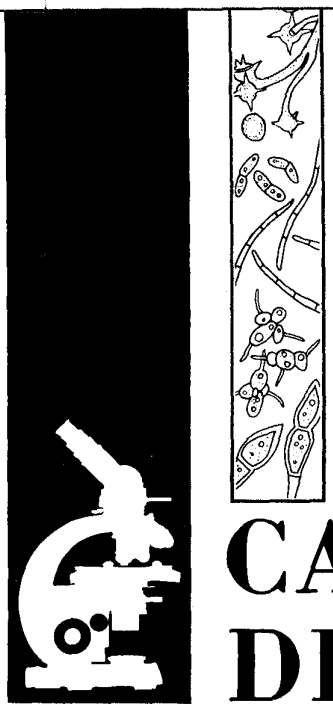
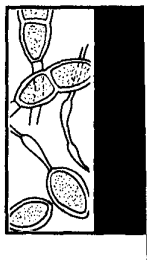
VOL. 54, No. 4, DECEMBER, 1974



CANADIAN PLANT DISEASE SURVEY



EDITOR W.L. SEAMAN

Agriculture Canada

Research Branch

VOL. 54, No. 4, DECEMBER, 1974

CANADIAN PLANT DISEASE SURVEY

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

CONTENTS

"The Canadian Plant Disease Survey is a periodical of information and record on the occurrence and severity of plant diseases in Canada. It will also accept other original information such as the development of methods of investigation and control, including the evaluation of new materials. Review papers and compilations of practical value to phytopathologists will be included from time to time."

AERIAL PHOTOGRAPHY — AN AID IN SURVEYING FOR DAMAGE BY ROOT - LESION NEMATODE IN FLUE - CURED TOBACCO

C.F. Marks,[1] J.M. Elliot,[2] J.R. Rainforth,[3] M.C. Watson,[4] and B. Back[2]

Abstract

Aerial infrared photography was assessed as a technique for detecting root-lesion nematode (Pratylenchus penetrans) damage in flue-cured tobacco by comparing photographic interpretation with ground observations, and by determining root-lesion nematode population densities and chemical analyses of soil samples. A total of 130 fields, representing about 525 ha of flue-cured tobacco, were surveyed. It was not possible to differentiate, from the aerial photographs, areas of nematode damage from those of poor growth due to other factors. However, aerial photography could be useful as a supplementary technique for surveys of nematode damage. Only 3% of the samples showed root-lesion nematode population densities greater than 2200/kg of soil; and at lower densities there was no apparent relationship between poor growth and numbers of nematodes in the soil.

Résumé

On a évalué les photographies aériennes infrarouges comme technique de détection des dégâts causés par le nématode radicicole (Pratylenchus penetrans) dans le tabac jaune, par comparaison de l'interprétation photographique avec les observations au sol et par détermination de la densité des populations de nématodes et des analyses chimiques d'échantillons de sol. On a ainsi prospecté un total de 130 champs comptant environ 525 ha de tabac jaune. A partir des photographies aériennes, il a été impossible de différencier les zones de dégâts dûs aux nématodes de celles de mauvaise croissance attribualbe à d'autres facteurs. Toutefois, la photographie aérienne s'est révélée utile comme technique supplémentaire d'évaluation des dégâts causés par les nématodes. Seulement 3% des échantillons ont donné des densités de population de nématodes supérieures à 2,200 organismes/kg de sol et, à des densités plus faibles, il ne semblait y avoir aucun rapport entre la mauvaise croissance du tabac et le nombre de nématodes dans le sol.

Aerial infrared photography is useful for detecting plant damage caused by a number of organisms (Brenchley, 1968). Recently, aerial photography has been used in Ontario to detect bacterial blight of field beans (Wallen & Jackson, 1971) and verticillium wilt of potatoes (Busch et al. 1970). In England, Dunning and Cooke (1967) used aerial photography in studies on the distribution of the docking disorder of sugar beets, often caused by nematodes (Trichodorus spp. or Longidorus spp.). Heald et al. (1972) also found that differences in growth of cotton in fumigated and non-fumigated plots infested with Rotylenchulus reniformis Linford and Oliveira could be readily detected by aerial infrared photography.

Agriculture Canada, Research Stations at [1]Vineland Station, and [2]Delhi, Ontario; and Ontario Ministry of Agriculture and Food, [3]Vineland Station and [4]Delhi, Ontario.

The root-lesion nematode, Pratylenchus penetrans (Cobb) Fillip & Stek. 1941, on flue-cured tobacco is the most serious nematode problem in Ontario. Olthof and Hopper (1973) have shown the general distribution of nematodes in the flue-cured tobacco growing area of southwestern Ontario. The objective of this work was to determine whether aerial infrared photography could assist in locating nematode affected areas of flue-cured tobacco. Aerial photographs, ground observations, nematode population densities, and chemical analyses of soil samples were compared.

Materials and methods

Kodak Aerochrome Infrared Film 2443 was used in conjunction with a Pan 520 filter on a Wild Heerbrugg RC 10 camera with a focal length of 88 mm and an exposure of F. 5.6 at 1/200 second. On July 29, 1972, about 6

Table 1. Relationship between numbers of root-lesion nematodes in soil samples, growth condition of flue-cured tobacco, and some chemical factors in the soil

No. of nematodes/sample		Samples/range			Concentration (ppm) of		
Range	Avg	Total no.	% from areas of poor growth	pH	P	K	Mg
0	0	46	62	6.5	113	240	66
10-99	35	198	59	5.6	101	220	69
100-499	220	66	49	5.4	107	226	55
500-999	670	15	27	5.2	99	227	55
1000-	2200	11	89	5.1	92	231	52

weeks after transplanting, when root-lesion nematode damage is usually most obvious, photographs were taken at 1220 m and 3810 m above ground level. Only the photographs taken at 1220 m were used in this survey. An area of 3.2 km x 16.1 km in North Walsingham township, Norfolk Country, Ontario, was photographed. This area was chosen because it had the greatest proportion of flue-cured tobacco acreage in the region.

Initially, type of crop and areas of poor growth were identified on the 9 x 9 inch (23 cm x 23 cm) color transparencies with the assistance of the Department of Engineering, University of Guelph. The areas to be checked for nematodes, however, were delineated by locating light-toned areas on black and white prints made from the color transparencies. Soil samples were taken in those areas of poor growth that were not due to obvious differences in topography. Soil samples, each consisting of about 20 cores of soil 2.5 cm in diam and 20 cm deep, were taken August 8-11 near the roots of plants; samples were collected from areas of poor growth and good growth in each field selected. Nematodes were extracted from 50 g of soil from each sample by the modified Baerman pan technique (Townshend 1963) for 1 week. The pH and the concentration of P, K, and Mg for each sample were determined by the Department of Land Resource Science, University of Guelph.

Results

A total of 336 soil samples from 130 fields (about 525 ha) of flue-cured tobacco were collected; 56% of these samples represented areas of poor growth. Pooling of the data from all of the samples showed no differences ($P>0.05$) between good and poor areas in numbers of root-lesion nematodes and concentrations of P, K, and Mg in the soil. However, when numbers of root-lesion nematodes in the soil were grouped as in Table 1, there was a high inverse correlation between numbers of nematodes and soil pH ($r = -0.98$). It was also found that growth in about 90% of the areas with nematode populations above 2200/kg of soil (3% of the samples) was rated as poor. There appeared to be no relationship between nematode numbers and growth of the plants at nematode population densities below 2200/kg of soil.

Discussion

The above-ground symptoms of root-lesion nematode damage to tobacco are indistinct and vary little from symptoms produced by various other organisms and soil factors. Therefore, from aerial photographs, it was not possible to differentiate between areas of nematode damage and areas of poor growth due to other factors. The aerial photographs did assist in the ground observations by permitting ground observers to identify and locate the tobacco fields and areas of poor growth within fields, thus minimizing the survey time required. A further saving of time may be possible by using aerial photographs in conjunction with topographic and soil survey maps to eliminate areas of poor growth due to drainage problems. Indeed, this technique appears to have potential as a tool in surveys of nematode damage in other crops and further developmental work is warranted.

To assess the technique of aerial photography for detecting root-lesion nematode damage in flue-cured tobacco it is necessary to correlate damage observed in the photographs to numbers of nematodes in the soil. In the present study this was difficult. First, approximately 85% of the acreage was fumigated and thus nematode numbers, and subsequently nematode damage, were low. Second, the samples were collected in early August when the numbers of root-lesion nematodes in the soil have usually declined to a minimum (Olthof 1971). These two factors, no doubt, accounted largely for the generally low numbers of nematodes in the soil in the fields surveyed. A third factor

in this survey was the general occurrence of areas of poor growth due to replanting because of the frost damage which occurred on June 11, 1972. In a normal growing season aerial photographs and soil samples could be taken at an earlier date when better correlations between damage and nematode numbers in the soil might be expected.

The inverse relationship between pH and numbers of root-lesion nematodes in the soil (Table 1) agrees with results of Kincaid and Gaumann (1957) who showed an inverse relationship between degree of coarse root of tobacco (caused by Pratylenchus sp.) and pH. Willies (1972) also showed in a greenhouse experiment that between pH 4.4 and 7.3 the greatest reproduction of P. penetrans and decrease in forage yields occurred at 5.2.

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ALTERNARIA FLOWER-STOCK ROT IN BROMUS INERMIS[1]

J. Drew Smith[2] and R.P. Knowles[3]

Abstract

Alternaria alternata was frequently isolated from tissues showing extensive rotting on the adaxial sides of flower stalks and from tissues between flower stalk bases of smooth bromegrass (*Bromus inermis*). Of four isolates tested, three caused typical rot when mycelial inoculum was applied to flower stalk axils of smooth bromegrass tillers. No toxic effect on seedlings was shown by culture filtrates of these isolates.

Résumé

Alternaria alternata a été fréquemment isolé des tissus des faces adaxiales des pédoncules, et de ceux qui provenaient de l'aisselle des pédoncules du brome inerme (*Bromus inermis*) et montraient des symptome de pourriture étendue. Trois des quatre isolats analysés ont provoqué une pourriture typique lorsque l'inoculum mycélien était appliqué à l'aisselle des pédoncules des talles du brome. Les filtrats de culture de ces isolats n'ont pas eu d'effets toxiques sur les plantules du brome.

Alternaria alternata (Fr.) Keissler, syn. *A. tenuis* Nees., is commonly seed-borne in grasses (4,5). It is usually regarded as a saprophyte (6) but in some circumstances behaves as a "low grade" pathogen on seedlings and mature plants (2). Some isolates produce toxic metabolites (3).

At Saskatoon, it was noticed, when scoring breeding clones of smooth bromegrass, *Bromus inermis* Leyss, for fertility in 1972, that dark lesions scmetimes occurred at the junctions of flower stalks with the main stem (Fig. 1 A-D). Occasionally necrosis was extensive; generally it involved tissues on the adaxial side and between flower stalks; rarely were abaxial tissues of flower stalk bases rotted (Fig. 1 C, D).

Lesioned flower stalk tissues that were surface sterilized with 70% alcohol and then plated onto potato dextrose agar yielded *A. alternata* almost exclusively. This fungus was isolated from 42 of 45 stalk bases; one of the remainder yielded *Stemphylium botryosum* Wallr., another *Trichothecium roseum* Link., and a third a sterile mycelium. The isolates of *A. alternata* sporulated on cornmeal-malt-yeast extract medium (CMMY) but varied considerably in morphology.

The pathogenicity of four morphologically dissimilar isolates of *A. alternata* to smooth bromegrass was tested. Fragments scraped from CMMY cultures of the fungus were placed in stalk axils in separate tillers of plants of a breeding group of smooth bromegrass clones in a greenhouse held at 21±3°C. Uninoculated agar fragments placed in similar locations in other tillers served as checks. There were five replicates. Seed set had occurred in most clones. Following inoculation, complete inflorescences were covered with polyethylene bags to maintain high humidity for 7 days. After a further 7 days the test inflorescences were removed and examined using a binocular microscope. Eight of the 25 inoculated inflorescences showed flower stalk lesioning (Fig 2), but five checks did not. One of the four isolates failed to cause disease. *A. alternata* was recovered from all rotted flower stalks and from adjacent lesions on the main stem.

The possible involvement of toxic metabolites in stalk rot was considered.

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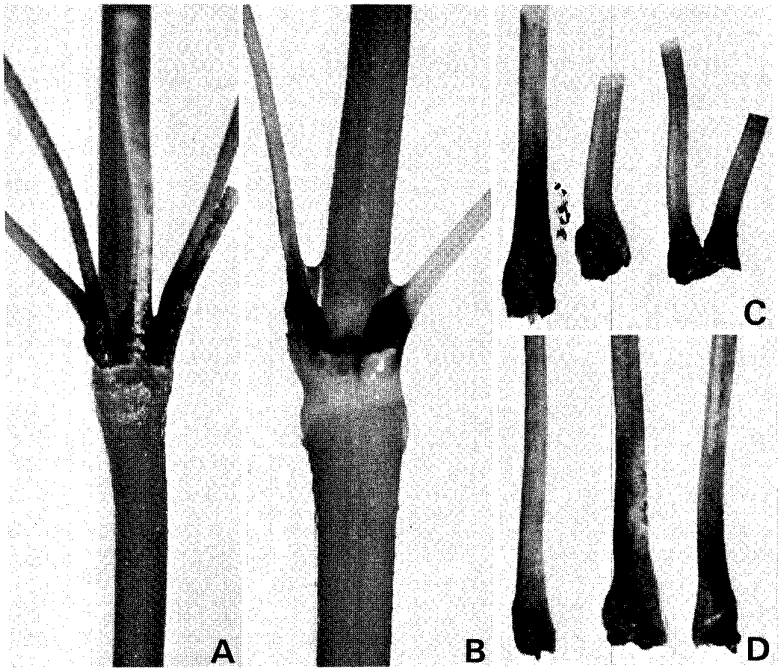

Figure 1. Field material of *Bromus inermis* showing lesioning of flower stalk bases due to natural infection by *Alternaria alternata*. In 1C and 1D stalk bases have been detached.

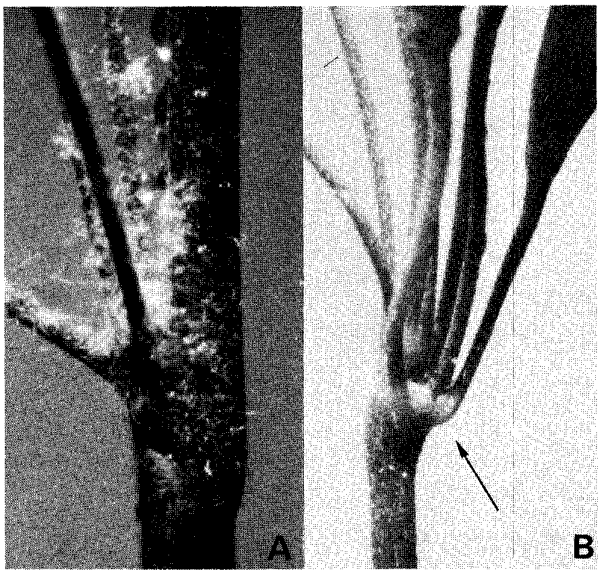

Figure 2. Flower stalk bases of *Bromus inermis*, A) artificially inoculated and incubated in a moist chamber to show mycelium of *A. alternata;* B) uninoculated, showing location of light-colored susceptible tissues (arrow) at base of flower stalks.

However, culture filtrates of four isolates grown in modified Richards solution and tested by the method described by Fulton et al. (3) showed no toxic effects towards seedlings of smooth bromegrass, Italian ryegrass (*Lolium multiflorum* Lam.), and common wheat (*Triticum aestivum* L.).

Flower stalk rot in smooth bromegrass may be incited by *A. alternata* and the junction of the flower stalks with the main stem is probably a favorable fungal infection site. Pollen trapped in this location and the sheltered microclimate there may provide nutrients for initial growth of the fungus and a favorable infection court. Ripening of the inflorescence in most grasses, and therefore general senescence of tissues, starts at the distal end and progresses downwards. The involvement of smooth bromegrass flower stalk base tissues in this rotting seems to be related to earlier senescence of these than of adjacent culm regions. The progress of rotting here in relation to maturation and filling of caryopses may be reflected in poor seed fertility since the ability of flower stalks to conduct nutrient may be impaired. Rotting may also be related to premature seed and spikelet shedding which is occasionally a problem in smooth bromegrass. Although there was no evidence that the isolates of *A. alternata* produced toxins capable of inhibiting chlorophyll formation in grass seedlings, as noted in some plant species (3), perhaps other toxic metabolites produced at sites such as flower stalk bases might initiate or increase rotting.

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LOSSES FROM FOLIAGE DISEASES OF FORAGE CROPS IN CENTRAL AND NORTHERN ALBERTA, 1973

B. Berkenkamp[1]

Abstract

The fourth annual survey of diseases of red, alsike, sweet clover and white clover, alfalfa, timothy, and brome in central and northern Alberta was carried out in 1973. Methods devised in 1970 to estimate loss were used to compare the data over the four year period 1970 - 73. The loss in 1973 due to foliar diseases of forage was 5.72% or $9.4 million.

Résumé

En 1973, on a effectué le quatrième relevé annuel des maladies du trèfle rouge, blanc, d'Alsike, du mélilot, de la luzerne, de la fléole et du brome dans le centre et le nord de l'Alberta. Les méthodes mises au point en 1970 pour évaluer les pertes ont été utilisées pour comparer les données durant la période de 4 ans de 1970 à 1973. En 1973, les pertes attribuables aux maladies foliaires des plantes fourragères ont été de 5.72%, soit 9.4 millions de dollars.

An extensive examination of 307 fields of forage crops in central and northern Alberta in 1973 completed a 4-year survey of foliage diseases (1,2,3). Methods used to estimate severity, distribution, and loss were described previously (1). One percent of the farms reporting forage were sampled in census divisions (CD) 8 through 15, excluding 9, from July 5th to August 29th, 1973. The percent area diseased on 10 shoots of each species in each field was used to determine a disease index for each disease. This figure was multiplied by 0.25 to give an approximate percent loss (4).

Results

The disease index for each disease of each species, the number of fields sampled and the number of fields affected are shown for each census division in Table 1. The figures for acreage of each species grown were obtained by multiplying the acres of forage in each CD by the average percentage of that species in the CD. Fescue and white clover were not shown in Table 1 in 1973, since fescue was harvested before CD 15 was sampled, and only one field of white clover was encountered this year. The percentage of each species over the area surveyed is shown in Table 2, with an overall average for the four years. Changes in the percentage loss from diseases from 1970 through 1973 can be compared with the four year average. Using data from the Alberta Marketing and Statistics Branch, the loss of forage in tons and the dollar value of this loss was computed for each CD (Table 3). Although the percentage loss was slightly less than in 1972, an increase in forage production and an increase of the value of hay to $27.50/ton caused the loss to rise to $9,366,300 from $5,526,700 in 1972.

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Table 1. Incidence and severity of foliage diseases of forage crops in central and northern Alberta, 1973

1. ALFALFA (*Medicago sativa* L.)

Census Division	Acres grown ('000)	No. fields sampled	Diseases* assessed** Yellow leaf blotch	Black stem	Stagon-ospora	Pepper spot	Downy mildew	Common leaf spot
8	92.8	23	23/14.77	23/3.31	4/0.04	0/0	0/0	23/ 2.66
10	109.9	38	33/ 9.56	38/4.21	16/0.47	1/0.03	1/0	36/ 7.82
11	134.3	31	31/16.13	31/4.22	17/0.39	0/0	0/0	31/ 5.79
12	155.5	22	16/ 3.10	22/6.32	13/1.14	0/0	0/0	22/14.21
13	108.7	20	20/14.49	20/4.92	6/0.28	0/0	1/0	20/ 7.42
14	16.3	2	2/12.20	2/2.95	0/0	0/0	0/0	2/ 1.65
15	182.2	16	16/ 8.02	14/3.80	3/0.38	1/0.13	0/0	16/ 7.27
Total	799.7	152	141/11.28	150/4.42	59/0.45	2/0.02	2/0	150/ 7.36

* Causal fungi: Yellow leaf blotch, *Leptotrochila medicaginis* (Fckl.) Schuepp; black stem, *Ascochyta imperfecta* Pk.; stagonospora, *Leptosphaeria pratensis* Sacc. and Briard; pepper spot, *Pseudoplea trifolii* (Rostr.) Petr.; downy mildew, *Peronospora trifoliorum* de Bary; common leaf spot, *Pseudopeziza trifolii* f. sp. *medicaginis-sativae* Schmiedeknecht.

** Number of fields affected/disease index.

2. RED CLOVER (*Trifolium pratense* L.)

Census Division	Acres grown ('000)	No. fields sampled	Diseases* assessed** Powdery mildew	Northern anthracnose	Black stem	Black-stem leaf-spot	Stagon-ospora
8	56.4	11	2/ 1.67	6/3.63	7/6.69	5/ 7.05	8/12.98
10	8.9	3	1/ 3.53	0/0	2/0.87	1/ 4.03	3/26.67
11	59.9	12	2/ 1.06	9/8.10	12/3.27	11/25.42	12/32.98
12	16.2	2	1/ 5.25	2/4.40	1/4.00	0/ 0	2/56.75
13	88.1	13	4/ 2.47	4/2.65	10/1.30	4/ 9.55	12/32.56
14	9.2	3	0/ 0	3/6.20	3/1.73	3/10.13	3/11.70
15	128.8	11	8/10.41	5/7.32	11/6.35	7/12.90	10/31.01
Total	367.5	55	18/ 3.61	29/5.08	46/3.92	31/12.57	50/27.85

* Causal fungi: Powdery mildew, *Erysiphe polygoni* DC. ex Mérat; northern anthracnose, *Kabatiella caulivora* (Kirchn.) Karak.; black stem, *Ascochyta meliloti* (Trel.) Davis; stagonospora, *Stagonospora recedens* (O. Massal.) Jones and Weimer.

Table 1 (Cont'd)

3. ALSIKE CLOVER (*Trifolium hybridum* L.)

Census Division	Acres grown ('000)	No. fields sampled	Diseases* assessed** Powdery mildew	Black stem	Stagon-ospora	Pepper spot	Rust	Sooty blotch
8	46.6	13	3/ 1.75	3/3.65	12/18.44	0/0	0/0	2/2.77
10	9.3	5	1/ 0.60	1/0.04	3/10.74	1/0.94	0/0	1/0.72
11	56.8	16	5/ 4.12	10/0.74	16/28.90	0/0	1/0.09	3/5.52
12	12.1	2	0/ 0	1/3.65	2/37.70	0/0	0/0	0/0
13	77.1	13	1/ 0.12	5/0.94	13/41.00	1/0.01	0/0	2/4.24
14	11.9	2	0/ 0	0/0	2/19.20	0/0	0/0	0/0
15	179.8	17	14/20.82	10/0.99	16/30.56	0/0	1/3.15	4/6.35
Total	393.6	68	24/ 6.57	30/1.41	64/28.27	2/0.07	2/0.81	12/4.28

* Causal fungi: Powdery mildew, *Erysiphe polygoni* DC. ex Mérat; black stem, *Ascochyta meliloti* (Trel.) Davis; stagonospora, *Leptosphaeria pratensis* Sacc. and Briard; pepper spot, *Pseudoplea trifolii* (Rostr.) Petr.; rust, *Uromyces trifolii* (Hedw. f. ex DC.) Lév.; sooty blotch, *Cymadothea trifolii* (Pers. ex Fr.) Wolf.

