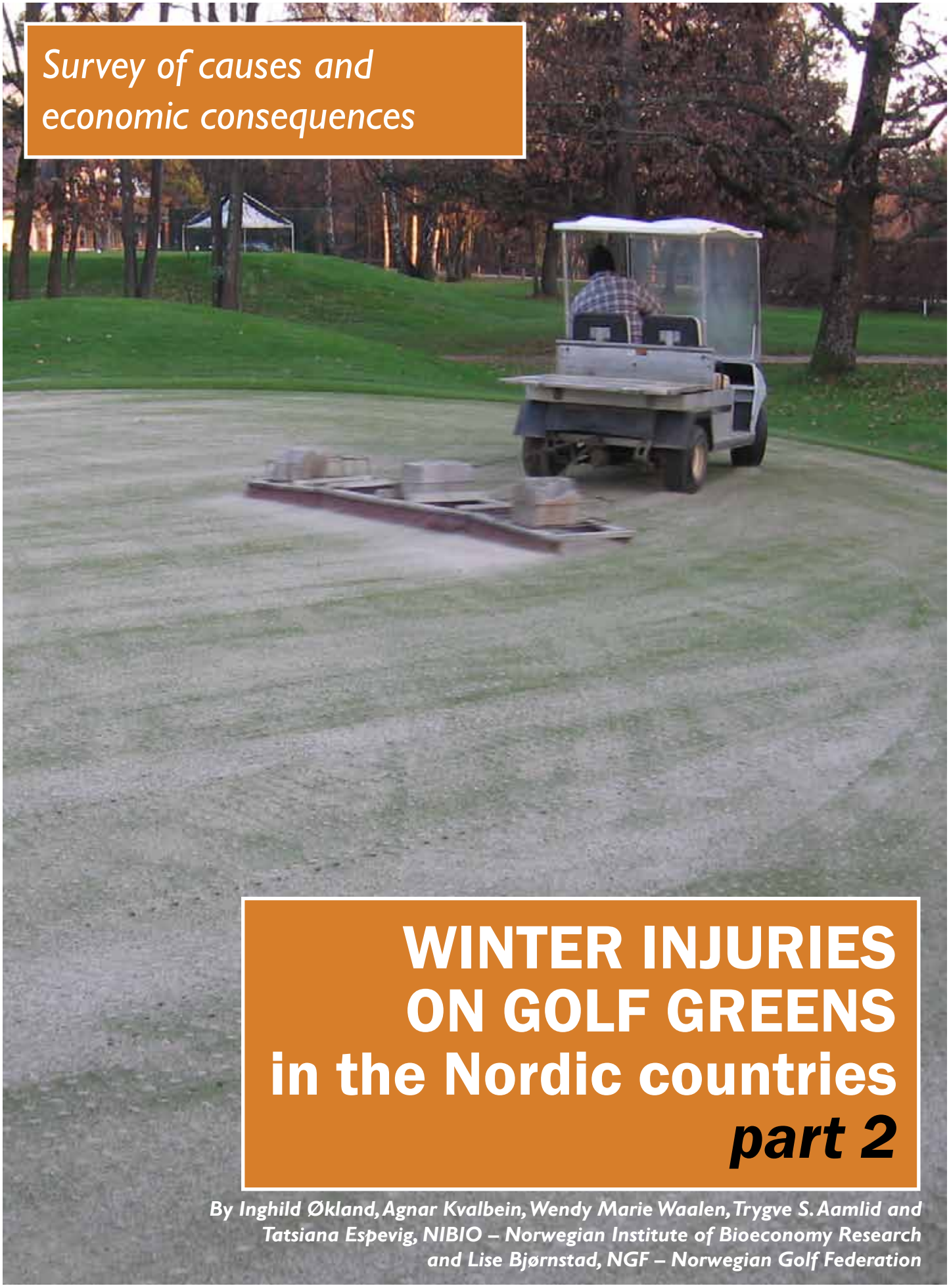

Survey of causes and economic consequences

WINTER INJURIES ON GOLF GREENS in the Nordic countries *part 2*

By Inghild Økland, Agnar Kvalbein, Wendy Marie Waalen, Trygve S. Aamlid and Tatsiana Espevig, NIBIO – Norwegian Institute of Bioeconomy Research and Lise Bjørnstad, NGF – Norwegian Golf Federation

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Winter injuries on golf greens in the Nordic countries (part 2)

- *Survey of causes and economic consequences*

In 2015 NGF and NIBIO with support of STERF ran a survey regarding winter damage on golf greens. The survey was distributed online, and included the five Nordic countries: Denmark, Finland, Iceland, Norway and Sweden.

While our first article from this survey focused on the causes and economic consequences of damage (Kvalbein et al., 2017b), this second article focuses on management before winter (2014-15): autumn fertilization, fungicide applications and winter maintenance. Winter survival of greens and snow mould infection are discussed in relation to different management methods. In each category, the number of answers indicates the robustness of the data.

Autumn fertilization of greens. Photo: Torbjörn Pettersson

Fertilization

Timing of last nitrogen input

A four year STERF project on late-autumn-nitrogen (N)-fertilization suggested that N-applications at a low rate might improve winter survival in the form of quicker green-up and less microdochium patch in the spring (Kvalbein et al., 2017b; Espevig et al., 2018). This is in line with the present survey showing that that autumn N-application is a common practice on several golf courses in the Nordic countries (Figure 1).

The effects of fertilization are influenced by the timing of the last N input, with different practices being a termination in August, September, or at the time of frozen greens, here annotated 'frost'. About 50% of the golf courses in Norway and Sweden fertilized the greens until frost. In contrast, the majority of golf courses in Denmark (56%), Finland (72%) and Iceland (48%) discontinued the N-application in September.

The turfgrass winter survival was slightly better when autumn N-fertilization continued until frost, and fertilizing until September was slightly better than conducting the last fertilization in August (Figure 2).

Still, these differences were small as 6% of greens with the last fertilization in August had less than 10% survival, compared to 3% and 1% when fertilizing until September and until frost, respectively. These results indicate that a small rate of N-fertilization until frost might be a good insurance against extensive winter damage. The reported rate of snow mould infection supported this. The more severe snow mould infections with a coverage of more than 10% of the green (Figure 3, orange and grey colour), decreased steadily with prolonged N-fertilization, from 21% with the last of N-fertilization in August, to 20% and 15% with the last fertilization in September and before frost, respectively (Figure 3).

