Winter Injury of Turfgrasses Associated with Ice Sheets*

By **JAMES B. BEARD,** Department of Farm Crops, Michigan State University

Introduction

Winter injury to turfgrasses has been an extensive problem in portions of the northern United States and Canada, particularly grasses maintained under fairway, tee, or putting green conditions. Much has been written regarding possible causes of this injury with practically no experimental evidence to support these theories. Before effective practices can be developed to reduce winter injury, the actual cause or causes must be determined.

Winterkill is a term encompassing a large number of types and causes of injury. It is used loosely to include any type of injury that occurs during the fall, winter, or spring period, including desiccation, heaving, flooding, disease (snow mold), and direct low temperature injury. This paper will be limited to winter injury associated with ice coverings. Winterkill associated with ice coverings is common in areas where sleet storms predominate and in poorly drained locations.

Survey of Literature

A review of the literature reveals only one paper which involves the study of winterkill on turfgrasses. In 1939, Carroll and Welton found that common Kentucky Bluegrass was more susceptible to winter injury when heavy, late fall nitrogen applications were made.

Several individuals have published theories as to the causes of winter injury. One of the current theories is suffocation beneath ice sheets. A more recent theory is the accumulation of toxic substances such as carbon dioxide under ice sheets. Another theory which has been suggested is the outward diffusion of water from the plant during ice incasement resulting in desiccation.

Types of Injury

In 1962, Beard divided winter injury into two major types. Type I was grass which was dead at the time of spring thaws. Type II was grass which appeared alive and healthy at the time of spring thaws but which subsequently died.

Type I injury kill may occur in five ways:

1. Deficient supply of oxygen under the ice sheet. The respiring plant requires oxygen for maintenance of plant tissue even at extremely low temperatures. The ice sheet could impair oxygen diffusion to the extent that, in time, it might become limiting.

2. Accumulation of toxic levels of carbon dioxide under the ice sheet. Carbon dioxide is a by-product of plant respiration processes. Even at below-freezing temperatures a minimum respiration rate exists. Thus, it is possible, in time, for killing concentrations of carbon dioxide to accumulate or for some similar toxic breakdown product to accumulate. Injury of this type has been reported in alfalfa.

3. Severe hydration of the plant tissue causing leaching of cell contents from the protoplasm. On sunshiny days light rays will pass through the ice and be absorbed by the opaque grass surface. It is possible that these absorbed light rays could heat the grass sufficiently to melt the ice surrounding them. This would result in a condition in which the leaves are incased in water with a heavy ice sheet still existing around them. This condition would be favorable for se-

*This article taken from Michigan Turfgrass Research Report, Spring 1963, Volume 1-Number 1.

vere leaching to occur, and has been observed in small grains.

4. **Outward diffusion of water from leaves incased in ice.** When leaves are incased in ice the relative concentrations of solutes is higher outside the leaf than internally, due to water existing in the solid phase. This could result in outward diffusion in water from the leaf in an attempt to attain equilibrium. If sufficient water is removed from the leaf, desiccation could occur. However, when the vapor pressures of water and ice are compared it appears that at equilibrium, sufficient water would not be removed to cause plant desiccation.

5. **Total destruction of the protoplasm within the hydrated growing tissue of the plant due to severe ice formation at low temperatures.** This is a mechanical injury to the brittle protoplasm caused by the formation of large ice crystals. This type of injury will be less in plants that are permitted to properly harden through dehydration or reduction in water content. If plants are improperly managed through over-watering, fertilization or any process which stimulates growth in the late fall, then the chance of direct kill by low temperature is much greater.

Type II injury could occur in two primary ways.

6. **Total destruction of cellular protoplasm within the hydrated growing tissue of plants which have prematurely initiated spring growth.** The grass may survive the winter in excellent condition. Subsequently, the weather may turn extremely warm for three or four days, resulting in a premature loss of hardiness due to an increase in hydration within the plant. If this is followed immediately by a severe drop to below-freezing temperatures, direct low temperature injury may occur. The chance of this type injury occurring can be reduced by avoiding any practices which encourage premature early spring growth.

7. **The mechanical injury of the lower crown tissue and root.** The original cause of injury is destruction of the cellular protoplasm in the lower crown tissue due to ice crystal formation. This in turn results in death of the root system and lower crown while the above-ground leaves and shoots appear normal. Cross-sections of the grass crown show a browning of the lower crown and roots. With the advent of spring thaws the grass plant will appear on the surface to be normal. However, warmer temperatures will result in growth and transpiration of the above ground tissue. Plants with severely injured crowns may not be capable of producing a new root system fast enough to meet the water uptake requirements of transpiration. Under these conditions the plant will die of desiccation resulting from the severe crown injury.

