Canadian Plant Disease Survey

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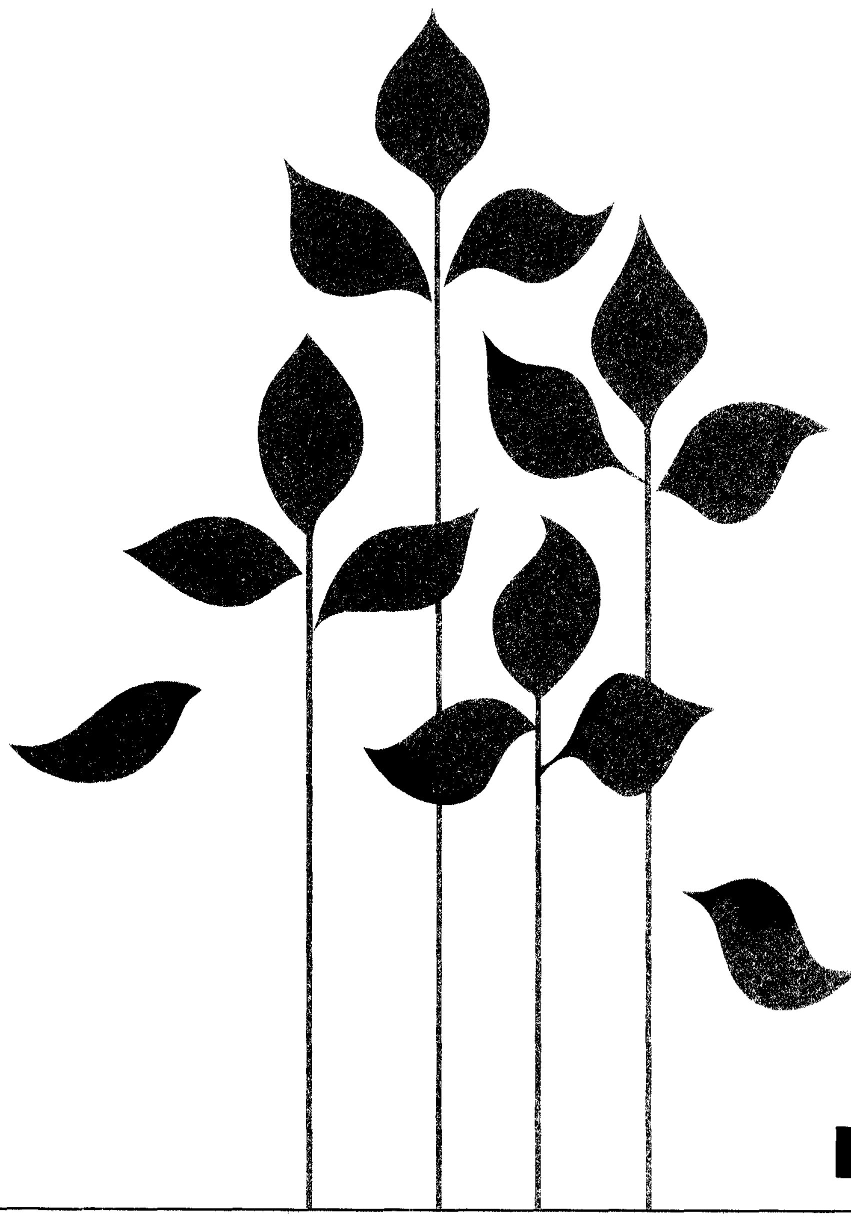

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Canadian Plant Disease Survey

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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.

Canadian Plant Disease Survey 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.

Research Branch, Agriculture Canada
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Importance of disease to sunflower in Manitoba in 1975[1]

J. A. Hoes and H. C. Huang

Sclerotinia basal stem rot or wilt, verticillium wilt, and premature ripening ascribed to an unidentified fungal root rot complex appeared to be the most prevalent and the most severe diseases of sunflower in Manitoba in 1975. Downy mildew, head rots, and rust were of lesser importance. Seed contamination, dense plant spacing, improper crop sequence, and host weeds are suggested to be epidemiological factors of sclerotinia wilt. Basal stem rot also occurred in wild *Helianthus annuus*, annual sow thistle, burdock, wild mustard, and volunteer rapeseed. Verticillium wilt often caused uncharacteristic symptoms of leaf yellowing and wilting rather than typical leaf mottle symptoms of chlorosis and necrosis, but masses of microsclerotia in tap roots were diagnostic.

Can. Plant Dis. Surv. 56: 75-76. 1976

La sclerotiniose [*Sclerotinia sclerotiorum*], la verticiliose [*Verticillium dahliae*], et une maladie provoquant maturité hâtive, attribuée aux fonguses non-identifiés, étaient les maladies les plus communes et graves de tournesols en Manitoba en 1975. Le mildiou [*Plasmopara halstedii*], des pourritures de capitules et la rouille [*Puccinia helianthi*] étaient moins importantes. Graines contaminées avec des sclerotes, des espacements petits des plantes trop serré, des successions de récoltes inappropiés et de mauvaises herbes sont des facteurs épidemiologiques de la sclerotiniose. Les tournesols naturels [*Helianthus annuus*], le laiteron rude, la petite bardane, le moutarde des champs et le moutarde des oiseaux ont été attaqué aussi par la sclerotiniose. La verticiliose a causé de symptômes non-characteristique de jaunissant et flétrissement de feuilles, plutôt que causant de chlorose et de necrose, symptômes characteristiques; des masses de microsclerotes dedans des racines pivotantes étaient diagnostiques.

Surveys on sunflower (*Helianthus annuus* L.) in 1975 were carried out throughout Manitoba in the September 10-17 period, a time when most sunflower diseases have reached a climax. Fifty-seven randomly selected fields were inspected; their total acreage was equivalent to about 5% of the 1975 acreage, estimated at 28,000 hectares. Oilseed varieties were encountered in all but one field. The distribution of disease within fields was commonly uniform; 300 or more plants in random areas in each field were examined.

Observations and discussion

The most important sunflower diseases in descending order of prevalence and severity were basal stem rot or wilt caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, wilt caused by *Verticillium dahliae* Kleb., and premature ripening ascribed to an unidentified fungal root rot complex (Table 1).

Downy mildew [*Plasmopara halstedii* (Farl.) Berl. et de Toni], head rots and rust [*Puccinia helianthi* Schw.] were of lesser importance (Table 1). Head rots were caused by *S. sclerotiorum, Botrytis cinerea* Pers. and *Rhizopus* sp., among which *S. sclerotiorum* was the most serious pathogen. Rust was widespread but was rather severe in only one field where it caused defoliation.

While no field was completely free of disease, it was common to find two or more diseases in the same field. For instance, there were 3 fields in which five diseases occurred, and 10 fields in which four diseases were prominent. As a consequence, the importance of disease to sunflower is greater than appears from Table 1. The number of fields with light, moderate, severe, or very severe disease (Table 1) was, respectively, 17, 14, 12 and 3. Therefore, about half of the fields were at least moderately diseased, and there is no doubt that yields in 1975 were seriously depressed. Estimates are that the yield of fields with light or traces of disease ranged from 900 to 2,000 kg/ha, averaging 1,360 kg/ha, while fields with moderate to very severe disease ranged from 100 to 1,350 kg/ha, averaging 800 kg/ha.

Sclerotinia wilt being the most important sunflower disease, the history of fields with a high disease incidence was traced in several instances. Seed contamination, dense plant spacing, improper crop sequence, and weediness are suggested to be epidemiological factors of sclerotinia wilt. The disease spreads by root contact (H. C. Huang and J. A. Hoes, unpublished data; Young and Morris 1927), and, as in solid seeded fields, the closer the spacing, the faster the spread of wilt (J. A. Hoes and H. C. Huang, unpublished data). Contaminated seed stock appeared to be the prime source of inoculum in a field in which 95% of the plants were wilted. No host crop was known to have been grown in that field during the past 10 years, and weeds were no problem. Inspection of the seed stock showed the presence of sclerotia at the rate of 1 per 100 seeds. The seed had obviously been produced by plants with sclerotinia head rot. The sclerotia were free of *Coniothyrium minitans* Campbell and other hyperparasites, and sclerotial viability was high in contrast to that of sclerotia

[1] *Contribution No. M-202, Research Station, Agriculture Canada, Morden, Manitoba R0G 1J0*

Table 1. Incidence of diseases in 57 sunflower fields in Manitoba in 1975

Disease severity and incidence	Sclerotinia wilt	Verticillium wilt	Premature ripening	Downy mildew	Head rots	Rust
None or trace	28	37	46	51	53	56
Light (1–10%)	13	12	9	4	3	
Moderate (11–40%)	5	7	2	2	1	1
Severe (41–80%)	8	1				
Very severe (80%)	3					

from plants with basal stem rot (Hoes and Huang 1975). Sclerotia and seed were deposited close together thus facilitating early infection, while disease spread was favored by dense seeding, which resulted in a within-row spacing of only 10 cm between plants. Another field with 95% wilt was solid seeded, and had been grown to rapeseed in 1970, sunflowers in 1971, and peas in 1973. A third instance of a field with 60% sclerotinia wilt and 20% sclerotinia head rot had been partially grown to sunflowers in 1971 and 1972 and had abundant wild mustard. In a field with 70% wilt, sunflowers were grown in rotation with rapeseed. In another instance of a field with 70% wilt, rapeseed had been grown in 1962, sunflowers in 1968, a year in which both sclerotinia head rot and wilt were rampant (Hoes 1969), and oilseed radish (*Raphanus sativus* L.) in 1972. Infested sunflower refuse dragged from an adjoining field was the undoubted source of inoculum in a solid-seeded field with 95% wilt. The adjoining field had been grown to sunflowers in 1972 and again in 1974 and sclerotinia wilt occurred there both years. Sclerotinia wilt also occurred in wild *Helianthus annuus* along a roadside, in annual sow thistle (*Sonchus oleracea* L.), burdock (*Arctium minus* (Hill) Bernh., and in wild mustard [*Brassica kaber* (DC.) L.C. Wheeler] and volunteer rapeseed (*Brassica campestris* L.).

Verticillium dahliae in oilseed sunflowers often caused uncharacteristic symptoms of leaf yellowing and wilting rather than typical "leaf mottle" symptoms of chlorosis and necrosis (Sackston et al. 1957). However, the masses of black microsclerotia discoloring the inside of tap roots were diagnostic.

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Further observations on zoosporic fungi associated with wheat spindle streak mosaic virus[1]

D.J.S. Barr[2] and J.T. Slykhuis[3]

Polymyxa graminis was generally found on the roots of wheat plants grown in soil samples collected from wheat fields in southern Ontario, Indiana, Kentucky, Pennsylvania, and Arkansas where wheat spindle streak mosaic virus (WSSMV) was found or suspected to be present. It was not found in soil from a field where wheat has not been grown, or in any of 21 samples of soil from fields of winter wheat in southern Alberta where there was no evidence of WSSMV. *Lagena radicicola, Olpidium brassicae, Rhizophydium graminis*, and several *Pythium* spp. were found in the soils from Alberta as well as from most of the other locations.

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On a généralement décelé la présence de *Polymyxa graminis* sur les racines de plants de blé provenant d'échantillons de sol prélevés d'emblavures du sud de l'Ontario, de l'Indiana, du Kentucky, de la Pennsylvanie et de l'Arkansas où on a constaté ou soupconné la présence du virus de la mosaïque striée fusiforme (WSSMV). Le sol provenant d'un champ non affecté à la culture du blé en était exempt, de même que les 21 échantillons provenant de champs de blé d'hiver du sud de l'Alberta où on n'a pu déceler la présence du virus. *Lagena radiciola, Olpiduim brassicae, Rhizophydium graminis*, et plusieurs espèces de *Pythium* ont été observées dans les sols provenant de l'Alberta et de la plupart des autres endroits.

Earlier experiments indicated that wheat spindle streak mosaic virus (WSSMV) is transmitted by a soil-borne agent that passes readily through fine screens (44 μm), is persistent in soils even when dry, but which can be transported via soil water (Slykhuis 1970). These observations and the examination of roots of diseased wheat plants indicate that natural transmission is by zoosporic fungi (Barr and Slykhuis 1969). *Polymyxa graminis* Ledingham (1939) (Plasmodiophorales), because of its spectacular presence in the roots of diseased wheat plants in Ontario and its association with wheat (soil-borne) mosaic virus in the USA (Rao and Brakke 1969), has been a prime suspect as vector of WSSMV. However, other zoosporic fungi are also generally found on the roots of diseased wheat plants and must be considered as possible carriers of the virus. One of these, *Olpidium brassicae* (Wor.) Dang. (Chytridiales), is a vector of several other plant viruses (Teakle 1969). It occurs on the roots of many species of plants and although there are many physiological strains (Garrett and Tomlinson 1967, Barr and Kemp 1975), most isolates from wheat grew on lettuce but not on cabbage and only one grew on both lettuce and cabbage. *Lagena radicicola* Vanterpool and Led. (Lagenidiales) was reported on cereals in eastern as well as western Canada (Truscott 1933, Vanterpool 1930). Although initially it was not detected in roots of wheat infected with WSSMV in Ontario (Barr and Slykhuis 1969), later observations showed that it was usually present. This fungus has also been found in the roots of barley in England (MacFarlane 1970). *Rhizophydium graminis* Led. (Chytridiales) is also found on wheat roots. It differs from the preceding fungi by producing epibiotic, but not endobiotic, zoosporangia and resting spores on root hairs and epidermal cells. The zoosporangia dehisce to release zoospores and the resting spores soon become separated from the host leaving no observable bodies on the roots, hence this fungus is easily overlooked. Several *Pythium* spp., some of which may produce zoospores, are also found frequently in the roots of wheat plants and have been considered as possible vectors of soil-borne viruses. Unlike the other zoosporic fungi considered here, *Pythium* spp. are readily cultured on artificial media and so are readily isolated in pure culture; however in roots they may cause necrosis and hence are less likely to be able to transmit a virus.