4. SWEET CLOVER (*Melilotus alba* and *M. officinalis* L.)

C.D.	Acres grown ('000)	No. fields sampled	Diseases* assessed** Black stem	Stagon-ospora
8	0.0	0	0/0	0/0
10	0.0	0	0/0	0/0
11	20.2	3	1/0.13	3/1.27
12	8.1	1	0/0	1/2.00
13	0.0	0	0/0	0/0
14	0.0	0	0/0	0/0
15	0.0	0	0/0	0/0
Total	28.3	4	1/0.10	4/1.45

* Causal fungi: Black stem, *Ascochyta meliloti* (Trel.) Davis; stagonospora, *Leptosphaeria pratensis* Sacc. and Briard.

5. BROME (*Bromus inermis* Leyss.)

C.D.	Acres grown ('000)	No. fields sampled	Diseases* assessed** Brown leaf spot	Selen-ophoma	Scald	White-head
8	82.3	22	22/ 6.72	10/0.39	2/0.08	2/0.46
10	76.2	30	30/ 8.05	20/0.91	7/0.17	1/0.33
11	58.5	19	19/ 6.16	7/0.32	5/0.14	3/1.58
12	32.4	7	7/16.90	0/0	3/0.81	0/0
13	50.9	11	11/ 7.67	3/0.12	1/0.05	0/0
14	22.2	3	3/ 6.43	1/0.20	1/0.17	0/0
15	115.4	11	11/ 6.61	7/0.75	0/0	0/0
Total	438.2	103	103/ 7.78	48/0.50	19/0.16	6/0.49

* Causal fungi: Brown leaf spot, *Drechslera bromi* (Died.) Shoem.; selenophoma, *Selenophoma bromigena* (Sacc.) Sprague and Johnson; scald, *Rhynchosporium secalis* (Oud.) J.J. Davis.; whitehead, *Fusarium poae* (Pk.) Wr.

6. TIMOTHY (*Phleum pratense* L.)

C.D.	Acres grown ('000)	No. fields sampled	Diseases* assessed** Purple spot	Leaf streak
8	90.9	27	17/0.18	27/ 4.15
10	12.2	8	3/0.05	8/ 1.49
11	80.8	31	22/0.17	31/ 5.54
12	18.6	5	5/0.40	5/21.50
13	95.4	20	19/0.40	20/ 7.89
14	16.3	2	2/0.15	2/ 2.70
15	81.4	9	5/0.40	9/17.70
Total	395.6	102	73/0.24	102/ 7.11

* Causal fungi: Purple spot, *Heterosporium phlei* Gregory; leaf streak, *Drechslera phlei* (Graham) Shoem.

Table 2. Percent losses from foliage diseases of forage crops in central and northern Alberta, 1970-73

Forage species	% of forage crops grown					Disease	Loss (%)				
	1970	1971	1972	1973	4 yr avg		1970	1971	1972	1973	4 yr avg
Alfalfa *(Medicago sativa)*	45.5	38.3	45.2	34.5	40.9	Yellow leaf blotch	2.87	2.81	4.07	2.82	3.14
						Black stem	1.45	0.83	0.90	1.11	1.07
						Stagonospora	0.11	0.10	0.07	0.11	0.10
						Pepper spot	0.06	0.09	0.46	0.01	0.15
						Downy mildew	0.02	0.01			0.01
						Common leaf spot	1.30	2.13	1.94	1.84	1.80
						TOTAL	5.81	5.97	7.41	5.89	6.27
Red clover *(Trifolium pratense)*	16.5	14.5	11.8	13.4	14.1	Powdery mildew	3.04	1.00	0.75	0.90	1.42
						Northern anthracnose	1.11	2.63	1.69	1.27	1.67
						Black stem	0.64	0.65	0.53	0.98	0.70
						Stagonospora	2.17	8.23	9.12	6.96	6.62
						Black stem leaf spot	0.32	0.61	1.41	3.14	1.37
						Pepper spot		0.10			0.02
						TOTAL	7.28	13.22	13.50	13.25	11.80
Alsike clover *(Trifolium hybridum)*	8.7	13.1	8.1	13.8	10.9	Powdery mildew	3.54	3.24	1.21	1.64	2.41
						Black stem	0.18	0.10	0.05	0.35	0.17
						Stagonospora	2.83	7.82	7.54	7.07	6.31
						Pepper spot	0.06	0.39	1.51	0.02	0.49
						Rust	0.24	0.02	0.12	0.20	0.14
						Sooty blotch	0.18	0.67	0.67	1.07	0.65
						TOTAL	7.03	12.24	11.11	10.35	10.17
Sweet clover *(Melilotus alba* and *M. officinalis)*	3.0	2.4	0.7	1.3	1.9	Black stem	0.28	0.05	0.01	0.02	0.09
						Downy mildew	0.01				
						Stagonospora	0.06	0.41	0.04	0.36	0.22
						Gray stem canker		0.01			
						TOTAL	0.35	0.47	0.05	0.38	0.31
White clover *(Trifolium repens)*	0.2	0.5	0.6	0.2	0.4	Pepper spot		4.12	2.08	2.25	2.11
						Stagonospora	0.01	1.25	5.67		1.73
						Rust	0.01	4.50	5.50	8.00	4.50
						Sooty blotch		4.00	0.17	8.00	3.04
						TOTAL	0.02	13.87	13.42	18.25	11.38
Brome *(Bromus inermis)*	11.0	14.5	18.1	19.1	15.7	Brown leaf spot	2.56	2.07	1.16	1.94	1.93
						Selenophoma leaf spot	0.02	0.12	0.04	0.12	0.07
						Scald	0.02	0.02	0.02	0.04	0.02
						Whitehead		0.13	0.20	0.12	0.11
						TOTAL	2.60	2.34	1.42	2.22	2.13
Timothy *(Phleum pratense)*	9.5	12.0	9.9	15.5	11.7	Purple spot	0.11	0.10	0.09	0.06	0.09
						Leaf streak	1.46	1.55	0.93	1.78	1.43
						TOTAL	1.57	1.65	1.02	1.84	1.52
Fescue *(Festuca rubra)*	3.2	3.4	3.4	0.0	2.5	Brown stripe	0.24	6.03	5.75		4.00
						Stem eyespot	0.91	7.42	1.41		3.24
						TOTAL	1.15	13.45	7.16		7.24
Other	2.3	1.1	2.1	2.2	1.9						

Table 3. Losses from foliage diseases of forage crops in Alberta Census Divisions 8 to 15, 1973

Census Division	No. of fields sampled	Acreage of forage crops ('000)	Yield (tons/acre)	Loss (%)	Actual production ('000 tons)	Potential production ('000 tons)	Loss ('000 tons)	Loss* ($'000)
8	48	376	1.98	4.32	742.7	776.2	33.5	921.2
10	53	219	1.77	4.05	388.1	404.5	16.4	451.0
11	63	424	1.98	6.76	839.5	900.3	60.8	1,672.0
12	30	243	1.89	6.52	459.0	491.0	32.0	880.0
13	48	440	1.89	6.68	831.2	890.7	59.5	1,636.2
14	7	76	1.89	2.52	143.3	147.0	3.7	101.7
15	58	705	1.89	9.19	1,330.4	1,465.1	134.7	3,704.2
Total	307	2,483	1.90	5.72	4,734.2	5,074.8	340.6	9,366.3

* Based on a farm value of $27.50 per ton of forage.

RECENT CONIFER DISEASE PROBLEMS IN FOREST NURSERIES IN THE MARITIME PROVINCES

R.E. Wall[1]

Abstract

Damping-off and root rot of pine and spruce seedlings have caused losses in three forest nurseries in the Maritime Provinces since 1970. Isolates of Rhizoctonia solani, Fusarium oxysporum, Pythium spp. and Cylindrocarpon sp. obtained from diseased seedlings were pathogenic in laboratory and greenhouse tests. Gray mold caused by Botrytis sp. and snow mold have caused some damage in spruce seedbeds in one nursery, and infections of pines by Lophodermium pinastri have been detected in two nurseries. The greatest losses in conifer nurseries have occurred in container stock grown on media consisting largely of sphagnum peat. These losses, however, were attributable to physical or chemical factors rather than to pathogenic organisms.

Résumé

Depuis 1970, la fonte des semis et le pourridié des racines de Pins et d'Epinettes ont causé des pertes dans trois pépinières forestières dans les provinces Maritimes. Furent trouvés pathogènes, lors de tests en laboratoire et en serre, des isolats de Rhizoctonia solani, Fusarium oxysporum, Pythium sp. et Cylindrocarpon sp. prélevés de semis malades. La moisissure grise, causée par un Botrytis, et la brûlure printanière (snow mold) endommagèrent les semis d'Epinette dans une pépinière, et on détecta des infections de Pins par Lophodermium pinastri dans deux pépinières. Les pertes les plus grandes en pépinières de résineux furent subies par les semis en potets poussant dans des sols qui consistaient surtout de tourbe de Sphagnum. Cependant, ces pertes, dans ce cas, étaient plutôt attribuables à des facteurs physiques ou chimiques.

In the provinces of New Brunswick, Nova Scotia, and Prince Edward Island the production of tree seedlings for reforestation has tripled since 1970 to a present level of 15- to 20-million trees per year. Most of the production is in conventional outdoor nursery beds that provide bare-root stock, but this is increasingly supplemented by container stock started in greenhouses. There are four major nurseries located at Juniper and Kingsclear, N.B., Lawrencetown, N.S., and Charlottetown, P.E.I. In addition, there are several private greenhouses that produce container stock for reforestation, and a small research nursery at Acadia Forest Experiment Station near Fredericton, N.B. Each of these nurseries experienced problems that caused mortality or retardation of seedling growth. Routine fungal isolations and pathogenicity tests indicated that some of these problems were due to pathogenic fungi.

Isolations of fungi were made from diseased tissues after the surface was sterilized for 2-3 minutes in 0.5% sodium hypochlorite solution. Three culture media were used: a modified Martin's peptone agar (6), 2% malt agar, and cornmeal agar amended with 100 ppm nystatin, 100 ppm neomycin, and 50 ppm cholesterol. Aseptic pathogenicity tests (Table 1) were conducted according to the method of Vaartaja and Cram (5). Red pine seeds were surface sterilized for 2 minutes in 0.1% $HgCl_2$, rinsed with sterile distilled water, and planted on the surface of a dilute mineral salts agar (5) in 18 x 150 mm tubes. These were incubated under 16-hour daylengths at alternating 22° - 16°C day-night temperatures until 3 to 4 days

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after the seeds had germinated. They were then inoculated from growing cultures of the test fungus and incubated under the same conditions until the seedling died. Pathogenicity was expressed in terms of days from inoculation to mortality.

Greenhouse pathogenicity tests were conducted on a soil mix (sandy loam, peat, vermiculite) inoculated before planting with cultures of the test fungus. Pathogenicity was expressed in terms of percent pre-emergence or post-emergence mortality.

Damping-off and root rots in outdoor nursery beds

These two disease complexes were considered together because they occurred on the same soils and were associated with the same fungi. Detectable outbreaks, causing losses in seedling numbers or reductions in seedling quality occurred at the Kingsclear, Acadia, and Lawrencetown nurseries (Table 1). The nursery beds at Kingsclear and Lawrencetown were converted from former farmland and probably inherited their populations of damping-off and root rot fungi from previous crops. Most of the damping-off at Kingsclear occurred on beds that had been treated the previous autumn with Vapam, suggesting either insufficient sterilization or recontamination as illustrated by Vaartaja (4). Similarly, damping-off and root rot in the Acadia nursery occurred in beds that had been fumigated the previous autumn with methyl bromide.

Most seedlings with root rot or damping-off yielded Fusarium oxysporum Schlect., many isolates of which proved to be pathogenic (Table 1). In addition, some seedlings yielded Rhizoctonia, Pythium, or Cylindrocarpon, most of which were highly pathogenic. It is not known if Fusarium plays a primary role in seedling disease in the nursery or is an invader of seedlings weakened by the more aggressive pathogens (1, 2, 3, 5).

Table 1. Damping-off and root rot occurrences in conifer seedlings in Maritime forest nurseries and pathogenicity of the major fungi isolated from diseased seedlings

Location and species	Stage	Date	Symptom	Fungi isolated: Species	Pathogenicity: Aseptic tests[1]	Pathogenicity: Greenhouse tests[2]
Kingsclear						
Red pine	2:1	9/71	Root rot	*Fusarium oxysporum*		
Red spruce[3]	1:0	7/73	Damping-off	*Rhizoctonia solani*	+++	+
				Fusarium oxysporum	++	0
Red pine[3]	1:0	7/73	Damping-off	*Rhizoctonia solani*	+++	+
				Fusarium oxysporum	++	0
Lawrencetown						
White spruce	2:1	11/71	Root rot	*F. oxysporum*	++	+
Scots pine	1:0	11/71	Root rot	*F. oxysporum*	+	0
Red pine	1:0	7/72	Damping-off	*R. solani*	+++	
				F. oxysporum	+	
Red pine	2:0	9/72	Root rot	*F. oxysporum*	++	
				Cylindrocarpon sp.	++	
Red pine	2:0	7/73	Root rot	*Pythium* sp.	++	
				F. oxysporum	+	
Acadia						
Red pine[4]	1:0	7/73	Damping-off	*Pythium* sp.	+++	
				F. oxysporum	++	
Spruces[4]	1:0	7/73	Root rot	*Pythium* sp.	+++	
				F. oxysporum	++	

[1] Seedlings killed in less than 20 days after inoculation (+++), 20-40 days (++), 40-80 days (+), or over 80 days (0).

[2] Mortality significantly greater than in uninoculated controls (+), or not significantly greater (0) at P = 0.05.

[3] Seedbeds fumigated with vapam (80 gal/acre) in the fall. Seeding took place in spring.

[4] Seedbeds fumigated with methyl bromide in the fall. Seeding of spruces in fall, red pine in spring.

Foliage diseases

Snow molds caused patches of dead seedlings in 2-0 white and black spruce in the Juniper nursery in the spring of 1972. The associated fungi were not identified. In the same nursery beds, patches of gray mold (Botrytis sp.) occurred during the summers of 1971 and 1972.

Needlecasts of pines caused by Lophodermium pinastri (Schrod. ex Hook) Chev. have been detected in a jack-pine windbreak in Juniper and in 3-0 red pine at Lawrencetown. The latter crop was unfit for planting because of the damage. Although this disease has not to date caused extensive damage in the Maritimes, its destructive effects have been observed in a nearby American nursery from which white pine seedlings, many infected with L. pinastri, were imported and planted in various localities in Nova Scotia during the spring of 1973.

Problems in container-grown seedlings

Large scale mortality in seedlings grown on peat in small plastic, styrofoam, or paper containers has resulted in the loss of nearly a million seedlings since 1970. Suspected causes, when determined, were temperature and moisture extremes, nutritional imbalances, and excessive applications of fungicides. Few of the fungi isolated from dying seedlings, e.g. Trichoderma viride Pers. ex S. F. Gray, Gliocladium roseum (Link) Bainier and Endogone pubescens (Sacc. and Ellis) Zycha, were pathogenic in either greenhouse or aseptic inoculations.

Acknowledgments

I wish to thank Dr. L. P. Magasi and Dr. A. Van Sickle for diagnoses of some of the disease problems, Dr. R. A. Shoemaker for identification of some of the fungi and R. H. Hallett, D. M. Levy, R. Bezzant, and E. M. Haines for information on nursery management.

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INFESTATATION OF CRUCIFER SEED IN WESTERN CANADA BY THE BLACKLEG FUNGUS LEPTOSPHAERIA MACULANS[1]

G. Allan Petrie[2] and T.C. Vanterpool[3]

Abstract

Of 1,890 seed samples of rape (Brassica napus) and turnip rape (B. campestris) produced in western Canada and plated between 1968 and 1973, 2.6% were infested with the blackleg fungus, Leptosphaeria maculans. The highest percentage of farm samples yielding the fungus in any year was 4.0 in 1969, and the highest infestation level in any sample, 2.7%. Contaminated samples originated in almost all major rape producing areas of the prairies from the Peace River region of Alberta to southern Manitoba. All three major strains of the fungus occurred in Brassica samples, with strain I (the 'brassica' strain) being by far the most common. Over 33% of the seeds in a sample of Raphanus sativus var. oleifera carried L. maculans (strains I and II) following surface disinfestation. The pathogen was detected in seed samples of Cheiranthus cheiri (strain I), Sisymbrium altissimum (strain II), and Thlaspi arvense (strain III). Observations made in field plots revealed that natural infections of pods of rape and oilseed radish usually started at the stigmatic end.

Résumé

Des 1,890 échantillons de graines de colza (Brassica napus) et de navette (B. campestris) produites dans l'ouest du Canada et semées de 1968 à 1973, 2.6% a été infesté par le champignon de la jambe noire (Leptosphaeria maculans). Le pourcentage le plus élevé d'échantillons infestés a été de 4 en 1969 et le plus fort niveau d'infestation de tous les échantillons, de 2.7%. Les échantillons contaminés provenaient de presque toutes les principales régions productrices de colza des Prairies, depuis la région de Rivière de la Paix en Alberta jusqu'au sud du Manitoba. On a trouvé les trois principales souches du champignon dans les échantillons de Brassica, la souche I (brassica) étant de beaucoup la plus abondante. Plus de 33% des graines d'un échantillon de Raphanus sativus var. oleifera était infesté par L. maculans (souches I et II) après désinfection de surface. On a observé le champignon pathogène dans les échantillons de graines de Cheiranthus cheiri (souche I), de Sisymbrium altissimum (souche II) et de Thlaspi arvense (souche III). Les observations des parcelles ont révélé que l'infestation naturelle des siliques du colza et du radis oléagineux débutait généralement à l'extrémité des stigmates.

In recent years, blackleg caused by Leptosphaeria maculans (Desm.) Ces. & de Not. [imperfect state: Plenodomus lingam (Tode ex Fr.) Hohn.] has again become a major cause for concern in certain rape and cabbage growing areas of the world (10, 23), and naturally, seed has been suspect as a reservoir of primary infection. That seed-borne infection plays a critical role in initiating field infections in rutabaga, rape, and similar crops has not been clearly demonstrated, although in the case of cabbage it appears to be important in establishing the disease in the seedbed prior to transplanting. Several workers have studied the problem of transmission of the pathogen in seed of rutabaga and turnip (1, 3, 5, 7, 9, 11), and others have conducted similar

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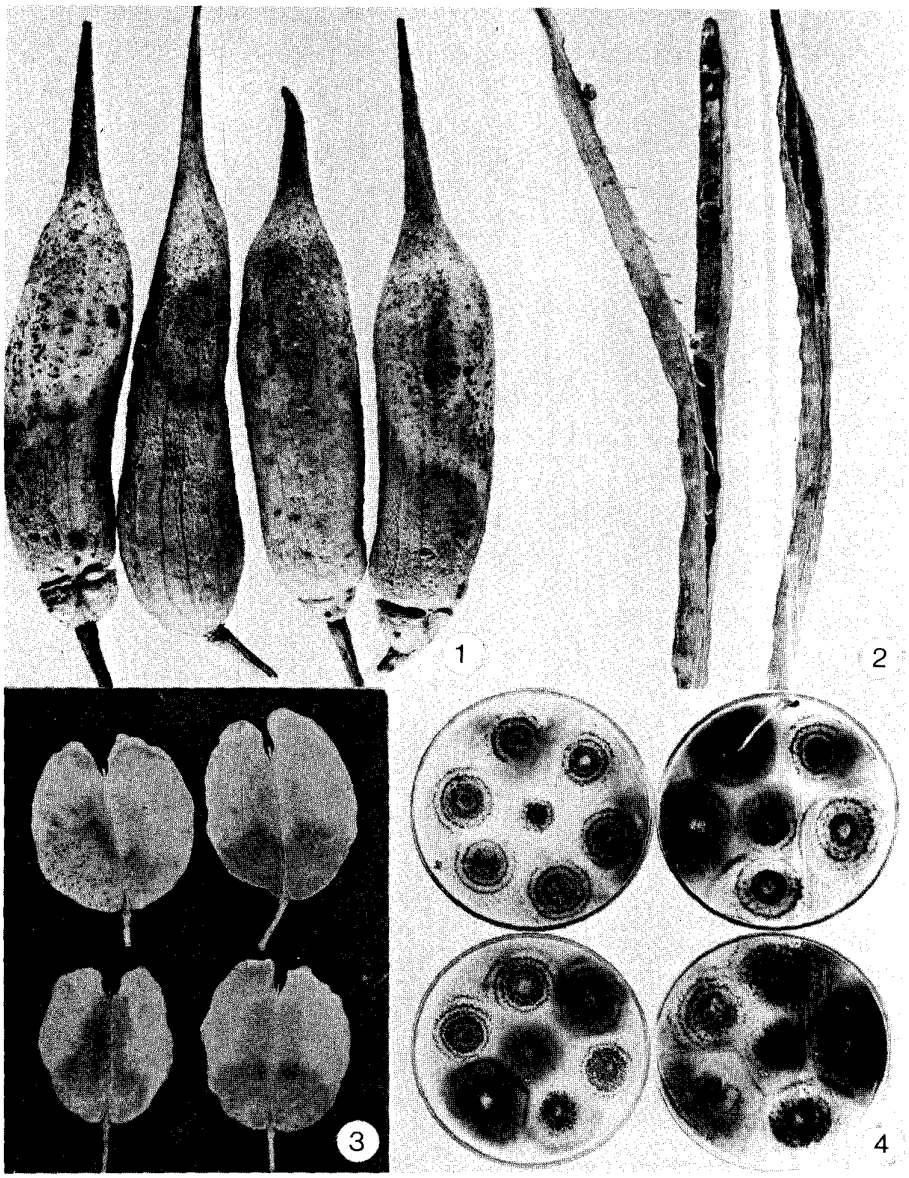

Figure 1. Lesions on pods of oilseed radish resulting from infection by *Leptosphaeria maculans* (upper portion of each pod). The small black spots were caused by *Alternaria raphani* Groves & Skolko.

Figure 2. Splitting of rape pods as a consequence of infection by *L. maculans*. Note shrunken and mycelium-covered seeds in the upper portion of pod at the left.

Figure 3. Lesions on pods of *Thlaspi arvense* resulting from infection by *L. maculans*.

