Figure 1. Direct low temperature kill of Kentucky bluegrass sod in depressional areas where the standing water had caused increased hydration of the turfgrass crowns just prior to a severe freeze.

LOW TEMPERATURE TURFGRASS KILL

By DR. JAMES B. BEARD
Professor, Department of Crop and Soil Sciences
Michigan State University

IN ORDER to take steps to prevent winter injury, it is first necessary to delineate the sepcific type or types of winter injury occurring on the particular turfgrass area under concern. The specific preventive practices selected will vary depending on the type of winter injury that most commonly occurs.

Specifically, the three major types of turfgrass winter injury that occur are direct low temperature kill, desiccation, and low temperature fungi. In some cases all three types of winter injury may be present, but one will usually be more dominant and result in greater damage to the turfgrass area. Damage associated with direct low temperature injury will be emphasized in this article.

DIRECT LOW TEMPERATURE KILL

CAUSES. The mechanism of direct low temperature injury involves mechanical disruption of the vital protoplasm in living cells due to the formation of large ice crystals, particularly when the vital meristematic tissues have a high hydration level or water content. *The actual killing temperature is determined not by the air temperature but rather the soil temperature surrounding the meristematic tissues of the grass crown and nodes of lateral shoots such as rhizomes and stolons.*

SYMPTOMS. At the time of spring thaw the leaves initially appear water-soaked with a whitish-brown color that turns rapidly to a dark brown. The leaves tend to lay in a limp mat over the soil surface. The damaged area is frequently associated with poor drainage such as depressions or drainage ways where water has been allowed to stand for a period of time. The appearance will vary in a large, irregular pattern or patches associated with sites where standing water occurred. In some cases a distinct, putrid odor occurs within 14 days after spring thaw.

TURFGRASS TOLERANCE. Turfgrasses vary in the ability to survive low temperature stress. This is dependent on the capability to harden-off in late fall. Hardening involves a series of physiological changes in which the water content of the plant tissue is reduced. It normally occurs at soil temperatures in the range of 35 to 45° F. over a period of three to four weeks during the fall. During this process the water content in the tissue will decrease from a normal level of 80% to between 60 and 70%.

The relative degree of low temperature hardiness varies seasonally through the winter. *Maximum hardiness is reached in December followed by a gradual decline until a minimal hardiness level exists just at the time of spring thaw.* At this point, the hydration level of the plant tissues is quite high and thus the plant is most prone to direct low temperature kill during this late winter-early spring period prior to the initiation of growth. Direct low temperature kill may occur if there is a rapid decrease in temperatures to below 20° F.

Turfgrass species vary in hardiness to direct low temperature kill as summarized in Table 1.

The creeping bentgrasses are exceeded only by rough bluegrass in terms of low temperature hardiness. There are also cultivar differences with Toronto creeping bentgrass being superior in low temperature hardiness followed in order by Cohansey, Penncross, and Seaside.

Table 1
The comparative low temperature hardiness of thirteen commonly used turfgrass species.

Low Temperature Hardiness Ranking	Turfgrass Species
Excellent	Rough bluegrass Creeping bentgrass
Good	Kentucky bluegrass Colonial bentgrass
Medium	Annual bluegrass Red fescue Tall fescue Zoysiagrass
Poor	Perennial ryegrass Bermudagrass Italian ryegrass Bahiagrass St. Augustinegrass

The Kentucky bluegrasses rank

good in low temperature hardiness. Cultivar differences in low temperature hardiness occur within the Kentucky bluegrasses with Nugget being superior in low temperature hardiness followed by A-34, Baron, Fylking, Galaxy, Merion, Pennstar, Sodco, and Sydsport. Delta, Kenblue, Park, and Prato are generally inferior in terms of low temperature hardiness.

Among the perennial ryegrass cultivars, the relative ranking from most to least low temperature hardiness is Norlea, Manhattan, Pennfine, and Pelo.

It is evident that selection of the appropriate turfgrass species and cultivar for a given area will assist greatly in minimizing low temperature injury.

PREVENTING LOW TEMPERATURE INJURY. Aside from selection of low temperature hardy turfgrasses, the most effective method of minimizing low temperature injury is to ensure adequate surface and subsurface drainage. This is particularly evident in Kentucky bluegrass sod production fields where serious low temperature kill has frequently occurred during the past six years (Figure 1). This injury is generally associated with low, poorly drained areas where standing water occurs.

Preventing this problem involves ensuring proper surface drainage by establishing modest slopes toward catch basins, waterways, and open drainage ditches. Subsurface drainage in the form of drain tile will also facilitate removal of excess water from the soil, providing it is not frozen.

