Snow mold control in turfgrasses with fungicides in Saskatchewan, 1971–74[1]

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Field tests were made from 1971 to 1974 to evaluate fungicides for the control of the nonsclerotial low-temperature basidiomycete (LTB), ***Fusarium nivale, Sclerotinia borealis,*** and a ***Typhula*** sp. (designated FW), which singly or in complexes cause snow molds of turfgrasses in Saskatchewan. Epidemics of the first three snow molds were started on domestic lawn-type turfs of ***Poa pratensis*** and of ***P. pratensis*** with ***Festuca rubra*** by inoculating them with cultures grown on sterile grain. Tests were also made on naturally infected fine turf of golf and bowling greens composed of ***Agrostis*** spp. with ***Poa annua.*** Infection levels varied from generally light in 1971-72, moderate in 1972-73, to very heavy in 1973-74. Quintozene, mercury chlorides, and chloroneb were usually the most effective control materials where the basidiomycetes LTB and ***Typhula*** FW were dominant or in disease complexes. In some tests, effective control of these pathogens also was achieved with phenyl mercuric acetate, two oxathiin derivatives, and chlorathalonil. A prehibernal attack of ***F. nivale*** was completely prevented by benomyl, dichlorophene, mercury chlorides, methyl thiophanate, quintozene, and the granular commercial products Bromosan and 3336 at half the usual fall dosage. Quintozene, chloroneb, phenyl mercuric acetate, and mercury chlorides also controlled snow mold where ***F. nivale*** was the pathogen predominant in a disease complex. Where S. ***borealis*** was the major cause, quintozene, was the most consistent and effective material but benomyl, methyl thiophanate, chlorothalonil, thiabendazole, phenyl mercuric acetate, and mercury chlorides also controlled the pathogen. Unless resistant ***P. pratensis*** cultivars are used, it is probable that mercury chlorides will be needed to control severe attacks of LTB. The Occurrence of more than one pathogen in snow mold complexes, common in natural infections, makes accurate evaluation of fungicide effectiveness difficult.

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Des essais de terrain ont ete effectues de 1971 a 1974 pour evaluer certains fongicides dans la lutte contre le basidiomycète psychrophile asclerotique (LTB), ***Fusarium nivale, Sclerotinia borealis*** et un ***Typhula*** sp. (désigné FW), qui, seuls ou en combinaison, causent des moisissures nivéales chez certaines graminées à gazon en Saskatchewan. A des fins d'essai, des foyers des trois premieres moisissures ont ete déclenchés sur des gazons d'habitation composes de ***Poa pratensis*** et d'un melange de ***P. pratensis*** et de ***Festuca rubra,*** en les inoculant avec des cultures produites sur grain sterile. Des essais ont egalement ete effectues sur du gazon fin et naturellement infecté de verts de golf et de parterres de boulingrins composes d'un melange d'*Agrostis* spp. et de ***Poa annua.*** L'infection a varie de generalement légère en 1971-1972 a tres prononcee en 1973-1974, en passant par moderee en 1972-1973. En general, le quintozene, les chlorures de mercure, et le chloronebe ont ete les materiels de lutte les plus efficaces là où les basidiomycetes LTB et ***Typhula*** FW dominaient dans les cas d'infections combinees. Dans certains essais, l'acetate de pheinylmercure, deux derives de l'oxathiine et le chlorathalonil ont pu combattre efficacement ces agents pathogenes. Une infection prehivernale de ***F. nivale*** a ete totalement enrayee par le benomyl, le dichlorophene, les chlorures de mercure, le thiophanate de methyle, le quintozene et les produits granulaires commerciaux Bromosan et 3336, a raison de la moitié de la dose habituelle d'automne. Le quintozene, le chloronebe, l'acetate de phenylmercure et les chlorures de mercure ont egalement detruit la moisissure nivéale la ou F. ***nivale*** dominait dans les cas d'infections combinees. Là ou S. ***borealis*** constituait le principal organisme pathogene, le quintozène s'est révélé le materiel le plus constamment efficace, mais le benomyl, le thiophanate de methyle, le chlorothalonil, le thiabendazole, l'acetate de phenylmercure, et les chlorures de mercure ont egalement donne de bons resultats. A moins d'utiliser des cultivars resistants de ***P. pratensis,*** il est probable que certains chlorures de mercure seront necessaires pour combattre les infections graves de LTB. La presence de plus d'un agent pathogene dans les combinaisons de moisissures niveales, generalisees dans les infections naturelles, rend difficile l'évaluation precise de l'efficacite des fongicides.

