Canadian Plant Disease Survey

Inventaire des maladies des plantes au Canada

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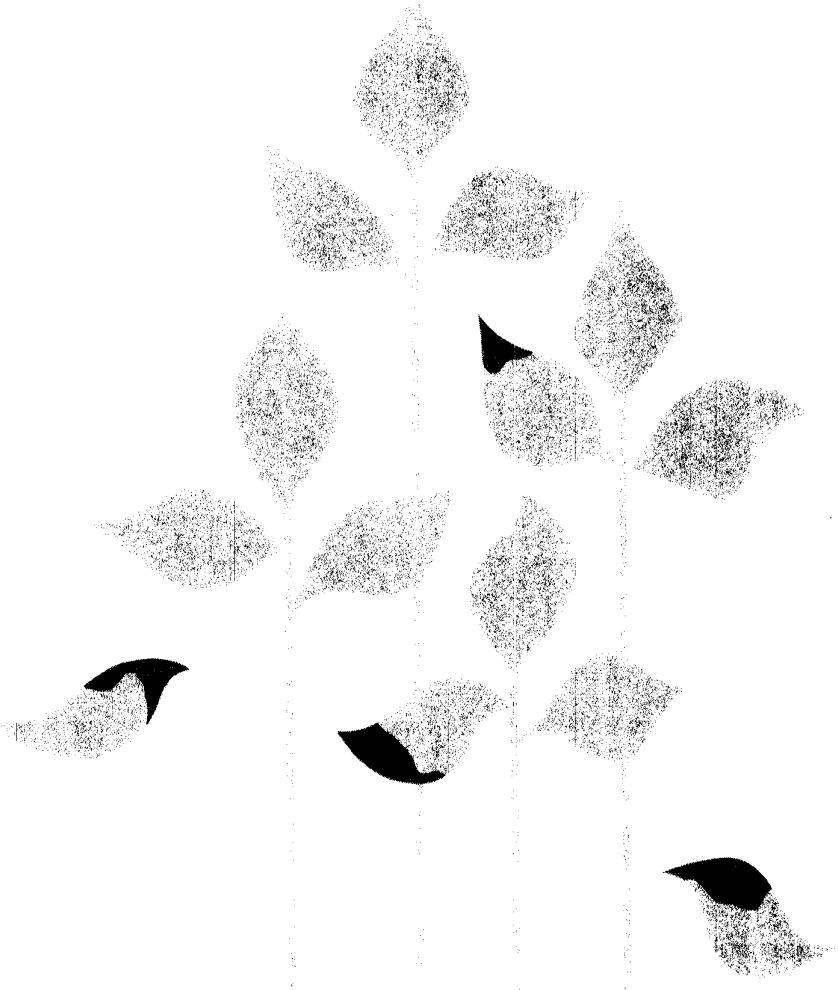

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CONTENTS

The *Canadian Plant Disease Survey* is a periodical of information and record on the occurrence and severity of plant diseases in Canada and on the assessment of losses from disease. Other original information such as the development of methods of investigation and control, including the evaluation of new materials, will also be accepted. Review papers and compilations of practical value to plant pathologists will be included from time to time.

L'inventaire des maladies des plantes au Canada est un périodique d'information sur la fréquence des maladies des plantes au Canada, leur gravité, et les pertes qu'elles occasionnent. La rédaction accepte d'autres communications originales notamment sur la mise au point de nouvelles méthodes d'enquête et de lutte ainsi que sur l'évaluation des nouveaux produits. De temps à autre, il inclut des revues et des synthèses de rapports d'intérêt immédiat pour les phytopathologistes.

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Lettuce Disease Survey in New Brunswick, 1986

Lynda Rankin[1]

Field lettuce (*Lactuca sativa* L.) is produced on approximately 12 ha in the southeast of New Brunswick. The most important varieties are Ithica, Queen Crown and Calmar (heading types), and Valmaine, Signal and Paris Cos Island (romaine types). Harvest is staggered from July to October through sequential transplanting and direct seeding. Only minimal efforts are made to manage disease and insect problems. The most important diseases in 1986 were grey mould (*Botrytis cinerea* Pers.), bottom rot (*Rhizoctonia solani* Kuhn.), drop or white mould (*Sclerotinia sclerotiorum* (Lib.) de By.), tip burn (a physiological disorder), aster yellows (a mycoplasma vectored by the *Macrosteles fascifrons* Stal. species complex) and downy mildew (*Bremia lactucae* Regel.). Low levels of mosaic virus were also found throughout the survey period. Economic loss from most of these diseases did not warrant control. Aster yellows vector control is already used. Gray-mold control is recommended for early season transplant crops. Downy mildew control is recommended for late season crops with spraying based on monitoring for the presence of the pathogen.

Can. Plant Dis. Surv. 67:2, 25-30, 1987.

La laitue des champs (*Lactuca sativa* L.) est cultivée sur approximativement 12 ha dans le sud-est du Nouveau-Brunswick. Les variétés les plus importantes sont: Ithica, Queen Crown et Calmar (Pomme), et Valmaine, Signal et Paris Cos Island (Romaine). La récolte s'étend de juillet à octobre grâce à une transplantation continue et au semis direct des graines. On consacre des efforts minimums pour la gestion des problèmes de maladies et d'insectes. Les maladies les plus importantes en 1986 furent la moisissure grise (*Botrytis cinerea* Pers.), la pourriture basale (*Rhizoctonia solani* Kuhn.), l'affaissement sclérotique (*Sclerotinia sclerotiorum* (Lib.) de By.), la brûlure de la pointe (un désordre physiologique), la jaunisse (un mycoplasme transmis par le complexe des espèces de *Macrosteles fascifrons* Stal.) et le mildiou (*Bremia lactucae* Regal.). On a détecté une faible présence du virus de la mosaïque tout le long de la saison. Les pertes économiques dûes à la plupart de ces maladies ne justifient pas leurs contrôle. On effectue déjà le contrôle du vecteur de la jaunisse. On recommande le contrôle de la moisissure grise pour les transplants des récoltes hâtives. On recommande le contrôle du mildiou pour les récoltes tardives en se basant pour traiter sur la présence du pathogène.

Introduction

Field lettuce (*Lactuca sativa* L.) production in New Brunswick consists of approximately 12 hectares in the southeast part of the province. The total value of the crop is approximately $160,000. This area, with a sandy loam soil, has a frost free period of approximately 130 days, 1600 — 1800 annual degree days above 5°C, and from May to September, 400 mm of precipitation.

Both iceberg or heading type lettuce (vars. Ithica, Queen Crown and Calmar) and romaine lettuce (vars. Valmaine, Signal and Paris Cos Island) are grown, with iceberg being the predominant type. The lettuce harvest is staggered through the use of sequential plantings of direct seeded and transplant crops, providing continuous harvest from July to October. Only minimal efforts are made to manage insect and disease problems occurring in the crop.

Prior to 1986 no studies had been done to determine the extent of yield loss in the crop due to disease. In answer to this a disease survey was conducted throughout the summer of 1986 to determine both the type of disease present and their effect on marketable yield.

Methods

The survey was conducted by inspecting the majority of commercial lettuce fields in the designated areas when they were 50-70% harvested. In each field three rows were randomly selected and within each row the number of healthy plants was determined. All harvested heads (evident by the remaining stem) were presumed healthy. Diseased heads, usually left standing in the row, but also those cut and discarded between the rows, were diagnosed on the basis of symptoms and when evident, by the signs of the pathogen. Type specimens of each disease, and plants exhibiting unusual symptoms were periodically returned to the lab and examined microscopically to confirm field diagnosis. At the time of rating the average number of plants per row was determined, as well as an estimate of field size. This information was combined with the data from each of the three rows rated to obtain an estimate of the total number of plants exhibiting the symptoms of each disease found in the field. For each sampling date these total numbers of each disease for each field were then added to determine an average percent disease (fig. 1 & 2). For the season disease totals (fig. 3 & 4) estimates of the numbers of diseased plants from each field as well as total plant numbers were summed for the entire season before being converted to percentage thereby accounting for variable production levels on the different sampling dates.

Lettuce drop can be incited by either *Sclerotinia sclerotiorum* (Lib.) de By., or *S. minor* Jagger. According to Purdy (1979) these two species can be differentiated on the basis of sclerotial size. During the course of this survey sclerotia were col-

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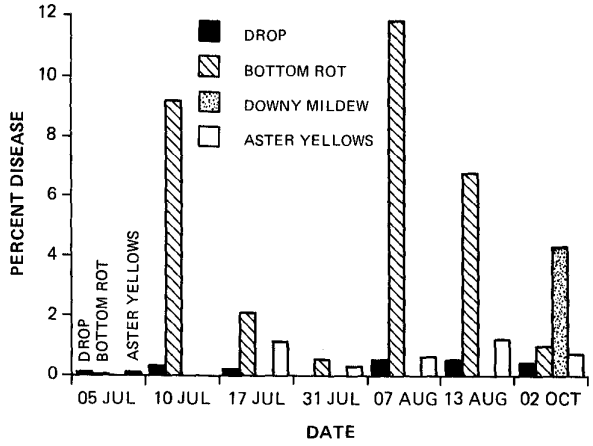


Figure 1. Iceberg lettuce percent disease by survey date.

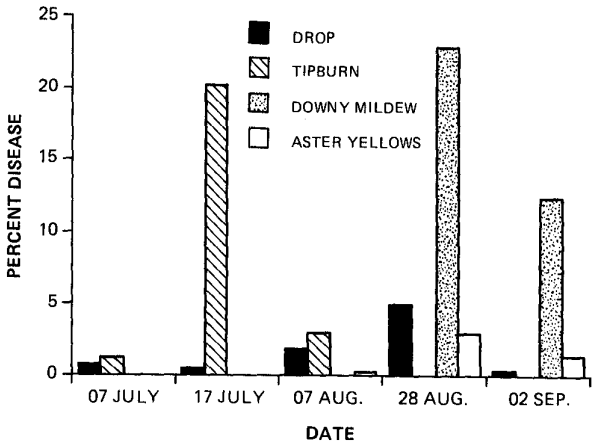


Figure 2. Romaine lettuce percent disease by survey date.

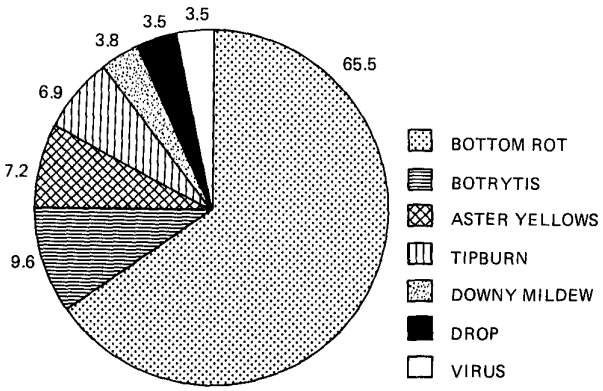


Figure 3. Iceberg lettuce disease type as a percent of total disease.

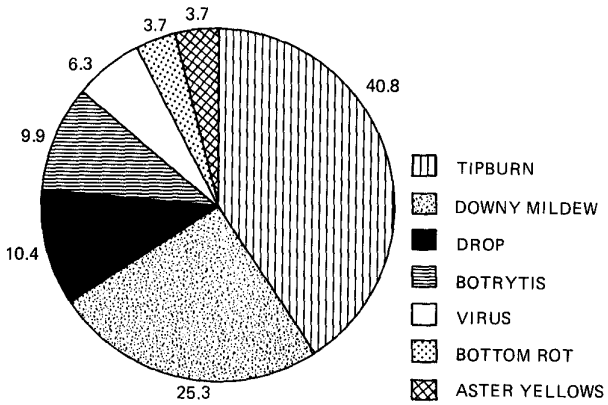


Figure 4. Romaine lettuce disease type as a percent of total disease.

lected off lettuce plants exhibiting drop to determine which species was the causal organism of drop in New Brunswick.