Figure 4. Colonies of *L. maculans*, strain I, growing from plated surface-disinfested seed of oilseed radish. Several cultural variants are present.

investigations in relation to cabbage (8, 13, 21, 23), and rape (2, 6, 9, 19). In Canada, isolation of the pathogen from seeds of rape was first reported in 1957 (20). Van Poeteren (19) reported that in Europe 50-60% of the seeds in rape samples sometimes carried the fungus. It also has been isolated from seed of several other cultivated members of the Cruciferae, including cauliflower (12, 13), kohlrabi (12), and brussels sprouts (4). Buddin (3) demonstrated its presence in seed of wild mustard (Brassica alba Rabenh. or B. hirta Moench), a common weed in British rutabaga fields. Neergaard (12) reported the occurrence of the blackleg pathogen on radish seed. Apart from this instance, it apparently has not been found on seed of members of cruciferous genera other than Brassica (14).

This paper presents 6 years' data for seed infestation of rape (Brassica napus L.), turnip rape (B. campestris L), and other Cruciferae by L. maculans in Western Canada. It is part of a larger study of the seed health of Brassica spp., flax, and safflower, the remainder which will be published shortly.

Materials and methods

Samples of western Canadian rape and turnip rape seed produced between 1968 and 1972 were obtained from the Plant Products Division of Agriculture Canada and from the Canadian Grain Commission. Seed from the 1973 western Canadian cooperative rapeseed tests was also plated. Untreated seeds were transferred by means of a vacuum seeder to plates of V8 juice agar containing 40 ppm rose bengal and 100 ppm streptomycin sulfate. For each sample 200-300 seeds were examined in lots of 15-20 per plate. Records of colony numbers were made after 7-10 days' incubation under diffuse light at room temperature. Fresh subsamples from heavily-infested lots of seed were treated for 20 minutes in a 10% solution of Javex and plated as before to determine the extent to which the fungus occurred within the seed coat. Naturally infected pods of a few cruciferous species were collected in field plots and a photographic record made of symptoms produced by L. maculans.

Results and discussion

The siliques of Brassica napus and oilseed radish (Raphanus sativus L. var. oleifera Metzg.) exhibited varying degrees of infection. The pathogen had gained entry at the stigmatic end in almost every case (Fig. 1). A brownish to whitish lesion bearing scattered pycnidia had then spread downward symmetrically from the point of invasion to engulf from about 1/3 to over 1/2 of the pod. Although insect-transmitted conidia would appear to be a likely source of this infection, no confirmation of this has been obtained. Premature splitting of rape pods with consequent loss of seed resulted from unequal drying out of infected and uninfected portions of the valves (Fig. 2). When intact infected pods were opened, the presence of a grayish mycelium was revealed on their inner surfaces. Seeds beneath lesions were shrunken, unsound and pale gray in color. Those from Raphanus pods often bore large black discolorations. Plating of surface-disinfested seeds from lesioned rape pods revealed the presence of L. maculans in almost all of them, even apparently healthy ones not adjacent to lesions. Lesions on silicles of Thlaspi arvense usually appeared to have originated basally rather than apically (Fig. 3).

Table 1. Prevalence of *Leptosphaeria maculans* seed infestation of rape and turnip rape in western Canada

Year	No. of samples plated	Samples infested (%)	Highest infestation recorded (% of seeds per sample)
1968	141	3.6	0.3
1969	353	4.0	2.7
1970	1,027	1.6	1.0
1971	284	3.2	0.6
1972	32	0.0	0.0
1973	53	9.4	1.0
Total	1,890	Overall % 2.6	Highest level 2.7

The seed plating data are presented in Table 1. Those for 1973 represent 53 samples from the cooperative varietal tests from five locations in Saskatchewan and a few in Alberta and Manitoba. Over 9% of these samples carried L. maculans. In Saskatchewan infested seed was obtained from the regional tests at Kelvington, Lake Lenroe, and Parkside. Seed infestation by the fungus was not detected in a number of farm samples that were plated between 1961 and 1967. From 1968 to 1972, no more than 4.0% of the growers' samples were infested in any year. However, contamination occurred in seed lots from across the prairies, from Beaverlodge, Alberta, in the northwest to Darlingford, Manitoba, near the United States border, a distance of 1000 miles. An indication of the geographical distribution of infested samples is given in Table 2. Most of these were from Saskatchewan, but this was not unexpected as 76% of all the samples plated originated in this province. Within Saskatchewan, crop district 8 had many more infested seed lots than did the others, but when the numbers

Table 2. Distribution by crop district of *Brassica* seed samples infested by *Leptosphaeria maculans*, 1968-1973

Crop district*	Saskatchewan			Alberta			Manitoba		
	No. of samples plated	infested	% infested	No. of samples plated	infested	% infested	No. of samples plated	infested	% infested
1	1	0	0.0	3	0	0.0	2	0	0.0
2	15	0	0.0	32	1	3.1	16	1	6.3
3	4	0	0.0	19	2	10.5	36	1	2.8
4	0	0	0.0	60	3	5.0	0	0	0.0
5	156	8	5.1	63	1	1.6	18	0	0.0
6	67	4	6.0	45	0	0.0	0	0	0.0
7	47	1	2.1	80	1	1.3	6	0	0.0
8	769	18	2.3				7	0	0.0
9	367	8	2.2				2	0	0.0
10							15	0	0.0
11							18	1	5.6
12-14							24	0	0.0
Unknown	0	0	0.0	18	0	0.0	0	0	0.0
Totals and averages	1,426	39	2.7	320	8	2.5	144	3	2.1

* There are 9 crop districts in Saskatchewan (disregarding subdistricts A and B), 14 in Manitoba, and 7 agricultural reporting areas in Alberta (22).

were related to the total samples plated per district, it was evident that crop districts 5 and 6 had proportionally higher rates of infestation. Affected samples were well spread across the northern half of the cultivated portion of the province. Relatively few samples from Alberta and Manitoba were infested, but they too were widely distributed. Although all three major strains of the pathogens were isolated from Brassica seed, by far the most common was strain I, the one usually associated with members of this genus (15).

Seed of other genera of the Cruciferae was also examined for L. maculans. In a 1968 sample of oilseed radish 33.4% of the seeds were found to be infected following surface-disinfestation (Fig. 4). The seed had been harvested from plants in an "introductions nursery" at Saskatoon. Both strain I and strain II (the 'sisymbrium' strain) were recovered, the latter infrequently. A sample of wallflower (Cheiranthus cheiri L.) seed purchased in Saskatoon, and likely imported from abroad, had about 1.0% L. maculans (strain I). In a sample of tumbling mustard (Sisymbrium altissimum L.) seed collected near Saskatoon, 1.0% infestation by strain II was detected, and in a sample of Thlaspi arvense L., 0.5% infestation by strain III (15) was found.

Although geographically widespread, L. maculans seed infestation probably has not constituted an infection source of first importance; relatively few samples were contaminated and the incidence of infestation was low. Conidia and ascospores from overwintered stem material of cultivated crucifers and weed species likely have played the major role in initiating spring infections. However, diseased seed may have contributed significantly to the spread of blackleg into new areas of production. In the years between 1963 and 1969, field surveys conducted in the spring and fall showed blackleg of rape to be steadily increasing in prevalence in Saskatchewan (17, 18). However, from 1970 to 1972, the disease was detected in from 15 to 19% of the fields entered in this province, and its incidence generally remained low (16). At present, therefore, blackleg remains one of a number of diseases of minor importance in Western Canada. Nevertheless, its wide distribution in the region, the considerable genetic diversity of the pathogen indicated by the occurrence of several strains, and its high virulence to cultivated varieties of rape and turnip rape indicate a potentially dangerous situation. These factors, in conjunction with the sudden dramatic losses caused by the disease in other parts of the world (10), indicate a need for the development now of control measures appropriate to the Canadian Prairies.

Acknowledgments

The senior author wishes to thank the National Research Council of Canada for financial assistance in the form of a bursary and scholarship during the course of his graduate work. Thanks are also due Mrs. Jean Key and Mrs. Marjorie Richardson for technical assistance. The authors are also grateful to staff members of the Saskatoon, Edmonton, and Winnipeg laboratories of the Plant Products Division of Agriculture Canada for supplying seed samples, with special thanks to Mr. F. W. S. Dale, District Seed Analyst, Saskatoon. We also express our gratitude to staff members of the Canadian Grain Commission.

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BARLEY SMUTS IN MANITOBA AND EASTERN SASKATCHEWAN, 1972-74[1]

P.L. Thomas

Abstract

Losses from barley smuts in Manitoba and eastern Saskatchewan were calculated to be 0.6% in 1972, 0.2% in 1973, and 0.9% in 1974. The major change in the last 6 years has been an increase in infection on the six-rowed varieties, accompanied by a decrease on the two-rowed varieties.

A biotype of Ustilago nuda that can infect the variety Conquest was detected in Alberta, Saskatchewan, and Manitoba. The level of infection in fields containing this biotype remained low, indicating that the Jet type of resistance in commercial varieties is still of value.

Résumé

Au Manitoba et dans l'est de la Saskatchewan, on a évalué à 0.6% en 1972, 0.2% en 1973 et 0.9% en 1974, les pertes attribuables aux charbons de l'orge. Depuis les 6 dernières années, le principal changement a été un accroissement de l'infestation des variétés à six rangs et une réduction de celle des variétés à deux rangs.

On a observé en Alberta, en Saskatchewan et au Manitoba un biotype de Ustilago nuda qui peut infester la variété Conquest. Le niveau d'infestation des champs où l'on a trouvé ce biotype est demeuré faible, ce qui prouve que le type de résistance Jet des variétés commerciales conserve toute sa valeur.

Incidence of smut in barley in farm fields

Surveys providing data on the occurrence and importance of the barley smut fungi [(Ustilago nuda (Jens.) Rostr., U. nigra Tapke, and U. hordei Pers. (Lagerh.)] in Manitoba and Saskatchewan were made in 1969, 1970, and 1971 (1,5,6). The losses due to these smuts in Manitoba were calculated to be 0.24% in 1969, 0.30% in 1970, and 0.50% in 1971. The loss in eastern and northern Saskatchewan in 1970 was calculated to be 0.56%. U. nuda was reported to have caused 0.50% loss in south and central Alberta in 1971 (2).

The author surveyed barley fields in Manitoba and eastern Saskatchewan in 1972, 1973, and 1974. Fields that were between the heading and the late soft dough stages were selected at random at 5-20 mile intervals depending upon the frequency of barley in the area. The routes were designed to traverse a variety of crop districts and were modified yearly. An estimate of the percentage of plants infected at each site was made while walking an ovoid path of approximately 100 meters in the field. The results are shown in Table 1.

Conditions adverse to the development of smut appear to have affected the 1973 crop, although the estimate may be low because the survey was made relatively early in the season. The stage of crop development at this time, early heading, facilitated the detection and collection of U. nuda but would tend to make U. hordei more difficult to detect.

The high proportion of affected fields, especially of six-rowed barley in 1974, has practical implications. The actual proportion of fields affected would be expected to be higher than that observed due to the difficulty of detecting trace-level infections in the relatively small area examined in each field. Therefore, inoculum for future infection exists in most fields and, given favorable conditions, could cause extensive damage in any given year.

Contrary to the results of the earlier surveys (5, 6), the two-rowed varieties exhibited less infection than the six-rowed varieties. This has apparently resulted from

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Table 1. Incidence of smut in barley in Manitoba and eastern Saskatchewan, 1972-74

Year	Number of fields examined		% fields affected			Mean % infected plants		
	2-rowed	6-rowed	2-rowed	6-rowed	All varieties	2-rowed	6-rowed	All varieties
1972	43	64	37	56	49	0.3	0.7	0.6
1973	100	144	44	47	46	0.1	0.3	0.2
1974	43	107	44	9	62	0.1	1.0	0.9

a decrease in infection on two-rowed varieties and a corresponding increase on the six-rowed varieties, since the mean percentage of infected plants has not dramatically changed from 1969 to 1974. An explanation may be found in the distribution of the barley varieties grown in Manitoba during this period as reported by the Federal Grain Co. Ltd. (1969-71) and the three Pool Elevator Companies (1972-74). The six-rowed variety Conquest and its close relative Bonanza have comprised approximately 40-50% of the barley acreage since 1968. The two-rowed variety Fergus is a more recent introduction, having increased from 8.2% of the acreage in 1971 to 36.6% in 1974, mainly as a replacement for Herta. Therefore an increase in the aggressiveness of the pathogens on Conquest and Bonanza would explain the increased frequency of smuts on six-rowed varieties, while the decrease on the two-rowed barley could be explained if Fergus were less susceptible to the smuts than Herta. Evidence for these assumptions will be presented later in this paper.

The distribution of the three species of Ustilago is shown in Table 2. Except for U. hordei in 1973, the percentage of fields affected by each of the three species increased over the 3-year period. The apparent increase of U. nuda on six-rowed barley may be due to the existence of a new race which will be discussed later. The increases in the percentages of fields affected for the other variety - species combinations, providing they are significant, could be due to varietal changes, more favorable conditions for fungus development, or more aggressive forms of the pathogens.

The mean percentage of plants infected with U. nuda has shown a downward trend, despite the increases in the percentage of fields affected. The change appears to be larger for the two-rowed varieties, perhaps due to the increase in the acreage of Fergus. Seed treatment with systemic fungicides may also be affecting the prevalence of U. nuda.

U. nigra appears to be increasing on the six-rowed varieties. The major change in the six-rowed population was the increase in acreage of Bonanza at the expense of Conquest. Since the two varieties are very closely related and have very similar reactions to smut under laboratory conditions, the increase in U. nigra probably results from either more favorable conditions or more aggressive forms of the pathogen.

With the exception of 1973, there appears to be an increase in the mean percentage of infection for U. hordei on the six-rowed varieties. However, the significance of the

Table 2. Incidence of three species of *Ustilago* on barley in field surveys, 1972-74

Ustilago species and type of barley affected		% fields affected			Mean % infected plants		
		1972	1973	1974	1972	1973	1974
U. nuda	2-rowed	37	38	55	0.3	0.1	0.1
	6-rowed	8	12	13	0.2	0.1	0.1
	all varieties	17	24	25	0.2	0.1	0.1
U. nigra	2-rowed	2	5	11	tr*	tr	tr
	6-rowed	36	37	43	tr	0.1	0.3
	all varieties	23	24	38	0.1	0.1	0.3
U. hordei	2-rowed	12	4	33	tr	tr	tr
	6-rowed	36	24	43	0.4	0.2	0.5
	all varieties	27	16	42	0.3	0.1	0.4

* tr = trace, <0.1%.

differences between the infection percentages must be judged with caution; e.g. in a population of 100 fields one field with 10% infection increases the mean percentage of infection by 0.1.

Physiologic specialization of U. nuda

Aqueous suspensions of the spores from all of the U. nuda collections were inoculated into florets of Conquest barley at anthesis. All inoculations were conducted on plants growing in growth cabinets and the inoculated seed was grown subsequently in greenhouses.

Three of the 18 collections in 1972 were found to be virulent on Conquest and other derivatives of Jet (7). Subsequently 12 of the 55 collections from 1973 were also found to be virulent on Conquest. The virulent collections from 1973 were found to be from more widely spread locations than the 1972 collections, ranging from Beausejour in eastern Manitoba to Wauchope in southeastern Saskatchewan and Canora in east-central Saskatchewan. In 1973, collections were forwarded from Prince Edward Island, Nova Scotia, Ontario, Saskatchewan, and Alberta. Collections from Hanna, Lethbridge, and Champion in southern Alberta were virulent on Conquest, considerably extending the range of the new biotype.

The level of infection attributed to natural infection by the new biotype has been trace, with the exception of one field at 1% and another at 5%. The widespread incidence of the new biotype has not yet, therefore, resulted in an increase in the mean percentage of infected plants.

Table 3. Infectivity of *U. nuda* collections, 1972

	% infection after floral inoculation		
Collection no.	Bonanza	Fergus	Herta
72- 20*	0	26	64
72- 40	0	60	67
72- 58	0	24	60
72- 66*	36	16	64
72- 70a	0	23	70
72- 70*	20	44	55
72- 73	0	12	56
72- 76	0	57	48
72- 81*	0	59	40
72- 82*	17	67	78
72- 84	0	25	67
72- 85	0	36	65
72-146	0	16	39
72-147	0	32	57
Control	0	0	0

* Collected from a 6-rowed variety. The remaining collections were from 2-rowed varieties.

There were sufficient spores of 14 of the collections of U. nuda from Manitoba and Saskatchewan to inoculate the remainder of the varieties that are currently recommended for farm use in Manitoba. The three collections that previously attacked Conquest were found to be virulent on the Jet resistance present in Bonanza (Table 3). The level of infection on Fergus was lower than that on Herta in all but two instances, indicating that Fergus is less susceptible than Herta to U. nuda.

As reported earlier (7), the varieties Trebi, Titan, Warrior, Compana, Valkie, and hybrids carrying gene Un8 were resistant to the collections from 1972 that were virulent on Conquest. That data had suggested (7) that 72-66 was virulent on Un8 in hybrid PR28. However, further testing has revealed that hybrids with Un8 are totally resistant to 72-66 and that the infection of PR28 was spurious. It was considered possible that the resistance due to Un in Trebi, Titan, and Warrior and the resistance in Valkie and Compana could be used in future breeding programs because these varieties are not currently grown commercially in Manitoba and eastern Saskatchewan. It was assumed that since there is no selection pressure by the host for the virulence genes capable of attacking the above varieties the necessary virulence would be lost from the natural population of the pathogen (3). The test for this assumption was to use the spores from the 14 collections that infected Herta (Table 3) to inoculate Trebi, Valkie, and Compana. CI 13662 was also included as a source of Un8. Collection 72-146, from a two-rowed barley growing near Winnipeg Beach, Man., was the only collection to give infection. Trebi was 48% infected, Compana 75%, Valkie 80%, and CI 13662 0%. The presence of this biotype limits the use of Un, Valkie, and Compana in breeding for resistance to U. nuda at the present time. Un8 appears to be a suitable candidate.

Several additional varieties have been screened for their reaction to 72-66. Ogalitsu, Golden Melon, Charlottetown, Olli, Parkland, Husky, and Gateway 63 were all very susceptible (>35% infection). Jet is apparently only moderately susceptible (approximately 10% infection). This means, however, that there are no additional genes for U. nuda resistance in Jet that would be of value.

Seed from plants of Conquest barley that had been inoculated with 72-66 was treated with a systemic fungicide to ascertain the practicality of control by such a practice. Forty grams of seed were treated with Vitaflo 280 (carbathiin 14.9%, thiram 13.2%) at the commercially recommended rate of 1.5 oz of fungicide per bushel of barley (42.5 g/21.8 kg). The seed was planted in the field in

ten 2.1-m rows, along with 4 g of untreated seed in two rows as a control. The control gave 21.6% infection while the treated material gave 2.9% infection. Therefore Vitaflo appears to give a significant measure of control of the new biotype.

Physiological specialization of U. nigra and U. hordei

The 1972 field collections of U. nigra and U. hordei were used to inoculate seed of the four varieties that are currently recommended in Manitoba. The inoculum was prepared by mixing one to three smutted heads in 400 ml of water in a Waring Blendor (4). Approximately 200 seeds of each variety were then treated in either 200 ml or 400 ml of the inoculum for 15 seconds in the Blendor. The seed from each treatment was planted in the field in two 2.1-m rows. The relatively high percentage infection figures (Tables 4 and 5) for the U. hordei collections numbered 72-7 to 72-42 were probably due to the use of 200 ml rather than 400 ml of inoculum. This treatment resulted in extensive damage to the seed and was therefore discontinued. However it was relatively effective and did not unduly impair the germination of the seed.

All of the U. nigra collections were apparently capable of producing some infection on all four varieties (Table 4). Three of the four U. hordei collections from two-rowed varieties did not infect the six-rowed varieties (Table 5). The remainder of the U. hordei collections were similar to the U. nigra collections in their ability to produce infection in all of the commercial varieties. The infection percentage for both U. nigra and U. hordei was almost invariably lower on Fergus than on Herta, demonstrating that Fergus is less susceptible than Herta to these species as well as to U. nuda. These data corroborate the assumption that the reduced mean percentage of infection found in the 1972, 1973, and 1974 surveys may have been due to the increased acreage of Fergus.

Conclusions

No dramatic changes have been observed in the level of barley smut infection in the last 6 years. The major changes observed were a decrease in the mean percent infection of the two-rowed varieties and an increase in

Table 4. Infectivity of *U. nigra* collections, 1972

	% infection after seed inoculation			
Collection no.	Bonanza	Conquest	Fergus	Herta
72- 5	9	5	10	33
72- 34	5	6	5	18
72- 38	13	7	9	43
72- 42	9	6	10	42
72- 44	12	7	14	29
72- 48	14	7	10	36
72- 52	8	7	8	41
72- 56†	4	3	6	16
72- 61	6	7	8	29
72- 62	3	5	10	12
72- 66b	3	3	3	8
72- 66d	7	4	5	26
72- 70†	6	3	4	20
72- 74	5	6	9	32
72- 78	8	6	14	50
72- 86		3	5	20
72- 90	7	5	12	39
72- 98	11	9	11	30
72-100	7	4	10	38
72-103	10	6	4	17
72-108	12	9	6	12
Uninoculated control	0	0	0	0

† Collected from 2-rowed varieties. The remaining collections were from 6-rowed varieties.

Table 5. Infectivity of *U. hordei* collections, 1972

	% infection after seed inoculation			
Collection no.	Bonanza	Conquest	Fergus	Herta
72- 7	32	5	9	21
72- 20	60	42	15	64
72- 24	8	37	10	23
72- 27	45	16	20	45
72- 34	25	7	15	40
72- 38	20	29	27	28
72- 42	9	14	13	35
72- 51	9	3	1	16
72- 52	7	3	2	6
72- 57	6	4	0	14
72- 61	13	8	5	15
72- 62	5	3	5	10
72- 64	7	2	1	9
72- 66	6	2	2	9
72- 70	9	6	3	11
72- 72	9	10	4	13
72- 74	2	3	4	3
72- 76†	6	4	4	10
72- 86	7	11	4	15
72- 90	7	8	10	14
72- 95	5	5	1	13
72-124†	0	0	4	10
72-139	13	12	8	19
72-146	0	0	7	15
72-155	12	11	7	25
72-156†	0	0	7	17
Control	0	0	0	0

† Collected from 2-rowed varieties. The remaining collections were from 6-rowed varieties.

infection on the six-rowed varieties. These changes were attributed to Fergus being less susceptible than Herta to smuts and to the presence of forms of the pathogens that are more aggressive on the six-rowed varieties.

The biotype of U. nuda that can infect Conquest has been detected in a large area; however, the level of infection in individual fields has remained low. This, together with the existence of a large proportion of the U. nuda population that is avirulent on Conquest and Bonanza, indicates that the resistance derived from Jet is still of value in our commercial varieties. This resistance should be complemented or replaced by new types of resistance to counter the potential threat that the new biotype represents.

The proportion of barley fields affected by smut in Manitoba and eastern Saskatchewan has not been reported previously. The calculation appears to have value since it should provide some information on the distribution of the inoculum available to infect subsequent crops. For example, the level of infection in the 1975 crop may reflect the high proportion of fields that were affected in 1974.