Subsurface drainage can also be enhanced by cultivation involving either coring or slicing that will reduce the degree of soil compaction. **The importance of proper drainage and the avoidance of standing water in depressional areas cannot be stressed too much.**

There are other cultural practices that also contribute to a decreased incidence of low temperature kill. Basically these practices either enhance the fall hardening process by avoiding excessive stimulation of shoot growth that increases the hydration level or they serve to enhance the degree of insulation against low temperature stress occurrence in the vicinity of the vital meristematic areas.

Specific practices that can be utilized include moderate nitrogen nutritional levels. This means avoiding nitrogen fertilization during the fall low temperature hardening pe-

(Continued on page 28)

Figure 2. Comparative tolerance of three turfgrasses after being held 150 days in an ice block. Toronto creeping bentgrass (l), Merion Kentucky bluegrass (c), and annual bluegrass (r).

TURFGRASS KILL *(from page 15)*

riod or the use of excessive quantities of nitrogen during late summer fertilizations.

The second nutritional consideration is to ensure that there are adequate potassium levels available to maximize the low temperature hardening capability. (Under Michigan conditions, a nitrogen-potassium ratio somewhere in the order of 2:1 to 3:1 has proven most effective.)

Other beneficial cultural practices involve (a) raising the cutting height to a moderate degree, (b) elimination of thatch problems that elevate the vital meristematic tissues above the protective layer of the soil, and (c) avoiding excessive irrigation that will waterlog the soil and increase the degree of crown hydration.

Insulation against direct low temperature kill can also be provided by placing an insulation cover over turfs that are of great importance and are particularly prone to low temperature kill. Materials that can be used effectively include the Conwed Winter Protection Cover, Soil Retention Mat, use of natural organic mulches such as straw, or enhancement of snow cover accumulation by means of snow fence or brush.

ICE SHEETS

Contrary to statements appearing in some literature, ice sheets that cause oxygen suffocation or lethal gas accumulations under the ice cover are not a major concern in terms of turfgrass winter injury. Most perennial cool season turfgrasses will survive at least 60 days of ice coverage. Serious injury to annual bluegrass can be anticipated if the ice cover remains in place for a period of 70 to 90 days (Figure 2).

Merion Kentucky bluegrass and Toronto creeping bentgrass have been subjected to ice coverage for up to 150 days with no significant injury. This length of ice cover will rarely occur in most sections of the United States. More commonly, turfgrass injury associated with ice and snow covers occurs prior to freezing or during thawing when the standing water results in an increased crown hydration level. *Serious kill may occur if the temperature subsequently drops at a rapid rate to below 20° F.*

REMOVING ICE AND SNOW COVERS. The best way of minimizing damage associated with ice covers is to ensure that there is adequate surface drainage from the area. From a turfgrass standpoint, the plants should enter the winter at a moderate growth rate with adequate but not excessive nitrogen nutritional levels of potassium nutrition.

The situations that have been documented where ice removal has reduced the degree of winter injury have usually been associated with direct low temperature kill. Rather than breaking up the ice barrier to enhance gas movement, the professional turfman was actually mechanically removing water from the turfgrass area; thus minimizing the degree of crown hydration that could occur and in turn reducing the chance of direct low temperature kill.

Where crown hydration due to standing water and subsequent direct low temperature kill associated with the ice cover is of primary concern, it is important to remove the ice cover and snow prior to periods of anticipated thaw. One should not attempt to remove the entire ice or snow cover but should leave a protective layer of between one and two inches remaining on the surface. This modest layer will serve to protect against winter desiccation injury and will also function to a certain degree in insulation against direct low temperature stress.

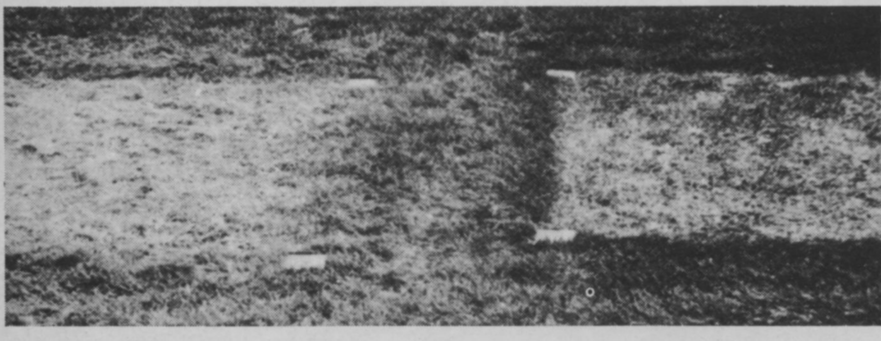
It is preferable to remove the ice and snow during periods when the turf and underlying soil are frozen in order to minimize damage to the surface itself.

