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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.

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

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ERRATUM

The article appearing on page 130 of Vol. 68, No. 1, 1988, entitled "Disease survey of commercial apple orchard in southern Ontario" was incomplete as submitted. The complete article is reprinted in this issue on page 169.

L'article publié à la page 130 du Vol. 68, N° 1, 1988, et intitulé "Disease survey of commercial apple orchard in southern Ontario" était incomplet tel que soumis. L'article complet est réimprimé dans ce numéro à la page 169.

Incidence of rhizoctonia and fusarium root rot of soybean in southwestern Ontario, 1986

T.R. Anderson[1], H. Olechowski[2] and T. Welacky[1]

A survey was conducted of fungi associated with stems and roots of stunted and normal soybeans in 71 fields in southwestern Ontario. Germination and emergence in areas with stunted plants was 74% of germination and emergence in areas with normal plants. *Rhizoctonia solani* and *Fusarium oxysporum* were isolated from 7% and 40%, respectively, of plants in stunted areas. Germination and emergence were only 46% and 60%, respectively, in areas with plants infected by *R. solani, F. oxysporum* and *F. graminearum*. Since most pathogens were also found in areas with normal plant growth, it is probable that local environment is an important factor in disease severity.

Can. Plant Dis. Surv. 68:2, 143-145, 1988.

On a réalisé une enquête sur les champignons associés aux tiges et aux racines de plants de soja rabougris et normaux dans 71 champs du sud-ouest de l'Ontario. Le pourcentage de germination et de levée dans les régions où croissaient les plantes rabougries était seulement de 74 % comparativement aux régions où l'on trouvait des plants normaux. On a isolé les champignons *Rhizoctonia solani* et *Fusarium oxysporum* chez respectivement 7 et 40 % des plantes rabougries. Seulement 46 et 60 % respectivement des plantes attaquées par *R. solani, F. oxysporum* et *F. graminearum* ont germé et levé. Comme la plupart des agents pathogènes ont aussi été trouvés dans les régions où les plantes croissaient normalement, il est probable que les conditions environnementales influent grandement sur la gravité de la maladie.

Introduction

Irregular patches and streaks of chlorotic and stunted soybeans [*Glycine max* (L.) Merr.] are frequently observed in fields in southwestern Ontario. These unthrifty areas are generally located in depressions and develop under wet or dry conditions. Upper leaves are chlorotic and plant growth is generally stunted. Secondary root growth of affected plants is limited and red or black lesions are evident on tap and lateral roots near the soil surface. With favourable weather, plants in these areas may recover but with unfavourable weather, plants remain unproductive.

The purpose of this survey was to determine the incidence of plants infected with pathogenic fungi in areas with stunted plants (SA) and areas with normal plants (NA) in the same field and to relate cultural practices with plant infection.

Materials and methods

Plant samples were collected in both SA and NA of soybean fields in Essex, Elgin, Kent, Lambton, and Middlesex counties in Ontario between 02/05/86 and 30/06/86.

Fifteen plants including upper roots were removed from each area and stored in plastic bags under cool conditions until processed in the laboratory. Plant emergence was determined in 5, 1 m row sections and plant height of 10 plants was measured in each sample area. Information on cultivar, soil type, previous crops, and seed treatment was obtained from each grower.

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In the laboratory, tops and lower roots of sample plants were removed leaving a 6 cm section of the lower stem and tap root. This section was surface sterilized for 3-5 min in 1.2% sodium hypochlorite solution. Five sections, 1-2 mm thick were cut within 1 cm of the transition zone between root and stem and plated on medium. A selective medium for isolating *Rhizoctonia* spp. from seeds (3) and potato dextrose agar (Difco), acidified with 0.6 ml of 85% lactic acid per litre of medium (APDA) to inhibit bacterial growth were used to culture fungi. Plates were incubated for 5 days at 20-22°C on the laboratory bench before fungi were identified.

Results and discussion

A total of 71 soybean fields with SA and NA were surveyed in 5 counties in southwestern Ontario. The extent and severity of chlorosis and stunting varied considerably from field to field. Wilted or dead plants were observed rarely. Sparse emergence was not always associated with stunted growth and stunting occurred in some areas with good emergence. On clay soil, stunted plants were found frequently in low areas of the field. On sandy loam soil, stunting was common on knolls. APDA was the best medium for identification of fungi from stem and root sections because colony growth was sufficient to directly identify genera. The selective medium was suitable for isolation of *Rhizoctonia solani* Kuehn but sparse mycelial growth of *R. solani* and contaminants caused difficulty in distinguishing fungi. Based on 71 sample fields, *R. solani* was found in 26% of plants from 23 fields using APDA and in 37% of plants in 19 fields using selective medium. The following results are based on fungi identified on APDA.

Eight genera of fungi that are potential pathogens of roots and stems of soybean were isolated in this survey (Table 1). With the exception of *F. graminearum* Schwabe, all fungi have been isolated and identified previously on soybean stems and roots in Ontario (1). *Fusarium oxysporum* Schlecht. and *R. solani*

Table 1. Incidence of fungi isolated from the lower stem and upper root of soybean in 71 fields in Southwestern Ontario, 1986.

Fungus	Plants infected (%)	
	Areas with normal plant growth	Areas with stunted plant growth
Colletotricum dematium var. *truncatum*	1.7	1.7
Corynespora cassiicola	1.3	2.6
Fusarium oxysporum	28.0	40.1
Fusarium graminearum	14.3	18.1
Fusarium spp.	41.4	42.8
Phomopsis/Diaporthe spp.	11.9	13.6
Phytophthora megasperma f. sp. *glycinea*	0.3	0.6
Pythium spp.	1.7	0.7
Rhizoctonia solani	1.0	7.1
Thielaviopsis basicola	1.6	0.6
Other[a]	54.7	53.9

[a]Other includes species of *Rhizopus, Mucor, Chaetomium, Alternaria* and unidentified fungi.

were consistantly associated with more plants in SA than in NA. Red lesions confined to the stem cortex near the soil line characteristic of *R. solani* (4) and red or brown vascular discolouration within roots characteristic of *F. oxysporum* (2) were observed frequently on plants collected for sampling. These two pathogens were more common in SA than in NA. *R. solani* was isolated from plants in 5% of NA sampled and 26% of SA sampled. The overall incidence of *R. solani* was lower than expected based on external plant symptoms. Surface sterilization of stem sections may have reduced the incidence of *R. solani* in isolation plates; however, similar counts were obtained in parallel trials with non-sterilized sections. *F. oxysporum* was isolated in 55% of NA and 71% of SA. In addition, *F. graminearum* was isolated in 44% of NA and 51% of SA.

The percentage reduction in both emergence and growth in the SA was 74% compared to NA in the same field regardless of fungi isolated from sample plants. In areas with plants infected by *R. solani* and other fungi, this reduction was 64 and 65%, respectively and in areas with *F. oxysporum* and other fungi this reduction was 65 and 66% respectively (Table 2). The influence of individual fungi on plant growth is difficult to determine because plant sections were frequently infected with 2 or more fungi. In 12 fields with *R. solani, F. oxysporum* and *F. graminearum*, emergence and plant growth was reduced to 46 and 60%, respectively. This suggests a synergistic effect by these pathogens on both emergence and subsequent growth of soybean under field conditions.

Table 2. Emergence and plant height of plants infected with fungi in areas with stunted plants as a percentage of emergence and plant height in areas with normal plants.

Fungi	Plant growth				
	Number of areas	Emergence (%) $\bar{x}$ SD[a] range		Emergence (%) $\bar{x}$ SD range	
R. solani	(19)	64 ± 31	(4-105)	65 ± 20	(28-93)
F. oxysporum	(38)	65 ± 24	(4-110)	66 ± 19	(17-100)
F. graminearum	(37)	64 ± 26	(4-105)	71 ± 22	(28-120)
R. solani + *F. oxysporum* + *F. graminearum*	(12)	46 ± 28	(4-105)	60 ± 21	(28-95)

[a]SD = population standard deviation.

Table 3. Effect of soil type, crop history and seed treatment on incidence of plants infected with *R. solani* and *F. oxysporum* in areas of soybean fields with stunted plants.

Parameter		Incidence of plant infection (%)		
		Number of samples	*R. solani* $\bar{x}$ SD[a]	*F. oxysporum* $\bar{x}$ SD
Soil type	clay	28	8 ± 20	50 ± 35
	loam	28	5 ± 12	31 ± 35
	sandy loam	9	6 ± 9	42 ± 30
Previous crop	soybean	20	4 ± 7	60 ± 33
	corn	34	10 ± 21	32 ± 30
	wheat	12	7 ± 16	33 ± 42
Seed treatment	none	21	10 ± 25	46 ± 35
	thiram-carbathiin	22	8 ± 15	47 ± 35
	captan	14	7 ± 9	34 ± 33

[a]SD = population standard deviation.

Soil type and crop rotation and little effect on incidence of *R. solani* and *F. oxysporum* in SA. Incidence of *F. oxysporum* was higher on clay soil and in fields with a previous crop of soybeans (Table 3). Seed treatment did not affect the incidence of *R. solani* and *F. oxysporum* in lower stems at the time of sampling (Table 3). Emergence in SA with treated and untreated seed was 70±25% and 80±19%, respectively, of emergence in paired NA. Seed treatment did not improve emergence compared to untreated seed but it is possible that poor quality seed was treated.

Although the survey was restricted in sample size and involved a diversity of soil types, cultural practices, cultivars and other variables, *R. solani* and *F. oxysporum* were frequently associated with reduced emergence and stunted plants over the entire survey area. *F. graminearum* was also isolated frequently. The same pathogens were found in NA as well as SA which indicates local environment may have a significant role in disease severity.

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Nematodes in potato soils in New Brunswick

J. Kimpinski[1] and E.M. Smith[2]

Root-lesion nematodes (*Pratylenchus* spp.) were the dominant plant-parasitic nematodes in potato fields in the Grand Falls region of New Brunswick, Canada. *Pratylenchus crenatus* was more prevalent than *P. penetrans*. The northern root-knot nematode (*Meloidogyne hapla*) and clover-cyst nematode (*Heterodera trifolii*) were not detected in the survey.

Can. Plant Dis. Surv. 68:2, 147-148, 1988.

Dans des champs de pommes de terre de la région de Grand Falls au Nouveau-Brunswick (Canada), les principaux nématodes parasites des végétaux identifiés étaient des nématodes radicicoles (*Pratylenchus* spp.). On a signalé plus de *Pratylenchus crenatus* que de *P. penetrans*. On n'a pas trouvé de nématode cécidogène du nord (*Méloidogyne hapla*) ou de nématode à kyste du trèfle (*Heterodera trifolii*) au cours de l'enquête.

Introduction

A nematode survey conducted in 1979 in the Grand Falls region of New Brunswick indicated that root-lesion nematodes (*Pratylenchus crenatus* Loof and *P. penetrans* (Cobb) Filipjev and Sch. Stek.) were the dominant species of plant-parasitic nematodes in potato roots and soils (4). It was also determined that population levels of the northern root-knot nematode (*Meloidogyne hapla* Chitwood) were very low, being detected in only 5% of the root and soil samples. Large populations of either root-lesion or northern root-knot nematodes can reduce potato tuber yields (1,5). This report summarizes the results of a recent nematode survey carried out in potato fields in the Grand Falls region of New Brunswick.