The advent of systemic fungicides has relegated U. nuda to the same status as U. nigra and U. hordei in terms of chemical control. Therefore the effort relegated to smut resistance in breeding programs should be evenly distributed among the three species.

Acknowledgments

The assistance of numerous people who submitted smut collections from various parts of Canada is gratefully acknowledged. Mr. D. M. Penner and Mrs. Vicki Bailey helped perform the technical aspects of this study.

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NOTES ON BACTERIAL DISEASES OF CEREALS AND SOME OTHER CROP PLANTS[1]

W.A.F. Hagborg

Abstract

My purpose is to place on record the results of isolations of bacterial plant pathogens made chiefly from cereal host plants collected mainly in Manitoba in the period 1932-71 and to make as many of the cultures of pathogens as possible available for genetic and taxonomic studies by other investigators. Hypersensitivity to bacteria is shown to be readily demonstrable in cereal seedlings and an inhibitory factor that develops following the injection of heat-killed bacteria was found to be readily separable from the cells by either centrifugation or Seitz filtration. A unique method for finding evidence of the relative field resistance of cereal varieties to bacterial plant pathogens by comparison with a standard variety over a period of years is described. The results are given with infection by Xanthomonas translucens (J.J. and R.) Dowson emend. Hagborg in wheat and barley. A case is stated for the use of the taxon formae speciales in the classification of bacterial plant pathogens.

Résumé

Mes recherches ont pour objet d'enregistrer les résultats des prélèvements de bactéries phytopathogènes, principalement à partir de plants de céréales hôtes récoltés surtout au Manitoba de 1932 à 1971, et de rendre accessible le plus grand nombre possible de cultures de microbes pathogènes pour les études génétiques et taxonomiques des autres chercheurs. Il est facile de démontrer l'hypersensibilité des plantules de céréales aux bactéries, et on a constaté qu'un facteur inhibiteur qui se développe après injection de bactéries détruites par la chaleur était facilement séparable des cellules par centrifugation ou filtration de Seitz. Le présent rapport expose une méthode originale d'établie la résistance relative des variétés de céréales sur pied aux bactéries phytopathogènes, par comparaison avec une variété courante pendant quelques années. Les résultats portent sur l'infestation du blé et de l'orge par Xanthomonas translucens. On préconise l'emploi du taxon des formes spéciales dans le classement des bactéries phytopathogènes.

Nearly 200 cultures of bacterial plant pathogens isolated at Winnipeg during the 40-year period 1932-1971 are available in lyophilized form to anyone wishing to study them. Most of the cultures have been deposited in the American Type Culture Collection, Rockville, Maryland, some of them are in the International Collection of Bacterial Plant Pathogens, Department of Bacteriology, University of California, Davis, Calif. 95616, and most are available at Winnipeg. Transfers can be made from them and the original material re-sealed in vacuo for further storage. Numerous isolates of Xanthomonas translucens (Jones, Johnson and Reddy) Dowson and of Pseudomonas coronafaciens (Elliott) Stevens might prove useful in genetic studies of intraspecific variation. Data on the collections from which the stored cultures were isolated and on other collections from which no cultures were stored are listed in Table 4 and summarized in Table 1. The original records of the collections and of studies made with the isolates are available for scrutiny at the Agriculture Canada Research Station, Winnipeg.

The method of lyophilization, adapted

[1] Contribution No. 616, Research Station, Agriculture Canada, Winnipeg, Manitoba, R3T 2M9.

Table 1. Summary of results of isolations at Winnipeg of bacterial plant pathogens from diseased plants

Host	Total number of collections	Number of collections yielding various genera of bacteria							
		Xanthomonas	*Xanthomonas* and *Pseudomonas*	*Xanthomonas* and Unidentified	*Pseudomonas*	*Corynebacterium*	*Erwinia*	*Agrobacterium*	Unidentified
Aconitum	1				1				
Agropyron repens	6	6							
Agropyron sp.	1	1							
Alfalfa	6					6			
Apple	2						2		
Argentine rape	1	1							
Barley	75	70	2	2	1				
Bean	24	4			15	3			
Bromus inermis	2	1			1				
Cabbage	3	3							
Carrot	2	2							
Cucumber	8				6				2
Dahlia	1							1	
Flax	1				1				
Geranium	1								1
Hawthorn	1						1		
Hedera helix	1	1							
Lathyrus venosa	2				2				
Lilac	2				2				
Millet	1								1
Mountain ash	1								1
Oats	121				120				1
Peas	8				7				1
Plum	1				1				
Potato	1					1			
Rice	1	1							
Rye	18	14			3				
Sweetclover	1				1				
Taraxacum kok-saghz	3	3							
Tomato	22	1			16	4			
Turnip	5	5							
Triticale	2	2							
Ulmus pumila	1								1
Wheat	276	211	6		55		2		
Wild mustard	1								1
Total	603	326	8	2	233	14	5	1	8

from that of Annear (1), was similar to that described for preserving barley stripe mosiac with a drying tube of anhydrous magnesium perchlorate (18), although a higher vacuum was used with the bacteria. Washed 25-40 mesh silica sand was coated lightly with equal proportions of proteose peptone and monosodium glutamate. With a glass tube fitted with a piston, a pea-sized portion of the coated sand was transferred to a gas-collecting tube (Durham) which was plugged with cotton and autoclaved at 121.5°C for 20 min. The tube was dried at a pressure of 0.25 mm of mercury for 6 hr in vapor contact with anhydrous magnesium perchlorate. A suspension from a 3-inch, 2-day-old streak growth of the bacterial culture was made in 2 ml of a solution containing 0.5% of proteose peptone and 0.5% monosodium glutamate. The sand in the gas-collection tube was moistened with one drop of the suspension. This small tube was then placed in a Kimax flint glass culture tube (ID 12.5 mm, OD 15 mm, L 150 mm), along with a few granules of silica gel (S-682, Fisher) which changes to bluish green when the relative humidity is below 1%. A ball of asbestos fibre was pressed down onto the plug of the internal tube to protect it from the heat. The external tube was then heated and drawn out to facilitate the later sealing operation. The extended tube was evacuated to a pressure of 5 um of mercury and the vacuum maintained for 18 hr, after which the outer tube was sealed off as an evacuated ampoule. The integrity of the seal was tested in a water-saturated atmosphere for several hours.

Etiological studies

The isolation studies began as an attempt to ascertain the causes of dark head and culm discolorations in hybrid populations developed from crosses with H-44-24 by Goulden and Neatby (4). The variety H-44-24 was selected by McFadden (24) from a cross between Yaroslav emmer, Triticum dicoccum Schrank, and common wheat, Triticum aestivum L. "Black chaff" caused by "Bacterium translucens var. undulosum" had been described in the U.S.A. (27), but the discolorations at Winnipeg did not seem to be consistently of bacterial origin. As a result of isolations, inoculations and environmental studies, Hagborg (6) and Johnson and Hagborg (20, 21) concluded that three main factors were involved. These were bacterial black chaff, alternaria blotch, and an inherent tendency for plants to develop melanism under certain environmental conditions. Other less common causes of head and culm discolorations were Puccinia graminis Pers., Cochliobolus sativus (Ito and Kurib.) Drechsl., Septoria nodorum Berk. and P. atrofaciens (McCulloch) Stevens. The dark discolorations appeared similar to the dark, water-insoluble pigmentation of the normally dark-pigmented wheats, the chemistry of which was explained by Lewicki (23). In addition, dark purple anthocyanin pigmentation, which

turned green when treated with a base and which was water soluble, occurred occasionally.

To cope with the problem of dark discolorations in general, the following procedures were adopted: (a) plants showing this tendency were discarded in the early generations and (b) the varieties in the Western Wheat Co-operative Tests were subjected annually to an artificial epiphytotic of bacterial black chaff in a field-plot test at Winnipeg to eliminate lines that had escaped detection in earlier generations and to detect susceptible lines from other plant breeders who did not cull out plants showing dark discolorations.

At a later date, much of the problem disappeared when the emmer wheat source of rust resistance was replaced by other sources in parental material. One of the diseases, bacterial black chaff, persisted in varieties with Thatcher parentage and this disease continued to flare up in commercial fields (16). Just how serious bacterial black chaff was at one time considered may be seen in the statements of Erwin F. Smith. In 1917, he said of bacterial black chaff, "should it increase, or even continue to prevail as extensively as in 1915 and this year, it will have to be reckoned with as a very serious disease of wheat, not as destructive as the rusts, but more destructive than the smuts and very likely more difficult to control" (25). At that time he had 14 people, besides himself, working on bacterial black chaff (26).

When destruction from smuts is low, as it has been recently in Manitoba, Smith's appraisal holds very well. For example in our 1971 disease loss survey (19), when bacterial black chaff was separated for the first time from other leaf-destroying diseases, the estimated loss from bacterial black chaff in Manitoba was 2.7 million bushels of wheat or 3.7% of potential production, and no losses from wheat smuts were recorded.

Bacterial diseases of cereals and grasses

Some items in Tables 1 and 4 require clarification. Wherever a Pseudomonas sp. and a Xanthomonas sp. were present together they were found to be P. atrofaciens and a special form of X. translucens. Two such organisms may cohabit the same small piece of surface-sterilized tissue, as in at least four collections of wheat (33032, 34002, 35024 and 37022) and one collection of barley (52072) where both organisms appeared in the same set of dilution plates.

Special forms of X. translucens were found in 217 collections of wheat, 72 of barley, and 14 of rye, while P. atrofaciens was found in 61 collections of wheat, 3 of barley, and 3 of rye. Although oats could become infected after wound inoculation with two different special forms, not a single field collection of oats yielded X. translucens.

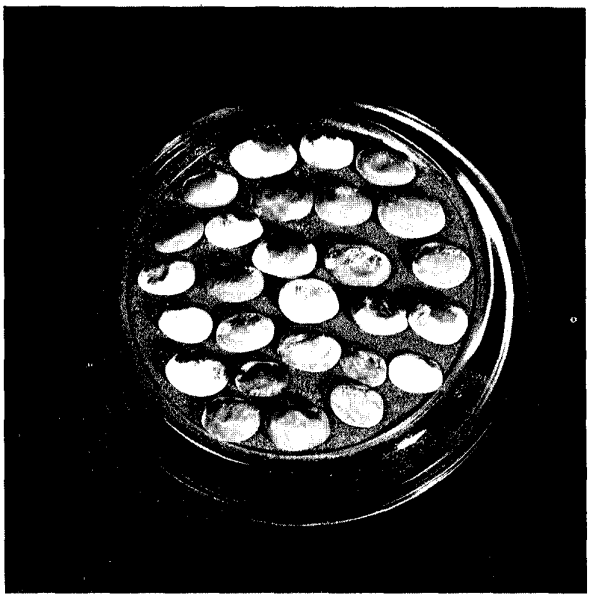

Figure 1. Seeds selected from a composite lot of "damaged" white navy beans obtained from the Grain Inspector, Board of Grain Commissioners for Canada, Chatham, Ontario, 1947.

In the 120 oat collections yielding bacterial pathogens, 1 was unidentified, 38 were halo-forming and 80 non-halo forming P. coronafaciens, and 1 was P. striafaciens. Apparently P. coronafaciens varies considerably in its ability to form the toxin responsible for halo production.

The low number of rye collections with bacterial infection does not imply resistance to X. translucens but is attributable primarily to the small proportion of the total cereal acreage devoted to rye in Manitoba.

In summation, of 487 collections of wheat, oats, barley, rye, and triticale that yielded bacterial pathogens, 305 were X. translucens, 119 P. coronafaciens, 61 P. atrofaciens, 1 P. striafaciens, and 1 an unidentified bacterial pathogen. One culture of X. translucens was isolated from plants of rice infected in an environmental chamber after inoculation with an isolate from wheat.

X. translucens was early subdivided into three so-called "varieties". Before the present 5 formae speciales were described in 1942 (10) the variety undulosa embraced some strains that are now classed as f. sp. cerealis. Similarly var. hordei included strains that are now classed as f. sp. hordei-avenae. For this reason I have designated the earlier or incompletely tested isolates of var. undulosa as "either f. sp. undulosa or f. sp. cerealis". These comprise cultures from 74 collections. Besides these,

92 collections yielded f. sp. undulosa and 47 f. sp. cerealis. Similarly 21 collections yielded either f. sp. hordei or f. sp. hordei-avenae, 8 f. sp. hordei, and 45 f. sp. hordei-avenae. In addition one collection of barley yielded f. sp. cerealis. X. translucens was also found in six collections of Agropyron repens (L.) Beauv., one collection of Agropyron sp., and one of Bromus inermis Leyss. All of the isolates from these grasses were f. sp. cerealis. P. atrofaciens was isolated from one collection of A. repens and one collection of B. inermis.

It will be noted that X. translucens f. sp. undulosa was isolated once (40015) from barley. This was from field plots of the variety Star included in a wheat varietal test and inoculated with f. sp. undulosa. Although this special form infects barley after inoculation it is not known to occur in commercial fields of barley. Furthermore, the record of barley infection with X. translucens var. undulosa made in 1934 (5) was later found to be incorrect as the host plant was wheat, not barley.

Bacterial diseases of vegetables

Supplementing the isolations from cereals and grasses, some isolations of bacteria were made from diseases in other hosts. A number were made from bean in connection with the development of a Health Approval Plan (13). This plan led to the adoption of "Part VIII - Health Approved Seed" under the Regulations of the Destructive Insect and Pest Act, Ottawa. It may be worthy of note that Collection 47008, from which the bacterial wilt organism Corynebacterium flaccumfaciens (Hedges) Dowson was isolated, was taken from a composite lot of "damaged" white navy beans (Phaseolus vulgaris L.) (Fig. 1) selected by the Grain Inspector, Board of Grain Commissioners for Canada, at Chatham, Ontario during the grading of carload lots originating throughout the commercial bean-growing areas of Ontario. From this collection I also isolated cultures of Xanthomonas phaseoli var. fuscans (Burkholder) Starr and Burkholder from four different bean seeds. One culture of these, 3645, was entered in the Canadian Collection of Micro-organisms (3). These may have been the first isolations of these two organisms in Canada. In Manitoba the halo blight of bean pathogen, Pseudomonas phaseolicola (Burkholder) Dowson, appeared to be somewhat more prevalent than that of common blight, X. phaseoli (Smith) Dowson.

Bacterial blight of peas caused by Pseudomonas pisi Sackett, sometimes caused heavy losses in field and garden peas in Manitoba. It was occasionally severe after hailstorms which predisposed the plants to infection (14). Similarly, the angular leaf spot of cucumber bacterium, P. lachrymans (Smith and Bryan) Alstatt, was frequently common in pickling cucumber.

In Manitoba the bacterial speck of tomato

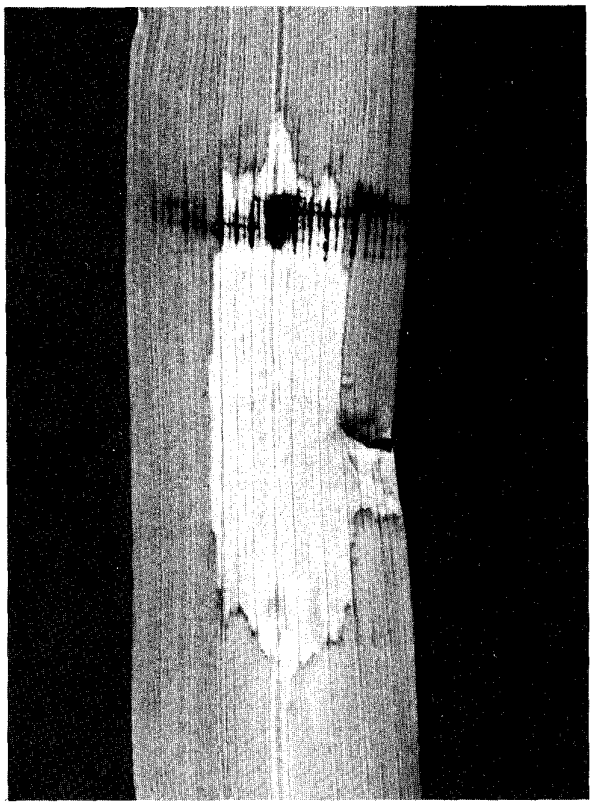

Figure 2. Seedling leaf of Titan barley 6 days after the injection of a suspension of 10^8 viable cells/ml of culture 3133, *P. atrofaciens*. (Black mark indicates margin of flooded area.)

pathogen, Pseudomonas tomato (Okabe) Alstatt, was first isolated from tomato in 1940, and in 1941 a survey indicated it was prevalent in the vicinity of Winnipeg, one grower having discarded 7 tons of tomatoes because of this disease (8). Bacterial spot, X. vesicatoria (Doidge) Dowson was isolated only once from tomato in Manitoba (9). Bacterial canker caused by C. michiganense (Smith) Jensen was occasionally present but was satisfactorily controlled by seed treatment with hot water (15).

Turnip, cabbage and Argentine rape (11) were somtimes infected with X. campestris (Pammel) Dowson. This organism is probably present every year to some extent in cabbage and turnip on the prairies. The disease has not been reported in the large acreages of rapeseed grown presently but it would be surprising if it were not present at least in the vicinity of vegetable farms where other crucifers are cultivated.

During the Second World War a shortage of carrot seed resulted in seed production of this vegetable in Manitoba. Some infection with X. carotae (Kendrick) Dowson on the umbels was encountered (7).

Bacterial ring rot of potato, C.

sepedonicum (Spieckermann and Kotthoff) Skaptason and Burkholder, was isolated only once, but that was no indication of rarity of the disease as it was detected by the Gram stain test in 377 of 747 samples submitted since 1939, mostly by inspectors of the Plant Protection Division.

Bacterial diseases of forage crops

Bacterial wilt of alfalfa caused by C. insidiosum (McCulloch) Jensen was surveyed for in 1946 (12) but was not considered capable of causing severe damage under the dry farming conditions practiced in Manitoba. P. syringae van Hall was isolated once from sweet clover, but it appeared to be of only sporadic occurrence on this host.

Hypersensitivity

One of the most interesting phenomena found in the study of bacterial diseases of plants is hypersensitivity reviewed by Klement and Goodman (22). They worked with thick leaves and pods and injected the inoculum with a hypodermic needle. I have been able to get similar results in the thin leaves of cereals by means of a simple device that floods the tissues by hydraulic pressure (17). If a young leaf of barley is flooded with a 10^8 cells/ml suspension of P. atrofaciens, hypersensitive necrosis develops in a few days (Fig. 2). If, however, a heat-killed suspension of the organism is injected, followed a day later by a suspension of the viable organism, no hypersensitive reaction develops. The inhibitory factor is readily separable (Seitz-filtration or centrifugation) from the cells after the heat treatment but not so easily separable from the viable cells (Hagborg, unpublished).

Varietal resistance to bacterial diseases of cereals

In studies of resistance to bacterial diseases in cereals evidence of varietal resistance is rare in the young seedling stage. To a great degree susceptibility to bacterial infection seems to be associated with the young tissues of seedling wheat, oats, or barley growing under the comparatively calm air of a greenhouse or environmental chamber. As the leaf tissues become older, the leaves may develop some resistance and lesions tend to be more restricted. This relationship becomes evident when the older, second-last leaves are inoculated at the same time as the younger flag leaves.

The most successful studies of varietal resistance to bacterial black chaff of wheat and bacterial blight of barley were made by inducing artificial epiphytotics of these diseases in field plot tests with four replicates. Each year the plots were rated for leaf-area destruction from bacterial infection. In wheat the degree of leaf-area destruction on the variety Marquis was used as the standard of comparison. In the varieties compared the mean rating of the test variety was taken as the numerator and the mean rating for Marquis in the same years as the denominator. This proportion, stated as a percentage, was the relative rating for the test variety. The results for a few selected varieties are shown in Table 2 and indicate that two, McMurachy and C.T. 615 (Sonora 64 x Tezanos Pintos Precoz), would be useful as sources of resistance. The most resistant variety, McMurachy, is low in quality, but the second best variety, C.T. 615, has a satisfactory level of resistance and good quality. Populations with C.T. 615 as one parent are now under study by the plant breeding staff of the Agriculture Canada Research Station, Winnipeg,

A similar comparison of certain barley varieties, with the variety O.A.C. 21 as the standard, indicated fairly high resistance to bacterial blight in the variety B.T. 313 and a little in Keystone (Table 3).

General comments

The incredible paucity of records of bacterial infection in the crops of western Canada compared with records of fungus infection may be largely a result of the practice of most plant pathologists of plating out whole pieces of tissue on the surface of a nutrient agar when attempting to isolate a pathogen. To isolate bacterial pathogens, I made a practice of tearing the tissues apart after surface sterilization and washing, and then mixing the fragments in liquefied, but cooled, agar before plating. Three additional dilution plates were made in the liquefied, cooled, nutrient agar. Furthermore, I used peptone beef agar (Difco) rather than a medium with potato content. Colony type is much sharper and characteristic on peptone beef agar, and it is the medium on which most colony types were described in the literature. Plating pieces of diseased material on the surface of a nutrient agar does not result in development of a characteristic colony and there is no certainty that a culture transferred from it will be pure as it might have arisen from one or more saprophytic cells. On the other hand, if saprophytic organisms are present in dilution plates they can usually be recognized as such by colony type. Dilution plates, without water blanks, could be used by many plant pathologists who frequently may be overlooking bacterial pathogens. Each dilution plate furnishes useful information. The first, if no bacterial pathogen is present, may show the growth of a fungus pathogen from the pieces of tissue. If a bacterial pathogen is present there will typically be a progression in the four plates from small, crowded colonies in the first plate to a few, fully-developed colonies in the third or fourth plate.

Table 2. Relative resistance of certain wheat varieties to bacterial black chaff infection on the leaves under field conditions

Variety	Proportion		Number of years in test	Specific years of test
	Mean ratio	%		
McMurachy	7/28	25	13	1946-48, '51-59, '63
C.T. 615	11/35	31	3	1969-71
Selkirk	17/28	61	11	1955-63, '65-67, '70
Manitou	25/32	77	8	1962-63, '65-67, '69-71
Neepawa	29/36	81	6	1965-67, '69-71
Lee	25/31	81	11	1947-48, '51-59
Cypress	27/31	87	11	1958-59, '61-63, '65-67, '69-71
Marquis	30/30	100	21	1946-48, '51-59, '61-63, '65-67, '69-71
Park	31/31	100	10	1959, '61-63, '65-67, '69-71
Thatcher	32/30	107	21	1946-48, '51-59, '61-63, '65-67, '69-71
C.T. 153	47/30	157	9	1946-48, '51-56
Saunders	47/26	181	12	1947-48, '51-59, '63

Table 3. Relative resistance of certain barley varieties to infection by bacterial blight under field conditions

Variety	Proportion		Number of years in test	Specific years of test
	Mean ratio	%		
B.T. 313	10/26	31	2	1970, '71
Keystone	10/12	84	5	1961, '62, '64, '66, '67
OAC 21	15/15	100	12	1954, '56-59, '61, '62, '64, '66, '67, '70, '71
Conquest	24/22	109	6	1962, '64, '66, '67, '70, '71
Galt	69/61	113	4	1966, '67, '70, '71
Husky	17/15	113	8	1954, '56-59, '61, '62, '64
Parkland	15/13	115	10	1954, '56-59, '61, '62, '64, '66, '67
Montcalm	22/15	157	8	1954, '56-59, '61, '62, '64
Olli	64/19	337	9	1954, '56-59, '61, '62, '66, '71

Another general comment that I would like to make is that plant pathologists who work with bacterial diseases of plants might very well reduce the confusion in taxonomy by using the taxon "forma specialis" wherever it applies. They, of all taxonomists, should regard pathogenic capability as an important taxonomic character. This character is the primary object of the pathologists' interest in the phytopathogen and it is, therefore, of fundamental value in characterizing the phytopathogenic bacteria. To differentiate,

within species, between organisms differing in pathogenic capabilities Eriksson defined the taxon "forma specialis" in 1894. This taxon has been used to good advantage for many years by mycologists and plant pathologists working with fungi, especially with the rusts. Bacteriologists have not yet fully appreciated the significance of physiologic specialization.

