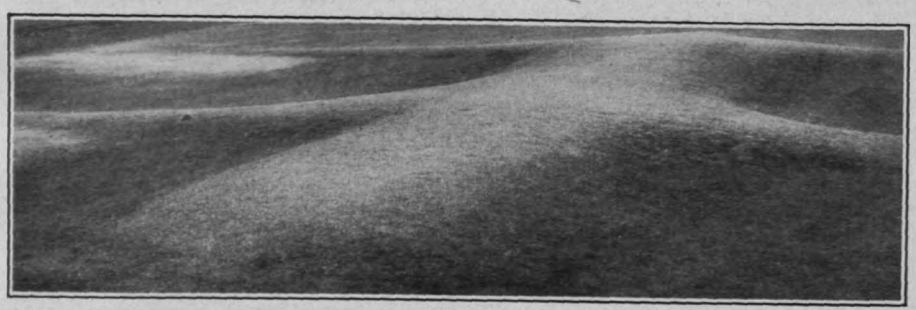

Fig. 1. Freezing injury to fescue turf, Nakoma Golf Course, Madison, Wis. On this green a mound was built in imitation of one of the Indian mounds commonly found throughout this section of the country. Wind keeps the snow swept from this mound so that throughout the winter the grass is exposed to low temperatures and the drying effect of the wind, resulting in the light brown color of the turf in the bare areas as contrasted with the dark green where it 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. The white areas at the left are of the much more serious winter-killing due to inadequate provision for surface drainage so that water collects during the winter

Although well established northern turf is seldom killed by low temperatures, it nevertheless is sometimes noticeably damaged. There is frequently a lifting or "heaving" of the plants well up from the soil level; a condition more likely to occur on one type of soil than another, especially where turf is thin, consequently it may be much worse on one part of the course than on the rest. This lifting of the plants and the resulting breaking of roots may kill some of the grass, and probably checks all of it to some extent. After such turf is rolled there is usually practically complete recovery, so this disturbance is by no means as serious as it may at times appear.

Another type of injury which is associated chiefly with low temperatures is that where turf is swept free of the normal covering of snow and appears bleached and lifeless when the rest begins to show green in the spring. Such areas are generally limited to knolls or ridges, from which snow is easily blown and which are constantly exposed to extremely low temperatures, combined with the drying influence of wind. This type of cold injury occurs chiefly on the more northern courses but even there the damage, seldom sufficient to actually kill the grass, simply results in a loss of the leaves and a slight delay in early spring growth. As a rule no preventive measures are resorted to but some greenkeepers feel that a covering of branches or some material to catch and hold the snow on a few most exposed areas will more than repay them for the extra labor involved.

Water and Ice Injuries

Throughout a large part of the country the most important turf problem during the winter months is that known generally as "winter kill" or "ice injury." This damage appears as large, irregularly shaped, discolored areas which become evident as soon as the ice and snow have gone. When the color is yellow or light brown the damage is usually of minor importance for the grass is only temporarily checked; but where it is a dull brown or gray the chances are that most of the grass is dead so recovery of the turf will be very gradual at best and such areas will ordinarily require replanting. In any case these unsightly patches remain long after the green should be in good condition and it is not infrequently found that their effect is noticeable throughout the season.

The real cause of this type of injury has not been definitely determined. The location of the dead areas indicates that it is due to poor drainage, the formation of pools of water and the alternate freezing and thawing of these accumulations. Various explanations, such as, ice acting as a lens to injure the turf beneath, cutting off the plant's supply of air by the ice sheet, "drowning" of the grass by the standing water, and many others have been suggested to account for this condition. It seems probable that the injury is due to a combination rather than to any one factor. Regardless of the actual cause, we do know that it is in some way correlated with water standing on turf during the winter months for it invariably occurs in depressions where water is likely to collect and remain for long periods. Occasionally it is found where there apparently is sufficient drainage, but in such cases it can usually be accounted for by a bank of snow or some other obstruction preventing the rapid draining off of surface water.

Although "winter kill" is ordinarily associated with the formation of ice sheets, it is a well recognized fact that a mere covering of ice does not ordinarily injure turf. The so-called "shell" ice, with an air cavity beneath, may act as a protection to the grass rather than injure it. Skating rinks are often made by spraying water on turf until there is a layer of ice several inches thick. The fact that these rinks frequently cause little or no damage indicates that such a covering in itself is not sufficient to kill grass. "Ice storms" occasionally cover entire courses with a sheet of ice which may remain in some places for many days or weeks and yet produce little or no turf injury.

Fig. 2. Winter-kill due to water and ice. A ridge across the entire width of this green serves as a dam, interfering with surface drainage. A very slight slope tends to drain the water toward the far side of the green but notice the mound which effectively prevents its escape in that direction. The top and left side of the ridge (northern exposure), are swept free from snow and the grass has been somewhat discolored, although not permanently injured, by exposure to wind and cold. This same ridge in summer is troublesome due to drying out and "scalping" by the mower. Again the question: Why build such abrupt ridges on greens?

The damage ordinarily occurs only where there is no outlet for the melted ice; where the water collects and remains for some time under the ice or in open pools after this covering has disappeared. It must be remembered that when soil is moist with the usual late fall or early winter precipitation it soon loses its customary porosity when the first hard freeze binds the upper layer into a solid sheet. Consequently, when rain or melted snow settles in depressions which have no surface outlet the water must stay there until removed by the gradual process of evaporation or until sufficient openings are melted through the frozen layer of soil. In either case, these pools remain for many days, or even weeks, subjected to the alternate freezing and thawing which appears to be in some way responsible

for the injury to the turf beneath. Since such accumulations of water are usually shallow they soon freeze solid and likewise quickly thaw during warm periods. Therefore, this sheet is ordinarily transparent, the so-called "black" ice, and serves as a pane of glass through which the sunlight readily penetrates to the grass and soil beneath where the heat is absorbed. Contrary to the usual order of thawing ice and snow, these thin layers of clear ice first melt at the bottom and thaw upward. There may be sufficient heat absorbed by the plants under such a covering to actually stimulate a slight growth which is checked again by the next freeze. The effect of this prolonged submersion, even though growth is almost negligible, probably has somewhat the same harmful influence on plants as does the "drowning" of grass during the growing season. For practical purposes it is perhaps sufficient to recognize that the damage occurs where water is held on the turf too long during a time of intermittent freezing and thawing.

Control of Ice-Sheet Injury

For this type of injury there is but one permanent solution; that is, removal of its cause by providing for proper drainage. This does not mean simply the subterranean kind, for many a green which is provided with all the most approved systems of tiling and other underground drainage is woefully defective in the simple provision for adequate surface elimination of excess water. When moist soil is frozen it becomes practically impervious to water so that all systems of subsurface drainage then fail to function.

Fig. 3. Typical winter-kill on a green where surface drainage has been completely ignored. "A word to the wise is sufficient"

Frequently the injury is nothing more serious than a temporary discoloration. This should be taken as a warning, for although the damage may be slight one year, during the following winter under somewhat different weather conditions there may be extensive killing. In a great many cases these depressions are slight and may be

gradually raised by repeated heavy applications of compost during the growing season, at such a rate that the process will not interfere with play. A small expenditure of money and labor applied in this manner will often save far greater expense and inconvenience in later years. In addition to insuring against future winter killing, this attention to low areas will serve to guard against summer difficulties, for large brown-patch and many other summer disturbances are likewise encouraged by defective surface drainage.

