Minimum fungicide rates for species-specific snow mold control

Knowing the optimal fungicide rate for controlling a particular species of fungus allows superintendents to reduce inputs and expenses.

Snow molds are the most important winter diseases of creeping bentgrass (*Agrostis palustris* subspecies *stolonifera*) and annual bluegrass (*Poa annua*) on golf courses in northern regions, where continuous snow cover persists for several months. Current recommendations for snow mold control revolve around tank-mixtures of multiple fungicides, which are applied just before continuous snow cover becomes established. Tank-mixtures of fungicides allow for protection against multiple fungal species, including *Typhula incarnata* and *T. ishikariensis* (*Typhula* blight), *T. phacorrhiza*, *Myriosclerotinia borealis* (snow scald) and *Microdochium nivale* (*Microdochium* patch or pink snow mold).

Diagnosis of snow mold fungal species is the first step in controlling snow molds using effective fungicides. A typical fungal sign of *Typhula* species is a gray-to-white mycelial mat on the diseased patch covering or embedded with sclerotia (compact masses of hyphae, the threadlike parts of the mycelium). *Typhula ishikariensis* produces very small (<0.0625 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 that have a gelatin-like texture. *Microdochium nivale* appears in a range of colors from light gray to orange-brown depending on environmental conditions. Unlike *Typhula* species, *M. nivale* does not produce sclerotia, but rather produces septate, canoe-shaped asexual spores called *conidia* that can be observed under a compound microscope.

A two-year survey of Wisconsin showed that *T. incarnata* was widely distributed and present on all the golf courses sampled. However, *T. Ishikariensis* occurred more often in formerly forested areas that had more snow-cover days. Given the genetic diversity and distribution of snow mold species, selecting the most effective fungicide and the proper application rate is not an easy task for superintendents who deal with snow molds every year. The objective of this field experiment was to determine the minimum application rate of individual fungicides required to yield acceptable disease control of each snow mold species. In addition to providing solid snow mold control recommendations for superintendents, the collected data can be useful to fungicide manufacturers for

Snow mold fungal species

Isolate ID	Species	Isolate ID	Species
NW 3.16.2	*Typhula ishikariensis* var. *ishikariensis* No. 1	SW 5.4.5	*T. incarnata* No. 1
NW 69.8.5	*T. ishikariensis* var. *ishikariensis* No. 2	NE 108.8.3	*T. incarnata* No. 2
NW 39.3.3	*T. ishikariensis* var. *canadensis* No. 1	SW 2.13.2	*T. phacorrhiza* No. 1
NW 10.6.5	*T. ishikariensis* var. *canadensis* No. 2	NW 3.2.3	*T. phacorrhiza* No. 2
SW 63.2.4	*T. ishikariensis* var. *idahoensis* No. 1	NW 48.7.1	*Microdochium nivale* No. 1
NW 39.5.5	*T. ishikariensis* var. *idahoensis* No. 2	NE 90.11.1	*M. nivale* No. 2

Table 1. Snow mold fungal species and isolates used to inoculate field plots.

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Fungicides

Chemical	Trade name	Formulation	Company name	Rates (per 1,000 square feet)
Chloroneb	Terraneb SP	65 WP	Kincaid	9, 7.5 and 6 oz.
Chlorothalonil	Daconil Weather Stik	6 F	Syngenta	5.5, 3.6 and 2 oz.
PCNB	Revere 4000	4 F	Lesco	16, 12 and 8 fl. oz.
Propiconazole	Banner MAXX	1.3 EC	Syngenta	4, 3 and 2 fl. oz.
Trifloxystrobin	Compass	50 WDG	Bayer	0.25, 0.2 and 0.15 oz.

Table 2. Fungicides and the rates evaluated for efficacy of snow mold control in this study.

determining control thresholds of each fungicide for labeling purposes.

Materials and methods

Field trials were conducted at two Wisconsin locations: SentryWorld Golf Course in Stevens Point and Gateway Golf Club in Land O' Lakes. Plots were fumigated with Basamid (dazomet, BASF) in the summer of 2005 to eliminate indigenous snow mold populations at each site. The plots were established with Penncross creeping bentgrass (*Agrostis stolonifera*) and maintained at a mowing height of 0.5 inch (1.3 centimeters). The experiment was a split-plot design with three replications.

