Swedish Golf Federation

Winter injury on golf courses in Scandinavia

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The aim of this paper is:
to give a short overview of winter damages on Scandinavian golf courses,
to describe the main causes of winter injury and some related research,
to discuss some methods to limit winter injury, and
to suggest important research and education areas that could help to avoid or limit winter damages.

Winter damages on Scandinavian golf courses

Golf in Scandinavia is big and growing. In Sweden for example about 7% of the population plays golf. The Scandinavian countries have about one million golf players and more people that want to play golf but there is no room for them at existing golf courses. There are about 1000 golf courses in Scandinavia and a large number are under construction (Hammarström, 2003).

The climatic conditions in Scandinavia are unique especially with respect to day length, daily mean temperature, and precipitation. The conditions also vary a lot from the south (55 degrees latitude) to the far north (70 degrees latitude). The middle part of Scandinavia, the Oslo, Stockholm and Helsinki area, is located at 59 to 60 degrees latitude. These conditions give a short and very intensive golf season. Approximately, there are 35 000 rounds of golf played per golf course during about six months.

Winter injury on turf, especially on putting greens, is a major problem on golf courses in Scandinavia. About 70% of the Scandinavian golf courses get severe winter damages every year. When turfgrass injury occurs, the opening of the golf course gets delayed and the playing conditions on e.g. putting greens might not be acceptable until after mid June. This causes a loss of revenue for the golf club, in many cases of more than 350 000 SEK (35 000 €) per year, as well as very dissatisfied members. It also causes increased maintenance costs and in some cases costs for reconstruction. When revenue is lost, maintenance costs are raised and golfers complain, there is also considerable pressure on the superintendent to quickly get the golf course, especially putting greens, back into playing condition (Stavås, 2003; Orsholm, 2003; Hammarström, 2003).

Causes of and methods to limit winter injury on turfgrass

The most common grass species on putting greens in Scandinavia are Annual meadow-grass/Annual bluegrass (*Poa annua*), Chewings fescue (*Festuca rubra*), Common bent grass (*Agrostis capillaris*), and Creeping bent grass (*Agrostis stolonifera*) (Svärd, 2003). The methods of putting green construction vary a lot between golf courses and might also vary between greens on the same golf course. The majority of putting greens in Scandinavia are built of soil that was present on the site, often with insufficient drainage and surface run off. Greens on newer golf courses, built 1995 and later, are in many cases constructed according to the USGA recommendations for a method of putting green construction (USGA 1993).

Plant hardening

Hardening is a physiological process where plants prepare to resist the freezing temperatures of winter by storing food in the form of simple sugars, carbohydrates, and other solutes in the crown area. These sugars increase the concentration of solutes in the cells, reducing the freezing point within the plants. The process of hardening occurs in the fall and early winter and is reversed in the spring when these stored food are rapidly used up. The plant de-hardens and becomes more susceptible to low temperature injury. Hardening is controlled by the climate e.g. day length and temperature but is also highly dependent on maintenance and varies between different grass species.

Plant hardening through the fall has been one area of research at the Prairie Turfgrass Research Institute, Alberta. Growth chamber and greenhouse studies have found that *Poa annua* will harden to survive approximately -20 C while *Agrostis stolonifera*, when fully harden can withstand temperatures as low as -40 C. During periods of active growth *Poa annua* and *Agrostis stolonifera*, were only able to withstand temperature of -5 C. In many cases the plants do not fully harden because of stress e.g. diseases, drought stress, moisture stress, poor gas exchanges in soil environment. Stress and other ailment disrupt the production of carbohydrates in the plant and the plant may not fully harden (Tompkins et al. 1995, 1996)

Causes of winter injury

Winter injury can be caused by freezing injury, ice cover injury, desiccation, and overwintering diseases, each of which will be discussed below.

