Successful reestablishment of golf greens following winter damages – Final Report

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SAMMENDRAG/SUMMARY:

A number of factors such as low soil temperature, desiccation and thatch can be serious limiting factors for the successful reestablishment of golf greens following winter damages. The rate of germination and seedling root growth have important implications for competition between species on a golf green. This research project has shown that *P. annua* is a very competitive species, due to quicker germination at lower temperatures, especially compared to *A. stolonifera* and *F. rubra* ssp *communtata*. Root growth of *P.annua* was also significantly quicker than of the *Agrostis* species tested. Seedlings of *Agrostis* species and *F.rubra* ssp *commutata* that germinate in close proximity to *P. annua* seedlings stand a large chance of being choked out. In order to reduce competition with *P.annua*, early seeding should be avoided. In this study, no difference in turfgrass establishment was observed when seedlings were grown using soil water extracts or soil from an ice-encased green, compared to a control. However, further investigations regarding reestablishment following ice encasement are warrant, and should be investigated on older greens with a higher organic matter content. The results from the demonstration trials emphasize the importance of using a sowing technique that ensures proper seed – soil contact. This is of particular importance for the establishment of turfgrass species on golf greens, due to the high risk of desiccation.

LAND/COUNTRY:	Norway
FYLKE/COUNTY:	Oppland
KOMMUNE/MUNICIPALITY:	Østre Toten
STED/LOKALITET:	Kapp

NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

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Innhold

1 Background

Reestablishing golf greens after winter injuries cause a considerable economic burden for Nordic golf course owners, and solid knowledge that can help the greenkeepers reduce the recovery time is in demand. A recent survey, including answers from more than 500 club managers, greenkeepers and other representatives for golf clubs in the five Nordic countries, showed that 56 % (even in Denmark) rated 'Winter Stress Management as the most important of STERF's research programs. Within Winter Stress Management, 68 % regarded 'Recovery from winter damage' to be one of the three issues of highest priority (Melbye, 2013).

Reestablishment from seed on dead greens in spring is difficult because of low soil temperature, high radiation, wind and unfavourable soil conditions (dead turf and thatch). Reestablishment following ice encasement has been shown to be particularly difficult. During the winter, ice encasement restricts gas exchange, thereby leading to anaerobic conditions that can kill the turf (Andrews and Pomeroy, 1989). Plants respond to the lack of O_2 by switching from aerobic respiration to fermentative metabolism which produces very little energy but potentially phytotoxic metabolites such as CO_2, ethanol, malate, citrate, lactate and propionate (Gudleifsson, 2009). A number of these substances are phytotoxic to germinating seeds in the springtime. Brandsæter et al. (2005) found that phytotoxic substances had a negative impact on seedling growth of *Agrostis capillaris* L. and *Dactylis glomerata* L. and recommended delayed seeding of hayfields after ice encasement.

Recommendations on how to achieve quick recovery from winter injuries of golf greens include good seeding techniques, use of spring covers, frequent irrigation and fertilization, increased mowing height, and reduced play (Skorulski 1994, Frank 2009, Vavrek 2010). A search in turf grass literature brought up little research relevant to re-seeding of cool season grasses into dead turf. A master thesis of Bogle (2009) showed that seedlings of creeping bent grass could replace annual bluegrass after winter kill. Plastic cover used during cold nights had no significant effect, but recovery benefitted from frequent fertilization.

This project has been set up to provide research based knowledge about factors that determine the success rate while re-seeding dead or partly dead greens in spring.

Main objective

Provide new knowledge that can help the greenkeepers to achieve faster reestablishment of turf after winter kill.

Sub goals

- Give species-specific guidelines for re-seeding after winter kill caused by anoxia.
- Investigate how sowing techniques and use of spring covers influence the rate of success.
- Provide the golf clubs with information that is useful when deciding the optimal day for opening the course.
- Disseminate research-based recommendations to the golf industry.

