Survey for snow mold diseases of winter cereals in central and northern Alberta, 1983-87

D.A. Gaudet[1] and M.K. Bhalla[2]

A survey for the incidence and distribution of snow molds on winter cereals in central and northern Alberta and northeastern British Columbia was conducted in early spring from 1983-87. The non-sclerotial form of cottony snow mold (*Coprinus psychromorbidus*) (LTB) was the most prevalent snow mold fungus and was responsible for severe reductions in winter survival of winter cereals, particularly in the south and north Peace River District of Alberta. The sclerotial form of *C. psychromorbidus* (SLTB) was infrequently recovered from diseased plants, but was commonly observed on decaying leaves of deciduous trees in the Peace River District. Snow scald (*Sclerotinia borealis*) and pink snow mold (*Gerlachia nivalis*) were also infrequent. *Plenodomus meliloti* and *Pythium* spp. were commonly isolated from diseased plants but the role of these fungi in reducing survival of winter cereals is unclear.

Can. Plant Dis. Surv. 68:1, 15-22, 1988.

Au debut du printemps de 1983 à 1987, on a enquêté sur la frbquence et la distribution des moisissures des neiges qui affectent les céréales d'hiver dans le centre et le nord de l'Alberta, et dans le nord-est de la Colombie-Britannique. La forme non sclbrotique de la moisissure cotonneuse des neiges (*Coprinus psychromorbidus*) (LTB) était le champignon le plus courant auquel on attribuait une grave diminution de la survie hivernale des céréales d'hiver, en particulier dans le sud et le nord du district de la Rivière-de-la-Paix en Alberta. On trouvait très rarement des sclérotes de *C. psychromorbidus* (SLTB) chez les plantes atteintes, mais on en trouvait souvent sur les feuilles en decomposition des arbres décidus dans le district de la Rivière-de-la-Paix. La brûlure des neiges (*Sclerotinia borealis*) et la moisissure rose des neiges (*Gerlachia nivalis*) étaient également peu frbquentes. Il était courant d'isoler *Plenodomus meliloti* et *Pythium* spp. des plantes atteintes mais le rôle joué par ces champignons dans la diminution de la survie des céréales d'hiver n'est pas défini.

Introduction

Current winter cereal varieties possess sufficient freezing resistance to survive in the Parkland regions of central and northern Alberta provided that the snow cover is sufficient to insulate the crop against low ambient temperatures. However, there are fewer than 10,000 ha seeded to winter cereals in these regions, annually. Lack of adequate snow cover is responsible for soil temperatures below -15°C at the crown level in less than one year out of ten (12); however, sublethal temperatures between -10 and -15°C were recorded in 28-45% of the winters examined. Exposure of winter cereals to these temperatures for prolonged periods will reduce survival and yields (13). Conversely, if a deep snow cover arrives early or persists in the spring, a frequent event in central and northern Alberta, snow mold caused by psychrophyllic fungi can virtually eliminate the winter cereal crop. Poor winter survival necessitates re-seeding to spring cereals.

A number of different snow mold diseases have been reported on winter cereals in the northwestern United States and western Canada (2, 3, 11, 15). They include cottony snow mold caused by the non-sclerotial (LTB) and sclerotial (SLTB) forms of *Coprinus psychromorbidus* Redhead and Traquair (15, 16), snow scald caused by *Sclerotinia borealis* Bub. and Vleug., pink snow mold caused by *Gerlachia nivalis* (Ces. ex Sacc.) W. Gams and E. Muller, grey snow mold caused by *Typhula incarnata* Lasch ex. Fr., and speckled snow mold caused by *T. ishikariensis* Imai var. *ishikariensis*, *T. ishikariensis* var. *idahoensis* Arsvoll and Smith, and *T. ishikariensis* var. *canadensis* Smith and Arsvoll (15). Other psychrophillic fungi associated with winter injury in grasses and legumes in North America are *Acremonium boreale* Smith and Davidson. *Plenodomus meliloti* Dearn. and Sanford (14) and *Pythium iwayamai* Ito (10).

The only practical control for snow molds is through the development of resistant crop varieties. A survey of winter cereal fields in central and northern Alberta was conducted in early spring from 1983-87 to determine the incidence and distribution of snow molds associated with winter injury in winter wheat and fall rye. The results of this survey will serve as a basis for initiating a breeding program to develop winter wheat and fall rye varieties resistant to snow molds.