When turf has been killed by these ice-sheets, the treatment involves greater expense and greater interruption of play for it will be necessary to resod or reseed. In order to prevent a recurrence of the same injury in the future, before replanting, the low area should be raised with soil or a suitable "run-off" should be cut. A line of tile will not suffice, for surface drainage must be relied upon when the ground is frozen.

Some greenkeepers have reported success in preventing injury by breaking off the ice-sheets whenever they form. Such a procedure is apt to do more harm than good for if it is frozen hard to the turf there is certain to be some injury to the grass if the ice is chopped off. If this sheet is not frozen fast to the grass, due to an air space below, it may be readily removed without injuring the plants. In such cases, however, there is nothing to be gained for a loose covering of this kind does not injure turf. On the other hand, there are conditions where removal of ice no doubt is beneficial. When water settles and freezes in a pocket on a green, if done at the right time, most of it can be readily removed without injury to the turf. When the sun shines on such ice it will usually first melt at the bottom. As soon as there is a film of water beneath it, this sheet can usually be lifted with very little injury to the grass. If repeated whenever ice collects in pockets, this process will greatly reduce the amount of damage. This should not be interpreted as a recommendation for control of the injury, but merely as an emergency procedure. If the labor involved in such a method were applied during the growing season to making adequate drainage for those areas, there would be no necessity for these precautions in future winters.

Snow-Mold Injury to Turf

On courses in our northern states and in Canada there is found an entirely different winter injury which is commonly referred to as "winter brown-patch" or "snow-mold." This type is often serious in Cleveland, Detroit and Chicago, but how much farther south it extends has not been determined. It may occur in combination with the "winter kill" due to poor drainage but more often it is found alone and on some courses may be far more destructive than all other forms of winter damage combined.

Snow-mold injury occurs in patches which are usually roughly circular in outline but may be very irregular in shape. The majority of the affected areas are only a few inches across but they vary anywhere up to three feet or more in diameter. They are first noticed as the snow melts away; at which time there is clearly evident a gray moldy growth covering the grass and causing it to decay and collapse in a slimy mat, see figure 4. When these patches dry they become brown or bleached and, as the healthy grass develops its

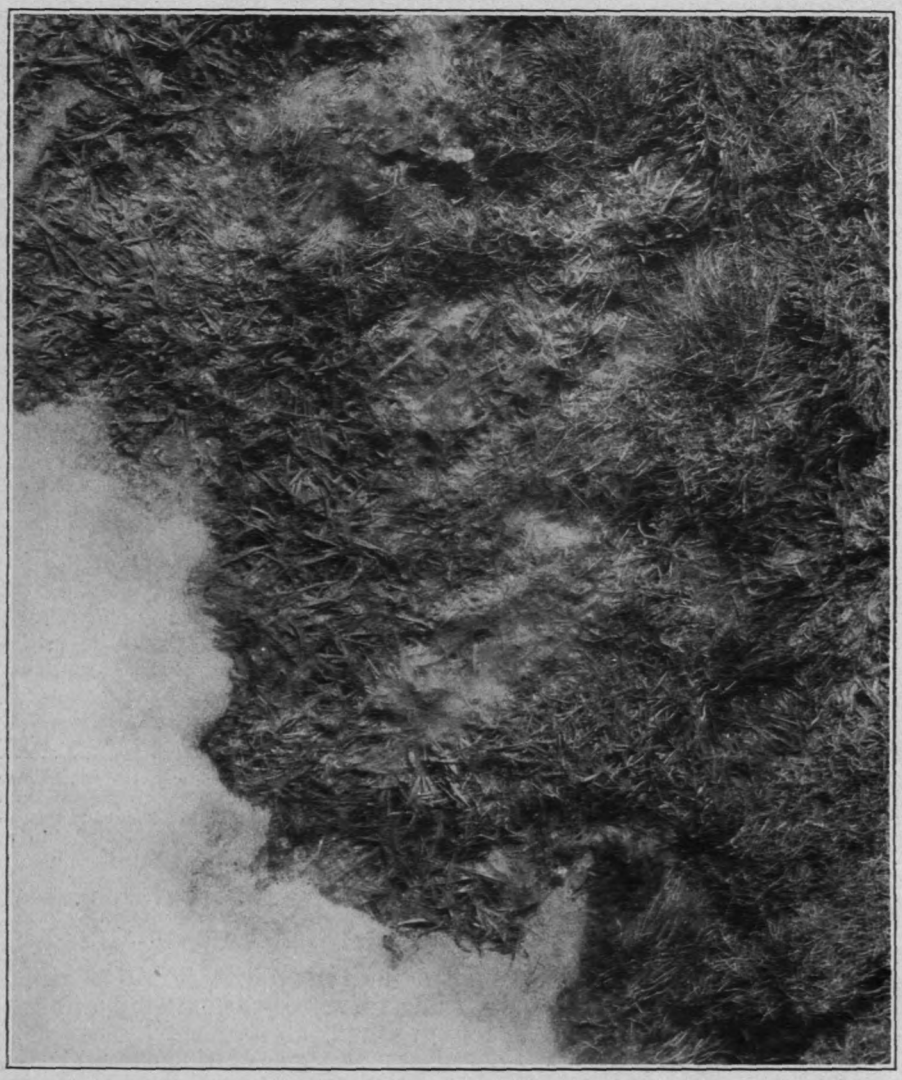

Fig. 4. Snow-mold developing on turf as the snow melts away. At the lower left is shown the melting snow and through the center of the photograph can be seen the gray slimy mats of fungus and decaying grass. Later when the turf is dry these affected areas give the spotted appearance shown in the following figures

green color, they stand out in sharp contrast (figure 5), giving the turf a badly speckled appearance which closely resembles that produced by large brown-patch. At times this injury amounts to little more than a temporary checking of the turf in early spring but frequently the plants are killed and the patches are left bare. In the latter case, clover, which apparently is not affected by snow-mold, is given a decided advantage for it may develop there with little or no competition. Weeds are likewise able to grow unchecked in these killed spots and can become well established before the neighboring desirable turf grasses are able to offer any competition.

