Chemical control of snow mold in bentgrass turf in southern Ontario

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Field trials were conducted on bentgrass greens over a period of 2 years to study the efficacy of fungicides in controlling snow mold. The pathogens encountered in the snow mold complex were *Fusarium nivale* and *3* species of *Typhula; T. incarnata, T. ishikariensis* var. *canadensis* and *T. ishikariensis* var. *ishikariensis.* Trials were carried out at 8 different sites in 1977-78 and at 3 sites in 1978-79. Fungicides did not perform equally well at all sites. The variability is being attributed to the difference in disease incidence at the different sites. With low to moderate disease (less than 65% damage) all fungicides tested gave satisfactory control when used according to supplier's directions. Under conditions of severe disease (more than 75% damage) some of the fungicides failed to control the disease. Fungicides containing mercury provided the most reliable overall control at all sites. The other broad spectrum fungicides (chlorothalonil, quintozene and iprodione) gave satisfactory control when used at high dosage rates. The fungicides containing benomyl, chloroneb, carbathiins and thiram did not control the disease under severe disease conditions. Of the experimental fungicides, Baymeb 6447 gave promising results. One season's results with DPX 4424 are inconclusive.

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Pendant deux ans, on a effectue des essais sur des verts de golf constitués d'agrostide pour etudier l'efficacité de certains fongicides contre la moisissure des neiges. Les champignons rencontrés dans le complexe de la moisissure ont ete *Fusarium nivale* et *3* especes de *Typhula (T. incarnata, T. ishikariensis* var. *canadensis* et *T. ishikariensis* var. *ishikariensis).* Les essais ont porte sur 8 emplacements en 1977-1978 et sur 3 en 1978-1979. Les fongicides n'ont pas donne les mêmes resultats a tous les emplacements. Cette variabilité est due a la difference de la frequence d'apparition de la maladie aux divers emplacements. Lors d'une frequence faible ou moderee (moins de 65% de degdts), tous les fongicides a l'étude ont donne des resultats satisfaisants lorsqu'ils etaient utilisés conformement au mode d'emploi. Dans les conditions de frequence elevee (plus de 75% de degdts). certains fongicides n'ont pu combattre la maladie. Ceux contenant du mercure se sont globalement reveles les plus efficaces a tous les emplacements. Les autres fongicides a large spectre d'activité (chlorothalonil, quintozene et iprodione) ont donne des resultats satisfaisants lorsqu'ils etaient utilises a fortes doses. Les fongicides contenant du benomyl, du chloronebe. des carbathiines et du thirame ne se sont pas reveles efficaces dans les cas de maladie grave. Parmi les fongicides experimentaux, le Baymeb 6447 s'est révélé prometteur. Les resultats du DPX 4424 portant une seule saison sont peu concluants.

Introduction

Snow mold, caused largely by *Fusarium nivale* (Fr.) Ces. and *Typhula* spp., is an important disease of turfgrass in most parts of Canada and other temperate regions of the world which experience appreciable snow cover during the winter. The disease is most destructive in fine turfgrasses such as *Agrostis palustris* L. *(A. stolonifera* var.) (creeping bentgrass) which is the principal species used in highly managed, fine turfgrass areas such as golf and bowling greens. Although proper cultural practices help reduce severity of damage, snow mold cannot be satisfactorily controlled in these fine turfgrasses without the use of fungicides.