In addition, throughout the survey period the aster leafhopper (*Macrosteles fascifrons* Stal.) population was monitored at six sites surrounding the lettuce fields. Leafhoppers were collected with a sweep net, using a standardized pattern of ten sweeps while walking ten steps through each site. Sampling was done at each site on a weekly basis. Capture values for the six sites were averaged for each date.

Results and discussion

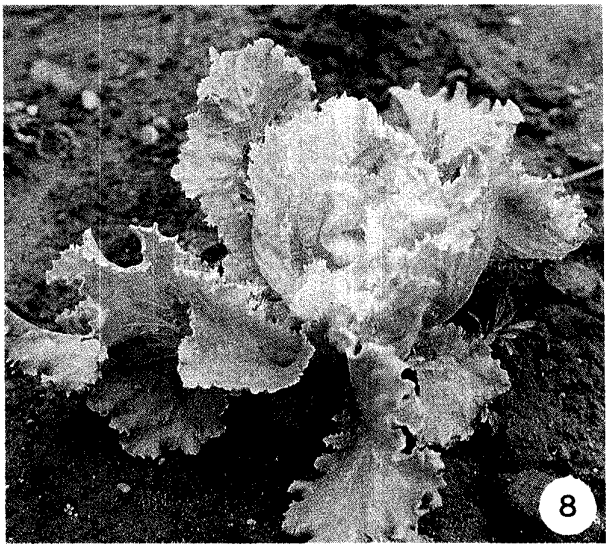
Botrytis cinerea Pers. (*Botryotinia fuckeliana*) (de By.) Whet., a weak parasite attacking dead and damaged plant tissue, was found infecting lettuce plants at all stages of growth.

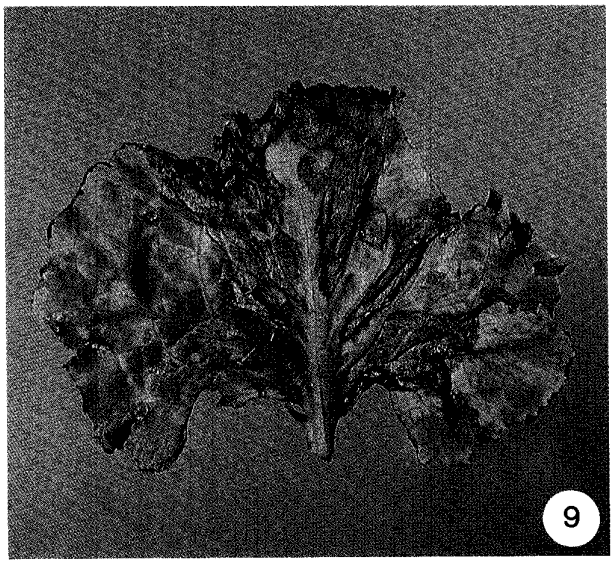
The greatest loss from *Botrytis* sp. occurred on the early season transplants. Greenhouse grown plants which were hardened outside in a cold frame and inadvertently frost damaged and then returned to the greenhouse, were then infected with *Botrytis* sp. Many young plants in the field were also infected with *Botrytis* sp. following frost damage. For two fields rated for early season transplant infection of this type, it was found that this damage resulted in 2 and 11% loss.

Low levels of this disease were found in fields of mature romaine and head lettuce throughout the growing season, often associated with damage such as tipburn. When these plants were encountered during field rating the damage was attributed to the primary pathogen when possible.

The results presented in figures 1 and 2 represent data from twenty nine lettuce fields and summarize four of the diseases with the highest incidences observed on head and romaine lettuce respectively.

Bottom rot (*Rhizoctonia solani* Kuhn.) was the most destructive disease on head lettuce and resulted in considerable losses. The greatest incidence was found on August 7, following a period of heavy rain. At that time yield losses of 9.7% occurred on surveyed fields and resulted in some fields being abandonned prior to complete harvest. These abandonned fields were not surveyed. Bottom rot is favored by warm and humid or wet conditions (Pieczarka, 1975). The first symptoms are discrete, somewhat depressed lesions on the midribs





5. Lettuce drop – *Sclerotinia sclerotiorum*
6. Bottom rot – *Rhizoctonia solani*
7. Tipburn
8. Aster yellows
9. Downy mildew – *Bremia lactuca*

and petioles of the outer wrapper leaves. Under favorable conditions these lesions expand causing a wet black rot that involves the entire head (fig. 5). In drier conditions the lesions develop but the extensive head decay does not occur (Pieczarka, 1975). As *R. solani* is common in soil, this could account for the low levels of the disease in other time periods. Heads with small lesions would possibly have been harvested and the damaged wrapper leaves removed. *R. solani* losses were negligible on romaine lettuce throughout the summer. It was only noted on two dates; August 7 and August 28, but in both cases the yield loss was found to be less than 1%.

Yield losses attributed to lettuce drop or white mold (*Sclerotinia* sp.) in head lettuce were always found to be below 1%. In romaine, levels reached over 5% loss on August 28.

Sclerotia collected from both head and romaine lettuce ranged in size from 1-22 mm with a mean size of 5.5 mm. This exceeds the size range for *Sclerotinia minor* but falls within the 1 to 30 mm range of *S. sclerotiorum* (Purdy, 1979). Sclerotia produced by *S. minor* were obtained from lettuce in one field within the survey area. This field also had high levels *S. sclerotiorum*. *S. minor* had not been recorded in Canada prior to 1984 when it was found in Southwestern Ontario (Jarvis, 1985).

Two distinct sets of symptoms caused by *Sclerotinia* sp. were found. The normal symptoms associated with drop is where the wrapper leaves wilt and lie flat on the ground, followed by collapse of the head (fig. 6). In the second type of drop found, in head lettuce only, the head did not collapse but remained erect. The outer leaves of the head lost turgidity and eventually became dry and papery. Profuse white mycelium characteristic of *Sclerotinia* sp. could be found in the heart region of such heads. Occasionally sclerotia ranging from 1 to 7 mm were found in decayed tissue of plants with these symptoms.

Yield loss due to tipburn (fig. 7) reached 20.2% on romaine lettuce when summer temperatures approached their maximum, but was less than 1% on head lettuce. In fields of romaine lettuce where the topography was uneven, the greatest incidence of tipburn corresponded with areas of greatest slope. A lower incidence was observed in field depressions perhaps reflecting the availability of soil moisture.

The lettuce growers in the survey area periodically sprayed the crop for control of the aster yellows (fig. 8) vector *Macrosteles fascifrons* Stal. Low levels of aster yellows were found in both romaine and head lettuce throughout the survey period. Since the decision to spray was not based on a monitoring system but rather on individual grower observation of *M. fascifrons* in his fields, no statements can be made regarding the effect the spray had on levels of aster yellows found. Levels of aster yellows in unsprayed fields have been reported to range from 78% in Prince Edward Island (Thompson, 1965) to 5.8% of plants infected in Ontario (Stevenson and Knibbe, 1979). In a lettuce variety trial established by the C.D.A. in Southeastern New Brunswick, aster yellows infection ranged from 0 to 3% (Agriculture Canada, 1986).

Leafhoppers were collected in the survey area between June 20 and September26. *M. fascifrons* was present in all samples, the maximum capture averaged for all sites being 8.6 leafhoppers/10 sweeps on July 7.

Downy mildew (*Bremia lactuca*) (fig. 9) began appearing in late crops coinciding with dropping temperatures. It was first noted on romaine lettuce on August 28 resulting in yield losses of 23%. It also caused considerable damage to the October 2 romaine and head lettuce crop. Downy mildew was found to cause considerable damage on head lettuce (var. Ithica) in Ontario. Damage ranged form 68.5 to 89% of plants with outer leaves infected and 1.8 to 23% of plants with inner leaves infected (Bruin and Edgington, 1978, 1979).

Low levels of a mosaic virus were also found in fields of head and romaine lettuce throughout the survey period.

Conclusions

Most diseases occurring in the New Brunswick lettuce crop in 1986 did not have incidences high enough to warrant the recommendation of control procedures.

Figures 3 and 4 show each disease occurring in the lettuce throughout the survey period as a percent of total disease in head and romaine lettuce respectively. The most serious disease in head lettuce was bottom rot (fig. 3). This disease can be controlled throught the use of a protectant fungicide, but further study is required to determine if this course of action would be economically feasable. The most serious disease on romaine lettuce was tip burn (fig. 4). Possibly this high occurrence resulted from over maturity of the lettuce prior to harvest. It should also be noted that the majority of the loss occurred on one harvest date, July 17, when summer temperatures approached their maximum. Timely harvesting of the romaine lettuce, prior to maturity, during this time period would reduce losses of this type.

Downy mildew was the most prevalent disease on romaine lettuce and was also a significant problem on head lettuce on one sampling date. Head lettuce was not being harvested on the sampling dates when the high losses on romaine occurred. This indicates that head lettuce being harvested during late August and September in subsequent years would have the potential for significant losses to occur. Control is therefore recommended for downy mildew in late summer and fall crops of both types of lettuce, with fungicide spraying based on grower monitoring for disease.

Preventive control of *Botrytis* sp. in the early season transplants is also suggested as the control is inexpensive and the potential for loss at this stage is great.

Acknowledgement

The author wishes to thank Kelvin Lynch for his valued advice during the course of this survey.

Literature cited

1. Agriculture Canada. 1986. Herve J. Michaud Experimental Farm, Buctouche, N.B., Research Report.
2. Bruin, G.C.A. and L.V. Edgington. 1978. Fungicidal control of downy mildew of lettuce. Pesticide Research Report, Agriculture Canada.
3. Bruin, G.C.A. and L.V. Edgington. 1979. *Ibid.*
4. Jarvis, W.R. 1985. *Sclerotinia minor* as the cause of lettuce drop in southwest Ontario. Can. Plant Dis. Surv. 65:7.

5. Pieczarka, D.J. and J.W. Lorbeer. 1975. Microorganisms associated with bottom rot of lettuce grown on organic soil in New York State. Phytopathology 65:16-21.
6. Purdy, L.H. 1979. *Sclerotinia sclerotiorum*: History, diseases and symptomology, host range, geographic distribution, and impact. Phytopathology 69:875-880.
7. Stevenson, A.B. and E.N. Knibbe. 1979. Control of aster yellows in lettuce with insecticides to control the vector, aster leafhopper, *Macrosteles fascifrons* (Stal.). Pesticide Research Report, Agriculture Canada.
8. Thompson, L.S. 1965. Aster yellows control in head lettuce and carrots in Prince Edward island. J. of Econ. Ent. 58:135-137.

Effects of *Cylindrocladium gracile, Fusarium roseum* and *Plenodomus meliloti* on crown and root rot, forage yield, and winterkill of alfalfa in north-eastern Alberta

S.F. Hwang[1] and G. Flores[2]

A field trial was conducted to compare the effects of three soil-borne pathogens on the incidence of crown and root rot, forage yield and winter survival of alfalfa. *Cylindrocladium gracile, Fusarium roseum* and *Plenodomus meliloti* were applied alone and in combination to test plots. There was no significant difference in fresh and dry matter yields among the treatments. Disease severity was significantly less in the control plots than in the treated plots. All treated plots were assessed an average disease severity rating of moderate. Percent winterkill in the plots inoculated with a combination of the three fungi was not significantly different than that of the other treatments except *F. roseum* alone.

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Un essai au champ a été fait pour comparer les effets de trois pathogènes du sol sur l'incidence de la pourriture du collet et de la racine, sur le rendement en fourrage et sur la survie en hiver de la luzerne. *Cylindrocladium gracile, Fusarium roseum* et *Plenodomus meliloti* ont été appliqués seul et en combinaison sur des parcelles expérimentales. Les rendements en poid frais et en matière sèche n'ont pas montré de différence significative entre les traitements. La sévérité de la maladie était significativement moins importante dans les parcelles témoins que dans celles traitées. L'on a estimé la sévérité de la maladie à modérée dans toutes les parcelles traitées. Le pourcentage de perte dû à l'hiver n'était pas significativement différent entre les parcelles inoculées avec les trois pathogènes et les autres traitements, exception faite, de celles inoculées avec *F. roseum.*

Introduction

The complex nature of crown and root deterioration in alfalfa is a product of an interaction of biological and environmental stress factors (3,5,14). In Alberta, crown and root rot has become a major limiting factor in the production of alfalfa two to three years after establishment (4). From surveys in central Alberta, *Cylindrocladium gracile* Bugn. (Boesew.) and *Fusarium roseum* (LK.) emend. Snyder and Hansen were recovered most frequently from three- and four-year old alfalfa with crown and root rot (3,8). Brown root rot, caused by *Plenodomus meliloti* Mark.-Let., was also frequently observed in the fields (2,3,10). This indigenous fungus, which causes symptoms that are most common in alfalfa early in the spring, infects dormant and semidormant alfalfa.