Snow blowing equipment or plows can be used in the removal of snow while thick layers of ice may have to be chipped and broken up by use of such equipment as powered rototillers. The latter procedure has been used quite effectively on sports fields in England.

Where poor drainage and crown hydration-low temperature stress problems are not a serious concern, the thaw and breakup of ice covers can be enhanced by placing a black organic material on the surface of the ice. On sunny days this functions quite effectively in absorbing the incident radiation and generating heat which will assist in thaw of the ice sheet from the surface rather than from the underside. Milorganite has been utilized very effectively in this regard.

Clear ice sheets frequently thaw from the underside when periods of high intensity sunlight occur. Under this condition it is not uncommon for a considerable quantity of water to be trapped under the ice sheet for an extended period of time which increases the turfgrass crown hydration level. If this thawing period with standing water under the ice sheet is followed by a severe freeze to below 20° F., the chance of direct low temperature kill is quite high.

Figure 3. Serious damage to a Kentucky bluegrass turf resulting from one person stepping uniformly over two 4 x 4 foot areas one time when two inches of wet, slushy snow was present and a severe freeze occurred the following night.



The placement of a black material on the surface of the ice will enhance surface thawing and more rapid breakup and drainage of water from the area.

TRAFFIC EFFECTS. Traffic is frequently a consideration on snow covered turfgrass areas that are utilized for recreational purposes as well as the areas immediately surrounding ice rinks.

Damage can be of two types. One involves traffic during moderate cold periods when a wet, slushy condition exists. The traffic forces the down into intimate contact with the turfgrass crowns which in turn increases the crown hydration level. If the effects of traffic on this wet slush are followed by a rapid freeze to below 20° F., there is a high probability of serious damage to the crowns, rhizomes, stolons, and roots (Figure 3).

The second type of injury may involve the use of motorized snow vehicles which, on thin snow covers, can mechanically disrupt or tear out pieces of turf by their abrasive action.

PREVENTING TRAFFIC INJURY. The first consideration so far as traffic is concerned is to **restrict** these activities during periods when a wet slushy condition exists. *This is one of the most important preventive measures.*

Snowmobile traffic is a more recent concern in terms of turfgrass winter injury. Serious damage and thinning of turfs can occur if snowmobile traffic is not controlled or restricted under certain conditions. Damage to dormant turfs is most common (a) during periods of minimal snow accummulation, (b) during wet slushy periods of alternate freezing and thawing, and (c) on trails where the traffic is intense causing rutting and removal of a major portion of the protective snow cover.

Under most conditions it is preferable to have a minimum of four to six inches of snow cover present over the turfgrass area. The minimum protective snow depth is less for compacted snow than for loose snow. Placing traffic barriers such as snow fence on high value turfgrass areas where any degree of injury would be costly should also be considered.

Finally, the development of specific snowmobile trails should be considered on sites where intensive snowmobile activity is anticipated. This will encourage travel on locations that are less critical in terms of turfgrass damage.

Turfgrass Ice Rinks

In discussions associated with ice covers and winter injury, the question of proper utilization of ice rinks on turfgrass areas is frequently raised.

Ice rinks can be effectively used on turfgrass areas with minimum permanent damage providing certain key considerations are followed.

First of all, it is very desirable to have a site where the existing turf is composed of the more low temperature hardy turfgrass such as creeping bentgrass or Kentucky bluegrass.

Second, the surface contours of the site on which the ice rink is to be constructed should be such that the water will drain rapidly from the area during late winter or early spring thaws.

Third it is preferable to have at least a two to three inch layer of compacted snow established under the ice sheet to provide a protective insulating zone for the turf. On smaller ice rinks, the use of a polyethylene cover that protects against standing water in contact with the turf will minimize direct low temperature kill.

The final consideration is to be sure that the appropriate preventive snow mold fungicide has been applied to the turf prior to establishment of the snow cover and ice sheet.

The ice should be formed by the application of water at very low rates over an extended period of time during the night when air temperatures are below 20°F. The flood application of water to a depth of one to two inches followed by slow freezing over a long period of time is not desirable due to the increased likelihood of direct low temperature kill to the turf.

The final consideration is during the thawing period in the spring. It is important to check the ice rink frequently at this time to ensure that no ice dams or other problems develop that result in water standing on the turf for an extended period of time. *All precautions should be taken to ensure rapid drainage of excess water from the area.*