Progress Report of Findings

In the fall of 1962 studies were initiated to determine the actual cause or causes of winterkill. Three species were utilized in the experiment: Common Kentucky bluegrass, Toronto creeping bentgrass, and *Poa annua*. All vegetative materials were allowed to harden naturally in the field. On November 26, 1962 (soil temperature 34°F.) four-inch plugs were taken for use in the experiment. The following treatments were applied: (1) flooding then freezing, (2) freezing, then applying thin ice layers, (3) freezing, then applying a snow layer followed by an ice layer, (4) placing in a sealed container and freezing, (5) balk pressure freezing, (6) no treatment, and (7) submerging in water at 35°F. All treatments were held at 25°F. except for number 7. At fifteen-day intervals, replicated samples from each variety and treatment were removed from the low temperature chamber, thawed, and placed in a 70° growth chamber.

The total length of the experiment was ninety days. Observations made included percent top survival, moisture content of leaves, microscopic crown examination, and top yield. Results of this study showed that during the 90-day period, winter injury by oxygen suffocation, toxic accumulations, cellular leaching, or outward water diffusion in ice were of no significant importance. No injury occurred in bentgrass, while a small degree of injury was observed in Kentucky bluegrass. Annual bluegrass was intermediate between the two. These results cast doubt on the importance of suffocation, toxic accumulations, or leaching in the winter injury of these three grasses when associated with ice covers. None of these treatments produced symptoms of lower crown injury of the type which was observed in the spring of 1962 in the Detroit area.

Evaluating Injury in the Field

The conditions under which each of these six types of injury occur are quite different. The turf specialist must be capable of recognizing both the type of winter injury and the causal conditions. This involves observations of types of ice and snow cover; duration of coverage; time of occurrence, degree, and duration of low temperature; occurrence of water incasement in ice; and physiological condition of the grass plant at the time of low temperature occurrence.

Samples of grass should be taken at key times in the winter and placed under higher growing temperatures to observe if injury has occurred. Cross-sections of the grass crown can be taken with a knife to check for lower crown injury which will typically appear as a browning of the lower crown and root. By this means, the turfman can ascertain if and when winterkill has occurred.

In time, the turfman will become experienced with the conditions under which injury occurs, as well as in what locations injury is most likely. With this knowledge proper precautionary measures can be taken. Hasty evaluations regarding winterkill causes based on superficial information can lead to erronous conclusions. On-the-spot, detailed observations are needed to arrive at the correct causal factors.

NEW SUBSCRIBERS TO THE USGA GREEN SECTION VISITING SERVICE

EASTERN REGION

Ala.	Country Club of Tuscaloosa, Tuscaloosa
Conn.	Green Hills Country Club, Greenwich Oak Lane Country Club, Woodbridge Shorehaven Golf Club, South Norwalk
Fla.	Palma Ceia Golf & Country Club, Tampa
Ga.	Pinetree Country Club, Kennesaw
Md.	Bainbridge Golf Club, Bainbridge
Mass.	Blue Hill Country Club, Canton Runaway Brook Golf Club, Bolton
N. C.	Old Town Club, Winston-Salem
N. J.	Tavistock Country Club, Haddonfield
N. Y.	Bethlehem Management Club, Hamburg Binghamton Country Club, Johnson City Chestnut Meadows Golf Club, Lockport En-Joie Golf Course, Endicott I.B.M. Country Club, Johnson City Midvale Golf & Country Club, Penfield Twin Ponds Golf & Country Club, New York Mills Woodstock Country Club, Woodstock
Pa.	Montgomeryville Golf & Country Club, Montgomeryville Shawnee Inn & Country Club, Shawnee on Delaware
S. C.	Green Valley Country Club, Greenville Sea Pines Plantation Golf Course, Hilton Head Island
Va.	Oakwood Country Club, Lynchburg Pinecrest Women's Golf Ass'n., Alexandria South Wales Golf & Ranch Club, Jeffersonton

MID-CONTINENT REGION

Colo.	Kissing Camels Golf Course, Colorado Springs Valley Country Club, Denver
Ill.	Morris Country Club, Morris Soangetaha Country Club, Galesburg
Kans.	Salina Country Club, Salina
Mich.	Gull Lake Country Club, Kalamazoo
Ohio	Avalon Golf Course, Warren Kirtland Country Club, Willoughby Winding Hollow Country Club, Columbus
Texas	Hill Crest Country Club, Vernon Shady Valley Golf Club, Arlington
Wis.	Blue Mound Golf & Country Club, Wauwatosa Butte Des Morts Golf Club, Appleton Hillmoor Golf Club, Lake Geneva

WESTERN REGION

Calif.	El Caballero Country Club, Tarzana Garden Air Golf Association, Calimesa Merced Golf & Country Club, Merced