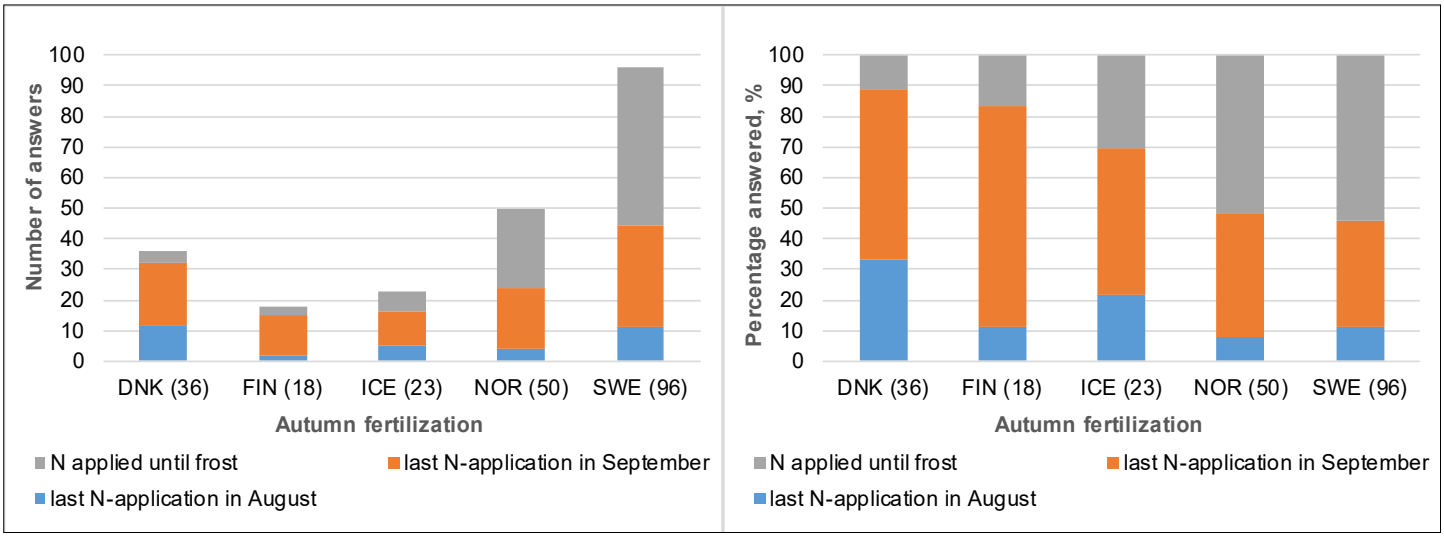


Figure 1. The application time of N-fertilization in the Nordic Countries.

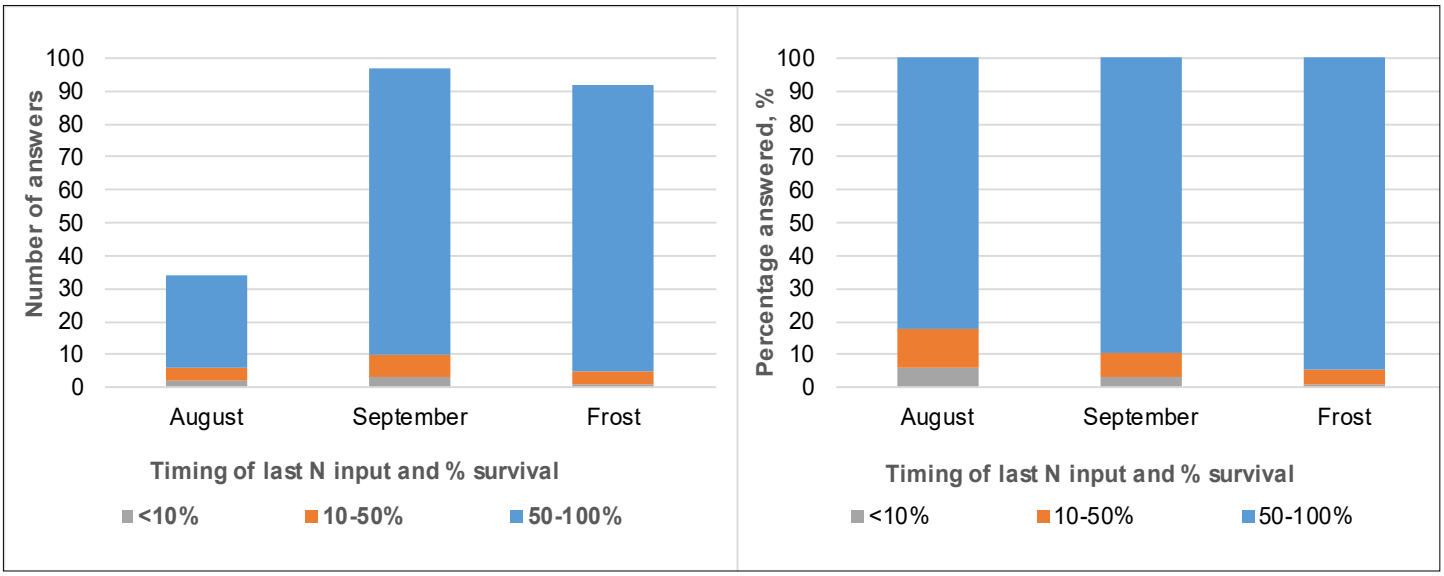


Figure 2. How N-fertilization in autumn affected survival of greens.

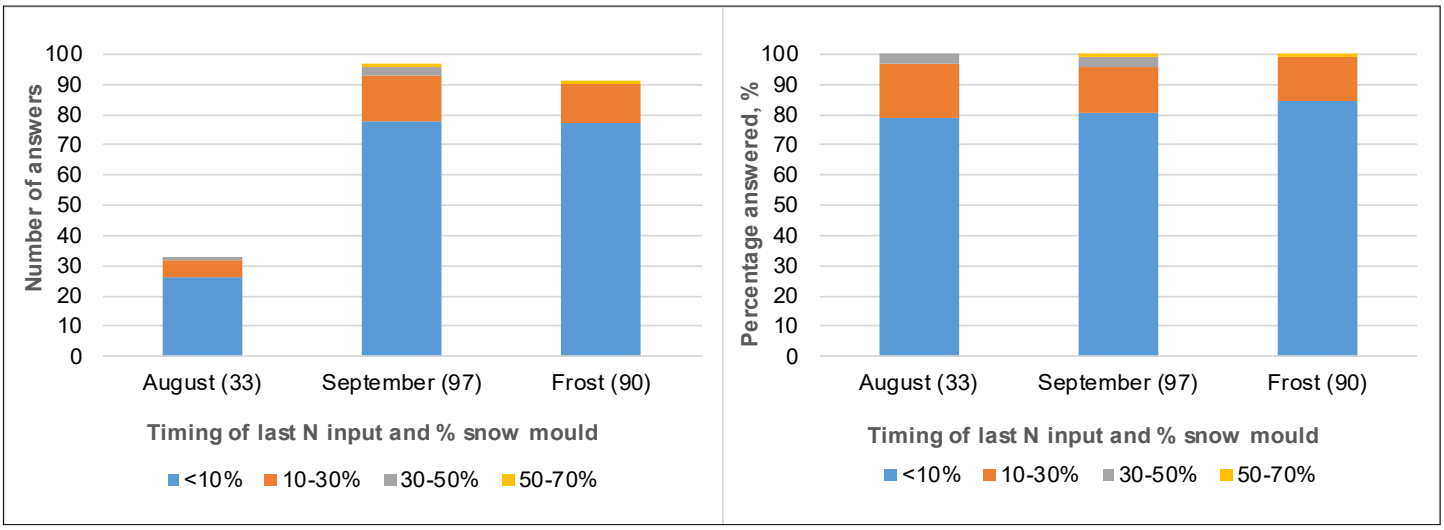


Figure 3. How N-fertilization in autumn affected snow mould infection in spring.

