WINTER DISEASES
Biotic winter damage

Photo: Agnar Kvalbein

Summary

- Several fungal species can grow and damage grasses at low temperatures. The most common and economically important winter diseases are microdochium patch and Typhula blight.
- In accordance with the principles of Integrated Pest Management, fungicides shall not be applied prophylactically, but only based on monitoring of disease development and when other methods are not sufficient. Winter diseases may, however, be an exception to this principle in areas with long-term snow cover.
- Information about the resistance to disease of grass species and cultivars, disease pressure, fertilization with nitrogen or other nutrients, use of winter covers, aeration, drainage, thatch control and other cultural management practices is important to decide if a green shall be sprayed or not.
- Systemic fungicides shall be used when the grass is still growing, while contact fungicides shall be used when growth has ceased and mowing is terminated for the season. Today's fungicides may contain both systemic and contact active ingredients.

General information about winter diseases and the environment under snow

Biotic damage of turf grass during winter is common in the Nordic countries. Unlike physical damage due to ice cover, freezing temperatures, desiccation, etc., biotic damage is caused by microorganisms, mainly fungi. A common name for fungal diseases that damage turf grasses during winter is 'snow moulds'. Not all snow moulds depend on snow cover to attack the grass, but they are all adapted to the environment under the snow. The snow insulates from frost and the temperature at ground level is often around 0 °C. Unlike under ice cover, oxygen is present and necessary both for low-temperature fungi and plants under snow (Figure 1).

Because low temperature limits the activity of other microorganisms, the snow moulds have few natural enemies and face little competition for 'food' in the form of grasses and other plants under snow cover.

There are several fungal species that survive and damage turf grasses at low temperatures. The most common and economically important winter diseases are microdochium patch and Typhula blight.

Several factors affect the severity of fungal damage (Figure 2).

Some fungal damage can be repaired quickly, usually much faster than ice damage. Fungicide applications or other measures to control other diseases during the growing season may also have an effect on the winter diseases. The biggest challenge with snow moulds is that if disease development occurs under snow, it is not possible to monitor disease development against thresholds and apply fungicides as needed during the winter. Therefore, where the winter implies long-term snow cover, it should be considered to spray prophylactically with fungicides approved for snow mould control.

Figure 1. *Oxygen that is needed for plants and fungi is usually available under snow but will soon be deprived under ice cover. On this mixed green with red fescue, browntop and annual meadow grass, the dead turf had been covered by ice, while the live turf with symptoms of microdochium patch had been covered by snow, Gjøvik and Toten GC, Norway, April 2018. Photo: T. Espevig*

Figure 2*. Snow mould damage on Nordic golf courses: to the left on an annual meadow grass green (Photo: A. Kvalbein) and to the right on a creeping bent grass/annual meadow grass green (Photo: A. Nyholt).*

Microdochium patch

The causal fungus and spread of the disease

Microdochium patch (formerly also called pink snow mould or fusarium patch) is caused by the fungus *Microdochium nivale* (Fries) Samuels and Hallet. In southern Norway, the first symptoms of microdochium patch are usually seen in September, but *M. nivale* can also be active in cool and humid periods during summer (Figure 3). The fungus is spread with spores or contaminated plant residues and thrives at low temperatures (0-13 °), in rainy weather and under snow on unfrozen ground. The risk of injury increases in spring as the turf grass plants have been weakened throughout the winter.

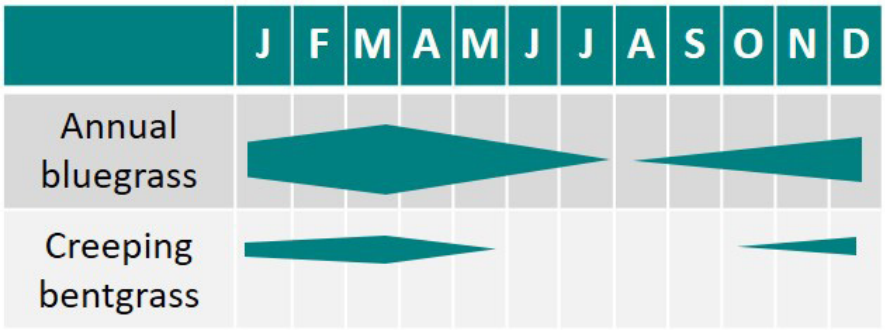


Figure 3. *Risk of microdochium patch on annual meadow grass and creeping bent grass at Landvik (South Norway). Illustration: T. Espevig.*