Only since 1970 have detailed studies been made on the causes and control of snow mold of turfgrasses in Saskatchewan. Until then it had been assumed that overwintering disease of turfgrasses was due to a low-temperature basidiomycete, LTB, and winter injury. The most commonly used snow mold fungicides on golf courses and lawns were based on inorganic and organic mercury compounds. However, in 1970-71 tests on domestic lawns where the dominant pathogen was the non-sclerotial low-temperature basidiomycete (LTB) and disease severity was generally light, quintozene, chloroneb, and an oxathiin derivative were as effective as the phenyl mercuric acetate used as a reference material (10); benomyl was not very effective and thiram ineffective (3).

Since 1970 surveys and taxonomic studies have been made on the causes of snow mold in turfgrasses, forage

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grasses, and cereals in parts of Manitoba, Saskatchewan, Alberta, British Columbia, and adjacent Idaho and Washington. These studies (3–6 and unpublished) indicated that the LTB often caused major damage to turfgrasses, even in years with below average or average snowfall (3–7); a sclerotial low-temperature basidiomycete, the SLTB (3, 6) was pathogenic towards turfgrasses; and an undescribed ***Typhula*** sp. at present designated FW was highly pathogenic on turf and forage grasses and on winter wheat and rye (6, 7). ***Fusarium nivale*** (Fr.) Ces. and ***Sclerotinia borealis*** Bub. & Vleug. were found for the first time on Gramineae generally. Descriptions of the symptoms and of these pathogens have been given elsewhere (3–6). A psychrophillic orange-colored, sclerotial fungus designated ORS and tentatively classified as a ***Cephalosporium,*** occurred on grasses, cereals, and forage legumes in the four western provinces of Canada and in Norway (Smith unpublished); Dr. G. N. Davidson (personal communication) has found it on a wide range of plant species in Alberta. It is antagonistic to several snow mold fungi at low temperature (6) although it is not an active plant pathogen.

Anomalies in the results of the 1970-71 tests of fungicides and the wide diversity of snow molds in different localities and on varying turf types suggested that the effectiveness of the different fungicides depended mainly on which pathogen was dominant. The prevalence of a pathogen might change from season to season according to microclimatic conditions (6). The effect of such changes may be minimized by inducing epidemics of particular pathogens by inoculation. This paper reports the results of tests on turf in Saskatchewan to find fungicides effective against the different pathogens. An attempt was made to find less toxic substitutes for mercurial fungicides.

Materials and methods

The effectiveness of fungicides in the control of different snow molds was examined in tests both on naturally infected golf course and bowling green turf in Saskatchewan and in plot tests at Saskatoon, Saskatchewan, where lawn turf was inoculated with specific pathogens.

Turf inoculation

All tests at the experiment grounds at Saskatoon in the 1971-72 and 1972-73 seasons used turf inoculated with a snow mold. Isolates of the LTB, ***S. borealis,*** and ***F. nivale*** obtained from severe outbreaks on turf in the province were grown on moist sterile grain, usually rye, in 1.14 liter (1 quart) milk bottles. Cultures of the LTB and S. ***borealis*** were incubated at approximately 6°C and ***F. nivale*** at approximately 15°C, and were harvested after 3 to 4 months growth, spread thinly on paper, dried at room temperature and screened through a 6-mm sieve. They were then refrigerated at −10°to −20°C until required. Evenness in distribution of inoculum on the turf was obtained by hand broadcasting portions of the total amount in several different directions. The inoculum was applied at rates of 1 to 2 kg/100 m^2 in August or September, several weeks before fungicides were used. In the case of test 4 in 1974, inoculum of S. ***borealis*** from cultures was supplemented with natural sclerotia of the same fungus which had been collected with a rotary carpet sweeper from a severe case of the disease on ***Agrostis*** turf.

Turf test plots

Turf of ***Poa pratensis*** **L.,** Common, and ***Festuca rubra,*** Common, sown in fall 1968, i.e. mature turf, was used for LTB, ***F. nivale*** and ***S. borealis*** control studies in 1971 and 1972 (Table 2) and for one test with the LBT in 1973 (Table 4). In plots inoculated with ***F. nivale*** in 1971, turf of ***P. pratensis*** cv. Merion of similar age was employed. All turf was mowed in the year after seeding with a 1.2-m-wide undersllung rotary mower. Later this was changed to mowing at 4 to 5 cm height with triple-gang reel mowers (each 1.2 m wide) drawn by a garden tractor. All turf was irrigated and maintained in a moderate state of fertility.

Tests on bowling and golf greens were on turf of different botanical compositions but composed mainly of various cultivars of bents, ***Agrostis*** spp., with varying proportions of annual bluegrass, ***Poa annua*** **L.,** which is a normal invader of bent turf previously damaged by snow molds. In the 1971-72 (Table 2) and 1972-73 (Table 3) tests, plot areas of 1.52 X 1.52 m (25 ft^2) were treated with fungicide. The size was changed to 1.0 X 1.0 m in the 1973-74 tests. One test with granular materials in 1973-74 (Table 4, site 1) used plots 3.66 X 3.05 m. Treatments were replicated five times with the following exceptions: Test N had three replicates and the North Battleford test two replicates in 1972-73 (Table 3); at the Saskatoon site 1 in 1973-74 each treatment was replicated six times.