Many forms of stress in nature may interfere with the hardening process and reduce alfalfa's full cold hardiness potential (6). In Alberta, winter survival is critical for the successful production of alfalfa. Evidence that diseases predispose alfalfa to winterkill is increasing (9,12,13). Undoubtedly, the cold hardiness potential of alfalfa after infection by *C. gracile, F. roseum* or *P. meliloti* would be considerably reduced, mainly because there is a reduction of food reserves in the rotted crown (11). This study was undertaken to determine the effect of these three soil-borne fungi alone and in all possible combinations on the incidence of crown and root rot and forage yield of alfalfa, and to determine their possible role in winterkill.

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Materials and methods

Experimental plots were established in the spring of 1983 at the Alberta Environmental Centre, Vegreville. Eptam® EC was incorporated in the soil at a rate of 4.5 L/ha as a pre-emergence herbicide along with 90 kg/ha of monoammonium phosphate (11-51-0), 20kg/ha of potash (0-0-60) and 19 kg/ha of elemental sulphur (0-0-0-90). Eight treatments were arranged in a randomized complete block design with six replicates (Table 1). Each plot consisted of four 6 m rows spaced 30 cm apart. Treatments were spaced 1 m apart and replicates 2.5 m. Seeds of alfalfa (*Medicago sativa* L.) cv. Beaver were seeded at 8 kg/ha and peat-based inoculant was used as a source of root-nodule bacteria. Due to poor stand establishment, gaps in rows were reseeded in the fall of 1983.

The substrate for fungus inoculum consisted of a mixture of rye, oats and distilled water which was autoclaved for 2 hrs. at 121°C in 2 L Erlenmeyer flasks. Suspensions of *C. gracile, F. roseum* and *P. meliloti*, grown on PDA in 9 cm culture plates and macerated in sterile water were added to the grain, once the flasks cooled. Autoclavable bags were filled with a mixture of rye, oats and distilled water and autoclaved as mentioned above. Infested grain from the Erlenmeyer flasks was used as a source of inoculum for further multiplication in the bags. During the summer of 1984, 9 kg of inoculated grain was incorporated into each plot. The treatments consisted of either a single fungus or a combination of fungi (Table 1). Sterilized grain without a fungus was used as a control.

Fresh and dry matter yields in each plot were recorded twice from the two centre rows in both 1984 and 1985. In the spring of 1986, winterkill was determined by counting the number of plants in the two middle rows of each plot without green shoots. Twenty randomly selected plants in total from the outside rows of each plot were dug up and the roots

Table 1. Inoculation Treatments.

Treatment Codes	Treatments	Amt. of inoculum/plot
C	*C. gracile*	9 kg
F	*F. roseum*	9 kg
P	*P. meliloti*	9 kg
C + F	*C. gracile* + *F. roseum*	4.5 kg + 4.5 kg
C + P	*C. gracile* + *P. meliloti*	4.5 kg + 4.5 kg
F + P	*F. roseum* + *P. meliloti*	4.5 kg + 4.5 kg
C + F + P	*C. gracile* + *F. roseum* + *P. meliloti*	3 kg + 3 kg + 3 kg
Control	Sterilized grain only	9 kg

Table 2. Effects of *C. gracile*, *F. roseum* and *P. meliloti* on crown and root rot, forage yield and winterkill of alfalfa.

Treatment	Fresh Weight (kg)		Dry Weight (kg)		% Winterkill	Disease Severity[X]
	1984	1985	1984	1985		
C	11.80a[Y]	7.37a	4.37a	2.58a	45.0ab	2.07b
F	10.57a	6.80a	4.07a	2.37a	28.3bc	2.43ab
P	10.93a	8.40a	4.17a	2.82a	40.6ab	2.53a
C + F	11.30a	7.81a	4.37a	2.71a	42.8ab	2.10b
C + P	11.65a	8.47a	4.33a	3.00a	41.7ab	2.53a
F + P	10.91a	7.13a	4.16a	2.46a	50.0a	2.37ab
C + F + P	12.13a	7.14a	4.48a	2.43a	47.2a	2.23ab
Control	10.79a	7.08a	4.14a	2.41a	15.6c	1.27c

X Scores assigned: 0 = clean; 1, 2 and 3 = slight, moderate and severe crown and root rot, respectively.
Y Values in a column followed by the same letter are not significantly different (P = 0.05)

bisected longitudinally to assess the severity of crown and root rot. Severity scores assigned were 0, no disease; 1, slight; 2, moderate; 3, severe. ANOVA and Duncan's Multiple Range tests were used to statistically analyze the data on disease severity, forage yield, and percent winterkill.

Fungi were isolated and identified from ten randomly selected plants from plots inoculated with the mixture. One hundred pieces of crown and upper tap root tissue from the ten plants were surface disinfested in 0.6% sodium hypochlorite for 2 min., rinsed in sterile water, blotted dry and plated on acidified PDA (3.0 ml sterile 85% lactic acid per L of medium). After incubation for two weeks in darkness at 5°C, the plates were examined and all fungi identified.

Results

There were no significant differences (P=0.05) in fresh and dry matter weights of alfalfa from the various treatments in 1984 and 1985 (Table 2). Forage yields were not collected from the three-year-old stand in 1986 because of severe winter injury. Non-inoculated plots had significantly less winterkill than the inoculated plots. Winterkill in the plots inoculated with a mixture of the three fungi did not differ significantly from the other treatments except for *F. roseum* alone.

Disease severity was significantly less in the control plots than in the mixtures or singly pathogen-treated plots. All treated plots were assessed an average disease severity rating of moderate (2.07 to 2.53). *F. roseum* was most frequently isolated from diseased plant tissue; *P. meliloti* was recovered with moderate frequency and *C. gracile* was recovered with low frequency.

Discussion

Successful fungal colonists need great independence and phenotypic plasticity (1). The chlamydospores of *F. roseum* can germinate and retreat into chlamydospores if conditions become unfavorable, which gives it greater survival capability. *C. gracile* and *P. meliloti* have no such retreat mechanism; there are no replacements if the hyphae die. These two fungi have a much lower competitive saprophytic ability compared to *F. roseum*. Moreover, the broad tolerance to temperature changes of *F. roseum* undoubtedly contributes to its high frequency of isolation (4).

Pathogens had no apparent effect on forage yields, either singly or in combination in the first two years. The ability of alfalfa to survive the winter depends, in part, on the storage of adequate food reserves in the roots and crowns during the fall (7). The presence of any one or a combination of the pathogens increased the percent of winterkill three years after establishment. This increased winterkill may have been the result of reduced food reserves due to pathogen infection prior to the winter. Parasitized plants may not compete well in spring and this may also lead to reduced food reserves. Additional research would be useful to determine how the presence of crown and root rot fungi on alfalfa in early spring or in late fall influences the degree of alfalfa stand survival. The development of disease-resistant cultivars offers the best possibility for controlling crown and root rot of alfalfa. At present, all recommended cultivars of *M. sativa* are susceptible to crown and root rot (4).

Acknowledgement

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Literature cited

1. Bruehl, G.W. 1976. Management of food resources by fungal colonists of cultivated soils. Ann. Rev. Phytopathol. 14:247-264.
2. Cormack, M.W. 1934. On the invasion of roots of *Medicago* and *Melilotus* by *Sclerotinia* sp. and *Plenodomus meliloti*. Can. J. Res. 11:474-480.
3. Cormack, M.W. 1937. *Cylindrocarpon ehrenbergi* WR., and other species, as root parasites of alfalfa and sweet clover in Alberta. Can. J. Res. 15:403-424.
4. Hawn, E.J., W.B. Berkenkamp, and J.B. Lebeau. 1981. Evaluation of losses in alfalfa hay production caused by crown rot. Can. J. Plant Pathol. 3:103-105.
5. Leath, K.T. and W.A. Kendall. 1978. Fusarium root rot of forage species: pathogenicity and host range. Phytopathology 68:826-831.
6. McKenzie, J.S. and G.E. McLean. 1980. Some factors associated with injury to alfalfa during the 1977-1978 winter at Beaverlodge, Alberta. Can. J. Plant Sci. 60:103-112.
7. McKenzie, J.S. and G.E. McLean. 1984. A field test for assessing the winter hardiness of alfalfa in northwestern Canada. Can. J. of Plant Sci. 64:917-924.
8. Reeleder, R.D. 1982. Fungi recovered from diseased roots and crowns of alfalfa in north central Alberta and the relationship between disease severity and soil nutrient levels. Can. Plant Dis. Surv. 62:21-27.
9. Richard, C., C. Willemot, R. Michaud, M. Bernier-Cardou and Gagnon, C. 1985. Low-temperature interactions in Fusarium wilt and root rot of alfalfa. Phytopathology 72:293-297.
10. Sanford, G.B. 1933. A root rot of sweet clover and related crops caused by *Plenodomus meliloti* Dearness and Sanford. Can. J. Res. 8:337-348.
11. Stelfox, D. and M. Bertsch. 1983. Low-temperature fungi associated with alfalfa root and crown rot in central Alberta. Can. Plant Dis. Surv. 63:7-11.
12. Tu, J.C. 1980. Incidence of root rot and overwintering of alfalfa as influenced by rhizobia. Phytopathol. Z. 97:97-128.
13. Tu, J.C. and T.M. Holmes. 1980. Effect of alfalfa mosaic virus infection on nodulation, forage yield, forage protein and overwintering of alfalfa. Phytopathol. Z. 97:1-9.
14. Turner, V. and N.K. Van Alfen. 1983. Crown rot of alfalfa in Utah. Phytopathology 73:1333-1337.

Snow mold diseases and their distribution on winter wheat in Ontario in 1982-84[1]

E.F. Schneider and W.L. Seaman

Field surveys in 1982-84 showed that damage from snow mold fungi occurred chiefly within three areas of white winter wheat production in southern Ontario. The most frequently occurring pathogens were *Microdochium nivale* var. *nivale*, *Typhula incarnata*, *T. ishikariensis* var. *ishikariensis*, and *T. phacorrhiza*. *Myriosclerotinia borealis* occurred only near the northern limit of production, and *T. ishikariensis* var. *canadensis* was found only once. Most fields were affected by more than one of the pathogens. During the winter, *M. nivale* was first isolated in mid December from naturally infected plants and from fall-inoculated plants in the field. *T. incarnata* was first isolated in mid January, and *T. ishikariensis* var. *ishikariensis* and *T. phacorrhiza* in mid March. Damage from snow mold occurred in 25% of fields examined in 1982 and 1984, with losses of up to 80%, averaging 12-15% each year. In 1983 a persistent snow cover was lacking in many areas throughout most of the winter, resulting in only isolated incidences of snow mold damage. All four snow mold fungi were widely distributed and mixed infections of two or more were common within fields and on individual plants.

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Des inventaires aux champs en 1982-84 ont démontré que les dommages causés par les moisissures nivales sont répartis principalement dans trois régions productrices de blé d'hiver du sud de l'Ontario. Les pathogènes les plus répandus sont *Microdochium nivale* var. *nivale*, *Typhula incarnata*, *T. ishikariensis* var. *ishikariensis* et *T. phacorrhiza*. *Myriosclerotinia borealis* ne croît qu'à la limite septentrionale de production et *T. ishikariensis* var. *canadensis* n'a été identifié qu'une seule fois. La plupart des champs contenait plus d'un pathogène. Durant l'hiver, *M. nivale* a été isolé pour la première fois à la mi-décembre, à partir de plants infectés naturellement et de plants inoculés à l'automne. L'on a isolé pour la première fois *T. incarnata* à la mi-janvier et *T. ishikariensis* var. *ishikariensis* ainsi que *T. phacorrhiza* à la mi-mars. 25% des champs examinés en 1982 et 1984 montraient des signes de dommage causés par la moisissure nivale, avec des pertes moyennes annuelles de 12 à 15% pouvant aller jusqu'à 80% dans certains cas. En 1983, l'absence d'une couche de neige au sol pour une grande partie de l'hiver dans plusieurs régions a eu pour conséquence une incidence très faible de dommage dûe à la moisissure nivale. Les quatre organismes responsables de la moisissure nivale avaient une distribution étendue et des infections de deux de ces organismes ou plus étaient choses courantes dans les champs et sur les plants individuels.

