Cold-weather management:

Understanding crown hydration damage

Though the fate of turf is largely dependent on Mother Nature, certain practices may help protect it from this devastating form of winterkill.

John M. Roberts, Ph.D.
University of New Hampshire

Crown hydration damage continues to be one of the most destructive — yet least preventable — forms of winterkill. It is a problem generally associated with turf growing in wet soils whose saturated cells rupture and die following extreme fluctuations in temperature.

Many of the specific environmental conditions required to cause damage are not fully understood. However, serious injury has been reported when warm temperatures are followed by rapid decreases in soil temperatures below 20 F.

Golf courses located in the central and northern regions of the United States are prime targets and can be damaged throughout the winter. Even so, turf in these regions is particularly vulnerable to crown hydration damage in the two- to three-week transition period during snowmelt in early spring, during which time standing water and saturated crown tissues often exist on semifrozen soil surfaces.

This is especially apparent on greens that have not been contoured to allow for surface runoff. Also during this transition period, wide-ranging daily temperature changes are common, and carbohydrate levels of the turf are low. As a result, the young tissues being produced are highly susceptible to crown hydration damage at this time.

One of the key principles in reducing injury involves maintaining low crown hydration levels. However, under field conditions, wet soil surfaces often exist because frozen soils are impermeable, and water moves upward from the frozen soil during thawing periods. As a result, large sections of greens can still be lost despite various attempts to limit excessive crown hydration.

John Roberts is an extension turfgrass specialist and an associate professor at the University of New Hampshire.

Extensive crown hydration damage on poorly drained fairways on which Poa was the predominant turfgrass. Tests indicated that Poa is the least tolerant grass to crown hydration injury.

Field experience has indicated that following severe winters, the portions of greens (especially of *Poa annua* greens) where water collects are most often injured. This includes greens built with permeable soils and those having subsurface drainage.

Water, being central to the problem, has some unusual properties when temperatures approach the freezing point. Unlike most liquids, which contract with cooling temperatures, water actually expands as temperatures drop below 39 F. When water freezes, a further expansion occurs, to the extent of about 109 percent of its original volume.

It would seem that this phenomenon would increase the potential for saturated tissues within the turf to rupture following periods of freezing and thawing. Yet during extracellular freezing, ice crystals outside the cell grow larger, withdrawing water which results in a dehydration and contraction of the cell. (It would seem then more appropriate to call this form of damage crown *dehydration*.) After rewarming, the cells — if they have not been injured — can soon reabsorb water and regain full turgor.

Detecting crown hydration damage

Continued on p. 52

HYDRATION

from p. 48

in the early days of snowmelt often is difficult. During the winter, despite having water-soaked blades, turf retains its green color under a snow or ice cover and still appears to be alive. It is not until the warmer temperatures of spring arrive (generally within a few days of the course opening for play) that turf injured by crown hydration damage will begin to turn brown as the green chlorophyll pigment fades from the leaves.

The process of overseeding usually follows, and two to three months generally are needed before injured greens are fully restored. The recovery time can be particularly slow if cool spring temperatures prevail.

Putting green studies

During the past two winters, studies have been conducted on putting green turfgrasses primarily to determine their tolerance to various freezing and thawing temperatures. The grasses used were taken from an experimental green that was mowed at 3/16-inch and otherwise was maintained as needed to produce a healthy turf.

In early December plugs were extracted and placed in perforated containers for easier removal later in the winter. While stored outside, the samples remained frozen but unsaturated through February.

Before the samples were subjected to alternating freezing and thawing cycles, they were brought indoors and submerged in cold water (40 to 44 F) for eight hours. The saturated and partially frozen samples were then placed in a freezer for 24 to 72 hours to ultimately lower the soil surface temperatures to 20 F and 10 F, respectively. (This rapid-freezing regime was considered more destructive than the slower fluctuations that might be encountered in the field.)

Following the freezing period, the samples were removed and thawed (still submerged) at room temperature (65 F) for 48 hours, increasing the crown temperatures to between 41 and 47 F. The freeze-thaw cycles were repeated three times. Finally, the samples were drained of excess water and transferred to a greenhouse for recovery. The amount of injury was recorded one month later relative to samples that were not subjected to the freeze-thaw cycles.