Materials and methods

Soil samples were collected in mid-November, 1987 from seed potato fields at 29 sites in the Grand Falls region of New Brunswick. Twenty-seven locations had been planted with the cultivar 'Atlantic' and two locations had been planted with the cultivar 'Alpha'. The size of the collection sites ranged from 2 to 3 ha and soil type was a gravelly sandy loam with a pH of 5.5-6.0. The usual crop rotation in the region is wheat and/or barley followed by potatoes, and the average rainfall from May to September is about 45 cm.

Twenty soil cores, each 2.5 cm in diameter and 20 cm deep, were taken in the rows at each site and combined to make one composite sample. Each sample was mixed thoroughly and screened through a 2-mm sieve. As the samples were collected 4-6 weeks after harvest, there was very little root material. Consequently, a 50-g subsample of soil together with any root debris was taken from each sample and placed in a modified Baermann pan (9). After 7 days at 20-25°C, root-lesion nematodes that had emerged from the sample were identified and counted, and other nematode genera were identified with a stereomicroscope at 60×. Extracted nematodes were preserved in 5% formalin and up to 100 nematodes from each sample were selected randomly and examined at 1000× with a compound microscope.

Results

Root-lesion nematodes were the dominant plant-parasitic nematodes and were detected in 24 of 29 sites. The mean population level from 29 sites was 6,300 with a range of 0-22,100 nematodes kg^{-1} soil. Over 85% of the adult root-lesion nematode females fit the characteristics of *Pratylenchus crenatus*, while the remainder were identified as *P. penetrans* (6). No male root-lesion nematodes were recovered. *Aphelenchoides* spp., or foliar nematodes, were also numerous in most samples but the counts were not recorded. A few specimens of *Aphelenchus* spp., *Helicotylenchus* spp., *Merlinius* spp., *Paratylenchus* spp., *Tylenchorhynchus* spp., and *Tylenchus* spp. were identified. No northern root-knot nematodes (*M. hapla*) or clover-cyst nematodes (*Heterodera trifolii* Goffart) were detected in this survey.

Discussion

The results agreed closely with a previous survey conducted in New Brunswick (4). It is possible that some of the sites with high populations of root-lesion nematodes may have had reduced yields. However, *P. crenatus* was the dominant root-lesion nematode species and it is thought to be less harmful than *P. penetrans* to potatoes (2). Furthermore, no information is available from New Brunswick on the effect of nematodes on potato tuber yields. *Aphelenchoides* spp. are not on record as being serious root pathogens (7), and their impact on tuber yields is not known. The absence of *M. hapla*, the only root-knot nematode species recorded to date in New Brunswick (10), and *H. trifolii* would have been due in large part to the inclusion of cereals in the rotation, since both wheat and barley are considered to be non-hosts for these nematode species (3,8).

Conclusions

Plant-parasitic nematodes did not appear to be a serious problem in potatoes in New Brunswick. However, it is likely that large populations of root-lesion nematodes will reduce tuber

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yields to some degree. Further surveys and nematicide trials are necessary to quantify the impact of nematodes on yields of different potato cultivars in New Brunswick.

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Determining the occurrence of replant disease in British Columbia orchard and vineyard soils by pasteurization[1]

R.S. Utkhede and Thomas S.C. Li

Experiments were conducted to determine by response to soil pasteurization what sequence of fruit trees or grapevines will grow without damage by replant disease after removing a particular fruit tree or grapevine crop. Apple seedlings developed replant disease in apple, peach, cherry, pear, and grape soils. Peach trees may be planted after any fruit tree or grapevine crop. Plums will grow normally when planted after grapes or any fruit trees except peach. Testing of orchard and vineyard soil is required for the proper diagnosis and treatment of replant disease.

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On a réalisé des expériences afin de déterminer, en se fondant sur la réaction à la pasteurisation du sol, quelle séquence d'arbres fruitiers ou de vignes ne serait pas endommagée par la maladie de la replantation après avoir éliminé une culture particulière d'arbres fruitiers ou de vignes. Les plantules de pommiers plantées dans des sols où l'on avait antérieurement cultivé des pommiers, des pêchers, des cerisiers, des poiriers et des vignes ont été frappées par la maladie de la replantation. En outre, les pêchers peuvent être plantés dans un sol où a poussé n'importe quel arbre fruitier ou n'importe quelle vigne. Les pruniers croîtront normalement s'ils sont plantés après des cultures de vignes ou d'un arbre fruitier, à l'exception du pêcher. Il est nécessaire d'analyser les sols de vergers et de vignobles afin d'établir un diagnostic exact et de déterminer le traitement des plantes atteintes de la maladie de la replantation.

Introduction

Many fruit crops grow poorly when replanted into orchards where fruit crops of the same or closely related species were previously grown. This "soil sickness" has been recognized for over 200 years (Traquair 1984). Because of the cost of fruit production and the limited supply of suitable land for fruit trees in portions of the U.S., Canada, and European countries, the replant problem has become a major concern to the fruit growers in these regions.

Confusion exists over use of the term specific and non-specific replant disease. Savory (1966) coined the term "specific replant disease (SRD)" to describe the poor growth of many fruit and plantation crops when planted on land previously occupied by the same or closely related species. No leaf symptoms are evident but the roots of affected plants are weak, sparsely branched, discoloured, and necrotic (Savory 1966). Trees with SRD symptoms are usually evenly distributed in the orchard (Mai and Abawi 1981). The causal agents of SRD appear to persist in the soil for a number of years. SRD persisted in apples even after the orchard soil was cropped for at least eight years with grasses and cereals (Hoestra 1968, Savory 1967, Sewell 1979). Because of the control obtained by soil fumigation and heat treatment, the causal agents are considered to be biotic (Jaffee *et al.* 1982, Mai and Abawi 1981, Sewell 1981, Slykhuis and Li 1985, and Westcot and Beer 1986).

Non-specific replant disease refers to the poor crop of fruit trees regardless of the previous fruit crop (Mai and Abawi 1981). Symptoms include stunting and retarded shoot growth, leaf chlorosis, discolouration and necrosis of feeder roots and, in severe cases, death of the tree within two to three years of planting. Necrosis of young roots by parasitic pathogens may or may not be obvious (Mai and Abawi 1981). Affected trees have patchy distribution in the orchard. The factors responsible for non-specific replant disease are toxic plant products, nematodes, unbalanced soil nutrition, poor soil structure and drainage, low or high pH, and cold or drought stress (Mai and Abawi 1981, Patrick *et al.* 1964).

Replant disease has become a major concern to the growers in the Okanagan and Similkameen valleys of British Columbia. Slykhuis and Li (1985) tested 51 orchard soils and found that apple seedlings on all of these soils responded to pasteurization, ammonium phosphate (11-55-0) fertilizer, or both, indicating that the soils might adversely affect the growth of apple trees. It has not been determined in what sequence fruit tree species or grape vines can be planted without harm from replant disease in old orchard/vineyard soils. The following experiments were conducted with seedlings to determine such sequential effects for six fruit tree species and grapes.

Materials and methods

Soils were collected from the root zone 15 cm below the surface under standing (25-30 years old) fruit trees [Peach (*Prunus persica* L.), Apricot (*Prunus armeniaca* L.), Apple (*Malus pumila* Mill.), Cherry (*Prunus avium* L.), Plum (*Prunus domestica* L.), Pear (*Pyrus communis* L.)] and grape vines (*Vitis vinifera* L. 10-20 years old) in the Okanagan and Similkameen valleys of British Columbia. These soils were placed in polyethylene bags, tightly closed to maintain moisture, and kept in a cool place (10°C) until used. Each soil sample was mixed thoroughly to assure uniformity, and passed through a 5-mm sieve to remove stones and root fragments. Samples were removed from each bag and passed through a 2-mm sieve to remove stones and root fragments. Chemical analysis of all soils for soil analysis were done by a soil testing laboratory and are presented in Table 1.

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Table 1. Soil analysis results of various soil samples used in this experiment.

Soil Source	Chemical analysis (ranges in ppm)						
	pH	N	P	K	Mg	Ca	B
Peach	5.7 - 7.6	2 - 152	56 - 144	142 - 364	92 - 610	654 - 3562	0.32 - 0.59
Apricot	6.5 - 7.4	7 - 65	38 - 210	100 - 892	354 - 700	1438 - 2982	0.36 - 0.91
Apple	6.1 - 7.3	3 - 80	39 - 400	160 - 322	176 - 388	1013 - 1528	0.30 - 1.02
Cherry	5.6 - 6.5	20 - 72	342 - 942	274 - 770	156 - 426	2734 - 5334	0.54 - 1.34
Plum	6.7 - 7.8	12 - 84	16 - 167	110 - 468	230 - 370	1345 - 8147	0.35 - 0.89
Pear	5.5 - 7.7	6 - 76	12 - 472	176 - 1526	126 - 870	858 - 12146	0.66 - 2.29
Grape	6.8 - 7.9	4 - 125	216 - 400	436 - 700	165 - 544	3120 - 7861	0.17 - 0.84

Half of the soil was pasteurized (70°C, 1 h) and the remaining half was non-treated. The soil was placed in 10-cm diameter pots. Each of the two treatments was replicated 5 times. Seeds of fruit trees were treated with Captan to control damping off and then stratified at 0-2°C in moist paper towels and sealed in plastic bags for 10 weeks. Seeds were planted in a peat-moss and perlite mixture (1:1). Germination occurred within a week at 20°C. After 7 days, seedlings were selected for uniformity. Two seedlings of fruit trees or root cuttings of grapevines were planted in each pot. Seedlings or rooted cuttings were grown in the greenhouse (20±2°C) supplemented with fluorescent lighting to give a 14 h photoperiod.

To determine the presence of replant disease in various orchard/vineyard soils, seedling growth was measured after 14 weeks. An increase of 50% or more in seedling height in pasteurized soil compared to non-pasteurized soil, plus being significant at 1% level was considered as evidence of replant disease.

Results and discussion

When peach orchard soil was used, pasteurization provided a definite increase in growth of apple, cherry, plum and grape seedlings, but apricot and pear seedling growth was not increased (Table 2). This indicates a possible replant problem

Table 2. The effect of pasteurization of soil from fruit orchards and vineyards on the growth of fruit and grape seedlings in the greenhouse.