Introduction

In Canada soft white winter wheat production is centered in southern Ontario, with about 80% being produced in the southwestern counties of Lambton, Essex, Kent and Huron. In that area and elsewhere abiotic stresses such as low temperature, flooding, desiccation and ice encasement during winter and early spring have an adverse effect on winter survival. In parts of Huron, Simcoe and other counties where snow cover is more persistent, biotic stresses during winter are caused chiefly by snow mold fungi. During 1980-1984 disease surveys and inoculation tests were undertaken to determine the extent of damage from snow mold diseases and to isolate and identify the causal fungi.

Materials and methods

Disease surveys of field-grown winter wheat were carried out in fall, winter and spring. During October-December, plants were collected at 3-week intervals from experimental plots and commercial fields within 100 km of Ottawa to determine whether fungal pathogens were associated with visible plant injury. In all three survey periods, plants also were collected from a naturally infested snow mold plot in a field near Hyndford in Renfrew Co. During the winter, from early December to snow melt, samples were collected at 4-week intervals from fields to determine the time of infection by snow mold fungi. These observations were supplemented with data from an experiment using inoculated plants (Schneider and Seaman, 1986). Fiber pots (20 cm diam.) containing a sterilized greenhouse soil mix were seeded to winter wheat, *Triticum aestivum* L. cv. Fredrick (25 seeds/pot, 2cm deep). A 1 cm deep layer of white silica sand was added to the soil surface of each pot and laboratory-produced inoculum (Table 1) was mixed into the sand. Inoculum consisted of sclerotia of *Typhula incarnata*, *T. ishikariensis* var. *ishikariensis*, *T. phacorrhiza*, and *Myriosclerotinia borealis*, produced on rye seed substrate (Smith, 1981); inoculum of *Microdochium nivale* var. *nivale* included a mixture of mycelium, conidia, and rye seed substrate. The pots were maintained in a greenhouse for germination and early plant growth and then transferred outdoors for hardening. In late November, the pots were placed in a field plot with about 2 cm of the rims above the soil surface and the plot was enclosed by snow fence to maintain snow cover. Permanent snow cover in 1983 began on 3 December and melt occurred on 15-16 April 1984. At intervals pots were retrieved for sampling of plant tissues and original inoculum and then placed in a greenhouse to observe regrowth of the plants. Tissues were examined microscopically for signs of colonization and were plated on agar medium with or without surface sterilization as described for field samples.

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Table 1. Pathogenic fungi and their frequency of isolation from winter wheat plants during the fall (mid October to early December).

Pathogen	No. of isolates
Fusarium tricinctum (Corda) Sacc.	4
F. graminearum (Schwabe)	2
F. avenaceum (Fr.) Sacc.	1
F. equiseti (Corda) Sacc.	1
F. moniliforme Sheldon	1
F. oxysporum Schlecht	1
Cylindrocarpon sp.	2
Phoma sp.	2
Stemphyllium sp.	1
Acremonium strictum W. Gams	1
Alternaria sp.	1
Cladosporium sp.	1
Helminthosporium sp.	1
Verticillium sp.	1

During the spring surveys, from mid April to early May, commercial winter wheat fields were assessed for snow mold damage. Fields were examined in all winter wheat growing areas of southern Ontario except the Niagara Peninsula and the southwestern counties of Essex, Kent and Elgin, which were found to be relatively free from snow mold damage in preliminary surveys in 1980 and 1981. In 1983, warm weather in January resulted in the loss of snow cover throughout the survey area and damage from snow mold fungi was uncommon. During the spring surveys, on-site visual estimates were made of the percentage of field area damaged by snow molds.

In each field, samples were taken from symptomless plants, from plants showing leaf necrosis, and from necrotic plants. Preliminary identificaiton of snow mold fungi was based on the presence of sclerotia or sporodochia on necrotic tissues. The samples were kept cool and dry until examined in the laboratory. Sclerotia and pieces of tissue from leaves and crowns were sterilized in 70% ethanol for 1 minute, washed three times in sterile distilled water and plated onto potato-sucrose- agar (PSA) or an antibiotic medium (Schneider and Seaman, 1986). The plates were maintained in the dark at 12°C and hyphal tips from the colonies were subcultured onto PSA for identification.

Observations and discussion

The snow mold pathogens associated with damage to winter wheat were *Typhula incarnata* Lasch ex Fr.; *T. ishikariensis* Imai var. *ishikariensis* Arsvoll and Smith; *T. phacorrhiza* Reichard ex Fries; *Myriosclerotinia borealis* (Bub. and Vleug.) Kohn; and *Microdochium nivale* (Fries) var. *nivale* Samuels and Hallett (Syn. *Gerlachia nivalis* (Ces. ex Sacc.) Gams and Müller var. *nivalis, Fusarium nivale* Ces. ex. Sacc.).

Annually various types of injury including chlorosis, discoloration or necrosis of leaves, crowns and subcrown internodes were observed on winter wheat plants during the fall. The amount of injury varied considerably but plant necrosis was rare. Plant-pathogenic fungi were isolated from only 4% of 500 plants showing some degree of necrosis of leaf, crown or subcrown internode tissues (Table 1). Six species of *Fusarium* were isolated from the plants, the most common ones being *F. tricinctum* and *F. graminearum*; *F. avenaceum, F. equiseti, F. moniliforme*, and *F. oxysporum* were isolated from one plant each. Of more than 50 other fungi isolated, only 8 were considered to be potential plant pathogens (Table 1); however none was tested for pathogenicity. Bruehl *et al.* (1966) reported isolating a large number of fungi from injured tissues, including four of the *Fusarium* spp. isolated here, but none was pathogenic in tests at low temperature. Snow mold fungi were not isolated from plants sampled before snow cover. In Japan Matsumoto and Araki (1981) isolated *T. iskikariensis* and *T. incarnata* from non-surface-sterilized leaves but not from surface sterilized leaves of meadow fescue and perennial ryegrass prior to a persistant snow cover. In Belgium Detiffe *et al.* (1981) isolate *T. incarnata* in November from winter barley growing in inoculated field plots. This is apparently the earliest that *T. incarnata* has been reported from plants under natural conditions and, in part, may be due to an adaptation of the pathogen to the mild climate in that region.

During the winter, marked differences were observed in the times at which the snow mold fungi were first isolated from plants in the naturally infested snow mold plot, and these results generally were in agreement with those from the pot experiment (Table 2). In mid December *M. nivale* var. *nivale* was first isolated from plants that were watersoaked and dark green in appearance, and by mid January 96% of the inoculated plants failed to produce new growth when moved to a greenhouse. Plants inoculated with *M. nivale* var. *nivale* that were collected from under snow cover between January and mid April had dark green, water soaked leaves, with sporodochia of the fungus on the surface. However the typical pink color associated with this disease (Smith, 1981; McBeath, 1985) developed only in plants in the field following snow melt. The leaf spot symptom caused by *M. nivale* var. *nivale* (Smith, 1981) was observed occasionally in the field following snow melt but was not seen in inoculated plants. One isolate of *M. nivale* var. *major* from a lawn grass was used in the inoculation tests but it was not recovered from the plants, and plant survival was equal to that of the uninoculated control. This pathogen was not found on winter wheat in Ontario.

T. incarnata was first isolated from inoculated and naturally infected plants in mid January (Table 2), and 98% of the inoculated plants collected in mid February failed to produce new growth in the greenhouse. Both *T. ishikariensis* var. *ishikariensis* and *T. phacorrhiza* were first isolated in mid March, and at snow melt a month later 96% and 97%, respectively, of the inoculated plants were dead. Plants inoculated with each of the three *Typhula* species were symptomless when the *Typhula* spp. were first isolated but in each case watersoaked leaves with newly formed sclerotia were observed on plants sampled one month later. Symptoms were similar to those described for the typhula snow molds on winter cereals (Smith, 1981; Schneider and Seaman, 1986) but were not as clearly defined as symptoms on plants in the field at snow melt.

The role of temperature, moisture and snow cover in initiating colonization and infection by snow mold fungi is not clear. In Japan *T. incarnata* colonized tissues before snow cover but was first isolated from surface-sterilized tissues of meadow fescue and perennial ryegrass after 6-8 weeks of snow cover,

Table 2. Plant survival and inoculum viability in the field following inoculation with snow mold fungi; plants and inoculum were sampled at monthly intervals following seeding and inoculation in pots in October and placement in the field on November 25.

Pathogen	Time of first isolation from plants	Plant Survival in spring (%)	Inoculum survival (%)[a] December	March
Uninoculated control		96		
Typhula incarnata	Jan	2	84	80
T. ishikariensis var. *ishikariensis*	Mar	4	86	78
T. phacorrhiza	Mar	3	88	84
Myriosclerotinia borealis	b	96	90	64
Microdochium nivale				
var. *nivale*	Dec	4	100	0
var. *major*	b	93	100	0

a Inoculum was sclerotia of *Typhula* spp. and *M. borealis* produced on rye seed, and rye seed colonized by *M. nivale*. Survival = average of values recorded each month from December to March for the *Typhula* spp. and *M. borealis; M. nivale* inoculum was recovered only in the December samples.

b *M. borealis* and *M. nivale* var. *major* were not isolated from plants.

in late January to early February (Matsumoto and Araki, 1981). The good agreement between the times of first isolation of *T. incarnata* observed here and in Japan may be related to the period that the plants were under a snow cover, about 6 weeks and 6-8 weeks respectively. The duration of snow cover also is an important factor in the overall incidence and severity of snow mold diseases in the USA (Bruehl *et al.*, 1966), but the role of snow cover may be much less important in determining when some snow mold pathogens become active in regions where the fall and winter climate is less severe. Above-freezing mean monthly temperatures and lack of a persistent snow cover (Arlery, 1970) in the region of Belgium where *T. incarnata* affects winter barley (Dentiffe *et al.*, 1981) suggests that the role of snow cover may be indirect. Perhaps in areas of Canada, Japan, Scandinavia and the USA that have a colder fall and winter climate than in Belgium a snow cover is necessary to maintain suitable temperatures for growth of the pathogens at the soil surface. The rarity of snow mold in Ontario in 1983 may have been due to the low soil temperatures that prevailed on the bare soil surface. A snow cover-temperature relationship also may be required in regions with cold winter climates for germination of *Typhula sclerotia*. The results in Table 2 show that the viability of sclerotia of all three *Typhula* species remained high (84-88%) throughout the winter months. Germinated sclerotia were first recovered from the soil at the same sampling times that the respective pathogen was first isolated from inoculated plants, and at each subsequent sampling 12-20% of the sclerotia recovered showed signs of germination.

In each species germination of sclerotia was myceliogenic, except that 12% of *T. incarnata* sclerotia had short (less than 2 mm) immature sporophore-like outgrowths at each sampling date. In contrast, in Belgium, where germination of sclerotia of *T. incarnata* in the field was 28% in November and 100% by early December, germination up to early December was myceliogenic, but by late December all of the sclerotia recovered had produced sporophores (Detiffe *et al.*, 1981). In this study and in the one in Belgium (Detiffe *et al.*, 1981) the *Typhula inoculum* consisted of laboratory-produced sclerotia; whether similar experimental results would be obtained with naturally produced sclerotia is unknown. In this study, germinated sclerotia of *T. ishikariensis* var. *ishikariensis* and *T. phacorrhiza* were not found until the March sampling, 2 months later than for *T. incarnata* sclerotia. In Japan *T. ishikariensis* was not isolated from grasses during the winter but sclerotia were found on plants occasionally after snow melt (Matsumoto and Araki, 1982). *T. phacorrhiza* has been regarded as a saprotroph but recently it was shown to be pathogenic on winter wheat at several locations in Ontario (Schneider and Seaman, 1986).