Materials and methods

A survey to establish the incidence and distribution of snow mold fungi in winter wheat and fall rye fields was conducted in April from 1983-87. The province was subdivided into three regions, central, southern Peace River, and northern Peace River (Fig. 1). The southern Peace River region included the northeastern portion of the British Columbia Peace River District. Because of the paucity of winter cereal fields in the survey area, district agriculturalists and regional crop specialists were asked to identify fields within their region.

Fields were surveyed by walking along one edge and to the centre of each field. Plants exhibiting chlorosis, discoloration, or signs of fungal activity were sampled. Leaf, stem, crown, and root sections were excised, surface-sterilized in 0.05% sodium hypochlorite for 3 minutes, plated on acidified Potato

[1] *Research Station, Agriculture Canada, Lethbridge, Alberta, T1J 4B1.*

[2] *Research Station, Agriculture Canada, Lacombe, Alberta, TOC 1SO.*

Accepted for publication December 14, 1987.

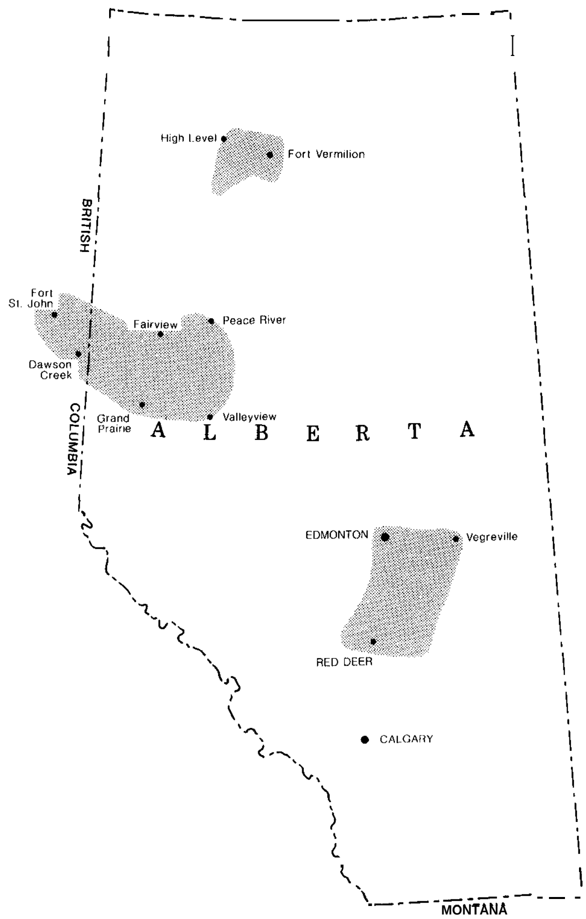


Figure 1. Map of Alberta showing the areas in central Alberta, southern and northern Peace River Districts surveyed for snow mold diseases of winter cereals.

Dextrose Agar (+HPDA) or acidified Corn Meal Yeast Extract Agar (+HCMMY), and incubated at 0.5°C for 4 weeks. The identity of fungi was confirmed by microscopic examination, or by the presence of characteristic structures such as sclerotia or protopycnidia on affected plant parts.

Results and discussion

The majority of the winter wheat or fall rye fields surveyed were seeded into fallow or worked forage fields. The practice of underseeding winter cereals by simultaneously planting it with barley, wheat, or canola in the spring, harvesting the spring crop in the late summer, and harvesting the winter wheat the following crop year, was common in the latter years of the survey. Fields in which winter wheat was seeded into standing stubble were infrequently encountered.

The non-sclerotial form of C. ***psychromorbidus***, the low temperature basidiomycete (LTB), was the most prevalent snow mold encountered in isolations from diseased winter wheat seeded into fallow fields (Table 1). It was observed in all three regions but was most prevalent in the Peace River Districts. The disease was often characterized by a white cottony mycelium which covered the leaves after snow melt (Fig. 2). When the outer leaf sheaths were removed from the plant, white plaques were often visible along the length of the stem (Fig. 3). When the disease was especially severe, crowns disintegrated and plants were easily pulled from the soil without attached roots. In a winter wheat field east of High Level, circular white mycelial mats were scattered over the soil surface (Fig. 4); similar mats have been observed in the same region on red fescue (***Festuca rubra*** L.). Smaller, denser mats were observed in winter wheat and fallow fields, and appeared independent of the presence of plant material. In light infestations, the cottony mycelium was visible on small groups of plants scattered throughout the field, whereas in severe infestations, the groups coalesced and the disease became generalized throughout the field. Circular patches of infected plants were sometimes visible. The disease was usually most severe in those areas where snow accumulated near windrows of trees, or where the snow became compacted such as under tire tracks.

