A fresh look at fungicides for snow mold control

Selecting the correct fungicide is the key to successful control of snow molds.

Snow molds are the most economically important winter diseases of turfgrass in the northern and alpine regions of the United States and Canada (2,3,4). In winter, turfgrass becomes weak as carbohydrate reserves are depleted. The psychrophilic (that is, thriving in the cold) pathogens take advantage of the weakened turf plants at low temperatures, usually under persistent snow cover. Snow mold damage appears as sunken spots after snow melt in the spring. Infected leaves are collapsed and often covered with fungal mycelia. In severe cases, the disease spots coalesce into a patch up to several feet in diameter. The diseases significantly compromise turf quality and delay rapid turf recovery when the temperature rises. Damaged turf is also vulnerable to encroachment by weeds, including annual bluegrass.

Even with a proper fertility program and sound cultural programs in place to promote winter hardiness of the turf, superintendents still need fungicides to control snow molds on greens, tees and, in many cases, fairways.

Various fungicides or, often, tank-mixtures of fungicides, are commonly applied preventively before the onset of snow cover (3,7) to control snow molds. For example, a high-budget golf course in northern Minnesota may spend more than $20,000 on fungicides to protect the turf from snow molds during the harsh winter. However, many fungicides labeled for snow mold control often yield inconsistent control at different locations or in different years. Recent field studies conducted in our lab have revealed significant discrepancies in efficacy among fungicides labeled for snow mold control.

What are we fighting?

A major difficulty in managing snow molds originates from the complex nature of the causal agents of snow molds. Snow molds are caused by several fungi that are taxonomically very different from each other. The three most common snow mold species in the United States include speckled snow mold caused by *Typhula ishikariensis* Imai, gray snow mold caused by *T. incarnata* Lasch ex. Fr. and pink snow mold caused by *Microdochium nivale* Samuels & Hallett. There are also three varieties of *T. ishikariensis*: *T. ishikariensis* var. *ishikariensis*; *T. ishikariensis* var. *canadensis*, and *T. ishikariensis* var. *idahoensis* (7). A winter wheat pathogen (5), *T. phacorrhiza* Fries, can be another potentially pathogenic fungus on turfgrass. Therefore, snow mold symptoms may indicate combinations of two different genera, four different species and three different varieties of fungi.

Key diagnostic characteristics

Learning what kind or kinds of snow mold fungi are at your golf course is the first step in designing an effective fungicide program. With knowledge of key morphological characteristics and symptoms of snow mold fungi, careful scrutiny with a simple magnifying glass will help you to identify the fungus. Asking for assistance or sending samples to obtain a precise diagnosis from turfgrass pathologists in the regional diagnostic lab is always a smart idea.

Typhula *species*

Taxonomically, *Typhula* and *Microdochium* are

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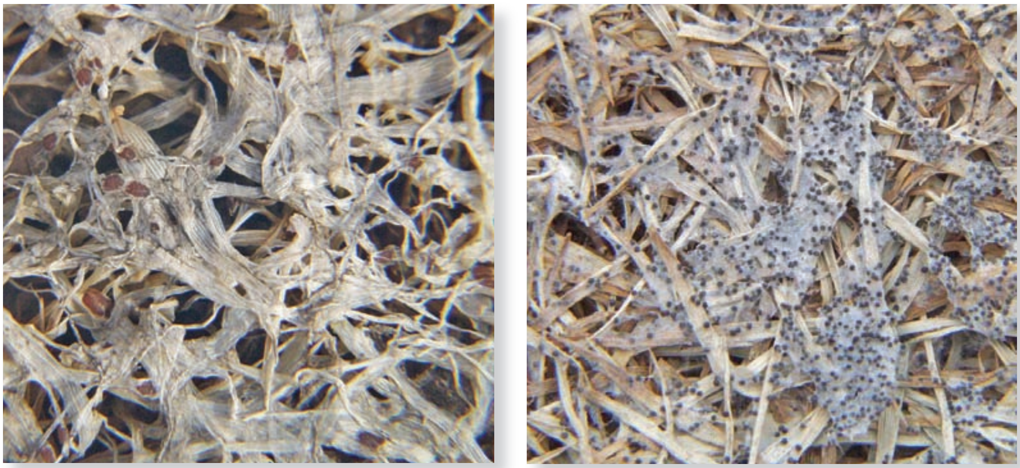
Snow mold damage on the creeping bentgrass practice green at Gateway GC in Land O' Lakes, Wisconsin.
Photos by G. Jung