The following is a report of the zoosporic fungi found on the roots of wheat plants grown in samples of soil tested for WSSMV from collections made in Ontario from 1972 to 1975, and also in samples obtained from Alberta, Arkansas, Indiana, Kentucky, and Pennsylvania.

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Methods

Most samples of soil from Ontario were collected during surveys for wheat spindle streak mosaic in May each year from 1972 to 1975. In 1974, additional collections were made in October from fields selected in May,

Table 1. Wheat spindle streak mosaic virus and root fungi on wheat grown in seven samples of soil from each of eight locations in Ontario, 1974

Collection no.	No. of plants with WSSM/no. tested*	Number of collections (out of 7) yielding fungi				
		Polymyxa graminis	*Lagena radicicola*	*Olpidium brassicae*	*Rhizophydium graminis*	*Pythium*
5	7/66 & 88/147	7	3	7	5	7 *aristosporum, arrhenomanes*
10	8/60	6	6	4	5	6 *aristosporum, tardicrescens, volutum*
13	10/72 & 80/143	7	6	6	4	5 *arrhenomanes, paroecandrum, vanterpooli, volutum*
17	8/71	5	7	0	7	7 *aristosporum, arrhenomanes, ultimum*
33	28/76 & 72/148	4	6	3	6	4 *aristosporum, arrhenomanes, ultimum*
54	22/69	5	6	1	2	2 *ultimum*
57	5/66	4	6	3	5	4 *aristosporum, arrhenomanes, volutum*
70	7/64 & 49/139	2	7	6	7	7 *arrhenomanes, vexans*

* Tests were made with composite soil samples from individual collections.

and six samples were collected from marked locations in each field for testing separately. All other samples were composites from locations where the disease was most prevalent in each field. The samples were dug by trowel to a depth of about 10 cm and usually included roots of diseased wheat plants. Most samples were from areas of southern Ontario where wheat is grown most intensively, but some collections were from eastern Ontario, including plots at the Central Experimental Farm, Ottawa, where wheat was grown every third year since about 1952 to 1967, then annually to increase the WSSMV infectivity of the soil.

Other samples of soil tested included collections from fields in which wheat was suspected or known to be affected by WSSMV. Samples were received from J.P. Jones, Department of Plant Pathology, University of Arkansas, Fayetteville, Arkansas, 72701; A.O. Jackson, Department of Botany and Plant Pathology, Purdue University, West Lafayette, Indiana 47907; T.P. Pirone, Department of Plant Pathology, University of Kentucky, Lexington, Kentucky 40506; and S.H. Smith, Department of Plant Pathology, Pennsylvania State University, University Park, Pennsylvania 16802. Some samples were provided from Alberta by U.J. Pittman, Research Station, Agriculture Canada, Lethbridge, including samples from a field in which winter wheat was grown twice every three years from 1951 until the samples were collected in 1974. Other samples from Alberta were collected from farm fields with long histories of winter wheat in short rotations including barley or oats and summerfallow.

The presence of WSSMV in soil samples was tested by sowing Kent wheat in 7.5-cm pots of each sample, growing at 15°C with about 15,000 lux of light 12 h per day for 3 weeks, then replanting in 10 cm pots of sterile soil or sand and growing at 10°C for about 3 months for symptoms to develop (Slykhuis 1973, 1976).

Table 2. Fungi in the roots of wheat plants grown in soil from fields at Ottawa with and without a crop history of wheat

Fungi	Incidence of fungi: 24 samples from a field of wheat highly infectious with WSSM virus	Incidence of fungi: 12 samples from an adjacent field that has not grown wheat
Polymyxa graminis	20/24	0/12
Lagena radicicola	24	12
Olpidium brassicae	10	5
Rhizophydium graminis	4	8
Number of samples with		
Pythium spp. in roots	24	6
Py. aristosporum	4	0
Py. tardicrescens	9	0
Py. volutum	10	4
Other *Pythium* sp.	2	2

To determine the presence of fungi, Kent wheat was sown in about 2 cm of the test soil placed on 4 cm of sterile quartz sand in 7.5-cm pots and grown at 15°or 20°C with 15,000 lux of light 16 h per day for 3 weeks. Roots that grew into the sand were cleaner and easier to examine unstained with phase contrast illumination than roots in soil. However, it was found in 1974 that longer incubation times were desirable for easier observations of *P. graminis*, hence for later tests, after an initial examination as described above, the plants were repotted in sterile sand, watered with 0.3- or 0.5- strength Hoagland's solution and grown a further 3 weeks under similar conditions, then the roots were reexamined for fungi.

Pythium spp. were isolated by placing pieces of washed roots on nutrient agar containing 200 ppm neomycin sulfate. The isolates were grown on V-8 juice agar (2.4% V-8 vegetable juice in 1% agar without $CaCO_3$), or on autoclaved hemp seed added to fresh, sterile water. Isolates were also plated on homemade potato dextrose agar and tested for growth at 25°, 30°and 35°C. The identity of each species was verified in culture.

Results

Fungi in roots of wheat grown in Ontario soils infectious with WSSMV

The roots of wheat were examined after growing for 3 weeks in soil samples from 53 fields in which WSSMV was prevalent when the samples were collected in May 1972, 1973, or 1974. *O. brassicae* was found in 46, *L. radicicola* in 45, *P. graminis* in 40, and *Rhizophydium graminis* in 32 of the soils tested. In three samples of soil from wheat fields in which WSSMV was not detected, only *O. brassicae* and *L. radicicola* were found.

Pythium aristosporum Vanterpool, *Py. arrhenomanes* Dreschsler, *Py. tardicrescens* Vanterpool and *Py. volutum* Vanterpool & Truscott were frequently isolated from wheat grown in Ontario soils and were associated with root necrosis of pot-grown plants. Also isolated from wheat roots but less frequently than the aforementioned species were *Pythium aphanidermatum* (Edson) Fitzpatrick, *Py. paroecandrum* Dreschsler, *Py. torulosum* Coker & Patterson, *Py. ultimum* Trow, *Py. vanterpooli* Kouyeas & Kouyeas and *Py. vexans* de Bary. *Py. graminicola* Subramaniam, sensu stricto, was not found; however, morphological and physiological characteristics of some isolates identified as *Py. aristosporum* overlapped the characteristics of *Py. graminicola*.

Examinations were made of wheat roots grown 3 weeks in sand following 3 weeks growth in seven samples of soil from each of eight fields in southern Ontario were WSSMV was prevalent in 1974. One sample tested was a composite of six samples collected in May. The other six samples were collected in October from the same locations as the samples collected in May. Each of the zoosporic fungi, including *L. radicicola, O. brassicae, P. graminis, Rhizophydium graminis* and one or more species of *Pythium*, was found on the roots of wheat grown in some of the samples from each field. Some were found in all samples from some fields but none was found in all samples from all of the fields (Table 1). There was no apparent correlation between the presence of any fungus and the numbers of test plants developing WSSMV.

Table 3. Incidence of wheat spindle streak mosaic virus and root fungi on wheat grown in samples of soil from Alberta and the United States

Virus and fungus isolated	Number of samples yielding virus and fungi				
	Alberta	Arkansas	Indiana	Kentucky	Pennsylvania
WSSM virus	0	0	1	3	2
Polymyxa graminis	0	1	1	3	2
Lagena radicicola	14	1	1	3	2
Olpidium brassicae	14	1	1	3	2
Rhizophydium graminis	4	0	0	2	1
Pythium aristosporum	0	1	1	0	0
Pythium arrhenomanes	5	0	0	0	1
Pythium tardicrescens	3	0	0	0	0
Pythium torulosum	0	0	1	1	0
Pythium volutum	5	0	0	1	0
Other *Pythium* spp.	1	0	0	1	0
Number of samples tested	21	1	1	3	2

Zoosporic fungi in infectious and noninfectious soils in adjacent fields at Ottawa

Tests were made for the presence of fungi in 24 samples of infectious soil collected throughout plots at the Central Experimental Farm, Ottawa, in which wheat had been grown every third year from 1952 to 1967, then annually until 1975, and in 12 samples of noninfectious soil from plots 100-150 m distant, in a field with similar soil in which wheat had not been grown for at least 15 years (Table 2). *P. graminis* was found in 20/24 samples from the infectious field but in none from the other. Also, *Pythium aristosporum* and *Py. tardicrescens* were found in some samples from the infectious field but in none from the other. *L. radicicola* was found in all samples from both fields, and the other fungi were found in some of the samples from each field.

Zoosporic fungi in relation to the presence of WSSMV in soils from different regions of Canada and the USA

Tests with samples of soil from Arkansas, Indiana, Kentucky, and Pennsylvania, where WSSMV-like symptoms were found on wheat, confirmed the presence of WSSMV in all except the sample from Arkansas. *P. graminis, L. radicicola, O. brassicae* and one or more species of *Pythium* were present in all these samples, and *Rhizophydium graminis* was present in some.

WSSMV was not detected in any of the 21 samples from the winter-wheat-producing areas of southern Alberta, which are about 2500 km from the nearest known sites of WSSMV. However, all groups of the zoosporic fungi under consideration, except *P. graminis*, were found in a number of the samples.

Discussion

Although *Olpidium brassicae, Rhizophydium graminis* and several species of *Pythium* were found on the roots of some of the wheat plants grown in samples of soil from wheat fields in which WSSMV was known to be present, *Polymyxa graminis* and *Lagena radicicola* were most commonly found in soils infectious with the virus. The occasional failure to find either of the latter fungi on roots of plants grown in virus infective soil could have resulted, not from the absence of the fungi in the soil, but from their suppression by other organisms in the soil complex under the conditions of the test. These fungi were difficult to find or absent in roots heavily invaded by *Pythium* spp., most of which caused some necrosis of wheat roots, and therefore are not likely to be vectors of the virus.

L. radicicola was present but *P. graminis* was not found on the roots of wheat plants grown in soil from a field at the Central Experimental Farm, Ottawa, where cereals have not been grown for at least 15 years. However, *P. graminis* was most abundant in another field in which WSSMV was prevalent after many successive crops of wheat. It appears that frequent cropping to wheat favors the buildup of WSSMV and *P. graminis* in soils in Ontario. However, neither *P. graminis* nor WSSMV was detected in samples of soil from fields in southern Alberta with long histories of frequent cropping to wheat.

The above results support the suggestion that transmission of WSSMV from soil occurs only when *Polymyxa graminis* is present.

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Pertes dues aux maladies chez la luzerne au Québec en 1975

C. Richard et C. Gagnon

Un second inventaire annuel des maladies de la luzerne au Québec a été effectué en 1975. Le pourridié fusarien, la mineuse virgule, et 5 maladies du feuillage ont été observées. Les pertes dues aux maladies du feuillage ont été estimées à 3.5% ou $3.0 millions. La mineuse virgule a causée des pertes de l'ordre de 0.3% ou $0.2 millions.

Can. Plant Dis. Surv. 56: 82-84. 1976

A second annual survey of alfalfa diseases in Quebec was performed in 1975. Fusarium root rot and five foliar diseases were observed. Losses from foliar diseases alone were estimated to be 3.5% or $3.0 million. Damage from the alfalfa blotch leaf miner *Agromyza frontella* was widespread and losses were estimated at 0.3% or $0.2 million.

Un inventaire préliminaire, effectué au Québec en 1974, nous avait permis d'évaluer, chez la luzerne (*Medicago sativa* L.), l'abondance et la fréquence de plusieurs maladies du feuillage et de constater l'omniprésence du pourridié fusarien (4).

Afin de déterminer les pertes dues à ces maladies, nous avons fait un nouvel inventaire en 1975 en augmentant l'intensité de l'échantillonnage.

Matériel et méthodes

L'inventaire inclut 18 comtés répartis dans 8 des 12 régions agricoles du Québec (2). Quatre régions ont été ignorées, soit à cause de leur éloignement, soit parce que peu de luzerne y est cultivée.

L'échantillonnage a été effectué selon la méthode de Berkenkamp (1) légèrement modifiée. Partant à 20 pas de la lisière du champ, nous avons prélevé, le long d'une ligne à 45 degrés, 10 plants à raison d'un plant à tous les 10 pas au lieu de 2 pas. Cette modification donne à l'échantillon une meilleure représentativité du champ.

Les observations ont porté sur les maladies du feuillage et les pourritures de racine. Nous avons particulièrement été attentifs à l'anthracnose [*Colletotrichum destructivum* O'Gara] souvent trouvée en serre, mais jamais observée en plein champ au Québec, et à la flétrissure bactérienne également apparemment absente au Québec. Vu sa grande abondance, nous avons aussi inclus la mineuse virgule (*Agromyza frontella* Rondami) dans l'inventaire.

L'indice des maladies du feuillage a été déterminé comme précédemment (4) selon la méthode de Berkenkamp (1). Dans le cas des dommages causés par la mineuse virgule, nous avons donné un indice correspondant au pourcentage de feuilles atteintes. Enfin, nous avons déterminé l'indice du pourridié fusarien selon une échelle établie précédemment (4). Nous n'avons que noté la présence des pourritures rhizoctoniennes et phytophtoréennes.

Les pertes dues aux maladies du feuillage, à l'exception de celles causées par la mineuse virgule, ont été estimées de la même façon que Berkenkamp (1). La sommation des indices des maladies du feuillage a été effectué pour chaque région et multipliée par un facteur de 0.25. La production actuelle de chaque région a été obtenue en multipliant sa superficie en luzerne (Toupin, D., Ministère de l'Agriculture du Québec, communication personnelle) par son rendement à l'acre (3). Nous avons évalué la production potentielle à partir du pourcentage de pertes et de la production actuelle. En soustrayant l'un de l'autre ces deux productions, nous avons déterminé le poids des pertes en matière verte. La valeur commerciale moyenne du foin de luzerne pour l'ensemble des mois de juin à octobre étant de $52 la tonne (Bureau de la statistique du Québec, 1976, communication personnelle), nous avons pu ainsi évaluer les pertes en argent.