Extra application of potassium and/or iron in autumn

In total for all countries, about 8% the golf courses applied an extra amount of potassium (K) in autumn. For iron (Fe) the corresponding figure was 26%, while 21% applied both (Figure 4).

Extra input of K was most common in Finland and Norway, while input of extra Fe was most common in Sweden and Denmark (data not shown). The survival of the greens was slightly improved when both K and Fe were used, compared to no fertilization. Applying only one of the elements was, in contrast, counterproductive as it resulted in less survival than on golf courses with no extra input. (Figure 4).

This suggests that more research is needed on the effects of K and Fe and their interaction when applied in autumn.

With regard to snow mould there was a relatively clear effect of Fe-fertilization (88% with less than 10% infection) but no effect of K-fertilization compared with the control group giving no extra fertilizer (Figure 5).

Thus, the responses of snow mould and green survival to autumn K/Fe-fertilization did not yield the same results, and this may perhaps be due to the influence of abiotic winter damages.

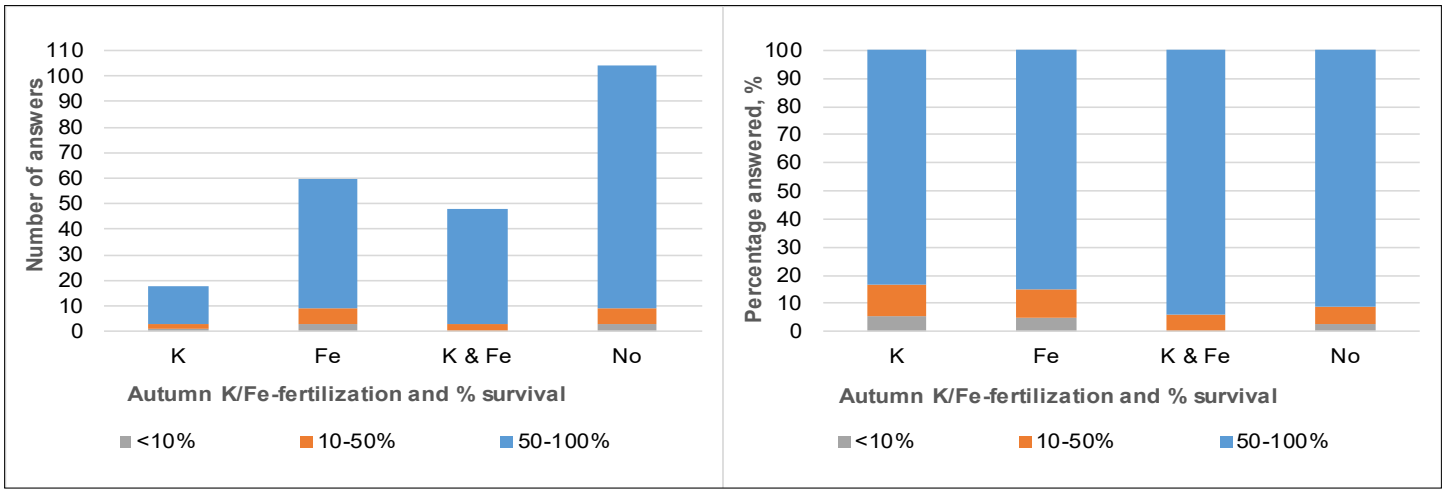


Figure 4. How K/Fe-fertilization in autumn affected survival of greens.

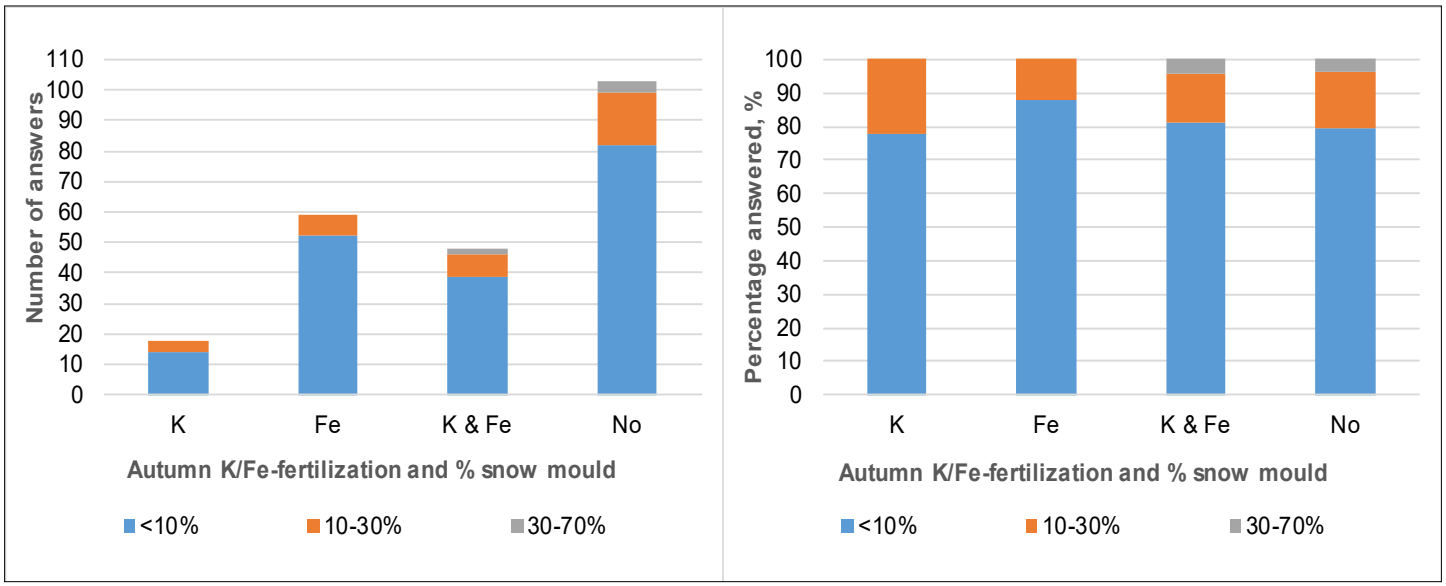


Figure 5. Snow mould infection and the impact of late autumn K/Fe fertilization.

Fungicides

Number of applications

The use of fungicides on golf courses in the Nordic countries is restricted. During the autumn/winter 2014-15, 38% did not apply fungicides, 16% applied 1 time, 21% applied 2 times, 23% applied 3-5 times and 2% applied 6-8 times (Table 1 and Figure 6). Of those using fungicides, products were applied only in autumn by 23%, only in winter by 19%, in autumn and winter by 56%, and in autumn, winter and spring by 3% (Table 1).

The number of fungicide applications throughout the season made a difference on snow mould infection. From 1 to 3 fungicide applications gave the best control of snow moulds and the proportion of greens with more than 10% snow mould seemed to be stable (Figure 6).