Ever since Monteith (1927) demonstrated effective reduction of fusarium snow mold with corrosive sublimate (mercuric chloride) mercurials have occupied an important place in turfgrass disease control. According to Meiners (1955) the standard treatment for control of snow mold was the application of mercury chlorides (Calomel - corrosive sublimate) in the late fall before snow cover. He also reported that phenylmercury fungicides were superior to the then recommended inorganic mercury fungicides and that Cadminate (60 percent cadmium succinate) showed promise, but other fungicides tested such as Spergonf (chloranil), Tersan† (thiram) and Orthocidef (captan) were ineffective. Lebeau et al. (1961), found that from a list of some 12 fungicides tested, only the inorganic mercuries gave satisfactory control. Cadminate and phenylmercury preparations, also actidione and Dyrene had little effect. Fushtey (1961) obtained good control with both organic and inorganic mercuries and some control with actidione-thiram but dismissed the latter as not likely useful because there was evidence of phytotoxicity at the high dosages required. Fushtey (1975) reported that non-mercurials such as Daconil† (chlorothalonil) and Tersan SP† (chloroneb) were comparable to mercuries in effectiveness on a site where *Typhula* was predominant but less effective on another site where *Fusarium* was the dominant pathogen. On the other hand, Tersan 1991† (benomyl) gave good control of fusarium snow mold but had no effect on incidence of snow mold caused by *Typhula.* He also reported that significantly better disease control was obtained with treatments

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applied on November 5 than those applied on October 11, and supported the view that fungicides for snow mold control should be applied as late in the season as possible, probably not before November 1 in southern Ontario.

Despite extensive testing by industry, university and government researchers prior to registration of a pesticide, reports of unsatisfactory control of snow mold by registered fungicides are rather common. One of the objectives of the present study was to find some reasons for this inconsistency. Secondly, due to pressures to further restrict or ban the use of mercurials, information was needed to determine whether mercurials can be satisfactorily replaced by non-mercurials which are presumably less environmentally hazardous.

A complementary objective was to establish, more specifically, the identity of the fungi involved in the snow mold complex in this part of Ontario. Smith (1973) reported that, in Saskatchewan, snow mold is caused by *Fusarium nivale, Sclerotinia borealis,* Bubak & Vleugel, *Typhula* spp. and two unidentified low-temperature basidiomycetes designated as (LTB) and (SLTB) either singly or in combination with one or more of the other fungi. In Ontario, *Fusarium nivale* and *Typhula* sp. are known to be involved in this disease complex (Fushtey, unpublished) but the identity of the *Typhula* species had not been determined nor have studies been made to determine whether fungi other than *F. nivale* and *Typhula* sp. are involved.

To achieve these objectives a series of trials was conducted during 1977-78-79 on a number of sites which, on the basis of prior observations, represented a range of pathogen combinations, from pure *Typhula* to a mixture of *Typhula* and *Fusarium* to predominantly *Fusarium* as the causal organisms.

Materials and methods

The 1977-78 tests were conducted on golf practise greens or nursery sod areas at 8 different sites as described in Table 1.

Fungicides were applied to test plots 1.23 x 3.74 m (4 x 12.5 ft) replicated 4 times. Wettable powders were applied with a hand sprayer using a T-jet nozzle and 0.6 l water per plot (3 gal 1000 ft²). Granular formulations were applied with a Scott's 75 drop-type spreader. The fungicides used are listed and described in Table 2.

Disease ratings were made soon after the snow melted (April 6-25, as given in Table 1). A visual estimate was made of the percentage of turf affected by the disease in each plot according to the Barratt-Horsfall grading system (3) and the scores for the 4 replicates for each treatment were then converted to percent disease using conversion tables of Redman, King and Brown (7).

A similar procedure was followed in 1978-79 using 3 sites, two of which were the same as in the previous year, namely sites 2 and 8. The third was a bowling green in Lawrence Park (Toronto) with a record of fusarium snow mold incidence.

At the time disease readings were made in 1978 a visual diagnosis of the fungi was made on the basis of signs and symptoms. Suspected *Typhula* was confirmed by close examination for the presence of sclerotia which were collected and samples sent away for identification to species. Suspected *Fusarium* was subjected to microscopic examination which usually revealed the presence of typical spore masses or the fungus *Fusarium nivale* was isolated into pure culture on PDA medium.