Aux fins de l'estimé des pertes, la mineuse a été considérée comme une maladie cryptogamique. Le facteur de 0.25 a donc été appliqué à l'indice pour obtenir le pourcentage de matière verte perdue.

Les pertes dues aux maladies du feuillage et celles dues à la mineuse virgule sont présentées séparément (tableau 2 et 3).

Nous évaluons présentement les pertes causées par le pourridié fusarien et nous en publierons les résultats ultérieurement.

Résultats

Les résultats de l'inventaire sont résumés au tableau I.

Les maladies du feuillage rencontrées ont été par ordre

[1] *Contribution no. 75, Station de recherches, Agriculture Canada, 2560 Chemin Gomin, Sainte-Foy, Québec G1V 2J3*

Tableau 1. Fréquence et gravité des maladies de la luzerne au Québec en 1975

Région	Superficie (acres)	Nombre de champs échantillonnés	Nombre de champs/Indice de maladie: Pourridié fusarien	Mineuse	Tige noire	Tache commune	Tache lep- tosphaeru- lienne	Mildiou	Tache stem- phyllienne
1	41,000	15	15/1.94	13/1.82	13/0.99	14/16.72	4/0.01	0	11/0.49
2	35,855	11	11/1.25	9/6.70	11/9.32	10/4.34	9/15.25	2/0.15	3/0.14
4	100,000	1	1/1.10	1/0.01	1/2.39	0	1/9.2	0	1/0.01
5	15,855	5	5/1.64	5/1.58	5/2.16	5/19.52	4/6.79	4/0.31	5/0.20
6	118,000	2	2/1.10	2/0.31	2/3.40	2/2.01	1/2.36	2/0.20	2/0.02
7	26,000	2	2/1.55	1/0.26	2/3.58	1/0.01	2/2.37	2/0.12	1/0.01
10	57,000	1	1/1.60	1/0.60	1/8.00	1/5.50	1/1.00	1/0.03	1/0.30
12	7,000	16	16/1.54	5/0.02	16/2.83	9/4.87	11/5.63	0	12/0.55
Total	400,710	53	53/1.47	37/1.41	51/4.08	42/6.62	33/5.33	11/0.10	37/0.21

Tableau 2. Pertes dues aux maladies du feuillage chez la luzerne*

Région	Nombre de champs échantillonnés	Superficié (acres)	Rendement (tonnes/acre)	Perte %	Production ('000 tonnes) Actuelle	Potentielle	Pertes ('000 tonnes)	Pertes ($'000)
1	15	41,000	3.92	4.51	160.72	168.31	7.59	394.68
2	11	35,855	3.88	7.30	139.12	150.07	14.34	745.89
4	1	100,000	4.02	2.90	402.00	414.01	12.01	624.31
5	5	15,855	3.74	7.25	59.30	63.93	4.64	241.03
6	2	118,000	4.45	2.00	525.10	535.82	10.72	557.25
7	2	26,000	4.45	1.52	115.70	117.49	1.79	92.82
10	1	37,000	3.96	3.71	146.52	152.17	5.65	293.56
12	16	7,000	3.19	3.48	22.33	23.14	0.81	41.87
Total	53	400,710	3.95	3.54	1,570.79	1,624.94	57.55	2,991.41

* Excluant les pertes dues à la mineuse virgule

d'importance: la tache commune [*Pseudopeziza medicaginis* (Lib.) Sacc.], la tache leptosphaerulinienne [*Leptosphaerulina briosiana* (Poll.) Graham et Luttrell], la tige noire [*Phoma medicaginis* Malbr. et Roum. var. *medicaginis*], la tache stemphylienne [*Stemphylium botryosum* Wallr.], et la mildiou [*Peronospora trifoliorum* de Bary]. Les trois premières ont été les plus graves avec des indices de 6.62, 5.33, et 4.08 respectivement.

Le pourridié fusarienne a été observé dans tous les champs échantillonnés. Quant aux pourritures phytophtoréenne et rhizoctonienne, des racines montrant les symptômes de ces deux maladies ont été récoltées au Lac Saint-Jean (région 12). Cependant, l'identification définitive des organismes responsables n'a pas encore été effectuée.

Ni l'anthracnose, ni les flétrissures fusarienne et bactérienne n'ont été observées, ce qui confirme l'opinion générale selon laquelle on ne trouve que très rarement ces maladies au Quebec.

Les pertes de fourrage dues aux maladies du feuillage (table 2) s'élèvent à $2,991,400, soit 57,526 tonnes ou 3.5% de la production potentielle (1,624,920 tonnes). Si on y ajoute la valeur des pertes dues à la mineuse virgule (tableau 3), soit $212,656, les pertes totales s'évaluent à $3,204,056.

Discussion et conclusion

Il semble que, par rapport à 1974, l'ordre d'importance des maladies à été modifié en faveur de la tache leptosphaerulinienne qui est passé de la quatrieme place

Tableau 3. Pertes dues à la mineuse virgule chez la luzerne

Région	Nombre de champs échantillonnés	Superficié (acres)	Rendement (tonnes/acre)	Perte %	Production ('000 tonnes) Actuelle	Production ('000 tonnes) Potentielle	Pertes ('000 tonnes)	Pertes ($'000)
1	15	41,000	3.92	0.46	160.72	161.46	0.74	38.62
2	11	35,855	3.88	1.68	139.12	141.49	2.38	123.61
4	1	100,000	4.02	<0.01	402.00	402.01	0.01	0.52
5	5	15,855	3.74	0.40	59.30	59.54	0.24	12.38
6	2	118,000	4.45	0.08	525.10	525.52	0.42	21.86
7	2	26,000	4.45	0.07	115.70	115.78	0.08	4.21
10	1	37,000	3.96	0.15	146.52	146.74	0.22	11.45
12	16	7,000	3.19	< 0.01	22.33	22.33	0	0
Total	53	400,710	3.95	0.26	1,570.79	1,574.87	4.09	212.65

à la deuxième place. L'apparente apparition du mildiou en 1975 est due au fait qu'en 1974 cette maladie n'avait pas été inventoriée à cause de sa faible abondance.

Au moment de l'inventaire, nous n'avons pas tenu compte des limites des régions pour déterminer les endroits à échantillonner. Aussi, ces régions ne sont pas représentées proportionnellement à leur surface en luzerne. La représentativité devra être améliorée lors d'un prochain inventaire.

A elles seules les pertes dues aux maladies du feuillage justifient la sélection de la luzerne pour la résistance à ces maladies. D'autre part, lorsque les pertes causées par le pourridié fusarien seront bien établies, nous saurons alors jusqu'à quel point il est important de sélectionner pour la résistance aux *Fusarium*.

Remerciements

Nos plus sincères remerciements vont à J.G. Martin et L. Lambert pour leur précieuse collaboration.

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Incidence of bacterial blight of field beans in southwestern Ontario in 1975[1]

V.R. Wallen and D.A. Galway

Bacterial blight [*Xanthomonas phaseoli*] was detected by aerial infrared photography in 83% of the field bean (*Phaseolus vulgaris*) fields surveyed in the Hensall, Ontario, area in 1975. The prevalence of blight in pedigreed seed crops in the area has increased since 1973, with 46% of the Select plots and 52% of the Foundation fields affected in 1975; however, the incidence of blight per field has remained at a low level. In the Chatham area only 7% of the fields examined were affected.

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En 1975, on a décelé, par photographie aérienne à l'infrarouge, la présence de brûlure bactérienne (*Xanthomonas phaseoli*) dans 83% des champs de haricots secs (*Phaseolus vulgaris*) étudiés dans la région de Hensall (Ontario). La fréquence de la maladie dans les cultures de semences généalogiques s'est accrue dans la région depuis 1973, atteignant 46 et 52% respectivement dans les superficies en semences sélectes et de fondation. Toutefois, la fréquence de la brûlure par champ est demeurée faible. Dans la région de Chatham (Ontario), seulement 7% des champs étudiés étaient atteints.

Bacterial blight [*Xanthomonas phaseoli* (E.F.Sm.) Dows., common blight, and *Xanthomonas phaseoli* var. *fuscans* (Burkh.) Starr. & Burkh., fuscous blight] has remained at a low level in the Ontario field bean crop for the past few years (1,2), due primarily to the Select Seed Program whereby basically healthy breeder-seed stocks of field beans are imported from Idaho. By rigid inspection of the Select plots, the progeny of breeder seed, and by rejection of any plots showing infection, initial seed stocks for Foundation seed fields have been, for the most part, disease-free. Trace infections in the Select seed may occur because of plants that do not exhibit infection at inspection time or are not detected in laboratory analysis.

Aerial infrared photography and a drum scanner technique (5) have been used to monitor the Ontario field bean crop for a number of years. At the same time, extensive ground surveys have been made to support the interpretation of the aerial photographs. In the first years of the survey, 1968 and 1970, 4.63% and 6.56% of the crop was affected by blight (3,4). Blight declined to 0.67% in 1972 (1), was too low to measure in 1973, and was less than 0.2% in 1974 (2).

Methods

In 1975, 28 fields (282 hectares) in the Chatham area and 59 fields (519 hectares) in the Hensall area were aerially photographed and ground surveyed for the incidence of bacterial blight. All photography was taken at a scale of 1:6,000 at an altitude of 6,900 ft above sea level. A Zeiss camera with a 12-inch focal length and Kodak Aerochrome Infrared 2443 film, 9 x 9 format, developed as a positive, were used. The photographs were taken on August 12 in the Hensall area and on August 14 in the Chatham area. The ground truth surveys commenced on July 28 and ended on August 21. Three hectares or more were examined in each field for blight and samples from infected leaves were forwarded to the Ottawa laboratory for identification of the causal organism.

For proof of pathogenicity, aqueous suspensions of colonies produced on nutrient agar were injected by means of a sterile hypodermic syringe into the primary leaf nodes of 2-week-old bean (*Phaseolus vulgaris* L. 'Seafarer') seedlings maintained in controlled environment growth chambers at close to 100% relative humidity, with a 16-h photoperiod at 26°C and an 8-h dark period at 18°C.

Disease interpretations were made from 9 x 9 inch color IR prints and from ground truth notes. Field infection percentages were determined using the drum scanner method (5).

Results and discussion

In contrast to the results of 1974, when blight was found in only 4 of 97 fields, measurable blight was detected by aerial photography in 49 of 59 fields surveyed in the Hensall area in 1975. The ground truth survey reported 21 fields affected. Of the 21 fields that were sampled, 16 yielded pathogenic cultures of *Xanthomonas phaseoli* and 4 yielded pathogenic cultures of *Xanthomonas phaseoli* var. *fuscans* (Table 1). Despite the high number of fields with blight, the amount per field was low because of a low seed-borne incidence in the Foundation seed stock used for planting

[1] *Contribution No.459, Ottawa Research Station, Agriculture Canada, Ottawa, Ontario K1A 0C6*

Table 1. Incidence of bacterial blight of field beans in the Hensall and Chatham areas in Ontario, 1975

			No. of fields affected		Causal organism	
Location	No. fields surveyed	Area (ha)	Ground truth survey	Aerial IR survey	*X. phaseoli*	*X. phaseoli* var. *fuscans*
Hensall	59	519	21	49	16*	4
Chatham	28	282	2	--**	2	

* In addition to the 16 pathogenic *X. phaseoli* types, one nonpathogenic *X. phaseoli* culture was isolated.
** Infection level in trace amounts, not detected by aerial photography.

Table 2. Incidence of bacterial blight in the Hensall, Ontario, area, 1975, as determined from aerial IR photographs

Field no.	Total area (ha)	Infected area (ha)	Percent infection
1	7.85	0.0133	0.170
2	1.90	0.0072	0.377
3	3.56	0.0190	0.533
4	8.46	0.0632	0.747
5	19.28	0.0393	0.204
6	8.18	0.3107	3.798
7	2.33	0.0062	0.266
8	9.44	0.0690	0.731
9	13.08	0.1338	1.022
10	35.11	0.0477	0.136
11	15.01	0.0076	0.051
12	3.24	0.1096	3.387
13	0.49		
14	2.11	0.0161	0.764
15	4.32		
16	0.90		
17	5.21	0.0222	0.425
18	8.46		
19	9.63	0.0039	0.040
20	1.11	0.0067	0.604
21	2.89	0.0148	0.511
22	10.76	0.0029	0.027
23	5.62	0.0277	0.492
24	4.85	0.0319	0.657
25	0.74		
26	3.78	0.0066	0.175
27	6.87	0.0046	0.068
28	12.29	0.0263	0.214
29	12.14	0.0597	0.492
30	7.30	0.0350	0.480
31	2.22	0.0072	0.323
32	0.22		
33	11.68	0.0626	0.536
34	9.00	0.0465	0.516
35	16.17	0.0462	0.286
36	14.01	0.0469	0.335
37	11.12	0.0053	0.048
38	5.08	0.0037	0.072
39	11.22	0.0256	0.228
40	23.58	0.0213	0.090
41	2.26	0.0037	0.162
42	0.81	0.0032	0.391
43	7.47		
44	7.47		
45	3.44	0.0094	0.273
46	17.69	0.0935	0.528
47	14.95	0.0193	0.129
48	4.63	0.0075	0.162
49	5.99	0.0032	0.0533
50	26.86	0.0318	0.118
51	26.76	0.0807	0.302
52	13.06	0.0178	0.136
53	8.40	0.0096	0.115
54	2.89	0.0457	1.584
55	6.82	0.2472	3.624
56	6.82	0.0617	0.905
57	13.54	0.0024	0.018
58	4.85		
59	11.86		
Total	519.24	1.9870	
Overall percent infection			0.383

most of the commercial seed fields in the area. The overall percent infection in the Hensall area was 0.383 and the highest infection level in any one field was 3.798% (Table 2).