Fungicide applications

Fungicide sprays were applied in 107 ml water/m^2 (10 ml/ft^2) with 1-liter capacity pneumatic hand sprayers. Warm water was used in some late fall applications to prevent nozzle icing. Dry powders were applied with a dusting can or by hand after bulking with sand or compost. In both 1971 and 1972 a single application of material was made between mid-October and early November, before the development of a permanent snow cover. In 1973 the first fungicide application was made in September and the second in October to turf in all tests except the one at Lloydminster which received only the last. The first application was at half dosage. The common and product names, percent active ingredients, formulations, and sources of fungicides used are given in Table 1. Both systemic and nonsystemic fungicides were included.

Polyethylene covers

It is a practice on some golf courses in Saskatchewan to cover greens before winter with polyethylene sheeting to reduce desiccation during snow-free periods in spring and to promote a "greenhouse effect" which encour-

Table 1. Fungicides used in snow mold tests

Index no.	Product name	Active ingredient* % and formulation†	Source
1	Benlate	benomyl 50%, WP	Du Pont
2	Cad-Trete	thiram 75% + $CdCl_2.H_2O$ 8.3%, Gran	Cleary
3	CD/Urea	$CdCl_2.H_2O$ 10% + urea, Soln	Smith
4	Tersan SP	chloroneb 65%, WP	Du Pont
5	Demosan	chloroneb 7.5%, Gran	Du Pont
6	Chlorophenate	chlorophenate mixture 18%, Soln	Cleary
7	Daconil	chlorothalonil 75%, WP	Diamond-Shamrock
8	DCP	dichlorophene 50%, WP	Smith
9	BAS 3460F	2(methoxy carbonil)-benzimidazole 50%, WP	BASF
10	Calo-clor	Hg 36.5%, WP	Malinckrodt
11	Mersil	Hg 42%, WP	May & Baker
12	CCS	Hg 100%, P	Smith
13	BAS 3050	methyl benzoic acid anilide 75%, WP	BASF
14	Topsin M	methyl thiophanate 70%, WP	Nippon soda
15	4222	polychlorphenate + quintozene** Gran	Cleary
16	PMA	phenyl mercuric acetate 10%, Soln	Smith
17	PMA-10	phenyl mercuric acetate 10%, Soln	Later
18	Terraclor	quintozene (PCNB) 75%, WP	olin
19	4221	sodium polychlorphenate 4%, Gran	Cleary
20	Salan	salicylanilide 50%, WP	Smith
21	Mertect	thiobendazole 40%, slurry	Merck
22	Tersan 75	thiram 75%, WP	Du Pont
23	4220	thiram + dyrene** Gran	Cleary
24	Arrest	thiram 50% + carbathiin 20% + oxycarbathiin 5%, WP	UniRoyal
25	Vitavax	carbathiin 75%, WP	UniRoyal
26	D-735	carbathiin 75%, WP	UniRoyal
27	Terrazole	5-ethoxy-3-trichloro methyl, 1,2,4 thiadiazole 95%, P	Olin
28	TCMTB	2 (thiocyanomethyl thio benzothiazole 40%, Slurry	Buckman
29	BAS 3201F	** 50%, WP	BASF
30	Bromosan	diethyl-4,4-O-phenylene bis (3-thioallophanate) 16.67% + thiram**, Gran	Cleary
31	Bromosan	diethyl-4,4-O-phenylene bis (3-thioallophanate) 16.67% + thiram 50%, WP	Cleary
32	CA 70203	** 20%, Soln	Cela
33	3336	diethyl-4,4 -O-phenylene bis (3-thioallophanate) 50%. Gran	Cleary
34	3336	diethyl-4,4 -O-phenylene bis (3-thioallophanate) 50%, WP	Cleary

* Where the common name of the active ingredient is not known or is inconveniently long the product name is used in the tables and text.

† WP = wettable powder, P = powder, Gran = granular. Soln = solution.

** Ingredient or % not available.

ages a more rapid recovery in spring. Two treatments in test 2 in 1971-1972 (Table 2) employed clear 4 mm polyethylene covers, either intact or perforated every 10 cm with 6 mm holes, to determine whether the amount of damage due to F. *nivale* snow mold was affected by this practice.

Rating of disease

An estimate was made of percentage of turf affected by disease in each plot. Usually this was done more than once, and occasionally three times. Only where there were considerable differences between ratings on different dates, resulting in different ranking of the fungicides, have these data been given in the tables.

