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Researchers from Washington State University investigated various combinations of fungicides for their efficacy in controlling both pink and gray snow mold, serious cold-weather diseases of golf courses located in the Intermountain Northwest and other parts of the U.S.

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## PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.


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# Snow Mold Control in the Intermountain Northwest

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## SUMMARY

Pink snow mold (Mirodochium patch) and gray snow mold (Typhula blight) are the most prevalent and destructive winter diseases on cool-season turfgrass in the northern USA. They are especially destructive in the Intermountain Northwest where deep snow cover may last four to five months. Pentachloronitrobenzene (PCNB, Quintozene) has been use to manage these diseases in turf on golf courses for many years.

When used alone, over time, pathogen resistance may develop, as well as other turf and environmental problems. This research sought to identify new chemistry and combinations of compounds that could be used in rotation with PCNB. Research was conducted on golf course bentgrass (*Agrostis stolonifera* L.)/*Poa annua* golf greens and nurseries during a three-year period (2000-2003).

- In locations with mild to moderate winters, many of the older chemistry fungicides used alone, or in combination with a compound with newer chemistry, gave good control.
- In locations with prolonged snow cover, combinations of two and possible three fungicides are needed for adequate control.
- Numerically, but not statistically different from all other treatments, overall sites and years the treatment with the best control with good spring turfgrass quality was Medallion + Banner MAXX + Daconil Ultrex.


**F**ungicide applications are the primary means to control, or manage (terminology preferred by Vargas, 8), Microdochium patch (pink snow mold), and Typhula blight (gray snow mold). Pentachloronitrobenzene (PCNB, Quintozene), is the primary fungicide used to manage these diseases on golf course greens and fairways in the Intermountain Northwest and throughout the northern USA.

Evidence suggests that resistant strains of snow mold fungi have developed with continued use of fungicides (2). Phytotoxicity to PCNB also has been reported, especially when PCNB is used at the upper end of the labeled rate of application, when overlapping of application occurs, or when applications are made during warm weather (7). Chlorsis also has been noted in turf and caution should be use with repeat applications after periods of rain or during mid-winter thaws (1). Non-target effects, both detrimental and beneficial, have been reported on putting greens by Landschoot et al. (6). Pentachloroaniline (PCA), a breakdown product of PCNB, has been found in golf green lechate (Johnston and Golob, 2004, unpublished data). Therefore, it is desirable to identify efficacious alternatives to be use in rotation with PCNB.

Washington State University (WSU) is currently conducting snow mold fungicide trials in Washington, Idaho, and Montana to identify such compounds (4). The availability of new snow mold products will be a major benefit to golf course superintendents in areas of prolonged snow cover susceptible to snow mold diseases.

**Figure 1.** The outer edge of a patch of putting green turf infected by *Microdochium nivale* transitioning to pink upon exposure to sunlight

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**Figure 2.** In the fall, pink upright fruiting bodies become evident in Typhula blight caused by *Typhula incarnata*.

## Snow Mold Diseases

*Pink Snow Mold (Microdochium patch)*

- Caused by the pathogen *Microdochium nivale* (Fr.) Samuels & Hallett.
- Favored by cool moist conditions of alternating snow and rain.
- Little or no snow cover needed.
- Circular patches two to 12 inches in diameter; most two to three inches in diameter.
- Patches following snow melt are tan to light gray or reddish bronze.
- Outer edge bronze fringe transitioning to pink upon exposure to sunlight (Figure 1).

*Gray Snow Mold (Typhula blight)*

Caused by the pathogen *Typhula incarnata* Lasch ex Fr.:

- In the fall, pink upright fruiting bodies (Figure 2).
- Generally associated with snow cover.
- Patches six inches to two feet in diameter; most six to 12 inches in diameter.
- Following snow melt, variable patches of gray-white matted turf.
- Sclerotia are large, up to five mm in diameter, and reddish brown (Figure 3).
- Generally less destructive that *T. ishikariensis*.

