Winter Injury

Eight major factors and a half dozen secondary ones cause turfgrass to be killed or seriously damaged during the cold season

By JAMES B. BEARD

The causes of winter injury of turfgrasses are divided into eight categories in this discussion. The order of presentation is not related to their relative importance. The degree of injury caused by any of the reasons listed may vary from year to year and from one location to another.

Direct Low Temperature Injury to Hardened Plant Tissue

Injury caused by freezing temperatures involves mechanical destruction of protoplasm in plant cells. Hardened plant tissue is more able to survive low temperatures because of changes which occur within the cell. The changes include an increase in soluble carbohydrates, a reduction in level of water content in the plant tissue and alteration in the proteins. Temperature conditions averaging between 30 and 40 degs. F. for a period of three to four weeks will produce a plant which is low temperature hardy. Any management practice which stimulates growth, such as nitrogen fertilization, will reduce the hardiness level.

The relative low temperature tolerance of 11 turfgrasses is presented below. The ranking is from most to least tolerant and is based on observations made in Michigan.

1. Bentgrass; 2. Roughstalk bluegrass; 3. Kentucky bluegrass.

4. Annual bluegrass; 5. Red fescue; 6. Redtop; 7. Tall fescue.

8. Perennial ryegrass; 9. Zoysia; 10. Annual ryegrass; 11. Bermudagrass.

Creeping bentgrass and roughstalk bluegrass have proved to be by far the most low temperature tolerant turfgrasses. The colonial bent, Astoria, is much less low temperature tolerant than creeping bent grasses. Next in degree of tolerance are Kentucky bluegrasses, Merion being more hardy than either common or Newport. Merion discolors and stops growth in early fall, permitting it to achieve maximum hardiness. But Newport continues to grow throughout the fall and is the least low temperature tolerant of the three varieties.

Although normally considered a weed, annual bluegrass (an intermediate) is included because it constitutes a major portion of many close-cut, irrigated turfs in certain areas. Kentucky 31 tall fescue is more low temperature tolerant than Alta tall fescue.

A third group, including perennial rye, zoysia, annual rye, and Bermuda show the least low temperature tolerance of the turfgrasses. The Norlea variety of perennial rye is more winter hardy than common perennial. Although there are Bermudagrass and zoysia selections that are quite low temperature tolerant, as a group the commonly used varieties rank low.

Several Factors Involved

The degree of low temperature kill at any one temperature depends upon these factors: (a) rate of freezing, (b) rate of thawing, (c) number of times frozen, (d) length of time frozen, (e) hydration level of the tissue, and (f) the post-thawing treatment.

Turfs killed by low temperatures during the MSU studies had a distinctive odor similar to that noted under field conditions.

Direct Low Temperature Injury to Plants in A Reduced State of Hardiness

Turfgrasses usually reach peak hardiness in December and then decline. The decline is relatively slow during January but is accelerated in February. The least low temperature tolerance of the entire winter period occurs in March and April.

The two critical periods for low temperature injury of turf are: (a) during late winter thaws, and (b) just after the spring thaw.

Certain combinations of freezing and thawing for four hours or more, followed by refreezing to temperatures below 25 degs. F. can cause serious injury to turfgrasses. Annual bluegrass is particularly susceptible to this type of kill since it initiates growth processes quite rapidly, resulting in reduced hardiness and greater susceptiblity to low temperatures. The more hardy perennial grasses, such as Toronto creeping bent and Kentucky blue do not exhibit any great degree of susceptibility to injury of this type.

Second Critical Period

The second critical period occurs when grass appears to have survived the winter in excellent condition. The weathr may turn warm for several days, accelerating the loss of low temperature hardiness. This results from the premature initiation of the plant growth processes, causing an increased hydration level within the plant. Should temperatures drop below 25 degs. F. at this time, serious direct low temperature injury to grass may occur. Grasses most susceptible to kill under these conditions include annual blue, red fescue, tall fescue, and rye.

Low temperature injury to turfgrasses, in a reduced state of hardiness, seems most prominent in the region from Chicago east through Michigan, Ohio, Pennsylvania, New York, and New England.

Desiccation

Kill from desiccation occurs when water loss from above-ground plant tissue exceeds uptake and transport from the roots. Inability of roots to take up water may be due to a lack of soil moisture or to the water being in a frozen state. Kill of this type commonly occurs on elevated locations, exposed to drying winds, and is more prevalent in dry winters. This is a major cause of winter injury in the northern plains states and Canadian provinces.