Freezing injury

Freezing injury or low-temperature injury is caused by the ice that is formed inside the plant cells. Good hardening is fundamental for the plant's possibilities to avoid freezing injury. Generally this type of injury occurs during the transition period between winter and spring or during mild periods of the winter as plants begin to de-harden (Figure 1).

Studies in controlled environment showed that plants that initiated growth in the spring had reduced hardiness and were more susceptible to freezing injury. Temperatures between 5 C and 8 C were sufficient to reduce the hardiness of *Poa annua* and *Agrostis stolonifera* (Tompkins et al, 1996). The longer the plants were subjected to these temperatures the greater the loss of hardiness. When plants break dormancy, the crown tissues become hydrated, increasing the likelihood of injury. Studies comparing *Poa annua* and *Agrostis stolonifera* found that the percentage of crown moisture was lower in *Agrostis stolonifera,* indicating a relationship between lower percentage of crown moisture and improved cold hardiness (Tompkins et al, 1996).

Desiccation

Desiccation, an injury condition that occurs when plants dry during the winter months causing cell mortality, usually affects plants located on sloped areas that are exposed to cold drying winds. Therefore, it is critical to maintain moisture in these areas and watering may be necessary during warm periods.

Ice cover injury

Ice cover injury occurs on putting greens following a prolonged covering of ice due to snowmelt or freezing rain. The ice build up occurs mainly on green areas with insufficient surface run off and drainage, caused by poor design and construction (Figure 2). Under ice cover, the oxygen level in turfgrass is depleted by activity of micro organisms or by the plant itself during respiration. As the oxygen is consumed, toxic gases are produced, which damages the plant.

The duration of ice cover leading to damage varies with grass species. Laboratory studies showed *Poa annua* to be more susceptible to ice cover than *Agrostis stolonifera.* After 30 days of ice cover, the hardiness level in *Poa annua* rapidly descreased and after 75 days it was completely dead. *Agrostis stolonifera* still maintained hardiness level at – 27 C after 90 days of continuous ice cover (Tompkins et al, 1998).

A new research and demonstration project "An Evaluation of Strategies for Removing Ice from Annual Bluegrass Putting greens" is set up at Prairie Turfgrass Research Centre, Alberta during 2003. The objectives of the project are to: determine effectiveness of different strategies for removing ice cover from annual bluegrass greens, and to determine effect of removing ice cover after different time intervals (Canadian Turfgrass Research Foundation, 2003)

Overwintering diseases

Fungi of importance for causing winter damages on putting greens in Scandinavia are *Fusarium Microdochium nivale, Typhula incarnata, Thyphula ishikariensis* and *Sclerotinia borealis.* The fungi have different distributions in the Nordic countries. *Fusarium Microdochium nivale* is of greatest importance in the southern and middle areas, *Typhula incarnata* somewhat futher to the north, and *Thyphula ishikariensis* and *Sclerotinia borealis* in northernmost part (Johansson, 1997, Svärd 2003). Applying fungicides prior to the hardening phase to control diseases caused by fungi has been necessary to successfully harden plants and deter severe winter damages. In Scandinavia there are only two or three fungicides allowed for use on golf courses. Therefore, overwintering diseases are a very serious problem, especially on golf courses where pesticide use is totally banned (Figure 3).

A new research project was set up in Norway, 2001 "Better winter survival of green grass". The goal for the project is to reduce the winter damage and use of fungicides by 30% on golf courses in eastern Norway (Tronsmo, 2001)

Overwintering diseases are further discussed in "Scoping paper on the R&D requirements to tackle the issue of managing diseases, pests, and weeds in a Europe where the availability of chemicals is on the decrease" (Killop & Mann, 2003) followed by a complete literature review concerning "What are the main pest and disease problems we face in Europe and how serious are they?"

Prevention of winter injury

There are two ways to prevent winter injury. The first is to choose suitable species and varieties and the second is to favour the plants by maintenance in order to ensure that it receives good hardening and become less susceptible to injury.