Findings

All samples were particularly vulnerable to repeated freeze-thaw cycles beginning in the snowmelt transition period of early spring. It was more noticeable in the Poa samples than in the more-tolerant bentgrasses. The main reason for this is the diversity of aspects involved in freezing injury.

Research has indicated that following severe winters, the sections of greens on which water has collected are most often damaged by excessive crown hydration.

Ice formation and the ensuing injuries take different courses depending upon species, state of hardiness and the conditions of freezing. Because of this, no single, generally effective mechanism can be said to be responsible for cell depth and survival. However, the plasma membrane plays a central role in cellular behavior during a freeze-thaw cycle, and disturbance of its semipermeable characteristics is a primary cause of freezing injury.

Even though the grasses were more resistant to crown hydration damage when dormant, 50 percent injury still occurred to the Poa samples in midwinter. At the same time and under similar conditions, the bentgrasses escaped injury. However, if subjected to more severe temperature fluctuations in the field, the likelihood of complete kill remains a distinct possibility.

During the snowmelt period, complete kill of the submerged Poa resulted following three alternating freeze-thaw cycles in which the soil surface temperatures rapidly (within 24 hours) dropped to 20 F. Only 5 to 30 percent injury occurred to the bentgrasses under similar conditions.

In order to injure 50 percent or more of the bentgrass during the transition period, three alternating freeze-thaw cycles were required, during which the low (crown) temperature

Continued on p. 54

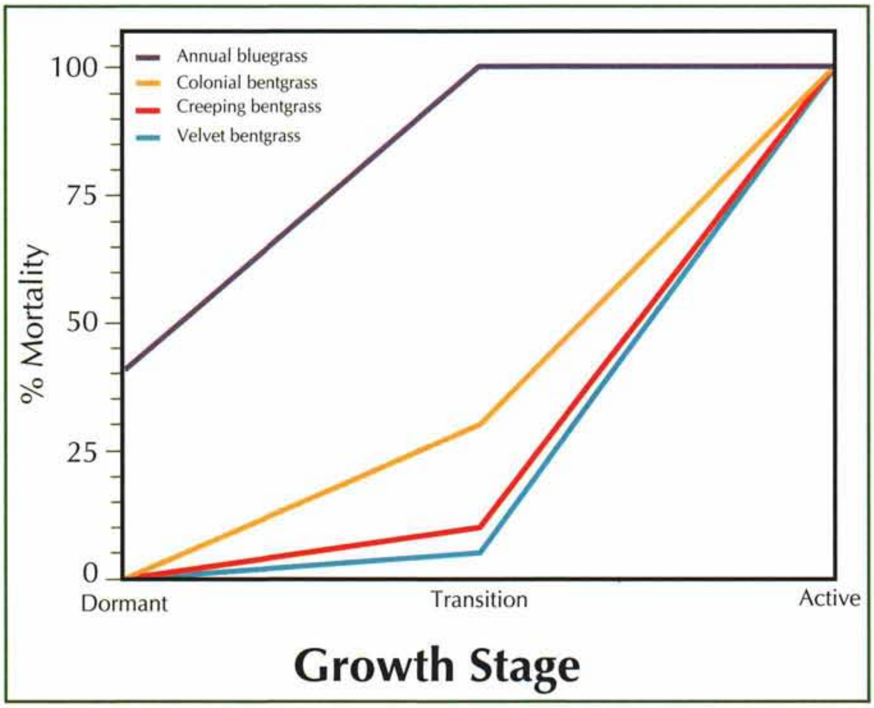

Figure 1. The effect of growth stage on crown hydration damage.

Test results showed that dormant bentgrass had more tolerance to freeze-thaw cycles than bentgrass that is actively growing.

HYDRATION *from p. 52*

dropped to 10 F. (A single, 12-hour freeze-thaw cycle caused no injury.) Even under the demanding conditions of these tests, complete kill never occurred to the creeping or velvet bentgrasses until active growth (and green-up) occurred two weeks later in the spring.