Results and discussion

In evaluating the effectiveness of the fungicides in controlling turfgrass snow molds, consideration must be given to level of infection and to the identity of the pathogens causing disease, as indicated by those which predominated on dead or damaged grass at snow melt.

In late April 1972 infections resulting from inoculation with F. *nivale,* LTB, and *S. borealis* in tests 1 to 4 (Table 2) were only moderately severe. Inoculation was not effective in the establishment of a predominantly *F. nivale* infection in test 2 since the LTB also developed. The low level of S. *borealis* infection in test 5, as compared with its high incidence in test 6, may explain

Table 2. Snow mold fungicide tests on amenity turf, Saskatchewan, 1971-72

Fungicide or cultural practice	Index no. (Table 1)	Dosage (a.i.g/m²)	Percent area of turf affected, April 1972* — Research Station, Saskatoon: Test 1	Test 2	Test 3	Test 4	Swift Current: Test 5	Test 6
Benomyl	1	0.33		14	37ij	9ab	6	
Benomyl	1	0.65			34hi			
Cadmium chloride + urea	3	0.08			38j			
Cadmium chloride + urea	3	0.17			28g			
Chloroneb	4	1.40	6a		3ab		10	
Chloroneb	4	2.80			7bc			
Mercurous/mercuric chlorides	12	0.78	3a	0	8cd	9ab	22	
Mercurous/mercuric chlorides	12	1.56			2a			
Methylbenzoic acid anilide	13	0.08		8		25d		
Methyl thiophanate	14	0.08		16		7ab		
Methyl thiophanate	14	0.16			279			
Phenyl mercuric acetate	16	0.07	4a	4	18f	6a	23	19c
Phenyl mercuric acetate	16	0.13			5abc			
Quintozene	18	0.98						11b
Qulntozene	18	1.95	7a		7bc	8ab	7	8ab
Quintozene	18	3.90			2a	9ab		4a
Salicylanilide	20	0.87			18f			
Salicylanilide	20	1.74			32h			
Thiram	22	1.63		6	13e	17c		
Thiram	22	3.26			20f			
D-735	26	0.49		3	11de	15c		
D-735	26	0.98		3	5abc			
BAS 3201F	29	0.05		13		6ab		
CA 70203	32	0.02		13		14c		
Polyethylene unperforated				12				
Polyethylene perforated				15				
Check - untreated			20b	15	32h	29e	20	70d
Predominant pathogens** at snow melt			F.n.†	F.n.† & LTB	LTB	S.b.†	S.b.	S.b.

* Damage assessed 28 April 1972 at Saskatoon Research Station and 13 April 1972 at Swift Current Golf Club. Within tests, figures subtended by the same letters do not differ significantly at the 1% level as determined by Duncan's multiple range test.

** F.n. = *Fusarium* nivale, LTB = low temperature basidiomycete, S.b. = *Sclerotinia* borealis.

† Artificial inoculation.

the lack of significant differences between the treatments in test 5. This disease was successfully established by inoculation with natural sclerotia and those from grain cultures in test 4, the only occasion in several attempts (unpublished) when this was successful. Ascospores may be necessary for heavy infection of turf by this fungus, at least this seems to be the case in the infection of grass plants in infection chamber studies (K. Årsvoll, personal communication). In the 1971-72 season with comparatively light infections, one application of quintozene, chloroneb, phenyl mercuric acetate, or a mercurous/mercuric chloride mixture effectively controlled F. *nivale* and the LTB. D-735 and BAS 3201F also gave a fair control of the LTB. Phenyl mercuric acetate, methyl thiophanate, quintozene, benomyl, and inorganic mercury chlorides reduced severity in a moderate attack of S. *borealis* induced by inoculation (test 4). Quintozene was more effective than phenyl mercuric acetate in controlling a heavy natural infection of S. *borealis* on *Agrostis* spp. turf on a golf green in southern Saskatchewan. The polyethylene sheets covering plots appeared to have had little effect on the severity of disease. In practice, covers do not usually increase the severity of fusarium patch disease where they are used on golf greens composed on *Agrostis* spp. and *Poa annua,* compared with uncovered.

In April 1973, levels of infection were higher than in 1972 on both artificially inoculated turf on the Saskatoon test area (Figs. 1 and 2) and on golf course greens (Table 3). On sites A and B, where the turf was of the Merion cultivar of *P. pratensis,* a very high infection resulted from inoculation with the LTB. Variation in disease rating from plot to plot of treatments was more apparent in golf course tests than on the Saskatoon test area (vide footnote 1, Table 3). On the Saskatoon and Prince Albert golf courses, a low level of infection by F. *nivale* was noted before fungicide application in 1972.