Desiccation can be a secondary cause of winter injury where extensive damage to the root system renders the plant incapable of providing water for above-ground plant parts. The primary casual factor is direct low temperature injury to the root meristematic tissue or lower crown. Subsequent total kill of the plant is caused by the secondary factor, desiccation.

Toxic Accumulation of Respiratory Products Under An Ice Sheet

Carbon dioxide is a by-product of plant respiration processes. Even at sub-freezing temperatures minimum respiration exists. Thus, it is possible for killing concentrations of carbon dioxide or similar toxic breakdown products to accumulate.

Investigations at Michigan State have not shown toxic accumulations of plant respiratory products after 90 days of ice coverage to be a serious problem in winterkill of perennial grasses. The degree of kill from four different types of ice cover was evaluated. Figure 1 shows the per cent survival of hardened Toronto creeping bent, common Kentucky blue and annual bluegrass which were flooded, frozen, and held at

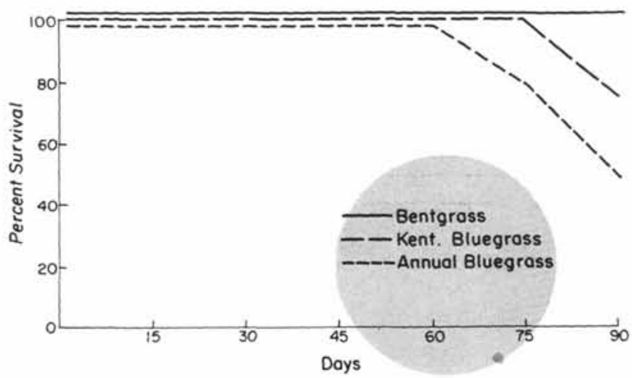

Figure 1

25 deg. F. for intervals up to 90 days. Note that the bent survived 100 per cent after 90 days coverage. Kentucky blue and annual bluegrass showed no significant injury after 75 days, but 30 and 50 per cent kill after 90 days.

Although toxic accumulations of plant respiratory products may cause kill from ice coverages in excess of 90 days, it still must be proved that it is a major cause of winterkill. These studies were conducted on relatively thatch-free material and do not rule out kill caused by toxic accumulations produced by fungi or fungicides.

Oxygen Suffocation Under An Ice Sheet

The respiring plant requires oxygen for maintenance of plant tissue, even at extremely low temperatures. An ice sheet may impair oxygen diffusion to the extent that, in time, it might become limiting. However, studies of the diffusion rate of oxygen through ice blocks showed no serious impairment and thus minimized the importance of oxygen suffocation in winterkill.

Leaching of Vital Cellular Constituents When Plants Are Submerged in Water

During thawing periods, the grass leaves and crowns may be submerged in water for a period of time due to poor internal or surface drain-

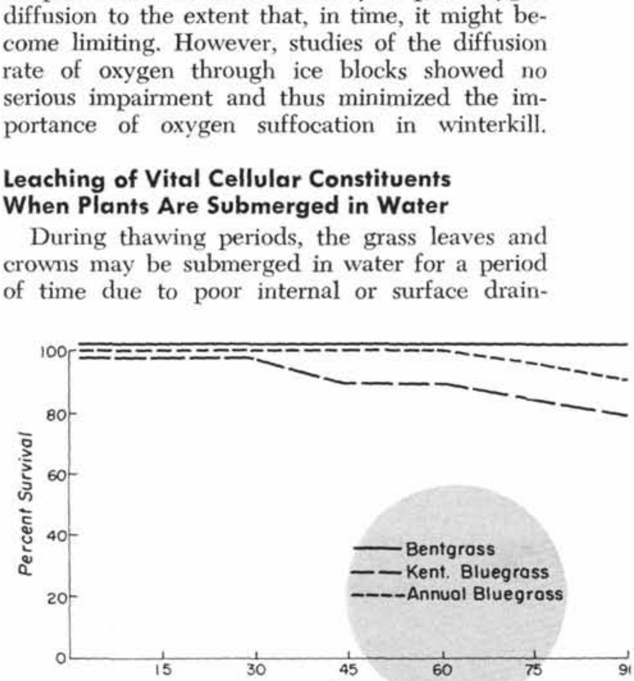

Figure 2

age. Injury due to severe leaching during submergence has been observed in small grains. Turfgrass injury caused by leaching was investigated at Michigan State. In Figure 2 is shown the per cent survival of field hardened Toronto bent, common Kentucky and annual bluegrass after being submerged in water at 35 degs. F. for periods of up to 90 days.