2 Materials and methods

WP 1. After-effects of ice encasement on seed germination of various species and at various temperatures

The field experiment in this project was conducted on a green seeded with creeping bent grass (*Agrostis stolonifera*) at the NIBIO Research Station, Apelsvoll, Norway, 61˚41' N (inland climate), during the winters of 2014-15 and 2015-16. New turf cover was established in early June of 2014 and 2015 due to destructive sampling throughout the experiment. Nitrogen was applied from June to September at two-week intervals and amounted to 2.45 kg m^{-2} $year^{-1}$. A metal frame was place around half of the green, and ice encasement was established in late November after the soil surface was frozen by adding small amounts of water in the frame over a period of three days. The remaining half of the green was sprayed with glyphosate in late autumn, and was used as the control treatment. Core samples (8 cm diameter, 10 cm deep) were removed from the plots immediately following spring thaw (early April). Core samples were centrifuged to remove soil water.

Photo 1. **Reestablishing a dead green in the spring is challenging. Are greens killed due to ice encasement even more difficult? Picture from experimental green at Apelsvoll, May 2015. Ice encased plot (left) and control plot (right)**

Photo: Wendy Waalen

Experiment 1: Phytotoxic effects of ice encasement on seed germination of various species and at various temperatures

Soil water from the ice encased and control plots was added to blotter paper in petri dishes where 100 seeds of colonial bent grass (*A. capillaris*) cv. Jorvik, velvet bent grass (*A. canina*) cv. Villa, creeping bent grass (*A. stolonifera*) cv. Independence, chewings fescue (*Festuca rubra* ssp *communtata*) cv. Musica and annual bluegrass (*Poa annua*) were placed. These five species were incubated at day/night temperatures of 15/5 °C and 25/15 °C, and seedlings were counted and removed as soon as they emerged after 3, 5, 7, 10, 12, 14, 17, 19 and 21 days of incubation.

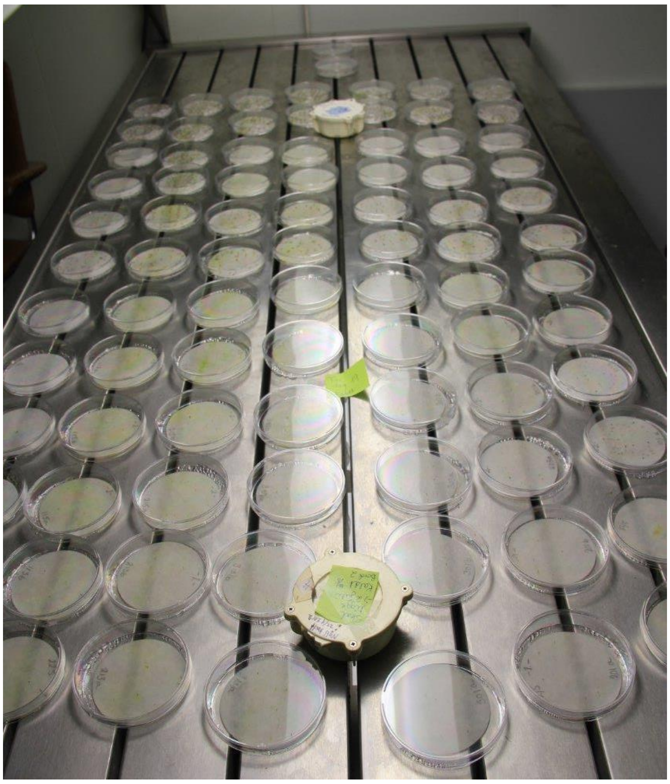

Photo 3. Germination trial in experiment 1 investigating the impact of soil water extracts from an ice-encased green, at two germination temperatures (day/night) 25/15 and 15/5 °C, on the germination of a range of golf green species.

Photo: Anne Steensohn.

Experiment 2: Phytotoxic effects of ice encasement on seedling root growth of various species

Fifty seeds of each species tested in experiment 1 were incubated in petri dishes saturated with distilled water at 25/15 °C. At seedling root emergence (after 1-2 days of incubation), ten uniform seeds per treatment were transferred to petri dishes filled with the same extracts as used in the first experiment. Seedling root length was recorded after 4 days. Both experiments included four replicates of each treatment.