In the 1972-73 tests a very heavy outbreak of the LTB on the very susceptible *P. pratensis* cultivar Merion *(8)* (Table 3, sites A and B) was not controlled by any fungicide other than inorganic mercury chlorides. These

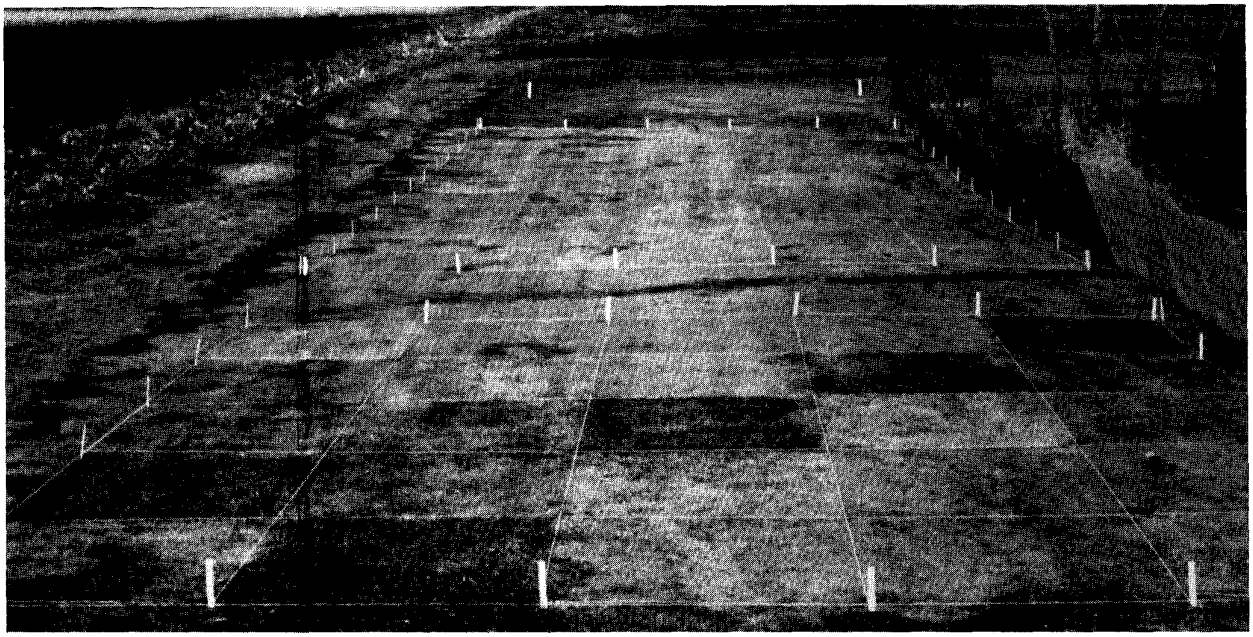

Figure 1. LTB test, Site A 1972-73. Only inorganic mercurials controlled heavy infection in April 1973.

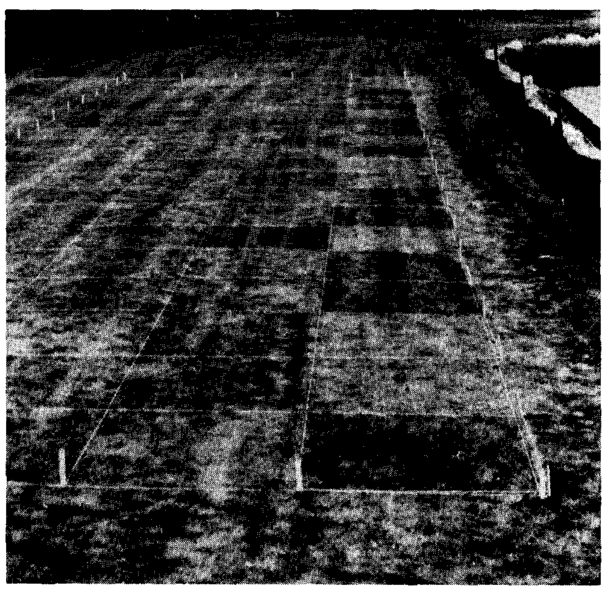

Figure 2. LTB test, Site D 1972-73. Inoculated plots showing effective control by some fungicides in April 1973.

materials were also the most effective in the test on site N with the less susceptible Park cultivar (8) in the same year. Where levels of infection were lower on turf containing the more resistant common Kentucky P. *pratensis* (8) (Table 3, sites D and E) than on the Merion turf several materials were effective against the LTB when applied only once in the fall. The most efficient were auintozene. chloroneb. and chlorothalonil although both thiabendazole and an oxathiin derivative (D-735) also considerably reduced disease severity. Inorganic mercuries, which have a fairly broad spectrum of effectiveness as fungicides, and to a lesser extent organic mercury compounds (1, 10) have been extensively used to control snow molds of turfgrasses in many