More than 30 years ago (10) I described five formae speciales of Xanthomonas translucens. These were still considered valid in 1966 by the editors of Index Bergeyana (2). A few others have been recognized but many more organisms could be redescribed as formae speciales.

In reducing the number of species of phytopathogens, a procedure advocated on various grounds, it is essential to pathology that we retain a means of referring to bacteria that agree in many characters but differ in pathogenic capabilities. Among the taxons available, forma specialis, has been defined in both the International Rules of Botanical Nomenclature and the International Code of Nomenclature of Bacteria.

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Table 4 follows on pages 137-151

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants[§]

Collection No.	Date	Location* †	Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
32001	5/ 7/32	WINNIPEG MAN	4953	9709	WHEAT	CERES	LEAF	88	XTU.OR CER.			
32013	8/ 8/32	WINNIPEG MAN	4953	9709	WHEAT	MARQUIS	NECK AND INTNODE	110	XTU.OR CER.	111	XTU.OR CER.	
33002	13/ 6/33	MORDEN MAN	4911	9805	BARLEY	STAR	LEAF	156	XTH.OR H-A.			
33003	13/ 6/33	GRETNA MAN	4902	9735	OATS		LEAF	145	P.C.NO HALO	147	P.C.NO HALO	1713
33004	13/ 6/33	ST JEAN BT MAN	4916	9721	OATS		LEAF	148	P.C.NO HALO			
33005	19/ 6/33	OAK BLUFF MAN	4947	9920	BARLEY		LEAF	285	XTH.OR H-A.	286	XTH.OR H-A.	
33006	16/ 6/33	03* W† SEDDONS CR MAN	5004	9631	BARLEY		LEAF	149	XTH.OR H-A.	157	XTH.OR H-A.	
33007	19/ 6/33	01 W OAK BLUFF MAN	4947	9926	WHEAT		LEAF	158	XTU.OR CER.	150	XTU.OR CER.	
33008	19/ 6/33	01 E STARBUCK MAN	4946	9736	WHEAT		LEAF	164	XTU.OR CER.			
33009	19/ 6/33	01 W ELM CREEK MAN	4941	9800	BARLEY		LEAF	151	XTH.OR H-A.	165	XTH.OR H-A.	
33010	19/ 6/33	06 W ST CLAUDE MAN	4940	9822	WHEAT		LEAF	152	XTU.OR CER.	160	XTU.OR CER.	
33011	19/ 6/33	02 W GLENBORO MAN	4932	9915	WHEAT		LEAF	153	XTU.OR CER.	161	XTU.OR CER.	
33012	20/ 6/33	02 S HARDING MAN	5000	10030	OATS		LEAF	154	P.C.NO HALO	163	P.C.NO HALO	3035
33013	23/ 6/33	WINNIPEG MAN	4953	9709	WHEAT	REWARD	LEAF	168	XTU.OR CER.	169	XTU.OR CER.	
33016	17/ 7/33	03 S JORDAN MAN	4923	9805	WHEAT	REWARD	NECK	173	XTU.OR CER.	174	XTU.OR CER.	
33019	18/ 7/33	02 E DELORAINE MAN	4912	10029	DURUM WH		LEAF	289	XTU.OR CER.	290	XTU.OR CER.	
33020	18/ 7/33	PIPESTONE MAN	4934	10058	WHEAT		LEAF	179	XTU.OR CER.	180	XTU.OR CER.	
33021	18/ 7/33	03 W RESTON MAN	4935	10102	BARLEY		LEAF	181	XTH.OR H-A.	182	XTH.OR H-A.	
33022	18/ 7/33	02 W LINKLATER MAN	5034	10453	WHEAT	REWARD	NECK	183	PS.ATROFAC.	184	PS.ATROFAC.	
33023	18/ 7/33	01 SE BUTLER MAN	4947	10120	BARLEY		LEAF	186	XTH.OR H-A.			
33024	18/ 7/33	07 NE BUTLER MAN	4947	10120	WHEAT	MARQUIS	GLUME	216	XTU.OR CER.	217	XTU.OR CER.	
33025	18/ 7/33	06 E GRISWOLD MAN	4945	10025	BARLEY		LEAF	219	XTH.OR H-A.	220	XTH.OR H-A.	
33026	18/ 7/33	03 NW SINCLAIR MAN	4934	10116	WHEAT		LEAF	222	XTU.OR CER.	223	XTU.OR CER.	
33027	18/ 7/33	02 E OAK LAKE MAN	4947	10038	WHEAT		NECK	225	XTU.OR CER.			
33028	18/ 7/33	04 W VIRDEN MAN	4951	10055	WHEAT		GLUME	232	XTU.OR CER.	233	XTU.OR CER.	
33029	18/ 7/33	03 W KEMNAY MAN	4951	10007	DURUM WH		LEAF	292	XTU.OR CER.	294	XTU.OR CER.	
33030	19/ 7/33	BRANDON MAN	4950	9957	BARLEY	COMFORT	KERNEL	190	XTH.OR H-A.			
33031	19/ 7/33	BRANDON MAN	4950	9957	WHEAT	5-28-1.8	LEAF	191	XTU.OR CER.			3068
33032	19/ 7/33	BRANDON MAN	4950	9957	WHEAT	MARQUIS	LEAF	194	PS.ATROFAC.	195	X.T.UNDULO	
33033	19/ 7/33	MINNEDOSA MAN	5014	9951	BARLEY		LEAF	295	XTH.OR H-A.			
33034	25/ 7/33	10 W OAK BLUFF MAN	4947	9926	DURUM WH		NECK	237	XTU.OR CER.	238	XTU.OR CER.	
33035	25/ 7/33	01 W FANNYSTELL MAN	4945	9750	BARLEY		LEAF	239	XTH.OR H-A.	240	XTH.OR H-A.	3070
33036	25/ 7/33	01 E ELM CREEK MAN	4941	9800	WHEAT	CERES	NECK	241	XTU.OR CER.	242	XTU.OR CER.	
33038	25/ 7/33	01 E TREHERNE MAN	4938	9841	WHEAT	CERES	NECK	245	XTU.OR CER.			
33039	25/ 7/33	01 SW MARGARET MAN	4926	9951	DURUM WH		GLUME AND NECK	250	XTU.OR CER.	252	XTU.OR CER.	
33040	26/ 7/33	03 N HAMIOTA MAN	5010	10030	WHEAT	REWARD	GLUME	301	XTU.OR CER.			
33041	26/ 7/33	03 N BIRTLE MAN	5032	10102	WHEAT	REWARD	GLUME	259	XTU.OR CER.	258	XTU.OR CER.	
33042	27/ 7/33	05 W MORGATE MAN	5041	9930	WHEAT	MARQUIS	GLUME	260	XTU.OR CER.	261	XTU.OR CER.	
33044	1/ 8/33	NEWTON MAN	4953	9802	WHEAT	MARQUIS	GLUME	313	XTU.OR CER.	314	XTU.OR CER.	
33049	10/ 8/33	WINNIPEG MAN	4953	9709	WHEAT		NECK	268	XTU.OR CER.			
33056	7/ 9/33	KAPUSKASIN ONT	4925	8226	WHEAT	R RKXMINHDY	NECK	277	XTU.OR CER.	278	XTU.OR CER.	
33058	20/10/33	WINNIPEG MAN	4953	9709	WHEAT		LEAF	282	XTU.OR CER.			

§ For explanation of abbreviations see page 151

*Distance (miles) and †direction from designated location

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date			Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
33059	20/10/33			WINNIPEG	MAN	4953	9709	WHEAT		NECK	283	XTU.OR CER.	284	XTU.OR CER.	
34002	8/ 6/34	03	W	STE ROSE	MAN	5103	9932	WHEAT		LEAF	323	XTU.OR CER.	322	PS.ATROFAC.	
34003	8/ 6/34	04	N	MACDONALD	MAN	5003	9828	OATS		LEAF	320	P.C.NO HALO	321	P.C.NO HALO	
34006	19/ 6/34			WINNIPEG	MAN	4953	9709	WHEAT		LEAF	325	PS.ATROFAC.	324	PS.ATROFAC.	
34007	20/ 6/34	03	S	CARMAN	MAN	4932	9800	RYE		LEAF	326	X.T.SECAL.	327	X.T.SECAL.	
34008	27/ 6/34			WINNIPEG	MAN	4953	9709	WHEAT		LEAF	330	XTU.OR CER.	331	XTU.OR CER.	
34009	27/ 6/34			WINNIPEG	MAN	4953	9709	WHEAT		LEAF	338	XTU.OR CER.	339	XTU.OR CER.	
34011	21/ 6/34			BRANDON	MAN	4950	9957	BARLEY	CONFORT	LEAF	344	XTH.OR H-A.	345	XTH.OR H-A.	
34012	21/ 6/34			BRANDON	MAN	4950	9957	OATS		LEAF	346	P.C.NO HALO	347	P.C.NO HALO	1715
34013	1/ 7/34			STE ROSE	MAN	5103	9932	WHEAT		LEAF	351	XTU.OR CER.	353	XTU.OR CER.	
34014	7/ 7/34			WINNIPEG	MAN	4953	9709	OATS	PASKEWITZ	LEAF	357	P.C.NO HALO			1716
34017	10/ 7/34			WINNIPEG	MAN	4953	9709	WHEAT		LEAF	363	XTU.OR CER.			
34026	24/ 7/34			MORDEN	MAN	4911	9805	BARLEY		LEAF	377	XTH.OR H-A.	379	XTH.OR H-A.	
34029	16/ 8/34			WINNIPEG	MAN	4953	9709	WHEAT	THATCHER	GLUME	384	XTU.OR CER.	385	XTU.OR CER.	
34030	16/ 8/34			WINNIPEG	MAN	4953	9709	WHEAT	C.T.201	GLUME	387	XTU.OR CER.	388	XTU.OR CER.	
34031	16/ 8/34			WINNIPEG	MAN	4953	9709	WHEAT	C.T.305	GLUME	391	PS.ATROFAC.	392	XTU.OR CER.	
34035	18/ 8/34			WINNIPEG	MAN	4953	9709	WHEAT	C.T. 107	LEAF	405	PS.ATROFAC.	406	PS.ATROFAC.	
34037	22/ 8/34			WINNIPEG	MAN	4953	9709	WHEAT	C.T.305	LEAF	409	PS.ATROFAC.	410	PS.ATROFAC.	
34041	20/ 8/34			WINNIPEG	MAN	4953	9709	WHEAT	C.T.202	INTNODE	416	PS.ATROFAC.			
34042	20/ 8/34			WINNIPEG	MAN	4953	9709	WHEAT	C.T.201	INTNODE	421	XTU.OR CER.			
35006	28/ 6/35			BRANDON	MAN	4950	9957	BARLEY		LEAF	448	XTH.OR H-A.	449	XTH.OR H-A.	
35007	10/ 8/35			BRANDON	MAN	4950	9957	BARLEY		LEAF	451	XTH.OR H-A.			
35009	9/ 7/35			EDMONTON	ALT	5333	11328	WHEAT		LEAF	453	PS.ATROFAC.	454	PS.ATROFAC.	
35010	10/ 7/35			BRANDON	MAN	4950	9957	DURUM WH		LEAF	456	PS.ATROFAC.	532	PS.ATROFAC.	
35011	19/ 7/35	03	W	FANNYSTELL	MAN	4945	9750	DURUM WH		LEAF	460	XTU.OR CER.			
35012	19/ 7/35	06	W	RATHWELL	MAN	4940	9832	WHEAT	CERES	GLUME	462	XTU.OR CER.			
35013	20/ 7/35	05	NW	VIRDEN	MAN	4951	10055	WHEAT	CERES	GLUME	463	XTU.OR CER.	464	XTH.OR H-A.	
35014	19/ 7/35	10	S	VIRDEN	MAN	4951	10055	WHEAT	CERES	GLUME	536	XTU.OR CER.	537	XTU.OR CER.	
35015	20/ 7/35	02	S	HARDING	MAN	5000	10030	WHEAT	MARQUIS	GLUME	471	XTU.OR CER.			
35016	20/ 7/35	03	E	OAK LAKE	MAN	4947	10038	WHEAT	CERES	GLUME	472	XTU.OR CER.	473	XTU.OR CER.	
35017	20/ 7/35	06	N	BINSCARTH	MAN	5037	10116	WHEAT	MARQUIS	GLUME	546	PS.ATROFAC.			
35018	22/ 7/35	07	S	ETHELBERT	MAN	5131	10022	WHEAT	MARQUIS	GLUME	476	XTU.OR CER.	477	XTU.OR CER.	
35019	22/ 7/35	04	E	SWAN RIVER	MAN	5206	10116	WHEAT	REWARD	LEAF	478	XTU.OR CER.	479	XTU.OR CER.	
35020	21/ 7/35	02	N	BOWSMAN	MAN	5214	10114	WHEAT	REWARD	LEAF AND GLUME	481	XTU.OR CER.	495	XTU.OR CER.	3049
35021	21/ 7/35	05	N	BOWSMAN	MAN	5214	10114	WHEAT	REWARD	LEAF	484	XTU.OR CER.			
35023	23/ 7/35	04	E	PORTAGE LA	MAN	4957	9825	WHEAT	MARQUIS	GLUME	486	XTU.OR CER.	487	XTU.OR CER.	
35024	23/ 7/35	04	E	MACDONALD	MAN	5003	9828	WHEAT	MARQUIS	GLUME	489	PS.ATROFAC.	491	XTU.OR CER.	
35025	19/ 7/35	02	NW	PIPESTONE	MAN	4934	10058	WHEAT	MARQUIS	GLUME	541	XTU.OR CER.	542	XTU.OR CER.	
35026	20/ 7/35	04	N	HARGRAVE	MAN	4955	10105	WHEAT	CERES	GLUME	494	PS.ATROFAC.			
35028	10/ 8/35	01	W	OCHRE RIVE	MAN	5103	9947	WHEAT	MARQUIS	GLUME	497	XTU.OR CER.	498	XTU.OR CER.	
35032	3/ 8/35			WINNIPEG	MAN	4953	9709	WHEAT	C.T.206	GLUME	508	XTU.OR CER.			
35033	1/ 8/35			WINNIPEG	MAN	4953	9709	WHEAT	C.T.202	GLUME	531	XTU.OR CER.			
35034	16/ 7/35			WINNIPEG	MAN	4953	9709	WHEAT	REWARD	GLUME	512	PS.ATROFAC.	513	PS.ATROFAC.	

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date	Location	Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
35035	10/ 8/35	01 W OCHRE RIVE	MAN	5103	9947	WHEAT	MARQUIS	KERNEL	515	PS.ATROFAC.	516	PS.ATROFAC.	
35037	15/ 8/35	ELNORA	ALT	5159	11312	WHEAT	MARQUIS	LEMMA AND KERNEL	517	PS.ATROFAC.	518	PS.ATROFAC.	
35038	15/ 7/35	WINNIPEG	MAN	4953	9709	WHEAT	R.L.716.1	LEMMA	522	PS.ATROFAC.	523	PS.ATROFAC.	
36001	6/ 6/36	E ELM CREEK	MAN	4941	9800	FALL RYE		LEAF	593	XTU.OR CER.	594	XTU.OR CER.	
36004	31/ 6/36	05 N NEEPAWA	MAN	5013	9929	WHEAT	MARQUIS	GLUME	616	XTU.OR CER.	617	XTU.OR CER.	3780
36017	30/ 7/36	06 E BIELD	MAN	5113	10111	WHEAT	MARQUIS	LEMMA	639	PS.ATROFAC.	640	PS.ATROFAC.	
36018	31/ 7/36	01 W OCHRE RIVE	MAN	5103	9947	WHEAT	REWARD	GLUME	650	XTU.OR CER.	651	XTU.OR CER.	
37001	9/ 7/37	05 E LA SALLE	MAN	4938	9712	BARLEY		LEAF	735	XTH.OR H-A.	736	XTH.OR H-A.	
37002	14/ 7/37	WINNIPEG	MAN	4953	9709	BARLEY	REGAL	LEAF	737	XTH.OR H-A.	738	XTH.OR H-A.	
37004	22/ 7/37	02 E PORTAGE LA	MAN	4957	9825	BARLEY		LEAF	741	XTH.OR H-A.	742	XTH.OR H-A.	
37005	9/ 7/37	05 E LA SALLE	MAN	4938	9712	DURUM WH		LEAF	743	XTU.OR CER.	744	XTU.OR CER.	
37006	21/ 7/37	04 E ST CLAUDE	MAN	4940	9822	WHEAT	CERES	GLUME	745	XTU.OR CER.	746	XTU.OR CER.	
37007	22/ 7/37	01 NW BENARD	MAN	4955	9752	DURUM WH		LEAF	747	XTU.OR CER.	748	XTU.OR CER.	
37008	21/ 7/37	BRANDON	MAN	4950	9957	WHEAT	THATCHER	LEAF	749	XTU.OR CER.	750	XTU.OR CER.	
37009	21/ 7/37	BRANDON	MAN	4950	9957	WHEAT	C.T.125	LEAF	751	XTU.OR CER.	752	XTU.OR CER.	
37010	21/ 7/37	TREHERNE	MAN	4938	9841	WHEAT	APEX	GLUME	753	XTU.OR CER.	754	XTU.OR CER.	
37013	6/ 7/37	MELITA	MAN	4916	10100	OATS		LEAF	762	P.C.NO HALO	761	P.C.NO HALO	
37014	7/ 7/37	WINNIPEG	MAN	4953	9709	OATS		LEAF	763	P.C.NO HALO	764	P.C.NO HALO	1719
37015	9/ 7/37	05 SE LA SALLE	MAN	4938	9712	OATS		LEAF	759	P.C.NO HALO	760	P.C.NO HALO	1718
37021	24/ 7/37	DARLINGFOR	MAN	4912	9822	WHEAT	MARQUIS	GLUME	770	PS.ATROFAC.	771	PS.ATROFAC.	
37022	24/ 7/37	04 E MORDEN	MAN	4911	9805	WHEAT	CERES	GLUME	772	PS.ATROFAC.	773	XTU.OR CER.	
37038	4/ 8/37	WINNIPEG	MAN	4953	9709	BARLEY	COLSESS	KERNEL	780	XTH.OR H-A.	781	XTH.OR H-A.	
37042	4/ 8/37	WINNIPEG	MAN	4953	9709	WHEAT	C.T.114	INTNODE	800	PS.ATROFAC.			
37047	4/ 8/37	WINNIPEG	MAN	4953	9709	WHEAT	C.T.126	INTNODE	808	PS.ATROFAC.			
37065	0/ 0/37	POCATIERE	PQ	4722	7002	WHEAT	MARQUIS	GLUME	826	XTU.OR CER.	827	XTU.OR CER.	
37066	0/ 0/37	POCATIERE	PQ	4722	7002	WHEAT	THATCHER	GLUME	822	XTU.OR CER.	823	XTU.OR CER.	
37067	1/12/37	LACOMBE	ALT	5228	11344	WHEAT	RL1134X6806	GLUME AND NECK	832	PS.ATROFAC.			
37068	1/12/37	LACOMBE	ALT	5228	11344	WHEAT	RL592XG2448	GLUME AND NECK	838	PS.ATROFAC.	839	PS.ATROFAC.	
38006	16/ 6/38	OAKVILLE	MAN	4956	9758	OATS		LEAF	865	P.C.NO HALO	866	P.C.NO HALO	
38016	13/ 8/38	SWAN RIVER	MAN	5206	10116	WHEAT	THATCHER	GLUME	884	XTU.OR CER.	885	XTU.OR CER.	3074
38017	13/ 8/38	LANGDON	ND	4876	8822	WHEAT	ND 1339	GLUME	886	PS.ATROFAC.	887	PS.ATROFAC.	
38022	19/ 8/38	WINNIPEG	MAN	4953	9709	WHEAT	C.T.122	GLUME	899	PS.ATROFAC.			
38026	18/ 8/38	WINNIPEG	MAN	4953	9709	WHEAT	C.T.132	GLUME	904	XTU.OR CER.	905	XTU.OR CER.	
38029	18/ 8/38	WINNIPEG	MAN	4953	9709	WHEAT	C.T.802	GLUME	908	PS.ATROFAC.	909	PS.ATROFAC.	
39001	21/ 1/39	WINNIPEG	MAN	4953	9709	FLAX		COTLEDN	929	UNIDENT.P.P.	933	UNIDENT.P.P.	0933
39002	15/ 6/39	DARLINGFOR	MAN	4912	9822	OATS		LEAF	960	P.C.NO HALO	961	P.C.NO HALO	
39003	15/ 6/39	PILOT MOUN	MAN	4916	9855	OATS		LEAF	962	P.C.NO HALO	963	P.C.NO HALO	
39004	15/ 6/39	BRANDON	MAN	4950	9957	BARLEY	REGAL	LEAF	995	XTH.OR H-A.	996	XTH.OR H-A.	
39005	15/ 6/39	BRANDON	MAN	4950	9957	OATS	VCTXGN R578	LEAF	965	P.C.NO HALO	966	P.C.NO HALO	
39006	16/ 6/39	10 S VIRDEN	MAN	4951	10055	FALL RYE		LEAF	970	PS.ATROFAC.			
39007	16/ 6/39	03 E PIPESTONE	MAN	4934	10058	FALL RYE		LEAF	971	PS.ATROFAC.	998	PS.ATROFAC.	