The increase in the number of fields with blight, as compared to 1974, can possibly be explained by the increasing number of Foundation fields affected since 1973: 5.8% in 1973, 22.1% in 1974, 51.8% in

1975. The percentage of Select plots affected by blight was low in 1973 and 1974, 5.7% and 12.2% respectively, but increased dramatically in 1975 to 46.5%. Despite the increase in the number of affected fields, the incidence per field has remained at a low level. At present we have no explanation for the sudden increase in prevalence of the disease.

In the Chatham area blight was at an extremely low level with only 2 of 28 fields affected, both by common blight.

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Further studies on replant disease of apple in Nova Scotia[1]

R. G. Ross and A. D. Crowe

Growth of newly planted apple trees in orchards from which a pot test had shown an apple replant problem was significantly better at soil sites fumigated with chloropicrin than at nonfumigated sites. In a 6-year-old orchard poor tree performance was associated with a replant problem that did not appear to be caused by nematodes. Growth was less at high arsenic soil sites but it was not proven that arsenic was responsible.

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La croissance de pommiers nouvellement plantés en vergers dans lesquels on avait constaté des difficultés de reprise a été significativement meilleure dans les parcelles fumigées à la chloropicrine que dans celles non fumigées. Dans un verger de six ans, la mauvaise croissance des pommiers a été associée à un problème de replantation qui ne semble pas être causé par les nématodes. La croissance a été moins rapide dans les sols à forte teneur en arsenic, mais il n'a pas été prouvé que cet élément était en cause.

In an earlier paper, we showed that a replant problem exists in Nova Scotia apple orchards (9) but did not definitely establish that specific apple replant disease (SARD) (5,10) was present; however in a pot bioassay, apple seedlings grew much better in most orchard soils fumigated with chloropicrin than in nonfumigated soils. The possible causes of specific apple replant disease have received a lot of attention, with no one causal factor being identified (10). Recently Sewell and Wilson (11) have shown *Thielaviopsis basicola* (Berk. & Br.) Ferraris to be the probable causal agent of specific replant diseases of cherry and plum, but this fungus had no effect on the growth of apple.

This paper reports further investigations on the replant problem in apple orchards in Nova Scotia.

Materials and methods

The greenhouse pot bioassay method was essentially that used in previous work (9). Soil was fumigated with chloropicrin in glass jars or in the field and a comparison was made of the growth of Beautiful Arcade (BA) apple seedlings in fumigated and nonfumigated soil. Ten 11.5-cm clay pots each containing 500 cc of soil were used for each treatment and randomized in blocks on the greenhouse bench. The fumigants ethylene dibromide and Vorlex (methyl isothiocyanate 20% + 1,3 dichloropropene and related C_3 hydrocarbons 80%, Nor-Am) were used as described for chloropicrin (9). Benlate 50W (benomyl 50%, Dupont) and Dasanit 10G (fensulfothion 10%, Chemagro) were mixed with the soil just before potting.

Fumigation of tree planting sites with chloropicrin was done as described by Pitcher and Way (8). The land was first cultivated to a fine tilth to a depth of about 23 cm, and an area of 137 cm x 137 cm was fumigated by injecting with a hand injector, at a depth of 15 cm, 1.5 ml chloropicrin per 22.9 cm^2, totalling 54 ml per tree site. Treatment was facilitated by using a square fiberboard templet with 36 holes, on 22.9 cm squares, through which the hand injector was inserted, and with a hole in the center to fit over a stake marking each planting site. The soil was fumigated when moist but not wet. After fumigation the surface of the soil was compacted by tramping or by overlapping passes with a garden tractor fitted with wide rubber tires.

Arsenic content of the soil was determined using the arsine-molybdenum blue procedure given by Hoffman and Gordon (4). Samples for water soluble arsenic were prepared by shaking 50 g of air dried sieved soil with 500 ml water for 8 h, letting stand overnight and then filtering. For total arsenic, the soil was digested with nitric, sulphuric, and perchloric acids to solubilize the arsenic, and the digests were made to suitable volumes with 1 N HCl. Populations of the nematode *Pratylenchus penetrans* (Cobb) Filip, and Stek. were determined as outlined by Townshend (12).

Two apple orchards, A and B, both on sandy loam soil, were used. Orchard A, located at Woodville, N.S., had been planted to McIntosh apples on BA seedling rootstock in 1968, and subsequent variation in the growth of the trees (Table 1) suggested a replant problem. Orchard B, located at the Agriculture Canada Research Station, Kentville, N.S., was cleared of apple seedlings in 1972, and previous work showed that it had a replant problem (Orchard I in our earlier study [9]). Soil from another orchard (C) at Woodville with a suspected replant problem was used in one test.

Results

In 1973 the replant bioassay was done on soil from under five trees in row 1 of orchard A. The tree locations

[1] *Contribution No. 1580, Research Station, Agriculture Canada, Kentville, Nova Scotia B4N 1J5*

Table 1. Trunk cross–sectional area of McIntosh apple trees at five sites in Orchard A; growth of BA* apple seedlings in a pot bioassay, and pH, nematode population, and arsenic content of soil samples from each site

Tree†	Trunk cross section (cm^2)	Length of BA* seedlings (cm)		pH	*Pratylenchus penetrans* no./kg dry soil	Arsenic (ppm)	
		Fumigated	Nonfumigated			Total	Water soluble
12	67	47.1	17.2	6.3	6332	15.8	0.25
20	70	44.9	24.1	6.2	2190	17.4	0.58
27	35	43.1	8.3	5.2	3656	68.5	1.54
30	24	51.7	3.5	5.6	9957	97.0	2.21
36	29	56.8	15.3	5.4	598	75.3	2.43

* Beautiful Arcade
† Tree no. in row 1

in the row and the cross-sectional area of each tree trunk measured about 30 cm above ground level are given in Table 1. Arsenic analyses were done on the bioassay soil samples, and nematode counts were made on soil collected in June 1974.

The data on trunk cross section (Table 1) show the variation in growth among the trees in the row. When BA apple seedlings were grown in nonfumigated soil and in chloropicrin-fumigated soil from under these trees, there were significant (P.05) differences among nonfumigated soils and a highly significant (P.01) response to fumigation of soil from each site. There were no differences in the growth of the seedlings among the fumigated soils from the five sites. The pH tended to be lower and the arsenic levels higher in the areas of poorer tree growth. There was considerable variation in numbers of nematodes among the tree sites with the lowest count in soil from tree 36, which had made poor growth.

In 1974 the pot bioassay was done on soil from tree 30 in orchard A and on soil from orchard C that had received the treatments given in Table 2 and Figure 1. The results show that orchard C had a replant problem similar to that of tree 30 in orchard A. In soil from both orchards the fungicide Benlate had no effect on the growth of the apple seedlings and, while there appeared to be a slight response to the nematicide Dasanit, growth was not significantly different from that in nontreated soil. The three fumigants all gave a marked response, with small differences in seedling growth.

In orchard A the effect of field fumigation on the growth of apple trees was tested at 13 tree sites 2.7 m apart in a row adjacent to trees 30 and 36. On 10 October 1974, alternate tree sites were fumigated with chloropicrin. Soil temperature was 10.5°C. On 12 November soil for pot bioassays was taken from tree sites 2, 6, and 12 (fumigated sites) and 1, 5, and 11 (nonfumigated sites). On 12 May 1975, uniform maiden whips of Northern Spy apple trees on Malling 7A rootstock were planted at each of the 13 tree sites and headed back to about 60 cm. At the end of the growing season the length and number of shoots were recorded for each tree.

In the growth of the Spy trees in the field (Table 3) there was generally a marked response to soil fumigation with chloropicrin. At nonfumigated sites, growth varied from good at site 3 to poor at sites 11 and 13. In the pot bioassay, growth of BA seedlings in soil from the three field-fumigated sites was almost identical, whereas in soil from nonfumigated sites growth was variable and reflected that of the Spy trees in the field (Table 3). Growth of BA seedlings in greenhouse-fumigated soil was superior to that of seedlings grown in soil from field-fumigated sites.

Another test on the effect of field fumigation on the growth of apple trees was done in orchard B in conjunction with a paired observation trial of 10 apple strains and cultivars on BA rootstocks. Twenty planting sites 2.7 m apart were laid out in a single row and divided into adjoining pairs. On 5 May 1974, one site of each pair chosen at random was fumigated with chloropicrin. Soil temperature was 5°C and soil pH 6.0. Maiden whips of the 10 strains and cultivars were planted in pairs on June 5 with one whip of each pair being assigned at random to a fumigated site. Extension shoot growth was measured in the fall of 1974 and 1975.

In the first year all except 2, Jonagold and Kress McIntosh, of the 10 selections showed a growth response to fumigation with chloropicrin (Table 4). However, in the greenhouse bioassay BA seedlings grown in soil from the fumigated sites of these two selections showed the same response as those in soil from other fumigated sites. With these two selections the response to fumigation came in the 2nd year when growth was considerably greater at the fumigated than at the nonfumigated sites.

Sites for another paired observation trial in orchard B, using the same layout as above, were fumigated with chloropicrin on 8 October 1974. Soil temperature was

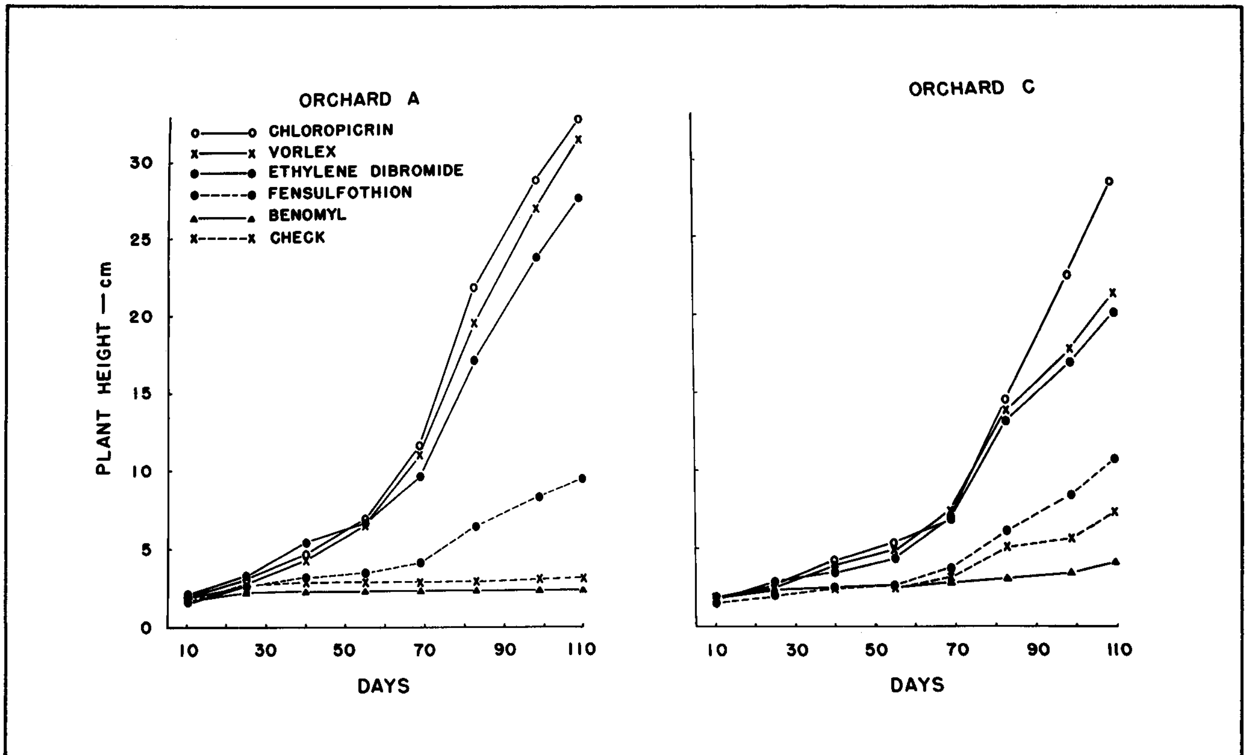

Figure 1. Growth of Beautiful Arcade apple seedlings in a greenhouse test with soil from orchard A (tree 30) and orchard C.

Table 2. Pot test with Beautiful Arcade apple seedlings grown in soil from two locations receiving different treatments

Treatment	Dose/liter of soil	Growth of seedlings (cm) Tree 30 Orchard A	Orchard C	Mean
Chloropicrin	0.20 ml	32.7	28.4	30.5 a
Ethylene dibromide	0.50 ml	27.5	20.1	23.8 b
Vorlex	0.50 ml	31.3	21.2	26.3 ab
Benlate 50W	0.50 g	2.4	4.2	3.3 d
Dasanit 10G	0.25 g	9.4	10.8	10.1 c
Check		3.1	7.3	5.2 cd

The small letters indicate treatments which do not differ significantly at the 0.05 level according to Duncan's Multiple Range Test.

12°C. Immediately following fumigation the fumigated sites were covered with polyethylene sheeting which remained in place over winter. On 4 November soil for greenhouse tests was taken from a fumigated plot and from a nonfumigated plot at each end of the row. Also included in the pot bioassay were samples of greenhouse-fumigated soil from sites that had not been treated in the field.

There was no significant difference between the height of seedlings grown in greenhouse-fumigated and field-fumigated soils but there was a significant difference (P.01) between growth in fumigated and nonfumigated soils (Table 5). Maiden whips were planted at these sites in the spring of 1975, but because of adverse growing conditions they did not grow satisfactorily and put out little or no extension growth.