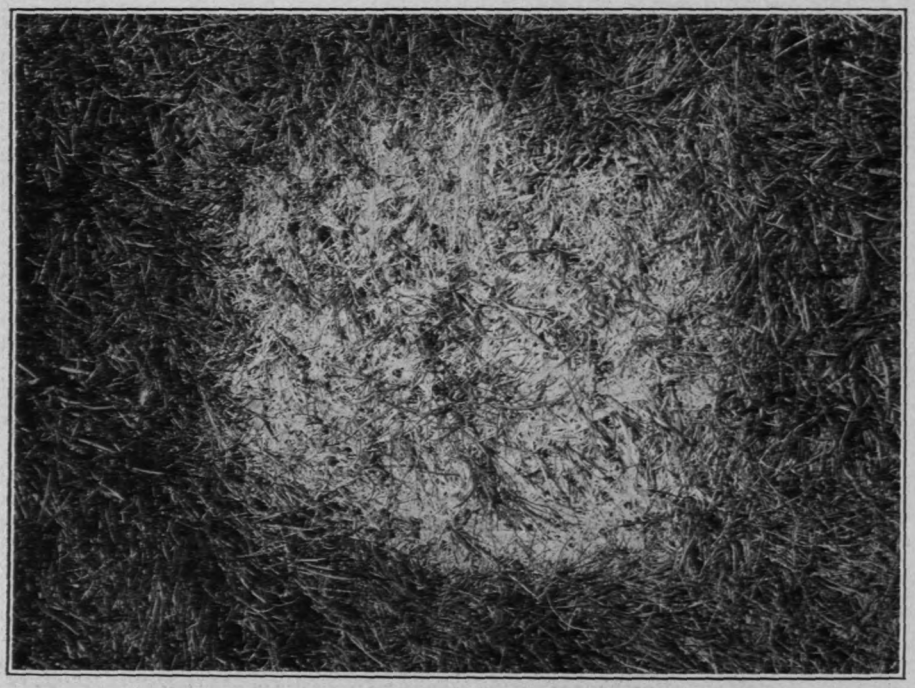

Fig. 5. A close-up of snow-mold injury in fescue turf, fairway length. The white portion, measuring 7 inches in diameter, shows where the grass has been killed. A scattering of dark, healthy blades can be seen in the bleached mat of dead plants, showing that in this case not all of the grass has been killed and that the turf will eventually recover. On close examination one may find here several leaves of clover and dandelion. These plants will now be able to develop much more rapidly in this injured area than nearby where the healthy grass is better able to compete with weeds. Therefore even though these injuries may not be permanent, they certainly serve to encourage weeds

These brown or dead areas are caused by a fungus which attacks the grass, destroying the leaves and often the entire crown of the plant. When the turf is kept wet by melting snow the mycelium of this disease-producing fungus is able to grow over it and to attack the grass in much the same manner as does the brown-patch organism during warm periods of summer when there is heavy dew. The fungus has been grown by laboratory methods and by inoculating healthy grass in the greenhouse we have been able to artificially produce the injury, proving that the fungus found on the diseased patches is actually the cause of the damage. "Snow-mold" has been reported as the cause of serious losses to grain in Europe and in this country is frequently a pest in evergreen nurseries. Whether these are identical with the "snow-mold" of golf courses has not been determined, but at any rate the development of the injury is much the same.

Although snow-mold is a fungus, it is by no means the same one which causes either the large or small brown-patch. As shown in the June, 1926, number of THE BULLETIN, the fungus causing brown-patch grows best at a relatively high temperature and is unable to develop at the low temperatures in which snow-mold must grow and do its damage. A name commonly used to designate this type of injury is "winter brown-patch." The term "brown-patch" is already

so generally misused in applying it to all browned areas in turf, leading to so much confusion, that it seems best to restrict it to its original meaning and to avoid any further general application. The name "snow-mold" for this particular fungus is already in common usage, is much more descriptive and serves to clearly distinguish it from other turf fungi.

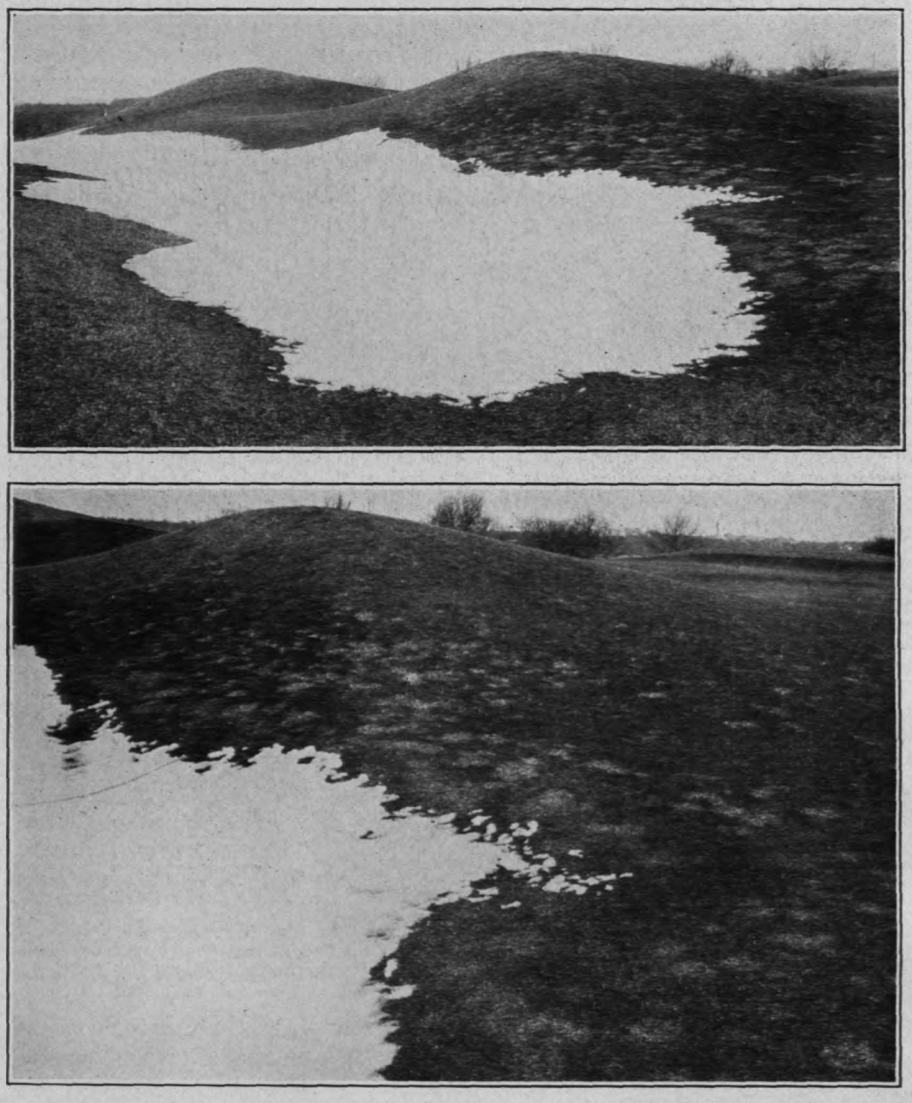

Fig. 6. Snow-mold injury. Damage in such locations is hard on the theory that "winter injury is nothing more than an indication of poor drainage." The two mounds shown in the upper picture are the highest points on this course so they are not troubled with seepage water from anywhere. The lower photograph shows the mound at the right in greater detail. In this case the injury has developed on one of those useless areas still maintained as a green on which a ball will not remain because of the steep slope. Although worthless from the standpoint of play, it has at least served nicely to illustrate the point that snow-mold injury is not dependent on poor drainage. The mound serves as a trap for snow, as shown in the upper illustration, and as the snow melts the fungus attacks the turf

Snow-mold occurs on all the common northern golf turf grasses;

including bents (both seeded and stolon plantings), fescues, bluegrass, redtop and many of less importance. It is found on greens, fairways or rough, but the injury on greens is naturally regarded as most important. It is this injury which has made many greenkeepers disgusted with the theory that winter injury is nothing more than an indication of defective drainage. Snow-mold very commonly occurs on steep slopes, which makes the "defective drainage" explanation appear ridiculous. It is most common where snow accumulates in deep drifts and therefore is frequently found near mounds which serve as snow traps. For that reason the injury is even more