According to NGF / STERF's survey on winter damage, snow mould damage predominates south of 60 ° N in the Nordic region, while physical winter damage predominates north of 60 °N. This may perhaps surprise those who think of snow moulds as related to snow cover, but microdochium patch, which is the most common winter disease, can also damage turf grass without snow cover. North of 60 °N where snow cover is a natural component of winter, it is more common to use approved and efficient fungicides that reduce the disease.

Symptoms and susceptible species

The first patches of diseased turf, which appear in autumn (or in some cases in summer), are round, small and brown. The shape of the spots vary among turf grass species (Figure 4) and is also dependent on mowing height, e.g. the patches are more diffuse on high-cut turf grass or on golf greens with red fescue rather than on greens with annual meadow grass or bents. Grey-white mycelium can be found in the patches in wet weather or just after the snow has melted in spring. As the patches fuse together, the middle of the large and old spots (where the grass is dead) usually becomes bleached or light grey, while the edges (where the fungus is still active) are often brown, pink or orange. The pink or reddish colour is due to lumps of mature spores (sporodochia) of *M. nivale* on the surface of the leaves (Figure 5).

Spores of *M.nivale* are banana-shaped and consist of 1-5 cells (Figure 5). All turf grass species used on golf courses are susceptible to microdochium patch, but to a different extent, see more information below.

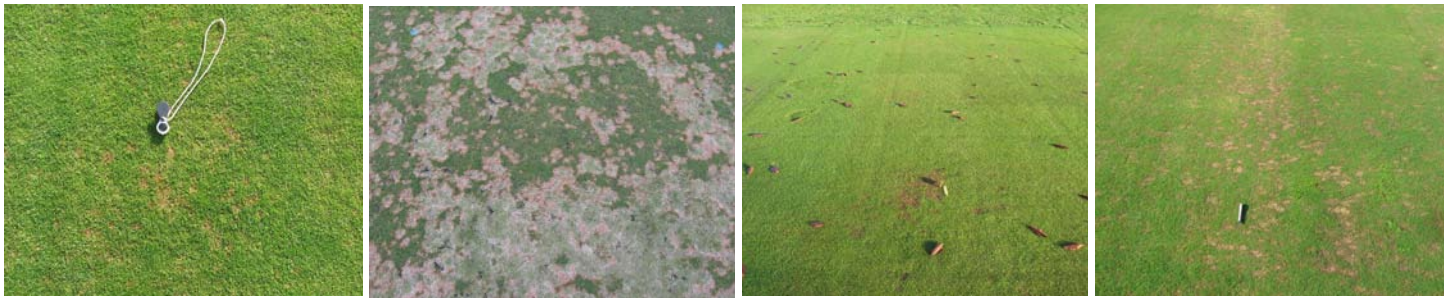


Figure 4. *Microdochium patch (a) on an annual meadow grass green in July 2011; (b) on an annual meadow grass green in March 2017 after a mild winter (six periods with snow cover lasting no longer that 2 days); (c) on a red fescue green in October 2013; and (d) on a velvet bent grass green in October 2007. All photos were taken at NIBIO Landvik. Photos: T. Espevig.*