No significant kill of the three species was observed during the 90 day period when held at near-freezing temperatures and provided with a 12 hour low intensity light period. This suggests that leaching of vital cellular constituents is not a primary cause of winter injury at near-freezing temperatures.

Heaving

Kill due to soil frost heaving is not a problem in established sod. However, on late fall or early spring planted grasses, heaving and kill of young seedlings can be a serious problem.

Winter Diseases of Turfgrasses

Low temperature parasitic fungi with which we are concerned are: snow mold (*Fusarium* spp., *Typhula* spp., etc.) and spring deadspot. These diseases can cause serious injury if steps are not taken to control them. If the soil does not freeze before a lasting snow cover is established, then microclimatic conditions under the snow are especially favorable for low temperature fungal activity. The potential seriousness of winter diseases is widely recognized and fungicides are available for protection and control.

Other Factors In Winter Injury

The following six factors are not basic causes of winter injury but can result in increased kill. For the most part, these are under the control of the professional turfman.

Increased Water Content in Tissue

Any increase in tissue moisture content will reduce the hardiness level of a plant and increase its susceptibility to low temperature kill. Investigations by Olien show that as the tissue moisture content of hardened barley plants is increased, the killing temperature is also raised. Also, root meristems or the lower crown are injured more at higher temperatures than shoot meristems, the upper crown tissue.

This differential susceptibility to injury of shoot and root meristems was observed in annual longitudinal section of an injured annual bluegrass by Beard and Olien. Figure 3 shows a grass crown, collected from a Michigan fairway in early April. The lower crown and root tissues have completely degenerated while the young leaves and leaf meristematic areas are uninjured. Note two new roots developing high on the crown.

Kill caused by low temperature injury to the roots and lower crown is characterized by the following symptoms. The turf exhibits healthy foliage at the time of spring thaw but subsequently dies after several warm, sunny days. Warm temperatures promote growth and transpiration of above-ground tissue as well as degeneration of injured root and crown tissue. Plants with severely injured crowns may not be capable of producing a new root system rapidly enough to meet the water uptake requirements of transpiration. Under these conditions, the upper plant tissue becomes desiccated and dies.

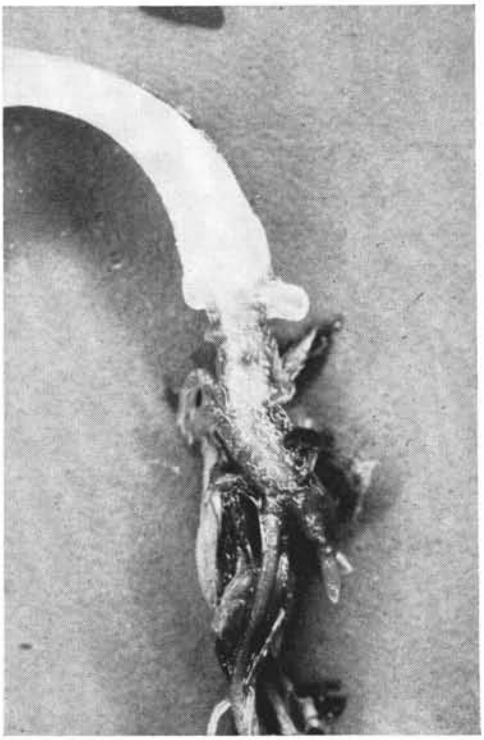

Figure 3

Physical and environmental factors which can cause increased tissue hydration levels (water content) include the following: (a) Poor surface drainage. Low spots accumulate water causing grass crown to be submerged; (b) inadequate internal drainage of the soil. Compacted soils impair drainage causing submergence of grass crowns. It is commonly observed that greater injury occurs on heavier or compacted soils; (c) Ice or snow accumulations which impair surface drainage and cause ponding and submergence of grass crowns; (d) Melting from beneath the ice or snow layer with no means of draining the water away from the grass crowns. In this condition the grass crown may be submerged for an extended period of time.