Orchard Soil	Seedlings planted						
	Peach	Apricot	Apple	Cherry	Plum	Pear	Grape
Peach	?(4)†	-(2)	+(4)	+(4)	+(2)	-(4)	+(4)
Apricot	-(4)	-(2)	-(4)	+(4)	-(2)	-(4)	+(4)
Apple	-(4)	?(2)	+(4)	-(4)	?(2)	+(4)	+(4)
Cherry	-(4)	+(2)	+(4)	+(4)	-(2)	?(4)	+(4)
Plum	-(4)	+(2)	-(4)	+(4)	-(2)	-(4)	-(4)
Pear	-(4)	?(2)	+(4)	?(4)	-(2)	?(4)	-(4)
Grape	-(4)	+(2)	+(4)	+(4)	-(2)	?(4)	?(4)

? Response to pasteurization not consistent.
+ 50% or more increase in growth after pasteurization and significant at p=0.01.
- No improvement from pasteurization.
† No. of orchard soils tested for replant disease of fruit trees and grape vines.

for apple, cherry, plum and grapes but not for apricot and pear in the peach orchard chosen for the test. The response of the peach seedlings was not clear. In apricot orchard soil, only cherry and grape seedlings responded to pasteurization.

No replant problem was observed for cherry or peach seedlings planted in apple orchard soil. These results are similar to that observed by Savory (1966), Pitcher *et al.* (1966), Hoestra (1968), and Jackson (1973). In our trial, apple seedlings planted in cherry orchard soils developed replant disease. But the growth of apple in old cherry soils, fumigated or not, showed increases of 51% in the Netherlands (Hoestra 1968) and 44 and 60% in England (Pitcher *et al.* 1966). The average increase in growth response in England soils were 52%. This value is slightly above that of ours.

Apples, pears or grapes should not be planted after apples without soil treatments; however, peach and cherry soils do not need any treatment. Similar observations were made by Hoestra (1968) and Sewell (1979).

Peach was the only tree crop that was free of replant disease after any of the tree fruits or grapes. Plum was free from replant disease except after peach. These observations suggest that replant disease is not crop specific. The planning for new orchards should start at least one year before pulling out old trees. These soils should be tested to determine the presence of replant disease. These tests also indicate the best possible soil treatment to avoid replant disease. It is essential to follow the standard horticultural production procedures to obtain the best growth of young fruit trees or grapevines planted in old orchard/vineyard sites.

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Overwintering of stripe rust in southern Alberta

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A survey conducted in 1986 found that stripe rust had overwintered on winter wheat fields in southern Alberta. Mild weather conditions during the winter followed by a cool, wet spring allowed the survival and early buildup of stripe rust which ultimately resulted in an epidemic on soft white spring wheat. A comparison of weather conditions from 1980 to 1987 showed that outbreaks of stripe rust were inversely related to negative degree days (NDD) in December and January. Warm, dry conditions during April and May in 1987 appeared to limit stripe rust development.

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Au cours d'une enquête réalisée en 1986, on a déterminé que le champignon responsable de la rouille jaune striée avait passé l'hiver dans des champs de blé d'hiver du sud de l'Alberta. Un hiver doux, suivi d'un printemps frais et humide, a permis à la rouille striée de survivre et de se multiplier tôt, ce qui a donné lieu à une épidémie sur le blé tendre blanc de printemps. Une comparaison des conditions atmosphériques entre 1980 et 1987 a permis de déceler que les épidémies de rouille striée étaient inversement corrélées au nombre de degrés-jours négatifs pour décembre et janvier. Il semble que la prévalence de conditions chaudes et sèches en avril et en mai 1987 ait freiné la prolifération de la rouille striée.

Introduction

Stripe rust caused by *Puccinia striiformis* West. (syn. *P. glumarum* Eriks. and Henn.) poses a serious threat to the production of soft white spring wheat (*Triticum aestivum* L. em Thell) in southern Alberta. Early infection of the leaves and heads of wheat can drastically lower yield and also result in downgrading because of shrivelled grain (3). Stripe rust epidemics occur infrequently in this area, but each year low levels of stripe rust are usually detected in soft white spring wheat.

Puccinia striiformis has no known alternate hosts and must survive the year in the uredial state on infected hosts. Sharp and Hehn (7) reported that stripe rust overwintered in Montana as mycelia in infected leaves of winter wheat. They found that dormant mycelia could survive as long as the fall-infected leaves survived. Coakley and Line (1) found that by using 7°C as a base, stripe rust survival and severity on winter wheat in Washington state could be predicted based on the number of negative degree days (NDD) or positive degree days (PDD) at specific times of the year. They chose 7°C as a base in their study because it is considered to be the optimum temperature for stripe rust development. They demonstrated that stripe rust survival in winter wheat was inversely related to NDD in December and January and to PDD from April to the end of June.

Sanford and Broadfoot (5) were the first to report that stripe rust could overwinter on winter wheat in southern Alberta. However, in a subsequent study they were unable to observe any signs of winter survival of stripe rust on fall infected leaves (6). In recent years, stripe rust was generally considered to be reintroduced each year into southern Alberta by airborne spores blown in from the Pacific Northwest of the United States and that local fields of winter wheat were not an important source of inoculum.

This study examines the overwintering of stripe rust on winter wheat in southern Alberta, relates it to weather conditions, and discusses its importance in the epidemiology of this disease.

Materials and methods

Sixty-six fields of Norstar winter wheat were surveyed throughout southern Alberta in 1986. The fields examined were selected at random and stripe rust severity was determined at five sites selected at 50-m intervals along a transect of each field. At each site the percentage of a leaf area infected on the bottom, middle and top third of 20 plants was visually estimated according to the modified Cobb scale (4). The data from each field were summarized as a mean of the percentage leaf area infected on the bottom third of the crop. The stage of crop development was also recorded for each field.

In 1987, twenty-three fields of winter wheat were surveyed for stripe rust. The fields sampled were located primarily in the Lethbridge and Bow Island areas.

Data from the weather stations in Lethbridge, Taber, Bow Island and Medicine Hat were used to determine the total number of NDD in December and January in the winters of 1980-81 to 1986-87. Similarly, the number of PDD and total precipitation between April and June were determined for each year from 1981 to 1987. Degree days were calculated according to the formula described by Coakley and Line (1):

Degree days = daily average temperature — 7°C.

This weather information was related to differences in stripe rust severity in different years.

Results and discussion

This study was prompted by the detection of stripe rust on winter wheat in the first week in May 1986. The infected winter wheat fields were located primarily around Lethbridge and always in areas where irrigated soft white spring wheat had been grown during the previous summer (Fig. 1). In fields

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Table 1. Total number of negative degree days in December and January and positive degree days between April and June at four locations in southern Alberta.

	Lethbridge		Taber		Bow Island		Medicine Hat	
	NDD[a]	PDD[b]	NDD	PDD	NDD	PDD	NDD	PDD
1980-81	695.7	417.1	699.3	471.9	696.8	476.3	792.8	492.1
1981-82	1238.5	395.2	1192.2	462.9	1212.0	487.8	1285.3	474.3
1982-83	618.2	423.8	621.1	454.1	771.0	508.1	757.1	510.4
1983-84	1007.2	411.1	1056.5	456.5	1167.9	552.9	1241.6	498.3
1984-85	923.5	483.8	1014.4	461.5	1138.2	571.3	1187.3	546.7
1985-86	502.6	527.4	500.2	530.2	563.5	631.5	657.9	598.9
1986-87	450.0	616.7	471.9	652.0	506.0	743.5	592.8	694.4

[a]NDD = Negative degree days, based on average daily temperature in December and January.
[b]PDD = Positive degree days, based on average daily temperature between April and June.

where stripe rust was present, only the lower third of the plant was infected. These observations, together with information that stripe rust was not a problem in the Pacific Northwest of the United States in 1986 (Personal communication E.R. Sharp to R.L. Conner), indicated that stripe rust overwintered on winter wheat in southern Alberta in 1986.

A series of circumstances worked in combination during the fall of 1985 and the winter and spring of 1986 which ultimately resulted in a stripe rust epidemic in the summer of 1986. It was noted in the fall of 1985 that a number of late-seeded fields of soft white spring wheat were heavily infected with stripe rust even though there had been little stripe rust present during the summer. These late-seeded fields of irrigated soft white spring wheat acted as a source of inoculum to nearby fields of winter wheat after they emerged. The winter of 1985-86 was relatively mild and there was adequate snow cover to protect the infected leaves during the coldest periods of the winter. Coakley and Line (1) reported that in Washington State total NDD in December and January of between 500 and 710 would allow a light to moderate buildup of stripe rust on susceptible winter wheat provided that the total PDD from April to June did not exceed 560. The number of NDD in December and January was well within the range that would allow good survival of stripe rust (Table 1). Cool, wet conditions in June and July 1986 allowed the stripe rust to spread from winter wheat to soft white spring wheat and ultimately resulted in an epidemic on soft white spring wheat.

The number of NDD during the winter of 1986-87 was low enough to allow stripe rust survival (1) but no stripe rust was detected in any of the 23 fields surveyed in 1987. Dry, warm conditions during April and May of 1987 (Table 2) caused early senescence of infected leaves and prevented further spread of the disease.

The winters that preceded 1985-86 had high numbers of NDD in December and January indicating that conditions were unfavorable for stripe rust survival (Table 1). Stripe rust was a problem on soft white spring wheat in 1981. There is a remote possibility that stripe rust survived the 1980-81 winter but it is more likely that the disease spread in from heavily infected fields in the Pacific Northwest. In the years be-

Table 2. Amount of precipitation received in April and May between 1981 and 1987 at four locations in southern Alberta.

	Precipitation (mm)[a]			
Year	Lethbridge	Taber	Bow Island	Medicine Hat
1981	139.0	97.4	79.4	86.8
1982	43.6	35.0	79.1	105.4
1983	61.0	61.3	102.1	60.7
1984	45.6	46.1	40.2	50.8
1985	70.9	91.9	81.7	84.7
1986	89.2	85.4	75.1	89.7
1987	35.9	54.6	22.6	37.1

[a]Based on data from the Daily Weather Bulletin issued by Climatic Services - Central Region, Environment Canada.