Caused by the pathogen *Typhula ishikariensis* Imai:

- In the fall, silvery/white, very small fruiting bodies may be present.
- Generally associated with deep prolonged snow cover, often greater than 100 days.
- Following snow melt, bleached patches generally six to 12 inches in diameter.
- Sclerotia are small, less that two mm in diameter, and black (Figure 4).
- Generally causes more turf injury than *T. incarnata*.
- Most severe injury occurs with snow over unfrozen soil.

## Objectives

1. Compare the efficacy of new and old fungicides, primarily combination products and new experimental chemistry, at several sites in the Intermountain Northwest.

Examples of older compounds evaluated:

***Propiconazole***: Banner MAXX; triazole; systemic; broad spectrum

***Iprodione***: Chipco 26GT; multi-site of action; contact and preventative; broad spectrum

***Chloroneb***: Fungicide V; substituted aromatic

**Figure 3.** Sclerotia of Typhula blight (*Typhula incarnata*) are large, up to five mm in diameter, and reddish brown.

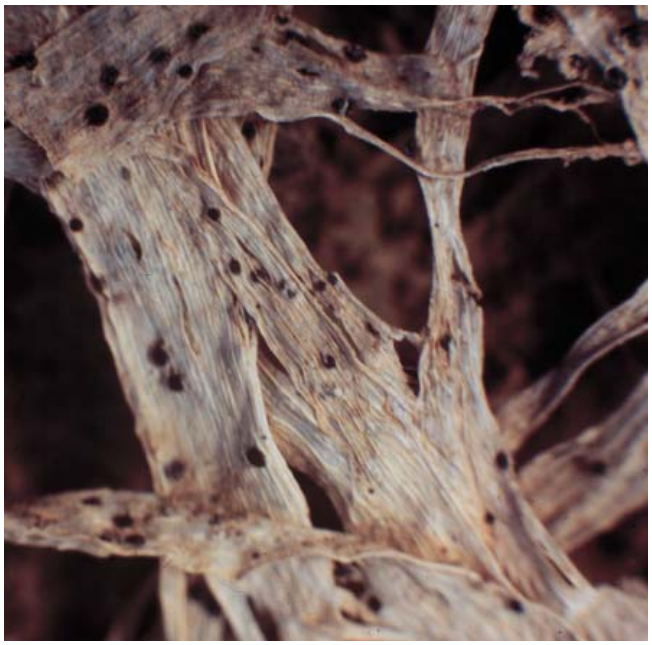

**Figure 4.** Sclerotia of *Typhula ishikariensis* are small, less than two mm in diameter, and black.

hydrocarbon; gray snow mold control (*T. incarnata*); contact
***PCNB***: Turfcide 400, FFII w/14-3-3; substituted aromatic hydrocarbon; multi-site; broad spectrum; contact
***Chlorothalonil***: Daconil Ultrex; substituted aromatic hydrocarbon; multi-site; broad spectrum; contact

Examples of newer compounds evaluated:
***Fludioxonil***: Medallion; phenylpyrrole; affects amino acid uptake and plasma membranes; contact and systemic
***Azoxystrobin***: Heritage; beta-methoxyacrylate; derived from wood decaying fungi; single site; broad spectrum; systemic
***Trichoderma atroviride***: Plant Helper; fungal parasite extracted from soil in Alaska

***Note*:** Inclusion or omission of products (or products marketed under trade names not mentioned) in this study is not intended as an endorsement, or discrimination, by the authors or WSU.

2. Assist manufacturers in obtaining labels for new products for use on golf courses in the Intermountain Northwest.

## Materials and Methods

*Whitefish, MT*

Late October/early November, 2000 and 2001, treatments were applied to a 'Penncross' creeping bentgrass/*Poa annua* (10%) practice green at the Whitefish Lake Golf Course. Treatments were also applied in 2002; however, disease development was not severe enough to warrant rating in spring, 2003. Treatments were applied with a $CO_2$-pressurized (40 psi) boom sprayer with flat-fan TeeJet nozzles using a 52 gal/A $H_2O$ carrier rate. Individual plots were five by 10 feet in a randomized complete-block experimental design with three replications of each treatment.