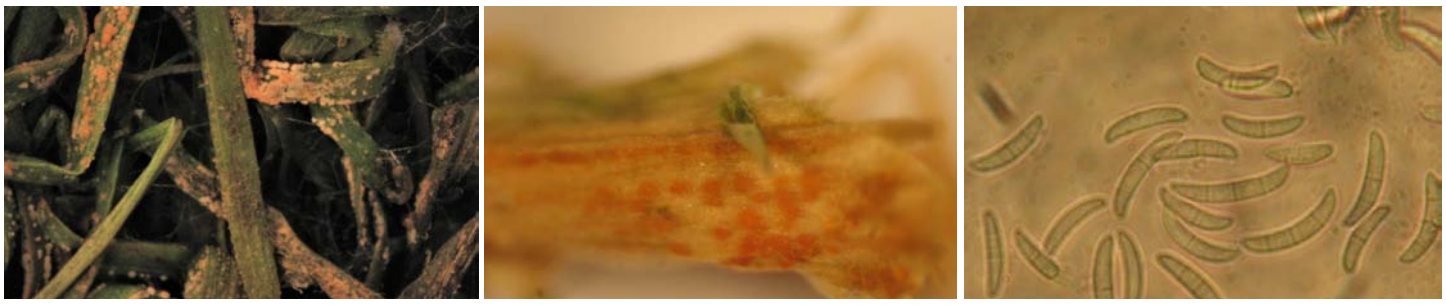


Figure 5. *Sporodochia of Microdochium nivale on leaves of annual meadow grass (left and middle) and spores of M. nivale (right, magnification 400x). Bilder: T. Espevig.*

Typhula blight (grey or speckled snow mould)

Typhula blight is caused by *Typhula incarnata* or *T. ishikariensis*. Both fungi belong to *Basidiomycota* and have different stages in the life cycle compared with *M. nivale* which belongs to *Ascomycota*.

Typhula blight requires snow to develop. *Typhula ishikariensis* requires 3-6 months of snow cover to cause significant damage, while the need for *T. incarnata* is shorter (1-2 months, although the damage becomes more severe when the duration of snow cover increases). When the duration of snow cover is short, *Typhula* spp. are unable to kill the grass, and the damage is therefore only superficial.

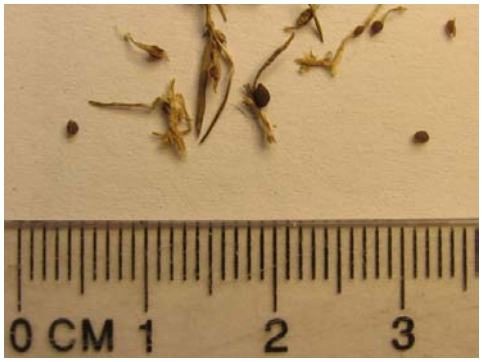
When covered by snow, both *Typhula* species form structures called sclerotia. In spring, right after snow melt, the diseased patches are often covered with glossy greyish mycelium and it looks like the grass leaves are 'glued together'. In these patches there are often sclerotia attached to the leaves. The sclerotia of *T. incarnata* are reddish and 0.5-3 mm in diameter, whereas those of *T. ishikariensis* (var. *ishikariensis*) are dark brown or almost black and not larger than 1 mm in diameter. On the Norwegian southern coast (for example at Landvik) we have only seen *T. incarnata*, but further north and in the inland (for example, at Apelsvoll), both *Typhula* species are common and sclerotia of both species can be often found in the same patch (Figure 6).

Typhula patches may become completely white when they dry out in spring (Figure 7). The sclerotia then fall into the mat/thatch where they survive the summer. In autumn when the temperature drops and it becomes more wet, the sclerotia germinate and form fruiting bodies that are pink if *T. incarnata* (Figure 8) and white if *T. ishikariensis*. The fruiting bodies contain many small spores which spread and infect the grass. If you see these fruiting bodies, you know that fungi are present. But it is the duration of snow cover, other weather conditions in winter and the acclimation status of the turf grass that determine whether or not there will be a significant attack in spring.

Figure 6. *Reddish-brown sclerotia of Typhula incarnata (to the left in the photo) and dark brown sclerotia of T. ishikariensis (to the right in the photo) in smooth-stalked meadow grass on a lawn at Apelsvoll in April 2018. Photo: T. Espevig.*

Figure 7. *Typhula blight caused by T. incarnata on a velvet bent grass green in April 2010. Photo: T. Espevig*

Figure 8. *Typhula incarnata: sclerotia (left), fruiting body growing from a sclerotium (middle), and fruiting bodies on a creeping bent grass golf green in late autumn. Photos: T. Espevig (left and middle) and T. Haugen (right).*



Other winter diseases

Other fungi may also attack the turf grass under snow (Figure 9).