Table 3. Snow mold fungicide tests on amenity turf, Saskatchewan, 1972-73

			Percent area of turf affected on dates indicated in 1973*									
			Research Station, Saskatoon					North Battleford	Saskatoon		Prince Albert	Swift Current
	Index no.	Dosage	Site D	Site B	Site A	Site E	Site N	G. & C. C.	G. & C. C.		G. & C. C.	G. C.
Fungicide	(Table 1)	(a.i.g/m^2)	13/4	18/4	18/4	13/4	18/4	17/4	20/3	28/3	10/4	3/4
Benomyl	1	0.33	55de				28					
Benomyl	1	0.66	36bcd	85		26ab	13	14	24ab	25abc	25abc	14ab
Benomyl	1	1.32	41cd	79			40					
Chloroneb	4	1.69	17ab	89	80b			9	3a	2a	10a	14ab
Chloroneb	4	3.38	8a	88								
Chlorothalonil	7	1.95	15a	87		8a		3	14ab	20abc	66def	14ab
Chlorothalonil	7	3.90	4a									
MBC	9	0.33	54de	98								
MBC	9	0.66	78f			34b		6	36b	41bc	38abcd	26b
Mercurous/mercuric chlorides	10	0.78			?a		7					
Methyl thiophanate	14	0.46	49de	91								
Methyl thiophanate	14	0.92	63ef			28ab		9	26ab	30abc	52bcde	12ab
Phenyl mercuric acetate	16	0.07	48de	88	88b		47					
Phenyl mercuric acetate	16	0.13	57de			23ab	40	23	la	la	4a	
Quintozene (PCNB)	18	0.98	14a									
Quintozene (PCNB)	18	1.95	6a	87	78b			1	2a	0a	la	4a
Thiabendazole	21	0.52					28	3			20ab	14ab
Thiabendazole	21	1.04	23abc			18ab	43		20ab	16ab		
Thiabendazole	21	1.56					23					
D735	26	0.98	23abc									
TCMTB	28	0.52		83		36b		6	26ab	31abc	84ef	17ab
CA 70203	32	0.13	82f									
CA 70203	32	0.26	57de	90		27ab		1	18ab	21abc	61cdef	18ab
Check - untreated			54de	85	79b	36b	37	21	38b	54c	92f	46c
Predominant pathogens** at snow melt			LTB†	LTB†	LTB†	LTB†	F.n. & LTB†	S.b.	F.n. & LTB	F.n. & LTB	F.n., T.sp. & S.b.	S.b., LTB, F.n.

* Within tests, figures subtended by the same letters do not significantly differ as determined by Duncan's multiple range test; at the 5% level in the Saskatoon and Swift Current C. C. tests and at the 1% level in the others.

† Artificial inoculation with LTB only.

** LTB = low temperature basidiomycete, F.n. = *Fusarium nivale*, S.b. = *Sclerotinia borealis*, T. sp. = *Typhula* sp.

parts of the world for several decades (9). While they are ecologically undesirable, present substitutes are not entirely satisfactory, particularly where a severe attack by the LTB on susceptible cultivars such as Merion is concerned. Several *P. pratensis* cultivars in use are more susceptible to the LTB than is Merion (8). It seems probable that from the data obtained in tests A, B, D, E, and N the effectiveness of materials other than the mercuric chlorides would be adequate if more resistant turfgrass cultivars were used (8).

One of the factors complicating the evaluation of the effectiveness of fungicides in the 1973-74 tests was the much above-average depth and longer duration of the snow cover in that season. Winter snowfall at Saskatoon for 1973-74 was 1,704 mm and a continuous snow cover persisted for 170 days from 30 October to 17 April. This was much above the average snowfall for the previous 33 winters of 1,087 mm and 143 days snow cover (personal communication, Dr. J. Maybank, Physics Department, Saskatchewan Research Council, 19 August 1974). The level of infection with pathogens was high at snow melt in April 1974 (Table 4). In fall 1973, infections of *F. nivale* developed on some test areas after the first application of fungicide. In the Emma Lake test (Table 4). a sufficiently high incidence of disease developed for a reliable estimation of the protective effect of fungicides against *F. nivale* to be obtained before a persistent winter snow cover formed in late October.

