Winterkill

THE WRATH THAT IS A CANADIAN WINTER

WINTERKILL, OR WINTER injury, is a much discussed topic among golf superintendents in Canada in the spring. Often we talk about it as if it were one thing. It is not. When you consider the length and breadth of Canada and the differences in the types of winter weather that are experienced from coast to coast, it becomes even more complex. Add to that the fact that there are no two golf greens that are identical and that no two winters are identical and the complexity of the situation multiplies. On top of all that, there is a lot in the area of turfgrass winter injury that we know about and a lot we don't know. Luckily for us in Canada, there are two very good research teams (Agriculture and Agri-food Canada, Quebec and Olds College, Alberta) that have added immensely to our knowledge of winter injury, its causes and how to prevent it.

So what exactly is winter injury? I think that there is agreement amongst turfgrass researchers that winterkill can be caused by desiccation, crown hydration, freeze injury, anoxia and snow moulds (Beard and Olien, 1963). For the purpose of this article, I am only going to focus on the abiotic causes of winter injury, so injury from snow moulds will not be discussed. Knowing which type of injury that you are most likely to encounter in your area will help you in your quest to prevent it.

Desiccation

Desiccation is defined as the process of extracting water. Turf can suffer from desiccation during the winter months. Injury from desiccation occurs when water loss from turf plants exceeds uptake and transport from the roots. Desiccation can only occur in the absence of snow cover. It can be a result of soil drought or atmospheric drought.

Desiccation from soil drought occurs when there is a lack of moisture in the soil due to lack of precipitation, sloped areas with high incidence of surface runoff or elevated areas that are exposed to prevailing winds. Desiccation can also occur when there is adequate soil moisture. This is desiccation due to atmospheric drought. This occurs when water is removed out of the above ground parts of the grass plant through evapo-transpiration and the roots cannot replace the water because the soil water is frozen. Desiccation is a common problem on golf greens and other golf course turf in the Prairie provinces and the lower British Columbia mainland.

In general, annual bluegrass is more susceptible to desiccation than creeping bentgrass. Greens in full sun are also more susceptible. It can take as little as several days of high winds and low relative humidity in the absence of snow cover to cause desiccation.

Desiccation Prevention

Fortunately, there are several methods available to help golf course superintendents prevent winter desiccation. They are:

ICE LAYER ON ANNUAL BLUEGRASS PLOTS AT THE GUELPH TURFGRASS INSTITUTE.

- irrigate turf prior to freeze up or before snow cover
- install windbreaks or snow fencing to reduce wind or to encourage snow cover
- apply mulch or light topdressing on greens
- cover greens with a synthetic permeable cover
- water greens in the winter
- minimize thatch
- maximize creeping bentgrass populations

Freeze Injury/Crown Hydration

Freeze injury occurs when plants are subjected to extremely cold temperatures or a severe rapid drop in temperature. This causes water inside and around the plant cells to freeze. Ice crystals can damage the cell membranes and the result is a death of the plant cells.

Crown hydration occurs when ice crystals form outside the plant cell (extracellular) of the turfgrass crown tissue. As these ice crystals form and enlarge, they pull water out of the cell, which results in dehydration of the cell. This type of injury is also called crown dehydration. Another property of water is that it likes to move from a high concentration to a low concentration. The solutes (mainly sugars) in a plant cell give the cell solution a higher concentration than the ice crystals outside the cell, so this further increases the movement of water outside of the cell. At some point a dehydrated cell and cell membrane stop functioning and the result is cell death. If enough of the cells in the crown of the turfgrass plant die, the entire crown will die (Rossi, 1996).

Conditions Favouring Freeze Injury/Crown Hydration

Crown hydration is a complex phenomenon and many factors are involved. Turfgrass plants are most susceptible to crown hydration in the transition period between winter and spring. At this point in the season the carbohydrates that the turf plant has stored in the fall to help withstand intercellular freezing have fallen to their lowest levels. At this point in the season, the plants are also dehardening and taking up water. (Tompkins et al., 2000)

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Micro-environmental factors which contribute to crown hydration injury are areas with poor surface drainage where water collects and goes through freeze/thaw cycles. Compaction will also exacerbate this. The most serious injury occurs when the warm temperatures are followed by a rapid decrease in temperature. A rapid drop in temperature has been shown to be more damaging than a more gradual drop in temperature. The length of the freeze cycle also influences the amount of damage.