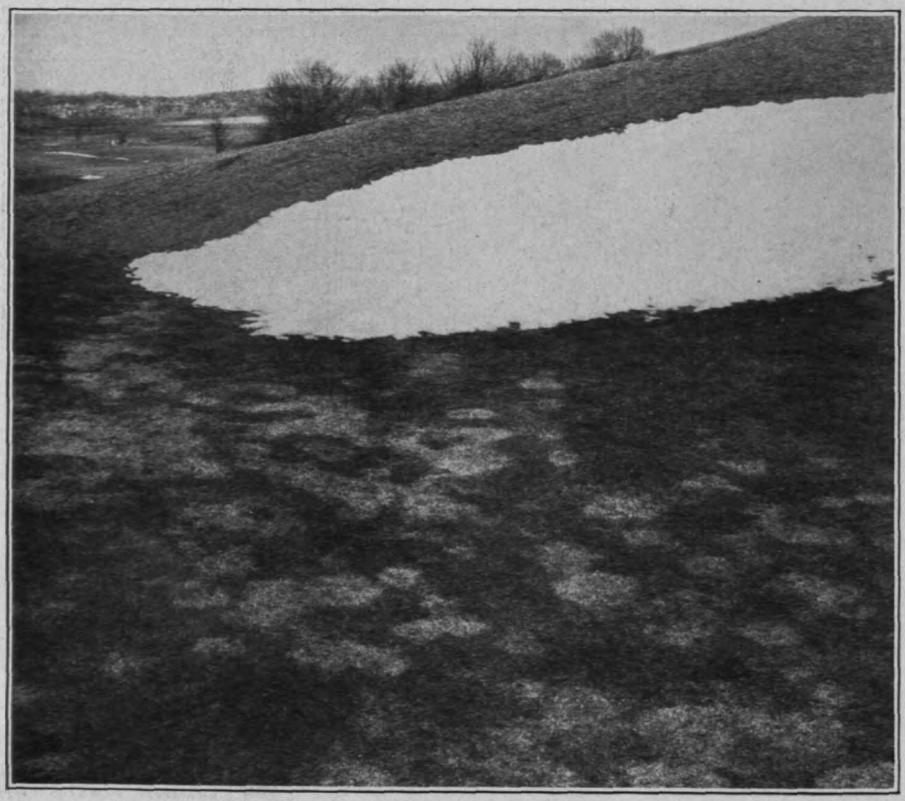

Fig. 7. Snow-mold injury below a snow bank where the turf is kept wet by water draining from the melting snow above. The mound in the background breaks the force of the wind so that snow drifts in to a depth of several feet on the turf where this injury is evident

apt to occur on slopes than on the poorly drained, level areas where the ice-sheet type of injury predominates. The reason why this disease is so generally associated with heavy blankets of snow is not as yet clear. When drifts of snow finally clear away in spring it is frequently noticed that the grass is greener where it has been thus covered. This indicates that growth occurs beneath the snow but so far it has not been determined whether the damage due to the fungus in such areas is due to greater susceptibility of the plants when growing under this covering, or due solely to the prolonged moist condition maintained by the bank of melting snow. At times the

disease is most prevalent on slopes with a southern exposure, as was the case shown in figure 6, but this is by no means a regular thing for in other places it is worse on a slope which faces north or in any other direction. Likewise there is no general rule as to its occurrence above or below a snow bank. The development of the fungus is dependent on the presence of sufficient moisture on the grass during warm days in winter or early spring. This condition may prevail where the snow is gradually melting, where the water runs beneath the drift and in so doing acts as a tunneling agent which produces an air space frequently half an inch deep. During the day, as the

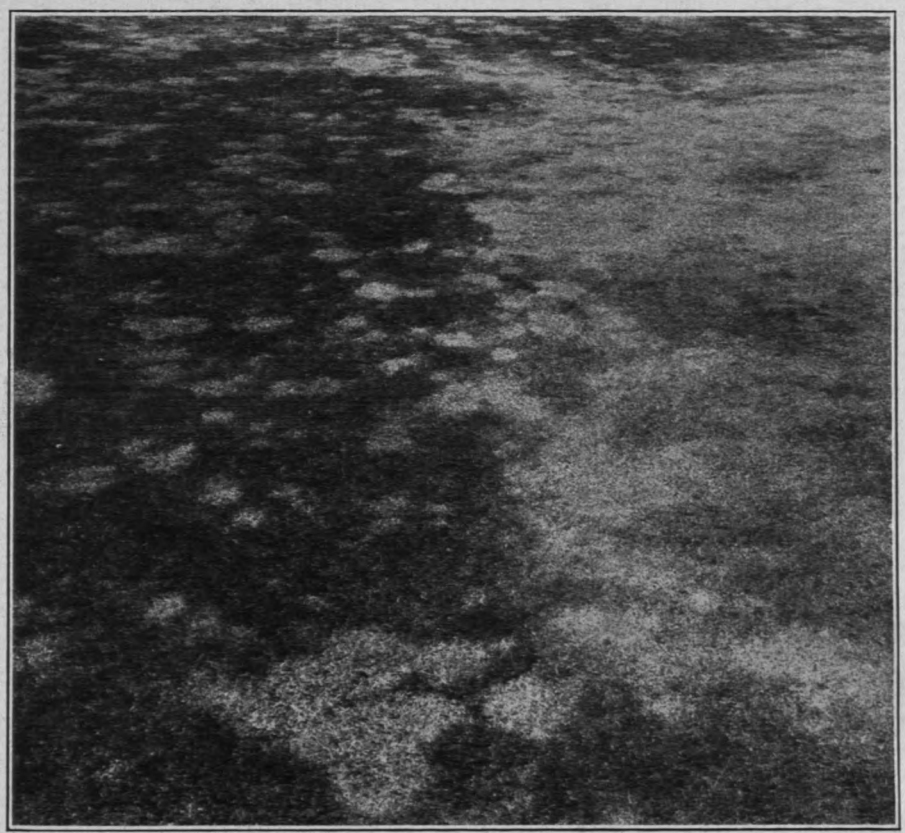

Fig. 8. Two types of winter injury. At the left is shown the light spots of grass killed by snow-mold. At the right is shown winter-kill where water collected in a slight depression during the winter. The snow-mold was active at the border of this winter-kill area and probably aided materially in the destruction of the grass throughout that portion of the green

sun shines through the thin layer of snow at the border of the drift, enough heat penetrates to raise the temperature several degrees in the cavity beneath. At night this roof of snow somewhat protects the turf from any slight freeze. The drip from above keeps the turf wet and conditions are thereby made ideal for the development of the fungus under this covering, so that as the snow bank recedes we find a condition such as that shown in figure 6. This probably accounts for the erroneous explanation offered by some observers

that winter injury is due to ice acting as a lens to focus the rays of the sun on the turf beneath and to burn it in small spots, for the patches produced by the fungus might readily be mistaken for burns produced by a lens concentrating sunlight in a restricted area. At other times the injury occurs on a slope where the snow drift is above, as shown in figure 7. In such cases there is usually no melted cavity beneath the snow and therefore no possibility for any lens-like action on the turf. The fungus under these conditions usually develops after the snow has left the turf but where there is a constant supply of water from the melting snow to keep the grass moist for some time.