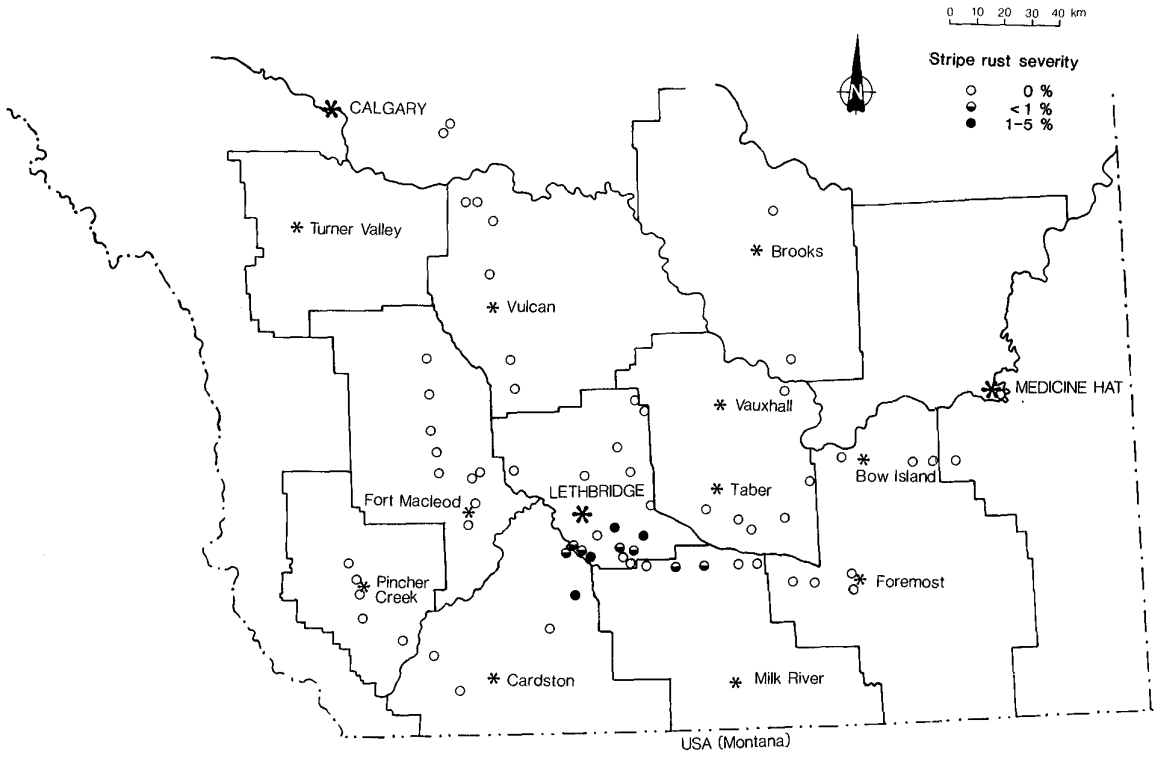

Figure 1. Map showing rust severity and the approximate location of winter wheat fields surveyed in 1986.

tween 1982 and 1985 stripe rust never became a problem because severe conditions during the winter resulted in the death of infected leaves. With the exception of 1987, weather conditions between April and June in all the years studied were cool and wet enough to allow a stripe rust buildup if the pathogen had survived the winter (Tables 1 and 2).

Coakley and Line (2) found that their prediction model did not always accurately forecast stripe rust severity at all locations and had to be further modified by standardizing NDD data according to the long-term mean for each location. Currently there are insufficient data on stripe rust survival on winter wheat in southern Alberta to allow meaningful comparisons of different predictive models on stripe rust survival but it seems likely that a more reliable model will be developed as more information on stripe rust survival is obtained. The impact of other factors on winter survival such as weather conditions during November or February, which often can be the coldest period of the winter, should also be considered. The amount of snow cover during the winter is another factor that can be limited in some years and could directly affect stripe rust survival in southern Alberta.

Stripe rust appeared to have little effect on the yield of Norstar winter wheat (Conner and Thomas, unpublished data). It was also noted that Norstar had a lower level of infection than most other winter wheat entries tested at the Lethbridge Research Station. This indicates that Norstar carries field resistance to stripe rust and this limited the spread of the disease in winter wheat. The occurrence of this disease on winter wheat is of concern because under favorable conditions it allows stripe rust to build up and spread onto soft white spring wheat early in the growing season.

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Beech bark disease - A survey of the Toronto area

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Beech Bark Disease is caused by a scale insect, *Cryptococcus fagisuga* Lind, and a fungus, *Nectria coccinea* var. *faginata* Lohman, Watson & Ayres, or *N. galligena* Bres. Investigation of six forest stands in the Toronto area revealed the presence of only the scale insect. Small trees (up to 17 cm in diameter) were less susceptible to attack by the insect than larger trees, but trees in the 11-31 cm range were the most suitable ones for the development of heavy infestations.

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La maladie corticale du hêtre est causée par une cochenille *Cryptococcus fagisuga* Lind et un champignon, *Nectria coccinea* var. *faginata* Lohman, Watson & Ayres ou *N. galligena* Bres. Dans six peuplements forestiers de la région de Toronto, on n'a décelé que l'insecte. Les petits arbres (d'au plus 17 cm de diamètre) étaient moins sensibles à l'attaque de l'insecte que les gros arbres, mais les arbres d'un diamètre de 11 à 31 cm étaient les plus susceptibles de présenter une infestation grave.

Introduction

Beech Bark Disease (BBD) is caused by the interaction of two organisms, a scale insect, *Cryptococcus fagisuga* Lind., and a fungus, *Nectria coccinea* var. *faginata* Lohman, Watson & Ayres or *N. galligena* Bres. (Cotter and Blanchard, 1981; Mielke *et al.*, 1982; Shigo, 1963). This disease complex was introduced into Canada from Europe at the end of last century, and it is found in Eastern Canada on American beech (*Fagus grandifolia* Ehrh). In 1934, Ehrlich reported the presence of BBD in Eastern Canada and indicated that it was depleting beech stands. BBD was then reported in Quebec in 1965 (Environment Canada, 1965), and the insect was first detected in Ontario at McKay Forest, Elgin County, in 1966, and again in 1981 at Holland Landing (FIDS, 1982).

C. fagisuga has a one-year life cycle, and it disseminates during the first-instar larval stage, from June to November (Ehrlich, 1934; Shigo, 1963). Insect infestations are reported to be followed 3-6 years later by *Nectria* infections (Shigo, 1963). Although the course of the disease may take several years, trees can be killed after two years of severe infection (Houston, 1975). However, differences in susceptibility of trees in affected stands have been reported (Ehrlich, 1934; Houston *et al.*, 1979; Shigo, 1963, 1964). These differences were thought to have a genetic basis (Shigo, 1964), or to be related to factors providing a better habitat for the pathogen, such as age of the tree and bark flora (Ehrlich, 1934), or be attributed to chance infestations (Houston *et al.*, 1979).

The aim of this study was to ascertain whether this disease complex was present in the Toronto area, and if so, the form in which it was present; and to determine whether there were differences among trees in susceptibility to the causal agents, and what the nature of these differences might be.

Materials and methods

Six forest stands, around the Toronto region, were examined for evidence of the presence of BBD in the summer of 1982. All of them, with the exception of the York University stand, are residual or remnant cutover stands of the beech-maple forest association located on the cooler more northerly slopes of the Humber, Don and Highland Creek Valley systems. The stand at York University was a wet mesic stand dominated by American elm (*Ulmus americana* L.), bur oak (*Quercus macrocarpa* Michx.) and pignut hickory (*Carya cordiformis* Wangenh. K. Koch). Beech was a relatively minor component of this stand.

Within these stands 100 m^2 plots were selected and the number of trees examined in each of them were: York University (44 trees), Sunnybrook (46 trees), Boyd Conservation Area (27 trees), Wilket Creek (17 trees), Earl Bales (14 trees) and Bestview (7 trees). Trees were grouped in eight diameter classes : 3-10, 11-17, 18-24, 25-31, 32-38, 39-45, 46-55, and >55 cm. Large trees predominated in Bestview and Earl Bales (86% and 57% respectively were over 31 cm in diameter); trees in the York University and Sunnybrook stands were mainly small (82% and 52% respectively had a diameter of less than 17 cm); and those in the Boyd Conversation Area and Wilket Creek were more or less evenly distributed among all diameter classes.

Trees infested with *Cryptococcus fagisuga* were tabulated and estimates of the degree of infestations recorded from ten randomly placed wire frames of 25 cm^2 each at breast height. Based on average values/25^2, the trees were grouped into five classes: 0 (no colonies or colonies scattered on branch stubs), 1-25, 26-50, 51-75, and 76-100 colonies/25 cm^2.

Within each stand trees representative of all diameter and infestation classes were examined for the presence of *N. cinnabarina* or *N. galligena*. A total of 47 trees were sampled. Sterile cotton pads were used to swab a portion of the bark approximately 5 cm^2. Dilution plates prepared on Oxoid malt agar (1.2%) amended with streptomycin were used to isolate the fungus from the bark. Plates were incubated for 7 days at 25°C prior to examination.

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Table 1. Infestation of American beech trees by the beech scale insect in relation to diameter classes of trees.

Diameter classes (cm)	Infestation classes[a] 0	1 - 25	25+ - 50	50+ - 75	75+ - 110	Percent infestation
3 - 10	44	8	2	-	-	19
10+ - 17	13	15	1	-	1	57
17+ - 24	3	13	-	1	1	83
24+ - 31	4	14	2	1	0	81
31+ - 38	-	9	1	-	-	100
38+ - 45	1	10	1	-	-	92
45+ - 55	1	7	-	-	-	88
>55	-	2	-	-	-	100

[a]Number of colonies per 25 cm^2.

Results

C. fagisuga - Classification of the trees according to the degree of infestation with *C. fagisuga* is presented in Table 1. Statistical analysis showed that trees up to 17 cm in diameter were less infested than the rest (Chi-square for contingency table: $X^2(.05)$, df:7, 56.18, $P<.001$), and that those in the lowest diameter class, 3-10 cm, were in turn less infested than those in the 11-17 cm class ($X^2(.05)$, df:1, 12.32, $P<.001$). Table 1 also shows that trees with the heaviest infestations per unit area were of intermediate size (11 to 31 cm).

In agreement with these observations, percent values of scale infested trees by stand (Table 2) indicate an increase in incidence of scale infestation with increase in size of the trees in the community (Bestview and Earl Bales having all trees infested), and a decrease in percent infestation with an increase in the percent of small trees in the other stands. The stands with a high percent of juveniles, York University and Sunnybrook, had mainly trees with scattered infestation (0 class) and a smaller percent of infested trees than the other stands.

Nectria - No evidence of *N. coccinea* var. *faginata* (or of *N. galligena*) was either observed or obtained from any isolation attempt.

Table 2. Beech scale infestation by stand and diameter classes of beech trees.

Site	Diameter classes (cm) 3-10	10+-17	17+-24	24+-31	31+-38	38+-45	45+-55	>55	Percent infestation[a]
Bestview	1	-	-	-	-	2	2	2	100
Earl Bales	-	1	1	4	5	2	1	-	100
Wilket Creek	5	1	4	3	2	1	-	-	71
Boyd Conservation Area	7	9	2	5	3	1	-	-	63
Sunnybrook	18	6	6	5	-	6	5	-	57
York University	23	13	5	3	-	-	-	-	30

[a]Based on number of trees infested with *C. fagisuga* in each stand, regardless of their infestation levels.

Discussion

The observations reported here agree with those of Ehrlich (1934), Houston *et al.* (1979), and Shigo (1963, 1964). Where *C. fagisuga* was present in a community, beech trees were commonly infested. However, trees varied in their pattern of infestation. Small-sized trees (3-10 and 11-17 cm classes) were clearly less susceptible to attack. Colonies on most of the smaller trees were almost invariably associated with branch stubs, which have been reported as one of the most suitable habitats for the insect (Ehrlich, 1934; Shigo, 1964).

We feel that length of exposure was probably not a factor in determining levels of infestation. It would be expected that large trees are probably more prone to attack by the insect because of the larger surface area exposed and, although the sample size was small, large trees sustained the greatest percent infestation. They had, however, very low infestation levels. The possibility remains that these large trees may have sustained greater infestations in the past and that the insect may have started to die out.