Discussion

This investigation has not met the criteria needed (5,10) to definitely establish that specific apple replant disease (SARD) is present in Nova Scotia. Nevertheless, at sites where a pot bioassay for SARD indicated a replant problem, fumigation of the planting site with chloropicrin resulted in a marked increase in the growth of apple trees (Tables 2 and 3). Field fumigation with chloropicrin tended to equalize any variability among planting sites.

The variation in the growth of the McIntosh trees planted in orchard A in 1968 (Table 1) was also probably due to

Table 3. Effect of fumigation (F) with chloropicrin on the extension growth of Spy apple trees in orchard A and of Beautiful Arcade apple seedlings in pots of soil from that orchard

Site No.	Spy shoot growth No.	Spy shoot growth Length (cm)	BA seedlings in pots of soil: Field fumigated	Greenhouse fumigated	Not fumigated
1	6	136		38.4	21.2
2 (F)	7	262	30.6		
3	9	320			
4 (F)	8	268			
5	9	151		46.8	17.5
6 (F)	14	346	30.3		
7	7	185			
8 (F)	7	234			
9	5	186			
10 (F)	5	230			
11	4	79		52.3	7.3
12 (F)	6	213	30.6		
13	6	79			

Table 4. Effect of field fumigation with chloropicrin on the performance of 10 strains and cultivars of apple trees in orchard B

Soil treatment	Average no. of shoots per tree 1st yr	2nd yr	Length of shoot growth per tree (cm) 1st yr	2nd yr
Fumigated	15.2	34.3	121.6	1037.9
Nonfumigated	10.1*	27.4	63.7**	757.7*

*P 0.05; **P 0.01

a replant problem. Tree sites 27, 30, and 36 were definitely in a replant area but it is not known if the area of sites 12 and 20 had been in orchard. The arsenic levels were not particularly high compared to those reported by Benson et al. (2). They found that arsenic was more toxic to growth in alkaline than in acid soil. They suggested that if the arsenic content was not over 100 ppm and the soil pH was less than 6.5, fumigation with methyl bromide would alleviate the replant problem; otherwise the soil at the planting site should be replaced with arsenic-free soil (2). In composite samples of Nova Scotia apple orchard soils Bishop and Chisholm (3) reported total arsenic levels ranging from 9.8 to 124.4 ppm.

According to Hoestra (5) *P. penetrans* is the most important nematode in apple orchards in the Netherlands and can cause serious damage to trees grown on light soils. The numbers reported here (Table 1) indicate a heavy infestation (5, 7) but there was no correlation between numbers and tree performance. In the pot bioassay the nematicide Dasanit did not significantly improve apple seedling growth in soil from the site most heavily infested with *P. penetrans* (Table 2, Fig. 1), although the fumigants ethylene dibromide and Vorlex gave a good response. These fumigants have generally not given as good a response as chloropicrin in the treatment of replant disorders (5, 10). The seedlings did not respond to the fungicide Benlate, which has been used successfully to control cherry replant disease caused by the fungus *Thielaviopsis basicola* (11).

In the paired observation trial in orchard B (Table 4) there was a good response in tree growth to field fumigation with chloropicrin. Most selections responded in the first year, but in two selections the response did not occur until the second year after planting. It had been thought that replant disease affected trees only in their first or second year, but Jackson (6) has recently shown that in later years growth was directly related to the size of the fumigated area.

Despite the fact that the cause of replant disease of apples in Nova Scotia is not known, the pot bioassay should be useful to indicate if a replant problem exists. Field fumigation with chloropicrin appears to alleviate the problem but further work is required to determine if one or more factors such as SARD, soil arsenic, and nematodes are the cause of the replant problem in Nova Scotia.

Table 5. Height (cm) of BA apple seedlings grown in soil from orchard B fumigated with chloropicrin in the field and in the greenhouse

Treatment	Site 1	Site 2	Mean
Field fumigated	13.3	14.8	14.1
Greenhouse fumigated	17.5	18.2	17.8
Nonfumigated	3.2	8.6	5.9

Acknowledgments

The authors thank the following from the Research Station, Kentville, N.S.; D. Chisholm for the arsenic analyses, G. L. Brown for the statistical analyses, D. N. Crouse and R. J. Newbery for technical assistance, and J. Kimpinski, Research Station, Charlottetown, P.E.I. for determining the nematode populations.

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Infection of additional hosts of Synchytrium endobioticum, the causal agent of potato wart disease: 1. Tomato

Michael C. Hampson[1]

Fifty-one commercial tomato cultivars were inoculated with European races 2 and 8 of *Synchytrium endobioticum*. All cultivars were infected. This is the first study of the responses of additional hosts in Newfoundland to potato wart disease.

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On a inoculé 51 cultivars commerciaux de tomate avec les races européennes 2 et 8 de *Synchytrium endobioticum*. Tous les cultivars ont été infectés. C'est la première étude des réactions d'hôtes additionnels à la tumeur verruqueuse de la pomme de terre à Terre-Neuve.

In 1973, the combined Newfoundland and Prince Edward Island tomato growing industry ranked sixth in production among Canada's Provinces (12). There are now about 20 Newfoundland operators producing tomatoes under 0.7 hectare of glass or plastic (M. Stapleton, personal communication).

Cotton, in 1916, demonstrated that solanaceous plants other than the potato, *Solanum tuberosum* L., can be attacked by *Synchytrium endobioticum* (Schilb.) Perc. (1). Four years later the first report was made of infection of tomato, *Lycopersicum esculentum* Mill., in wart-infested soil (8). Other studies, notably in the United States (13), England (9), Germany (2, 6, 7) and India (10), have demonstrated that tomato tissue is highly susceptible.

Since potato wart disease is endemic in Newfoundland (4), information on the susceptibility of tomato varieties was of importance to local growers. No previous study had reported the inoculating fungal race, and since several races exist in Newfoundland tomato susceptibility tests were made with European races 2 and 8, the most common races of *S. endobioticum* in Newfoundland.

Materials and methods

Tomato seedlings were raised in a controlled environment room (3). Seed was surface sterilized for 2 min in 1% formalin, rinsed in sterile distilled water, and planted in sterilized potting mix (peat:perlite, 2:1, v/v). At the four-leaf stage, five seedlings of each cultivar were transferred to 5.1-cm pots containing wart-infested potting mix and grown under the following conditions: photoperiod, 16 h/day; temperature, 22°C; R.H., 80%; watering regime, daily; fertilization, weekly, van der Elst's solution (10). Seedlings were examined macro- and microscopically (25 X) 4 wk after inoculation. The number of resting spores/plant was recorded and the plants indexed: L 5-20 resting spores; M 20-100; H >100. In preliminary experiments to determine the most effective means of inoculation, seedlings were either rooted in infested mix, planted with wart pieces placed in contact with plant stem bases, or subjected to Hille's (5) immersion-inoculation technique.

Results and discussion

Attempts were made to duplicate Hille's immersion-inoculation technique but no infection developed in our plants. No reason could be found for this failure, although parallel experiments using both races with infested potting mix gave positive results. Hille developed his technique for large-scale screening purposes but, as our study was not confounded by the factor of massive screening, our approach was developed along the lines described. The potting mix method was selected since it offered better control over inoculum density; however the same infection picture developed using the mix or the wart piece inoculation technique.

Searching for resting spores was time consuming since the roots of tomato are attacked. This is in contrast with potato cultivars in which roots are not known to be attacked. Generally less than 20 resting spores were recorded on 50% of the plants at stem bases or on lateral roots attached at stem bases. The fungus occurred as isolated or small groups of resting spores. The response of the tomato cultivars to infection appears to be of a different order than that of potato since no galls were found on the tissues.

This study, presenting the first data on the reaction of additional hosts to Newfoundland races of the potato wart fungus, agrees with other results showing that tomato tissue is susceptible to potato wart infection. Although each cultivar was attacked by races 2 and 8, some difference in virulence was found because up to 13% of the tomato specimens escaped infection by race 8, and 7% escaped infection by race 2.

[1] *Contribution No. 48, Research Station, Agriculture Canada, St. John's, Newfoundland A1E 3Y3*

Table 1. Infection of 51 tomato cultivars inoculated with two races of the potato wart disease fungus *Synchytrium endobioticum*

Tomato cultivar	No. of seedlings*/ infection level**					
	Race 2			Race 8		
	L	M	H	L	M	H
Vogue	5	0	0	4	1	0
Stokesalaska	3	0	0	4	1	0
Hybrid Red No. 22	5	0	0	3	2	0
Rocket	2	2	1	2	2	0
Vision	5	0	0	5	0	0
Burpee's VF	2	2	0	5	0	0
Quebec No. 13	5	0	0	1	0	0
Quebec No. 314	4	0	0	3	0	0
Nova	5	0	0	0	1	0
Campbell No. 28	3	0	0	1	3	0
Veeset	2	2	0	3	1	0
Spring Giant Hybrid	3	0	0	1	0	0
Rideau	4	1	0	3	0	0
Stakeless	5	0	0	3	0	0
Campbell No. 19	4	0	0	4	0	0
Crackproof Pink	4	1	0	3	0	0
Early Fireball	1	4	0	4	0	0
Bush Beefsteak	2	3	0	3	2	0
Ultra Boy VFN	3	2	0	4	1	0
Valiant	4	0	0	4	0	0
New Yorker	0	2	3	5	0	0
Livingstone Globe	3	0	2	4	0	0
Earliest of All	3	0	0	3	0	0
Ponderosa	0	2	2	4	0	0
San Marzano	2	3	0	5	0	0
Viceroy	3	2	0	4	1	0
Longred	0	5	0	0	2	3
John Baer	5	0	0	4	0	0
Moira	2	3	0	3	2	0
McMullen	5	0	0	0	4	1
Early Bird	1	3	0	1	4	0
Selandia	3	0	2	4	1	0
Roma	4	0	1	1	3	1
Burpee's Big Early	5	0	0	4	1	0
Hybrid Pink No. 12	5	0	0	4	0	1
Early Red Chief	1	4	0	2	3	0
Stokesdale	3	2	0	3	2	0
Veebrite	0	5	0	0	4	0
Super–standard Bonny Best	4	1	0	2	3	0
Hybrid Pink No. 6	2	3	0	3	2	0
Early Stokesdale No. 4	5	0	0	5	0	0
Early Detroit	4	1	0	3	2	0
Tomato Glamour	4	1	0	3	2	0
Manitoba	5	0	0	4	1	0
Dwarf Champion	1	3	0	2	1	1
Springset VF	0	4	1	5	0	0
Fantastic Hybrid	2	3	0	0	5	0

Table 1. (Cont.)

Tomato cultivar	No. of seedlings*/ infection level**/					
	Race 2			Race 8		
	L	M	H	L	M	H
Cold Set	3	0	0	3	1	0
Beefeater Hybrid VFN	4	1	0	0	3	2
Hybrid Pink No. 1	3	2	0	2	3	1
Hybrid Pink No. 2	5	0	0	5	0	0

* Five seedlings used in each test.

** Infection level based on No. of resting spores/plant: L = 5 – 20; M = 20 – 100; H = >100.

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Spoilage of rapeseed in elevator and farm storage in western Canada[1]

J. T. Mills

Elevator managers of the Alberta, Saskatchewan, and Manitoba Pools were surveyed by mail on the extent of rapeseed spoilage and heating in their elevators and on customers' farms. Signed questionnaire replies were received from 440 managers (54% return) who had handled 209,500 metric tonnes (9,300,000 bu) or 25% of the 1974 rapeseed crop delivered to Prairie elevators. Spoilage and heating, and mite infestations of the 1974 crop were reported by 23% and 24% of the managers respectively; corresponding figures for 1975 rapeseed were 19% and 25%. The average amount of spoiled or heated rapeseed reported in elevators was 62.0 tonnes (2,752 bu) in 1974 and 55.3 tonnes (2,456 bu) to mid December in 1975. Generally crop districts with high incidence of farm spoilage and heating in 1974 coincided with districts of high elevator spoilage. Turning (moving grain from bin to bin during storage) in many instances did not prevent spoilage and heating. The higher the seed moisture content the higher the probability of spoilage and heating even with turning. In elevators spoilage and heating were mostly detected by odor and by grain examination during turning.

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On a effectué une enquête postale auprès des exploitants de silos-élévateurs de l'Alberta, de la Saskatchewan et du Manitoba pour tenter d'évaluer l'importance de l'altération et du chauffage du colza dans leurs installations, de même que dans celles de leurs clients. Quelque 54% d'entre eux (440) ont retourné le questionnaire signé, de sorte que les données de l'enquête portent sur 209 500 tonnes métriques (9 300 000 boiss.) ou 25% des livraisons totales de 1974 aux silos-élévateurs des Prairies. Les répondants ont déclaré de l'altération et du chauffage dans une proportion de 23%, et des infestations par les acariens dans une proportion de 24%, contre 19% et 25% respectivement pour la récolte de 1975. La quantité moyenne de colza altéré dans les silos-élévateurs se montait respectivement à 62.0 et 55.3 tonnes (2 752 et 2 456 boiss.) en 1974 et en 1975 (mi-décembre). En général, les régions de culture affichant une forte fréquence d'altération dans les fermes correspondaient à celles où les silos-élévateurs déclaraient le plus d'altération. Dans nombre de cas, le retournement du colza (par transvasage d'un coffre à l'autre pendant l'entre-posage) n'a pas éliminé ces phénomènes qui, par ailleurs, sont plus fréquents quand la teneur en eau des grains est forte. En général l'altération et le chauffage sont décelés à l'odorat ou par examen des grains au moment du retournement.