During both winters, snow cover began late November and remained on the plots approximately four months. Plots were rated late March/early April for disease (2001, approximately 70% gray snow mold, *T. ishikariensis*, and 30% pink snow mold; 2002, essentially 100% gray snow mold, 90% *T. ishikariensis* and 10% *T. incarnata*, with a trace of pink snow mold) and turfgrass quality (quality rated 1-9; 9 = excellent turf quality).

*McCall, ID*

Late October, 2000 and 2001, treatments were applied to a 'Providence' creeping bentgrass nursery at the City of McCall Golf Course. Treatments were also applied in 2002; however, disease development was slight and no treatments were significantly better than the non-treated control. Treatments were applied with a $CO_2$-pressurized (40 psi) boom sprayer with flat-fan TeeJet nozzles using a 52 gal/A $H_2O$ carrier rate. Individual plots were five by 10 feet in a randomized complete-block experimental design with four replications of each treatment.

Continuous winter snow cover is common at McCall. During both winters, snow cover began late October to mid-November and remained on the plots 132 and 167 days in 2000-2001 and 2001-2002, respectively. Plots were

| Fungicide Treatment | Rate (oz or fl oz prod/1000ft$^2$) | Disease area (% area with symptoms) | Turf quality[1] (1-9) |
|---|---|---|---|
| Medallion + Banner MAXX + Daconil Ultrex | 0.25 oz + 2.0 fl oz + 2.4 oz | 1.3 a[2] | 5.3 ab |
| Chipco 26GT + Signature + Terraclor | 4.0 fl oz + 4.0 oz + 4.0 oz | 1.7 a | 5.7 a |
| Medallion + Banner MAXX + Terraclor | 0.25 oz + 2.0 fl oz + 4.0 oz | 2.7 a | 4.7 abc |
| Medallion + Banner MAXX | 0.5 oz + 3.0 fl oz | 3.3 a | 4.7 abc |
| Medallion + Banner MAXX + CGA 245704 | 0.25 oz + 2.0 fl oz + 0.4 oz | 3.3 a | 4.7 abc |
| Chipco 26GT + Daconil Ultrex + Terraclor | 4.0 fl oz + 3.6 oz + 4.0 oz | 5.7 a | 4.7 abc |
| Medallion | 0.5 oz | 6.0 a | 5.3 ab |
| Medallion + CGA 245704 | 0.5 oz + 0.4 oz | 6.3 a | 4.0 d |
| Banner MAXX + CGA 245704 | 0.4 oz + 3.0 fl oz | 6.3 a | 4.3 cd |
| Chipco 26GT + Prostar | 4.0 fl oz + 3.75 oz | 6.7 a | 5.0 abc |
| Terraclor | 6.0 oz | 7.7 a | 4.7 abc |
| Non-treated control | 0 | 65.7 b | 2.3 e |

[1]Turf quality rated 1-9; 9 = excellent, 1 = dead

[2]Means within a column followed by the same letter are not significantly different (P = 0.05).

**Table 1.** Efficacy of several different fungicide combinations compared to PCNB for pink snow mold and gray snow mold control on a creeping bentgrass ('Penncross')/annual bluegrass practice green at Whitefish Lake Golf Course, Whitefish, MT. Fungicides were applied 10/31/00. Plots were rated on 3/29/01.

rated for disease late April 2001 (90% gray snow mold, 10% pink snow mold) and early May 2002 (essentially 100% gray snow mold, 95% *T. ishikariensis* and 5% *T. incarnata*) and turfgrass quality (quality 1-9; 9 = excellent turf quality).

## Results and Discussion

Whitefish, MT; Winter 2000-2001

Disease infection was high (non-treated control 66%) at Whitefish during the winter 2000-

2001 (Table 1). All fungicide treatments had significantly less disease than the non-treated control. Although not statistically different from several other treatments, numerically the best control (< 2% disease) was given by Medallion + Banner MAXX + Daconil Ultrex and Chipco 26GT + Signature + Terraclor. No fungicide treatment was statistically better than PCNB (Terraclor) for disease control.