Treatments were arranged to determine the efficacy of five fungicides against four snow mold species (*Typhula incarnata, T. ishikariensis, T. phacorrhiza* and *Microdochium nivale*). The five fungicides were selected based on previous studies (5). The "fungicide rate" treatment was the main plot and the "snow mold species inoculation" was the subplot. The size of individual plots was 2 feet × 2 feet (0.6 meter × 0.6 meter).

The plots at both locations were inoculated with 12 different isolates of six snow mold species or subspecies (two isolates each of *T. incarnata, T. ishikariensis* var. *ishikariensis, T. ishikariensis* var. *canadensis, T. ishikariensis* var. *idahoensis, T. phacorrhiza* and *Microdochium nivale*) before fungicide applications (Table 1). The inoculum of each snow mold isolate was prepared by placing mycelium/agar plugs from an actively growing culture on sterilized Kentucky bluegrass seeds, which served as a medium for fungal growth. One plot that was not inoculated served as an untreated control.

We had previously evaluated 17 different fungicides for snow mold control at SentryWorld GC and Gateway GC in the winters of 2003-2004 and 2004-2005. The five most effective fungicides, which were selected based on the results of their efficacy of reducing snow mold diseases, were applied at three different rates: high, intermediate and low label rates on Nov. 5, 2005, at both locations (Table 2). Individual plots were rated at SentryWorld GC on March 30, 2006, and at Gateway GC on April 7, 2006, to determine the percentage of damage caused by the individual inoculations of the snow mold pathogen.

The two test sites were at Gateway GC (**top**) and SentryWorld GC (**bottom**) in Wisconsin. All of the plots except for the untreated control plots were inoculated with snow mold species and sprayed with the fungicides tested. The blighted and nonblighted areas show how effective the fungicides were against different snow mold species. **Photos courtesy of G. Jung**

Results and discussion

Disease severity was significantly influenced by snow mold species, fungicide rate and snow cover at the site. At SentryWorld GC, *Typhula incarnata* was the most aggressive of the four species. In contrast, *T. ishikariensis* varieties were more aggressive than *T. incarnata* and *Microdochium nivale* at Gateway GC because of their longer snow cover. *Typhula phacorrhiza* did not cause noticeable disease symptoms in either location. The field pathogenicity of *T. phacorrhiza* remains to be confirmed.

Fungicide rate

The effect of application rate on fungicide efficacy varied depending on the type of fungicide, the fungal species or isolates, and location. Revere 4000 4F (PCNB, Lesco) at the intermediate and high label rates was more effective on *T. incarnata* isolate No. 1 than on isolate No. 2 at Gateway GC. This result helps illustrate how different isolates within the same species can show different levels of fungicide sensitivity.

Of the fungicides evaluated, different interactions between the fungicide and snow mold species or isolate were observed at both locations. Revere 4000 4F was effective at controlling all snow mold species except *T. ishikariensis* varieties at both locations. Banner MAXX 1.3 EC (propiconazole, Syngenta) was particularly effective against *T. ishikariensis* varieties at both sites. However, Banner MAXX 1.3 EC did not provide acceptable control of *Microdochium nivale* or *T. incarnata*. Compass 50 WDG (trifloxystrobin, Bayer) at the intermediate and high label rates effectively reduced only *M. nivale* at both locations.

Fungicide rates did not seem to have any significant effect on snow mold control at SentryWorld GC. However, at Gateway GC, fungicide rate did have an effect with the fungicides Revere 4000 4F, Banner MAXX 1.3 EC and Compass 50 WDG. For example, the severity of *M. nivale* on the plots treated with Compass 50 WDG at Gateway GC decreased significantly as fungicide rate increased. This trend was not observed at SentryWorld GC (Figure 1), most likely because disease pressure was lower at SentryWorld.

Snow mold species

The results from these field evaluations support the need to apply a tank-mix of multiple active ingredients where more than one snow mold species commonly occurs. Different snow mold species showed significantly different levels of sensitivity to each of the five fungicides tested in our study and 17 fungicides tested in the 2007 study by Jung et al.