Canada produced an estimated 1.2 million metric tonnes (52.0 million bu) of rapeseed in 1974 of which 240,000 tonnes (10.5 million bu) were in store in primary and terminal elevators and 38,000 tonnes (1.7 million bu) on farms at the end of the 1973-74 crop year (2). Most of this seed was harvested and stored without becoming spoiled or heat-damaged. Some rapeseed, however, spoils and heats in storage, becomes downgraded by primary elevators, is often rejected by oil processors, and may be sold to feed mills or discarded. Accurate figures for the amount of spoiled or heat-damaged rapeseed are difficult to obtain as deliveries rejected by oil processors or elevators are not usually recorded nor are losses that occur in farm storage. Because of the large number of verbal reports of rapeseed spoilage and heating from growers and persons handling the crop, it was decided to determine the extent of spoilage and heating through a postal survey of primary elevator managers of the Manitoba, Saskatchewan, and Alberta Wheat Pools. Primary elevator managers were considered to be the best source of information as they often have an intimate knowledge of storage problems occurring on their customers' farms plus practical knowledge obtained through handling rapeseed in their elevators. This report summarizes the replies received from elevator managers handling the 1974 and 1975 crops.

Methods

A one-page questionnaire containing 31 questions prepared by the Agriculture Canada Research Station, Winnipeg, was circulated by the country elevator divisions of 3 major grain companies, the Manitoba, Saskatchewan, and Alberta Wheat Pools. Elevators surveyed were located throughout the provinces of Manitoba and Alberta and in Wheat Pool areas C and D, approximately equivalent to crop districts 19 to 23 and 28 to 32, in Saskatchewan. Elevator managers were requested to answer questions relating to spoilage and heating of the 1974 and 1975 rapeseed crops in their elevator and on customers' farms. Signed questionnaires from the responding elevator managers handling rapeseed were analyzed and any comments abstracted. A reply is defined as one report from one elevator manager for the crop produced in a particular year.

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Table 1. Frequency of occurrence of degraded, rejected, spoiled, heated, and mite–infested rapeseed from the 1974 and 1975 crops in elevators under survey

	Manitoba		Saskatchewan		Alberta		Prairie	
	1974	1975	1974	1975	1974	1975	1974	1975
No. of elevator replies*	126	131	200	200	106	109	432	440
No. of elevators reporting spoilage and heating in the elevator	31	21	50	40	18	21	99	82
% of total elevators reporting spoilage and heating in the elevator	25	16	25	20	17	19	23	19
No. of elevators degrading at purchase	22	11	43	27	28	13	93	51
% of total elevators degrading at purchase	17	8	22	14	26	12	22	12
No. of elevators rejecting rapeseed	28	17	44	39	18	12	90	68
% of total elevators rejecting rapeseed	22	13	22	20	17	11	21	15
% of total elevators with mite infestations	19	26	30	29	22	19	24	25

* Data was supplied in some instances for only one year

Replies to specific questions relating to elevator storage are grouped under four headings, 1) the frequency of occurrence and amounts of degraded, rejected, spoiled, heated, and mite-infested rapeseed in elevators; 2) frequency of occurrence and amounts of spoiled and heated rapeseed in elevators arranged by crop district; 3) most commonly used methods of detection of spoilage and heating of rapeseed in elevators; and 4) turning of stocks.

Replies to questions relating to storage on farms are grouped under three headings, 1) the frequency of occurrence and maximum amounts of spoiled, heated, and mite-infested rapeseed on farms as reported by customers to managers; 2) the frequency of occurrence and distribution of farm spoiled and heated rapeseed rejected by elevators; and 3) the most commonly used methods of disposal of spoiled and heated rapeseed by farm customers. Managers were requested to also send 900-g samples of sound and of some spoiled or heated rapeseed. These samples were subjected to biological, physical, and chemical tests to determine spoilage and heating levels of rapeseed. Results of these analyses are presented elsewhere. The term "spoiled rapeseed" denotes seeds that may or may not be heated but are deteriorated in quality usually manifested by a strong odor when compared to sound rapeseed of the same age. The term "heated rapeseed" denotes seed which has become charred, discolored, or otherwise affected as a direct result of abnormal rise in temperature; such seeds usually have a light brown or dark brown internal coloration.

Results

There were 432 replies to the questionnaire from managers handling the 1974 crop and 440 replies for the 1975 crop. Results are presented under elevator (Tables 1 to 6) and farm (Tables 3, 7, and 8) headings.

Spoilage and heating in primary elevators

1) Frequency of occurrence and amounts of degraded, rejected, spoiled, heated, and mite-infested rapeseed in elevators—On a prairie-wide basis, 23% of managers experienced spoilage and heating with the 1974 crop and 19% with the 1975 crop (Table 1). Spoiling and heating for the 1974 crop and incidence of rejection of rapeseed at purchase were less commonly experienced in Alberta than in Manitoba and Saskatchewan. Degrading of the 1974 and 1975 crops was less frequent in Manitoba than in the other provinces. Mite infestations were most commonly experienced in Saskatchewan.

During 1974, a total of 211,000 tonnes (9,369,000 bu) of rapeseed was purchased at the 440 elevators (Table 2), representing 25% of the rapeseed delivered to primary elevators during 1974-75 (3). This amount purchased by the elevators represents 22% of the Alberta, 33% of the Manitoba, and 37% of the Saskatchewan totals for the 1974 crop. Spoilage and

Table 2. Amounts of rapeseed purchased, degraded, rejected, spoiled or heated in elevators under survey

	Manitoba		Saskatchewan		Alberta		Prairie	
	1974	1975	1974	1975	1974	1975	1974	1975
Total no. tonnes* purchased by elevators in the survey	35,650.7	40,264.9	107,741.3	91,295.2	67,622.8	71,600.0	211,014.7	203,159.8
No. tonnes purchased and degraded because of spoilage or heating	1,061.9	604.7	3,396.4	1,948.9	2,101.4	837.8	6,559.6	3,391.4
No. tonnes rejected because of spoilage or heating	1,598.2	550.9	3,464.5	2,572.1	805.2	639.6	5,867.9	3,762.6
No. tonnes spoiled or heated in the elevators	1,701.3	1,037.6	2,775.0	2,374.5	1,655.4	1,123.9	6,131.7	4,536.0
% of total tonnes purchased that spoiled or heated in elevators	4.8	2.6	2.6	2.6	2.4	1.6	2.9	2.2

* To convert tonnes of rapeseed to bu multiply tonnes by 44.4

heating of the 1974 crop occurring in Manitoba elevators was higher, at 4.8% of elevator purchases, than in Saskatchewan and Alberta elevators, which experienced about 2.5% spoilage.

2) Frequency of occurrence and amounts of spoiled and heated rapeseed in elevators arranged by crop district—Frequency of spoilage tended to be higher in some crop districts in 1974 (Tables 3, 4).

The average amount of rapeseed spoiled or heated in elevators reporting such incidence, on a prairie-wide basis, was 62.0 tonnes (2,752 bu) for the 1974 and 55.3 tonnes (2,456 bu) for the 1975 crops. The highest spoilage and heating of the 1974 crops occurred in Alberta with an average of 92.0 tonnes (4,030 bu) per elevator (Table 4).

3) Most commonly used methods of detection of spoilage and heating of rapeseed in elevators—The principal means used to detect spoilage and heating were odor and turning accompanied by crushing or temperature sensing either by hand or thermometer. Occasionally the presence of molds was used as the criterion of spoilage. Metal rods were used rarely to detect heating. Approximately the same trends of usage occurred in each province.

4) Turning of elevator stocks in relation to occurrence of spoilage and heating—Most managers, in their considered opinion, thought that spoilage and heating did not increase after stocks were turned (Table 6). However, when questioned specifically on the most recent report of spoilage or heating in their elevator, many managers stated that they had experienced such problems after turning stocks. This suggests that turning, in many instances, did not prevent spoilage and heating.

Managers were asked several other questions on the most recent report of spoilage or heating in their elevators. The questions and the replies are summarized in Table 6.

Moisture contents of the spoiled or heated rapeseed stocks before turning were mostly between 8.6% and 10.5%. Generally the higher the seed moisture content, the higher the likelihood of spoilage and heating even with turning.

Maximum temperatures attained by turned bulks were mainly in the range of 26°to 45°C. There were 16 reports of heating with maximum temperatures of 25°C and below, 122 reports between 26°and 45°C, 19 reports between 46°and 60°C, and 5 reports of 66°C.

The number of days after turning when spoilage and heating occurred varied from 0 to 200 days but was mainly between 6 and 30 days. In Manitoba most spoilage and heating occurred between 6 and 15 days and between 26 and 30 days after turning. In Saskatchewan the same trend probably occurs but the two peak periods are less distinct than in Manitoba. In Alberta, less spoilage and heating appears to occur 6 to 10 days after turning than in Manitoba and Saskatchewan (Table 6).

Many instances of spoilage and heating were reported after turning stocks in the months July to October. This is also, however, the period during which most purchasing and turning of all rapeseed stocks normally take place. It is thus not possible, from the present data, to

Table 3. Frequency of occurrence of spoilage and heating, and rejection of rapeseed in primary elevators by crop district

	1974 crop					1975 crop				
Crop District *	No. elevators replying	No. elevators with spoilage and heating	% of replying elevators with spoilage and heating	No. elevators rejecting rapeseed	% of replying elevators rejecting rapeseed	No. elevators replying	No. elevators with spoilage and heating	% of replying elevators with spoilage and heating	No. elevators rejecting rapeseed	% of replying elevators rejecting rapeseed
Manitoba										
1	10	2	20	2	20	10	2	20	2	20
2	14	6	43	6	43	14	2	14	3	21
3	20	3	15	7	35	21	4	19	4	19
4	2	0	0	0	0	2	0	0	0	0
5	12	1	8	1	8	12	2	17	2	17
7	9	3	33	1	11	9	0	0	0	0
8	13	0	0	3	23	14	1	7	3	21
9	8	3	38	1	13	9	0	0	0	0
10	18	3	17	0	0	20	5	25	1	5
11	8	3	38	3	38	8	2	25	1	13
12	4	1	25	0	0	4	0	0	0	0
13	6	5	83	4	67	6	3	50	1	17
14	2	1	50	0	0	2	0	0	0	0
Total	126	31		28		131	21		17	
Saskatchewan										
19 (5a)	16	1	6	5	31	16	3	19	6	38
20 (6a)	15	3	20	3	20	14	0	0	2	14
21 (7a)	11	1	9	1	9	10	0	0	1	10
22 (8a)	27	12	44	10	37	27	11	41	9	33
23 (9a)	31	9	29	6	19	31	8	26	3	10
28 (5b)	35	12	34	7	20	36	5	14	6	17
29 (6b)	8	0	0	0	0	8	1	13	1	13
30 (7b)	19	2	11	0	0	19	2	11	1	5
31 (8b)	17	5	29	5	29	18	5	28	6	33
32 (9b)	21	5	24	7	33	21	5	24	4	19
Total	200	50		44		200	40		39	
Alberta										
35 (1)	2	1	50	0	0	2	1	50	0	0
36 (2)	12	2	17	0	0	13	3	23	1	8
37 (3)	8	0	0	2	25	8	0	0	0	0
38 (4)	36	6	17	5	14	36	6	17	4	11
39 (5)	21	2	10	0	0	23	5	22	2	9
40 (6)	15	3	20	6	40	15	2	13	3	20
41 (7)	12	4	33	5	42	12	4	33	2	17
Total	106	18		18		109	21		12	

* The crop district designations are those used by Sinha, R.N., et al. Oecologia (Berlin) 12:69 - 88, 1973. For Manitoba these designations are the same as those of the traditional crop districts; for Saskatchewan the corresponding traditional crop districts and for Alberta the agricultural reporting areas appear in parentheses.

state that turning of stocks in e.g. October is implicated as a factor in spoilage and heating.

Spoilage and heating on farms

1) Frequency of occurrence and maximum amounts of spoiled, heated, and mite infested rapeseed on farms as reported by customers to managers—Across the prairies 6.5% of elevator farm customers had experienced heating and spoilage problems with their 1974 rapeseed (Table 7). Provincially, Manitoba had the highest percentage, 7.7% in 1974, but also the lowest percentage, 3.4% in 1975. Mite infestations on farms were

Table 4. Amounts of spoiled and heated rapeseed in primary elevators by crop district *

Manitoba

	1974 crop		1975 crop	
Crop District	No. tonnes spoiled and heated	No. elevators	No. tonnes spoiled and heated	No. elevators
1	64.2	2	103.6	2
2	243.2	6	122.7	2
3	259.0	3	308.6	4
5	67.6	1	67.6	2
7	193.7	3		
8			22.5	1
9	107.8	3		
10	250.0	3	87.2	5
11	225.2	3	225.0	2
12	18.0	1		
13	268.0	5	100.2	3
14	4.5	1		
Totals	1,701.2	31	1,037.4	21
Avg per elevator	54.9 t (2,437 bu)		49.4 t (2,193 bu)	

Saskatchewan

	1974 crop		1975 crop	
Crop District	No. tonnes spoiled and heated	No. elevators	No. tonnes spoiled and heated	No. elevators
19 (5a)	45.0	1	114.9	3
20 (6a)	128.4	3		
21 (7a)	22.2	1		
22 (8a)	641.9	12	653.2	11
23 (9a)	346.8	9	347.5	8
28 (5b)	938.4	12	427.9	5
29 (6b)			78.8	1
30 (7b)	94.6	2	78.8	2
31 (8b)	287.4	5	434.7	5
32 (9b)	270.3	5	238.7	5
Totals	2,775.0	50	2,374.5	40
Avg per elevator	55.5 t (2,464 bu)		59.4 t (2,637 bu)	

Alberta

	1974 crop		1975 crop	
Crop District	No. tonnes spoiled and heated	No. elevators	No. tonnes spoiled and heated	No. elevators
35 (1)	67.6	1	90.1	1
36 (2)	90.1	2	195.9	3
37 (3)	596.8	6	326.6	6
38 (4)	202.7	2	153.1	5
39 (5)	85.6	3	135.1	2
40 (6)	612.6	4	223.0	4
41 (7)				
Totals	1,655.4	18	1,123.8	21
Avg per elevator	92.0 t (4,084 bu)		53.5 t (2,375 bu)	

Avg amount of rapeseed spoiled in elevators on a prairie-wide basis: 1974 crop, 62.0 tonnes (2,752 bu)
1975 crop, 55.3 tonnes (2,456 bu)

* See footnote, Table 3.

reported less frequently than heating and spoilage problems.