At more than 4 fungicide applications the proportion of golf greens with 10-30% snow mould increased to the same level as when fungicides were not applied. A possible explanation for this might be fungicide resistance or less sensitivity of the pathogens to fungicides on the greens that received the highest number of applications. These observations could also be due to a higher disease pressure on the golf courses that sprayed more than four times, which would explain the need for repeated applications. Five and seven applications were reported totally seven and six times, respectively, and eight applications was reported from one Finnish golf course (data not shown).

Season	Number of applications	DNK	FIN	ISL	NOR	SWE
No fungicides	0	18	-	21	27	30
Autumn*	1-2	1	2	4	16	8
	3-5	-	4	-	-	1
	6-8	-	-	-	-	-
Autumn & Winter	1-2	9	3	-	4	19
	3-5	7	6	-	7	31
	6-8	-	1	-	-	2
Winter	1-2	8	1	-	5	13
	3-5	1	-	-	-	1
	6-8	-	2	-	-	-
Autumn & Winter & Spring	1-2	-	-	-	1	-
	3-5	1	-	-	-	1
	6-8	-	-	-	1	-
SUM		45	19	25	61	106

* – Autumn: September and October; winter: November-February; spring: March

Table 1. Number of fungicide applications in the Nordic countries prior to and during the winter 2014-15.

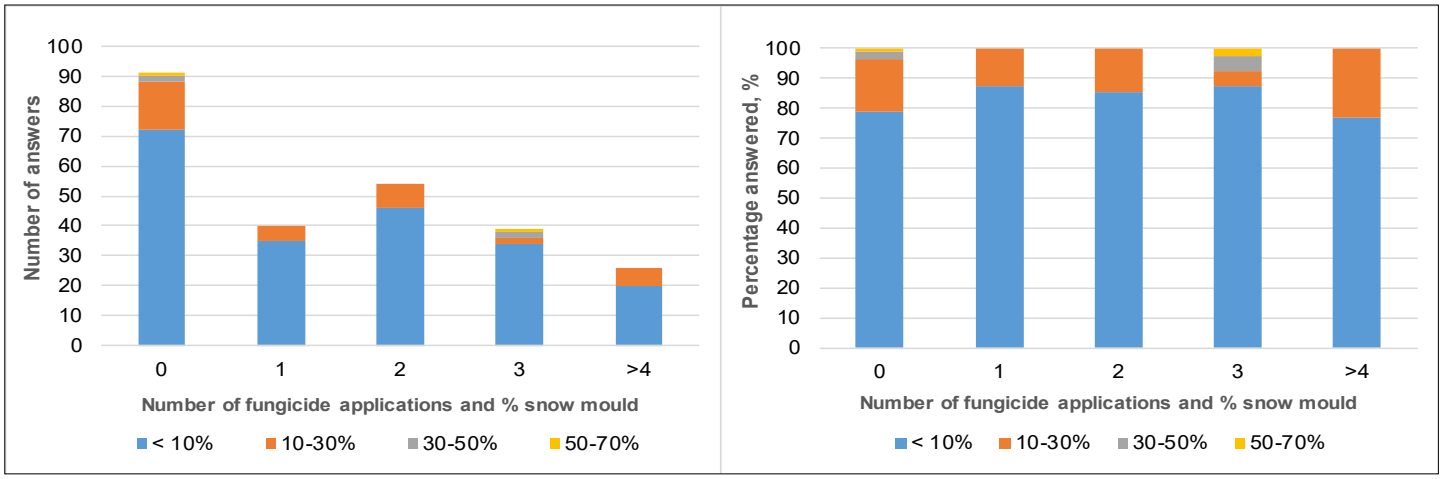


Figure 6. Number of fungicide applications and the amount of snow mould

Systemic vs. contact products

A total of 13 commercial fungicide products were reported used in this survey. Table 2 shows a grouping of these products according to mobility in plants and formulation / registration status.

Among those golf courses that applied fungicides, 58% used systemic products only followed by 34,5% which used both systemic and contact. Only 7,5% used contact fungicides only (Figure 7).

While use of only systemic or systemic and contact fungicides were practiced in approximately equal amounts in Sweden and Denmark, the use of only systemic fungicides alone dominated in Norway, Finland and Iceland (data not shown). As for snow mould control, systemic fungicides alone and systemic fungicides in combination with contact gave 82% and 85% control respectively.

Snowmould on an annual bluegrass green. Photo: Agnar Kvalbein.

Commercial product name	**Active ingredient(s)**	**Approved for use in 2014-2015**	**Phytomobility**			**Formulation / registration status**		
			Systemic	Contact	Both	Agricultural formulation with ordinary turgrass registration	Agricultural formulation with off-label turgrass registration	Speical turfgrass formulation
Acanto Prima	cyprodinil + picoxystrobin	NOR	X				X	
Amistar	azoxystrobin	SWE	X			X		
Banner Maxx	propiconazole	SWE	X					X
Basso	propiconazole + prochoraz	FIN				X		
Delaro	prothioconazole + trifloxystobin	NOR	X			X		
Folicur	tebuconazole	DNK	X				X	
Headway	azoxystrobin + propiconazole	SWE	X					X
Medallion	fludioxonil	SWE NOR		X				X
Proline	prothioconazole	DNK	X				X	
Stratego	propiconazole + trifloxystrobin	NOR	X			X		
Sportak	prochoraz	FIN	X			X		
Switch*	fludioxonil + cyprodinil	DNK			X		X	
Tilt	propiconazole	FIN	X			X		

Table 2. Classification of fungicides according to mobility and formulation / registrationstatus