Sclerotia of *Typhula* species. **Left:** Reddish brown sclerotia of *T. incarnata* (gray snow mold) embedded in infected leaf tissues. **Right:** Black pepper-like sclerotia speckled on the mycelium mat of *T. ishikariensis* (speckled snow mold).

as far apart as birds and butterflies. *Typhula* species belong to the basidiomycetes, which include most mushroom-forming fungi. A typical sign of *Typhula* species is a gray-to-white mycelial mat on the disease patch. The sclerotia (compact masses of hyphae, the threadlike parts of the mycelium) can also be used to identify species. *Typhula ishikariensis* produces very small (<0.063 inch [1.6 millimeters] in diameter), dark brown-to-black sclerotia that resemble black pepper. *Typhula incarnata* produces larger (0.125 inch [3.2 millimeters] in diameter) reddish-brown sclerotia.

Sometimes in early winter, *Typhula* species produce club-shaped sporocarps, which are homologous to mushrooms and contain sexual spores. Sporocarps of *T. incarnata* are pinker and larger (0.5 inch [12.7 millimeters] in height), whereas those of *T. ishikariensis* are whitish and smaller.

Typhula ishikariensis is further separated into three varieties by minute morphological variations in sclerotia, but trained eyes are required to discern the differences. Detection of sclerotia speckled on mycelial mats, embedded within collapsed plant tissues or under thatch is definitive evidence of the presence of *Typhula* species.

Thanks to the recent development of accurate and rapid DNA diagnostic tools for each of the *Typhula* species and for the varieties of *T. ishikariensis*, we can identify a species within hours from a single tiny sclerotium.

All fungicides tested

Common name	Trade name	Company name	Application rate: Ounces/1,000 square feet	Application rate: Grams/100 square meters
Azoxystrobin	Heritage 50WG	Syngenta	0.4	12.2
Chloroneb	Terraneb SP	Kincaid	9.0	274.6
Chlorothalonil	Daconil WeatherStik	Syngenta	5.5	167.8
Fenarimol	Rubigan AS	Gowan Co.	8.0	244.1
Fludioxonil	Medallion 50WP	Syngenta	0.5	15.3
Flutolanil	Prostar 70WP	Bayer	4.5	137.3
Iprodione	Chipco 26019	Bayer	4.0	122.1
Mancozeb	Dithane 37WF	Dow AgroSciences	8.0	244.1
Myclobutanil	Eagle 20EW	Dow AgroSciences	1.2	36.6
Pentachloronitrobenzene (PCNB)	Revere 4000 4F	Chemtura	12.0	366.2
Propiconazole	Banner Maxx	Syngenta	2.0	61.0
Pyraclostrobin	Insignia 20WDG	BASF	0.9	27.5
Thiophanate-methyl	Cleary's 3336 50W	Cleary Chemical	2.0	61.0
Thiram	Thiram 75DG	Cleary Chemical	8.0	244.1
Triadimefon	Bayleton 50WSP	Bayer	1.0	30.5
Trifloxystrobin	Compass 50WDG	Bayer	0.25	7.6
Vinclozolin	Curalan 50EG	BASF	1.0	30.5

Note. Individual treatments were applied at a nozzle pressure of 40 pounds/square inch (275.8 kilopascals), using a carbon-dioxide-pressurized boom sprayer equipped with two XR Teejet 8005 VS nozzles. All fungicides were sprayed in the equivalent of 3 gallons of water/1,000 square feet (0.12 liter/square meter).