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date	Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
39008	15/ 6/39	THORNHILL	MAN	4912	9814	OATS		LEAF	972	P.C.NO HALO	973	P.C.NO HALO	
39009	16/ 6/39	OAK LAKE	MAN	4947	10038	OATS		LEAF	975	P.C.NO HALO	976	P.C.NO HALO	
39015	16/ 6/39	GLENBORO	MAN	4932	9915	WHEAT		LEAF	1001	PS.ATROFAC.	1002	PS.ATROFAC.	
39016	16/ 6/39	NESBITT	MAN	4937	9952	WHEAT		LEAF	1003	PS.ATROFAC.	1004	PS.ATROFAC.	
39017	15/ 6/39	LA RIVIERE	MAN	4913	9843	WHEAT		LEAF	983	PS.ATROFAC.	984	PS.ATROFAC.	
39018	16/ 6/39	VIRDEN	MAN	4951	10055	OATS		LEAF	1005	P.C.NO HALO	1006	P.C.NO HALO	
39019	13/ 6/39	WINNIPEG	MAN	4953	9709	OATS	ANTHONY	LEAF	1007	P.C.NO HALO	1008	P.C.NO HALO	
39020	21/ 6/39	WINNIPEG	MAN	4953	9709	OATS		LEAF	1009	P.C.NO HALO	1010	P.C.NO HALO	
39021	23/ 6/39	WINNIPEG	MAN	4953	9709	BARLEY	COLSESS	LEAF	1011	XTH.OR H-A.			
39022	27/ 6/39	WINNIPEG	MAN	4953	9709	OATS	ANTHONY	LEAF	1013	P.C.NO HALO	1014	P.C.NO HALO	3003
39023	27/ 6/39	WINNIPEG	MAN	4953	9709	OATS	VICTORY	LEAF	1015	P.C.NO HALO	1016	P.C.NO HALO	1720
39025	29/ 6/39	WINNIPEG	MAN	4953	9709	BARLEY	SUCCESS	LEAF	1018	X.T.HORDEI	1019	X.T.HORDEI	
39026	4/ 7/39	WINNIPEG	MAN	4953	9709	OATS		LEAF	1020	P.C.NO HALO	1021	P.C.NO HALO	
39027	14/ 7/39	WINNIPEG	MAN	4953	9709	WINTR WT		LEAF	1022	X.T.UNDULO	1023	X.T.UNDULO	
39032	19/ 7/39	10 S VIRDEN	MAN	4951	10055	WHEAT	THATCHER	GLUME	1027	X.T.UNDULO	1028	X.T.UNDULO	5437
39037	19/ 7/39	01 W SCARTH	MAN	4944	10057	RYE		LEAF	1031	PS.ATROFAC.	1032	PS.ATROFAC.	
39040	13/ 7/39	ELMBROOK	ONT	4405	7705	OATS	MABEL	LEAF	1035	P.C.NO HALO	1036	P.C.NO HALO	1702
39044	21/ 7/39	02 W GLADSTONE	MAN	5015	9850	WHEAT	RENOWN	GLUME	1037	X.T.UNDULO	1038	X.T.UNDULO	
39045	21/ 7/39	02 W GLADSTONE	MAN	5015	9850	WHEAT	RENOWN	INTNODE	1045	PS.ATROFAC.	1046	PS.ATROFAC.	
39051	21/ 7/39	01 W NEEPAWA	MAN	5013	9929	WHEAT	RENOWN	GLUME	1064	PS.ATROFAC.	1065	PS.ATROFAC.	
39052	21/ 7/39	PIGEON LAK	MAN	4957	9736	BARLEY		LEAF	1066	X.T.HORDEI	1067	X.T.HORDEI	
39054	21/ 7/39	01 W BASSWOOD	MAN	5019	10002	OATS		LEAF	1071	P.C.NO HALO	1072	P.C.NO HALO	1721
39058	22/ 7/39	RIDING MTN	MAN	5035	9924	OATS		LEAF	1076	P.C.NO HALO	1077	P.C.NO HALO	1703
39059	22/ 7/39	03 S EDEN	MAN	5023	9927	OATS		LEAF	1079	P.C.NO HALO			1722
39062	24/ 7/39	08 S STE AGATHE	MAN	4934	9710	WHEAT		GLUME	1082	X.T.UNDULO	1083	X.T.UNDULO	
39063	31/ 7/39	WINNIPEG	MAN	4953	9709	WHEAT		GLUME	1086	X.T.UNDULO	1087	X.T.UNDULO	
39064	31/ 7/39	WINNIPEG	MAN	4953	9709	WHEAT		LEMMA	1088	PS.ATROFAC.	1089	PS.ATROFAC.	
39065	3/ 8/39	WINNIPEG	MAN	4953	9709	WAX BLAN		POD	1090	P.PHASEOL.	1091	P.PHASEOL.	
39066	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	35-71	GLUME	1093	X.T.UNDULO	1094	X.T.UNDULO	
39067	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	REWARD	GLUME	1096	X.T.UNDULO	1097	X.T.UNDULO	
39068	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 211	GLUME	1098	X.T.UNDULO	1099	X.T.UNDULO	
39069	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	RENOWN	GLUME	1100	X.T.UNDULO	1101	X.T.UNDULO	
39071	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	C.T.135	GLUME	1105	X.T.UNDULO	1106	X.T.UNDULO	
39072	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	C.T.309	GLUME	1108	X.T.UNDULO	1109	X.T.UNDULO	
39073	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	THATCHER	GLUME	1110	X.T.UNDULO	1111	X.T.UNDULO	
39074	25/ 7/39	02 W BURNSIDE	MAN	4958	9829	WHEAT	THATCHER	GLUME	1115	PS.ATROFAC.			
39075	3/ 8/39	WINNIPEG	MAN	4953	9709	WHEAT	THATCHER	INTNODE	1116	X.T.UNDULO	1117	X.T.UNDULO	
39077	25/ 7/39	KENMORE	ONT	4513	7524	OATS	VICTORY	LEAF	1119	P.C.NO HALO	1120	P.C.NO HALO	1723
39078	13/ 8/39	MELFORT	SAS	5252	10436	WHEAT	THATCHER	LEAF AND NECK	1048	X.T.UNDULO	1049	X.T.UNDULO	
39079	8/ 8/39	GRONLID	SAS	5306	10428	WHEAT	REGENT	LEAF	1102	PS.ATROFAC.	1103	PS.ATROFAC.	
40002	27/ 6/40	WINNIPEG	MAN	4953	9709	OATS	ANTHONY	LEAF	1139	P.C.NO HALO	1140	P.C.NO HALO	
40003	17/ 6/40	PORTAGE LA	MAN	4957	9825	OATS		LEAF	1141	P.C.NO HALO	1142	P.C.NO HALO	
40004	17/ 6/40	07 NW MORRIS	MAN	4921	9722	OATS	VANGUARD	LEAF	1145	P.C.NO HALO			

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date	Location	Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
40005	19/ 6/40	04 W MORRIS	MAN	4921	9722	BR INERM	LEAF	1169	P.C.V.ATRO.	1170	P.C.V.ATRO.	
40008	19/ 6/40	ST ADOLPHE	MAN	4940	9706	OATS	LEAF	1171	P.C.NO HALO	1172	P.C.NO HALO	
40009	19/ 6/40	UNION POIN	MAN	4931	9714	OATS	LEAF	1151	P.C.NO HALO	1152	P.C.NO HALO	1724
40010	19/ 6/40	STE AGATHE	MAN	4934	9710	OATS	LEAF	1153	P.C.NO HALO	1154	P.C.NO HALO	
40011	19/ 6/40	03 N MORRIS	MAN	4921	9722	BARLEY	LEAF	1156	X.T.HORDEI			
40014	27/ 6/40	WINNIPEG	MAN	4953	9709	BARLEY	LEAF	1173	X.T.H-AV.	1174	X.T.H-AV.	5735
40015	3/ 7/40	WINNIPEG	MAN	4953	9709	BARLEY	STAR	LEAF	1175	X.T.UNDULO	1176	X.T.UNDULO	
40016	4/ 7/40	PORTAGE LA	MAN	4957	9825	WHEAT	RENOWN	LEAF	1177	PS.ATROFAC.	1178	PS.ATROFAC.	
40018	5/ 7/40	07 NW MORRIS	MAN	4921	9722	OATS	VANGUARD	LEAF	1179	P.C.NO HALO	1180	P.C.NO HALO	
40022	5/ 7/40	STE AGATHE	MAN	4934	9710	OATS		LEAF	1185	P.C.NO HALO	1186	P.C.NO HALO	
40027	10/ 7/40	WINNIPEG	MAN	4953	9709	OATS	EARLY MILLR	LEAF	1191	P.C.NO HALO	1192	P.C.NO HALO	
40028	18/ 7/40	WINKLER	MAN	4911	9756	OATS	VANGUARD	LEAF	1193	P.C.NO HALO	1194	P.C.NO HALO	
40029	15/ 7/40	MORDEN	MAN	4911	9805	OATS	ERBAN	LEAF	1195	P.C.NO HALO	1196	P.C.NO HALO	1725
40030	15/ 7/40	MORDEN	MAN	4911	9805	OATS	BOND	LEAF	1197	P.C.NO HALO			
40031	9/ 7/40	MATHER	MAN	4906	9907	OATS		LEAF	1199	P.C.NO HALO	1200	P.C.NO HALO	1726
40032	9/ 7/40	SOMERSET	MAN	4924	9839	OATS	VANGUARD	LEAF	1202	P.C.NO HALO			
40033	15/ 7/40	LA RIVIERE	MAN	4913	9843	OATS		LEAF	1204	P.C.NO HALO	1205	P.C.NO HALO	3034
40034	15/ 7/40	MANITOU	MAN	4915	9831	OATS		LEAF	1206	P.C.NO HALO			1705
40036	16/ 7/40	BRANDON	MAN	4950	9957	OATS		LEAF	1209	P.C.NO HALO	1210	P.C.NO HALO	
40037	15/ 7/40	CARROLL	MAN	4936	10002	OATS		LEAF	1211	P.C.NO HALO	1212	P.C.NO HALO	
40039	17/ 7/40	MACDONALD	MAN	5003	9828	OATS		LEAF	1167	P.C.NO HALO	1168	P.C.NO HALO	3797
40040	9/ 7/40	RUSSELL	MAN	5047	10115	OATS		LEAF	1213	P.C.NO HALO	1214	P.C.NO HALO	
40041	8/ 7/40	HIGH BLUFF	MAN	5000	9815	OATS		LEAF	1215	P.C.NO HALO	1216	P.C.NO HALO	1706
40045	16/ 7/40	MINIOTA	MAN	5008	10100	WHEAT		GLUME	1219	PS.ATROFAC.	1220	PS.ATROFAC.	
40048	25/ 7/40	WINNIPEG	MAN	4953	9709	BEAN		POD	1221	X.PHASEOLI	1222	X.PHASEOLI	3778
40054	24/ 7/40	HARTNEY	MAN	4928	10030	OATS	VANGUARD	LEAF	1232	P.C.NO HALO	1234	P.C.NO HALO	1727
40055	25/ 7/40	AUSTIN	MAN	4947	9855	WHEAT	RENOWN	GLUME AND PETIOLE	1235	X.T.CEREAL.	1236	X.T.CEREAL.	1503
40062	31/ 7/40	VISTA	MAN	5037	10043	OATS	VANGUARD	LEAF	1247	P.C.NO HALO			1728
40063	1/ 8/40	SOLSGIRTH	MAN	5029	10054	OATS		LEAF	1249	P.C.HALO	1250	P.C.HALO	1708
40064	2/ 8/40	KELWOOD	MAN	5038	9922	OATS		LEAF	1251	P.C.NO HALO			
40068	0/ 8/40	MORDEN	MAN	4911	9805	TOMATO		FRUIT	1253	P.TOMATO	1254	P.TOMATO	
40070	0/ 9/40	FORT SIMPS	NWT	6200	12200	OATS		LEAF	1257	P.C.NO HALO	1258	P.C.NO HALO	1729
41009	2/ 7/41	WINNIPEG	MAN	4953	9709	RYE		LEAF	1285	X.T.UNDULO	1286	X.T.UNDULO	
41020	10/ 7/41	OAK LAKE	MAN	4947	10038	WHEAT	THATCHER	LEAF	1307	X.T.UNDULO			
41021	10/ 7/41	06 W BRANDON	MAN	4950	9957	WHEAT	THATCHER	LEAF	1309	X.T.UNDULO			
41035	19/ 8/41	WINNIPEG	MAN	4953	9709	TOMATO	BOUNTY	FRUIT	1331	P.TOMATO	1332	P.TOMATO	
41036	19/ 8/41	BAGOT	MAN	4957	9837	TOMATO		FRUIT	1333	X.VESICAT.	1334	X.VESICAT.	
41039	10/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO	BOUNTY	FRUIT	1341	P.TOMATO	1342	P.TOMATO	
41040	11/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1343	P.TOMATO	1344	P.TOMATO	
41041	11/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1345	P.TOMATO	1346	P.TOMATO	
41042	10/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1347	P.TOMATO	1348	P.TOMATO	
41043	11/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1349	P.TOMATO	1350	P.TOMATO	
41044	10/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1351	P.TOMATO	1352	P.TOMATO	

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date	Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
41045	10/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1353	P.TOMATO	1354	P.TOMATO	
41046	10/ 9/41	WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1355	P.TOMATO	1356	P.TOMATO	
41054	6/12/41	WINNIPEG	MAN	4953	9709	POTATO		PETIOLE	1367	COR.SEPED.	1368	COR.SEPED.	
42001	0/ 0/42	TORONTO	ONT	4339	7923	HED HELX		LEAF	1389	X.HEDERAE	1390	X.HEDERAE	
42002	0/ 0/42	WINNIPEG	MAN	4953	9709	TOMATO	BOUNTY	COTLEDN	1392	P.TOMATO			
42007	15/ 6/42	WINNIPEG	MAN	4953	9709	OATS	VICTORY	LEAF	1411	P.C.HALO	1412	P.C.HALO	
42009	15/ 6/42	WINNIPEG	MAN	4953	9709	OATS	VICTORY	LEAF	1413	P.C.HALO	1414	P.C.HALO	
42015	9/ 7/42	WINNIPEG	MAN	4953	9709	OATS	AJAX	LEAF	1423	P.C.NO HALO			
42016	12/ 7/42	PORTAGE LA	MAN	4957	9825	BEAN		LEAF	1425	P.PHASEOL.			
42020	15/ 7/42	BRANDON	MAN	4950	9957	BARLEY	NEWAL	LEAF	1429	X.T.H-AV.	1449	X.T.H-AV.	
42021	15/ 7/42	BRANDON	MAN	4950	9957	BARLEY	PLUSH	LEAF	1430	X.T.H-AV.	1450	PS.ATROFAC.	
42022	15/ 7/42	BRANDON	MAN	4950	9957	BARLEY	U.S.5	LEAF	1451	X.T.H-AV.			
42035	30/ 7/42	SASKATOON	SAS	5207	10638	WHEAT	PELISSIER	LF SHTH	1435	PS.ATROFAC.	3635	PS.ATROFAC.	3635
42036	18/ 8/42	KYLE	SAS	5050	10802	WHEAT	THATCHER	GLUME	1436	X.T.UNDULO			4126
42039	22/ 8/42	PARKSIDE	SAS	5310	10633	WHEAT	THATCHER	GLUME	1440	PS.ATROFAC.			
42055	29/ 7/42	CRESTON	BC	4906	11631	OATS	MABEL	LEAF	1475	P.C.NO HALO			3784
42059	0/ 0/42	KEMPTVILLE	ONT	4501	7539	OATS	ERBAN	LEAF	1489	P.C.HALO			
42061	9/ 9/42	WINNIPEG	MAN	4953	9709	TX K-SAG		LEAF	1476	X.TARAXICI			
42073	0/ 0/42	KAPUSKASIN	ONT	4925	8226	WHEAT	THATCHER	GLUME	1499	X.T.UNDULO	1500	X.T.UNDULO	
42076	24/11/42	WINNIPEG	MAN	4953	9709	TX K-SAG		LEAF	1527	X.TARAXICI			
43002	10/ 2/43	WINNIPEG	MAN	4953	9709	TX K-SAG		ROOT	1533	X.TARAXICI	1534	X.TARAXICI	
43005	14/ 7/43	05 W ELM CREEK	MAN	4941	9800	WHEAT	THATCHER	LEAF	1544	X.T.CEREAL.			3638
43006	14/ 7/43	TREHERNE	MAN	4938	9841	OATS		LEAF	1545	P.C.HALO			1710
43015	14/ 7/43	10 N STONEWALL	MAN	5009	9721	OATS	VANGUARD	LEAF	1549	P.C.HALO			1711
43018	23/ 7/43	MORDEN	MAN	4911	9805	WHEAT	GARNET	LEAF	1551	X.T.UNDULO			
43019	23/ 7/43	MORDEN	MAN	4911	9805	WHEAT	MARQUIS	LEAF	1552	X.T.UNDULO			
43020	23/ 7/43	03 S CARMAN	MAN	4932	9800	OATS		LEAF	1613	P.C.HALO			5589
43024	4/ 8/43	WAWANESA	MAN	4936	9941	WHEAT	RENOWN	HEAD	1557	X.T.CEREAL.			
43026	6/ 8/43	01 W STE ROSE	MAN	5103	9932	WHEAT	THATCHER	GLUME	1563	X.T.UNDULO			
43027	6/ 8/43	03 N EDEN	MAN	5023	9927	OATS		LEAF	1614	P.C.HALO			1712
43029	6/ 8/43	MACDONALD	MAN	5003	9828	BARLEY	TWO ROW	LEAF	1565	X.T.H-AV.			3044
43039	25/ 8/43	WINNIPEG	MAN	4953	9709	WHEAT	CT405	GLUME	1579	X.T.UNDULO			
43040	25/ 8/43	WINNIPEG	MAN	4953	9709	WHEAT	CT404	GLUME	1583	X.T.CEREAL.	1584	X.T.UNDULO	3042
43041	25/ 8/43	WINNIPEG	MAN	4953	9709	WHEAT	APEX	GLUME	1589	X.T.UNDULO	1590	X.T.UNDULO	
43046	23/ 8/43	ROSTHERN	SAS	5240	10617	WHEAT		GLUME	1593	PS.ATROFAC.	1594	PS.ATROFAC.	
43048	18/ 8/43	WINNIPEG	MAN	4953	9709	SOYBEAN		LEAF	1585	P.GLYCINEA			1636
43054	3/ 9/43	WINKLER	MAN	4911	9756	SOYBEAN	KABATT	LEAF	1658	P.GLYCINEA	1659	P.GLYCINEA	
43064	0/ 0/43	MANOTICK	ONT	4513	7541	WHEAT	RENOWN	GLUME	1609	X.T.UNDULO			
43066	0/ 0/43	KAPUSKASIN	ONT	4925	8226	WHEAT	THATCHER	GLUME	1610	X.T.UNDULO			
43075	1/12/43	WINNIPEG	MAN	4953	9709	SOYBEAN	PAGODA	LEAF	1636	P.GLYCINEA	1637	P.GLYCINEA	
44003	21/ 2/44	WINNIPEG	MAN	4953	9709	OATS	RICHLAND	SEM JNT	1746	P.C.HALO			
44014	12/11/44	WINNIPEG	MAN	4953	9709	TOMATO	BOUNTY	FRUIT	1774	P.TOMATO			
44017	8/ 7/44	MORDEN	MAN	4911	9805	WHEAT		LEAF	1777	X.T.CEREAL.			
44018	4/ 7/44	HEADINGLEY	MAN	4953	9724	WHEAT	THATCHER	LEAF	1778	X.T.UNDULO			

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Collection No.	Date			Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
44019	5/ 7/44			BINSCARTH	MAN	5037	10116	OATS		LEAF	1779	P.C.HALO			
44021	5/ 7/44			SHELLMOUTH	MAN	5056	10126	OATS		LEAF	1781	P.C.HALO			
44023	4/ 7/44			WOODSIDE	MAN	5011	9846	OATS		LEAF	1844	P.C.HALO			
44026	5/ 7/44			SHOAL LAKE	MAN	5026	10034	OATS		LEAF	1786	PS.ATROFAC.	1845	P.C.HALO	1786
44031	6/ 7/44			BRANDON	MAN	4950	9957	WHEAT	RENOWN	GLUME	1795	X.T.CEREAL.			3039
44042	2/ 8/44	05	S	STE ROSE	MAN	5103	9932	WHEAT	THATCHER	GLUME	1807	XTU.OR CER.			
44045	9/ 8/44			WINNIPEG	MAN	4953	9709	WHEAT	R.L.2040	GLUME	1811	X.T.CEREAL.			3040
44046	9/ 8/44			WINNIPEG	MAN	4953	9709	WHEAT	R.L. 1834.1	GLUME	1812	XTU.OR CER.			
44047	9/ 8/44			WINNIPEG	MAN	4953	9709	WHEAT	R.L. 1834.1	GLUME	1815	XTU.OR CER.	1817	XTU.OR CER.	
44048	5/ 7/44			GILBERT PL	MAN	5108	10030	OATS		LEAF	1846	P.C.HALO			
44049	9/ 8/44			WINNIPEG	MAN	4953	9709	WHEAT	R.L.2040	GLUME	1819	XTU.OR CER.	1820	XTU.OR CER.	
44050	9/ 8/44			WINNIPEG	MAN	4953	9709	WHEAT	R.L. 3038	GLUME	1822	XTU.OR CER.	1823	XTU.OR CER.	
44052	9/ 8/44			WINNIPEG	MAN	4953	9709	WHEAT	C.T.408	GLUME	1828	X.T.UNDULO			
44055	0/ 8/44			MORDEN	MAN	4911	9805	WHEAT	RENOWN	GLUME	1837	XTU.OR CER.			
44063	12/ 9/44			MORDEN	MAN	4911	9805	TURNIP		LEAF	1853	X.CAMPEST.			
44066	8/ 9/44			WINNIPEG	MAN	4953	9709	SOYBEAN	KABATT	LEAF	1857	P.GLYCINEA	1860	P.GLYCINEA	
44068	22/ 9/44			SASKATOON	SAS	5207	10638	CABBAGE		STALK	1863	X.CAMPEST.			
44076	25/ 9/44			WINNIPEG	MAN	4953	9709	TOMATO		FRUIT	1871	P.TOMATO	1872	P.TOMATO	1871
45015	19/ 6/45			MORDEN	MAN	4911	9805	LILAC	NOKOMIS	LEAF	2009	P.SYRINGAE	2010	P.SYRINGAE	2009
45016	19/ 6/45			MORDEN	MAN	4911	9805	LILAC	SKINRS LOUV	LEAF	2027	P.SYRINGAE			2027
45020	19/ 6/45			MORDEN	MAN	4911	9805	ASIA ELM		LEAF	2011	UNIDENT.P.P.	2012	UNIDENT.P.P.	
45030	19/ 6/45			MORDEN	MAN	4911	9805	PLUM		FRUIT	2014	P.SYRINGAE			
45038	27/ 6/45			RESTON	MAN	4935	10102	ACONITUM	MONKSHOOD	STALK	2018	P.SYRINGAE			
45039	25/ 6/45	02	N	BRADWELL	SAS	5157	10615	MEL ALBA	SW.CLOVER	ROOT	2020	P.SYRINGAE	2021	P.SYRINGAE	
45041	8/ 7/45			GILBERT PL	MAN	5108	10030	OATS	R.L.1273	LEAF	2030	P.C.HALO	2031	P.C.HALO	2030
45043	9/ 7/45	01	S	MINNEDOSA	MAN	5014	9951	BARLEY		LEAF	2049	X.T.HORDEI	2050	X.T.HORDEI	
45051	18/ 7/45			BRANDON	MAN	4950	9957	WHEAT	THATCHER	LEAF	2054	X.T.UNDULO			
45053	10/ 7/45			PORTAGE LA	MAN	4957	9825	OATS		LEAF	2038	P.C.NO HALO			2038
45058	27/ 7/45	05	W	MARIAPOLIS	MAN	4921	9900	WHEAT	THATCHER	LEAF	2040	X.T.UNDULO			3045
45093	1/ 8/45	04	E	SWAN RIVER	MAN	5206	10116	RYE		LEAF	2043	X.T.UNDULO			
45095	30/ 7/45	03	N	MINNEDOSA	MAN	5014	9951	WHEAT	RENOWN	GLUME	2063	X.T.UNDULO			
45096	30/ 7/45	05	W	BASSWOOD	MAN	5019	10002	WHEAT	RENOWN	GLUME	2045	X.T.UNDULO			
45109	11/ 8/45			WINNIPEG	MAN	4953	9709	WHEAT		GLUME	2074	X.T.UNDULO			
45111	20/ 8/45			WINNIPEG	MAN	4953	9709	BEAN		LEAF	2075	X.PHASEOLI			
45113	20/ 8/45			WINNIPEG	MAN	4953	9709	BEAN		LEAF	2076	P.PHASEOL.			2076
45114	20/ 8/45			WINNIPEG	MAN	4953	9709	BEAN	CALAPPROVED	LEAF	2077	X.PHASEOLI			
45115	20/ 8/45			WINNIPEG	MAN	4953	9709	BEAN		LEAF	2078	P.PHASEOL.			2079
45116	25/ 7/45			WINNIPEG	MAN	4953	9709	BEAN		LEAF	2079	P.PHASEOL.			2079
45128	10/ 8/45	06	NE	MORDEN	MAN	4911	9805	ARG RAPE		LEAF	3000	X.CAMPEST.	3001	X.CAMPEST.	3000
46008	28/ 1/46			BRANDON	MAN	4950	9957	TURNIP		ROOT	3024	X.CAMPEST.	3025	X.CAMPEST.	
46015	23/ 3/46			WINNIPEG	MAN	4953	9709	BARLEY	STAR	LEAF	3032	X.T.H-AV.			
46021	5/ 6/46	01	S	SWAN RIVER	MAN	5206	10116	ALFALFA		ROOT	3080	COR.INSID.	3081	COR.INSID.	
46023	5/ 6/46	02	N	ETHELBERT	MAN	5131	10022	ALFALFA		ROOT	3083	COR.INSID.	3084	COR.INSID.	
46024	11/ 6/46			GROSSE ISL	MAN	5000	9725	ALFALFA		ROOT	3085	COR.INSID.	3086	COR.INSID.	