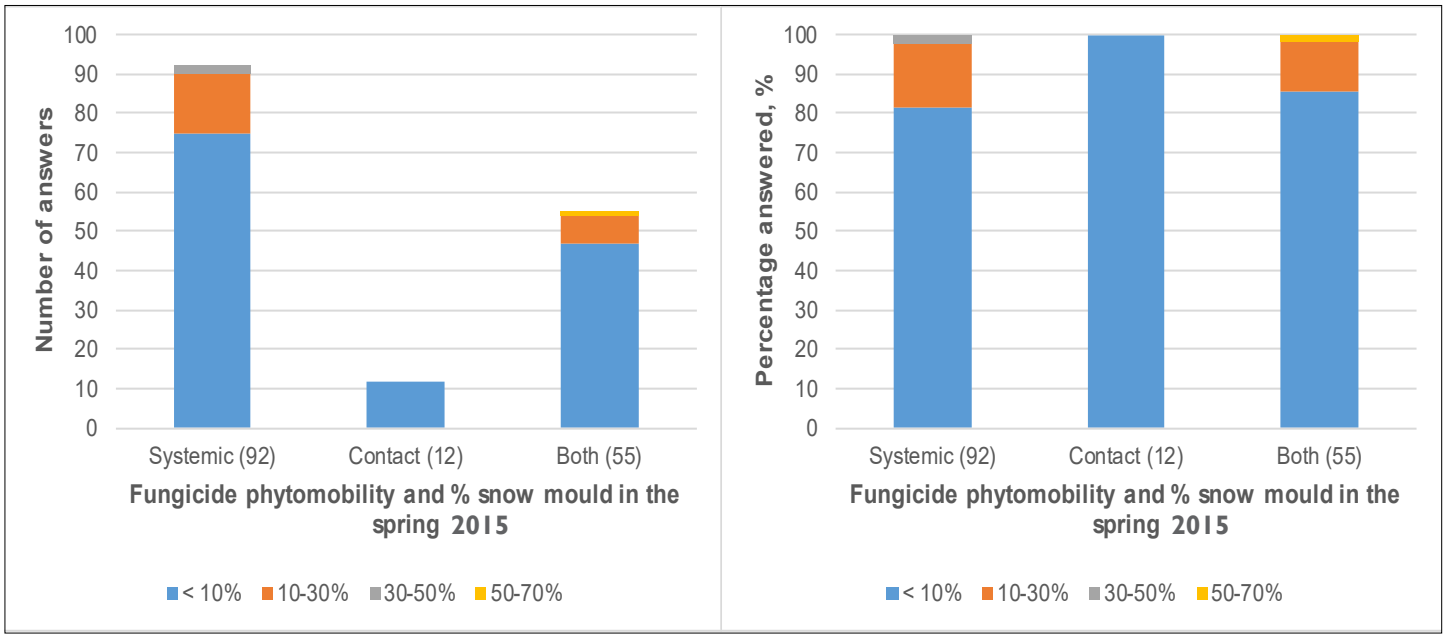


Figure 7. The relationship between fungicide mode of action and percentage snow mould in the spring 2015. Switch was considered a contact fungicide in this survey because it was applied from November to February by 27 of 31 answered.

The fungicides used in Denmark had off-label registrations for use in turf (Table 2). The use of fungicides registered for agriculture (off-label and ordinary) was the dominant practice in Norway (68%), while use of turfgrass formulations only or both agricultural and turfgrass formulations were less common (6% and 12% respectively) (Figure 8).

The use of only agriculturally registered fungicides in Sweden was 39%, though the use of both agricultural and turf fungicides was the dominant practice, with 44%.

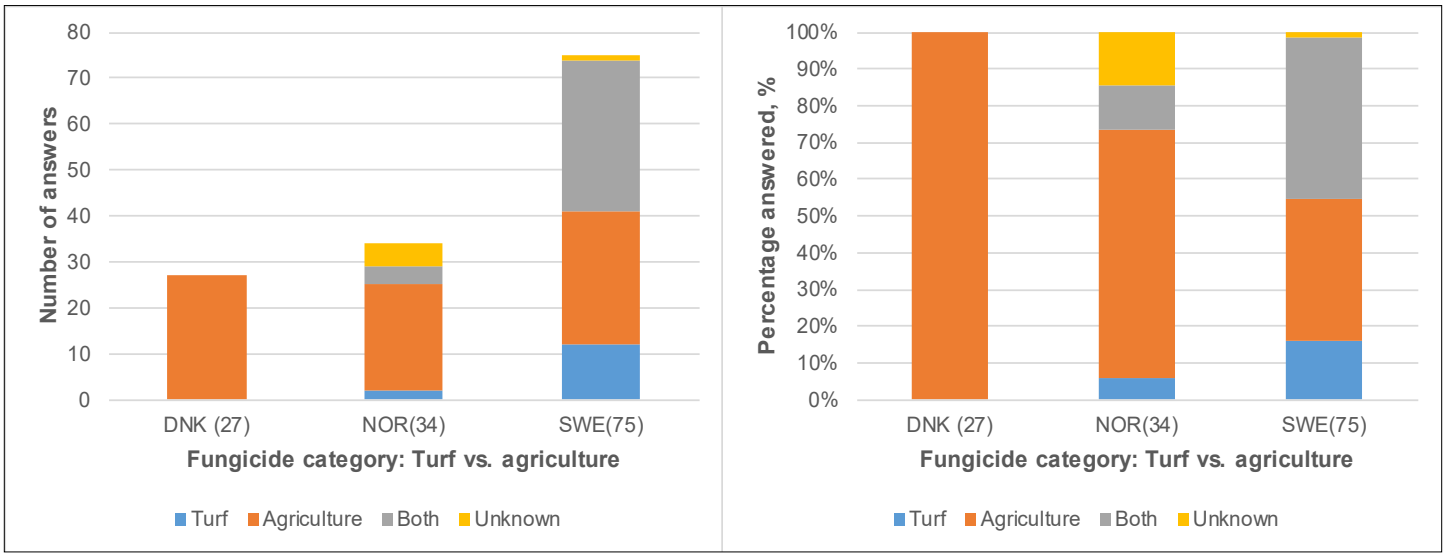


Figure 8. Use of agricultural and special turfgrass formulations in Denmark, Norway and Sweden. 'Unknown' means that fungicide name was not specified.

Green topography

The survey also included a question on winter damage depending on green topography. In most countries, the answers indicated an even distribution or no particular differences between lower spots and the higher and presumably drier areas. The most prominent exception was Iceland where about 50% of the respondents reported that winter injuries were most severe in the low spots (Figure 9).

This is not surprising as ice is the main cause of damage on Icelandic golf courses (Kvalbein et al., 2017b). Greens with injuries concentrated on high and dry areas seemed to have been more susceptible to high snow mould infection (Figure 10).

Of these areas, 40% had snow mould on 10-30% of the surface area. For other topography classes, 70-89% of the greens had less than 10% snow mould infection. A bigger sample size would be needed to further unravel the effects of topography on snow mould infection.