Table 1. Fungicides tested in this study and their application rates.

Microdochium nivale

Depending on environmental conditions, pink snow mold caused by *Microdochium nivale* appears in a range of colors from light gray to orange-brown. The fungus is active under prolonged periods of cold and wet weather and may not require a long period of snow cover. Unlike *Typhula* species, *M. nivale* does not produce sporocarps or sclerotia, but rather produces septate, boat-shaped asexual spores that can be observed under a compound microscope.

Field evaluation of fungicides

To evaluate the efficacy of fungicides for snow molds, we established field plots at two golf courses in Wisconsin: Sentryworld Golf Course in Stevens Point and Gateway Golf Course in Land O' Lakes. Stevens Point, located in central Wisconsin, has an average 80-day snow cover of 5 inches (12.7 centimeters) or more in winter, and Land O' Lakes in northern Wisconsin has an average 110-day snow cover of 5 inches (12.7 centimeters) or more.

Sporocarps of *Typhula* species. **Left:** Sporocarps of *T. incarnata* (gray snow mold) are pinkish white and look like elongated clubs. **Right:** Sporocarps of *T. ishikariensis* (speckled snow mold) are smaller and white.

Materials and methods

Field plots (3 feet × 4 feet [0.9 meter × 1.2 meters]) were arranged in a split-plot design. We tested the efficacy of 17 fungicides (Table 1) for controlling six different snow mold fungi, which were artificially introduced into the plots. The six fungi included three *T. ishikariensis* varieties (var. *ishikariensis*, var. *canadensis* and var. *idahoensis*), *T. incarnata*, *T. phacorrhiza* and *M. nivale*. Fungicides were applied to field plots that were inoculated with the six snow mold fungi before snow cover. This experiment was repeated for three winters from 2003 to 2006.

Results

We have combined the data from the three years of experiments and have summarized the most significant findings for this article.

Snow mold disease severity was greater in Land O' Lakes because there were more snow-cover days and lower temperatures than in Stevens Point. *Typhula ishikariensis* varieties were most active and aggressive in Land O' Lakes, but *T. incarnata* and *M. nivale* were most active in Stevens Point. Fungicide efficacies were significantly lower in Land O' Lakes than in Stevens Point. Most fungicides significantly reduced snow mold damage below 30% at Stevens Point, but only 10 fungicides were effective against at least one fungal species at Land O' Lakes. This difference might be caused by the longer snow cover in Land O' Lakes, which may have diluted fungicide effects and favored fungal activity (6).

In general, Revere 4000 4F (PCNB), Banner Maxx (propiconazole), Terraneb SP (chloroneb), Dithane 37WF (mancozeb) and Eagle 20EW (myclobutanil) significantly reduced disease severity (<2% infection) against all snow mold pathogens at Stevens Point, where the disease pressure was low, but only Revere 4000 4F and Banner Maxx maintained relatively consistent efficacy (<15% infection) in controlling two or more pathogens at Land O' Lakes, where disease pressure was high.

Significant interactions between fungicides and snow mold fungi were also observed. Certain fungicides provided better control for certain fungal species but not for other species, especially under high disease pressure (Table 2). For example, Banner Maxx, Terraneb SP and Bayleton 50WSP (triadimefon) yielded acceptable levels of disease control against speckled snow mold and gray snow mold, but Revere 4000 4F, Terraneb SP, Compass 50WDG (trifloxystrobin) and Bayleton 50WSP were more effective on pink snow mold.