Results and discussion

The summarized disease results for 5 of the 8 sites in 1977-78 are given in Table 3. The results for the remaining 3 sites are not given because circumstances at these sites did not permit satisfactory assessment of disease control. At one site disease level was too low (less than 3 percent) to observe any differences among treatments. At the other 2 sites severe damage due to desiccation made it impossible to estimate the damage due to snow mold.

Under conditions of low disease intensity, as was experienced at sites 4 and 5, nearly all the fungicidal

Table 1. Site details 1977-78 Trial.

Site No.	Location of trial	Date of treatment	Date of snow mold readings	Kind of snow mold*
1.	Barrie G.C. (Barrie)	Oct. 31	Apr. 25	*Typhula* only
2.	Puslinch Lake G.C. (Cambridge)	Oct. 27	Apr. 14	*Typhula* only
3.	Elmira G.C. (Elmira)	Oct. 27	Apr. 17	*Typhula* only
4.	Board of Trade (Woodbridge)	Nov. 1	Apr. 6	*Fusarium* + *Typhula*
5.	St. George's G.C. (Etobicoke)	Nov. 3	Apr. 5	Mostly *Fusarium*
6.	Cambridge Research Station	Nov. 4	Apr. 13	Mostly *Typhula*
7.	Galt G.C. (Cambridge)	Nov. 8	Apr. 14	Mostly *Typhula*
8.	Cutten G.C. (Guelph)	Nov. 10	Apr. 18	*Fusarium* + *Typhula*

**Fusarium* + *Typhula* = Both in roughly equal amounts with Fusarium somewhat more abundant.
Mostly *Fusarium* = Predorninantly *Fusarium* with some *Typhula* present,

Table 2. Fungicides used in snow mold trials.

Produce Name	Active ingredient and formulation	Source
1. Tersan 1991	benomyl 50 WP	Dupont
2. Tersan SP	chloroneb 65 WP	Dupont
3. Arrest	thiram 50 + carbathiin 20 + oxycarbathiin 5 WP	Uniroyal
4. Quintozene	quintozene (PCNB) 75 WP	Plant Products
5. Rovral	iprodione 50 WP	May & Baker
6. Caloclor	mercurous chloride 50 mercuric chloride 30 WP	Mallinckrodt
7. Bravo	chlorothalonil 54 flowable	Diamond Shamrock
8. Baymeb 6447	experimental 50 WP	Chemagro
9. Proturf Broad Spectrum	PMA 0.69 + thiram 4.65 gran.	Scotts
10. Proturf F II	chloroneb 6.25 gran.	Scotts
11. Lawn Disease Control	quintozene (PCNB) 16.9 gran.	Scotts
12.* DPX 4424	experimental 50 WP	DuPont
13.* Mersil	mercurous chloride 28 mercuric chloride 14 WP	May & Baker

*used in 1978-1979 only.

treatments yielded an acceptable degree of control (a recorded rating of less than 3 percent represents a situation where 1 or more of the 4 replications were disease free). The two instances where disease exceeded the 3 percent level occurred at site 4 where snow mold was caused by both *Fusarium* and *Typhula.* The lack of better control in these instances can be explained on the basis that: (1) Tersan 1991† (benomyl) does not control *Typhula.* (2) In treatment 18, Proturf FII† (chloroneb) was applied at the single dosage rate which is that prescribed for control of summer disease. In treatment 17, where the recommended double dosage was used adequate control was achieved.