Managers were asked for information on the maximum amount of spoiled or heated rapeseed that they had heard about on any one farm. The total of these estimates amounted to 8660 tonnes (385,000 bu) of the 1975 crop across the prairies (Table 7). This amount does not take into account all lesser amounts in the elevator customer areas.

2) Frequency of occurrence and distribution of farm-spoiled and heated rapeseed rejected by elevators—Generally crop districts with high incidence of farm heating and spoilage in 1974, indicated by high incidence of elevator rejection, coincide with districts of high elevator spoilage (Tables 3, 4).

3) Most commonly used methods of disposal of spoiled and heated rapeseed by farmers—The most frequently used method of disposal was the sale of affected seed to an elevator or to a feed mill (Table 8). Other frequently used alternative methods included selling to crushers or other seed houses, mixing with sound rape, and mixing for livestock feed on the farm. Discarding was generally the least popular method of disposal of spoiled and

Table 5. Most commonly chosen methods of detection of spoilage and heating of rapeseed in elevators by managers

		Chosen method expressed by % of total choice							
Province	Choice	Odor	Turning	Moldiness	Metal rod	Turning and crushing	Turning and temperature—sensing	Turning and sampling	Unspecified
Manitoba	1 st	11	13	1	1	3	0	0	1
	2 nd	14	4	3	2	1	0	0	0
	3 rd	1	0	14	4	0	0	0	3
	4 th	1	0	5	17	0	0	0	1
Saskatchewan	1 st	18	14	1	1	1	2	0	0
	2 nd	9	4	5	3	1	1	1	0
	3 rd	1	2	10	6	0	0	0	1
	4 th	0	1	5	12	0	0	0	1
Alberta	1 st	15	16	0	1	1	1	0	0
	2 nd	12	4	6	1	0	1	0	0
	3 rd	1	2	13	5	0	0	0	0
	4 th	0	1	5	15	0	0	0	0
Prairie	1 st	15	14	0	1	2	2	0	1
	2 nd	11	4	5	2	1	1	0	0
	3 rd	1	1	12	5	0	0	0	1
	4 th	0	1	5	14	0	0	0	1

heated seeds, but nevertheless it was used as a first choice by a few farmers in Saskatchewan (Table 8).

Managers were asked whether more information was needed to protect rapeseed from spoilage and heating during storage. Most managers, 77-80%, were in favor of more information, 14-19% were not in favor and 1-8% gave no answer. Twenty-three managers, including 13 in Saskatchewan, thought that farmers needed more information on all phases of harvesting and storage of rapeseed.

Additional comments were received on many questionnaires. Forty managers, constituting 9.9% of replies, stated that the upper moisture content limit for dry rapeseed should be lowered from the present 10.5%. Twenty-nine managers suggested new upper moisture content limits for dry rapeseed; three suggested 10.0%, one 10.0-9.5%, nine 9.5%, ten 9.0%, one 9.0-8.5%, three 8.5%, and two 8.0%.

Regarding detection of spoilage and heating in large elevator bins two managers stated that the presence of a spoilage smell meant that considerable spoilage and heating damage had already occurred. They thought that increased temperature was an earlier indicator of heating and spoilage.

Discussion

The data for purchases and degradings at elevators were considered to be accurate, as elevator companies encouraged truthful replies without recrimination. Further, managers are in a position to know accurately the condition and amounts of potential and actual purchases.

There is reason to believe that the 6.5% figure for farmers (Table 7) who had experienced spoilage and heating of rapeseed on their farms during 1974-75 does not reflect the true situation on farms. A similar elevator survey of wheat, oats, and barley during 1970-71 revealed at least five times as many moldy grain bulks and mite infestations on farms than in elevators (1,5). In the present survey, the percentage frequency of spoilage and heating in elevators is three times that occurring on farms of elevator customers. The 6.5% figure would have been much increased if all managers had supplied data on actual rather than potential customers. Also the figure would have been increased if more information on spoiled and heated rapeseed farm stocks mixed with good seed and sold off, fed to pigs, or discarded had been brought to the attention of managers.

Mite infestations of stored rapeseed in prairie elevators have been reported frequently. Work in the United Kingdom (4) and France (6) has also demonstrated mite infestations in storage that are probably related to the presence of seed-borne fungi.

It is important to be able to detect spoilage and heating in large bulks at an early stage. Checking the rapeseed temperature whilst turning stocks is a preferred method of detecting early damage; by the time odor is detectable

Table 6. Turning of elevator stocks in relation to occurrence of spoilage and heating

Question: Does spoilage and heating sometimes increase after turning?
% replies received

	Yes	No	No reply
Man.	33	43	24
Sask.	28	53	19
Alta.	14	59	27

Question: In the last case of heating or spoilage in your elevator, was the grain first turned?
% replies received

	Yes	No	No reply
Man	40	9	51
Sask.	40	12	48
Alta.	28	13	59

Question: If so, what was the moisture content of the stocks before turning?

No. of reports of heating or spoilage at specified range of moisture content (%)

	7.1–7.5	7.6–8.0	8.1–8.5	8.6–9.0	9.1–9.5	9.6–10.0	10.1–10.5	10.6–11.0	11.1–11.5	14.5	15.6	17.5
Man.	0	1	3	13	9	18	12	1	1	0	1	0
Sask.	0	4	2	15	21	25	17	7	2	1	0	1
Alta.	2	0	2	4	5	9	10	4	2	0	0	0

Question: What was the maximum temperature attained?

No. of reports of heating or spoilage at specified temperatures (°C)

	20°C & below	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70
Man.	3	4	8	8	8	3	2	2	0	0	4(66°C)
Sask.	0	6	15	16	29	10	4	3	3	0	1(66°C)
Alta.	0	3	7	11	3	4	2	2	1	0	1

Question: What was the number of days after turning when heating and spoilage occurred?

No. of reports of heating or spoilage at intervals (days) after turning

	0–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	>76
Man.	1	15	6	1	2	8	2	2	3	0	0	0	0	0	0	1**
Sask.	5	13	17	14	7	11	1	3	0	0	0	2	1	1	1	3*
Alta.	1	4	3	6	6	4	1	1	2	0	1	2	1	0	0	1**

Question: What was the month of turning?

No. of reports of heating or spoilage following turning of rapeseed stock in the month indicated

	January	February	March	April	May	June	July	August	September	October	November	December
Man.	1	0	0	1	1	3	8	3	7	13	3	1
Sask.	2	0	2	0	1	4	6	8	16	20	4	3
Alta.	0	0	0	1	0	0	2	2	8	7	1	2

* One report each 78, 90 and 200 days after turning

** 90 days after turning

Table 7. Frequency of occurrence and maximum amounts of spoiled, heated, and mite–infested rapeseed from the 1974 and 1975 crops on customers' farms known to managers

	Manitoba		Saskatchewan		Alberta		Prairie	
	1974	1975	1974	1975	1974	1975	1974	1975
Total no. customers' farms serviced by elevators in the survey	4,147	4,770	10,982	11,612	5,212	5,825	20,341	22,207
No. customers' farms known by managers to have experienced spoilage and heating	318	164	705	595	309	205	1,332	964
% of total customers' farms with heating and spoilage problems	7.7	3.4	6.4	5.1	6.0	3.5	6.5	4.3
No. of farms with mite infestations in customer areas	175	172	316	242	114	78	605	492
% of total farms with mite infestations	4.2	3.6	2.9	2.1	2.2	1.3	3.0	2.2
Maximum amount (tonnes*) spoiled or heated rapeseed on any one farm known to manager	225.2	112.6	247.7	252.2	112.6	225.2	247.7	225.2
Total of above maximum amounts (tonnes)	2,051.4	1,198.4	4,805.2	5,010.9	1,804.1	1,484.3	8,660.6	7,693.6

* To convert tonnes to bu multiply tonnes by 44.4

Table 8. Most commonly chosen methods of disposal of spoiled and heated rapeseed by farm customers

		Chosen method expressed as % of total choice							
Province	Choice	Sell to elevator	Sell to feed mill	Discard	Unspecified	Sell to crusher	Other elevators seed houses	Mix for feed	Mix with good rape
Manitoba	1 st	24	4	1	0	1	1	0	0
	2 nd	6	17	2	0	0	0	0	0
	3 rd	1	4	11	6	1	1	2	0
	4 th	1	0	13	3	1	0	0	0
Saskatchewan	1 st	24	1	3	1	1	1	0	0
	2 nd	3	15	4	1	1	1	1	0
	3 rd	1	7	7	3	1	1	1	1
	4 th	2	1	12	3	1	1	2	0
Alberta	1 st	26	0	2	0	2	0	0	0
	2 nd	3	14	4	1	4	0	0	0
	3 rd	1	8	12	2	1	0	1	0
	4 th	0	2	10	5	0	1	1	0
Prairie	1 st	24	2	2	1	1	1	0	0
	2 nd	3	15	3	1	2	1	1	0
	3 rd	1	7	9	3	1	1	1	1
	4 th	1	1	12	3	1	1	1	0

in a large bulk considerable damage has already occurred.

Results from the present survey indicate that more information is required in certain areas to improve the storability of the crop on farms and in elevators. On the farms, producers should know that rapeseed differs in storability from wheat, oats, and barley and should be swathed, combined, and stored with extreme care. If spoilage is prevented on farms a better product will be delivered to elevators. In elevators, information is required on the effects of turning on the storability of stocks as results obtained suggest that turning in many instances does not prevent spoilage and heating. Finally information is required on the individual and collective roles of molds, mites, and of seed respiration in spoilage and heating of rapeseed stocks of different varieties and ages and at different times of year.

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Snow mold control in bentgrass turf with fungicides, 1975[1]

J. Drew Smith and W. W. Reiter

Heavy infections resulted from the application of inoculum of *Sclerotinia borealis* and *Typhula* FW grown on moist sterile rye to fine turf composed of the Seaside and Penncross cultivars of *Agrostis stolonifera*. Quintozene, R-28921 and benomyl were the most consistently effective materials against both pathogens; Arrest and benomyl effectively reduced severity of *S. borealis* damage; benomyl, LFA and chloroneb performed well against *Typhula* FW in individual tests. Chloroneb was not effective against *S. borealis* and Vitavax (oxathiin) performed poorly against *Typhula* FW. In the fall following fungicide application a moderately severe natural outbreak of disease caused by *F. nivale* developed on the same turf plots. R-28921 and benomyl showed marked residual effectiveness but on quintozene plots there was significantly more *F. nivale* than on untreated checks. Residues of the latter may suppress other fungi thereby favoring *F. nivale*.

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L'inoculation de *Sclerotinia borealis* et de *Typhula* FW à des cultivars Seaside et Penncross d'*Agrostis stolonifera* a provoqué de fortes infestations. Le quintozène, R-28921 et le bénomyl se sont révélés les plus efficaces contre les deux agents pathogènes. Par ailleurs, dans certains essais, Arrest et bénomyl ont sensiblement réduit les dégâts causés par *S. borealis*, et le bénomyl, LFA et le chloronèbe ont donnés de bons résultats contre *Typhula* FW. En revanche, le chloronèbe est resté inefficace contre *S. borealis* et Vitavax (oxathiine) a donné des résultats médiocres contre *Typhyla* FW. Au cours de l'automne suivant l'application des fongicides, une infestation naturelle modérément grave de *Fusarium nivale* s'est produite dans les mêmes parcelles. R-28921 et le bénomyl ont affiché une efficacité résiduelle prononcée. Toutefois, on a observé une beaucoup plus grande incidence de la maladie dans les parcelles traitées au quintozène que dans les parcelle témoins. Il y a donc lieu de croire que ce produit élimine d'autres champignons au profit de *F. nivale*.

Previously results were presented on the performance of fungicides against the range of common snow molds on amenity turf of different types in Saskatchewan (3). The studies reported here were made to evaluate the effectiveness of standard and newer materials against disease produced by inoculating golf green type turf formed from cultivars of *Agrostis stolonifera* L. with cultures of *Sclerotinia borealis* Bub. & Vleug. and *Typhula* FW (5). Information was also obtained on the residual effects of the materials against a natural infection of *Fusarium nivale* (Fr.) Ces. a year after their application.

Materials and methods

Turf inoculation

Test turf at the experiment grounds at Saskatoon were inoculated with cultures of pathogenic isolates of *S. borealis* and *Typhula* FW grown on sterile, moist rye grain by hand broadcasting as previously described (5). The culture of *S. borealis*, strain De715, from bowling green turf in Saskatoon was applied at 25 g/m^2 on 6 August 1974. The *Typhula* FW inoculum comprised a mixture of nine isolates from turf grasses in Saskatchewan, Alberta, and British Columbia and was also applied at approximately 25 g/m^2 on 12 August, 1974.