In the 1973-74 tests quintozene, mercurous/murcuric chloride and chloroneb were overall the most effective materials in a year of prolonged, deep snow cover when the basidiomycetes *Typhula* (FW) and the LTB were prominent. However, in practice a greater reduction in infection than that achieved would be desirable. Control of a moderately severe, prehibernal attack of fusarium patch disease was obtained in the Emma Lake test (Table 4) by half dosage of many of the materials, including two granular products. The control of this

Table 4. Snow mold fungicide tests on amenity turf, Saskatchewan, 1973-74

			Percent area of turf affected on dates indicated'							
					Lloydminster	Prince Albert	Prince Albert National Park		Saskatoon Research Station	
	Index no,	Dosage	Emma Lake G. C.		G. C.	G. C.	Turf nursery	Bowling green	Site 1	Site 2
Fungicide	(Table 1)	(g a.i./m²)	11/10/73†	9/5/74	17/4/74	8/5/74	26/4/74	26/4/74	20/4/74	29/4/74
Benomyl	1	1.0	0a	96b	81b	87cde	95d	91e	76d	65bc
Cadmium complex	2	25.00**							76d	65bc
Chloroneb	4	1.95	7ab	52a	69b	66bc	48ab	31a		
Chloroneb	5	25.00**								42b
Chlorophenate	6	1.08				97e	58bc	65bcd		
Chlorothalonil	7	2.02	12b	93b	74b	74bcd	74bc	79bcde		
Dichlorophene	8	1.00	0a	91b	82b	96de	84cd	78bcde		
Dichlorophene	8	2.00			82b					
Mercurous/mercuric chlorides	1	1.08	0a	38a	17a	77bcde				
Methyl thiophanate	14	0.98	0a	95b	74b	92de	83cd	86cde		
Polychlorphenate + quintozene	15	25.00**							76d	65bc
Phenylmercuric acetate	17	0.05	5ab	85b		32a				
Quintozene (PCNB)	18	2.02	0a	52a	37ab	62b	26a	17a	30abc	13a
Sodium polychlorphenate	19	25.00**							58abcd	71c
Thiabendazole	21	1.00			81b	86cde	95d	91e		
Thiram + dyrene	23	25.00**							66bcd	67bc
Arrest	24	2.15			3a		79cd	55b		
Vitavax	25	1.50			19a		83cd	62bc		
Terrazole	27	0.98	12b	84b		94de	79cd	94e		
Bromosan	30	25.00**							26a	68bc
Bromosan	30	15.00**	0a	95b	81b	96de	86cd	78bcde		
Bromosan	31	1.02			67b	88de	79cd	78bcde		
3336	33	25.00**							19a	61bc
3336	34	1.0	0a	95b	82b	93de	84cd	89de		
Check - untreated			27c	93b	73b	98e	92d	91e	70cd	77c
Predominant pathogens § at snow melt			F.n.	T. FW	T. FW	S.b. & T. FW	T. FW	T. FW 6 S.b.	LTB 6 F.n.	LTB††

• Within tests, figures subtended by the same letter do not differ significantly at the 1% level using Duncan's multiple range teat.

† Rated before snow cover between first and second applications of fungicide.

** g formulation/m²

†† Artificial inoculation.

§ F.n. = *F. nivale*, T. FW = Typhula FW, S.b. = *S. borealis*, LTB = low temperature basidiomycete.

disease, common in wet, cold fall weather in western Canada (4, 5), and economy in fungicide usage were being attempted by half dosage. However, full dosage of fungicides in September as well as in the later application might have improved control of the *Typhula* snow mold in spring under particularly arduous conditions. In the Lloydminster test, the effectiveness of oxathiins plus thiram (2) and to a lesser extent a mercury chloride fungicide at half dosage was remarkable (Table 4). The only other material showing some control effectiveness here was quintozene. The mode of action of systemic fungicides such as the oxathiins (11) and the inorganic mercury chlorides is quite different (1); the action of the latter being mainly due to mercury in the vapor phase. Nevertheless, excellent control was achieved by both materials. Granular materials, with the exception of the commercial products 3336 and Bromosan, were not as effective as a quintozene spray against a complex of the LTB and *F. nivale.* A granular chloroneb fungicide showed some activity against the LTB (Table 4). The main advantage of granular materials appears to be in convenience of application in top dressings or by simple applicators and not in their efficiency of disease control.

Where *S. borealis* was the principal cause of snow mold in tests 4 and 5 in 1971-72 (Table 2) and in the North Battleford test in 1972-73 (Table 3), materials other than quintozene, viz benomyl, chloroneb, phenyl mercuric acetate, methyl thiophanate, chlorothalonil, thiabendazole, mercurous/mercuric chlorides, TCMTB, and CA 70203 gave some control. However, when *S. borealis* was associated with other pathogens in tests on golf greens at Prince Albert and Swift Current in 1972-73 (Table 3) and at the Prince Albert National Park Golf Club and bowling green in 1973-74 (Table 4), quintozene was generally the most effective. The systemic fungicide benomyl, which showed varying degrees of control where *F. nivale* was present, was ineffective