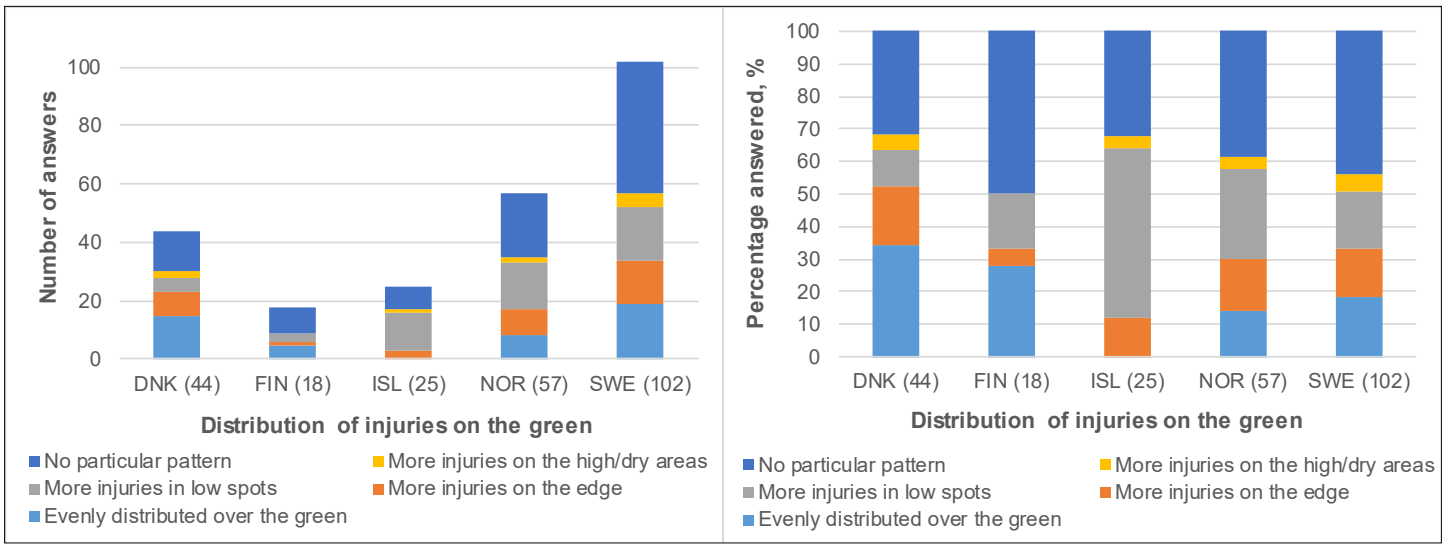


Figure 9. Distribution of injuries on greens.

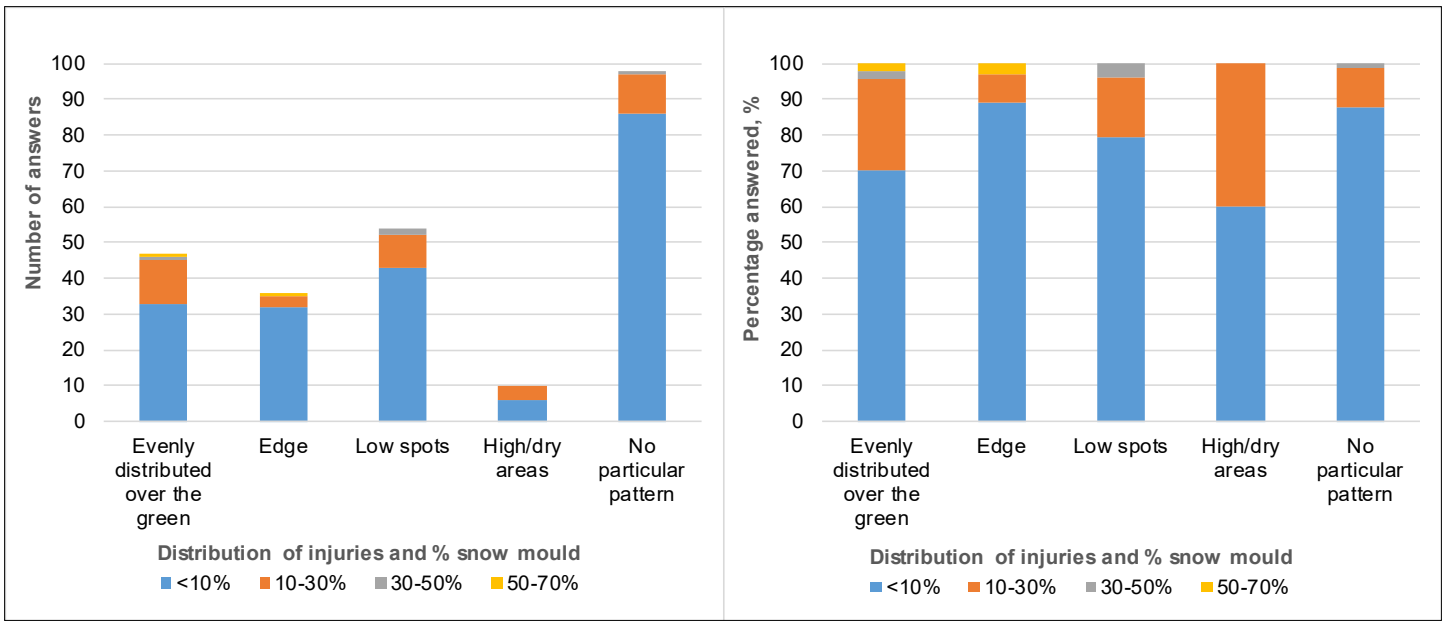


Figure 10. Distribution of injuries and % snow mould on the greens.

Treatments during winter

Toppdressing after aeration in autumn. Photo: Tatsiana Espevig

Mechanical treatments and topdressing before winter

Prior to winter, different methods of mechanical maintenance were practiced in the Nordic countries. All respondents answered that they used one or another type of aeration or/and topdressing on golf greens prior to winter (Figure 11).

The majority of golf courses in Denmark, Finland and Sweden used spiking with or without topdressing: 63%, 45% and 43%, respectively. Hollow-coring was the main aeration method in Iceland (44%), most likely due to the high impact of winter damage from ice.

Otherwise 18-28% of golf courses in the rest of the Nordic Countries used hollow-coring (with or without topdressing). From 14% to 31% of the golf courses in the Nordic countries used topdressing as the only maintenance of their greens before winter.

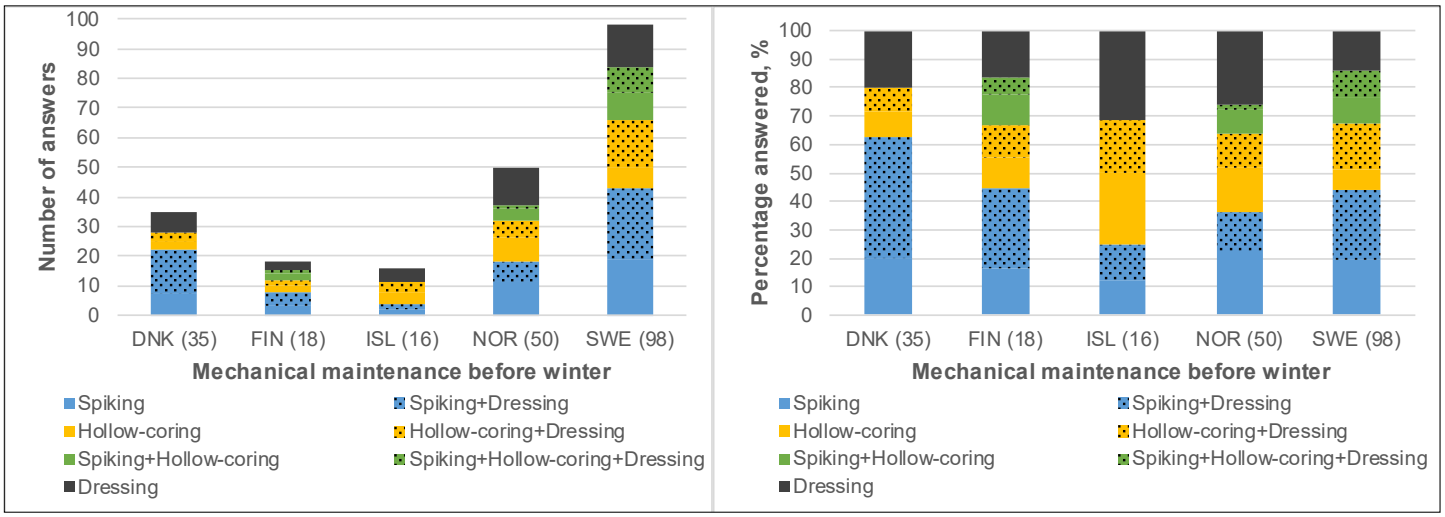


Figure 11. Management of golf courses prior to winter, using different mechanical methods.