Grass species and varieties

There are important differences in hardening and cold tolerance between species and varieties within a species. Different species and varieties may also be susceptible to different types of injury (Table 1).

Table 1. Summary of a literature study concerning sensitivity of different species to different types of winter injury (Johansson, 1997)

Type of injury	*A. stolonifera*	*A. tenuis*	*F. rubra*	*P. annua*
Low temperature	Least sensitive	Mod. sensitive	Most sensitive	Most sensitive
Rapid drop in temperature	Highly sensitive	Highly sensitive	-	-
Suffocation	-	-	-	Highly sensitive
Ice cover	Least sensitive	Least sensitive	-	Most sensitive
Fusarium Microdochium nivale	Highly sensitive	-	-	Highly sensitive
Desiccation	Highly sensitive	-	-	-

Poa annua is very common on putting greens and winterkill is recurrently observed on *Poa annua* greens in northern climates. Although, *Poa annua* susceptibility to freezing temperatures has been pointed out as a major factor responsible for winter damages, little information exists on freezing tolerance and cold hardening of green-type *Poa annua*. The freezing tolerance has been determined in three ecotypes of green-type *Poa annua*. The ecotypes originated from Western Pennsylvania (OK), Costal Maryland (CO) and Central Québec (CR). The ecotypes differed significantly with regard to their freezing tolerance (LT_{50} ranking: OK < CO < CR) (Dionne, 2001).

A new Scandinavian research project is set up during 2003, "Evaluation of *Agrostis* and *Festucs* varieties for use on Scandinavian golf greens". The main objective for the project is to clarify which varieties of *Agrostis* and *Festuca* are best suited for golf greens in two contrasting climates in Scandinavia. Ten common varieties of *Agrostis* and *Festuca* are going to be evaluated (Aamlid, 2002; Engelsjord, 2003).

Improving the defence of the plant

First and foremost, it is important to ensure all plants fully harden in the fall. To be able to fully harden the plants must be healthy. It is best to keep plants cold and dormant through the transition period from winter to spring – beginning when snow starts to melt and ending the last night with temperatures below -8 C. By maintaining the dormancy for as long as possible, plants can retain their hardiness and prevent freezing injury.

Ice cover should be removed after 30 days of continuous coverage, especially with *Poa annua*. The worst type of ice coverage is that resembling a clear sheet since there is a buildup of toxic gases beneath the ice. However, ice formation due to snow melt may not be as lethal since channels may remain open, allowing for the dissipation of toxic gases. If temperature falls below -20 C after ice layer has been removed from the turf, freezing injury may occur. A good strategy is to

recover turf, especially *Poa annua,* with snow or winter covers to protect the grass from low temperatures (Tompkins et al, 2000).

Winter protection of golf greens

Various types of protective covers are used to reduce winter damages to putting greens especially *Poa annua* greens. The cover can be invaluable tools for protecting golf greens against freezing temperatures, ice encasement and desiccation injury. There is a wide array of winter covers available for use.

To be able to set up some recommendations concerning covering a seven-year research programme was established at The Horticultural Centre of Laval University, Québec and during the same time a smaller programme was set up in Scandinavia in co-operation with The Horticultural Centre of Laval University. Eight different winter protection treatments were tested in Canada and four treatments in Scandinavia. The study showed that winter protective covers improved turfgrass quality and surface conditions earlier in the spring (Dionne 1997, 2000, Strandberg et al, 2000).

There are some practical steps for optimizing the winter protection (Dionne 2000; Strandberg et al, 2000):

* A preventive fungicide for snow mould diseases control must be applied before the installation of winter protective cover.
* Consider local winter conditions and snow cover. It is not necessary to use a heavy insulating material if snow cover is deep and continuous.
* Always use impermeable protective cover to keep the insulating material dry and reduce injury from ice encasement.
* Monitor the temperature under winter protective covers.
* Install and remove the protective cover at the right time.
* Spring permeable cover should be used after winter protective covers have been removed.
* The covers will be most successful when used together with a sound turfgrass management plan.