Experiment 3: Germination and seedling growth following ice encasement

In springtime, following ice melting and soil thawing, half of the experimental plot was aerated to 10 cm depth using 6 mm solid tines. On day 1, 5 and 10 following aeration, core samples (8 cm diameter, 10 cm depth) were removed from the green and put into pots of the same diameter. The pots were sown with five species/subspecies with a predetermined number of seeds per pot (1 seed per cm^2). The pots were placed in a growth chamber at 10˚C and irrigated gently with 2 mm water once a day. Plant coverage was registered weekly for three weeks. After 3 weeks the fresh and dry weight of the total shoot biomass was registered. Each treatment combination was replicated four times.

WP 2. Large scale sowing equipment trials

Three demonstration trials on winter-killed greens at Fagersta GK, Surahammar GK and Sundsvalls GK in Sweden were established during the spring of 2015 and 2016. Four different sowing techniques were tested: 1) Scarification, 2 mm deep, followed by drop seeding 2) Seeding with spikes (Blec Turfmaker) 3) Slit machine 1 (Turfco triwave) 4) Slit machine 2 (Agrimetal). Scarification without seeding was used as a control. Two replicates of each sowing technique were established using creeping bentgrass, annual bluegrass or rough bluegrass (*Poa trivialis* L.). The seeded areas was covered with a permeable spring tarp until emergence. The greens were irrigated as required during establishment.

Turfgrass coverage was registered two and four weeks after sowing. Weather conditions and maintenance were monitored and reported.

Photo 4. Equipment used to re-sow the demonstration trial in 2016.

Photo: Carl-Johan Lönnberg

3 Results and Discussion

WP 1. After-effects of ice encasement on seed germination of various species and at various temperatures

Experiment 1 and 2

Ice encasement did not significantly decrease the final number of germinated seeds in this study (Table 1). This experiment was conducted on a newly established green with very little thatch. The experiment should be repeated on an older green with a higher level of organic matter, as this is expected to aggravate anoxic conditions (Rochette *et al.*, 2005).

Table 1. Final number of germinated seeds after 21 days, shown as the average of germination at 15/5 °C and 25/15 °C.

	A.capillaris	A. canina	A. stolonifera	F. rubra ssp communtata	P. annua
	Final number of germinated seeds after 21 days				
Ice encasement	96.7	95.7	72.3	87.8	97.8
Control	97.0	91.7	80.0	87.8	96.2

The number of germinated seedlings was significantly impacted by germination temperature (p=0.000), with 25/15 °C resulting in quicker germination than 15/5 °C. *A. capillaris*, *A. canina*, *A. stolonifera* and *P. annua* germinated at a similar rate at 25/15 °C, whereas *F. rubra* ssp *communtata* showed a significantly slower start (figure 1a). *A. capillaris*, *A. canina* and *P. annua* also germinated the quickest at 15/5 °C. The germination rate was significantly slower for *F.rubra* ssp *communtata* and *A. stolonifera* at 15/5 °C, and final number of germinated seeds was significantly lower than for the three other species.

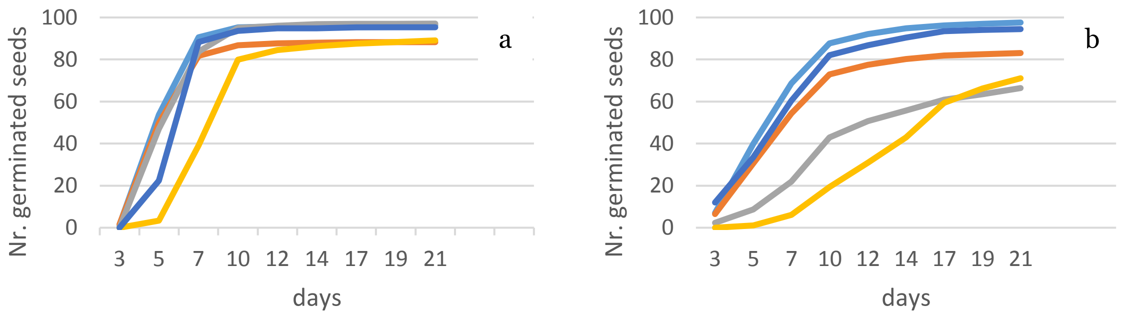

Figure 1. The effect of day/night temperature of 25/15 °C (a) and 15/5 °C (b) on the germination of *A. capillaris* (light blue), *A. canina* (orange), *A. stolonifera* (grey), *F. rubra* ssp *communtata* (yellow) and *P. annua* (dark blue) during a three-week period.