Use of covers

The use of protective covers was not a common practice on Nordic golf courses (Figure 12), but some golf courses in Finland and Sweden benefitted from them. In Sweden, 5% of the respondents used some sort of protective cover, but the type of cover differed among courses. In Finland, 5% installed a water- and air-tight plastic cover before snowfall. Ice and water was reported as a major cause for winter damage in Finland (figure 1, Kvalbein et al., 2017b), and impermeable covers are most likely an attempt to reduce the damage.

The vast majority of the participants (213) answered that they used no protective covers during winter, and 79% of those had a 50-100% survival rate of grass on their greens (Figure 13). Clearly, even without a winter cover, the chances of high grass survival rates are good. Although none of the six repondents using covers in Finland and Sweden had less than 10% survival, a bigger sample size shall be needed to see the possible effects of winter cover on grass survival.

Wintercovering of greens, Sala GK. Photo: Torbjörn Pettersson

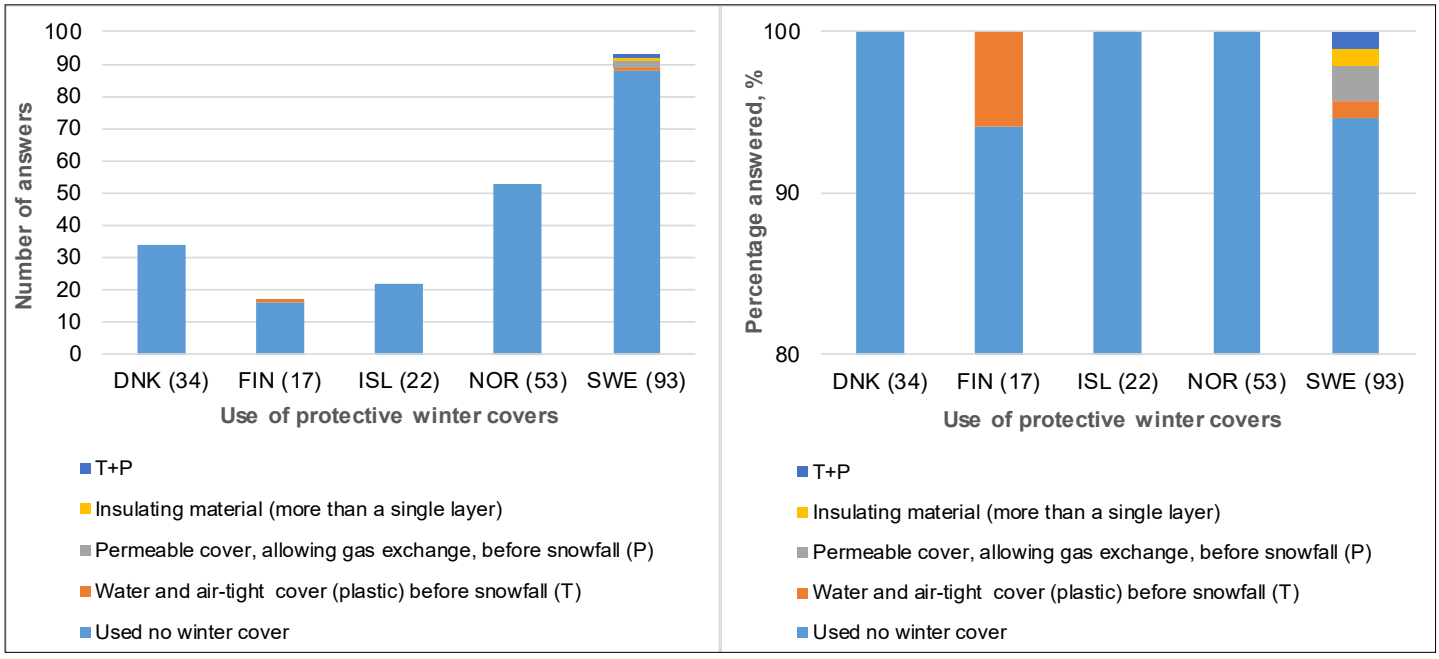


Figure 12. Use of different protective covers in the Nordic countries.

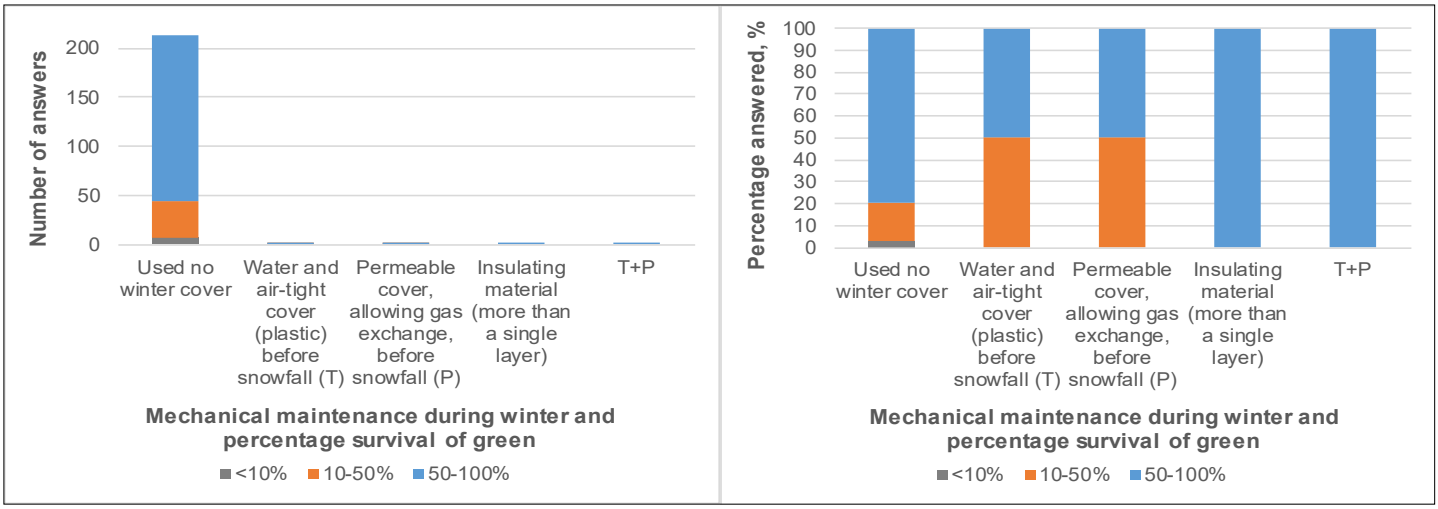
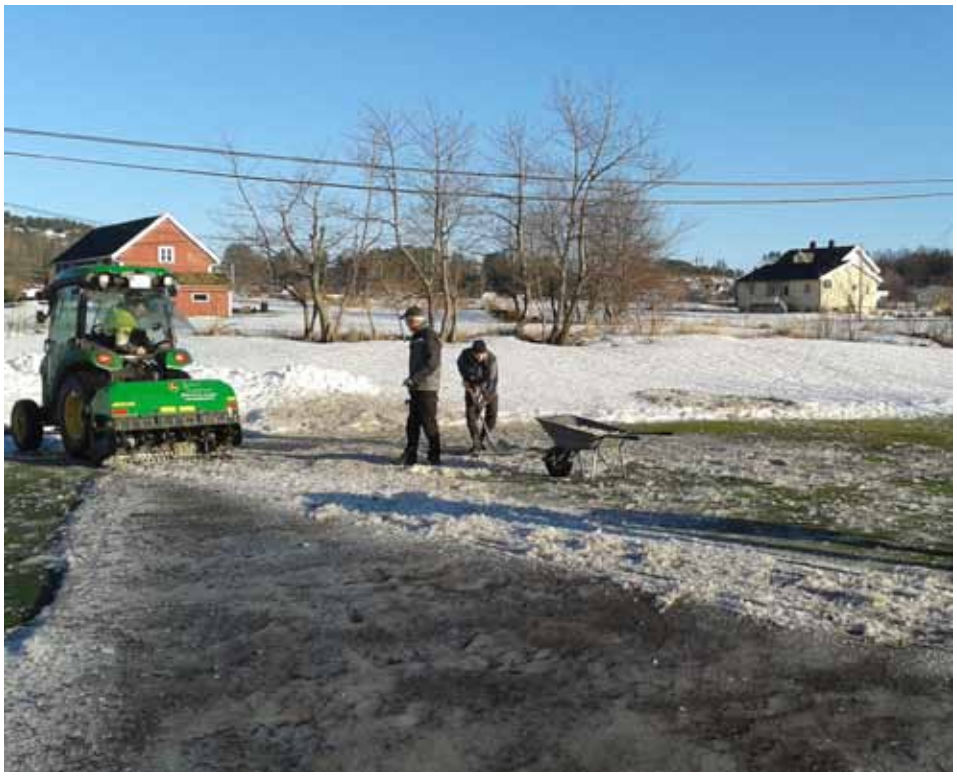