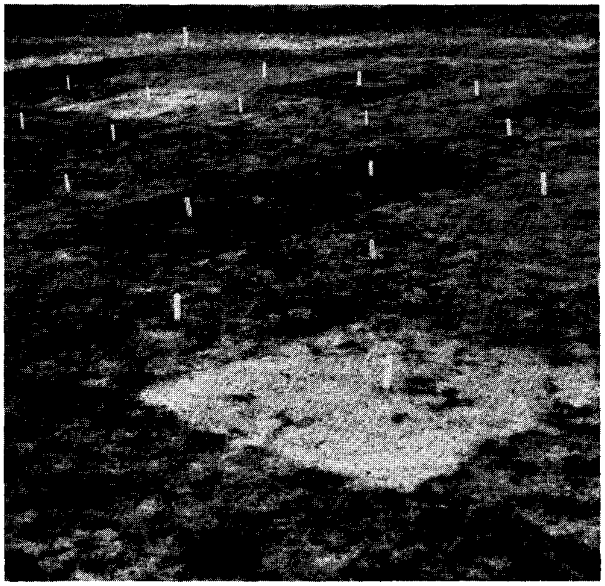

Figure 3. Turf nursery test, Prince Albert National Park, 1973-74. *Typhula* FW mycelium developed on thiabendazole plots in foreground and left rear.

against the LTB in all the 1971-72 tests and also in all tests in 1973-74 where snow cover was prolonged and infection level high. The systemic fungicide thiabendazole failed to reduce severe damage caused mainly by ***Typhula*** FW on the turf nursery test in 1973-74 and appeared to stimulate mycelial development of this fungus (Fig. 4). This effect was not seen with other materials. Chlorothalonil significantly reduced severity of infection in three and considerably reduced the areas of turf damaged in four of the eight 1972-73 tests (Table 3) but was effective in only one of the six tests in 1973-74 (Table 4). When infection levels were much higher than in the previous year, it appeared to have a wide spectrum of activity. Chloroneb gave effective control over a wide range of pathogens although it was not fully tested against ***S. borealis.***

While some progress was made in the three seasons in evaluating the effectivness of fungicides against snow molds in tests on golf greens under playing conditions, the main difficulty is still related to the occurrence of complexes of pathogens. This problem was suggested by earlier work (4, 6). The balance of these pathogens shifts from year to year under the influence of climatic factors. It seems possible, by establishing test areas under uniform management practices, to develop test sites with specified pathogens dominant (7, 8). So far the LTB has been most amenable to this treatment but further attempts with *S.* ***borealis*** and ***Typhula*** FW appear warranted.

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Literature cited

1. Booer, J. R. 1944. The behaviour of mercury compounds in soil. Ann. Appl. Biol. 31: 340-359
2. Edgington, L. V., G. S. Walton, and P. M. Miller. 1966. Fungicide selective for basidiomycetes. Science 153: 307.
3. Smith, J. Drew. 1972. Snow mold of turfgrass in Saskatchewan in 1971. Can. Plant Dis. Surv. 52: 25-29.
4. Smith, J. Drew. 1973. Overwintering diseases of turfgrasses in Western Canada. Proc. 25th N. W. Turfgrass Assoc. Conf., Harrison Hot Springs, British Columbia. pp. 96-103.
5. Smith, J. Drew. 1974. Winter diseases of turfgrasses. Summary 25th Annu. Nat. Turfgrass Conf. Roy. Can. Golf Ass., 19-21 March 1973. Winnipeg, Manitoba.
6. Smith, J. Drew. 1974. Snow molds of turfgrasses in Saskatchewan. Pages 313-324 ***in*** E. C. Roberts, ed. Proc. 2nd Int. Turfgrass Res. Conf., June 1973, Blacksburg, Virginia. Int. Turfgrass Soc., Amer. Soc. Agron., & Arner. Crop Sci. Soc.
7. Smith, J. Drew. 1975. Snow molds on winter cereals in northern Saskatchewan in 1974. Can. Plant Dis. Surv. 55: 91-96.
8. Smith, J. Drew. 1975. Resistance of turfgrasses to low-temperature-basidiomycete snow mold and recovery from damage. Can. Plant Dis. Surv. 55: 147-154.
9. Smith, J. Drew, and N. Jackson. 1965. Fungal diseases of turfgrasses. Sports Turf Res. Inst., Bingley, W. Yorks. 97 p.
10. Ulfvarson, U. 1969. Organic mercuries. Pages 303-329 ***in*** D. C. Torgeson, ed. Fungicides. Vol. II. Academic Press, New York.
11. Woodcock, D. 1972. Systemic fungicides. 3. Structure-activity relationships. Pages 34-39 ***in*** R. W. Marsh, ed. Systemic fungicides. Longmans, London, England.