The trees that seemed to be more prone to develop high infestations were in the 11-31 cm range, which points to the suitability of the bark of smaller trees as substrate for the insect, and to the importance of these medium-sized trees as a source of inoculum for scale infestations. This is not in agreement with the observation that large, old trees, are generally a source of infestation and that should therefore be considered in forest management (Houston *et al.*, 1979).

Although the nature of the bark is then clearly playing a role in the build-up of heavy infestations in medium-sized trees, other factors also seem to be determining their susceptibility. One of these may be the deterioration of the trees resulting from *Xylococculus betulae* (Perg.) Morrison infestations which were observed in a high number of trees and particularly in very high numbers in the Boyd Conservation Area, the stand with the highest proportion of trees in the highest infestation levels (23% of trees with more than 25 colonies/25 cm^2). *X. betulae* could predispose beech to *C. fagisuga* attack by creating suitable infestation sites and shelter for the insect (Shigo, 1964). In addition, the presence of the lichen *Lecanora conizaeoides* Barkm. observed in some of the trees, particularly in the Boyd Conservation Area, could also encourage insect colonization (Houston *et al.*, 1979).

The insect is undoubtedly influenced by the local climate at or near the northern extreme of its range, and this may be the most important factor governing its distribution. In the spring following the year these observations were made at least some colonies did not survive the winter. Whether survival is influenced by microclimatic differences related to tree age or size is not known at this time.

In any case, development of heavy insect infestations would be expected to determine the establishment of *Nectria* spp. and further progress of the disease (Houston, 1975), which warrants close monitoring of these and other stands in the Ontario region.

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An evaluation of winter wheat for resistance to the snow mold fungi *Microdochium nivale* (Fr.) Samu & Hall and *Typhula ishikariensis* Imai

L.D. Litschko[1], L.L. Burpee[1], L.G. Goulty[1], L.A. Hunt[2] and B.D. McKersie[2]

Forty-seven cultivars or breeding lines of winter wheat, 2 cultivars of winter rye and 1 cultivar of triticale were evaluated for resistance or tolerance to *Microdochium nivale* and *Typhula ishikariensis* at Arkell and Elora, Ontario in 1985. All inoculated plants exhibited >50% foliar necrosis 4 to 5 days after snow melt (ca. 135 days after inoculation) at both locations. Observations made 6 weeks later indicated that several entries exhibited an enhanced capacity to produce new foliage. The cultivars of winter rye were generally more resistant to both pathogens than the wheats. Twelve entries of wheat exhibited no significant reduction in the number of heads formed per plant in plots infested with *Microdochium*. Four entries were tolerant to *Typhula*. The cultivar Albidum-11 exhibited tolerance to both pathogens.

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On a évalué la résistance ou la tolérance de 47 cultivars ou lignées généalogiques de blé d'hiver, de deux cultivars de seigle d'hiver et d'un cultivar de triticale à *Michodochium nivale* et à *Typhyla ishikariensis*, à Arkell et à Elora (Ontario), en 1985. Aux deux endroits, plus de 50 % du feuillage de toutes les plantes inoculées était nécrosé 4 à 5 jours après la fonte des neiges (environ 135 jours après l'inoculation). Des observations réalisées 6 semaines plus tard indiquent que plusieurs entrées avaient une capacité accrue de produire de nouvelles feuilles. Les cultivars de seigle d'hiver étaient généralement plus résistants aux deux agents pathogènes que les cultivars de blé. On n'a observé aucune réduction significative du nombre d'épis par plant chez 12 entrées de blé cultivés sur des parcelles infestées par *Microdochium*. Quatre entrées se sont révélés tolérants à *Typhula*. Le cultivar Albidum-11 a montré une tolérance aux deux agents pathogènes.

Introduction

Winter losses limit winter wheat production in Canada (Smith 1981; Andrews *et al.* 1986). Causes of these losses include direct low-temperature kill, hydration injury (flooding), desiccation, soil heaving and/or infection by low-temperature-tolerant plant pathogenic fungi (snow mold fungi).

The snow mold fungi, *Microdochium nivale* (Fr.) Samu & Hall., *Typhula incarnata* Lasch. ex. Fr. and *T. ishikariensis* Imai Var. *ishikariensis* have been observed frequently on winter wheat in Ontario (W.L. Seaman, personal communication). Losses that result from infection by these fungi have not been determined. However, surveys have revealed that snow molds occur annually between 43° and 46° N latitude, and, among fields, the incidence of disease ranges from low to high depending on the duration of snow cover (W.L. Seaman, personal communication).

Current recommendations for control of snow molds of wheat include early seeding (Bruehl 1982) and a rotation with legumes (Wiese 1977). The use of resistant cultivars is also recommended (Bruehl 1982); however, their availability is limited. For example, the cultivar Sprague is the only soft white winter wheat in North America that is recommended specifically for planting in areas with histories of losses caused by snow mold fungi (Bruehl 1982). As a result of this limitation, and a lack of information on how cultivars grown in Ontario respond to infection, the present study was conducted to evaluate cultivars and lines of winter wheat for resistance or tolerance to *M. nivale* and *T. ishikariensis*.

The Canadian Winter-Hardiness Cereal Nursery was used as a source of genetic variation for this study. The nursery consisted of a collection of cultivars and breeding lines of winter cereals (mostly wheat) from the USA, Sweden, Finland, USSR, Japan, and Canada that have exhibited winter hardiness and/or resistance to snow mold fungi under various conditions. These cultivars and breeding lines have been planted in locations across Canada to evaluate their survival under Canadian conditions. Since low-temperature hardiness and snow mold resistance are unrelated (Bruehl *et al.*, 1966), this group of winter cereals must be evaluated specifically for resistance or tolerance to snow mold fungi as well as for resistance to abiotic factors associated with winter kill.

Materials and methods

Field plots

In 1984, 50 entries in the Canadian Winter-Hardiness Cereal Nursery were evaluated for resistance to *M. nivale* and *T. ishikariensis* at the Ontario Ministry of Agriculture and Food research stations near Arkell, Ontario and Elora, Ontario. The experimental design was a split-block with 6 blocks. Inoculation or fungicide treatments were the main treatments and cultivars or breeding lines (entries) were the subtreatments. Each plot contained 50 entries. Plot dimensions were 1.8 m × 2.6 m with 0.4 m between plots within a block and 1.0 m between

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blocks. Plants of the 50 entries, within each plot, were arranged randomly in rows (groups of 10 plants) 10-15 cm long, with a depth of 5 rows and a breadth of 10 rows per plot. Rows were approximately 25 cm apart. Plots were separated by a guard row of winter wheat cv. Fredrick.

In the fall (see Table 1 for specific dates), plant emergence was assessed, each row was thinned to 10 plants, and 100 kg/ha of 6-24-24 was broadcast on the plots. In early December, a snow fence was erected on the windward side of the plots to promote deep snow cover.

Table 1. Treatment dates and general information for the snow mold trials conducted at Arkell and Elora, Ontario.

Dates and Information	Locations	
	Arkell	Elora
Year	1984-85	1984-85
Soil type	Burford loam	London loam
Planting dates	20/ 9 /84	19/ 9 /84
Emergence counted	10/10/84 to 11/10/84	15/10/84 to 16/10/84
Fungicide treatment & inoculation	29/11/84	29/11/84
Isolates:		
Microdochium nivale	F028	F028
Typhula spp.	T039	T039
Fertilization:		
Fall-100 kg/ha-6-24-24	22/10/84	22/10/84
Spring - 90 kg/ha - 34-0-0	23/ 4 /85	23/ 4 /84
Initial rating	11/ 4 /85	15/ 4 /85
Final rating	23/ 5 /85	24/ 5 /85

Inoculum preparation
Inoculum consisted of mixed grain infested with mycelium of the snow mold fungi. The grain mixture for *Typhula* was 50% wheat, 25% oats and 25% cracked corn. The mixture for *M. nivale* was 50% cracked corn, 25% wheat and 25% oats. Prior to adding the fungi, the mixtures of grain were soaked in deionized water overnight and placed in 1 litre mason jars (750 cm^3 grain per jar). The jars were sealed with a foam plug, capped with aluminum foil and autoclaved at 121°C for 45 minutes. The grain was allowed to cool for 24 hours and then autoclaved again at 121°C for 30 minutes.

Isolate F028 of *M. nivale* and isolate T039 of *T. ishikariensis* var. *ishikariensis* were cultured on potato dextrose agar (PDA) and BASM agar (15 g Difco agar, 10 g Difco malt extract, decanted water from 120 g diced potatoes boiled in 500 ml dH_2O, 500 ml dH_2O [Smith, 1981]), respectively. An actively growing mycelial plug was removed from a culture and placed in a mason jar (one isolate/jar). The grain cultures of *Typhula* were incubated at 10°C and the grain cultures of *Microdochium* were incubated at 14°C for 3 months. Prior to inoculation of plants in the field, the inoculum was removed from the mason jars and allowed to air-dry overnight. The inoculum was then ground in a Waring blender (chop cycle, 10 seconds) to break up any large clumps.

Treatments
Treatments consisted of inoculations with *M. nivale* or *Typhula*. Plants in uninfested plots, and in plots treated with fungicide, served as controls. The fungicide was an inorganic mercury (Mersil, 34% mercury equivalent, with 14% as mercuric chloride and 28% as mercurous chloride; May and Baker Canada Inc.) applied at a rate of 12.5 g a.i./ha in 1600 L H_2O/ha with a CO_2 propelled back-pack sprayer at 207 kpa.

Fungicide and inoculation treatments were applied on 29 November before the snow fence was erected. Inoculum was applied by hand at a rate of 300 cm^3 per plot to ensure an even distribution of the pathogens in the plots. Inoculum was not applied to plots that served as uninfested controls and fungicide-treated controls.

Assessment of foliar necrosis
In April, 4-5 days after snow-melt, each row of plants was evaluated for severity of foliar necrosis using the Horsfall-Barratt rating scale (Horsfall and Cowling, 1978). This rating was used to determine the resistance of each cultivar to foliar necrosis induced by the snow mold fungi. A second rating (4-6 weeks later, see Table 1) was used to assess the growth potential of each cultivar after infection.

Assessment of yield
Detiffe, *et al.* (1984) reported that, in winter barley, the yield component most affected by snow mold infection was the number of heads produced. Therefore, in July, the number of heads per row (10 plants) was counted.

Data analysis
When the F-test from an ANOVA was significant ($P=0.05$) for treatments and cultivars, further analysis was performed using Duncan's new multiple range test (Steele and Torrie, 1980) or the Scott-Knott cluster analysis procedure (Gates and Bilbro, 1978). Percentage values, presented as estimates of the incidence of foliar necrosis were transformed prior to ANOVA, using the Freeman-Tukey method for arcsine transformation (Mosteller and Youtz, 1961). This transformation was used to reduce heterogeneity of variance normally associated with percentage data (Little and Hill, 1978). Values for the number of heads formed per plant were not transformed prior to analysis. Poor emergence resulted in missing data at the Arkell location. As a result, cluster analysis could not be used. Therefore, Duncan's new multiple range test was used as a mean separation procedure. Cultivars or breeding lines were deleted from analysis if poor emergence in the fall resulted in fewer than four replications per entry, or fall emergence was less than 8 plants/row (omitted only from analysis of yield data).