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Collection No.	Date	Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
46025	12/ 6/46	WINNIPEG B	MAN	5031	9658	ALFALFA		ROOT	3088	COR.INSID.	3089	COR.INSID.	
46026	12/ 6/46	KOMARNO	MAN	5028	9712	ALFALFA		ROOT	3092	COR.INSID.	3093	COR.INSID.	3095
46032	8/ 7/46	NINGA	MAN	4913	9951	OATS		LEAF	3110	P.C.HALO	3111	P.C.HALO	3110
46033	8/ 7/46	03 N HORTON	MAN	4908	10007	OATS		LEAF	3112	P.C.HALO	3113	P.C.HALO	3112
46034	8/ 7/46	03 E LYLETON	MAN	4902	10110	OATS		LEAF	3114	P.C.HALO	3115	P.C.HALO	
46035	9/ 7/46	06 S TILSTON	MAN	4924	10118	OATS		LEAF	3116	P.C.HALO	3117	P.C.HALO	
46036	12/ 7/46	02 S EDEN	MAN	5023	9927	OATS		LEAF	3131	P.C.NO HALO	3132	P.C.NO HALO	3132
46037	11/ 7/46	01 S BOWSMAN	MAN	5214	10114	RYE		LEAF	3169	X.T.UNDULO	3170	X.T.UNDULO	
46039	10/ 7/46	05 S HARDING	MAN	5000	10030	WHEAT	REGENT	LEAF	3133	PS.ATROFAC.	3134	PS.ATROFAC.	3133
46040	11/ 7/46	04 W KENVILLE	MAN	5200	10120	OATS		LEAF	3135	P.C.HALO	3136	P.C.HALO	
46043	10/ 7/46	01 E NEWDALE	MAN	5020	10008	OATS		LEAF	3120	P.C.HALO	3121	P.C.HALO	
46044	10/ 7/46	02 E VISTA	MAN	5037	10043	WHEAT	THATCHER	LEAF	3122	X.T.UNDULO			
46046	10/ 7/46	03 N GRISWOLD	MAN	4945	10025	OATS		LEAF	3164	P.C.HALO			3164
46054	20/ 7/46	WINNIPEG	MAN	4953	9709	TOMATO	BOUNTY	LEAF	3126	P.TOMATO			3126
46057	30/ 7/46	HIGH BLUFF	MAN	5000	9815	OATS		LEAF	3173	P.C.HALO			3173
46060	5/ 8/46	PORTAGE LA	MAN	4957	9825	FIELD PE	ARTHUR	POD	3152	P.PISI	3153	P.PISI	
46061	5/ 8/46	PORTAGE LA	MAN	4957	9825	PEAS	DASHAWAY	STALK	3154	P.PISI	3155	P.PISI	4591
46072	6/ 8/46	SELKIRK	MAN	5009	9652	TOMATO		STALK	3143	P.TOMATO	3144	P.TOMATO	
46073	9/ 8/46	WINNIPEG	MAN	4953	9709	TOMATO	BOUNTY	FRUIT	3146	COR.MICH.	3147	COR.MICH.	
46074	9/ 8/46	WINNIPEG	MAN	4953	9709	TOMATO	BOUNTY	STALK	3148	COR.MICH.	3149	COR.MICH.	3148
46075	27/ 8/46	BRANDON	MAN	4950	9957	CUCUMBER	MINCU	LEAF	3179	P.LACHRY.	3180	P.LACHRY.	
46078	26/ 8/46	MORDEN	MAN	4911	9805	LIMA BN		LEAF	3187	UNIDENT.P.P.			3187
46082	27/ 8/46	WINNIPEG	MAN	4953	9709	BEAN	TENDERGREEN	POD	3196	P.PHASEOL.			3196
47008	17/ 6/47	CHATHAM	ONT	4224	8211	BEAN		KERNEL	3290	COR.FLACC.	3291	COR.FLACC.	3291
47037	9/10/47	WINNIPEG	MAN	4953	9709	TURNIP		ROOT	3318	X.CAMPEST.	3319	X.CAMPEST.	3318
47039	20/10/47	WINNIPEG	MAN	4953	9709	BEAN	G STRLS GPD	STALK	3320	UNIDENT.P.P.	3321	UNIDENT.P.P.	
47046	5/11/47	WINNIPEG	MAN	4953	9709	BEAN	G STRLS GPD	STALK	3333	COR.FLACC.	3334	COR.FLACC.	3333
48006	25/ 6/48	WINNIPEG	MAN	4953	9709	WHEAT		LEAF	3391	X.T.UNDULO	3392	X.T.UNDULO	
48007	3/ 7/48	WINNIPEG	MAN	4953	9709	BEAN		LEAF	3407	P.PHASEOL.	3408	P.PHASEOL.	
48029	20/ 7/48	WINNIPEG	MAN	4953	9709	WHEAT	SAUNDERS	LEAF	3409	X.T.UNDULO	3410	X.T.UNDULO	3409
48031	19/ 7/48	WINNIPEG	MAN	4953	9709	OATS	EXETER	LEAF	3412	P.C.HALO			
48032	19/ 7/48	WINNIPEG	MAN	4953	9709	OATS	EXETER	LEAF	3414	P.C.HALO			
48033	19/ 7/48	DAUPHIN	MAN	5109	10003	CUCUMBER		LEAF	3415	P.LACHRY.	3416	P.LACHRY.	3416
48034	17/ 7/48	WINNIPEG	MAN	4953	9709	BEAN		LEAF	3417	X.PHASEOLI			
48035	17/ 7/48	WINNIPEG	MAN	4953	9709	TOMATO		LEAF	3420	P.TOMATO	3421	P.TOMATO	3420
48040	12/ 7/48	BROOKDALE	MAN	5004	9934	OATS		LEAF	3427	P.C.HALO	3428	P.C.HALO	3428
48044	23/ 7/48	PILOT MOUN	MAN	4916	9855	OATS	AJAX	LEMMA	3431	P.C.HALO			3431
48048	26/ 7/48	WINNIPEG	MAN	4953	9709	BARLEY		LEAF	3465	X.T.H-AV.			4721
48050	28/ 7/48	WINNIPEG	MAN	4953	9709	CABBAGE		LEAF	3438	X.CAMPEST.			4790
48084	30/ 8/48	WINNIPEG	MAN	4953	9709	WHEAT		GLUME	3507	X.T.UNDULO			
48092	20/ 8/48	WINNIPEG	MAN	4953	9709	CUCUMBER		STALK	3516	UNIDENT.P.P.	3517	UNIDENT.P.P.	
49010	2/ 6/49	LAROCHELLE	MAN	4922	9659	PEAS	PRIDE	LEAF	3541	P.PISI	3542	P.PISI	
49012	3/ 6/49	SEDDONS CR	MAN	5004	9631	LATH VEN		LEAF	3543	UNIDENT.P.P.	3544	UNIDENT.P.P.	3812
49013	3/ 6/49	SEDDONS CR	MAN	5004	9631	LATH VEN		STALK	3545	UNIDENT.P.P.	3546	UNIDENT.P.P.	

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date	Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
49021	11/ 6/49	LAROCHELLE	MAN	4922	9659	FALL RYE		LEAF	3553	X.T.UNDULO	3554	X.T.UNDULO	3554
49028	23/ 6/49	WINNIPEG	MAN	4953	9709	PEAS	DELW COMMDO	LEAF	3565	UNIDENT.P.P.			
49030	23/ 6/49	05 E WINKLER	MAN	4911	9756	FALL RYE		LEAF	3569	X.T.UNDULO	3570	X.T.UNDULO	3570
49033	24/ 6/49	LIMERICK	SAS	4940	10615	BARLEY		LEAF	3571	X.T.H-AV.			
49034	14/ 7/49	WINNIPEG	MAN	4953	9709	BEAN		LEAF	3573	P.PHASEOL.	3574	P.PHASEOL.	3573
49035	16/ 7/49	WINNIPEG	MAN	4953	9709	BARLEY	TITAN	LEAF	3575	X.T.H-AV.	3576	X.T.H-AV.	4813
49036	12/ 7/49	SASKATOON	SAS	5207	10638	OATS		LEAF	3578	P.STRIAF.			
49059	0/ 0/49	EDINBURGH	SCO	5557	310	OATS		LEAF	3580	P.C.HALO	3581	P.C.HALO	
49061	21/ 7/49	WINNIPEG	MAN	4953	9709	TOMATO		PETIOLE	3584	COR.MICH.	3585	COR.MICH.	3584
49062	75/ 7/49	WINNIPEG	MAN	4953	9709	TOMATO		STALK	3589	COR.MICH.			
49063	28/ 7/49	DONCREST	SAS	5235	10250	OATS		LEAF	3616	P.C.NO HALO			3616
49077	9/11/49	WINNIPEG	MAN	4953	9709	HED HELX		LEAF	3625	X.HEDERAE			3625
50001	15/ 3/50	WINNIPEG	MAN	4953	9709	BARLEY	TITAN	LEAF	3643	X.T.H-AV.	3644	X.T.H-AV.	
50013	22/ 8/50	05 N SELKIRK	MAN	5009	9652	MILLET		LEAF	3718	UNIDENT.P.P.	3719	UNIDENT.P.P.	3719
50014	26/ 8/50	BRANDON	MAN	4950	9957	WHEAT	LEE	NECK	3720	X.T.CEREAL.			
50023	6/ 9/50	BELLE PLAI	SAS	5024	10509	WHEAT	RESCUE	KERNEL	3730	PS.ATROFAC.	3731	PS.ATROFAC.	
50026	21/ 9/50	CHOICELAND	SAS	5327	10425	WHEAT		NECK	3736	X.T.UNDULO	3738	X.T.UNDULO	4136
50027	4/10/50	LUMSDEN	SAS	4902	10110	CABBAGE		STALK	3748	X.CAMPEST.	3749	X.CAMPEST.	
50028	10/10/50	POCATIERE	PQ	4722	7002	ALFALFA		ROOT	3746	COR.INSID.	3747	COR.INSID.	
51012	15/ 1/51	WINNIPEG	MAN	4953	9709	WHEAT	REDMAN	GLUME	3775	X.T.CEREAL.	3776	X.T.CEREAL.	
51023	15/ 9/51	SASKATOON	SAS	5207	10638	RYE	PROLIFIC	LEAF	3829	UNIDENT.P.P.	3830	UNIDENT.P.P.	
51026	15/ 6/51	WINNIPEG	MAN	4953	9709	OATS		LEAF	3831	P.C.HALO			
51027	15/ 6/51	WINNIPEG	MAN	4953	9709	OATS		LEAF	3832	P.C.NO HALO			
51031	6/ 7/51	05 S MARQUETTE	MAN	5003	9736	OATS		LEAF	3853	P.C.HALO	3854	P.C.HALO	
51032	12/ 7/51	WINKLER	MAN	4911	9756	HAWTHORN		PEDUNCL	3855	ER.AMYLOV.	3856	ER.AMYLOV.	3856
51034	17/ 7/51	WINNIPEG	MAN	4953	9709	OATS		LEAF	3859	P.C.HALO	3860	P.C.HALO	
51036	25/ 7/51	MEADOWS	MAN	4949	9731	PEAS	FREEZONIAN	LEAF	3863	P.PISI	3864	P.PISI	
51060	9/ 8/51	04 N PORTAGE LA	MAN	4957	9825	PEAS	DASHAWAY	LEAF	3886	P.PISI	3887	P.PISI	
51061	10/ 8/51	02 SE ST EUSTACH	MAN	4958	9747	PEAS	ARTHUR	LEAF	3888	P.PISI	3889	P.PISI	
51062	10/ 8/51	02 SE ST EUSTACH	MAN	4958	9747	CUCUMBER		LEAF	3890	P.LACHRY.	3891	P.LACHRY.	
51064	15/ 8/51	BELLEVIEW	MAN	4936	10050	WHEAT	SAUNDERS	LEAF	3894	PS.ATROFAC.	3895	PS.ATROFAC.	3894
51065	17/ 8/51	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 713	GLUME	3896	PS.ATROFAC.	3899	PS.ATROFAC.	
51069	30/ 7/51	WINNIPEG	MAN	4953	9709	BARLEY	PANNIER	LEAF	3945	X.T.H-AV.			4805
51070	14/ 8/51	WINNIPEG	MAN	4953	9709	WHEAT	APEX	LEMMA	3901	PS.ATROFAC.	3902	PS.ATROFAC.	3901
51071	21/ 8/51	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 153	GLUME	3903	PS.ATROFAC.	3905	PS.ATROFAC.	3905
51072	30/ 7/51	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 153	LEAF	3909	X.T.UNDULO	3910	X.T.UNDULO	
51073	28/ 8/51	PULP RIVER	MAN	5148	10038	WHEAT	REGENT	KERNEL	3923	PS.ATROFAC.	3924	PS.ATROFAC.	
51074	28/ 8/51	PULP RIVER	MAN	5148	10038	WHEAT	REGENT	LEMMA	3925	PS.ATROFAC.			3925
51075	28/ 8/51	PULP RIVER	MAN	5148	10038	WHEAT	REGENT	GLUME	3926	PS.ATROFAC.			3926
51088	0/ 0/51	CHARLOTTET	PEI	4614	6308	DAHLIA		ROOT	3990	AGRO.TUMEF.	3991	AGRO.TUMEF.	4722
52008	6/ 6/52	03 W ST NORBERT	MAN	4946	9710	OATS		LEAF	4011	P.C.NO HALO	4012	P.C.NO HALO	4011
52014	10/ 7/52	STEEP ROCK	MAN	5126	9848	OATS		LEAF	4072	P.C.HALO			4072
52015	10/ 7/52	NIPAWIN	SAS	5322	10400	OATS		LEAF	4019	P.C.NO HALO	4058	P.C.NO HALO	
52016	11/ 7/52	05 W ST NORBERT	MAN	4946	9710	RYE		LEAF	4020	X.T.SECAL.	4059	X.T.SECAL.	

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date	Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
52019	16/ 7/52	OAK LAKE	MAN	4947	10038	QUACK GR		LEAF	4021	X.T.CEREAL.	4060	X.T.CEREAL.	
52020	17/ 7/52	GRISWOLD	MAN	4945	10025	WILD MUS		POD	4022	UNIDENT.P.P.	4061	UNIDENT.P.P.	
52021	16/ 7/52	KEMNAY	MAN	4951	10007	WHEAT		GLUME	4023	PS.ATROFAC.	4063	PS.ATROFAC.	4023
52022	16/ 7/52	ST FRANCOI	MAN	4955	9732	BARLEY		LEAF	4101	X.T.H-AV.	4079	X.T.H-AV.	4079
52023	16/ 7/52	POPLAR POI	MAN	5004	9758	BARLEY		LEAF	4081	X.T.CEREAL.	4082	X.T.CEREAL.	4081
52025	17/ 7/52	03 N PIPESTONE	MAN	4934	10058	RYE		LEAF	4024	X.T.SECAL.	4064	X.T.SECAL.	
52026	17/ 7/52	04 W RESTON	MAN	4935	10102	RYE		LEAF	4025	X.T.SECAL.	4065	X.T.SECAL.	
52027	17/ 7/52	02 N PIPESTONE	MAN	4934	10058	OATS		LEAF	4066	P.C.NO HALO			
52028	16/ 7/52	ST EUSTACH	MAN	4958	9747	CUCUMBER		LEAF	4027	P.LACHRY.	4067	P.LACHRY.	
52030	16/ 7/52	ST EUSTACH	MAN	4958	9747	CUCUMBER		LEAF	4028	P.LACHRY.	4068	P.LACHRY.	
52035	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	MARQUIS	GLUME	4029	XTU.OR CER.			4029
52038	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	MARQUIS	GLUME	4032	X.T.UNDULO			
52040	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	REDMAN	GLUME	4034	X.T.UNDULO			
52041	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT		GLUME	4035	X.T.UNDULO			
52042	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT		GLUME	4036	X.T.UNDULO			
52043	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	LEE	GLUME	4037	X.T.UNDULO			
52045	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	LEE	GLUME	4039	X.T.UNDULO			
52046	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	LEE	GLUME	4040	X.T.UNDULO			
52047	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 179	GLUME	4041	X.T.UNDULO			
52049	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 179	GLUME	4042	X.T.UNDULO			
52050	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 179	GLUME	4043	X.T.UNDULO			
52051	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 316	GLUME	4044	X.T.UNDULO			
52055	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 707	GLUME	4049	X.T.UNDULO			
52056	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT		GLUME	4050	X.T.UNDULO			
52059	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	H44-24	GLUME	4053	X.T.UNDULO			
52060	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	H44-24	GLUME	4054	X.T.UNDULO			
52061	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	H44-24	GLUME	4056	X.T.UNDULO			
52062	15/ 7/52	WINNIPEG	MAN	4953	9709	WHEAT	H44-24	GLUME	4057	X.T.UNDULO			
52066	1/ 8/52	WINNIPEG	MAN	4953	9709	WHEAT	LEE	LEAF	4087	PS.ATROFAC.	4088	PS.ATROFAC.	
52068	1/ 8/52	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 186	LEAF	4089	PS.ATROFAC.	4090	PS.ATROFAC.	4089
52071	1/ 8/52	BRANDON	MAN	4950	9957	BARLEY	VANTAGE	LEAF	4075	PS.ATROFAC.	4076	PS.ATROFAC.	
52072	1/ 8/52	02 W ST FRANCOI	MAN	4955	9732	BARLEY	MONTCALM	LEAF	4093	PS.ATROFAC.	4094	X.T.H-AV.	4094
52078	15/ 8/52	WINNIPEG	MAN	4953	9709	CARROT	NANTES	LEAF	4110	X.CAROTAE	4111	X.CAROTAE	
52079	15/ 8/52	SASKATOON	SAS	5207	10638	WHEAT		GLUME	4102	PS.ATROFAC.	4103	PS.ATROFAC.	4103
53005	29/ 5/53	WINNIPEG	MAN	4953	9709	GERANIUM		STALK	4140	UNIDENT.P.P.	4141	UNIDENT.P.P.	
53006	15/ 6/53	BRANDON	MAN	4950	9957	OATS	EXETER	LEAF	4143	P.C.NO HALO	4145	P.C.NO HALO	
53009	10/ 7/53	WINNIPEG	MAN	4953	9709	BARLEY		LEAF	4271	X.T.HORDET	4272	UNIDENT.P.P.	
53010	10/ 7/53	WINNIPEG	MAN	4953	9709	WHEAT	SAUNDERS	LEAF	4273	X.T.UNDULO	4274	PS.ATROFAC.	4274
53011	13/ 7/53	WINNIPEG	MAN	4953	9709	BARLEY		LEAF	4149	X.T.H-AV.	4150	UNIDENT.P.P.	
53013	14/ 7/53	WINNIPEG	MAN	4953	9709	TURNIP	ALLSWEET	LEAF	4152	X.CAMPEST.			4152
53014	14/ 7/53	WINNIPEG	MAN	4953	9709	CUCUMBER	NEW PROLIFC	LEAF	4153	UNIDENT.P.P.	4154	UNIDENT.P.P.	4154
53015	14/ 7/53	WINNIPEG	MAN	4953	9709	PEAS	HMSTDRXMRVL	LEAF	4155	P.PISI	4156	P.PISI	
53016	14/ 7/53	WINNIPEG	MAN	4953	9709	SOYBEAN		LEAF	4157	P.GLYCINEA	4158	P.GLYCINEA	4157
53017	15/ 7/53	BRANDON	MAN	4950	9957	BARLEY	MTCLMXANOID	LEAF	4159	X.T.H-AV.	4160	X.T.H-AV.	