Sclerotinia borealis can kill the grass if the snow cover lasts for at least half a year and *Phythium iwayamai*, which is not a true fungus but belongs to *Oomycota*, grows rapidly in freezing water. Please, note that rare and new diseases may also occur.

If in doubt, send samples to a laboratory for identification as this is always important for the correct management and disease control strategy.

Figure 9. *Left: An active fungus on a fairway at Landvik in April 2013; most likely it was Typhula incarnata but due to absence of sclerotia (too short snow cover?) the fungus could not be identified (photo: T. Espevig). Right: These patches contained an active Rhizoctonia spp. on a red fescue green in March 2011 (photo: P. Bengtsson).*

Integrated management of winter diseases

Resistant species and cultivars

Snow moulds (like other turf grass diseases) develop as a result of the interaction between (1) susceptible plants, (2) presence of a pathogen with a certain amount of inoculum and (3) an environment that is favourable for disease development. This interaction is illustrated by the 'disease triangle'. Since all three components must be present for a disease to develop (Figure 10), it is important to use species and cultivars with a certain level of disease resistance on golf courses that are exposed to snow moulds. This applies not only to greens but also to fairways and tees because susceptible grasses that are quickly diseased will also increase the disease pressure on neighbour grasses. In this context, it is particularly important to control annual meadow grass.

There is a large variation between species and cultivars within a species in resistance to different snow moulds. When it comes to microdochium patch on greens, annual meadow grass is most susceptible followed by browntop and velvet bent grass. Creeping bent grass is usually quite strong against microdochium patch during the growing season, but can be severely damaged by both microdochium patch and Typhula blight under snow cover. Red fescue is usually considered to have high resistance against snow moulds but both within this species and within creeping bent grass there are significant differences among cultivars (Figure 11).

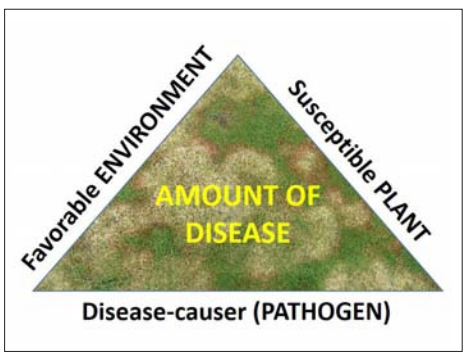


Figure 10. *Disease triangle.*

Figure 11. *There is a big difference in resistance to snow moulds among turf grass species and cultivars. SCANGREEN (cultivar trial) at Apelsvoll in April 2018 (right) and at Landvik in April 2011 (left). Photos: T. Espevig*

On golf courses that are more prone to fungal damage than to damage caused by ice or other physical stresses, it is important to choose not only resistant species but also resistant cultivars. The webpage http://scanturf.org/ is based on the SCANGREEN (testing at green's mowing height) and SCANTURF (testing at fairway mowing height) cultivar testing programmes, and here you can find information about which cultivars are suitable for golf courses in different parts of the Nordic countries. For many species, the tables on this website contain not only information about overall winter's strength, but also more specifically about resistance to Typhula blight under snow cover or to microdochium patch, either attacking during the growing season or under snow cover.

Cold acclimation and shade

Cold acclimation in autumn is very important not only to increase the tolerance of turf grasses to physical winter damage, but also for their resistance to snow moulds. Velvet bent grass, for example, is susceptible to microdochium patch during the growing season, but it can become more resistant than creeping bent grass after being cold acclimated in autumn (Figure 12). This is one of the reasons why it is so important to create good light conditions and avoid shade from trees on golf greens in autumn.