The cottony mycelium was not always present on diseased plants; isolations on artificial media were necessary to confirm the presence of the LTB fungus. Occasionally, plants that appeared green and healthy soon after snow melt subsequently turned yellow and died. LTB was the predominant fungus isolated from the stems and crowns of these plants.

Cottony snow mold infection appeared closely associated with mortality of the plants sampled during the survey. This disease was especially destructive in the Peace River Districts where 30-50% of the winter wheat fields surveyed were subsequently ploughed under. Fall rye appeared to be more resistant to cottony snow mold infection than winter wheat, but plant mortality exceeding 50% was observed. The disease was common in fields which had been continuously cropped to spring cereals and oilseeds; however, a field which had recently been cleared of trees and had no history of crop production also had damaging levels of cottony snow mold in the fall rye crop. The LTB fungus was observed on annual, biennial, and perennial weeds and grasses (Fig. 5), and on canola, wheat, and grass stubble. Cormack (3, 4) demonstrated that numerous weed, ornamental, and native plant species were susceptible to the cottony snow mold fungus. The prevalence of LTB in surveyed fields which had never been cropped to winter cereals or forages may be due to its wide host range. Consequently, control of this disease through rotation to a spring crop may not be effective.

The presence of the cottony mycelium was not characteristic of winter cereal plants infected with the SLTB form of C. ***psychromorbidus***. Symptoms of SLTB infection consisted of yellow or brown discoloration of the crown, and the presence of small dark spherical or elongate sclerotia embedded in leaf sheath and crown tissues (Fig. 6).

The SLTB fungus was infrequently recovered from diseased plants and it caused slight mortality in winter cereals in central Alberta (Table 1). In the Peace River Districts, SLTB sclerotia were commonly observed on decaying leaves (Fig. 7) of deciduous trees sampled from fields, seeded to winter wheat or left fallow, and on lawn grasses; subsequent isolations confirmed the presence of the SLTB form. However, SLTB was isolated only once from diseased winter cereals (Table 1) in the Peace River Districts.

Table 1. Summary of survey results for snow molds on winter wheat and fall rye during April, 1983-87.

Region	No. fields surveyed	Number of fields with LTB	SLTB	*S. borealis*	*Plenodomus meliloti*	*Pythium* spp.
1983						
Central Alberta	2	0	0	0	2	1
Southern Peace River	7	6	0	0	6	2
Northern Peace River	0	–	–	–	–	–
1984						
Central Alberta	1	1	0	0	1	0
Southern Peace River	2	1	0	0	2	1
Northern Peace River	6	4	0	0	6	5
1985						
Central Alberta	11	1	2	0	5	2
Southern Peace River	14	9	0	1	3	1
Northern Peace River	6	4	0	1	2	1
1986						
Central Alberta	7	1	2	0	5	3
Southern Peace River	10	8	0	3	1	1
Northern Peace River	6	4	0	1	2	1
1987						
Central Alberta	19	9	2	0	10	7
Southern Peace River	10	7	0	2	2	2
Northern Peace River	7	6	1	0	7	0
1983-87						
Central Alberta	40	12(30)*	6(15)	0	23(57)	13(37)
Southern Peace River	43	31(72)	0	6(13)	14(30)	7(16)
Northern Peace River	25	20(80)	0	2(8)	17(68)	7(28)
All Regions (1983-87)	108	63(58)	6(5)	8(7)	54(50)	27(25)

* Figures in brackets represent the percentage of fields in which the fungus was observed.

