When Ice Kills

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Winterkill of turf is a serious issue in our part of the country. The major causes of winterkill (snow molds, desiccation, low temperature) were reviewed in a previous issue of The Grass Roots (Stier, 2003). This year, though, the primary concern seems to center on ice. During my eight winters in Wisconsin, this is the first year that ice has been an issue. The purpose of this article is to describe why ice can be deadly to turf, particularly putting greens, and to provide information on what to do before it's too late.

Some turf, such as Kentucky bluegrass lawns, can withstand ice cover for extended lengths of time as found in backyard skating rinks. But we worry about putting greens and fairways. Why is that? Textbooks tell us that creeping bentgrass is more cold tolerant than Kentucky bluegrass. But the issue is deeper: first, tolerance to ice is not necessarily the same as cold tolerance; secondly, many golf turfs have an abundance of annual bluegrass (Poa annua) which isn't as cold tolerant as creeping bentgrass or Kentucky bluegrass.

Types of ice matter

Clear ice has high density which greatly restricts air movement between the soil and aboveground air. Ice with a whitish or milky appearance is less dense and does not restrict air movement as much. Whether ice forms above or below snow can also matter. In general, a sheet of ice forming over an uncompacted snow layer is less likely to cause turf injury than ice forming under a snow layer (Beard, 1973). The uncompacted snow layer allows air movement, thus an ice sheet above the snow has less of an effect than ice underneath a snow layer. But the type of snow matters too: compacted snow also restricts air movement compared to uncompacted snow. This can be one of the reasons winterkill can occur under snowmobile tracks. Unfortunately, I've never seen any information on the effects different depths of ice may have on

the turf. I expect it will vary with the situation, with increasing thickness of ice being more detrimental than thin ice, especially as winter progresses into spring and low temperature hardiness decreases.

Why is air movement important during the winter?

Despite freezing conditions, all living organisms continue to respire during winter. This includes both turf and soil microbes. Oxygen-loving organisms, or aerophiles (including humans), use oxygen as an electron acceptor during respiration in order to use energy necessary for survival. Carbon dioxide (CO_2) gas is produced by respiration and, if trapped under ice, may lead to turf death. Occasionally fungi can produce deadly levels of cyanide under ice (Lebeau, 1966; Lebeau and Cormack, 1956). Both gases can be toxic at relatively low concentrations. In addition, the lack of oxygen essentially stops respiration: a situation known as anoxia. Though anoxia may be less frequent than a buildup of toxic gases, Rochette et al. (2000) reported that anoxia occurs within 60 days of ice cover and kills turf within 100 days.

Ice problems may worsen as the winter continues

Cold tolerance of turfgrasses is at its maximum in December and January. Cold tolerance begins to decline during February, and is essentially lost in March. Unfortunately, March often brings thaws which melt snow and ice, but the liquid moisture can easily be re-frozen during a single cold night. Part of the hardening process that occurs in late autumn includes a mild loss of water from the plant tissues. Thawed plants are likely to reabsorb moisture which, if quickly frozen, can generate ice crystals within or between the plant cells, essentially causing low temperature kill. In these cases ice formation on the turf surface may not be at fault.

What about turfgrass types?

Grass type has a huge impact on the potential for ice to kill turf. Research published in the 1960s indicated annual bluegrass tolerated ice cover for less than 75 days, while creeping bentgrass survived 120 days under ice (Beard, 1964; Beard, 1965). More recently, Tompkins et al. (2004) brought a more narrow focus to these parameters through a combination of laboratory and field studies. In both cases, greens-height turf of annual bluegrass (biotype MN 42) and creeping bentgrass (cv. Penncross) was either covered with snow, or ice, or saturated with water which was allowed to freeze followed by placing an ice "cap" on the turf. In the field study, ice was removed from half of each treatment 45 days after it was formed. Turf samples were removed at 15 to 30 day intervals over several months. Results showed that cold hardiness decreased faster under ice cover than under snow cover, particularly for annual bluegrass. In their field study, annual bluegrass died between 60 and 75 days after ice cover, whether or not ice was removed 45 days after it formed. Creeping bentgrass was still alive at the end of the 90 day field trial and the 150 day laboratory trial. The authors concluded that if ice is to last for 60 days or longer on annual bluegrass, then ice removal needs to occur sooner than 45 days after it forms in order to protect the turf.