Fungus-specific fungicide application

Multiple fungicides or tank-mixtures of fungicides have been commonly used to control

Fungicide efficacy

Snow mold	Low disease pressure (< 100 snow cover days)	High disease pressure (> 100 snow cover days)
Typhula ishikariensis (speckled snow mold)	Terraneb SP, Dithane 37WF, Medallion 50 WP, Eagle 20EW, Revere 4000 4F, Banner Maxx	Banner Maxx
T. incarnata (gray snow mold)	Heritage 50WG, Terraneb SP, Daconil Weather-Stik, Rubigan AS, Prostar 70WP, Chipco 26019, Dithane 37WF, Eagle 20EW, Revere 4000 4F, Banner Maxx, Insignia 20WDG, Thiram 75DG, Bayleton 50WSP, Curalan 50EG	Heritage 50WG, Terraneb SP, Daconil WeatherStik ,Rubigan AS, Prostar 70WP, Revere 4000 4F, Banner Maxx, Insignia 20WDG, Bayleton 50WSP
Microdochium nivale (pink snow mold)	Terraneb SP, Rubigan AS, Medallion 50 WP, Prostar 70WP, Dithane 37WF, Eagle 20EW, Revere 4000 4F, Banner Maxx, Insignia 20WDG, Thiram 75DG, Bayleton 50WSP, Compass 50WDG	Revere 4000 4F, Compass 50WDG

Table 2. Fungicides that provided more than 80% control of three different snow mold fungi under low and high disease pressure.

Different rates of efficacy for fungicides controlling snow mold fungi. **Top:** Banner Maxx (propiconazole) effectively reduced speckled snow mold caused by *Typhula ishikariensis* but did not control gray snow mold caused by *T. incarnata*. **Bottom:** Revere 4000 4F (PCNB) was more effective in controlling gray snow mold than speckled snow mold.

Fungicides vs. snow mold fungi

	Low disease pressure			High disease pressure		
Fungicide	***T. ishikariensis***	***T. incarnata***	***M. nivale***	***T. ishikariensis***	***T. incarnata***	***M. nivale***
Terraneb SP	•	•	•		•	
Daconil WeatherStik	•	•			•	
Revere 4000 4F	•	•	•		•	•
Banner Maxx	•	•		•	•	
Compass 50WD			•			•

Table 3. The five most effective fungicides for three different snow mold fungi at low and high disease pressure.

snow molds (7). However, there is little scientific knowledge to support this practice because fungicide efficacy can be influenced by various compound factors, such as the physical or chemical properties of active ingredients or carriers of fungicides, plant physiology and fungal pathogenicity under varying environmental conditions in winter (1,8).

Our field evaluations clearly revealed that the efficacy of fungicides on snow molds depends on disease pressure and fungal species. With the exception of *Typhula phacorrhiza*, which did not cause noticeable disease symptoms in our study, most snow mold pathogens increased in disease severity as the number of days of snow cover increased. Significant interactions between fungicide efficacy and snow mold fungi suggest that tank-mix applications with fungus-specific fungicides should be used to successfully control snow mold diseases (Table 2).

The first step in developing a snow mold fungicide program is to choose the appropriate fungicides based on the level of disease pressure and the species of snow mold fungi on the golf course. For example, our field data indicate that for an area with more than 120 days of heavy snow, the best bet is Revere 4000 4F or Compass 50WDG for pink snow mold; Banner Maxx, Terraneb SP or Daconil WeatherStik (chlorothalonil) for gray snow mold; and Banner Maxx for speckled snow mold (Table 3).

Additional field studies are being conducted to evaluate application rates and various combinations and tank-mixtures of fungicides for maximizing the efficacy of managing the snow mold disease complex.

The research says

- ➔ Snow mold disease severity increased as the number of days of snow cover increased.
- ➔ Fungicide efficacy decreased as snow cover days increased.
- ➔ Banner Maxx (propiconazole) and Revere 4000 4F (PCNB) provided the most consistent efficacy against snow molds.
- ➔ Selecting the correct fungicide is the key to successful control of snow molds.

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