Traquair and Smith (16) reported the occurrence of SLTB on leaves and twigs of deciduous trees from central Alberta and on winter wheat and grasses. The reason for the common occurrence of SLTB on leaf and tree litter but not on winter cereals in the central and northern Peace River Districts is unknown but may be due to the weak pathogenicity of SLTB isolates to winter cereals at the low soil temperatures which prevail in northern Alberta. Traquair and Smith (16) and Gaudet (7) reported that SLTB isolates exhibited lower pathogenicity than LTB isolates. Gaudet (7) demonstrated that the optimal temperature for some SLTB isolates was above 0.5°C whereas LTB isolates were highly pathogenic at temperature3 between -8 and -3°C. McBeath (11) observed the SLTB form of C. ps*ychromorbidus* on winter cereals in Alaska.

Plants infected with S. ***borealis.*** the snow scald pathogen, were bleached in appearance with a white appressed mycelium covering the leaves and stems. Conspicuous black sclerotia were common on the leaf surface (Fig. 8). This pathogen was not encountered in central Alberta and was infrequently observed on winter cereals, but was prevalent on golf greens throughout the Peace River District. Snow scald was frequently observed on winter cereals in central and northern Alberta prior to 1983 (L. Piening, J.G.N. Davidson, personal communication). Low incidence of snow scald in the last 5 years may be due to the relatively low average snow fall during this period. Snow scald develops best under a deep and persistent snow cover (8).

Pink snow mold, caused by ***G. nivalis,*** was only observed in two winter cereal fields in 1986 located east of Fort St. John, B.C., although the fungus was commonly observed on grasses in all years throughout the survey area. Damage attributed to this fungus was light. Distinct salmon-pink circular patches were visible (Fig. 9). Pink snow mold has been reported previously to cause damage on winter cereals in Alberta (9) and Alaska (11).

Plenodomus meliloti, which causes a root and crown rot in sweet clover and alfalfa (14), was frequently isolated from winter cereals (Table 1). The occurrence of protopycnidia on the surface of the roots and crown was also diagnostic for ***P. meliloti*** (Fig. 10). Results from experiments conducted under controlled environmental conditions have failed to demonstrate pathogenicity of P. ***meliloti*** on healthy winter wheat plants (Gaudet, unpublished). Possibly, this fungus develops in plants which have been injured or killed by environmental stresses such as low temperature or ice encasement.

The ***Pythium*** species commonly isolated from the crown regions of winter cereals were P. ***ultimum*** Trow and ***P. volutum*** Vanderpool and Truscott. Neither species was associated with a characteristic symptom on winter cereals. ***Pythium iwayamai*** causes a snow rot of winter wheat in the northwestern United States (9). ***Pythium ultimum*** has been reported nonpathogenic to winter wheat but may invade root and leaf tissues without causing a snow rot (10). ***Pythium volutum*** has been associated with a root rot of wheat in Ontario (1). However, fungicides specific to water mold fungi have been shown to be effective in increasing winter wheat yields (5). These fungi may play a role in reducing winter survival and yields of fall sown cereals and require further investigation.

Underseeded winter cereals. The stems and crowns of winter wheat or fall rye which had been underseeded with spring cereals or canola, appeared soft and decayed when examined the following spring. Estimates of plant mortality based on reports from district agriculturalists and producers ranged from 10 to 80%. In 14 fields surveyed in 1986 and 1987, incidences of the LTB fungus, P. ***meliloti,*** and ***Pythium*** spp. were all less than 20%. ***Cochliobolus sativus*** (Ito and Kurib.) Drechs. and ***Fusarium*** spp. were more frequently isolated from decayed plant parts. Consequences of early planting of winter wheat include the increase of snow mold resistance (2), and the decrease of freezing resistance (6). The lower incidence of snow mold fungi may be due to enhanced snow mold resistance which develops in older plants. The practice of underseeding winter wheat would also be conducive for the buildup of large populations of the wheat curl mite, ***Aceria tulipae*** Kiefer, the vector of wheat streak mosaic virus. It is possible that the winter mortality was due to the lower levels of freezing resistance which developed in underseeded winter wheat and that the fungi isolated from decayed plant parts were saprophytes or weak parasites invading damaged or dead tissues. Further studies are required to identify the role of plant parasites and winter injury in the poor winter survival of underseeded winter wheat.

Acknowledgements

The authors wish to thank J.G.N. Davidson, J. Dobbs, J.C. Clayton and L. Piening for their assistance in this survey.