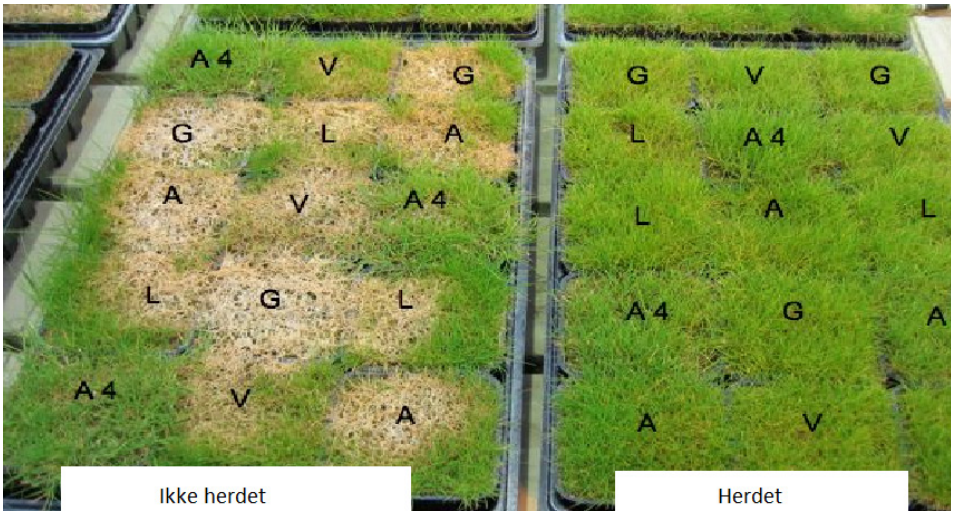


Figure 12. *In a trial in controlled environments, it was found that cultivars of velvet bent (A = Avalon, V = Villa, G = Greenwich and L = Legendary) that were not acclimated were susceptible to microdochium patch and less resistant than the creeping bent grass Penn A-4 (left). After acclimation, velvet bent became resistant to microdochium patch (right). Photo: K. Gundsø Jensen*

Fertilization in autumn

In the 1970s, it was recommended that the seasonal fertilization with nitrogen (N) should be terminated in September because later inputs would stimulate growth, reduce acclimation and lead to less winter survival, including more snow mould damage (read more about defence mechanisms to snow moulds in STERF's handbook 'Turf Grass Winter Stress Management '). Later studies confirmed that this is correct when using large N amounts. However, if the turf grass, is fertilized lightly and frequently with small amounts of N corresponding to its needs and uptake capacity in autumn, acclimation will only be reduced to a very small extent. On the other hand, light and balanced fertilization in autumn has been shown to provide many advantages such as better winter colour, earlier green-up and better overall impression in spring (Figure 13). More about autumn fertilization can be found in STERF's handbooks 'Precision Fertilization' and 'Turf Grass Winter Stress Management'.

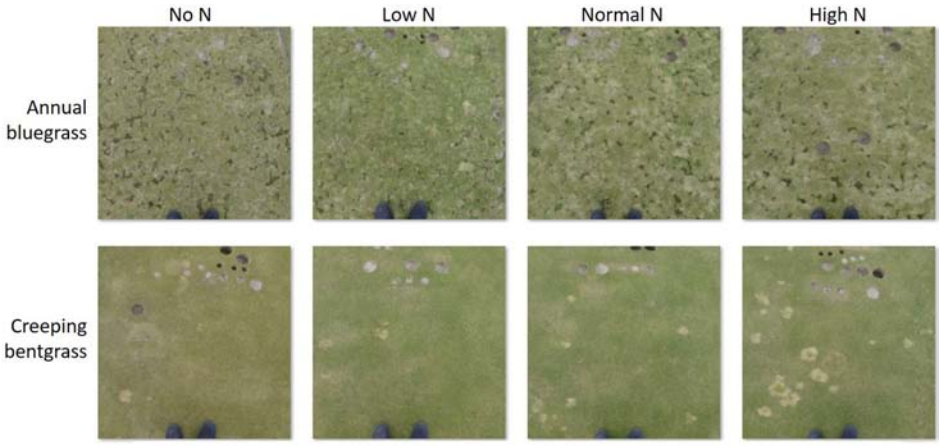


Figure 13. *Low-N-fertilization from September to November 2014 (in total 2.8 g N per m^2) did not lead to more microdochium patch in March 2015 on golf greens with annual meadow grass or creeping bent grass. Colour and overall impression were, however, improved compared to No-N. Photos: A. Kvalbein.*