Results

Arkell
The initial and final Horsfall-Barratt (H-B) ratings were made 133 and 175 days after inoculation, respectively. Due to poor seedling emergence 10 entries were omitted from the analysis of data collected from plots infested with *Microdochium*.

Table 2. Incidence of foliar necrosis on winter cereals 133 and 175 days after inoculation with *Microdochium nivale* at Arkell, Ontario in 1984*.

Cultivar or breeding line**	Foliar necrosis (%)	
	133 days	175 days
Sprague	72 a	22 abcde
Augusta	84 b	25 abcde
Musketeer Rye	84 bc	2 a
Hokuei	88 bcd	23 abcde
Frankenmuth	90 bcd	52 ef
CI-14106	91 bcd	6 abcde
Hybrid-481	91 bcd	6 abcde
Odesskaya-16	92 bcd	3 ab
Jo-3057	93 bcd	40 abcdef
WT84	95 bcd	22 abcde
Genesse	95 bcd	38 abcdef
Tulun-407	95 bcd	9 abcde
Kharkov 22MC	95 bcd	6 abcde
Albidum-11	95 bcd	3 ab
Sundance	96 bcd	2 a
Gordon	96 bcd	7 abcde
Starke-2	96 bcd	25 abcde
Krasnodarskaya-39	96 bcd	4 ab
Jo-3022	96 bcd	3 ab
Olympia	97 cd	3 ab
PPG-559	97 cd	76 f
Ulyanovka	97 cd	40 def
Moskowskaia	97 cd	29 abcde
93-Hong	97 cd	72 f
Norstar	98 d	27 abcde
Fredrick	97 d	42 abcdef
WT166	98 d	27 abcde
Lennox	98 d	18 abcde
Bruehl VM801046	98 d	22 abcde
Jo-3067	98 d	4 ab
Beltskaya	98 d	4 ab
Yorkstar	99 d	4 ab
Tecumseh	99 d	42 abcdef
Albasskaya	99 d	46 cdef
Argee	99 d	27 abcde
Winalta	99 d	43 bcdef
Lutescens-230	99 d	4 ab
Bruehl VM801147	99 d	13 abcde
OAC Wintri Triticale	99 d	4 ab
Redwin	100 d	80 f

*Inoculum consisted of autoclaved mixed grain infested with isolate F028.

**Due to poor seedling emergence, ten entries were omitted from the analysis.

Values represent non-transformed mean percent foliar necrosis based on the Horsfall-Barratt grading system (Horsfall and Cowling, 1978).

Data were transformed for the purpose of statistical analysis using the Freeman-Tukey (1950) acsine formula.

Means followed by the same letter are not significantly different (P = .10, Duncan's new multiple range test).

Table 3. Incidence of foliar necrosis on winter cereals 133 and 175 days after inoculation with *Typhula ishikariensis* at Arkell, Ontario in 1984*.

Cultivar or breeding line**	Foliar necrosis (%)	
	133 days	175 days
Olympia	79 a	2 a
Kodiak Rye	86 a	2 a
Alabasskaya	87 a	38 abcde
CI-14106	93 b	6 ab
Odesskaya-16	94 b	22 abc
Albidum-114	94 b	26 abcd
Fredrick	94 b	76 cde
Lutescens-230	96 b	42 abcde
Krasnodarskaya-39	96 b	22 abcd
Houser	96 b	27 abcd
Musketeer Rye	96 b	2 a
Moskowskaia	97 b	52 abcde
PPG-559	97 b	22 abcde
WT84	97 b	52 abcde
Tulun-407	98 b	26 abcde
Frankenmuth	98 b	55 abcde
Tecumseh	98 b	58 abcde
Norstar	98 b	82 e
Genesse	98 b	64 abcde
Bruehl VM801046	98 b	29 abcde
Beltskaya	98 b	24 abcd
Redwin	98 b	27 abcd
Jo-3067	98 b	21 abcd
Albidum-11	98 b	48 abcde
Kharkov 22MC	99 b	43 abcde
Ulyanovka	99 b	29 abcde
Hokuei	99 b	42 abcde
OAC Wintri Triticale	99 b	27 abcd
Lennox	99 b	43 abcde
WT166	99 b	36 abcde
Starke-2	99 b	80 cde
Lovrin-11	99 b	51 abcde
Sprague	99 b	22 abcd
93-Hong	99 b	55 abcde
Hybrid-481	100 b	37 abcde
Sundance	100 b	77 cde
Yorkstar	100 b	84 e
Favor	100 b	81 de
Augusta	100 b	48 abcde
Kharkov/Ulyanovka	100 b	27 abcd
Argee	100 b	54 abcde
Winalta	100 b	76 cde

*Inoculum consisted of mixed grain infested with isolate T039.

**Due to poor seedling emergence, eight entries were omitted from the analysis.

Values represent non-transformed mean percent foliar necrosis based on the Horsfall-Barratt grading system (Horsfall and Cowling, 1978).

Data were transformed for the purpose of statistical analysis using the Freeman-Tukey (1950) arcsine formula.

Means followed by the same letter are not significantly different (P = .10, Duncan's new multiple range test).

Table 4. Comparison of the mean number of heads formed per plant in plots infested with *Microdochium nivale* or *Typhula ishikariensis* and in uninfested control or fungicide treated plots at Arkell, Ontario in 1984*.

Cultivar or Breeding Line**	Control	Fungicide	*M. nivale*	*Typhula*
Winalta	—	3.5 a	1.1 b	—
Sundance	3.5 a	3.4 a	3.2 a	0.6 b
Lennox	3.4 a	3.9 a	2.4 b	2.9 a
Genesse	—	2.3 a	1.4 a	1.0 b
OAC Wintri Triticale	2.4 a	1.7 a	1.7 a	—
Bruehl VM801046	3.8 a	3.2 a	3.1 a	2.8 a
Kharkov 22MC	2.9 a	—	2.2 a	1.3 a
Sprague	2.9 a	—	2.9 a	0.9 b
CI-14106	3.8 a	—	3.1 a	—
Hokuei	—	3.1 a	2.8 a	2.1 b
Lutescens-230	2.7 a	—	2.2 a	2.1 a
Redwin	1.0 a	—	0.5 a	—
Albidum-11	2.9 a	2.5 a	2.8 a	2.4 a
Alabasskaya	3.0 a	3.0 a	1.6 a	2.1 a
WT84	2.0 a	2.6 a	1.7 a	0.9 b
WT166	3.1 a	—	1.2 a	0.5 b
Tulun-407	3.1 a	3.6 a	2.2 a	2.3 a
Hybrid-481	2.7 a	2.7 a	3.3 a	2.2 a
Jo-3022	1.3 a	—	2.1 a	—
Odesskaya-16	3.3 a	—	3.0 a	—
Argee	2.7 a	—	2.4 a	2.8 a
Yorkstar	—	3.1 a	1.9 a	0.8 b
93-Hong	0.7 a	—	1.1 a	—
Augusta	3.3 a	3.1 a	1.9 a	2.9 a
Bruehl VM801147	—	3.1 a	2.2 a	—
Frankenmuth	3.0 a	2.7 a	2.1 a	2.5 a
Norstar	—	3.0 a	—	0.3 b
Albidum-114	—	3.1 a	—	1.2 b
Ulyanovka	2.4 a	—	—	1.9 a
Tecumseh	—	3.6 a	—	3.4 a
Favor	—	2.2 a	—	2.5 a
Lovrin-11	2.0 a	2.1 a	—	2.2 a

* Treatments included mixed grain infested with *M. nivale* (isolate F028), *T. ishikariensis* (isolate T039) or an application of the fungicide Mersil (12.5 g a.i./ha).

** Cultivars or Breeding lines with less than 80% emergence in more than 2 replicated plots were omitted from the analysis. Means followed by the same letter are not significantly different ($P = 0.05$, Duncan's new multiple range test).

Analysis of the initial H-B ratings, for plants inoculated with *Microdochium*, revealed that the cultivar Sprague exhibited significantly less foliar necrosis than the other 39 entries (Table 2). Analysis of the final H-B ratings, recorded 42 days after the initial ratings, indicated that all entries exhibited growth and development of symptomless foliage. This resulted in a reduction in the intensity of foliar necrosis. Plants of seventeen entries exhibited <10% foliar necrosis when the final H-B ratings were recorded (Table 2).

Forty-two entries were evaluated in plots infested with *Typhula*. At the initial rating, plants of Kodiak rye, and plants of Olympia and Alabasskaya winter wheat exhibited significantly less foliar necrosis than plants of the remaining 39 entries (Table 3). Forty-two days later, plants of 2 cultivars of winter rye (Kodiak and Musketeer), 1 cultivar of winter wheat (Olympia) and 1 breeding line of wheat (CI 14106) had less than 10% foliar necrosis (Table 3).

Due to poor seedling emergence (<80%), yield data from fourteen of the 40 entries inoculated with *Microdochium* were not analyzed. Only three cultivars of winter wheat, Winalta, Lennox and Yorkstar, exhibited a significant reduction in the number of heads formed per plant compared to the uninoculated control and/or fungicide treatments (Table 4).

The entries Norstar, Sundance, Genesse, Sprague, Hokuei, WT84, WT166, Yorkstar, and Albidum-114 winter wheats exhibited a significant reduction in the number of heads formed per plant in plots infested with *Typhula* as compared to the uninoculated and/or fungicide treatments (Table 4). Unfortunately, the four entries that exhibited the best recovery (Olympia, CI 14106, Kodiak rye and Musketeer rye) did not have adequate replication to facilitate statistical analysis of yield data.

Table 5. Incidence of foliar necrosis on winter cereals 137 and 176 days after inoculation with *Microdochium nivale* at Elora, Ontario in 1984*.

Cultivar or breeding line	Foliar necrosis (%)	
	137 days	176 days
Kodiak Rye	74 a	18 a
Musketeer Rye	77 a	2 a
Argee	86 b	21 a
Gordon	87 b	24 a
Olympia	88 c	11 a
Jo-3057	88 c	36 a
Hybrid-481	89 c	33 a
Albidum-114	90 c	36 a
Odesskaya-16	90 c	7 a
CI-14106	91 c	14 a
Bruehl VM801046	93 c	18 a
Ulyanovka	93 c	45 b
Lutescens-230	93 c	15 a
Albidum-11	93 c	15 a
Tulun-407	93 c	58 b
Alabasskaya	93 c	35 a
Lutescens-116	93 c	11 a
Sprague	94 c	19 a
Roughrider	94 c	76 b
WT84	94 c	36 a
Beltskaya	94 c	39 a
Favor	94 c	55 b
Hokuei	94 c	32 a
Yorkstar	94 c	36 a
Jo-3067	95 c	30 a
Norstar	95 c	21 a
Jo-3022	95 c	39 a
Sundance	95 c	21 a
Frankenmuth	95 c	55 b
Starke-2	95 c	55 b
Bruehl VM801047	96 c	58 b
Lutescens-329	96 c	18 a
Redwin	96 c	47 b
Winalta	96 c	14 a
Krasnodarskaya-39	96 c	30 a
Moskowskaia	96 c	58 b
Kharkov/Ulyanovka	96 c	34 a
PPG-559	96 c	52 b
Penzanskaya Morostoikaya	96 c	33 a
Lennox	96 c	21 a
Kharkov 22MC	96 c	32 a
Augusta	97 c	69 b
Genessee	97 c	65 b
Lovrin-11	97 c	49 b
OAC Wintri Triticale	98 c	60 b
Houser	98 c	25 a
Fredrick	97 c	81 b
Tecumseh	98 c	50 b
WT166	98 c	53 b
93-Hong	98 c	81 b

continued...