Literature cited

1. Barr, D.S. and J.T. Slykhuis. 1976. Further observation on zoosporic fungi associated with wheat spindle streak mosaic virus. Can. Plant Dis. Surv. 56:77-81.
2. Bruehl, G.W. 1982. Developing wheats resistant to snow mold in Washington State. Plant Dis. 66: 1090-1095.
3. Cormack, M.W. 1949. Winter crown rot or snow mold of alfalfa, clovers, and grasses in Alberta. I. Occurrence, parasitism, and spread of the pathogen. Can. J. Res. C. 26:71-85.
4. Cormack, M.W. 1952. Winter crown rot or snow mold of alfalfa, clovers, and grasses in Alberta. Can. J. Bot. 37:685-693.
5. Davidson, J.G.N. 1983. Efficacy of fungicides for control of snow molds of winter wheat in 1981-82. Pesticide Research Report. Expert Committee on Pesticide Use in Agriculture p. 309.
6. Fowler, D.B. and L.V. Gusta. 1977. Influence of fall growth and development on cold tolerance of rye and wheat. Can. J. Plant Sci. 57:751-755.
7. Gaudet, D.A. 1986. Effect of temperature on pathogenicity of sclerotial and non-sclerotial isolates of ***Coprinus psychromorbidus*** on winter wheat under controlled conditions. Can. J. Plant Pathol. 8:394-399.
8. Jamalainen, E.A. 1949. Overwintering of Graminae-plants and parasitic fungi. I. ***Sclerotinia borealis.*** Maat. Aikak. 21: 125-142.
9. Lebeau, J.B. 1968. Pink snow mold in southern Alberta. Can. Plant Dis. Surv. 48: 130-131.
10. Lipps, P.E. and G.W. Bruehl. 1978. Snow rot of winter wheat in Washington. Phytopathology 68: 1120-1127.
11. McBeath, J.H. 1985. Pink snow mold on winter cereals and lawn grasses in Alaska. Plant Dis. 69:722-723.
12. McKenzie, J.W. 1976. Alfalfa cold hardiness - a complex problem. Northern Res. Group Agric. Can. No. 76-14. pp. 1-11.
13. Pomeroy, M.K., C.J. Andrews and G. Fedak. 1975. Cold hardening and dehardening responses in winter wheat and winter barley. Can. J. Plant Sci. 55:529-535.
14. Sanford, G.B. 1932. A root rot of sweet clover and related crops caused by ***Plenodomus meliloti***. Can. J. Res. C. 8:337-348.
15. Smith, J.D. 1985. Snow molds of winter cereals: Guide for diagnosis, culture, and pathogenicity. Can. J. Plant Pathol. 3:15-25.
16. Traquair, J.A. and J.D. Smith. 1982. Sclerotial strains of ***Coprinus psychromorbidus,*** a snow mold basidiomycete. Can. J. Plant Pathol. 4:27-36.