All treatments had turfgrass quality superi-

| Fungicide Treatment | Rate (oz, fl oz, or lbs prod/1000ft$^2$) | Disease area (% area with symptoms) | Turf quality[1] (1-9) |
|---|---|---|---|
| Medallion + Heritage | 0.5 oz 0.4 oz | 0.7 a[2] | 7.0 a |
| Heritage + Banner MAXX + Daconil Ultrex | 0.4 oz 3.0 fl oz 5.0 oz | 1.7 a | 6.0 a |
| Medallion + Banner MAXX + Daconil Ultrex | 0.33 oz 3.0 fl oz 5.0 oz | 2.3 a | 6.3 a |
| Turfcide 400 | 12.0 fl oz | 2.3 a | 6.0 a |
| Medallion + Banner MAXX | 0.5 oz 4.0 fl oz | 2.5 a | 6.0 a |
| FF II w/14-3-3 | 6.5 lbs | 2.7 a | 7.0 a |
| Medallion + Heritage + Daconil Ultrex | 0.3 oz 0.4 oz 5.0 oz | 2.7 a | 6.0 a |
| Medallion + Daconil Ultrex | 0.5 oz 5.0 oz | 3.0 a | 6.0 a |
| Chipco 26GT Daconil Ultrex + Turfcide 400 | 4.0 fl oz 5.5 oz 8.0 fl oz | 3.0 a | 6.0 a |
| Fungicide V | 6.0 lbs | 19.0 b | 4.3 b |
| Medallion | 0.5 oz | 22.3 b | 3.7 bc |
| [3]Plant Helper | 5.9 fl oz | 63.3 d | 1.7 c |
| Non-treated control | 0 | 36.7 c | 2.7 c |

[1]Turf quality rated 1-9; 9 = excellent

[2]Means within a column followed by the same letter are not significantly different (P = 0.05).

[3]Plant Helper is a liquid concentrate that contains a fungus: *Trichoderma atroviride*

**Table 2.** Efficacy of fungicides for pink snow mold and gray snow mold control on a creeping bentgrass ('Penncross')/annual bluegrass practice breen at Whitefish Lake Golf Course, Whitefish, MT. Fungicides were applied 11/1/01. Snow cover persisted from 11/26/01 to 4/7/02 (132 days). Plots were rated 4/10/02.

| Fungicide Treatment | Rate (oz, fl oz, or lbs prod/1000ft$^2$) | Disease area (% area with symptoms) | Turf quality[1] (1-9) |
|---|---|---|---|
| Medallion +<br>Banner MAXX +<br>Daconil Ultrex | 0.25 oz<br>2.0 fl oz<br>2.4 oz | 10.0 a [2] | 6.7 a |
| Medallion +<br>Banner MAXX | 0.5 oz<br>3.0 fl oz | 20.0 ab | 5.7 ab |
| Banner MAXX +<br>CGA 245704 | 0.4 oz<br>3.0 fl oz | 21.7 ab | 5.7 ab |
| Medallion +<br>Banner MAXX +<br>Terraclor 75WP | 0.25 oz<br>2.0 fl oz<br>4.0 oz | 28.3 abc | 4.7 bc |
| Chipco 26GT +<br>Daconil Ultrex +<br>Terraclor 75WP | 4.0 fl oz<br>3.6 oz<br>4.0 oz | 35.0 abcd | 5.0 abc |
| Medallion +<br>Banner MAXX +<br>CGA 245704 | 0.25 oz<br>2.0 fl oz<br>0.4 oz | 41.7 bcd | 5.0 abc |
| Chipco 26GT +<br>Prostar | 4.0 fl oz<br>3.75 oz | 50.0 cde | 3.3 cde |
| Chipco 26GT +<br>Signature +<br>Terraclor | 4.0 fl oz<br>4.0 oz<br>4.0 oz | 56.7 de | 4.3 bcd |
| Terraclor | 6.0 oz | 68.3 ef | 3.3 cde |
| Medallion | 0.5 oz | 84.0 f | 2.7 de |
| Medallion +<br>CGA 245704 | 0.5 oz<br>0.4 oz | 91.7 f | 2.0 e |
| Non-treated control | 0 | 94.0 f | 1.7 e |

[1]Turf quality rated 1-9; 9 = excellent

[2]Means within same column followed by the same letter are not significantly different (P = 0.05).