Fig. 9. "A mulitude of evils." A green where winter left the greenkeeper with a real problem, and incidently supplied us with a nice illustration for this article because the different types of winter injury are here combined in one photograph. This green was originally fescue but such injuries are rapidly converting it to clover and weeds. The light speckled appearance is due to damage produced by snow-mold. The larger irregular blotches are due chiefly to ice-sheets, although the snow-mold probably increased the injuries even there. At the far edge in the center is shown a mound from which a pronounced ridge projects into the green. The turf on the crest of the ridge dries out badly in the summer months. During the winter, snow is blown off it and the exposure to cold and drying wind results in a winter injury comparable to summer drying, as is here shown by the light color of the turf on this short ridge. This light area does not extend to the top of the mound, due to the fact that the upper portion was "scalped" by the mower and consequently no turf was there to be injured by winter exposure. Just why clubs still insist on trying to maintain turf of putting-green length on such abrupt ridges remains a mystery

This should not be confused with the injury due to water standing on the turf. In the case of the snow-mold, it is true, the turf must be wet but the injury in such a case is very distinct. Although a bank of snow may keep the soil in a large area soaked for many days the damage occurs only in patches where the fungus is active, whereas, in the ice-sheet injury all the grass in the low wet area is involved. This difference is clearly illustrated in the accompanying illustrations.

Control of Snow-Mold Injury

The control of this disease has been a puzzle. The usual recommendation of providing adequate surface drainage as a sure means for controlling all winter injury, obviously proves of no value whatever against this particular form. Many greenkeepers report that

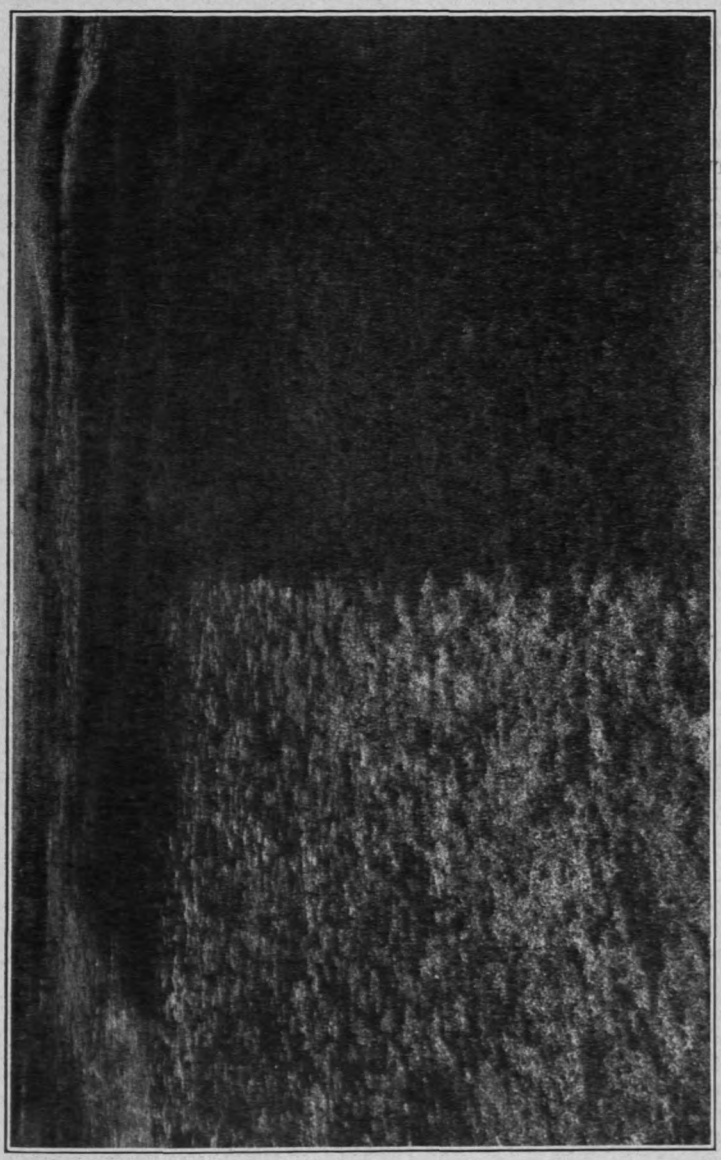

Fig. 10. Control of snow-mold by corrosive sublimate on No. 3 green, Nakoma Golf Club, Madison, Wis. During the first week of October, 1926, rectangular areas of 1,000 square feet were treated with corrosive sublimate at different rates. Two plots shown here were arranged in the form of an L. That in the right foreground received 3 ounces of corrosive sublimate whereas the 1,000 square feet rectangle forming the bottom of the L, shown in the background, received 2 ounces of the chemical. This green slopes toward the north and is so built that most winters it usually receives and holds a heavy covering of snow. This spring as the snow melted during February and early March the snow-mold disease developed on all untreated portions of the green but, as is shown in the photograph, all the turf treated last fall with corrosive sublimate at either of the above rates remained healthy. Note the light-colored spots of dead grass everywhere present on the untreated turf in the left foreground and also on the back portion of the green, surrounding the rectangle of dark healthy grass.

they have been able to somewhat lessen the amount of injury by sweeping the affected areas just after the snow melts, while the slimy mass of fungus and decayed grass tissue is still spreading. This treatment is no doubt effective in breaking the coating over the grass and by so doing the as yet unaffected buds beneath are given a chance to dry more quickly and will probably escape and be able

to develop and replace the injured grass as soon as the weather is suitable. This method is more effective where the grass is comparatively long, as on fairways or approaches. On greens where the turf is so short that this mat of decayed grass is far less dense there is some question as to whether such a practice is to be advised.

The question has been raised as to the possibility of controlling this disease by using grass resistant to its attacks. Unfortunately, there is no information available which can be relied on to answer this question. It will attack practically all of the northern turf grasses, but some species and strains are unquestionably more resistant than others. Redtop is more likely to be injured than bluegrass in fairways. Fescue greens are generally more seriously affected than those of creeping bent. There seems to be some difference in resistance between the various strains of creeping bent planted vegetatively but observations are as yet insufficient to justify any general conclusions.

Since this injury is caused by a fungus, we naturally expect it to be controlled or at least checked by some fungicide, as is brown-patch. The disease develops when snow is melting so any treatment with chemicals at the time it first appears would be a difficult procedure. It would be necessary to watch the greens constantly for a long period and to work on them when they are in a wet condition which would frequently result in far greater damage due to tramping than to the fungus. The most promising method of control is that of using a preventive treatment which can be applied the previous fall and which will serve to protect the greens throughout the winter. At Madison, Wis., we have found that corrosive sublimate will serve such a purpose. It is likely that any of the mercury combinations which have proven effective against brown-patch will prove equally effective against this injury, provided they are used in such quantities as will give the equivalent amount of mercury. We prefer the corrosive sublimate for the reasons that it is cheaper, it can be used as a combination worm eradicator and fungicide and the quantity required for this purpose is harmless to turf when applied during the fall months. In figure 10 is shown a green where corrosive sublimate was used at different rates. One section received 2 ounces and another 3 ounces per 1,000 square feet. These applications were made the first week in October of 1926, the disease developed on this green in late February and early March of 1927. Although the disease was generally distributed over all the untreated portions of the green, there was no sign of spotting on the areas treated with either the 2 or 3 ounces of corrosive sublimate per 1,000 square feet. On another 1,000 square feet area on the same green one ounce of corrosive sublimate was applied the same day that these heavier applications were made. This lighter treatment greatly checked the disease but there was a scattering of slightly infected patches which indicated that this amount was somewhat too light. The two or three ounces per 1,000 square feet are much more effective in bringing up earthworms so the heavier applications are doubly advisable. The cost of the treatment is not excessive, especially in its double capacity and is recommended for trial on greens which from past experiences have proven to be subject to attacks of snow-mold. It is apparent that this chemical is not to be expected to serve as a means for controlling or even checking the winter injury caused by ice-sheets.