Soil extracts from the ice encasement plots did not affect root length of the five species, compared to soil extracts from the control (data not shown). Significant differences were however observed between the species, with *F.rubra* ssp *communtata* and *P. annua* showing significantly longer roots after four days, compared to the other species (table 2).

Table 2. Seedling root length 4 days after root emergence.

	A. capillaris	A. canina	A. stolonifera	F. rubra ssp communtata	P. annua
	Root length per seedling after 4 days (mm)				
Root length†	8.8b	4.8b	6.7b	14.0a	21.0a

†Tukey method of comparison, 5% significance level.

Experiment 3

As shown in table 1, there was no effect of the soil water extracts from the ice-encased green on germination, compared to the control plot. Experiment 3 confirmed these results, as turfgrass establishment in soil core samples removed from ice encased and control plots were not significantly different (photo 5). As there was no influence of ice encasement on the establishment of a range of turfgrass species, there was no interaction with aeration and delayed sowing as strategies to improve establishment following ice encasement.

Photo 5. Red fescue growing in core samples taken from plots which had been ice-encased and aerated following ice melt (left), ice encased and not aerated following ice melt (middle) and from control (no ice-encasement) plots (right).

Photo: Wendy Waalen

WP 2. Large scale sowing equipment trials

The results from the large scale sowing experiment varied depending on the weather conditions during the establishment phase. The spring of 2015 was very cool, which resulted in slow germination and turfgrass establishment in all treatments (table 3). Warmer temperatures in 2016 were much more conducive to turfgrass establishment. Turfgrass coverage four weeks after sowing in 2016 was higher in all treatments compared to 2015.

The results from both years suggest that seeds must have good soil contact for successful establishment. The" slit" machines and the spike machine resulted in improved turfgrass coverage, compared to drop seeding and control treatment.

Table 3. The influence of sowing technique on turfgrass coverage 4 weeks after sowing.

	Fagersta GK, 2015	Surahammar Gk, 2015	Sundsvalls GK, 2016	Average
	Turfgrass coverage, %			
Scarification followed by drop seeding	15	45	70	43
Seeder with spikes (Blec)	30	50	80	53
Slit machine 1 (Turfco triwave)	50	65	75	63
Slit machine 2 (Agrimetal)	30	60	65	52
Control (verticut with no seeding)	15	40	60	38

Photo 6. The demonstration trial at Sundsvalls GK 8 days after seeding.

Photo: Boel Sandström

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STERF (Scandinavian Turfgrass and Environment Research Foundation) is the Nordic golf federations' joint research body. STERF supplies new knowledge that is essential for modern golf course management, knowledge that is of practical benefit and ready for use, for example directly on golf courses or in dialogue with the authorities and the public and in a credible environ-mental protection work. STERF is currently regarded as one of Europe's most important centr es for research on the construction and upkeep of golf courses. STERF has decided to prioritise R&D within the following thematic platforms: Integrated pest management, Multifunctional golf facilities, Sustainable water management and Winter stress management.

More information about STERF can be found at www.sterf.org

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NIBIO - Norwegian Institute of Bioeconomy Research was established July 1 2015 as a merger between the Norwegian Institute for Agricultural and Environmental Research, the Norwegian Agricultural Economics Research Institute and Norwegian Forest and Landscape Institute.

The basis of bioeconomics is the utilisation and management of fresh photosynthesis, rather than a fossile economy based on preserved photosynthesis (oil). NIBIO is to become the leading national centre for development of knowledge in bioeconomics. The goal of the Institute is to contribute to food security, sustainable resource management, innovation and value creation through research and knowledge production within food, forestry and other biobased industries. The Institute will deliver research, managerial support and knowledge for use in national preparedness, as well as for businesses and the society at large.

NIBIO is owned by the Ministry of Agriculture and Food as an administrative agency with special authorization and its own board. The main office is located at Ås. The Institute has several regional divisions and a branch office in Oslo.

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