Each fungicide was effective in controlling at least one — but not all six — snow mold species. For example, PCNB and Compass were very effective on *Microdochium* patch, and Banner MAXX effectively controlled *T. ishikariensis* but not *T. incarnata*. In contrast, PCNB was more effective in controlling *T. incarnata* than *T. ishikariensis*. Within the same snow mold species, certain isolates were more difficult to control, indicating fungicide efficacy may depend on the composition of the fungal population.

Two fungicides, Revere 4000 4 F and Banner MAXX 1.3 EC, show different levels of efficacy on two snow mold species, *Typhula incarnata* and *T. ishikariensis*. **Photos courtesy of G. Jung**

Longer snow cover

In high-pressure areas (where snow cover lasts more than 100 days and there are multiple fungal species), we recommend applying a tank-mix of fungicides at the high label rate: PCNB (for example, Revere 4000); chlorothalonil (for example, Daconil Weather Stik 6F, Syngenta); iprodione (for example, Chipco 26GT, Bayer); demethylation inhibitors such as Banner MAXX 1.3 EC (propiconazole, Syngenta), Trinity (triticonazole, BASF) and Tourney (metconazole, Valent); and strobilurins (for example, Compass, trifloxy-

Fungicides vs. snow mold

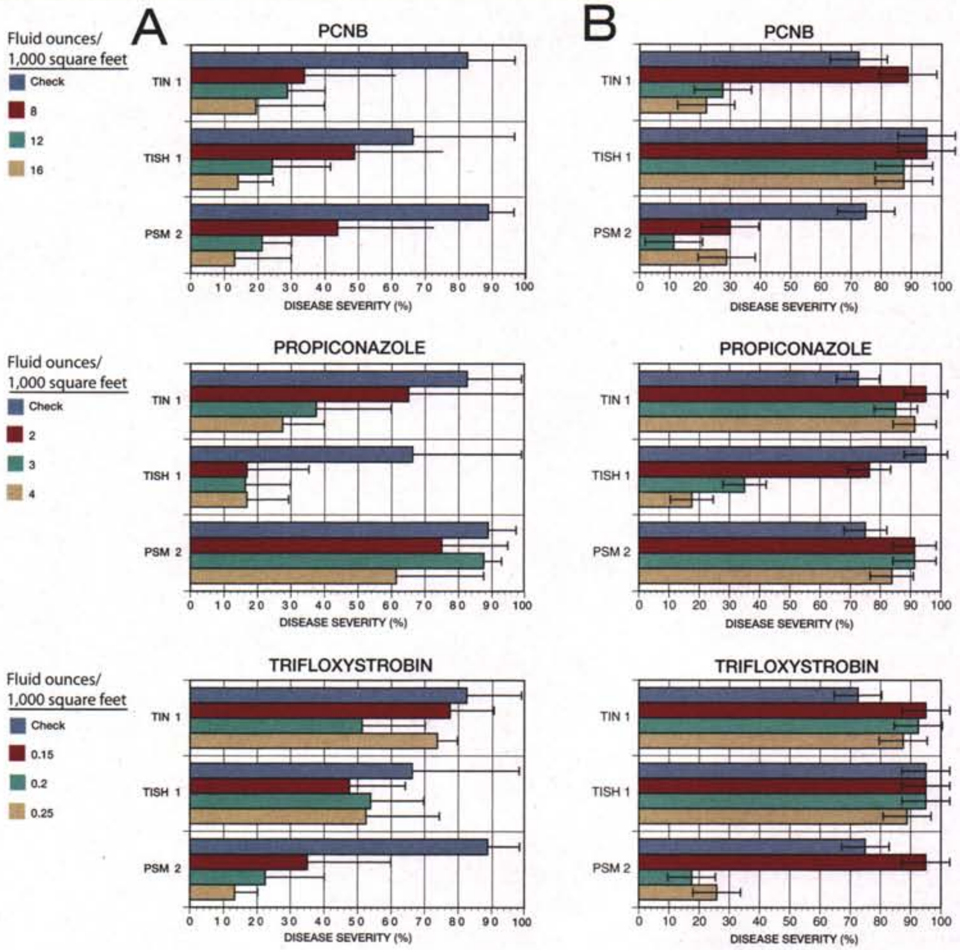

Figure 1. Bar graphs showing snow mold control by fungicides. The effect of three application rates (fluid ounces/1,000 square feet) of three fungicides on snow mold fungi at Sentryworld GC (**A**) and Gateway GC (**B**) in Wisconsin during the winter of 2005-2006. Disease severity was based on percent disease area. TIN 1: *Typhula incarnata* No. 1; TISH 1: *T. ishikariensis* var. *ishikariensis* No.1; PSM 2: *Microdochium nivale* No. 2. Bars represent standard error of the mean.