Table 5 - continued

*Inoculum consisted of autoclaved mixed grain infested with isolate F028.
Values represent non-transformed mean percent foliar necrosis based on the Horsfall-Barratt grading system (Horsfall and Cowling, 1978).
Data were transformed for the purpose of statistical analysis using the Freeman-Tukey (1950) arcsine formula.
Means followed by the same letter are not significantly different (P = .10 Scott-Knott cluster analysis method).

Elora

One hundred and thirty seven days after inoculation with *Microdochium*, plants of Kodiak and Musketeer rye and plants of Argee and Gordon winter wheats exhibited significantly less foliar necrosis than plants of other cultivars or breeding lines (Table 5). Thirty-nine days later, 32 entries in the nursery exhibited significantly less foliar necrosis than the remaining 18 entries (Table 5).

At the initial H-B rating of plants inoculated with *Typhula*, Kodiak and Musketeer rye exhibited significantly less foliar necrosis than the other entries (Table 6). Thirty-nine days later, plants of 16 entries had significantly less foliar necrosis (Table 6).

Analysis of the yields revealed a significant reduction in the number of heads formed in 13 and 20 entries in the plots infested with *Microdochium* and *Typhula*, respectively (Table 7).

Discussion

The Canadian Winter-Hardiness Cereal Nursery is a collection of cultivars and breeding lines from around the world that possess some superior overwintering characteristics. Entries that have been reported to exhibit resistance to snow mold fungi are listed in Table 8.

According to the H-B ratings made 4-5 days after snow melt, all entries in the Canadian Winter-Hardiness Cereal Nursery that were exposed to *Microdochium* or *Typhula* exhibited considerable foliar necrosis (>50%) at both locations. This suggested that none of the entries were resistant. However, H-B ratings made 4-6 weeks later, indicated that several entries exhibited an enhanced capacity, relative to other lines, to produce new foliage. This potential for regrowth (i.e., crop recovery) was used along with yield, to select entries with tolerance to snow mold fungi. Jamalainen (1974) and Bruehl (1982) have also identified resistance or tolerance to snow molds

Table 6. Incidence of foliar necrosis on winter cereals 137 and 176 days after inoculation with *Typhula ishikariensis* at Elora, Ontario in 1984*.

Cultivar or breeding line	Foliar necrosis (%)	
	137 days	176 days
Kodiak Rye	53 a	2 a
Musketeer Rye	81 b	2 a
Bruehl VM801046	93 c	21 a
Lutescens-329	94 c	35 a
Beltskaya	94 c	31 a
Bruehl VM801047	94 c	41 b
Jo-3057	95 c	54 b
Sundance	95 c	19 a
Sprague	95 c	26 a
Albidum-11	95 c	15 a
Kharkov 22MC	95 c	41 b
Krasnodarskaya-39	95 c	34 a
Albidum-114	95 c	22 a
Hybrid-481	96 c	55 b
Argee	96 c	55 b
Odesskaya-16	96 c	41 b
CI-14106	96 c	33 a
Olympia	96 c	17 b
Houser	96 c	18 a
Winalta	96 c	24 a
Frankenmuth	96 c	63 b
Hokuei	96 c	47 b
Yorkstar	96 c	55 b
Lutescens-116	97 c	51 b
Norstar	97 c	22 a
Genesse	97 c	54 b
WT84	97 c	9 a
Tulun-407	97 c	62 b
Gordon	97 c	48 b
Jo-3067	97 c	55 b
Alabasskaya	97 c	41 b
Lennox	97 c	55 b
Roughrider	97 c	46 b
Lovrin-11	97 c	47 b
Moskowskaia	98 c	61 b
Favor	98 c	69 b
Penzanskoya Morozostoikaya	98 c	69 b
Starke-2	98 c	47 b
Jo-3022	98 c	49 b
Tecumseh	98 c	61 b
PPG-559	98 c	70 b
Lutescens-230	98 c	70 b
WT166	98 c	57 b
OAC Wintri Triticale	98 c	34 a
Augusta	99 c	72 b
Redwin	99 c	75 b
93-Hong	99 c	94 b
Ulyanovka	100 c	79 b
Fredrick	100 c	99 b
Kharkov/Ulyanovka	100 c	79 b

continued...

Table 6 - continued

* Inoculum consisted of mixed grain infested with isolate T039. Values represent non-transformed mean percent foliar necrosis based on the Horsfall-Barratt grading system (Horsfall and Cowling, 1978).
Data were transformed for the purpose of statistical analysis using the Freeman-Tukey (1950) arcsine formula.
Means followed by the same letter are not significantly different (P = .10, Scott-Knott cluster analysis method).

based on the ability of an infected plant to regrow from the crown. The cultivars Musketeer and Kodiak rye and Argee, Gordon and Sprague winter wheats exhibited significantly less foliar necrosis in the initial rating of plants inoculated with *Microdochium* at the Arkell and Elora locations. In the plots infested with *Typhula*, the cultivars Kodiak and Musketeer rye and Olympia and Alabasskaya winter wheat exhibited superior winter survival, according to the initial H-B rating. Kodiak rye was the only cultivar that was consistant in reaction at both locations.

In the plots infested with *Microdochium*, Odesskaya-16 was the only winter wheat that exhibited no significant reduction in yield and had $<10\%$ foliar necrosis 6 weeks after snowmelt at both locations. The rye cultivar, Musketeer, the triticale cultivar OAC Wintri and the winter wheat entries, Sundance, Olympia, Jo-3022, Albidum-11, Krasnodarskaya-39, Jo-3067, Beltskaya, Lutescens-230, Yorkstar, Kharkov-22 MC, CI 14106, Hybrid-481, Gordon and Tulun-407 exhibited $<10\%$ foliar necrosis at the final rating at Arkell or Elora in 1985.

In the plots infested with *Typhula*, the rye cultivars Musketeer and Kodiak as well as the winter wheats, Olympia and CI 14106 exhibited $<10\%$ foliar necrosis at the last rating at Arkell in 1985. Unfortunately, yields could not be analyzed for these cultivars at the Arkell location. At the Elora location, only the rye cultivars Musketeer and Kodiak and one winter wheat breeding line (WT84) exhibited $<10\%$ foliar necrosis according to the last H-B rating. All three of these entries exhibited no significant reduction in yield at Elora.

Yield is the most important component of winter cereal production. Entries in the nursery that displayed no significant reduction in yield compared to control or fungicide treated plants are listed in Table 9. The breeding line Albidum-11 was the only entry that exhibited tolerance to isolates of both species of snow mold fungi tested. The entries in Table 9 are by no means the extent of useful material from the nursery. Entries that were not replicated adequately because of poor emergence may also be useful, but they must undergo further testing.

Table 7. Comparison of the mean number of heads formed per plant in plots infested with *Microdochium nivale* or *Typhula ishikariensis* and in uninfested control or fungicide treated plots at Elora, Ontario in 1985*.

Cultivar or Breeding Line	Control	Fungicide	*M. nivale*	*Typhula*
Norstar	3.3 a	3.0 a	3.3 a	3.0 a
Winalta	1.6 a	2.8 a	2.0 a	2.2 a
Sundance	2.8 a	3.8 a	3.2 a	3.7 a
Lennox	4.8 a	3.6 ab	2.4 b	1.5 b
Fredrick	1.2 a	1.6 b	0.5 a	0.5 a
Genesse	1.7 a	2.5 a	1.5 a	1.0 a
Musketeer Rye	5.6 a	4.2 a	6.1 a	4.4 a
Kodiak Rye	4.8 a	4.6 a	5.1 a	4.3 a
OAC Wintri Triticale	2.5 ab	3.5 a	1.2 b	1.6 a
Bruehl VM801046	4.7 a	3.6 ab	2.7 b	2.4 b
Kharkov 22MC	2.2 ab	3.1 a	1.7 b	2.2 a
Sprague	2.4 a	2.2 a	1.6 a	2.7 a
CI-14106	1.8 a	3.3 a	2.6 a	2.0 a
Hokuei	3.3 a	3.5 a	2.2 a	1.2 b
Lutescens-230	2.4 a	3.5 a	2.2 a	1.2 b
Redwin	1.5 a	1.9 a	1.6 a	0.7 b
Albidum-11	3.4 a	4.4 a	3.4 a	3.6 a
Albidum-114	3.6 a	3.4 a	3.3 a	2.5 a
Lutescens-329	3.8 a	3.8 a	3.2 a	2.1 a
Alabasskaya	1.8 b	4.3 a	1.8 b	1.4 b
Ulyanovka	3.3 a	2.6 a	2.2 a	0.8 b
Kharkov/Ulyanovka	2.2 a	3.2 a	1.8 a	0.9 b
Roughrider	1.8 a	2.1 a	0.9 a	1.8 a
WT84	2.2 a	2.6 a	2.4 a	3.0 a
WT166	2.7 a	2.7 a	1.0 b	1.1 b
Tulun-407	3.1 a	2.9 a	2.1 a	1.0 b
Olympia	3.0 a	3.3 a	1.9 a	1.9 a
Beltskaya	3.4 a	2.6 a	2.0 a	1.4 a
Moskowskaia	2.2 a	2.4 ab	1.3 a	1.2 a
Hybrid-481	2.6 ab	3.4 a	2.0 b	1.7 b
Tecumseh	2.9 a	3.0 a	1.6 a	1.6 a
Jo-3022	2.7 a	2.6 a	1.7 a	1.5 a
Jo-3057	3.4 a	2.9 ab	2.0 b	1.7 b
Jo-3067	3.2 a	3.0 a	2.1 a	1.4 b
Odesskaya-16	4.1 a	2.9 a	3.6 a	1.8 a
Penzanskaya Morozostoikaya	2.5 a	3.1 a	1.9 a	0.7 b
Lutescens-116	2.6 a	2.5 a	2.8 a	0.8 b
PPG-559	2.0 ab	2.8 a	1.1 b	1.3 b
Starke-2	2.6 a	1.7 ab	0.9 b	1.7 a
Argee	2.9 a	3.7 a	2.6 a	1.8 a
Favor	1.7 a	1.7 a	1.7 a	0.9 a
Gordon	3.4 a	3.0 a	2.4 a	0.9 b
Houser	1.6 a	3.1 a	2.3 a	1.9 a
Yorkstar	2.9 a	2.2 a	1.5 a	1.3 a
93-Hong	0.2 b	1.0 a	0.5 ab	0.4 ab
Augusta	2.5 a	2.3 a	1.4 a	0.7 a
Bruehl VM801147	3.4 a	3.4 a	1.4 b	0.7 a
Krasnodarskaya-39	3.6 a	3.6 a	2.6 a	1.7 b
Lovrin-11	0.5 a	1.5 a	0.7 a	1.4 a
Frakenmuth	3.6 a	2.5 ab	1.8 b	1.8 b

* Treatments included mixed grain infested with *M. nivale* (isolate F028), *T. ishikariensis* (isolate T039) or an application of the fungicide Mersil (12.5 g a.i./ha).