**Table 3.** Efficacy of fungicides for pink snow mold and gray snow mold control on a creeping bentgrass ('Providence) nursery at the City of McCall Golf Course, McCall, ID. Fungicides were applied 10/26/00. Plots were rated 4/30/01.

or to the non-treated control (Table 1). Although not statistically different from several other fungicide treatments, numerically the best spring turfgrass quality was given by Chipco 26GT + Signature + Terraclor.

Whitefish, MT; Winter 2001-2002

Disease infection was moderate (non-treated control 37%) at Whitefish during the winter 2001-2002 (Table 2). Except for Plant Helper, which showed no disease control, all fungicide

treatments had significantly less disease than the non-treated control. Although not statistically different from several other treatments, numerically the best control (< 1% disease) was given by Medallion + Heritage. No fungicide treatment was statistically better than PCNB (Terraclor) for disease control.

In April 2002, most treatments had turfgrass quality superior to the non-treated control (Table 2). Although not statistically different from several other fungicide treatments, numerically the best spring turfgrass quality was given by Medallion + Heritage and FF II w/14-3-3.

| Fungicide Treatment | Rate (oz, fl oz, or lbs prod/1000ft$^2$) | Disease area (% area with symptoms) | Turf quality[1] (1-9) |
|---|---|---|---|
| Medallion + Banner MAXX + Daconil Ultrex | 0.33 oz<br>3.0 fl oz<br>5.0 oz | 6.0 a | 6.0 a |
| Heritage + Banner MAXX + Daconil Ultrex | 0.4 oz<br>3.0 fl oz<br>5.0 oz | 6.3 a | 6.0 a |
| Medallion + Heritage + Daconil Ultrex | 0.33 oz<br>0.4 oz<br>5.0 oz | 7.3 a | 5.3 a |
| Medallion + Banner MAXX | 0.5 oz<br>4.0 fl oz | 8.0 a | 5.7 a |
| Medallion + Heritage | 0.5 oz<br>0.4 oz | 11.0 a | 5.5 a |
| Medallion + Daconil Ultrex | 0.5 oz<br>5.0 oz | 35.0 b | 3.3 b |
| Chipco 26GT + Daconil Ultrex + Turfcide 400 | 4.0 fl oz<br>5.5 oz<br>8.0 fl oz | 53.3 bc | 3.0 bc |
| Fungicide V | 6.0 lbs | 65.0 cd | 2.0 cd |
| Medallion | 0.5 oz | 78.3 de | 2.0 cd |
| Turfcide 400 | 12.0 fl oz | 78.3 de | 1.7 d |
| FFII w/14-3-3 | 6.5 lbs | 91.7 e | 1.3 d |
| Non-treated control | 0 | 95.0 e | 1.3 d |

[1]Turf quality rated 1-9; 9=excellent

[2]Means within a column followed by the same ltter are not significantly different (P = 0.05.)

**Table 4.** Efficacy of fungicides for pink snow mold and gray snow mold control on a creeping bentgrass ('Providence')/annual bluegrass nursery green at the City of McCall Golf Course, McCall, ID. Fungicides were applied 10/24/01. Snow cover persisted from 11/15/01 to 5/1/02 (167 days). Plots were rated on 5/3/02.

McCall, ID; Winter 2000-2001

Disease infection was severe (non-treated control 94%) at McCall during the winter 2000-2001 (Table 3). Several treatments had less disease than the non-treated control. Although not statistically different from several other treatments, numerically the best disease control (10% disease) was given by Medallion + Banner MAXX + Daconil Ultrex. Also, the lack of disease control (68% disease) when PCNB (Terraclor) was used alone indicated possible pathogen resistance to PCNB had developed at this location, probably due to long-term, continuous use (Table 3).