Myriosclerotinia borealis was isolated from several fields near the northern limit of winter wheat production (areas A and C, Fig. 1) in Ontario (Schneider and Seaman, 1987). One isolate of *M. borealis* was used in the pot experiment, but none of the test plots became infected under the conditions of the test and none of the sclerotia recovered from the pots showed signs of having germinated. However viability of sclerotia of *M. borealis* recovered from the pots was 90% in December and 64% in March (Table 2).

During previous spring surveys in 1980-81 Seaman (unpublished) observed that although abiotic injury to winter cereals was common throughout Ontario, counties in the southwest appeared to be relatively free of damage from snow mold

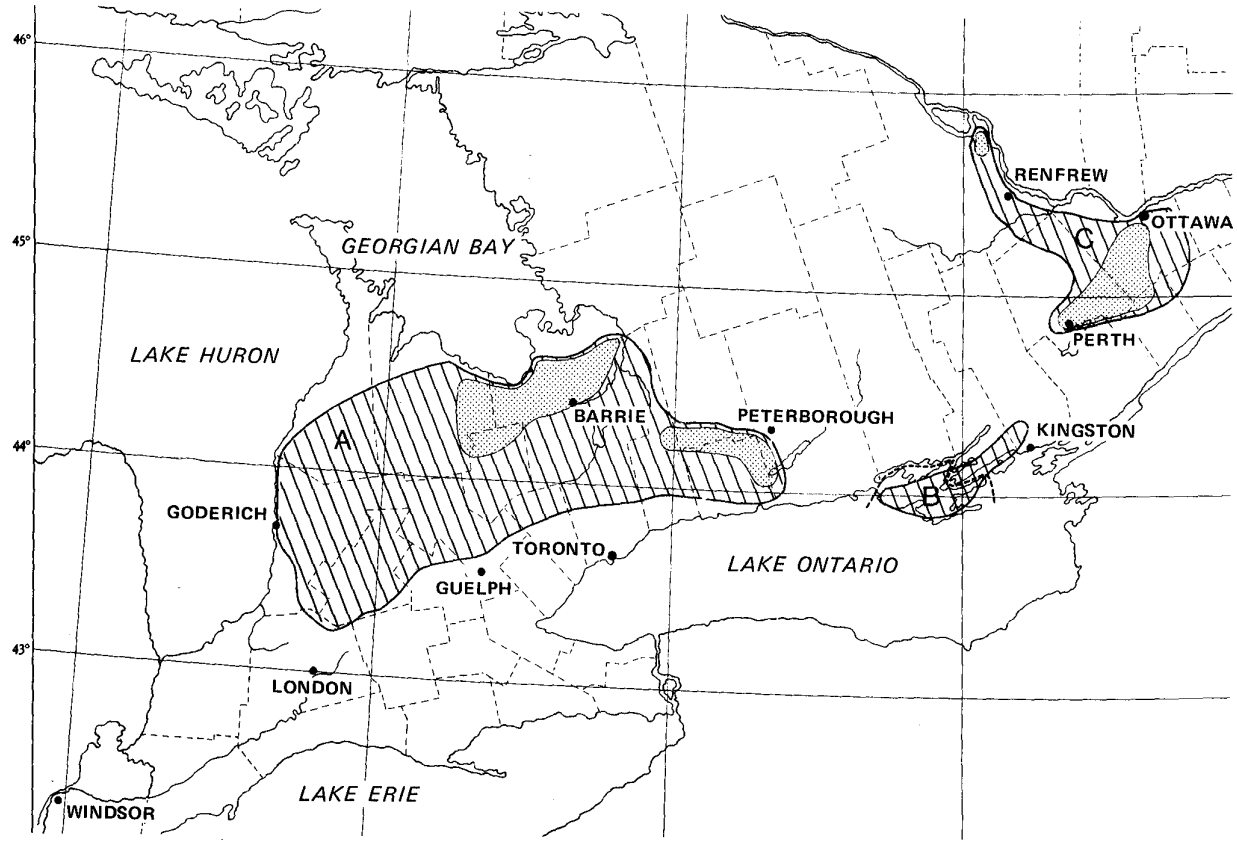

Figure 1. Snow mold region of southern Ontario (Areas A, B and C). Stippled areas represent centers of higher incidence examined in 1981-84.

fungi, with damage observed in only 3 of 212 fields in Essex and Kent counties. In the 1982 and 1984 surveys snow mold damage was observed in 109 of 418 fields. For convenience, the snow mold region is shown in Figure 1 as three distinct areas, with stippling indicating locations of highest incidence. The southern boundary of the snow mold regions approximates the lines for 2700-2900 corn heat units (CHU) (Ontario Ministry of Agriculture and Food, 1985). Area A (Fig. 1) extends northward to about 2500 CHU and includes the 2300-2500 CHU zone in Dufferin, Grey, and Wellington counties. Area B is essentially on the 2900 CHU line, while Area C extends from about 2500 to 2700 CHU. These three areas lying between 43° and 46° latitude are those in which snow mold damage has been found most years; damage from snow mold fungi has been found on wheat outside these areas, but both prevalence and severity have been low, with few cases of economic loss encountered.

The three *Typhula* spp. and *M. nivale* were observed on plants throughout the snow mold region, and most of the fields were affected by two or more of these pathogens. The northern limit for snow mold activity is unknown at present; all five snow mold pathogens involved in southern Ontario were isolated from test plots of winter wheat grown in 1984 at the Agriculture Canada Experimental Farm at Kapuskasing (latitude 49°25′) in northeastern Ontario. A limited production of hard red winter wheat occurs in the Rainy River District of northwestern Ontario, but snow mold surveys have not been carried out in that area. Within the snow mold region described here, plant mortality in individual fields varied from a trace (less than 2%) to over 80%, with an estimated average annual plant loss of 12-15%. This estimate does not include other variables that have an adverse role in winter wheat production. For example when plant stands are reduced by 30% or more many fields are disked in early spring and sown to spring crops. Similarly little is known of the effects of different patterns of snow mold damage, which may vary from a thinning of plants throughout a field in which snow cover was uniform to conspicuous areas of complete killing where terrain or other factors result in snow drifts which persist for lengthy periods during snow melt, thus extending the period of pathogen activity (Bruehl *et al.*, 1966).

During the period of these surveys, the soft white winter wheat cultivar Fredrick comprised more than 80% of the fields. However snow mold fungi were also observed in fall-seeded fields of other white wheat cultivars, red wheat, barley, triticale, rye, and winter rape. In all of the cereal crops the symptoms observed after snow melt were as described by Smith (1981) on winter cereals in western Canada.

Other snow mold fungi reported on winter wheat and rye in western Canada include *T. ishikariensis* var. *canadensis* Smith and Arsvoll and *Coprinus psychromorbidus* Redhead and Traquair, formerly known as LTB (Smith, 1981). In Ontario *T. ishikariensis* var. *canadensis* occurs on turf grasses in the area

around Guelph and Barrie (Fushtey, 1980) and was isolated from wheat plants grown in one field near Ottawa in 1984. *Coprinus psychromorbidus* was not observed during these surveys.

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Literature cited

1. Arlery, R. 1970. The climate of France, Belgium, The Netherlands and Luxembourg. Pages 135-160 *in* C.C. Wallen, ed. World Survey of Climatology. Vol. 5, Elsevier Publishing Co. Amsterdam-London-New York.
2. Bruehl, G.W., R. Sprague, W.R. Fischer, M. Nagamitsu, W.L. Nelson and O.A. Vogel. 1966. Snow molds of winter wheat in Washington. Agric. Exp. Stn. Wash. State Univ. Bull. 677:1-21.
3. Detiffe, H., H. Maraite and J.A. Meyer. 1981. Evolution de l'infection de *Typhula incarnata* Lasch ex. Fries sur escourgeon en Belgique. Med. Fac. Landbouwiw. Rijksuniv. Gent. 46:841-849.
4. Fushtey, S.G. 1980. Chemical control of snow molds in bentgrass turf in southern Ontario. Can. Plant Dis. Surv. 60:25-31.
5. McBeath, J.H. 1985. Pink snow mold on winter cereals and lawn grasses in Alaska. Plant Dis. 69:722-723.
6. Matsumoto, N. and T. Araki. 1982. Field observations of snow mold pathogens of grasses under snow cover in Sapporo. Res. Bull. Hokkaido Nat. Agric. Exp. Sta. 135:1-10.
7. Ontario Ministry of Agriculture and Food. 1985. Ontario field crop recommendations. OMAF Publ. 296. Toronto.
8. Schneider, E.F. and W.L. Seaman. 1986. *Typhula phacorrhiza* on winter wheat. Can. J. Plant Pathol. 8:269-276.
9. Schneider, E.F. and W.L. Seaman. 1987. Occurrence of *Myriosclerotinia borealis* on winter cereals in Ontario. Can. Plant Dis. Surv. 67:1-2.
10. Smith, J.D. 1981. Snow molds of winter cereals: guide for diagnosis, culture and pathogenicity. Can. J. Plant Pathol. 3:15-25.

Prevalence and severity of sclerotinia stalk rot of tobacco on Prince Edward Island, 1985 and 1986

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Survey results showed that the prevalence of sclerotinia stalk rot of tobacco increased from 40% of fields in 1985 to 76% in 1986. Infection levels were relatively low in 1985 at 1% of the total plants surveyed, increasing to 6.1% in 1986. Relative severity varied widely, from slight symptom expression to dead plants. On a rating scale of 0 to 10 (disease free to severe) the severity on diseased plants ranged from 1 to 10 with a mean rating of 3.7. Yield losses in some fields were estimated to be as high as 10%.

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Les résultats d'une enquête ont montré que la prévalence du pourridié sclérotinien de la tige du tabac a augmenté de 40% des champs en 1985 à 76% en 1986. Le niveau d'infection relativement bas en 1985, 1% des plants examinés, a augmenté jusqu'à 6.1% en 1986. La sévérité relative de la maladie variait beaucoup allant de symptômes légers jusqu'à la mort des plants. Sur une échelle de 0 à 10 (sain à sévère) la sévérité de la maladie variait de 1 à 10 sur les plants atteints avec une moyenne de 3.7. Les pertes de rendement dans certains champs ont été estimées jusqu'à 10%.

Introduction

Flue cured tobacco (*Nicotiana tabacum* L.) is an important cash crop on Prince Edward Island, particularly in the eastern portion of the Island where approximately 1500 ha. are grown on sandy loam soils. Tobacco producers on Prince Edward Island had reported a *Botrytis* sp. infection problem on the lower stalk regions which was causing premature leaf fall and in advanced stages stem breakage. A survey was undertaken in 1985 to determine the incidence and severity of botrytis stalk rot.

The survey indicated that the problem producers were experiencing was being enhanced and confused with sclerotinia stalk rot. While *Botrytis* sp. infections were occurring it appeared that sclerotinia stalk rot may have been the more serious of the two diseases. *Sclerotinia sclerotiorum* (Lib.) de Bary incited stalk rot (rattle box) has been recorded on flue-cured tobacco in Ontario but it was not considered at the time to be a serious problem (3). To determine the extent of sclerotinia stalk rot on Prince Edward Island a two year survey was instigated.

Methods

Tobacco fields in the main production area on Prince Edward Island were randomly selected. Ten fields were surveyed in 1985 and 17 in 1986. Incidence was recorded in 1985 and 1986, while severity was also rated in 1986. For severity a 0 to 10 scale was used; zero indicated no visible symptoms, a rating of 5 designated plants with lesions approximately 5 cm in length or which girdled the stem, leaves often appeared wilted at this point, a rating of ten indicated plants which were dead.

After proceeding 10 paces into the field, ten consecutive plants were each assessed for sclerotinia stalk rot. Further samples were taken on a regular basis, approximately 30 to 50 m between samples, while following a capital letter 'M' configuration through the field, on several of the smaller fields on inverted 'V' configuration was used. A total of at least 100 plants were rated for disease in each field. The period of assessment was during the mid to late harvest period, after the bottom leaves had already been removed.