Interestingly, less injury occurred to local golf greens having similar alternating soil temperatures perhaps because the rate of temperature change was considerably slower than the experimental test conditions. This seems to indicate that the insulating properties of snow were helpful in reducing injury. Of course, snow melts during warming trends, saturating soil surfaces and when temperatures drop again, ice layers are formed. Neither of these environments would be considered advantageous for extended periods of time.

Turfgrass tolerance

It became quite clear during the various freeze-thaw cycles (not all tried are reported) that Poa was the most sensitive to crown hydration injury. This comes as little surprise to many who have witnessed the loss of only Poa in greens equally mixed with bentgrass.

Among the three bentgrass species the velvet (Kingstown) and creeping bentgrasses generally exhibited greater tolerance than the colonial bentgrass (Bardot). Four creeping bentgrasses were used. Penncross showed better tolerance than either Cobra or Carmen. The most-resistant variety, however, was a strain from a local course.

In the second winter of testing, Penncross bentgrass samples fertilized in October with a 1:2 ratio of nitrogen-to-potassium (at 0.75 lbs. of urea nitrogen) had 30 percent less damage than samples receiving nitrogen without potassium (unreported data).

Providing protection

A better understanding of crown hydration damage, innovative ideas to solve it, new technology, genetic breakthroughs and even small miracles might be necessary to help eliminate this complex problem. Clearly many fundamental questions remain unanswered. But no matter what attempts are made, the ultimate fate of the turf still appears largely dependent on Mother Nature.

However, today's best management practices may help provide protection. These practices include:

- Maximizing bentgrass populations. (Poa greens and harsh winters often are incompatible.)
- Designing greens that allow for rapid surface runoff.
- Constructing greens with permeable soils and installing drainlines for rapid subsurface drainage.
- Avoiding cultural practices that stimulate excessive growth during the hardening period of late fall.
- Maintaining high potassium levels entering the winter. □

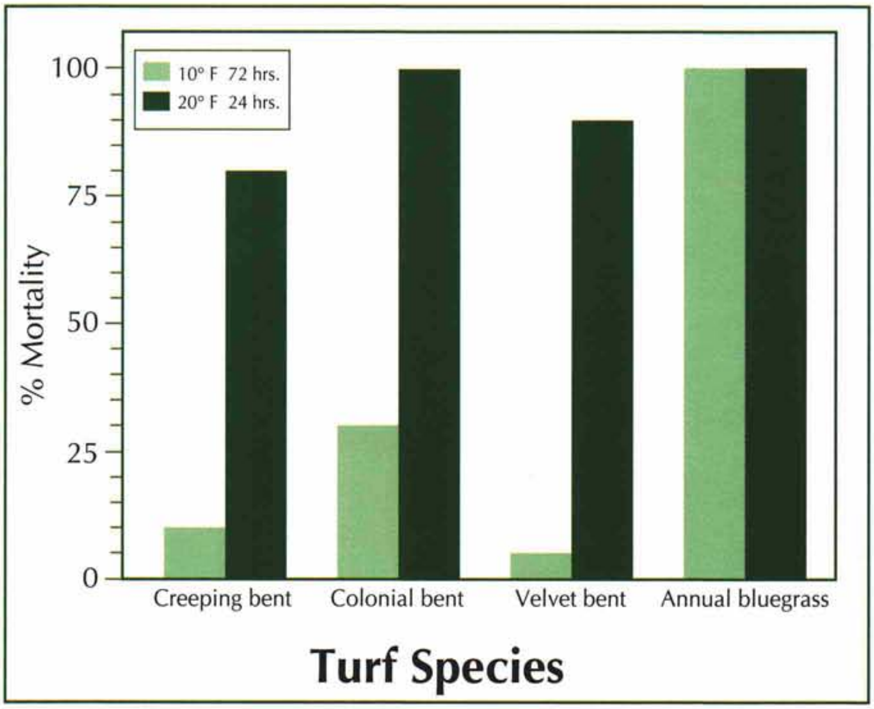

Figure 2. The effect of low temperatures at the soil surface in early spring on crown hydration damage.