Submergence will not cause serious injury due to leaching. However, it does result in increased water levels within the tissue. If these tissues are exposed to temperatures below 25 degs. F., serious kill may result.

Late Fall Fertilization

Any factor which stimulates growth, tends to increase the tissue hydration level and to reduce low temperature hardiness. The effect of

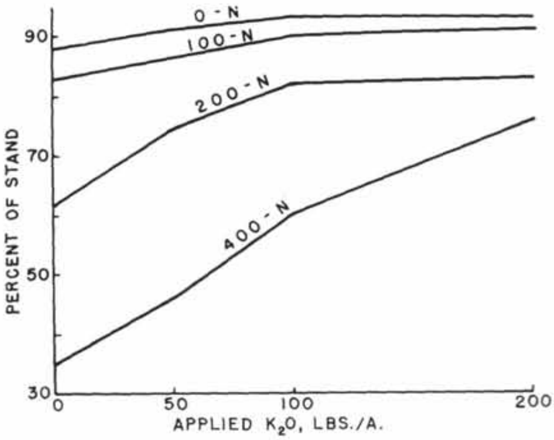

Figure 4

high nitrogen fertilization in increasing low temperature kill of 16 turfgrasses was reported by Carrol of Ohio in 1943. Table 1 shows the effect of high nitrogen fertilization on five of the grasses included in this study. In every instance, the grass survived better at a lower nitrogen level. Other studies of Carroll and Welton showed that late fall nitrogen fertilization of common Kentucky bluegrass caused increased low temperature kill.

TABLE 1 Per cent survival of five field hardened turfgrasses following a single cooling to different soil temperatures. Carrol, Wooster, Ohio. 1943.

Grass	LoN 23°F.	HiN 23°F.	LoN 14°F.	HiN 14°F.	LoN 5°F.	HiN 5°F.	LoN —4°F.	HiN —4°F.
Common Kentucky	100	90	80	60	25	5	20	5
Annual bluegrass	80	50	40	10	3	1	5	0
Astoria bent	90	80	60	50	0	0	0	0
Red fescue	80	65	60	25	0	0	0	0
Perennial rye	70	20	0	0	0	0	0	0

Adams and Twersky in Georgia have shown that increased potassium levels reduce low temperature injury of coastal Bermuda. Using potash rates of 0, 50, 100, and 200 pounds per acre, the degree of stand survival was increased with each increased increment of potash (Figure 4). The effect of potassium in reducing kill was the greater at higher rates of nitrogen.

Height of Cut

General field observations indicate that grass cut at one inch or more survives low temperature injury better than when cut shorter. The higher cutting height could function in two ways: (a) as an insulating factor, or (b) by providing increased photosynthetic area for carbohydrate production and ultimate storage for low temperature hardiness. It might prove beneficial to permit fairways, particularly in bluegrass, to go into the winter at a one inch or higher cut.

Excessive Thatch Accumulation

Thatch tends to elevate the grass crowns, rhizomes, and stolons above the soil where there is a great chance of low temperature injury. This is due to a reduction in protective influence of the soil since soil temperature minimums are generally not as low as air temperatures. Also, turfs with excessive thatch are more susceptible to injury from low temperature fungi and desiccation.

Finally, areas subjected to human and mechanical traffic during winter have a greater chance of being injured. It is hardly necessary to bring this to the attention of superintendents who are so well aware of it.

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USGA Changes Two Rules to Combat Slow Play

New measures to combat slow play on and near the putting green have been taken by the USGA and appear in the 1966 Rules of Golf booklet.

There no longer is a penalty for striking an unattended flagstick in play from off the putting green within 20 yards of the hole. Striking an unattended flagstick is prohibited only when the ball is played from the putting green. Rule 34-3c has been amended to this effect.

Optional Local Rules

The new rules book authorizes two optional local rules tried successfully in recent USGA championships, to the following effect:

1. In stroke play, the player is to play continuously until he holes out, except that a fellow competitor may request him to lift in order to avoid standing on the competitor's line of putt.

2. In match play and stroke play, lifting the ball solely for cleaning will be allowed only once per hole, and then only before the first stroke on the green. Cleaning may be done incidentally when the ball is lifted under other rules.

Change in the flagstick rule is expected to save time used in measuring and in attending the flagstick and also to reduce risk of injury to the person attending the flagstick on strokes from bunkers. The present rule has been in effect the last two years.