Results and discussion

Sclerotinia stalk rot of tobacco was characterized by canker like lesions which formed at the base of the stalk and occasionally at the point of attachment for lower leaves. The lesions were tan to black in colour with a white mycelial mass often present. Lesion margins were a darker colour than the central portion. Black sclerotial bodies were present on the surface and when the stalks were split open the pith region would often contain sclerotial bodies. Sclerotia were of various sizes with the largest being 5×20 mm. Leaves on infected plants often appeared wilted and yellow to dead. Symptom expression tended to be most evident at the time of harvesting, however indications of early infections were found. In the more severly infected fields gaps in plant stand and the presence of sclerotial bodies where plants should have been indicated their possible loss to early *Sclerotinia* infection.

In 1985 the severity of sclerotinia stalk rot was relatively low on individual plants and was not rated. While severity was not rated in 1985, sclerotinia stalk rot was found in 40% of the fields surveyed (Table 1). This increased to 76% of fields surveyed in 1986. The incidence of sclerotinia stalk rot also increased dramatically from 1985 to 1986. In 1985 a total of 1% of the plants rated demonstrated symptoms of *S. sclerotiorum* infection. Sclerotinia stalk rot increased to 6.1% of plants surveyed in 1986 with up to 20% in one of the fields surveyed. The mean severity rating for diseased plants was 3.7 but ranged as high as a rating of 10 (plants dead).

The increased incidence and severity in 1986 when compared to 1985 may have been a reflection of high moisture and cool temperatures during July 1986 when compared to 1985 and the 77 year averages (Table 2). Apothecia of *S. sclerotiorum*

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Table 1. Prevalence, incidence and severity of sclerotinia stalk rot of tobacco on Prince Edward Island, 1985 and 1986.

	Year	
	1985	1986
Number of fields surveyed	10	17
Prevalence *	4	13
Incidence **		
Mean	1	6.1
Range	0 – 4	0 – 20
Severity ***		
A) On all fields surveyed		
Mean	–	0.3
Range	–	0 – 1.3
B) On all infected plants		
Mean	–	3.7
Range	–	1 – 10

* Prevalence – number of fields with at least one plant with sclerotinia stalk rot
** Incidence – Percent of plants with sclerotinia stalk rot
*** Severity on a 0 – 10 scale, disease free to severe (plants dead)

Table 2. Mean monthly temperatures and total precipitation on Prince Edward Island in 1985 and 1986, as measured at the Charlottetown Research Station.

		Year		
		1985	1986	77 yr. avg.
Total precipitation (mm)	June	163.6	78.4	77.9
	July	26.2	148.2	78.7
	August	90.4	71.6	86.5
Mean daily temp. (°C)	June	14.1	13.4	14.8
	July	19.7	16.5	18.9
	August	17.9	17.7	18.5

are not found during dry weather but have been found to be associated with heavy rains within one week prior to their formation (1). From the weather data for P.E.I. it would appear that the higher than normal rainfall in July of 1986 may have stimulated apothecia production and hence spore release to a greater extend than in 1985. If stalk infection is related to plant maturity, as has been indicated for leaf infection (2,5) the high moisture levels in June of 1985 may have resulted in the major apothecial development and spore release being in advance of availability of host material at a suitable level of maturity for infection.

Hartill indicated that *S. sclerotiorum* ascospores were trapped only when apothecia were found near the trap, indicating the source of inoculum was most likely the field itself (1). Avoiding infected fields is recommended given the relationship between spores released and number of sclerotia formed in the previous crop (4). In 1986 sclerotinia stalk rot was high in fields which were in rotation with non-susceptible hosts such as cereals however the length of the rotations may have been insufficient to satisfactorily reduce the density of sclerotia in the soil.

While disease loss assessments were not undertaken in the current survey, it was evident that sclerotinia stalk rot on P.E.I. could result in significant yield losses, and possible quality effects. Low severity levels did not appear to severly affect the plant. Moderate infections (ratings of 3 to 5) did decrease the plants ability to stand in the field. Infected plants were often found broken over, or were easily broken at the point of infection indicating reduced wind resistance. Plants damaged in this manner are usually not harvested.

In addition to direct losses due to stem breakage, infection of the lower stalk areas may have reduced the harvestable yield by causing the leaves to wilt and by advancing their maturity. Leaves on infected plants appeared to be more susceptible to *Alternaria* sp. infection.

These factors led to a significant percentage of the plants with sclerotinia stalk rot to be left unharvested even when stalk breakage was not a contributing factor. Several of the surveyed fields in 1986 had mean severity ratings on plants with scletotinia stalk rot that were in excess of 5 and with greater than 15% of the plants in the field exhibiting sclerotinia stalk rot. In these fields yield losses were significant, with an estimated 10% of the plants unharvested. Indirect evidence of early season mortality would indicate a further contributing factor to yield reduction from sclerotinia stalk rot.

One field in 1986, not part of the actual survey, was found to have an infection level of greater than 75%. The field was plowed down shortly after the first leaves were harvested due to poor curing. Direct losses from sclerotinia stalk rot would also have been significant as disease severity was at a level where stem strength was being affected, and wilting was starting to occur. The poorer quality of wilted leaves and the secondary *Alternaria* sp. infection would have precluded their harvest, as would stem breakage. Whether or not the poor curing was related to the sclerotinia stalk rot was not determined, however, the circumstantial evidence would indicate a possible relationship between infection and early leaf maturity.

In the 1986 Prince Edward Island tobacco crop, sclerotinia stalk rot was the most apparent yield limiting disease of those observed during harvest.

Literature cited

1. Hartill, W.F.T. 1980. Aerobiology of *Sclerotinia sclerotiorum* and *Botrytis cinerea* spores in New Zealand Tobacco crops. N.Z. Journal of Agricultural Research 23:259-262.
2. Hartill, W.F.T. and J.M. Campbell. 1977. Effects of leaf maturation on development of the *Sclerotinia/Botrytis* complex of tobacco. N.Z. Journal of Agricultural Research 20:415-420.
3. Gayed, S.K. and M.C. Watson. 1975. Diseases of flue-cured tobacco in Ontario and estimates of disease losses, 1972-73. Can. Plant Dis. Surv. 55:31-35.
4. Hartill, W.F.T. 1978. Controlling sclerotinia and botrytis diseases. N.Z. Tobacco Growers Journal 16:18-19.
5. Hartill, W.F.T. 1975. Germination of *Botrytis* and *Sclerotinia* spores in the presence of pollen on tobacco leaves. N.Z. Journal of Agricultural Research 18:405-407.

Incidence and severity of diseases caused by *Botrytis cinerea, Pythium tracheiphilum,* and *Sclerotinia* spp. on lettuce in Quebec, 1985-1986.

R.D. Reeleder and F. Charbonneau[1]

Disease surveys were carried out in Quebec muck soils in 1985 and 1986 to determine losses caused on lettuce by *Sclerotinia* spp., *Pythium tracheiphilum,* and *Botrytis cinerea.* Losses due to *B. cinerea* (gray mold) averaged 4.6% in 1985 and 3.9% in 1986. Pythium wilt (stunt) resulted in losses of 0.7% in 1985 and 2.4% in 1986. Losses due to *Sclerotinia sclerotiorum* were 0.3% in 1985 and 1.7% in 1986. *S. minor* was found in three fields in 1985 and losses in these fields ranged from 1.7 — 9.5%. Losses in transplanted crops were consistently higher than in seeded crops.

Can. Plant Dis. Surv. 67:2, 45-46, 1987.

Des enquêtes ont été effectuées au Québec en 1985 et 1986 afin de déterminer les pertes causées par *Sclerotinia* spp., *Pythium tracheiphilum* et *Botrytis cinerea* sur la laitue cultivée en sol organique. Les pertes dûes à *B. cinerea* (moisissure grise) étaient en moyenne de 4.6% en 1985 et de 3.9% en 1986. Le nanisme causé par *Pythium* spp., a été responsable de pertes de l'ordre de 0.7% en 1985 et de 2.4% en 1986. Les pertes dûes à *Sclerotinia sclerotiorum* étaient de 0.3% en 1985 et de 1.7% en 1986. *S. minor* était présent dans trois champs en 1985 et les pertes dans ces champs variaient de 1.7 à 9.5%. Les pertes dans les laitues transplantées étaient régulièrement plus élevées que dans celles semées.

Introduction

Lettuce in Quebec is grown primarily on organic (muck) soils and is either direct-seeded or transplanted. Diseases such as downy mildew and gray mold are common and broad-spectrum fungicides are applied regularly by most growers to reduce the severity of these diseases. Observations that some growers were applying additional fungicides aimed at control of lettuce drop, caused by *Sclerotinia sclerotiorum* L., led to surveys in 1985 and 1986 to ascertain the severity and incidence of this and other diseases in Quebec muck soils.

Methods

Commercial lettuce fields located near St-Patrice-de-Sherrington, St-Clotilde, and St-Remi, Quebec, were selected to represent the muck soil region. Twenty-five fields were surveyed in 1985 and ten in 1986. Four sampling sites were selected at random within each field. An individual site consisted of 80 m of row. Plants within each site were assessed weekly and rated for incidence of lettuce drop and stunt (*Pythium tracheiphilum* Matta), and incidence and severity of gray mold (*Botrytis cinerea* Pers.).

Severity of gray mold was rated on a scale of 1 — 5, where 1 = presence of dark brown spots, 3 — 15 mm in length, on basal leaves, but with no conidiophores present; 2 = presence of conidiophores in dark brown spots on basal leaves; 3 = conidiophores in basal leaf spots and lesions but no conidiophores on second level of leaves; 4 = conidiophores visible on lesions on second level of leaves; 5 = widespread rotting of the head. Field observations indicated that plants rated as 4 or 5 in the week prior to harvest were rejected at harvest and, therefore, plants rated at this level of severity one week before harvest were considered as being lost from production. Severity values were not assigned to plants infected by *Pythium tracheiphilum* or *Sclerotinia* spp. since these infections normally resulted in death of the plant. Mean values of incidence and severity for each field were obtained by averaging values from the four sites. Incidence and severity values represent the maximum levels found in each field during a given growing season.

Results and discussion

Loss data for 1985 and 1986 for all diseases are given in Table 1. Incidence values for *Sclerotinia sclerotiorum* were generally quite low in both years. Since infection by *S. sclerotiorum* normally resulted in death of the plant, the losses indicated here represent, to a large degree, the proportion of plants infected. These low values would not justify the cost of a fungicide application aimed specifically at *Sclerotinia sclerotiorum* for most fields. *S. minor* was found in only three fields but, where present, caused considerable losses, up to 9.5% in 1985. It is unclear whether *S. minor* has been recently introduced or has been restricted in distribution in this area for some reason. The spread of this species would have a major impact on lettuce production in the muck soil region.

Of the diseases studied, gray mold caused the greatest losses, despite the application of broad spectrum fungicides on a regular schedule by most growers. Currently, captan and zineb are recommended in Quebec for use on lettuce. Growers generally apply fungicides on a 5 — 7 day schedule, depending upon weather conditions. Improved fungicide application techniques or alternative fungicides would be useful for control of *Botrytis.* Losses in transplanted crops were consistently higher than in seeded crops (Table 1).

Stunt (or wilt) caused by *P. tracheiphilum* was generally more important than Sclerotinia diseases, and in some fields was

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Table 1. Losses in Quebec lettuce fields due to *Pythium tracheiphilum, Sclerotinia* spp., and *Botrytis cinerea,* 1985 – 1986.