Another old 'truth' that seems difficult to get rid of is that large amounts of potassium in autumn lead to less winter diseases and better overall winter survival. Special 'autumn fertilizers' that typically contain 3-5 times as much potassium as nitrogen are still on the market, but their use is not anchored in scientific testing. On the contrary, recent results show more microdochium patch after high amounts of potassium fertilizer in autumn (Moody 2011; Soldat & Koch 2016). This is why STERF's fertilizer handbook (Ericsson et al. 2012) recommends to apply N and K in a ratio of 100: 65 throughout the year.

Chemical control of winter diseases

Number of applications and allowed fungicides

The last big survey on the use of fungicides on golf courses in the five Nordic countries was carried out in 2014-2015 (Økland et al., 2018). Response from almost 1 000 greenkeepers / golf courses showed that 38% of golf courses did not spray the greens against snow moulds, 16% sprayed once, 21% sprayed twice and 25% sprayed three or more times. The survey showed most winter diseases on unsprayed greens, but there was no overall reduction in attack with increasing number of applications. Here we must, however, be careful to draw conclusions because it is reasonable that the golf courses most exposed to disease were also those with most fungicide applications. Based on many years of experiments with various fungicides on golf courses in the Nordic countries, we can expect that one successful spraying in September-October controls about 70% of the disease and that the level of control increases to over 90% with one additional application 1-4 weeks before the snow arrives in November-December. The effect of more than two applications against winter diseases will therefore be quite marginal, and more than three applications per season can hardly considered in line with the intentions of Integrated Pest Management.

Programmed spraying?

In accordance with the principles for Integrated Pest Management, fungicides shall not be applied profylactically, but only 1) based on monitoring of the disease and 2) when other methods are not sufficient.

Disease forecasting models can also be used. They are usually based on weather

data from the last period and/or on weather forecasts for the coming days. Such models have been developed for microdochium patch in late summer and autumn. In our experiments, spraying after forecast has not led to less disease or less use of fungicides than spraying at 'first sign of disease' in the field. Since the 'the first sign' of disease can often be quite small and cover only 0.1 - 0.5% of the green surface area, warnings on a PC or smartphone can nonetheless be a useful reminder for the greenkeeper. Daily monitoring for disease is always important in periods when outbreaks can be expected, especially on greens with susceptible grasses such as annual meadow grass, browntop or velvet bent grass.

On creeping bent grass greens there are often few or no symptoms of microdochium patch in the autumn, but still significant attacks after snow melt in spring. In order to prevent such attacks, the decision whether or not to use fungicides must be taken before the snow is coming. Greens that have been severely affected by disease during one winter usually contain more inoculum and are therefore more exposed during the following year. Together with information about the susceptibility of the predominant species and cultivars, fertilization with nitrogen, iron and other nutrients, winter covers, drainage, thatch control and aeration and other management practices, this is useful information to including in the decision whether or not to spray a green on a golf course.

Systemic or contact fungicides?

Fungicides have traditionally been divided into systemic agents that are taken up and transported in the plant, and contact agents that only form a protective film on the leaf surface. With today's active substances, this distinction is not as sharp as before, and there are also many mixed products on the market (Table 1).

When advising on optimal fungicide use, it is nonetheless useful to distinguish between the two categories. Then, the principle is that systemic agents shall be used when the grass is still growing, while contact fungicides shall be used when growth has ceased and mowing has been discontinued for the season. The first application of an efficient systemic fungicide usually protects the turf for 4-6 weeks, and when 3-4 weeks have gone, it is important to follow up and spray again at first sign of disease. Under Norwegian conditions, the first application of a systemic fungicide usually takes place mid September to early October and the second application of a contact fungicide in late October or November. In both cases, higher latitudes or altitudes means earlier applications.

