The Science and Management of Turfgrass Winter Injury

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Editor's Note: A familiar author appears here - Frank Rossi, Cornell University Turfgrass Team Member and former UW-Madison faculty member. This article originally appeared in Vol. 9, No. 3 of ***CUTT*** *- Cornell University Turfgrass Times. Frank's interest in winter injury is still strong; New York State can experience vast areas of intense winter weather. I have permission from both the author and from the editor of* ***CUTT*** *- they are one in the same. He sends greetings to all.*

Each year acres of turfgrass across the northern regions are affected by winter injury. In some cases the injury can be severe and lead to "winterkill:" turf death resulting from singular or combined effects of freezing stress, ice encasement, traffic, desiccation, soil frost heaving, and low temperature fungi. Many of these factors, such as ice encasement or species susceptibility to freezing stress, are not easily managed.

Extensive turf loss can have significant environmental and economic consequences on the functional and aesthetic quality of recreational turf areas. Turf loss from winter injury, most evident in the spring, results in increased weed encroachment, greater soil erosion, and often requires energy intensive reestablishment procedures to restore the environmental benefits of a contiguous and healthy turf cover.

Low Temperature Acclimation

Survival of perennial vegetation such as turfgrasses, trees and other species that persist in northern climates requires adjustments in growth in response to day length and temperature changes. These adjustments (acclimation mechanisms) that are required for winter hardiness can begin to occur in mid- to late summer. This fact is easily proved when bentgrass plants are taken from the field in June, they are easily killed at about 32 degrees F, while plants taken at peak hardiness in early January can survive down to -35 degrees F.

Maximizing energy production from photosynthesis is essential for winter hardiness. The plant produces energy from photosynthesis and utilizes a portion for additional biomass (leaves, roots, etc.) then begins to store energy for the winter.

Energy storage is vital for winter survival for several reasons. The first and most important reason is that while the plant in dormant, it continues to respire (burn) energy. It is similar to when we sleep: we continue to breathe, we just breathe differently (deeper, more slowly). Therefore the plant must have the necessary energy to respire or it will be more susceptible to diseases and other stress.

The next important aspect of acclimation has to do with cell membranes. The membrane structure is altered in a similar fashion as it does when a plant enters dor-

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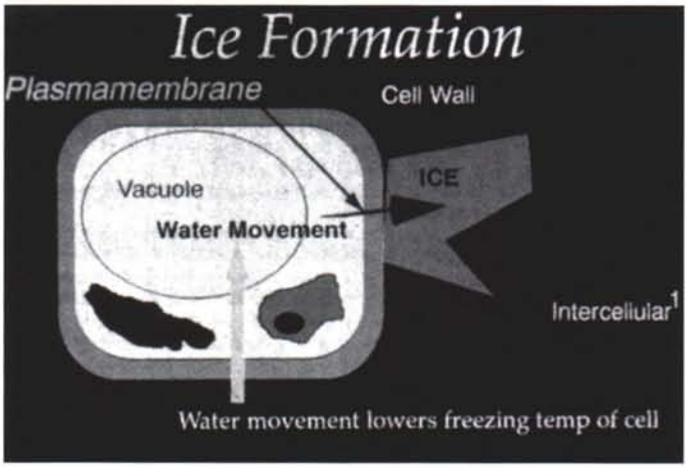

Fig. 1

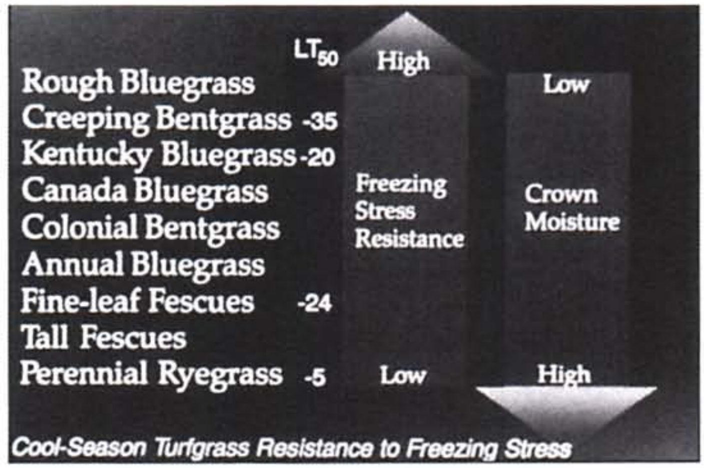

Fig. 2

mancy from moisture stress. In fact, studies have shown with some plants that slight moisture stress during acclimation can enhance winter hardiness. Also, there appears to be a requirement for certain turfgrasses to experience primary acclimation following freezing temperatures around 32 degrees F, then secondary hardening when temperatures fall into the 15 degree to -25 degree range.