Pathogen	Disease	1985 Loss (%)		1986 Loss (%)	
		Mean	Range	Mean	Range
P. tracheiphilum	wilt or stunt	0.7	0 – 6	2.4	0 – 24
Sclerotinia sclerotiorum	drop	0.3	0 – 1	1.7	0 – 4
Sclerotinia minor	drop	3.7	1.7 – 9.5	–*	–
Botrytis cinerea	gray mold				
	all fields	4.6	0 – 49	3.9	0 – 20
	seeded fields	0.4	0 – 2.3	0	–
	transplanted fields	13.0	0 – 49	6.2	0 – 20

*Fields with *S. minor* were not included in the 1986 survey. 1985 values for *S. minor* are from three fields only, out of 25 fields surveyed.

the limiting factor in production. It appears that some growers may have been confusing these two diseases due to a superficial similarity of symptoms. They can however be readily separated by examining the vascular tissue, which is discolored in the case of *P. tracheiphilum,* or by the characteristic soft rotting of the crown, which is typical of infection by *Sclerotinia* spp. In addition, plants attacked by *P. tracheiphilum* tend to be killed prior to the midway point in the growing season, whereas symptoms of invasion by *S. sclerotiorum* tend to occur later in the season. *P. tracheiphilum* is rarely reported as a pathogen of lettuce (2,3) although *Pythium* spp. have often been reported as causal agents of root rot and stunt (1). *P. tracheiphilum* is probably much more common than is generally recognized and, on the basis of the results reported here, more studies on the control and biology of this species appear warranted.

Literature cited

1. Chupp, C. and A. Sherf. 1960. Vegetable diseases and their control. Ronald Press. New York. 1960.
2. Matta, A. 1965. Una malatia della lattuga prodotta da una nuova specie di Pythium. Phytopathol. Mediterr. 4:48-53.
3. Tortolero, O. and L. Sequeira. 1978. A vascular wilt and leaf blight disease of lettuce in Wisconsin caused by a new strain of *Pythium tracheiphilum.* Plant Dis. Reptr. 62:616-620.

Postharvest rot by *Coprinus psychromorbidus* on apples and pears in cold storage in British Columbia

J.A. Traquair[1]

A sterile, low-temperature tolerant basidiomycete consistently isolated from apples in cold storage, is identified as *Coprinus psychromorbidus*, Redhead and Traquair. The fungus grew well at 10°C and produced white, cottony to woolly colonies on malt agar and potato dextrose agar. Hydrogen cyanide production was weak. Compatibility of dikaryotic mycelium of this fungus with monokaryotic isolates of *C. psychromorbidus* causing snow mold of alfalfa and winter wheat, is genetical evidence for their conspecificity.

Can. Plant Dis. Surv. 67:2, 47-50, 1987.

Un champignon basidiomycète stérile, tolérant les basses températures et isolé régulièrement à partir de pomme entreposé au froid, a été identifié comme *Coprinus psychromorbidus*, Redhead et Traquair. Le champignon montre une bonne croissance à 10°C et produit des colonies blanche d'aspect cotoneux à laineux sur de l'agar de malt et de l'agar de pomme de terre et de dextrose. La production de cyanure d'hydrogène est faible. La compatibilité du mycellium dikaryote de ce champignon avec des isolats monokaryote de *C. psychromorbidus* qui cause la moisissure nivale de la luzerne et du blé d'hiver, constitue une évidence génétique de leur conspécificité.

Introduction

Coprinus rot of apples in cold storage has become a serious problem in the Okanagan Valley of British Columbia. Golden Delicious, McIntosh, Spartan, Newton and Red Delicious apples are all affected (Meheriuk and McPhee 1984). The dry, dark brown lesions with tan centers are variable in appearance but in all cases, advanced stages of rot are marked by masses of cottony, white mycelium that cover the surface of infected apples and packing materials. The same fungus causes a storage rot of d'Anjou pears in British Columbia (Meheriuk and McPhee 1984). In Oregon, the pear rotting fungus was identified simply as a *Coprinus* sp. in the *urticicola* complex and was shown to be conspecific with the low-temperature basidiomycete (LTB) that causes cottony snow mold of grasses and winter crown of alfalfa (Spotts *et al.* 1981). Taxonomic revision of *Coprinus* species in the section *Herbicolae* showed that the snow mold LTB was a new species, *Coprinus psychromorbidus* Redhead & Traquair (Redhead and Traquair 1981). The precise identity of the apple-rotting LTB has not been published.

The apple-rotting basidiomycete that grows at 10°C is described here and identified as *C. psychromorbidus* based on the results of dikaryon-monokaryon mating tests.

Materials and methods

The fungus (78-2) used in this study was isolated by W. McPhee from rotted Golden Delicious apples in cold storage in Summerland, B.C. and was stored in the culture collection at the Lethbridge Research Station as LRS-070.

Cultures for the description of growth and colony features were grown in the dark on malt extract agar (MA) as outlined by Nobles (1965) and on Difco potato dextrose agar (PDA) in 9-cm plastic petri plates at 10 and 22°C.

Radial growth was measured weekly for six weeks. The fungus was also cultured on PDA and MA on the laboratory bench at 22±1°C under alternating dark and fluorescent light conditions (8 h/da at 9 $uEM^{-2}s^{-1}$).

Mycelium was examined weekly using squash-mounted samples in distilled water or in 5% KOH and 1% phloxine B. Drawings were made with the aid of a camera lucida.

Tests for the production of extracellular polyphenoloxidase were performed by growing the fungus on gallic acid agar and by dropping a freshly prepared solution of alcoholic gum guaiacum on the margin of 21-day-old colonies (Nobles 1965). Production of brown diffusion zones and blue pigment in the gallic acid and gum guaiacum tests, respectively indicated a positive reaction. The ability to produce hydrogen cyanide (HCN) in culture was determined by observing color changes in alkaline sodium picrate on PDA in Conway diffusion dishes (Chalkley and Millar 1982; Lebeau and Hawn 1963). A change from yellow to orange or red indicated a positive reaction.

The margins of 10-day-old colonies of four monokaryotic tester isolates of *C. psychromorbidus* (DAOM 175227-1, 175227-2, 175227-7, and 175227-13) grown separately on PDA in 9-cm plastic petri plates were inoculated with dikaryotic mycelium from a 10-day-old culture of the unidentified basidiomycete grown on PDA at 10°C in the dark. In addition, the tester monokaryons were paired with dikaryotic colonies of *C. psychromorbidus* (DAOM 175227 and DAOM 175229) as a check for mating potential. Hyphae from the colony margin of the tester distal to the unidentified dikaryon were examined 7 and 14 days after pairing, by mounting in KOH and phloxine as previously described and by looking for the presence of clamp connections and binucleate cells with the aid of phase contrast light microscopy.

Results and discussion

Cultural characteristics

Colony growth was moderate (4.5 mm/da) to slow (1.6 mm/da) at 10°C and 22°C respectively. The margin of the ad-

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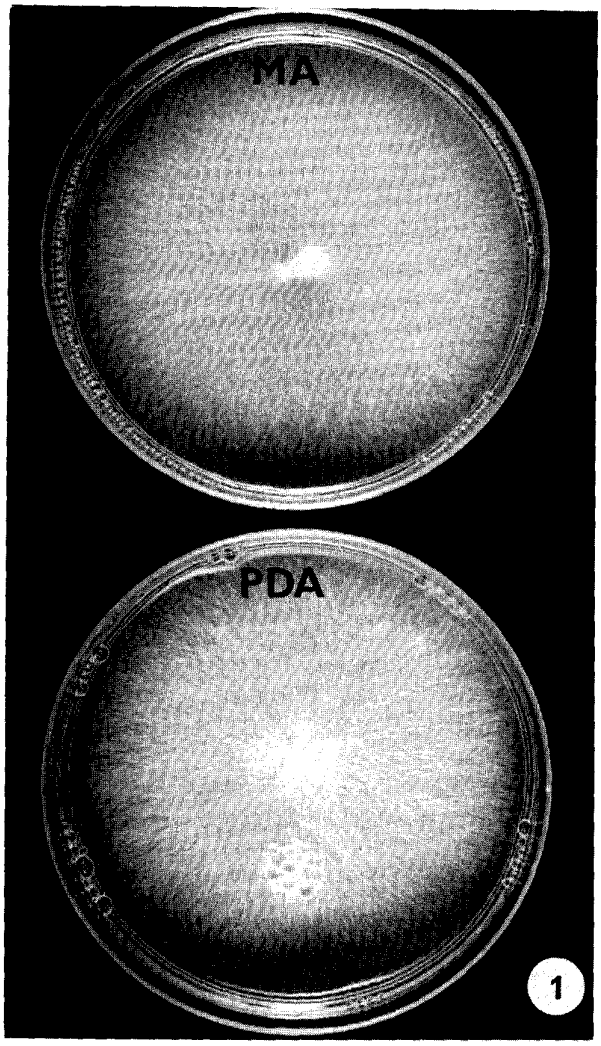

Figure 1. Woolly aerial mycelium of 3-week-old colonies of the low temperature basidiomycete (78-2), *Coprinus psychromorbidus* on malt agar (MA) and potato dextrose agar (PDA) × 0.8.

vancing colony was even, thin and appressed or cottony to woolly after 3 weeks. Aerial mycelium was white and cottony to woolly at 3 weeks (Fig. 1); after 6 weeks the aerial of colonies was unchanged in color on PDA but on MA in the light, a yellow pigment diffused into the agar. After 3-5 days exposure to fluorescent light on the lab bench, this pigment turned pink to purple. The odor of cultures was mushroom-like or not distinctive. No fruiting or sclerotium production was observed in culture on PDA or MA media during the 6-week study period.

Tests for extracellular polyphenol oxidases using gum guaiacum solution were positive (blue pigment appearing within 5 min.) as were tests using gallic acid medium (brown diffusion zones were produced in 10-14 days). Results were weakly positive after 30 days in tests for HCN using alkaline sodium picrate (color change from yellow to orange).

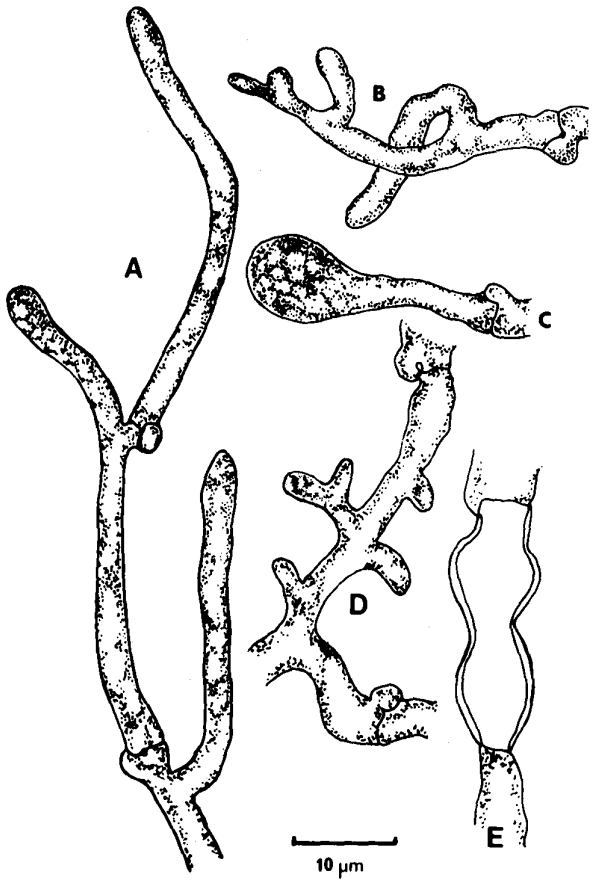

Figure 2. Thin-walled generative hypha with clamp connections (A), antleroid branch (B), allocyst-like branch (C), gnarled submerged hypha (D) and thick-walled swollen hypha (E) in 4-week-old PDA colonies of *Coprinus psychromorbidus*, isolate 78-2.

Generative hyphae were hyaline and thin-walled with clamp connections at cross walls (Fig. 2A). Hyphae in the advancing zone were 2.5-3.0 µm wide and sparsely branched, often at the site of a clamp connection. Hyphae on the agar surface and in the aerial mycelium were 2.5-4.0 µm wide and frequently branched. Scattered antleroid (Fig. 2B) and allocyst-like (Nobles 1965) branches (Fig. 2C) were observed on the surface hyphae. The submerged hyphae (3.0-5.0 µm wide) were gnarled and contorted (Fig. 2D) with thin- and thick-walled swellings (Fig. 2E) that ranged in diameter from 5-6.5 µm.