Typhula life cycle

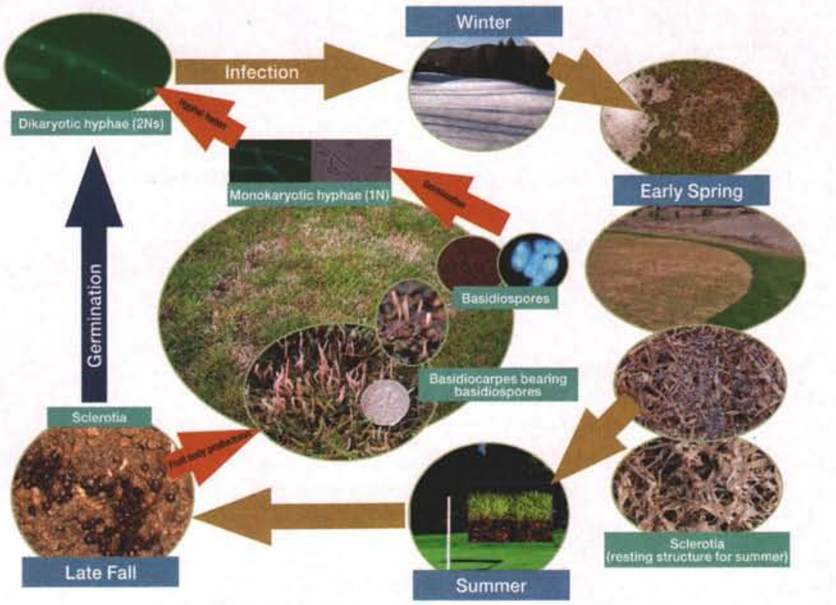

Figure 2. The life cycle of *Typhula* blight, which is caused by *T. incarnata* and *T. ishikariensis*. **Clockwise from the upper right:** As snow starts to melt in early spring, *Typhula* mycelia, which infect and colonize turfgrass, form fungal structures called sclerotia that can survive hot, dry summer conditions in thatch or soil. In fall, the sclerotia swell and are stimulated by the cool, wet weather and short days. The stimulated sclerotia go into either asexual or sexual reproduction pathways. Asexual mycelia (dikaryotic stage [2N], meaning two nuclei in one cell), germinate directly from the sclerotia and start to infect and colonize plant tissues under the snow. Through sexual reproduction, the sclerotia form sexual fungal structures called basidiocarps that bear basidiospores (1N, one nucleus per cell) that, in turn, germinate to produce monokaryotic mycelia. Individual monokaryotic mycelia fuse with each other if they are vegetatively compatible. The fused dikaryotic mycelium contains two nuclei (2N) within one cell and is capable of infecting and colonizing turfgrass under the snow. A new cycle begins in early spring. **Photos by S. Chang**

The research says

→ Field trials were conducted at two Wisconsin golf courses to determine the efficacy of five fungicides (each applied at three different rates) against four snow mold species on creeping bentgrass mowed at 0.5 inch.

→ Disease severity was significantly influenced by snow mold species, fungicide rate and snow cover at the site.

→ Different snow mold species showed significantly different levels of sensitivity to each of the five fungicides tested in our study.

→ Where disease pressure is high, applying a tank-mix of fungicides is recommended; split applications are also more effective than single applications.

strobin, Bayer Environmental Science).

In addition, a split application of the fungicides (that is, an application at half the high label rate followed by another application at half the high label rate 10 to 14 days later) has been shown to provide better control than a single application. For example, if the normal single application is made in the first week of November, the first half of the split application can be made 10 to 14 days before the first week of November, and the second half of the split application would be made in the first week of November. Basidiocarp production was observed at Gateway GC in Land O' Lakes in late October, so a split application would enhance the chances of reducing snow mold severity by knocking down initial inoculum and fungal mycelia germinating from sclerotia and basidiospores (Figure 2).

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