Under conditions of severe disease, as in sites 1, 2 and 8, the degree of control was highly variable. At site 1, where snow mold was due to an extremely heavy infestation of pure *Typhula,* only those fungicides containing mercury (Caloclor and Proturf Broad Spectrum†) and chlorothalonil (Bravo? at the high dosage) gave satisfactory control. Quintozene at the higher dosage gave substantial but inadequate control. In one plot (not evident from the tabulated results) where the two dosage portions (180 g + 270 g) were applied to the same plot in error, total control was achieved. At site 2, where damage was also due to *Typhula* alone but not quite as severe an infestation, the results were quite different. All but 2 of the treatments gave satisfactory control. Treatment 2 (benomyl) was ineffective but this was expected because benomyl is known to be ineffective against *Typhula.* Treatment 12 (iprodione) was ineffective but treatment 13 (iprodione at twice the dosage of 12) gave satisfactory control. The results at site 8 were somewhat similar to those at site 1 although the heavy snow mold at site 8 was caused by both *Typhula* and *Fusarium,* with *Fusarium* possibly predominating, as compared to pure *Typhula* at site 1. Satisfactory control was obtained with quintozene and fungicides containing mercury at both sites. Bravo? (chlorothalonil) which gave good control at site 1 did not give satisfactory control at site 8. On the other hand, the experimental fungicide Baymeb 6447† which gave no measurable control at site 1 gave promising control at site 8.

In the 1978-79 trials no snow mold developed on 2 of the 3 sites used. This was unexpected because one of these (site 8) was virtually devastated by a *Fusarium-Typhula* complex the previous year. The results from the third site (site 2, in the previous year) are given in Table 4. No attempt was made to analyze these results statistically because of the uneven distribution of

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disease. The disease was concentrated within about one-third of the plot area which corresponded roughly to that part under heavy snow cover in the winter.

According to the results in Table 4, good control of snow mold was achieved with Tersan SP†, Quintozene, Arrest†, Mersil† and Rovral† at the higher dosage. Of the experimental fungicides used, Baymeb 6447† gave excellent control but DPX 4424 was inadequate at the dosage used.

Concerning the identity of the *Typhula* species encountered, the sclerotia collected from the various sites were identified as follows: -

site 1 - *Typhula ishikariensis* var. *canadensis*

site 2 - *T. ishikariensis* var. *ishikariensis*

sites 3, 4, 5 & 7 - (no sclerotia collected).

site 6 - *Typhula incarnata*.

site 8 - *T. ishikariensis* var. *canadensis*.

Table 3. Effect of fungicides on percent snow mold. April, 1978.

Treatment	Dosage (product)		Mean percent snow mold (4 reps)				
	oz per 1000 ft²	g per 100 m²	Site 1	Site 2	Site 4	Site 5	Site 8[a]
1. Check (no treatment)			95 d	65 d	7.0 c	6.4 b	85 c
2. Tersan 1991	4	120	84 d	71 d	3.5 c	1.8 a	65 c
3. Tersan SP	8	240	92 d	4 b	1.2 b	0.0 a	38 ab
4. Tersan 1991 + SP	3+6	90+180	91 d	4 b	1.2 b	0.0 a	68 c
5. Arrest	8	240	93 d	6 c	2.3 b	1.2 a	57 bc
6. Arrest	12	360	93 d	3 b	1.2 b	0.6 a	65 c
7. Quintozene	6	180	35 b	6 b	0.6 ab	1.2 a	3 a
8. Quintozene	9	270	18 ab	3 b	"0.0 a	"1.2 a	2 a
9. Bravo	8	240	31 b		1.8 b	0.6 a	64 c
10. Bravo	12	360	4 a		1.2 b	0.6 a	25 ab
11. Caloclor	3	90	0 a	1 a	"0.0 a	"0.0 a	4 a
12. Rovral	2	60	52 c	48 d	1.2 b	1.8 a	38 ab
13. Rovral	4	120	80 d	7 c	0.6 ab	0.6 a	55 bc
14. Baymeb 6447	4	120	70 c	1 a	0.0 a	0.0 a	8 a
15. Lawn Disease Control	(2)		17 ab	1 a	*0.0 a	*0.0 a	4 a
16. Proturf Broad Spectrum	(2)		5 a	3 b	0.0 a	1.2 a	2 a
17. Proturf FII	(2)		93 d	1 a	0.6 ab	0.0 a	35 ab
18. Proturf FII	(1)		92 d		3.5 c		
19. Lawn Disease Control	(1)		16 ab		0.6 ab		

[a] Based on 3 reps with some missing values due to severe dessication damage.
*Turfgrass somewhat discolored in comparison to other plots, indicating slight phytotoxicity.
-No test.
Values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 5% level

Table 4. Effect of fungicides on percent snow mold. Puslinch Lake G.C. March 20, 1979.