In April 2001, several treatment had turfgrass quality better than the non-treated control (Table 3). As with disease control, numerically the best spring turfgrass quality was observed in plots treated with Medallion + Banner MAXX + Daconil Ultrex.

McCall, ID; Winter 2001-2002

Disease infection was severe (non-treated control 95%) at McCall during the winter 2001-2002 (Table 4). Although not statistically different from several other treatments, numerically the best disease control (< 7% disease) was given by Medallion + Banner MAXX + Daconil Ultrex and Heritage + Banner MAXX + Daconil Ultrex. As in 2001, the lack of disease control (78% and 92% disease) when PCNB (Turfcide 400 and FFII w/14-3-3, respectively) was used alone indicated that possible pathogen resistance had developed (Table 4).

In May 2002, several treatments had turfgrass quality better than the non-treated control (Table 4). As with disease control, numerically the best spring turfgrass quality was observed in plots treated with Medallion + Banner MAXX + Daconil Ultrex and Heritage + Banner MAXX + Daconil Ultrex.

**Importance of Correct Pathogen Identification and Fungicide Combinations**

Proper pathogen identification is always important prior to making any chemical application. This is especially true when managing the snow mold complex of pathogens in the Intermountain Northwest. It is not uncommon to observe *M. nivale*, *T. incarnata*, and *T. ishikariensis* alone or in combinations on golf greens, which typically depends on the severity and length of snow cover. Vargas (8) noted that trizole fungicides are often effective against *T. incarnata* but not *T. ishikariensis*. Yet, trizole fungicides are sometimes listed as controlling Typhula blight (3).

**Figure 5.** Along the plot borders where overlap of treatments occured (an experimental fungicide and fludioxonil), excellent control of both *T. incarnta* and *T. ishikariensis* occurred.

In Figure 5, an experimental trizole fungicide provided good control of *T. incarnata* (plot area was essentially *T. ishikariensis*), while fludioxonil (Medallion) provided good control of *T. ishikariensis*. It is important to note in Figure 5, that where there was an application overlap of the two compounds excellent control of both *T. incarnta* and *T. ishikariensis* occurred.

In regions with mild winters where *M. nivale* occurs alone or with *T. incarnata*, single compounds of the older chemistry are generally effective. However, in areas of prolonged snow cover when *T. ishikariensis* and *T. incarnata* dominate, two- and/or three-way combinations (often containing one or two compounds with new chemistry) are required to manage snow mold disease.

An interesting observation was that regardless of the dominant pathogen, combinations of products are needed to control snow mold in areas with prolonged snow. This was evident at McCall, ID, in 2001-2002 (Table 4). Visual observation in the spring 2002 indicated that the dominant pathogen was *T. ishikariensis* (95%)

with minor *T. incarnata* (5%). As expected, Fungicide V (chloroneb), which is effective against *T. incarnata* performed poorly (65% disease). However, Medallion (fludioxonil), which in our testing appeared quite effective against *T. ishikariensis*, gave equally poor control.

These results indicate that even when *T. ishikariensis* is the dominant pathogen and is controlled, if *T. incarnata* is present, even initially at low disease pressure, in the absence of *T. ishikariensis* it can cause considerable turfgrass injury. Finally the possible resistance of gray snow mold to PCNB noted at McCall, ID, needs to be verified. Because of the unusually low development of snow mold disease throughout the Northwest during the winter of 2002-2003, these observations could not be confirmed. Additional testing during 2003-2004 may provide much needed information for the management of snow mold in the Intermountain Northwest.

## Conclusions

- Snow mold pathogens must be correctly identified for effective control.
- During moderate winters, more fungicide options are available to control snow mold.
  - -When using a single fungicide, use multisite (old chemistry) fungicides.
  - -Combine one new with one old chemistry fungicide for increased control.
- During severe winters, the use of fungicide combinations of two and possible three fungicides is a must.
- PCNB resistance may develop with repeated applications under conditions where severe winters are the norm.
- Efficacious fungicides that can be rotated with PCNB to mitigate the potential for the development of pathogen resistance are available for use in the Intermountain Northwest.

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