Care of Bermuda Putting Greens

By Dr. Thomas P. Hinman, Atlanta, Ga.

It is generally recognized that there are two distinct methods of handling Bermuda putting greens; one, known as the "starvation method," in which no water is used except the natural rainfall and little or no fertilizer applied. In the other method, which I believe is the correct one, fertilizer is used and also artificial watering to supplement the rainfall. Having used and observed both methods, I feel that I am in a position to pass on my observation and experience which, in a small way, may be a help to those who have the same problems to solve.

In our immediate section, the playing season on Bermuda lasts only about five months, beginning from the first to the fifteenth of June and lasting until about the fifteenth of November to the first of December when the frost kills the Bermuda. As playing is continuous throughout the year, we plant our winter greens around the fifteenth of September to the first of October. We have found that English perennial rye planted on a Bermuda base is very satisfactory—that is, greens are made double size and one-half used for summer play and one-half used for winter. In some instances there are two distinct greens for the same hole—one for summer, the other for winter play.

Bermuda that comes up after winter play has ceased, comes up rather scatteringly. Care must be taken of these greens during the summer so that in the fall all that is necessary is to cut the greens closely, scarify the surface with sharp rakes, clear off the débris that is left, by raking, sow them to English perennial rye at the rate of about 10 pounds to every thousand square feet, fertilize with bone meal and tankage—half and half—at the rate of about 75 pounds per green. This will vary according to the size of the green —I am speaking now of a green containing an area of around 3,000 square feet. A light topdressing to cover the seed is used, composed of woods earth, 50 percent; and sharp sand, 50 percent. It is sometimes wise to mix the fertilizer with the topdressing. Water immediately after planting. Growth is very rapid, grass showing in about a week's time.

When the grass has gotten high enough so that it begins to slightly droop, it needs cutting. The cutting is done with an ordinary lawn mower, being sure that the blades are very sharp. The cutting is continued with this high-up mower until the green is ready to play. Then, the usual mowing is done, the green topdressed, or filled, and rolled.

During the growing season it is not wise to do much topdressing, as it is liable to smother the young grass. If the green has a sufficient Bermuda base, no topdressing is needed except just previous to play. Bone meal is used because it is very slow in giving up its ammonia and works particularly well on this type of grass.

In the springtime, the Bermuda greens that have been laid aside during the winter should be prepared for summer play. In our section, they are usually filled with *Poa annua*. It has been found that the best way to handle this situation is to take sharp hoes and skim off the surface, thus removing all foreign grass and weeds.

Bermuda greens never come up uniformly; there are always a

number of dead spots. These should be scarified and sprigged with fresh Bermuda stolons, as well as the sowing of fresh Bermuda seed each year. The amount of seed needed each year will depend entirely on the green. As soon as the green gets a good start, applications of sulfate of ammonia at the rate of 6 pounds per 1,000 square feet should be made; these applications made preferably in a water solution. However, this fertilizing may be done by broadcasting and the water applied afterwards.

The Bermuda should never be allowed to get high and rank. Early cutting is advisable. The mower should be set low and the green clipped regularly. Early and constant cutting seems to cause the Bermuda to spread. An additional application of ammonium sulfate should be made at frequent intervals, depending on the growth of the particular green under consideration. A light application of fertilizer—about every two weeks—during the growing season is advisable.

It is not necessary to do any topdressing until a few days before the green is to be put in play. To get the best results with Bermuda greens it has been found, in a majority of instances, that a topdressing should be made by using 50 percent of woods earth and 50 percent finely screened sharp sand, using this filling about every three weeks to a month.

To get a good Bermuda green the stolons should be kept buried, only the leaves of the grass showing through. Sometimes a Bermuda green can go as long as six weeks without topdressing, but this is unusual. Where giant Bermuda is used for putting greens more frequent dressings are necessary. In the so-called Atlanta strain, where the stolon is much smaller and the leaf much finer and the growth much more compact, such frequent topdressing is not necessary.

Poa Bulbosa

By H. L. Westover and O. B. Fitts

The Green Section, in cooperation with the U. S. Department of Agriculture, has been experimenting with *Poa bulbosa* at the Arlington Turf Garden for several years. Little has been written about this grass as the results of the experiments thus far have not been such as to warrant very definite conclusions regarding its possibilities for putting green purposes. However recent press publicity has resulted in so many inquiries concerning the value of the grass for winter putting greens that a short article giving such information as we have regarding the grass should be timely.

Poa bulbosa is a bluegrass, the underground stems of which are true bulbs about the size of a grain of wheat. The leaves are fine and of a bright green color. At Arlington Farm it begins to grow about October 1 and remains green until May 1, when it dies down. For this reason it is often spoken of as a winter annual, though it is in reality a perennial since the bulbs remain dormant during the summer, sending up new shoots in the fall. The grass seldom grows to a height of more than three inches until in April when it sends up scattering seed stalks about twelve inches in height. Most of the

panicles are normal in the Eastern States except that they produce no viable seed. In some cases, especially on the Pacific Coast, the spikelets are proliferous, small bulblets developing in the seed heads. The underground bulbs multiply about ten to fifteen fold per annum at Arlington farm and are known to retain their vitality for a year or more when stored in a warm, dry room. The grass is easily propagated by planting the bulbs produced underground or the bulblets produced above ground. The bulblets, while much smaller than the underground bulbs, apparently produce just as vigorous plants.

Poa bulbosa is a native of Europe. The grass has been established in different sections of this country for fifteen years or more, though it was not identified until 1916. Just when and how it was intro-

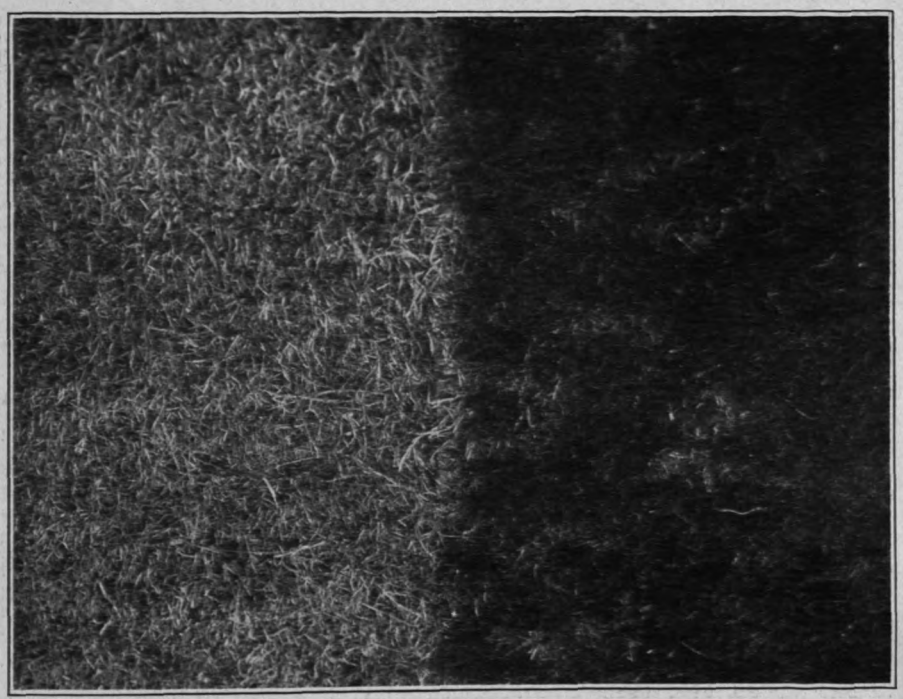

Fig. 1. Poa bulbosa growing in dormant Bermuda turf on the right contrasted with dormant Bermuda turf on the left.