Treatment	Dosage (product)		Percent snow mold			
	oz per 1000 ft2	g per 100 m²	Rep 1	Rep 2	Rep 3	Rep 4
Tersan SP	8	240	2"	0	0	0
Tersan SP + 1991	8+4	240+120	2"	0	0	0
Quintozene	8	240	2"	0	0	0
Quintozene	12	360	0"	0	0	0
Arrest	8	240	5	5	5"	0
Arrest	12	360	0	0	5"	0
Check (no treat)			5	5	60"	95"
Rovral	4	120	0	20*	0	2
Rovral	8	240	0	2"	0	0"
DPX-4424	4	120	0	10"	0	10"
Bay-6447	4	120	0	0"	0	0"
Mersil	4	120	0	0	0	5"

*Plots located within heavy snow mold area, corresponding to heavy snow cover,

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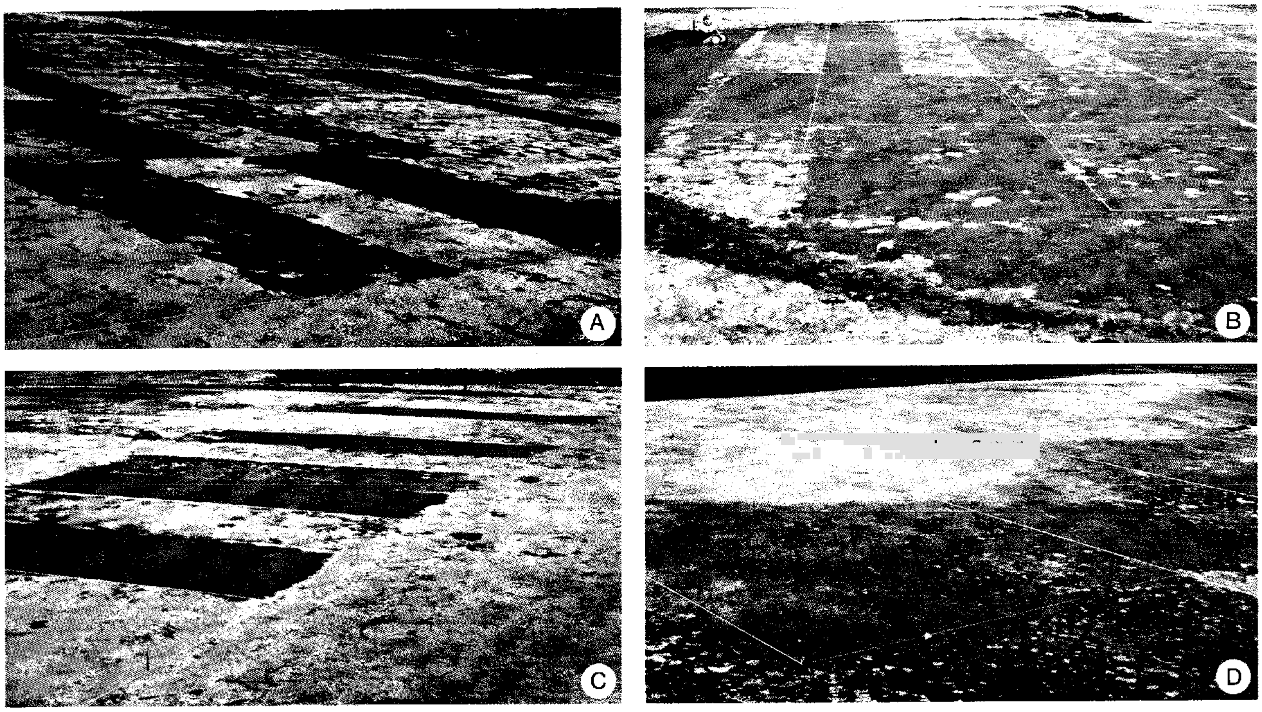