Shaded turf is also more vulnerable. This may be due to the fact that annual bluegrass often dominates greens in the shade. In addition, shaded greens may not produce as much carbohydrate to provide maximum winter hardiness.

Undoubtedly, turfgrass species is the most important factor determining whether there is a potential for crown hydration. Annual bluegrass is much more susceptible to crown hydration injury than creeping bentgrass. One of the main reasons that it is believed that annual bluegrass is so much more susceptible to crown hydration injury is because it is the most susceptible to dehardening. Research has shown that a rise in temperature to 8°C for 48 hours is sufficient to deharden annual bluegrass (Tompkins and Ross, 1997). It is also know that annual bluegrass comes out of dormancy earlier than creeping bentgrass and the crown tissues become hydrated. This makes annual bluegrass more susceptible to crown hydration injury. It has been demonstrated that there is a range in hardiness amongst annual bluegrass biotypes (Dionne et al., 2001), but as a species they are by far the most susceptible.

Freeze Injury/Crown Hydration Prevention

Maximizing cold hardness can help reduce the risk of crown hydration injury. Management practices that help the hardening process are:

- late fall fertilization
- increased mowing height in the fall

Other factors that help prevent crown hydration are:

- maximize creeping bentgrass populations

CROWN HYDRATION INJURY ON ANNUAL BLUEGRASS GOLF COURSE TURF.

- provide adequate surface drainage and minimize soil compaction
- minimize shade
- thatch control

Protective covers are used in many areas to prevent freeze injury and crown hydration. Different covers or cover combinations are recommended depending on your location, the amount of snow fall and the type of injury that is prevalent. For instance, in the Quebec City area, where adequate insulating snow cover is predictable, impermeable covers alone are recommended. In the Montreal area, where the amount of snow each winter varies, a system of a permeable cover, an insulating layer (usually straw) and an impermeable cover is recommended. Permeable covers can be used in the spring when winter protective covers are removed (Dionne, 2000). Dionne also recommends that temperature under the protective covered be monitored throughout the winter.

Anoxia

Anoxia is a condition that can occur under an ice cover or under a winter protective cover that can kill turf. Anoxia means lack of oxygen. Under covers the turf plants use up oxygen and other toxic gases such as carbon dioxide (CO_2) can build up. During the winter, under snow, ice or covers, turfgrass plants respire. In this process organic sugars within the plant are mobilized in the presence of oxygen to provide energy for the plant so that it can stay alive during the winter. The equation for respiration is:

- $C_6H_{12}O_6$ (hexose sugar) + $6O_2$ (oxygen) $6CO_2$ (carbon dioxide) + $6H_2O$ (water) + energy

In a closed system, where there is no gas exchange, under anoxic conditions (lack of oxygen), this process or reaction can not occur. If this is the case the plant will run out of energy and eventually die. The other aspect of respiration in a closed system is that as the oxygen is depleted, carbon dioxide builds up and it has been shown to have potential phytotoxic effects.

In addition to respiration from turfgrass plants under covers, there are also soil bacteria that are respiring. This further contributes to the oxygen depletion and the carbon dioxide buildup. Factors that affect the rate of respiration of plants and soil bacteria are temperature, soil water content, degree of plant dormancy and soil organic matter content. Usually anoxia can be detected by the foul smell that emanates from a green when it is uncovered in the spring. The smell is a result of the build up of gases under the cover and there is usually turf injury accompanying it.

Factors Affecting Anoxia

Again, as with all other forms of winter injury, the species under the ice or greens cover has a big impact on whether or not anoxia will result in turf injury. Research conducted at Olds College in Alberta (Tompkins et al., 2004) found ice encased annual bluegrass plants were all dead after 45 days while creeping bentgrass plants could withstand 90 days.

In the Quebec City area there have been many golf courses that have been using the winter protective covers consisting of a permeable cover, straw and an impermeable cover. There were some greens which recurrently had come out of the winter with dead turf, in spite of being covered. The death of the turf could not be attributed to freezing stress, excess water or snow mould. Rochette et al. (2006) set up an experiment with greens that recurrently had damage under covers and those which over wintered successfully with covers. They measure temperature, the O_2 and CO_2 levels under the covers throughout the winter. What they found was that the greens that had recurrent damage had anoxic conditions by day 90, where the greens that traditionally had over wintered successfully had sufficient O_2 levels up to the end of the winter (day 130). The greens with recurrent damage

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also had high levels of CO_2 by day 90 and the other set of greens that over wintered well had equal amounts of O_2 and CO_2. The greens that suffered recurrent damage under cover had a 69% higher respiration rate on average than the greens that over wintered successfully. These two sets of greens were all annual bluegrass greens, so the differences in respiration could not be attributed to the turfgrass species. The difference in respiration and hence oxygen depletion were due to the soil biological activity. The greens with recurrent damage had significantly higher total nitrogen and total organic carbon. To verify these results they tested the respiration rates of soil based greens vs. USGA specification greens and found that the soil based greens consistently had higher respiration rates than the USGA specification greens.