Dikaryon-monokaryon matings

The apple isolate, LRS 070 (78-2), from British Columbia dikaryotized all the monokaryotic tester isolates of *C. psychromorbidus* (Table 1). The colonies merged and a barrage-type (Traquair and Kennedy 1974) interaction with less dense mycelium (Fig. 3) was noted in the confrontation zone of pairings with one of the two mating types (Traquair 1980).

Dikaryotization of *C. psychromorbidus* mycelium in di-mon mating tests with the apple-rotting isolate, is genetical evi-

Table 1. Results of matings between monokaryotic tester isolates of *Coprinus psychromorbidus* and the dikaryotic isolate of a low-temperature basidiomycete from apples in cold storage.

C. psychromorbidus dikaryon	*C. psychromorbidus* (DAOM 175227-) monokaryon			
	175227-1	175227-2	175227-7	175227-13
LRS 070 (78-2)	+*	+	+	+
DAOM 175227	+	+	+	+
DAOM 175229	+	+	+	+

* + denotes complete dikaryotization as recognized by presence of clamp connections and binucleate cells throughout the tester colony.

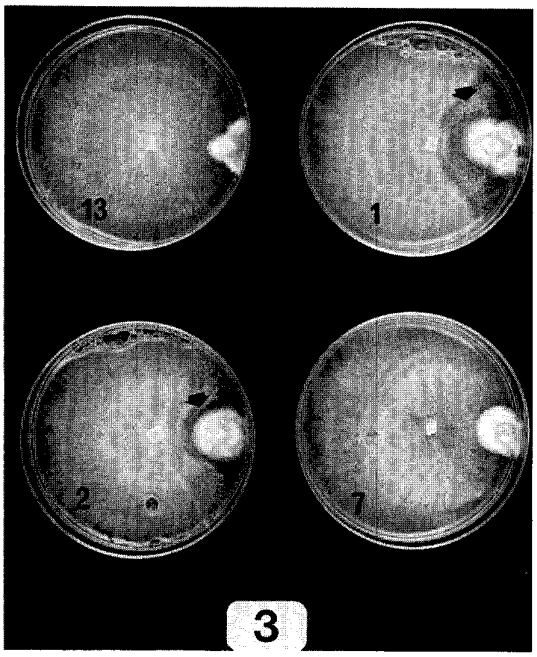

Figure 3. Dikaryon-monokaryon matings of the dikaryotic apple isolate (78-2) with monokaryotic tester isolates (-1,-2, -7,-13) of *Coprinus psychromorbidus* (DAOM 175227). Note the barrage-like interaction with one mating type (arrows) × 0.4.

dence of their conspecificity. These results are also supported by similar growth characteristics of the fungi in culture. The white, cottony-woolly colonies that grow well at 10°C are typical of the *Coprinus* sp. rotting d'Anjou pears (Spotts *et al.* 1981) and of the non-sclerotial strains of *C. psychromorbidus* causing cottony snow mold of alfalfa, grasses and winter cereals (Traquair 1980).

Coprinus rot of apples and pears could be confused with tan-spot rot or fisheye rot caused by *Butlerelfia eustacei* Weresub & Illman (= *Corticium centrifugum* (Lév.) Bres.) except for the fact that the fungus causing coprinus rot grows better at 10°C than at 25°C (Meheriuk and W.J. McPhee 1984; Weresub and Illman 1980). Within 6-10 days on PDA, the *B. eustacei* produces characteristic cremaceous waxy granules or membranous patches which are the basidiome (Weresub and Illman 1980).

The psychrophilic apple isolate is a weak HCN producer but, previous work with *C. psychromorbidus* has shown that ability to produce HCN in culture varies with the isolate and cultural conditions (Traquair 1980; Ward *et al.* 1961). Although analysis of infected apple tissue for HCN was not done, previous work has shown that isolates of *C. psychromorbidus* (identified then as LTB) producing little to no HCN in culture, are the most aggressive on host plants (Gaudet 1986; Traquair 1980; Traquair and Hawn 1982; Ward *et al.* 1961).

Although sclerotial production was not observed for the apple isolate causing coprinus rot, black sclerotia were observed on the wood of storage crates infested with this fungus on pears in Oregon (Spotts *et al.* 1981). Sclerotia are likely to be significant survival propagules and sources of infection. Sterol inhibitors and dithiocarbamates were shown to reduce mycelial growth of the *Coprinus* sp. and, ziram applied to trees before harvest was shown to control coprinus rot in stored fruit (Spotts *et al.* 1981).

Washes with 5% borax have been recommended in the early literature as a means of disinfecting timber in cold stores that are in contact with food stuffs (Cartwright and Findlay 1958). It is interesting to note that symptoms of LTB snow mold on inoculated alfalfa have been reduced by applying borax solutions (Lebeau and Atkinson 1967). Good sanitation in the cold storage facility is an important part of control for coprinus rot of pome fruits.

Literature cited

1. Cartwright, K.St.G. and W.P.K. Findlay. 1958. Decay of timber and its prevention. 2nd ed. H.M.S.O. London, U.K.
2. Chalkley, D.B. and R.L. Millar. 1982. Cyanide-insensitive respiration in relation to growth of a low-temperature basidiomycete. Plant Physiol. 69:1121-1127.
3. Gaudet, D.A. 1986. Effect of temperature on pathogenicity of sclerotial and nonsclerotial isolates of *Coprinus psychromorbidus* on winter wheat under controlled conditions. Can. J. Plant Pathol. 8:394-399.
4. Lebeau, J.B. and T.G. Atkinson. 1967. Borax inhibition of cyanogenesis in snow mold of alfalfa. Phytopathology 57:863-865.

5. Lebeau, J.B. and E.J. Hawn. 1963. Formation of hydrogen cyanide by the mycelial stage of a fairy ring fungus. Phytopathology 53:1395-1396.
6. Meheriuk, M. and W.J. McPhee. 1984. Postharvest handling of pome fruits, soft fruits, and grapes. Agric. Can. Public No. 1768E, Ottawa.
7. Nobles, M.K. 1965. Identification of cultures of wood-inhabiting Hymenomycetes. Can. J. Bot. 43:1097-1139.
8. Redhead, S.A. and J.A. Traquair. 1981. *Coprinus* section *Herbicolae* from Canada, notes on extralimital taxa, and the taxonomic position of a low temperature basidiomycete forage crop pathogen from western Canada. Mycotaxon 13:373-404.
9. Spotts, R.A., J.A. Traquair and B.B. Peters. 1981. D'Anjou pear decay caused by a low temperature basidiomycete. Plant Disease 65:151-153.
10. Traquair, J.A. 1980. Conspecificity of an unidentified snow mold basidiomycete and a *Coprinus* species in the section *Herbicolae*. Can. J. Plant Pathol. 2:105-115.
11. Traquair, J.A. and E.J. Hawn. 1982. Pathogenicity of *Coprinus psychromorbidus* on alfalfa. Can. J. Plant Pathol. 4:106-108.
12. Traquair, J.A. and L.L. Kennedy. 1974. Distinctions between *Hirschioporus subchartaceus* and *H. pargamenus*. Can. J. Bot. 52:1975-1881.
13. Ward, E.W.B., J.B. Lebeau and M.W. Cormack. 1961. Grouping of isolates of a low-temperature basidiomycete on the basis of cultural behavior and pathogenicity. Can. J. Bot. 39:297-306.
14. Weresub, L.A. and W.I. Illman. 1980. *Corticium centrifugum* reisolated from fisheye rot of stored apples. Can. J. Bot. 58:137-146.

Author Index to Volume 67

Viruses of potatoes and seed-potato production

J.A. de Bokx and J.P.H. van der Want (Eds)

1987, 259 pages, 16 pages with watercolour illustrations, 2nd ed. revised, hardbound, index, glossary,
ISBN 90-220-0859-2
Price ƒ125.00/US$ 62,50

The first edition of this book received wide acclaim. So many developments in knowledge and experience have occurred that it was felt necessary to update the book. For example, great progress has been made in describing the properties of viruses and viroids. This edition also incorporates new views on the role aphids play in disseminating viruses, plus recent ideas on breeding potato cultivars for resistance. Another new aspect dealt with relates to seed-potato production in regions other than the Netherlands, including several countries in which this practice was introduced relatively recently.
This book is not a complete manual, but is intended to help all those striving to grow healthy potatoes.

Contents

Instructions to authors

Articles and brief notes are published in English or French. Manuscripts (original and one copy) and all correspondence should be addressed to Dr. H.S. Krehm, Research Program Service, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6.

Manuscripts should be concise and consistent in style, spelling, and use of abbreviations. They should be typed, double spaced throughout, on line-numbered paper. All pages should be numbered, including those containing abstract, tables, and legends. For general format and style, refer to recent issues of the *Survey* and to *CBE Style Manual* 3rd ed. 1972. American Institute of Biological Sciences, Washington, D.C. Whenever possible, numerical data should be in metric units (SI) or metric equivalents should be included. Square brackets may be used to enclose the scientific name of a pathogen, following the common name of a disease, to denote cause.

Titles should be concise and informative providing, with the Abstract, the key words most useful for indexing and information retrieval.

Abstracts of no more than 200 words, in both English and French, if possible, should accompany each article.

Figures should be planned to fit, after reduction, one column (maximum 84 × 241 mm) or two columns (maximum 175 × 241 mm), and should be trimmed or marked with crop marks to show only essential features. Figures grouped in a plate should be butt-mounted with no space between them. A duplicate set of unmounted photographs and line drawings is required. Figures should be identified by number, author's name, and abbreviated legend.

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Recommandations aux auteurs

Les articles et les communiqués sont publiés en anglais ou en français. Les manuscrits (l'original et une copie) et toute la correspondance qui s'y rapporte doivent être envoyés à D[r] H.S. Krehm, Service des programmes de recherche, Direction de la recherche, ministère de l'Agriculture du Canada, Ottawa, (Ontario) K1A 0C6.

Les manuscrits doivent être concis et faire preuve de suite dans le style, l'orthographe et l'emploi des abréviations. Ils doivent être dactylographiés à double interligne, de préférence sur des feuilles à lignes numérotées. Toutes les pages doivent être numérotées y compris celles portant le résumé, les tableaux et les légendes. Pour plus de renseignements sur le format des feuilles et le style, prière de consulter nos dernières publications et le *CBE Style Manual* (3e ed. 1972) de l'American Institute of Biological Sciences, Washington (DC). Dans la mesure du possible, les données numériques doivent être exprimées en unités métriques, (SI) ou être suivies de leur équivalent métrique. L'emploi de crochets est autorisé pour l'identification du nom scientifique d'un micro-organisme pathogène après le nom commun de la maladie dont il est l'agent causal.

Les titres doivent être courts et révélateurs en contenant, avec le résumé, les mots clés les plus utiles pour le classement et l'extraction de l'information.

Chaque article doit être accompagné d'un *résumé* d'au plus 200 mots en anglais et en français, si possible.

Les figures doivent pouvoir, après réduction, remplir une colonne (maximum 84 × 241 mm) ou deux colonnes (maximum 175 × 241 mm) et devraient être taillées ou montrer les parties essentielles à garder. Les figures groupées sur une même planche doivent être montées côte à côte, sans intervalle. L'article doit être accompagné d'un double des photographies non montées et des graphiques. Les figures doivent être numérotées, porter le nom de l'auteur et une légende abrégée.

Les tableaux doivent être numérotés en chiffres arabes et avoir un titre concis. Ils ne devraient pas avoir de lignes verticales. Les renvois doivent être identifiés par un signe typographique particulier (* † § # ¶ ** ††) surtout lorsqu'il s'agit de nombres.

Les références bibliographiques devraient être citées par ordre alphabétique comme dans les livraisons courantes. On peut utiliser le système de numération ou le système nom-et-année. Pour l'abrégé du titre des périodiques, on suivra l'édition la plus récente de *Biosis List of Serials* publiée par les Biosciences Information Services de Biological Abstracts ou la *NCPTWA Word Abbreviation List* et l'American National Standards Institute, Standards Committee Z39.