Figure 1 (A to D). Snow mold test plots. April, 1978. (A), Site 1. Severe Typhula blight; an estimated 95% damage in untreated plots and varying degrees of control. Caloclor was the only fungicide that gave satisfactory control at normal dosage, (B), Site 2. Less severe infestation of Typhula blight; an estimated 65% in untreated plots. Satisfactory control was achieved with a number of fungicides including mercurials. (C), Site 8. Severe snow mold caused by a complex of Typhula sp. and *Fusarium* nivale. Only the mercurials and quintozene gave satisfactory control. (D), Site 8 at the lower end of the experimental green which was blown free of snow most of the winter. Damage due to snow mold was slight but severe damage occurred due to desiccation. Note the patches of snow mold in the lower left corner: typical bleached patches caused by Typhula SP. light reddish-brown patches due to ***Fusarium nivale.***

Although experimental areas were carefully examined for presence of the other fungi reported to cause snow mold in Western Canada none other than *Typhula* spp. and *F. nivale* were encountered.

Observations made during the course of this study confirm those made in previous years that snow mold in the southern part of Ontario is a complex disease caused by at least two fungi, *Fusarium nivale* and *Typhula* sp. and that efficacy of fungicides varies with the kind of fungus and intensity of disease pressure. Smith (1976) made a similar observation when he stated that in evaluating the effectiveness of fungicides against snow molds in tests on golf greens under playing conditions the main difficulty is related to the occurrence of complexes of pathogens and that the balance of these pathogens shifts from year to year under influence of climatic factors. This kind of behavior was particularly evident at site 8 which was under observation for a number of years prior to the present study. When first examined (about 8 years ago) *Fusarium nivale* was by far the dominant pathogen, with *Typhula* occurring as occasional spots on some greens. At the time of the 1977-78 trial *Typhula* was the dominant pathogen on the playing greens but a roughly equal proportion of both pathogens, in great abundance, was present on the test practise green. In 1978-79, although there was abundant snow cover there was no snow mold on this test green, but the green was severely damaged by what was diagnosed as hydration injury.

There was considerable difference in fungicide efficacy at some sites and this was apparently not due to difference in kind of pathogen present but rather due to difference in disease severity. The most striking difference in efficacy was between sites 1 and 2 where the snow mold was due to *Typhula* sp. only (no *Fusarium)* at both sites. Identification of the fungi to species did reveal a difference in variety of pathogen: *T. ishikariensis* var. *canadensis* vs. *T. ishikariensis* var. *ishikariensis,* but it is not likely, although not impossible, that this small difference could result in such marked differences in fungicidal efficacy. However, difference in severity of disease between those two sites was substantial and probably sufficient to affect fungicidal efficacy.

Assessment of efficacy must be based on control to a practical level; a level where damage is negligible. With fine turfgrass this needs to be somewhat less than 5% damage. With 7% disease (site 4) this is achieved with less than 50% control; with 65% disease (site 2) about 90% control is required; and with 95% disease (site 1) more than 95% control is needed. Thus, a much higher degree of control is necessary under conditions of high disease incidence than when disease is moderate to low. How this operates in practise is illustrated by the performance of Bravo† (chlorothalonil) as given in Table 3. Satisfactory control was achieved at the low dosage rate (240 g) at sites 4 and 5 where disease incidence was low, but no practical control at sites 1 and 8 where disease incidence was exceptionally high. However, at the higher dosage (360 g) satisfactory control was achieved at site 1 and a significant degree of control, although inadequate at site 8. Increased dosage increased efficacy under high disease pressure. Thus, disease pressure is probably the main factor responsible for the difference in fungicidal performance among the different sites in this study, and higher disease pressure requires higher fungicide dosage if satisfactory control is to be achieved.

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