Figure 13. Use of protective covers and survival of green.

Snow or ice removal

Various measures may be taken to remove or melt snow and ice and get an earlier spring start on golf greens. Not surprisingly, the survey showed that no such measures were practiced in Denmark, and the majority of golf courses in Iceland (59%), Norway (57%) and Sweden (60%) also reported no special attempt to remove or melt the snow. A certain percentage of Finnish (28%), Norwegian (10%) and Swedish (15%) golf courses used less labor-intensive measures such as topdressing only or snow removal at first sign of spring with or without topdressing to speed up snow melt. Ice crushing and removal, being the most labor-intensive method, was used by some courses in all Nordic countries (except Denmark). In Finland, 33% of the respondents crushed the ice, making it the dominant method in this country. Ice crushing ice was also extensively used by the respondents in Iceland (32%), Norway (26%) and Sweden (18%), and was the second most common practice in these countries.



Snow and ice removal on annual bluegrass green, Landvik, January 2013. Photo: Tatsiana Espevig

An attempt was made to investigate the effects of different mechanical treatments and topdressing on green survival. This proved difficult as mechanical treatments will vary and be highly dependent on the severity of winter stress (e.g. amount of ice) at a given location. Thus, the results could just as well be a result of the amount of ice as of ice crushing or other treatments having a significant beneficial effect on green survival. Crushing of ice, for example, seems to correlate to some extent with greater damage on greens. Rather than the damage being an effect of the crushing ice-treatment, the damage could be more severe simply because of a greater amount of ice, thereby demanding treatment.

Still, mechanical treatments during winter, in the form of ice crushing and snow removal, are not without risk. Crushing of ice has the highest risk of incurring damage. Still, there seems to be a small benefit from treatment, especially combined with topdressing, compared to no treatment.

Conclusions

The survival of golf greens can be improved and the severity of snow mould infection can be reduced by continuing N-fertilization at low and decreasing rates until the greens freeze in late autumn. More research is needed on the effects of late K- and Fe-fertilization before clear guidelines on this practice can be given, although there seemed to be an effect of iron in reducing snow mould infection.

Use of only systemic or systemic and contact fungicides gave the same good control of snow mould infection.

There was no overall effect of green topography on winter survival, but indications that lower areas are more susceptible to ice and water damage and higher areas may be more susceptible to snow mould.

Due to the low number of respondents who used protective covers in this survey, there was not enough information to conclude whether there is a benefit from using protective covers or not.

There are still unanswered questions about the mechanical treatments of golf greens during winter, and their respective beneficial effects. A field experiment could be carried out to explore these, in which the survival of green could be compared with different combinations and separate treatments within one location, thereby eliminating the variable of winter stress pressure.

An overview of the answers from each country are available here:

Denmark
http://web.easyresearch.se/APP/ReportLogin.aspx?R=3965771.78287421

Finland
http://web.easyresearch.se/APP/ReportLogin.aspx?R=3965772.46117874

Iceland
http://web.easyresearch.se/APP/ReportLogin.aspx?R=3965773.96683195

Norway
http://web.easyresearch.se/APP/ReportLogin.aspx?R=3965774.58979569

Sweden
http://web.easyresearch.se/APP/ReportLogin.aspx?R=3965775.83764265

Overview
http://web.easyresearch.se/APP/ReportLogin.aspx?R=3854636.69265494

References

Aamlid T.S., Espevig T., Pettersen T., Waalen W., Heltoft P., Tangsveen J. og Melbye P. 2018. Vinteren 2017-18: Større skader enn normalt på to av tre golfbaner på Sørlandet, Østlandet og i Trøndelag. Gressforum 2:4-8.

Espevig T., T.S. Aamlid, T.O. Pettersen and A. Kvalbein. 2018. Effect of nitrogen in late autumn on microdochium patch on Nordic golf greens. p. 16-17. In S. Brown et al. (ed.) Different shades of green. Eur. Turfgrass Soc. Conf., 6th, Manchester, UK. 2-4 July 2018. Eur. Turfgrass Soc. Quinto Vicentino, Italy.

Kvalbein A., Espevig, T., Waalen, W.M. and Aamlid, T.S. 2017a. Turf grass winter stress management. Golf course managers' handbook. STERF. http://www.sterf.org/Media/Get/2892/winter-stress-mgmt-handbook

Kvalbein A., Waalen, W.M., Bjørnstad, L., Aamlid, T.S. and Espevig, T. 2017b. Winter injuries on golf greens in the Nordic countries: Survey of causes and economic consequences. Int. Turfgrass Soc. Res. J. 13:604-609.

Schärer, J. 2018. Utfordrende sesongstart for norske golfbaner. NIBIO nyheter. https://www.nibio.no/nyheter/utfordrende-sesongstart-for-norske-golfbaner?locationfilter=true

The first article about this survey can be found in the Library at **www.sterf.org**