Ice Formation Within the Plant

Plants that are most successful in surviving winter are able to tolerate ice formation between the cells. On extremely rare occasions, ice will form within a cell, if temperatures drop rapidly, however for grasses this is thought to be a minor issue. Rather, it is the formation of ice between cells that draws water from within a cell and results in desiccation (see Figure 1).

The phenomenon of crown hydration is a result of excessive cell dehydration. For example, during the most sensitive period from late winter through early spring when most winter injury occurs, freezing and thawing temperature fluctuations prevail. If the turf is saturated, in standing water, or a blackening agent is applied and allowed to accumulate and absorb heat, that heat is transferred to the plant and growth is stimulated. When growth is stimulated, the tissue fills with the water that drives growth (cell expansion). That water is now available for freezing when the temperature drops. As the ice begins to form between the cells, the crystals "draw" water from inside the cell and cause cell death.

Researchers have speculated for years that one of the single most important aspects for enhancing winter hardiness is delayed de-acclimation or breaking of dormancy. This is most difficult with annual bluegrass that is likely to break dormancy rapidly in the spring. In fact, researchers at the Prairie Turfgrass Research Center have quantified the reduced hardiness of annual bluegrass following 8 hours of temperatures above 40 degrees F. It was concluded that freezing tolerance was reduced 5 - 10 degrees F following that slight warming.

It is important to understand a few of these basic principles, because they assist with determining the most effective management program for ensuring survival. Still, winter hardiness is extremely dependent on the species of turf growing (see Figure 2). Creeping bentgrass is one of the most winter hardy species, while annual bluegrass is one of the more susceptible. Perennial ryegrass and tall fescue can be marginally hardy in the northern climates in the first few years following establishment. Mature stands can be more winter hardy, especially if the soils are well drained and the area is somewhat protected.

Ice Encasement

As indicated previously, turfgrasses continue to respire energy throughout the winter. This physiological process requires gas exchange. Therefore, when winter conditions result in ice formation on the turf surface, the necessary gas exchange cannot occur and the area beneath the ice becomes anaerobic (lacks oxygen). In addition, there are substantial amounts of gas given off from the soil as some microbes remain active, such as the snow mold organisms.

The cool-season grasses have varying abilities to tolerate ice encasement. For example, under research conditions, annual bluegrass can survive up to 60 days under ice, Kentucky bluegrass 100 days and creeping bentgrass 150 days. This is probably consistent with most turf managers' experience with the regular loss of annual bluegrass under winter conditions.

Severe incidents of ice encasement are sporadic, occurring one out of every three to five years in most northern regions, and management can be difficult. Yet, the key to alleviating the problem is simply to break the ice to allow adequate gas exchange (see Figure 3). This can be accomplished by physically disrupting the ice. Several turfgrass managers have utilized core cultivation equipment fitted with solid, "hammer-like" tines to break the ice. Still, the use of a "blackening agent" such as dark compost or natural organic fertilizers, such as Milorganite, applied to the ice surface on bright days absorbs heat and creates pores in the ice that allow for gas exchange.

Fig. 3

Unfortunately, ice encasement is not the only challenge from this phenomenon. During the transitional period between late winter and early spring when freezing and thawing can occur, the plants experience warm, saturated conditions. These conditions, described earlier in this article, can lead to freezing stress, where ice forms within the plant, causing severe cell dehydration. Again, this argues for adequate surface drainage as a means of minimizing this problem.

Factors that Influence Hardiness

Drainage. One of the most critical aspects of winter injury whether it is ice encasement, snow molds or crown hydration (cell dehydration) is free water for freezing to encourage disease. In addition, wet fall periods prior to winter will reduce winter hardiness. The importance of proper surface drainage cannot be stressed enough, especially on turf areas such as athletic fields and golf greens that are trafficked in the early spring.