duced is not known. It has been established in the lawn of the Capital Square at Richmond, Va., for many years where it was brought to the attention of the U. S. Department of Agriculture in June, 1915, and was positively identified in February, 1916. Since that time *Poa bulbosa* has been found growing in relatively large areas in Washington, Oregon and southern California, and in smaller areas in the vicinity of Middletown, Conn., and Virginia Beach and Ashland, Va. In 1915 a small quantity of the bulbs from the lawn at Richmond, Va., were held in the Forage Crop office of the U. S. Department of Agriculture at Washington, D. C., for a year or more. In the fall of 1916 these dry bulbs were planted in a plot at the Arlington Turf Garden and produced a fairly good stand of grass the first year.

The stand was much thicker the second year, however, and the third year a very dense turf developed. Regardless of the fact that a considerable quantity of bulbs have been harvested each spring since 1922, this thick, uniform stand has been maintained to date. In 1926 some of the bulblets were harvested on the Pacific Coast and for the first time offered for sale.

Wherever *Poa bulbosa* has been observed under turf conditions it has shown conclusive evidence of its value as a winter grass for fairways and lawns. In combination with Bermuda it furnishes a turf that is green throughout the greater part of the year. In the vicinity of Washington, D. C., *Poa bulbosa* begins growing about October 1, which is about the time the Bermuda begins to turn brown, and re-

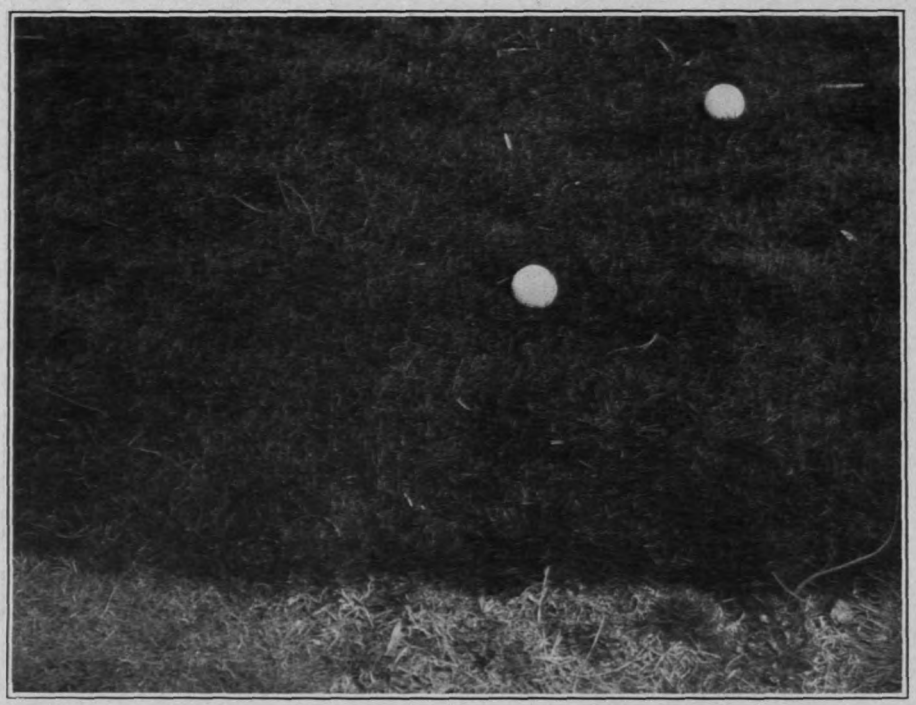

Fig. 2. A good lie on Poa bulbosa.

mains green until May 1, which is usually about two weeks before the Bermuda starts to grow. This lapse of two weeks is the only time during the year that the turf is really unsightly in appearance, whereas Bermuda, growing alone, is brown or straw colored from October 1 to May 15, and where *Poa bulbosa* is grown alone the ground is bare from May 1 to October 1. The accompanying photograph (Fig. 1) shows the difference during the winter months between the combination of these two grasses and Bermuda alone.

The Bermuda does not seem to interfere in the least with the growth and durability of *Poa bulbosa*, and it is doubtful if the latter will interfere with the Bermuda where conditions are favorable for Bermuda. At Arlington Farm, where the two have been growing in combination for several years, the Bermuda has thinned out con-

siderably. This, however, is not regarded as a fair test since Arlington Farm is in the extreme northern range of Bermuda grass, where it is often injured by low temperatures during the winter. Under such conditions the apparent lack of endurance of the Bermuda turf can not be attributed entirely to the *Poa bulbosa*. A valuable characteristic of this grass so far as fairways and lawns are concerned is its dwarf habit of growth, eliminating the necessity of mowing during the winter months as it seldom attains a height of more than three inches. The turf is usually dense enough to provide a good lie for the ball on fairways as shown in Fig. 2.

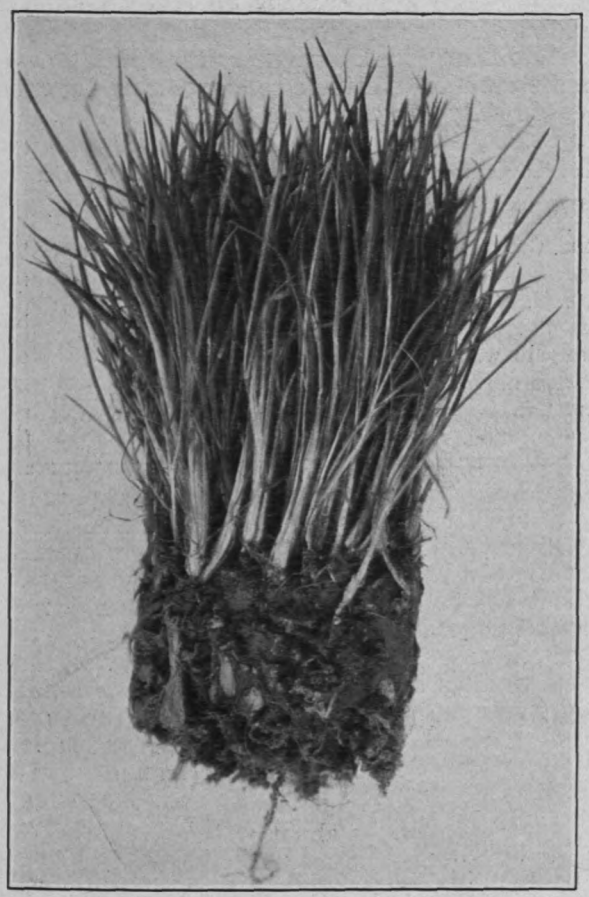

Fig. 3. Natural size photograph showing characteristics of individual Poa bulbosa plants.