Though the limited information which is available agrees that annual bluegrass is less tolerant of ice than creeping bentgrass, the biotype of annual bluegrass may also be important. Dionne et al. (2001) collected annual bluegrass from western Pennsylvania, coastal Maryland, and central Quebec. Plants were subjected to sub-freezing temperatures in freezers, and the lethal temperature to kill 50% of the plants (LT50) was determined. Annual bluegrass from Quebec was more cold-tolerant than plants from Maryland or Pennsylvania (LT_{50} values of 14.7 °F versus 18.3 and 19.6 °F, respectively-remember, ground temperatures below ice or snow may be warmer than air temperatures, which is why turf won't necessarily be killed by an air temperature of -5 °F).

Avoiding ice damage

Good drainage is essential to avoiding ice problems. Both internal and surface drainage are important. Remember the skating rink situation discussed at the beginning of the article? Turf in backyard skating rinks can survive extended periods under ice if the soil and turf is first frozen before surface ice forms. In this case, internal drainage must be good to ensure the soil is not saturated prior to freezing conditions. Good internal drainage prevents excessive ice formation in the soil which could either desiccate roots or lead to direct freezing injury. Research at the University of Wisconsin showed freezing begins first in small roots then rapidly progresses up into the crown (Stier et al., 2003), killing the growing point for new roots. This phenomenon explained why *P. annua* leaves may be green as winter turns to spring, but the plants eventually die for lack of a root system. Secondly, surface drainage must be good: as the ice melts, it must be able to move off-site before re-freezing on the turf. Since ice melts from the surface downwards, the ground is usually frozen while surface snow and ice are melting. Thus, surface slope must be sufficient to provide surface drainage as ice melts.

A second way to avoid ice damage is to remove ice that forms. One method is to melt the ice then remove the water before it refreezes. Ice could be melted using heat, though it takes a lot of energy and is usually cost-prohibitive. In fact, I've never seen it done. (Incidentally, don't pour hot water on the ice because it will quickly refreeze and you'll only make the problem worse.) A second way to remove ice is to melt it passively. This is done by applying a dark material such as Milorganite or black sand. The dark colors absorb solar heat on sunny days to melt through ice. Not all of the ice needs to be melted as long as air exchange can occur. Unfortunately there are no research data on the amount of material to apply because that will depend on ice thickness, air temperature, and sunlight. Water-soluble fertilizer such as urea can also be applied, but caution must be used as excessive rates can cause salt damage to the turf. Road de-icers are generally not suitable, though our research is continuing this winter with experimental products. A third option is to chip the ice away using core aerators, shovels, picks, or other equipment. Not all of the ice needs to be removed-Beard (1973) suggested holes made at 1 to 3 foot intervals could be sufficient.

Knowing the causes of any problem make it possible to develop a solution. If ice has completely encased the turf and surrounding soil, removing the ice from the surface may not be sufficient. If this happens, it's time to convince the Green Committee that the time has come to rebuild or regrade the area, re-grassing it with creeping bentgrass. Fortunately, ice is usually the least likely cause for turf death during the winter. Remember, annual bluegrass should be able to withstand up to 60 days of ice cover, while creeping bentgrass should withstand nearly 4 months or longer. If ice cover occurs early in the winter it may be worthwhile to at least punch holes in it; if it occurs with 2 months or less of winter to go, it usually can be left alone.

References

Beard, 1964. The effects of ice, snow, and water covers on Kentucky bluegrass, annual bluegrass, and creeping bentgrass. Crop Sci. 4:638-640.

Beard, 1965. Effects of ice covers in the field on two perennial grasses. Crop Sci. 5:139-140.

Beard, 1973. Turfgrass: Science and culture. Prentice-Hall, Englewood Cliffs, NJ.

Dionne, J., Y. Castonguay, P. Nadeau, and Y. Desjardins. Freezing tolerance and carbohydrate changes during cold acclimation of green-type annual bluegrass (*Poa annua* L.) ecotypes. Crop Sci. 41:443-451.

Lebeau, J.B. 1966. Pathology of winter injured grasses and legumes in western Canada. Crop Science 6:23-25.

Lebeau, J.B., and M.W. Cormack. 1956. A simple method for identifying snow mold damage on turf grasses. Phytopathology 46:298.

Rochette, P., J. Dionne, and Y. Desjardins. 2000. Anoxia-related damage to annual bluegrass golf greens under winter protective covers. p. 151. *In* 2000 Agronomy abstracts. ASA, CSSA, and SSSA, Madison, WI.

Stier, J. 2003. Winterkill. The Grass Roots 32(2):5-7.

Stier, J.C., D.L. Filiault, and J.P. Palta. 2003. Visualization of freezing progression in turfgrasses using infrared video thermography. Crop Sci. 43:415-420.

Tompkins, D.K., J.B. Ross, and D.L. Moroz. 2004. Effects of ice cover on annual bluegrass and creeping bentgrass putting greens. Crop Sci. 44:2175-2179.