Turf test plots

Tests 201 and 202 (Table 2) were on *A. stolonifera* cv. Seaside established by sprigging in summer 1971 and top-dressed in fall with a sand/soil/peat mixture. Plots for Tests 203 and 204 were of the same species and cultivar but sown in spring 1972. Tests 205 and 206 were sown with *A. stolonifera* cv. Penncross, also in spring 1972. All turf received topdressing applications in fall 1972, 1973, and 1974 and was irrigated and maintained in a moderate state of fertility from the outset. In 1974, before inoculation, it received 3.0 kg/100 m^2 of 23-23-0 granular fertilizer on 30 May, 3.5 kg/100 m^2 of the same material on 30 June, and 1 kg/m^2 of 16-20-0 fertilizer on 2 August. All mowing was done with a 55 cm reel type greens mower as necessary and the cuttings were removed. Three snow fences 60 cm high were positioned in a north/south direction along the western and eastern edges of the tests and midway between these two (Fig. 1) to trap snow on the turf; these were erected on 10 October 1974 and removed on 6 May 1975. All tests were of randomized block design; plot size was 1.0 m^2 and treatments were replicated six times.

[1] *Contribution no. 639, Research Station, Agriculture Canada, 107 Science Crescent, Saskatoon, Saskatchewan S7N 0X2*

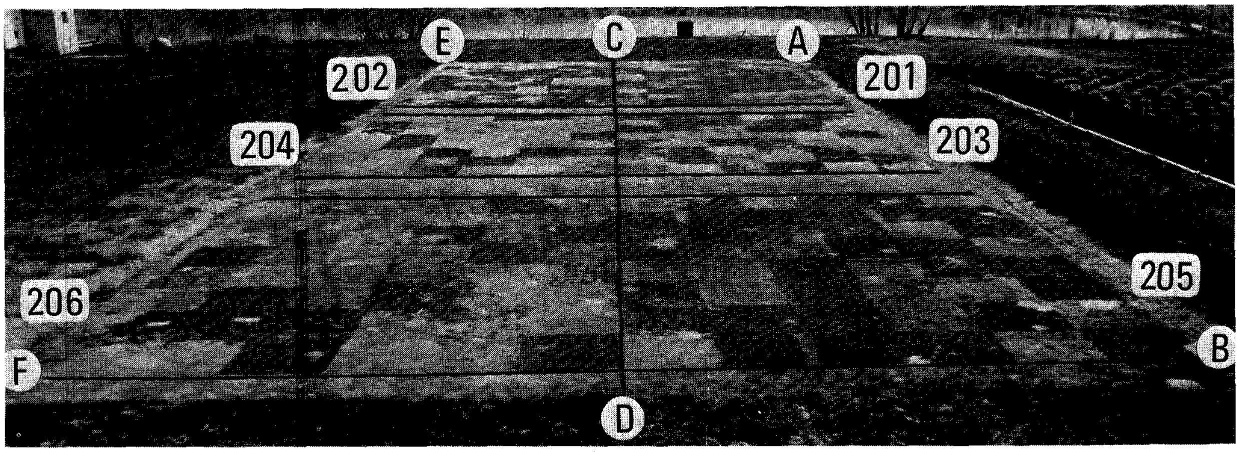

Figure 1. Appearance of test in early May 1975. Tests 201 and 202 were inoculated with *S. borealis* and Tests 203 - 206 with *Typhula* FW. Snow fences were positioned A to B, C to D, and E to F.

Fungicide applications

Fungicide sprays were applied in 107 ml water/m^2 (10 ml/ft^2) with 1 litre capacity pneumatic hand sprayers. Sulphur as a wettable powder was applied in a water suspension with a sprinkling can. Two applications of each material were made, the first between 9 and 11 September 1974 and the second on 8 and 9 October before any disease was apparent. The common and product names, percent active ingredients, formulations, and sources of fungicides are given in Table 1.

Rating of disease

An estimate was made of the percentage area of turf affected by disease caused by *S. borealis* and *Typhula* FW in each plot on 7 May and 2 June 1975. A moderately severe natural infection with *F. nivale* which developed in the fall of 1975 was rated in a similar fashion on 7 October 1975.

Results and discussion

An even snow cover resulted from the suitable placing of the snow fences. This cover was present on the test areas for approximately 130 days, which was less than the average for the previous 33 years of 143 days. Snowfall for the winter at Saskatoon was 1015 mm, only slightly less than the average of 1087 mm for the 33 winters previous to 1974 (personal communication, Dr. J. Maybank, Physics Department, Saskatchewan Research Council, 19 August 1974). In early May, just after complete snow melt it was apparent that uniform infections typical of severe disease caused by *S. borealis* and *Typhula* FW had resulted from the heavy inoculation of the turf. Symptoms of other snow molds were not observed on the test blocks except for a few scattered patches caused by the non-sclerotial low-temperature basidiomycete, LTB (Fig. 1). Some of this disease occurred on the east side of the most easterly snow fence on *Poa pratensis* L. turf adjacent to Test 206 where the snow had remained longer in drifts (Fig. 1); generally the disease was light on susceptible turf in the vicinity of the fungicide tests. At the first rating, on 7 May, disease severity was similar in both Seaside (Table 2, Tests 201-204) and Penncross check plots (Table 2, Tests 205-206). Sown Penncross had less *Typhula* FW damage than sown Seaside bent at the second rating on 2 June, i.e. its recovery was more rapid. Severe damage from *S. borealis* persisted longer than that from *Typhula* FW but the latter pathogen left turf scars which had not completely healed by late fall 1975. Some antagonism between colonies produced from the different isolates of *Typhula* FW that had been used as inoculum was seen on plots where infection had been partly controlled by fungicides (6). However, all signs of competition between colonies were blotted out where infection was overwhelmingly heavy. Considerable recovery from damage occurred between 7 May and 2 June but the degree of recovery could not be related either to the initial level of infection or to the particular material used.

Quintozene and R-28921 were the most consistently effective materials against both *S. borealis* and *Typhula* FW (Tests 202, 204, and 206). Arrest at the higher dosage and benomyl effectively reduced the severity of *S. borealis*. The effectiveness of the latter fungicide against *S. borealis* has been noted (5). In Test 205 benomyl was one of the most effective materials against *Typhula* FW: this was not expected because of its reported spectrum of activity (1) and since in previous tests it had shown little effectiveness against this pathogen, at least in disease complexes (5). Here the infection was almost completely due to *Typhula* FW. LFA at the lowest dosage effectively controlled *Typhula* FW in Test 203. Chloroneb, which with quintozene and mercury chlorides was very effective in previous tests where the LTB and *Typhula* FW were dominant in complexes (5), gave good control of *Typhula* in Test 205 on Penncross but was only moderately effective against

Table 1. Fungicides used in snow mold tests, 1974 – 75

Index no.	Product name	Active ingredient* % and formulation†	Source
1	Benlate	benomyl 50%, WP	Dupont
2	Tersan SP	chloroneb 65%, WP	Dupont
3	Chlorophenate	chlorophenate mixture 18%, Soln	Cleary
4	Metazoxolon	4 – (3 – chlorophenylhydrazone) – 3 – methyl – 5 – isoxazolone 40%, Slurry	Chipman
5	Daconil	chlorothalonil 75%, WP	Diamond–Shamrock
6	Vitavax	carbathiin 75%, WP	UniRoyal
7	LFA 2043	(1 – (isopropylcarbamoyl) – 3 – (3, 5 – dichlorophenyl) hydantoin 50%, WP	May & Baker
8	Mersil	mercurous/mercuric chloride mixture, Hg 42%, WP	May & Baker
9	R – 28921	2 – ((3' – methoxycarbonyl) – thioureido) – 0, 0 – diethylphosphoranilide 50%, WP	Stauffer
10	PMA – 10	phenyl mercuric acetate 10%, Soln	Later
11	Terrachlor	quintozene (PCNB) 75%, WP	Olin
12	Sulphur	sulphur 90%, WP	Smith
13	Arrest	thiram 50%, carbathiin 20%, oxycarbathiin 5%, WP	UniRoyal

* Where the common name of the active ingredient is inconveniently long the product name may be used in tables and text.

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

this fungus on the more susceptible Seaside bent. As expected from previous tests (5), chloroneb was not very effective against *S. borealis*. The poor performance of Vitavax against the basidiomycete *Typhula* FW was not expected (Tests 204 and 206) since basidiomycetes are particularly sensitive to the oxathiins (Table 1) (1). At higher dosage Vitavax showed some activity against *S. borealis* (Test 201); however the oxathiin/thiram combination in Arrest was more effective with a much lower content of systemic oxathiin. On the basis of the early ratings on 7 May, apart from the materials already mentioned, significant reductions in disease severity were noted also with chlorothalonil and LFA 20403 against *S. borealis* in Tests 201 and 202 and with chlorothalonil against *Typhula* FW in Test 205. Both inorganic mercury chlorides and PMA gave poor control of both diseases. Previous results for these materials suggested that they could behave in an erratic fashion. Dosage of PMA was kept low in these tests because of the tendency of this material to be phytotoxic on fine turf. Sulphur was applied as a soil amendment rather than a fungicide. Since it reduces the pH of the turf surface (2) and this has an effect on the severity of some diseases (2), there was an interest in its effects on *S. borealis* and *Typhula* FW. It had no apparent effect on disease severity.

Against the moderately severe natural outbreak of disease caused by *F. nivale* in the fall of 1975, several materials applied in 1974 showed a considerable residual control effect. At all dosages the experimental fungicide R-28921 showed significantly greater effectiveness than any other material in Tests 202, 204, and 206. Benomyl, known to be effective against *F. nivale* from previous tests (5) was most effective in Test 203 and was apparently the best material in Tests 201 and 205. Mercurous/mercuric chlorides and PMA in Test 202 and PMA in Test 204 showed some residual control of the latter fungus. On the other hand, plots sprayed with quintozene showed more damage from *F. nivale* than any other treatment in all tests where it was employed and significantly more than the untreated check in Test 204. The practical implication of this is that it would be unwise to rely entirely on quintozene for winter disease control on fine turf in the prairie region. It effectively controlled snow mold due to the LTB, *Typhula*

Table 2. Effect of fungicides on severity of snow mold on turf of *Agrostis stolonifera* cultivars Seaside and Penncross; snow mold resulted from inoculation with *Sclerotinia borealis* (S.b.) and *Typhula* FW (T.FW) in August 1974 and also from natural infection by *Fusarium nivale* in October 1975; fungicides were applied twice, in September and in October 1974

			Percent area of turf affected on dates indicated in 1975*																	
			Seaside — sprigged						Seaside — sown						Penncross — sown					
			Test 201			Test 202			Test 203			Test 204			Test 205			Test 206		
	Index no.	Dosage	*S.b.*		*F.n.*	*S.b.*		*F.n.*	*T.* FW		*F.n.*	*T.* FW		*F.n.*	*T.* FW		*F.n.*	*T.* FW		*F.n.*
Fungicide	(Table 1)	(a.i. g/m^2)	7/5	2/6	17/10	7/5	2/6	17/10	7/5	2/6	17/10	7/5	2/6	17/10	7/5	2/6	17/10	7/5	2/6	17/10
Benomyl	1	0.31	21a	15ab	1				43ab	43bc	33a				12a	13a	0a			
Chloroneb	2	1.59				61c	44bc	20cde	71cd	26ab	18cd				25ab	9a	1a			
Chlorophenate	3	0.88	82c	43de	24				99e	65cd	23cde				92c	41b	3ab			
Metazoxolon	4	0.50	97c	59ef	25															
Metazoxolon	4	1.00	91c	54def	23				98e	76d	22cde				87c	41b	2a			
Chlorothalonil	5	2.75	41b	25bc	14				82de	58cd	17bc				40b	15a	1a			
Vitavax†	6	0.46	84c	39cd	24							99c	59bcd	24bc				92c	38cde	10b
Vitavax†	6	0.92	53b	21ab	23							99c	50bc	27cd				94c	25abc	10b
Vitavax†	6	1.84	47b	13ab	22															
LFA 2043†	7	0.50				56c	57c	23de	22a	29ab	12b									
LFA 2043†	7	1.00				47c	47c	16cd							16a	15a	0a			
Mercurous/ Mercuric chlorides	8	0.51				82d	58c	11bc				96c	47b	20bc				93c	29bcd	6ab
R–28921†	9	0.31				48c	47c	5ab												
R–28921†	9	0.61				43bc	50c	4ab				20a	16a	3a				24b	20ab	1a
R–28921†	9	1.22				23ab	24ab	1a												
PMA	10	0.03				91d	80d	13bc				98c	73d	18b				92c	52e	9b
Quintozene	11	2.75				15a	14a	30e				38b	21a	33d				8a	10a	17c
Sulphur	12	10.00				99d	91d	27e				100c	70cd	20bc				99c	52e	9b
Arrest†	13	1.22	52b	21ab	19															
Arrest†	13	2.44	20a	5a	15				55bc	17a	28e				35b	6a	4b			
Check, untreated			96c	68f	24	99d	89d	24de	97e	74d	25de	99c	65bcd	24bc	97c	38b	1a	99c	48de	12bc

* Within columns, figures subtended by the same letters do not significantly differ as determined by Duncan's multiple range test at the 5% level of probability.

† Product name (see Table 1).

FW, *S. borealis*, and *F. nivale*, alone and in complexes, in tests when applied in fall (3, 4, 5). However *F. nivale*, unlike the other snow mold pathogens, has been found to be the common cause of disease, more appropriately called fusarium patch than pink snow mold (2), in the prairie region in late summer and fall (4). Quintozene in low concentrations is used in selective culture media for the isolation of *Fusarium* spp. from soil (7). A possible explanation therefore, for the effect of the latter material in these tests, is that its residues from the previous fall applications suppressed organisms antagonistic to *F. nivale*, allowing the latter to develop and cause moderately severe disease.

Acknowledgments
We are indebted to Mr. E. E. Underwood for the photograph and to the chemical firms cited in Table 1 for the supply of chemicals.

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Correction

Basu, P.K., et al. Yield loss conversion factors for fusarium root rot of pea.
Volume 56, page 28, text col. 1, lines 1–4: delete the first sentence beginning "The actual...."

page 31, col. 1, para 4, lines 3–4:
% yield loss = % severely affected plants X 0.57

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