We have no knowledge of this grass having been tried out under turf conditions any farther south than Richmond, Va., but there is no apparent reason why it should not grow successfully on fairways in most parts of the southeast. Recently experiments have been started in different sections of the South and it is hoped that more conclusive information will be available in the near future.

At Arlington Farm close cutting of *Poa bulbosa* which would be necessary under actual putting green conditions, has thus far been rather discouraging. We have as yet been unable to produce a satisfactory putting turf with this grass as it produces a rather long stem between the surface of the ground and the leaves (Fig. 3) and when cut closely enough to provide a putting surface the foliage is practically all removed, leaving a stubble rather than a turf. This stubble is unsightly and not at all satisfactory to putt on. Furthermore, the grass is very slow to renew its growth after being cut closely; in fact it never has recovered from more than one mowing during the entire winter. This experience, of course, is limited to the Arlington Turf Garden and there is a possibility that under different conditions it may produce a satisfactory putting green surface. How-

ever, based on our experience, we can not recommend this grass for putting greens.

Poa bulbosa should be sown in the fall and if the bulblets are used the rate of sowing should be about 4 to 5 pounds per 1,000 square feet; if the underground bulbs are used a somewhat heavier rate is advised. The preparation of the soil for sowing *Poa bulbosa* should be similar to that for other grasses. Where it is to be sown on established Bermuda grass turf, all that is necessary is to cut the Bermuda as closely as possible and rake or harrow lightly in order to loosen the surface, after which the bulbs or bulblets may be sown broadcast. The ground should then be rolled and in case of a dry season an occasional sprinkling will be found beneficial until the grass becomes well established. Watering is not absolutely essential, however, as the bulblets will not start until moisture conditions are favorable. For this reason there is little danger of the plant starting and then being killed by drought.

QUESTIONS AND ANSWERS

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

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

1. Improving sandy fairway soil; growing rye for soil improvement.—We are preparing to build the last four holes of our 18-hole course. The area is about 15 acres, which were covered with a sparse growth of scrub-pine and scrub-oak. The land is extremely sandy. There is a top layer of about 1½ inches of black sand produced, no doubt, by the decomposition of vegetation over a period of years, but when plowed to a depth of about 4 inches, which was necessary in order to dispose of the pine needles and smooth and level the land, this black sand was turned under and pure sand brought to the surface. Loam is scarce and expensive here, costing about $3 per cubic yard delivered. Stable dressing can be obtained only in small quantities and is also very expensive. Can you suggest some inexpensive method of fertilizing this area? It has been suggested that we grow a crop of rye on it in the spring, to be turned under as soon as sufficiently grown, thereby getting some organic matter into the soil, and then in early September to seed the land with equal proportions of red fescue and redtop. (Massachusetts.)

ANSWER.—If you can get a fair turf once started on your sandy soil you should be able to bring it later to good condition by fertilizing. If you have reason to believe that it would be unwise to sow your land until the soil is improved, and if you desire to seed the land this fall, we know of no other way by which you can bring your soil to a satisfactory condition than to add loam, and mushroom soil, or manure this spring. It is not likely that a crop of rye planted in the spring would make sufficient growth by early summer to permit you by turning it under to add any appreciable amount of humus to

your soil. In order to become of any value, the rye would have to be turned under so early in the season as to permit it to rot and give the soil time to settle so that a firm seed bed could be established by early September. Rye sown in the fall, however, may be expected to make sufficient growth by the following spring to permit being turned under to some advantage. As to sowing your fairways with red fescue and redtop in equal proportions, we do not believe either of these grasses will give you a permanent turf. Under the conditions you describe, your best fairway grass should be Rhode Island bent. Although Rhode Island bent seed costs more per pound than red fescue, the seed is much smaller, and you would therefore require considerably less seed, and even if sown in mixture with redtop would give you a permanent turf.

2. Value and use of pig manure.—We have available a large quantity of pig manure. Is it suitable for composting, and if so, how should it be treated? Can it be deodorized without destroying its value if used in compost heaps? (New York.)

ANSWER.—We consider pig manure as very good material to use in compost piles. The piles should be kept for a considerably longer period than in the case of cow manure, as the solid excrements of hogs decompose less rapidly than those of horses, cows, or sheep. There is a prejudice among farmers against the use of pig manure, but no real basis for this prejudice has ever been discovered. Probably the best preservatives to use in connection with the composting of manure, and both of which have more or less of a deodorizing effect, are gypsum and floats, the latter being raw rock phosphate finely ground. If either of these substances is used it should be used at the rate of 4 pounds to 100 pounds of manure.

3. Improving bent greens that are fluffy.—Two of our greens were planted from bent stolons last fall, but unfortunately the greenkeeper let them get away from him so that the mower could not cut the grass at all. The result was that the greens were practically hopeless; although soft and comfortable to walk on, they were impossible as putting surfaces, being neither true nor fast enough. Personally I think the turf is too thick and matted and far too long, and our problem is to get it into condition where it can be properly cut with a mower and kept so. (New York.)

ANSWER.—You have no remedy except to rake up and then cut away the tall, matted growth. When this is once done, by topdressing every month and cutting closely each day you can get a good putting surface again. Your greens will look bad for a time, of course, but they can be kept in good condition only in the manner we have outlined.

4. Poultry manure as a fertilizer.—What in your opinion is the value of poultry manure as a fertilizer? (Pennsylvania.)

ANSWER.—In our experiments we have found pulverized poultry manure to be a very quickly acting and effective fertilizer. For bent putting greens, however, our best results so far have been obtained with ammonium sulfate and ammonium phosphate.

Since the publication in the October BULLETIN of results in controlling brown-patch with calomel, questions have been received as to whether the Green Section definitely recommended that clubs shift entirely to this chemical as a means for controlling brown-patch. Questions are also asked as to where calomel may be purchased and in what form it should be used.

As far as we know, calomel has been used against brown-patch only experimentally so we hesitate to recommend it in any dogmatic way. We prefer the policy of using results of experiments at Arlington simply as indicators. There a large number of chemicals and various methods may be tested, the great majority of which are obviously worthless and therefore discarded. An occasional one shows promise and is repeatedly tested until its worth is proven under the conditions obtaining at the Turf Garden. Under our present system we are unable to carry the tests further. The suggestion is then passed on to clubs through THE BULLETIN. Differences in soil or climate may produce results on some courses quite different from those observed at the Turf Garden. Past experiences, however, indicate that in the majority of cases experimental results at Arlington may be regarded as safe criteria for a large proportion of the courses in the region where bent is used. At present the calomel method for checking brown-patch is at the stage of being "passed on to clubs." A number have promised to test this chemical and report results as soon as the disease appears during the coming season. We will then feel sufficiently informed to make a more general recommendation. For the benefit of those who purchase supplies well in advance we advise that chemicals for the control of brown-patch be purchased in quantities sufficient only for the first emergency. Later, if calomel continues to prove as effective as the more expensive mercury compounds, clubs will have time to shift to calomel for later applications. Certain clubs which have followed previous experiments at Arlington and found that results on their courses closely correspond with those at Arlington may feel more confident in using calomel extensively and may be able to effect a considerable saving in cost of material during the summer.

Calomel is used for human medicinal purposes and may be purchased at any drug store. In bulk it may be obtained from any of the large chemical houses, for since not a patented product it is not controlled by any one company. It is produced in the crystalline form but is usually sold as a fine powder. For brown-patch control it should be bought only in the powdered form.