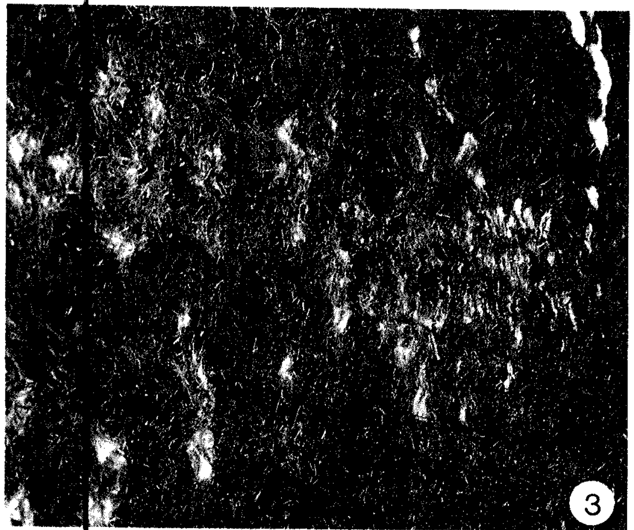
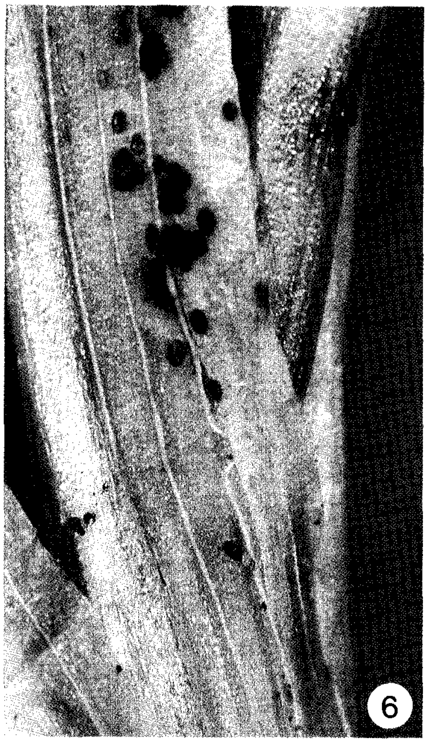
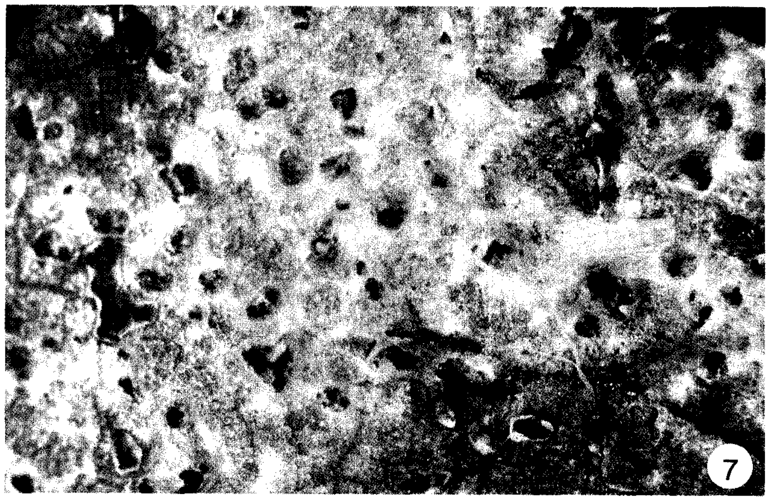


Figure 2. Winter wheat plants infected with the LTB form of cottony snow mold.
Figure 3. Mycelial mats of the LTB form of cottony snow mold in a winter wheat field.
Figure 4. Mycelial plaques of the LTB form of cottony snow mold in a fall rye stem.
Figure 5. Dandelion (*Taraxacum officinale* Weber) infected with the LTB form of cottony snow mold.





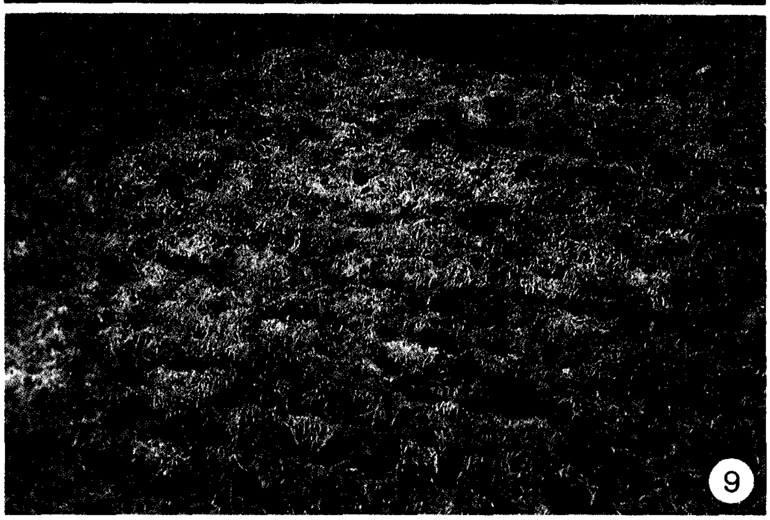


Figure 6. Sclerotia of the SLTB form of cottony snow mold on the leaf sheath of a winter wheat plant.
Figure 7. Sclerotia of the SLTB form of cottony snow mold on a poplar leaf.
Figure 8. Sclerotia of *S. borealis* on fall rye.
Figure 9. A pink snow mold patch in a field of fall rye.
Figure 10. Protopycnidia of *P. meliloti* on the crown and roots of winter wheat.