Fertility. For the grass plant to maximize photosynthetic activity, adequate, well balanced nutrition must be available. In fact, many studies have shown increased energy (carbohydrate) storage following late fall fertilization. Products that have a high percentage of water soluble nitrogen are ideal for this purpose; however, on sandy soils, care should be taken to use more moisture dependent slow release materials such as IBDU to ensure water quality.

The late fall fertility is best applied after top growth has ceased which typically coincides with seven to ten days when the mean daily average temperature is 50 degrees F. This ensures that any warming periods that might stimulate top growth (Indian summer) and reduce hardiness have passed. There is usually a period from late September through late October, depending where you are in the north, when fertilizer should not be applied.

Many turf managers apply excessive amounts of potassium (K) in the late season to enhance winter hardiness. Keep in mind, there is no conclusive evidence that indicates K levels above that which is required for adequate growth (indicated by soil test) will enhance winter hardiness. Furthermore, there may be severe consequences from excessive application of high salt content fer-

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tilizer as suggested by researchers investigating bentgrass decline in the southeastern United States.

Mowing heights. If we can accept that grass leaves are where the energy is produced that enhances hardiness, it follows then to have as much leaf surface area available in the late season as possible. Excessive close mowing, at or below the acceptable range for a particular species, will compromise energy production and reduce winter hardiness. It is advisable to raise the mowing height on putting greens if golfers will tolerate reduced ball roll distances.

There is no research data that indicates that a final "close" mowing will reduce snow mold incidence. Still, close mowing may benefit when the turf is excessively tall and folds over onto itself, matting up in a fashion similar to tree leaves left on the turf.

Thatch. Excessive thatch accumulation will reduce winter survival as a result of plant crowns and other perennial structures being elevated from the soil/thatch interface and less buffered from extreme temperatures. In addition, thatch levels above one inch can promote desiccation and turfgrass disease incidence. Late season core cultivation that incorporates the soil from the cores into the thatch layer can assist with solving this problem and actually improve drainage by breaking through layers.

Disease Management. Two research projects from Japan suggested that low temperature pathogens could "sense" weak plants that might be more susceptible to infection. Subsequently, as indicated several times to this point, maximizing plant health through proper acclimation with water management, fertility and mowing height, could result in reduced snow mold. Nevertheless, species such as perennial ryegrass, creeping bentgrass, and annual bluegrass are highly susceptible and will require preventative management to ensure survival.

Topdressing. Many turfgrass managers have practiced heavy, late season topdressing that serves to insulate the turf and protect the crown from desiccation in open winters. However, golf turf managers in the north central United States have experienced problems from late season sand topdressing that might be dragged or brushed in. Dr. Don Taylor at the UW-River Falls has begun a study investigating this management practice. Results from the first year were inconclusive. Still, it may not be wise to topdress with highly angular sand and brush it in. This practice may abrade the leaf surface and accelerate desiccation.

Traffic. Of all the management factors that are under the control of the turfgrass professional, minimizing traffic during periods when the soil is frozen or just when turf in not actively growing can be the most difficult. Players want to use the turf and that conflicts with what is known regarding maintaining healthy plants. While there is limited data on early season play, estimates suggest that active play during the "shoulders" of the growing season can require many weeks of active growth for recovery. Therefore, if possible, minimize traffic when the plants are dormant or the soil is frozen.

Turf Covers. The use of synthetic protective turfgrass covers, for enhancing winter survival, has provided variable results over the years. Recent studies from Laval University in Quebec have indicated that snow is the best insulator and should be kept on as long as possible. The next best thing is any cover that used an air layer to insulate the turf from extreme temperature and moisture. Keep in mind that covers accelerate green up in the spring and can result in reduced winter hardiness if temperatures drop suddenly.

Let's Talk!

With the variety of technology available to the turfgrass manager, winter injury reminds us how "biology rules" and we remain governed by the laws of nature. However, many strategies are available to enhance hardiness through adequate drainage, proper nutrition (especially timing), and minimizing traffic during dormancy or on frozen soil. Still the grass may suffer winterkill.

It is essential for the turfgrass manager to develop and utilize this opportunity to communicate, when users are paying attention to the potential for dead turf. This is a chance to discuss aspects of the management program that is adjusted to meet the unrealistic expectations of late season play, that neglected drainage project or possibly an extra fertilizer application to enhance hardiness. It is human nature to avoid some issues until a crisis. When winterkill is widespread, it tends to get people's attention. Be prepared to seize the moment and talk to the users.

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