Important future research areas

The Scandinavian Turfgrass Research Foundation has identified winter injury and winter stress management as one of the most important categories of research and education related to golf in Scandinavia. The Scandinavian Turfgrass Research Foundation was set up in March 2001 by the Golf Federations in Denmark, Finland, Norway and Sweden and The Swedish Greenkeeper Association.

Plant hardening

Hardening is a very complex process and several aspects of hardening is still insufficiently researched.

Hardening is controlled by climatic conditions, mainly day length. Most putting green grass species in Scandinavia originate from southern latitudes, compare to Scandinavia. More research is needed concerning the effects of Nordic climate on plant hardening of grass species from southern latitudes.

Hardening is also highly dependent on maintenance. It is important to identify maintenance strategies that help the plants to fully harden. More research is needed concerning construction and maintenance factors that influence plant hardening in the fall and early winter e.g. plant

nutrients and fertilizing, disease control, plant regulators, soil organic matter and microbiological activity in the root zone, soil physic properties in the root zone, wearing and mowing in the late fall.

Freezing injury

Generally, freezing injury occurs during the transition period between winter and spring as plants begin to de-harden. It is important to identify maintenance strategies for different Scandinavian climatic zones that keep plants dormant during the transition period from winter to spring.

A critical period of turfgrass is in the spring when the plants break dormancy, de-harden and growth is initiated. More research and demonstration projects is needed for optimizing the maintenance during this period e.g. concerning plant nutrients and fertilizing, spring covering of putting greens, irrigation regimes, topdressing strategies, and disease control.

Ice injury

The ice build-up occurs mainly on green areas with insufficient surface run off and drainage caused by poor design and construction. Information and education is needed to make the golf course architects and constructors aware of the importance of putting green design and construction that allows sufficient water run off and drainage.

A Scandinavian demonstration project, evaluating effectiveness of different strategies for removing ice cover from putting greens, would be very useful.

Evaluation of putting green grass species and varieties

There are important differences in hardening and cold tolerance between species and varieties. Continually, new grass varieties are imported and sold in Scandinavia without being tested under Scandinavian climatic conditions. The pilot research project set up in Norway, 2003, "Evaluation of *Agrostis* and *Festucs* varieties for use on Scandinavian golf greens", is the only project in Scandinavia where species and varieties are tested under putting green conditions. There is a large need of evaluation of grass species and varieties for putting greens under different Scandinavian climatic conditions.

Winter and spring protective cover of putting greens

Various types of protective covers are used to reduce winter damages to putting greens especially *Poa annua* greens. There is a wide array of winter covers available for use. Many superintendents reports inconsistent results with the use of protective covers, and there are few precise recommendations for their use and almost no data comparing the effectiveness of different covers available in northern climates.

Demonstration projects to evaluate different winter and spring protective covers available need to be set up in different climatic zones in Scandinavia. Education and future research concerning maintenance related to winter and spring covering of putting greens is needed as well.

Overwintering diseases

Applying fungicides prior to the hardening phase to control diseases has been necessary to successfully harden plants and deter severe winter damages. Very few fungicides are allowed for use on golf courses in Scandinavia and in a close future pesticide use will be banned in many areas. Overwintering diseases is a very important research area and more research is needed concerning alternatives to chemical disease control. This will be discussed in a literature review by Ruth Mann at STRI, 2003.

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Figure 1. Winter damages on a *Poa annua* green caused mainly by freezing injury and ice injury, Falun GK, April 2003.

Figure 2. Winter damages on an *Agrostis stolonifera* green caused mainly by ice injury, Edenhof GK, May 2003.

Figure 3. Winter damages on a *Poa annua* green caused mainly by *Fusarium Microdochium nivale*. Södertälje GK where pesticide use is totally banned, May 2003.