Ice Encasement and Ice Cover and Winterhardiness

Separate from the issue of how ice covers affect the O_2 and CO_2 levels available to turf, research has shown that ice covers and ice encasement lower tufgrass winter hardiness levels. Tompkins et al., 2004 conducted research to determine whether or not it is beneficial to remove an ice sheet from a putting green. To determine this they looked at cold hardiness levels of annual bluegrass and creeping bentgrass under ice cover or ice encasement for various lengths of time in a laboratory and a field study.

In the laboratory study, plants in the ice cover treatment were covered with a 2.5 cm thick layer of ice which was formed gradually by spraying the surface of the turf with a mist bottle in a freezer. Ice encasement was accomplished by completely saturating the soil of a plug of turfgrass and then adding the 2.5 cm layer of ice as described above for the ice cover treatment. The control treatments had a thick layer of snow cover maintained throughout the experiment.

Snow covered treatments maintained cold hardiness for the longest period of time and ice encasement produced the most rapid loss of cold hardiness. The differences were greater for annual bluegrass than creeping bentgrass. At 90 days after treatment, snow covered annual bluegrass had cold hardiness levels of -18ºC, while the ice covered plants had cold hardiness levels of -4ºC and ice encased annual bluegrass plants were dead.

Ice covered annual bluegrass had a rapid loss of hardiness between 75-90 days after treatment and ice encased annual bluegrass rapidly lost hardiness between 45-60 days after ice encasement. By contrast creeping bentgrass began to lose hardiness at 90 days after treatment in both ice treatments but retained moderate hardiness levels for 150 days. In the field study, annual bluegrass had a more rapid loss of hardiness than in the lab. Annual bluegrass plants subjected to ice encasement lost cold hardiness between day 45 and day 60.

In addition to the potential for development of anoxia under ice cover, there is also a loss of cold hardiness and they may, in fact, be related to one another. High respiration rates under the ice covers may use up the plants stored energy leaving it more susceptible to the cold and the high respiration rates also could contribute to the build up toxic gases that injure the plants.

Anoxia Prevention

In the case of annual bluegrass putting greens with ice encasement, the annual bluegrass plants in the study conducted by Tompkins et. al., 2004, showed that all the plants were dead by 45 days after ice encasement. It would be advisable that attempts be made to remove ice before the 45 day mark to prevent anoxic conditions from killing the turfgrass plants. This can be accomplished through the use of dark coloured topdressing materials that absorb heat. These can range from natural organic fertilizers to coloured topdressing sands, inorganic amendments, etc. These products honeycomb the ice layer allowing for gaseous exchange.

In the case of soil based greens with high organic matter under straw and impermeable covers, it is recommended that these greens be vented using perforated drain pipe under the impermeable covers. These pipes must vent to the outside of the greens covers without letting water in under the covers. The optimum spacing of these pipes is not known and many superintendents are experimenting on venting methods and venting spacing. With each passing winter, more information on specific recommendations should be available to superintendents.

General Recommendations for Successful Overwintering of Turf

There are many agronomic practices that can help prepare turf for the onslaught of the various winter stresses that Mother Nature has up her sleeve. Regardless of the type of winter injury, the following sound turf management practices should be followed:

- raise the mowing height in the fall
- fertilize with nitrogen and potash in the fall to increase winter hardiness levels
- provide adequate surface drainage
- maximize creeping bentgrass populations
- minimize shade
- minimize thatch
- alleviate soil compaction

Winter injury is a complex physiological phenomenon and injury may occur as a result of and interaction between the plant, the soil, the micro-environment and the climate. More than one type of winter injury may be involved. We continue to learn more each year due to research into winter injury and there are many factors we can control. Ultimately, though, we are at the mercy of the weather and a great deal of luck is involved. ●

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