Within a row, means followed by the same letter are not significantly different (P = 0.05, Duncan's new multiple range test).

Table 8. List of wheat cultivars or breeding lines in the Canadian Winter-Hardiness Cereal Nursery that have exhibited resistance to snow mold fungi.

Pathogen	Cultivar or Breeding Line	Origin	Reference
Microdochium nivale	Lennox (selection from (Mironovskaya-808)	Canada (USSR)	Gotoh 1978
	Lutescens-116	USSR	Prutskov 1973
	CI-14106	USA	Bruehl 1982
Typhula spp.	Sundance	Canada	
	Albidum-11	USSR	Prutskov 1973
	Albidum-114	USSR	Prutskov 1973
	Olympia	Finland	Jamalainen 1974
	CI-14106	USA	Bruehl 1982
Snow Molds (unspecified)	Sprague	USA	Bruehl 1982

Table 9. Cultivars or breeding lines that exhibited no significant reduction in yield (mean heads formed per plant) after inoculation with snow mold fungi at the research stations at Arkell and Elora, Ontario in 1985.

Pathogen	Cultivar or Breeding Line
Microdochium nivale	Sprague CI-14106 Hokuei Lutescens-230 Albidum-11 Sundance WT84 Tulun-407 Jo-3022 Odesskaya-16 Argee Augusta
Typhula spp.	Kharkov 22MC Albidum-11 Beltskaya Lovrin-11

The winter wheat cultivars currently available and recommended in Ontario (Fredrick, Augusta, Favor, Frankenmuth, Gordon and Houser) (Anonymous, 1986), generally did not fare well in any of the snow mold evaluations. If the limits of winter wheat production in Ontario are to be extended, plant breeders must incorporate some of the available sources of snow mold resistance or tolerance into useful cultivars.

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CROP: Apple cv McIntosh and Delicious

LOCATION: Ontario

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TITLE: DISEASE SURVEY OF COMMERCIAL APPLE ORCHARDS IN SOUTHERN ONTARIO.

METHODS: Fruit harvest assessments were carried out in southern Ontario in 108 different commercial orchards. Fruit from four trees per orchard were sampled at or just prior to harvest maturity. From standard sized trees, 33 fruit from the top, skirt inside and skirt outside were checked. One extra apple was checked from each tree to bring the sample total to 100 apples per tree. In two orchards (one from the St. Lawrence Valley, one from Prince Edward) which had a light crop load 300 apples were checked.

From dwarf sized trees, 33 fruit from each of the top, middle and bottom portions of the tree were checked. One extra apple was picked from each tree to bring the sample size to 100 apples per tree.

Fruit was checked for apple scab (*Venturia inaequalis* (Cke.) Wint.), fly speck (*Leptothyrium pomi* (Mont. and Fr.) Sacc.), sooty blotch (*Gloeodes pomigena* (Schw.) Colby) and insect injury. These were reported by area as to the presence or absence of disease or insect injury. Disease data from the Norfolk-Haldimand, Brant area from 1979 to 1987 was included for comparison. Observations on blister spot (*Pseudomonas syringae* pv *papulans* van Hall), fire blight (*Erwinia amylovora* (Burr.) Winsl. et al.) and powdery mildew (*Podosphaera leucotricha* Ell. & Ev.) were made during the growing season.

RESULTS AND COMMENTS: Fruit damage from diseases was considerably less than injury from insects in all areas surveyed in 1987. Apple scab and fly speck was less prevalent in the Norfolk-Haldimand, Brant area during 1987 than in previous years due to dry weather in 1987. In the Durham region in 1987, 45 of the scab infested fruit were from one orchard where a high inoculum pressure was present from the previous year. Sooty blotch has only shown up in large, poorly managed trees. The sooty blotch reported in the St. Lawrence Valley all occurred in one orchard.

In all areas of Southern Ontario, blister spot and fire blight were less severe, while foliar powdery mildew was more prevalent during 1987 than in 1986. Powdery mildew did not cause any economic loss of fruit due to russetting in 1987.

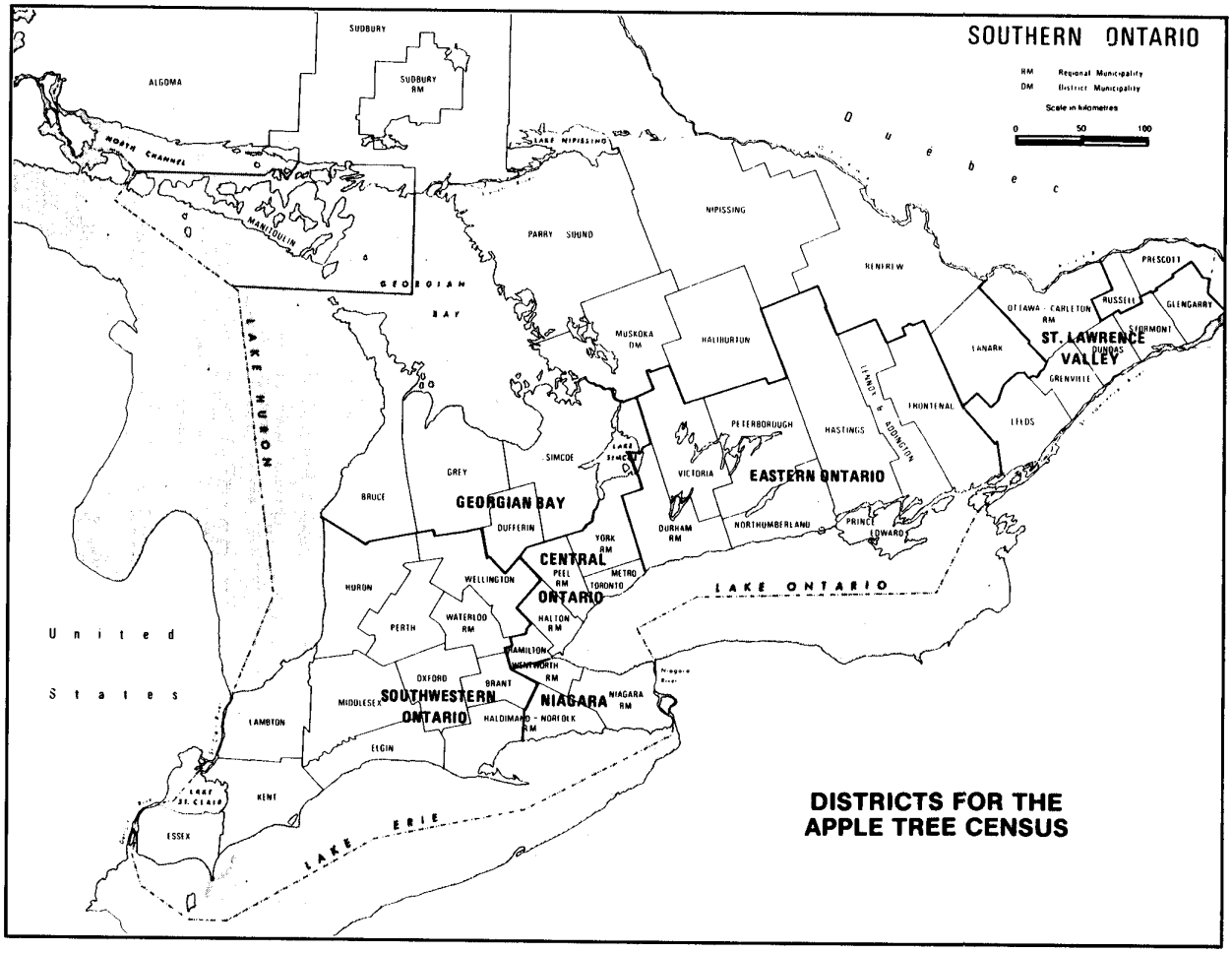
Harvest Assessment, Southern Ontario, 1987

Area	Number of Orchards	Number of Apples	Number of Fruit Affected			
			Scab	Fly Speck	Sooty Blotch	Total Insect
Norfolk-Haldimand, Brant	52	20700	26	3	1	1983
Halton, Peel	5	2000	14	13	0	97
Georgian Bay	7	2800	36	0	0	166
Niagara	8	3200	13	0	0	125
Essex, Kent	6	2400	10	0	0	32
Elgin	2	800	0	0	0	20
Middlesex, Lambton	4	1600	6	1	0	33
Durham	9	3600	49	27	1	110
Northumb'ld, Prince Edward, Hastings	10	3900	8	2	0	432
St. Lawrence Valley	5	1900	37	0	18	66

Harvest Assessment, Norfolk-Haldimand, Brant Area 1979-1987

Year	Number of Orchards	Number of Apples	Per Cent Fruit Affected		
			Scab	Fly Speck	Sooty Blotch
1979	43	17200	1.9	-	-
1980	44	17600	2.5	1.4	0.03
1981	48	19400	0.8	2.9	0
1982	54	23600	0.9	0.1	0.03
1983	60	24400	3.0	0.7	0
1984	60	24100	0.7	1.3	0
1985	64	25600	0.6	0.2	0
1986	57	22800	1.8	0.3	0
1987	52	20700	0.1	0.01	0.005

- indicates records not available


SOUTHERN ONTARIO
RM Regional Municipality
DM District Municipality
Scale in kilometres
0 50 100
SUDBURY
ALGOMA
SUDBURY RM
NORTH CHANNEL
LAKE NIPISSING
MANITOULIN
GEORGIAN BAY
PARRY SOUND
NIPISSING
RENFREW
PRESCOTT
RUSSELL
GLENGARRY
OTTAWA - CARLETON RM
STORMONT DUNDAS
ST. LAWRENCE VALLEY
LANARK
GRENVILLE
LEEDS
FRONTENAC
LENNOX & ADDINGTON
HASTINGS
PETERBOROUGH
MUSKOKA DM
HALIBURTON
LAKE HURON
LAKE SIMCOE
SIMCOE
GREY
BRUCE
VICTORIA
EASTERN ONTARIO
GEORGIAN BAY
DUFFERIN
DURHAM RM
NORTHUMBERLAND
PRINCE EDWARD
YORK RM
CENTRAL ONTARIO
PEEL RM
METRO TORONTO
LAKE ONTARIO
HURON
WELLINGTON
WATERLOO RM
PERTH
HALTON RM
HAMILTON WENTWORTH RM
United States
OXFORD
BRANT
MIDDLESEX
SOUTHWESTERN ONTARIO
NIAGARA
NIAGARA RM
HALDIMAND - NORFOLK RM
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DISTRICTS FOR THE APPLE TREE CENSUS

Author Index to Volume 68

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

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