In the past, it was often recommended that the contact fungicides should be sprayed as shortly as possible before snow fall. There is, however, no experimental evidence for this as today's contact fungicides work equally well if they are applied one or three weeks before snow cover. What is more important is that fungicides shall not be sprayed if there is frost in the soil or during periods with rainfall or sleet as this can easily result in surface runoff of fungicides from the greens. In the aforementioned survey from 2014-15, there were very few greenkeepers who in addition to the autumn applications also sprayed the greens after snow melt in spring, and this is in agreement with our experimental results showing little benefit of spring applications.

Resistance

Repeated use of the same fungicide or a group of fungicides can sometimes cause patogens to develop fungicide resistance. This risk is greater for systemic fungicides than for contact fungicides, and in order to reduce the risk, commercial products often combine two active ingredients with different modes of action.

Alternatively, products with different modes of action may be applied sequentially. On greens that are sprayed only twice a year, first with a systemic and then with a contact funcicide, there is generally little risk of resistance development.

Read the label carefully

The chemical pesticide label contains information on the legal use of the product, including harmful organisms, dosage, spraying time, maximum number of applications per year and minimum distance to open water. Any use of product that is not mentioned on the label is illegal and may result in the retention of the right to use pesticides. The regulations for the use of pesticides differ from country to country, and it is always important to follow the national rules. Some national golf federations have so-called minor-use registrations, in which case the federation's instructions must be followed closely.

As mentioned, different snow mould are caused by different fungi. This means that an active ingredient may be effective against *M. nivale* but not against Typhula spp. or the other way round. This is even more the case if some the symptoms are caused by Pythium, which is not a true fungus. Therefore, it is important to know which disease is on green and then select a fungicide according to label.

Table 1. *Registered fungicides in the Nordic countries per 15 October 2018.*

FUNGICIDE -Active ingredient	SYSTEMIC / CONTACT	SWEDEN	NORWAY	FINLAND	DENMARK
Amistar (t.o.m. 2019) -Azoxystrobin, 250 g/L	S	1 L/ha x3*			
Banner Maxx -Propiconazole, 156 g/L	S	3 L/ha x4			
Banner Maxx II -Propiconazole, 161.6 g/L	S	3 L/ha x2**		3 L/ha x3	
Bolt XL -Propiconazole, 250 g/L	S			0.5 L/ha x3	
Basso -Prochloraz, 400 g/kg -Propiconazole, 90 g/L	S			1.25 L/ha	
Comet Pro -Pyraclostrobin, 200 g/L	S			1.2 L/ha/season x2 Minor use	
Delaro 325 EC -Trifloxystrobin, 157 g/L -Prothioconazole, 182.4 g/L	S		1 L/ha x2		
Exteris Stressgard -Trifloxystrobin, 12.5 g/L -Fluopyram, 12.5 g/L	S	10 L/ha x2			
Headway (t.o.m. 2019) -Azoxystrobin, 62.5 g/L -Propiconazole, 104 g/L	S	3 L/ha x2			
Heritage -Azoxystrobin, 500 g/kg	S	0.5 kg/ha x2			
Instrata Elite -Difenoconazole, 80 g/L -Fludioxonil, 80 g/L	S	3 L/ha x2			
Juventus 90 -Metconazole, 90 g/L	S			3 L/ha x1 Minor use	
Librax -Metconazole, 45 g/L -Fluxapyroxad, 62.5 g/L	S			2 L/ha/season x2	
Medallion TL -Fludioxonil, 125 g/L	**C**	3 L/ha x4	3 L/ha x4	3 L/ha x4	
Proline EC 250: -Prothioconazole, 251 g/L	S				0.8 L/ha x2 Minor use
Stratego EC 250: -Trifloxystrobin, 130.2 g/L -Propiconazole, 134.4 g/L	S		1 L/ha x1		
Switch 62,5 WG: -Cyprodinil, 375 g/kg -Fludioxonil, 250 g/kg	S/**C**				1 kg/ha x1 Minor use
Tilt 250 EC: -Propiconazole, 250 g/L	S			0.5 L/ha x3	

* Maximum dosage and maximum number of applications.
** Banner Maxx II, Sweden: Max 2x every year on greens and tees. Max 1x every second year on fairways.

Microdochium-patch on a Poa annua green, Landvik 20.November 2018. Photo: T. Espevig.

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Read more

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