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date	Location	Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
53019	16/ 7/53	05 E BOISSEVAIN MAN	4914	10003	BARLEY		LEAF	4173	X.T.H-AV.	4174	X.T.H-AV.	4173
53020	16/ 7/53	05 E BROOMHILL MAN	4923	10105	BARLEY		LEAF	4175	X.T.H-AV.	4176	X.T.H-AV.	4175
53021	15/ 7/53	PIGEON LAK MAN	4957	9736	BARLEY		LEAF	4177	X.T.H-AV.	4178	X.T.H-AV.	4177
53022	15/ 7/53	ST FRANCOI MAN	4955	9732	BARLEY		LEAF	4179	X.T.H-AV.	4180	X.T.H-AV.	4179
53023	15/ 7/53	03 E SIDNEY MAN	4954	9904	BARLEY		LEAF	4181	X.T.H-AV.	4182	PS.ATROFAC.	4182
53024	16/ 7/53	PIPESTONE MAN	4934	10058	BARLEY		LEAF	4185	X.T.H-AV.	4187	X.T.H-AV.	4185
53025	15/ 7/53	BRANDON MAN	4950	9957	BARLEY		LEAF	4190	X.T.H-AV.	4191	X.T.H-AV.	
53026	16/ 7/53	02 E MORDEN MAN	4911	9805	DURUM WH		LF SHTH	4192	PS.ATROFAC.	4193	PS.ATROFAC.	4192
53027	16/ 7/53	05 E DELORAINE MAN	4912	10029	WHEAT	LEE	LEAF	4194	X.T.UNDULO			
53029	15/ 7/53	BRANDON MAN	4950	9957	WHEAT		LEAF	4196	X.T.UNDULO			
53030	16/ 7/53	02 E PILOT MOUN MAN	4916	9855	WHEAT	THATCHER	LEAF	4199	PS.ATROFAC.	4276	PS.ATROFAC.	4276
53031	16/ 7/53	04 SW VIRDEN MAN	4951	10055	WHEAT	THATCHER	LEAF	4201	X.T.CEREAL.			
53032	15/ 7/53	BRANDON MAN	4950	9957	WHEAT	CHINOOK	LEAF	4204	PS.ATROFAC.			4204
53033	15/ 7/53	POPLAR POI MAN	5004	9758	WHEAT		LEAF	4205	PS.ATROFAC.			4205
53034	16/ 7/53	02 E MORDEN MAN	4911	9805	DURUM WH		LEAF	4207	X.T.CEREAL.			
53035	16/ 7/53	05 S PIPESTONE MAN	4934	10058	DURUM WH		LEAF	4209	X.T.CEREAL.			
53036	16/ 7/53	05 E BROOMHILL MAN	4923	10105	WHEAT	LEE	LEAF	4211	X.T.CEREAL.			
53038	16/ 7/53	05 E BROOMHILL MAN	4923	10105	AGP RPNS		LEAF	4216	X.T.CEREAL.			
53039	15/ 7/53	E OAK LAKE MAN	4947	10038	AGP SP		LEAF	4217	X.T.CEREAL.			
53040	16/ 7/53	05 E DELORAINE MAN	4912	10029	AGP RPNS		LEAF	4228	X.T.CEREAL.			
53041	15/ 7/53	05 E DELORAINE MAN	4912	10029	BR INERM		LEAF	4230	X.T.CEREAL.			4230
53042	15/ 7/53	DOUGLAS MAN	4953	9946	RYE		LEAF	4232	X.T.CEREAL.			
53043	16/ 7/53	05 E BROOMHILL MAN	4923	10105	RYE		LEAF	4234	X.T.SECAL.			
53044	16/ 7/53	KILLARNEY MAN	4912	9942	AGP RPNS		LEAF	4277	PS.ATROFAC.			
53045	15/ 7/53	BRANDON MAN	4950	9957	BEAN	TENDERGREEN	LEAF	4236	P.PHASEOL.			
53046	15/ 7/53	BRANDON MAN	4950	9957	OATS		LEAF	4238	P.C.NO HALO			4238
53047	15/ 7/53	08 S JORDAN MAN	4923	9805	OATS		LEAF	4240	P.C.HALO			
53048	9/ 7/53	STEINBACH MAN	4932	9641	BEAN		LEAF	4161	P.PHASEOL.	4162	P.PHASEOL.	
53049	15/ 7/53	WINNIPEG MAN	4953	9709	OATS		LEAF	4163	P.C.NO HALO			
53051	20/ 7/53	WINNIPEG MAN	4953	9709	BARLEY	3870	LEAF	4166	X.T.H-AV.			
53052	20/ 7/53	WINNIPEG MAN	4953	9709	BARLEY	HARLAN	GLUME	4169	X.T.H-AV.	4170	X.T.H-AV.	4170
53053	16/ 7/53	MINNEDOSA MAN	5014	9951	OATS		LEAF	4171	P.C.NO HALO	4172	P.C.NO HALO	
53055	22/ 7/53	AVONLEA SAS	5000	10504	APPLE		SPUR	4243	ER.AMYLOV.	4244	ER.AMYLOV.	4243
53056	4/ 8/53	WINNIPEG MAN	4953	9709	CUCUMBLR		LEAF	4220	P.LACHRY.			4220
53061	6/ 8/53	EDMONTON ALT	5333	11328	BARLEY	TITAN	LEAF	4223	X.T.H-AV.			
53064	22/ 8/53	WINNIPEG MAN	4953	9709	CARROT		LEAF	4249	X.CAROTAE	4250	X.CAROTAE	
53079	21/ 8/53	WINNIPEG MAN	4953	9709	WHEAT	MARQUIS	LEAF	4293	X.T.UNDULO	4294	X.T.UNDULO	
54015	25/ 6/54	FANNYSTELL MAN	4945	9750	BARLEY		LEAF	4350	X.T.H-AV.	4351	X.T.H-AV.	
54016	25/ 6/54	FANNYSTELL MAN	4945	9750	BARLEY		LEAF	4352	X.T.H-AV.	4352	X.T.H-AV.	
54017	25/ 6/54	FANNYSTELL MAN	4945	9750	OATS		LEAF	4354	P.C.HALO			
55002	7/ 2/55	WINNIPEG MAN	4953	9709	WHEAT	LITTLE CLUB	LEAF	4374	ER.UREDOV.			
56008	13/ 4/56	WINNIPEG MAN	4953	9709	WHEAT	THATCHER	LEAF	4499	X.T.UNDULO	4500	X.T.UNDULO	4499
56018	10/ 7/56	01 S DOMAIN MAN	4936	9719	BARLEY		LEAF	4511	X.T.H-AV.			4511
56020	10/ 7/56	MORDEN MAN	4911	9805	TOMATO		LEAF	4513	P.TOMATO			

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Collection No.	Date	Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
56024	1/ 8/56	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 424	HEAD	4523	X.T.UNDULO			
56029	21/ 8/56	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 424	GLUME	4524	X.T.UNDULO	4525	X.T.UNDULO	4528
56030	21/ 8/56	WINNIPEG	MAN	4953	9709	WHEAT	C.T. 733	GLUME	4533	X.T.UNDULO	4534	X.T.UNDULO	4821
57024	31/ 5/57	MORDEN	MAN	4911	9805	APPLE		BRANCH	4615	ER.AMYLOV.	4617	ER.AMYLOV.	
58018	15/ 5/58	MORDEN	MAN	4911	9805	APPLE	COLLET	BRANCH	4731	ER.AMYLOV.	4732	ER.AMYLOV.	
58021	25/ 6/58	MORDEN	MAN	4911	9805	OATS	RODNEY	LEAF	4740	P.C.NO HALO	4741	P.C.NO HALO	4740
58022	11/ 7/58	WINNIPEG	MAN	4953	9709	BARLEY	OLLI	GLUME	4743	X.T.H-AV.	4744	X.T.H-AV.	4743
58023	11/ 7/58	WINNIPEG	MAN	4953	9709	BARLEY	OLLI	GLUME	4745	X.T.H-AV.			4745
58036	29/ 7/58	WINNIPEG	MAN	4953	9709	WHEAT	KENYA FARMR	PEDUNCL	4751	X.T.UNDULO	4752	X.T.UNDULO	4751
58035	29/ 7/58	WINNIPEG	MAN	4953	9709	WHEAT	KENYA FARMR	GLUME	4749	X.T.UNDULO	4750	X.T.UNDULO	4749
58038	29/ 7/58	WINNIPEG	MAN	4953	9709	WHEAT		LEAF	4765	X.T.CEREAL.			4765
58039	29/ 7/58	WINNIPEG	MAN	4953	9709	WHEAT		LEAF	4766	X.T.CEREAL.			4766
58042	21/ 7/58	FLEMING	SAS	5005	10130	BARLEY		LEAF	4758	X.T.H-AV.	4759	X.T.H-AV.	4758
58049	13/ 8/58	WINNIPEG	MAN	4953	9709	MTN ASH		TRUNK	4762	UNIDENT.P.P.			4762
58054	26/11/58	WINNIPEG	MAN	4953	9709	WHEAT	LITTLE CLUB	LEAF	4795	ER.UREDOV.	4796	ER.UREDOV.	
59006	17/ 6/59	CARMAN	MAN	4932	9800	OATS		LEAF	4847	P.C.NO HALO	4848	P.C.NO HALO	4847
59031	17/ 7/59	PORTAGE LA	MAN	4957	9825	BARLEY	LTH 4363-32	LEAF	4875	X.T.H-AV.			4875
60010	2/ 8/60	BEULAH	MAN	5016	10102	WHEAT	PEMBINA	NECK	5010	XTU.OR CER.	5011	XTU.OR CER.	5010
60012	4/ 8/60	NIVERVILLE	MAN	4937	9701	WHEAT	PEMBINA	LEAF	5015	XTU.OR CER.	5016	XTU.OR CER.	5015
62031	19/ 7/62	01 E GAINSBOROU	SAS	4910	10126	OATS		LEAF	5260	P.C.HALO			5260
62033	18/ 7/62	CHRISTIE	MAN	4904	9715	BARLEY	MONTCALM	LEAF	5252	X.T.HORDEI	5253	X.T.HORDEI	
62036	18/ 7/62	01 W FANNYSTELL	MAN	4945	9750	OATS		LEAF	5266	P.C.HALO			5266
62037	18/ 7/62	01 W CYPRUS RIV	MAN	4934	9905	OATS		LEAF	5264	P.C.NO HALO			5264
62038	16/ 7/62	WINNIPEG	MAN	4953	9709	BARLEY		LEAF	5262	X.T.HORDEI	5263	X.T.HORDEI	5262
63006	19/ 6/63	02 W OAK BLUFF	MAN	4947	9926	OATS		LEAF	5313	P.C.NO HALO	5314	P.C.NO HALO	
63012	4/ 7/63	WINNIPEG	MAN	4953	9709	OATS		LEAF	5338	P.C.NO HALO	5339	P.C.NO HALO	5338
63015	16/ 7/63	MELFORT	SAS	5252	10436	OATS	GARRY	LEAF	5331	P.C.NO HALO	5332	P.C.NO HALO	5331
63017	11/ 7/63	WINNIPEG	MAN	4953	9709	BARLEY	PANNIER	LEAF	5335	X.T.H-AV.	5337	X.T.H-AV.	
63021	16/ 7/63	WINNIPEG	MAN	4953	9709	BARLEY	LTH 5134-4	LEAF	5348	X.T.H-AV.			
63022	17/ 7/63	WINNIPEG	MAN	4953	9709	BARLEY	L50824-12-5	LEAF	5350	X.T.H-AV.			5350
63023	16/ 7/63	VANKLEEK H	ONT	4531	7439	OATS		LEAF	5352	P.C.HALO	5353	P.C.HALO	5352
63024	19/ 7/63	02 S GLENLEA	MAN	4938	9709	OATS		LEAF	5354	P.C.NO HALO			5354
63027	19/ 7/63	STE AGATHE	MAN	4934	9710	OATS		LEAF	5356	P.C.NO HALO			5356
63039	29/ 7/63	PORTAGE LA	MAN	4957	9825	BARLEY		LEAF	5393	X.T.H-AV.			5393
63042	25/ 7/63	HAMIOTA	MAN	5010	10030	WHEAT	PEMBINA	GLUME	5385	PS.ATROFAC.			5385
63046	25/ 7/63	HAMIOTA	MAN	5010	10030	WHEAT	PEMBINA	LEAF	5383	PS.ATROFAC.			5383
63048	27/ 7/63	EDGERTON	ALT	5245	11027	WHEAT	SAUNDERS	GLUME	5374	PS.ATROFAC.			5374
63067	17/ 8/63	GLADSTONE	MAN	5015	9850	OATS	RODNEY	LEAF	5423	P.C.NO HALO	5429	P.C.NO HALO	5429
64018	24/ 9/64	LASHBURN	SAS	5308	10936	BARLEY	MONTCALM	KERNEL AND KERNEL	5484	X.T.H-AV.	5485	X.T.HORDEI	5484
64029	23/12/64	WINNIPEG	MAN	4953	9709	TURNIP		ROOT	5497	X.CAMPEST.	5498	X.CAMPEST.	5499
65007	15/ 7/65	GLENLEA	MAN	4938	9709	OATS		LEAF	5514	P.C.NO HALO	5515	P.C.NO HALO	
65018	21/ 8/65	DOMAIN	MAN	4936	9719	WHEAT	MANITOU	LEAF	5529	X.T.CEREAL.	5530	X.T.CEREAL.	5544
65021	0/ 0/65	REGINA	SAS	5025	10439	DURUM WH	D.T.184	GLUME	5522	X.T.UNDULO	5523	X.T.UNDULO	5523

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date			Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
65022	21/ 8/65			DOMAIN	MAN	4936	9719	WHEAT	MANITOU	LEAF	5531	X.T.UNDULO	5532	X.T.UNDULO	5533
66015	4/ 7/66			WINNIPEG	MAN	4953	9709	DURUM WH		LEAF	5544	X.T.UNDULO			
66018	28/ 6/66			MORDEN	MAN	4911	9805	OATS		LEAF	5548	P.C.NO HALO			
66021	28/ 6/66	01	E	ELM CREEK	MAN	4941	9800	WHEAT	MANITOU	LEAF	5554	X.T.CEREAL.			
66022	21/ 7/66	03	W	GRAYSVILLE	MAN	4930	9810	RYE		LEAF	5556	X.T.SECAL.			5556
66023	21/ 7/66	05	N	CARMAN	MAN	4932	9800	RYE		LEAF	5558	X.T.SECAL.			5558
67001	17/ 7/67			GLENLEA	MAN	4938	9709	WHEAT	REWARD	LEAF	5621	X.T.CEREAL.	5622	X.T.CEREAL.	
67003	17/ 7/67			GLENLEA	MAN	4938	9709	OATS	VICTORY	LEAF	5629	P.C.NO HALO			
67004	18/ 7/67			GLENLEA	MAN	4938	9709	DURUM WH	STEWART 63	LEAF	5627	X.T.CEREAL.	5628	X.T.CEREAL.	5628
68001	19/ 6/68			WINNIPEG	MAN	4953	9709	OATS		LEAF	5636	P.C.NO HALO	5637	P.C.NO HALO	
68003	10/ 7/68			STONY MTN	MAN	5005	9714	OATS		LEAF	5639	P.C.NO HALO	5640	P.C.NO HALO	5639
68005	19/ 6/68	01	N	STONY MTN	MAN	5005	9714	OATS		LEAF	5642	P.C.NO HALO			5642
68006	19/ 6/68	01	E	STONEWALL	MAN	5009	9721	OATS		LEAF	5643	P.C.NO HALO			
68007	19/ 6/68	02	S	STONEWALL	MAN	5009	9721	OATS		LEAF	5644	UNIDENT.P.P.	5645	UNIDENT.P.P.	
68008	19/ 6/68	05	N	WINNIPEG	MAN	4953	9709	BARLEY		LEAF	5646	X.T.H-AV.	5647	X.T.HORDEI	5646
68011	22/ 7/68			LETELLIER	MAN	4908	9718	WHEAT	MANITOU	LEAF	5661	X.T.UNDULO	5662	X.T.UNDULO	5661
68012	22/ 7/68	01	W	ST JOSEPH	MAN	4909	9724	BARLEY		LEAF	5663	X.T.H-AV.	5664	X.T.H-AV.	5663
68013	22/ 7/68	03	W	ST JOSEPH	MAN	4909	9724	DURUM WH		LEAF	5657	X.T.CEREAL.			5657
68015	22/ 7/68			WINNIPEG	MAN	4953	9709	TRITICAL		LEAF	5670	X.T.UNDULO	5671	X.T.UNDULO	5670
68016	22/ 7/68			WINNIPEG	MAN	4953	9709	WHEAT	MANITOU	LEAF	5672	X.T.UNDULO	5686	X.T.UNDULO	5686
68017	22/ 7/68			WINNIPEG	MAN	4953	9709	TRITICAL	ROSNER	LEAF	5673	X.T.UNDULO	5674	X.T.UNDULO	5673
68018	22/ 7/68			WINNIPEG	MAN	4953	9709	WHEAT	MEXICAN	LEAF	5675	X.T.UNDULO	5676	X.T.UNDULO	
68021	31/ 7/68			WINNIPEG	MAN	4953	9709	WHEAT	PITIC 62	LEAF	5688	X.T.UNDULO	5689	X.T.UNDULO	5689
68022	1/ 8/68	02	N	GRETNA	MAN	4902	9735	AGP RPNS		LEAF	5690	X.T.CEREAL.	5691	X.T.CEREAL.	5690
68023	31/ 7/68			WINNIPEG	MAN	4953	9709	WHEAT	TRIPLE DIRK	LEAF	5692	X.T.UNDULO	5695	X.T.UNDULO	
68024	31/ 7/68			WINNIPEG	MAN	4953	9709	WHEAT	MANITOU	LEAF	5698	X.T.UNDULO			5698
68025	1/ 8/68			HALBSTADT	MAN	4905	9720	WHEAT	MANITOU	GLUME	5699	X.T.UNDULO	5700	X.T.UNDULO	5699
68026	1/ 8/68	01	E	GRETNA	MAN	4902	9735	WHEAT	MANITOU	LEAF	5701	X.T.UNDULO	5703	X.T.UNDULO	5703
68027	1/ 8/68	02	N	GRETNA	MAN	4902	9735	WHEAT	MANITOU	LEAF	5706	X.T.CEREAL.			5706
68028	2/ 8/68			GLENLEA	MAN	4938	9709	DURUM WH		LEAF	5709	X.T.CEREAL.	5710	X.T.UNDULO	
68029	12/ 8/68	15	S	GLENLEA	MAN	4938	9709	WHEAT	MARQUIS	LEAF	5713	UNIDENT.P.P.			5713
68030	12/ 8/68			GLENLEA	MAN	4938	9709	WHEAT	MARQUIS	LEAF	5714	X.T.UNDULO	5715	X.T.UNDULO	5714
69006	31/ 3/69			WINNIPEG	MAN	4953	9709	RICE	IRRI 442LTC	LEAF	5749	X.T.UNDULO			
69008	24/ 6/69	06	W	ST JOSEPH	MAN	4909	9724	AGP RPNS		LEAF	5752	X.T.CEREAL.			
69009	24/ 6/69	01	E	ALTONA	MAN	4906	9733	AGP RPNS		LEAF	5754	X.T.CEREAL.			
69017	25/ 7/69	03	S	ALTONA	MAN	4906	9733	WHEAT		LEAF	5775	X.T.UNDULO			
69018	25/ 7/69	01	SE	GRETNA	MAN	4902	9735	WHEAT	SELKIRK	LEAF	5756	X.T.CEREAL.			
69019	25/ 7/69	02	E	GRETNA	MAN	4902	9735	WHEAT	MANITOU	LEAF	5758	X.T.UNDULO			
69020	25/ 7/69	01	E	GRETNA	MAN	4902	9735	WHEAT	MANITOU	LEAF	5760	X.T.UNDULO			
69023	30/ 7/69	01	N	MINTO	MAN	4923	9959	WHEAT	MANITOU	LEAF	5764	X.T.UNDULO			5764
69024	30/ 7/69	01	E	LAUDER	MAN	4923	10040	WHEAT	MANITOU	LEAF	5766	X.T.CEREAL.			
69025	31/ 7/69	03	E	MANITOU	MAN	4915	9831	WHEAT	MANITOU	LEAF	5768	X.T.UNDULO			
69026	31/ 7/69	02	E	CRYSTAL CI	MAN	4909	9856	WHEAT		LEAF	5770	X.T.UNDULO			5770
69027	30/ 7/69	03	W	HARTNEY	MAN	4928	10030	DURUM WH		LEAF	5772	X.T.CEREAL.			5772

Table 4. Isolates of plant pathogenic bacteria from collections of diseased plants

Collection No.	Date			Location		Lat.	Long.	Host	Variety	Plant part	Isolate 1 No.	Isolate 1 Species	Isolate 2 No.	Isolate 2 Species	Culture stored
69028	11/ 8/69			GLENLEA	MAN	4938	9709	WHEAT	SAUNDERS	GLUME	5777	X.T.UNDULO			5777
69030	24/ 7/69			WINNIPEG	MAN	4953	9709	BARLEY		LEAF	5781	X.T.H-AV.			5781
69035	8/ 9/69			LACOMBE	ALT	5228	11344	WINTR WT		LEAF	5791	X.T.CEREAL.	5792	X.T.CEREAL.	5791
70001	8/ 7/70			STE ROSE	MAN	5103	9932	OATS		LEAF	5869	P.C.HALO	5870	P.C.HALO	5869
70002	13/ 7/70			WINNIPEG	MAN	4953	9709	OATS		LEAF	5871	P.C.NO HALO	5872	P.C.NO HALO	
70003	28/ 7/70	10	N	LA RIVIERE	MAN	4913	9843	WHEAT	MANITOU	LEAF	5875	X.T.CEREAL.	5876	X.T.CEREAL.	
70005	28/ 7/70	04	E	MANITOU	MAN	4915	9831	WHEAT	NEEPAWA	LEAF	5879	X.T.CEREAL.	5880	X.T.CEREAL.	
70006	23/ 7/70			OAK BLUFF	MAN	4947	9926	BARLEY	SIX ROW	LEAF	5873	X.T.H-AV.	5874	X.T.H-AV.	5873
70008	29/ 7/70			MELITA	MAN	4916	10100	WHEAT	MANITOU	GLUME	5893	X.T.CEREAL.			
70009	5/ 8/70			LACOMBE	ALT	5228	11344	WHEAT	PARK	LEAF	5902	X.T.CEREAL.	5903	X.T.CEREAL.	5902
70011	11/ 8/70	04	W	MELITA	MAN	4916	10100	WHEAT	NEEPAWA	GLUME	5910	X.T.CEREAL.	5911	X.T.CEREAL.	
70012	11/ 8/70	03	S	MELITA	MAN	4916	10100	DURUM WH		LEAF	5904	X.T.CEREAL.	5905	X.T.CEREAL.	
70018	12/ 8/70	13	N	PIPESTONE	MAN	4934	10058	DURUM WH		LEAF	5889	X.T.CEREAL.	5890	X.T.CEREAL.	
70019	12/ 8/70	04	E	OAK LAKE	MAN	4947	10038	WHEAT	NEEPAWA	LEAF AND GLUME	5914	X.T.UNDULO	5915	X.T.UNDULO	
70020	12/ 8/70	05	E	BRANDON	MAN	4950	9957	WHEAT	NEEPAWA	LEAF AND GLUME	5895	X.T.CEREAL.	5896	X.T.CEREAL.	
70021	11/ 8/70	02	S	MELITA	MAN	4916	10100	DURUM WH	STEWART 63	NECK	5897	X.T.CEREAL.	5926	X.T.CEREAL.	5897
70022	12/ 8/70			CABRI	SAS	5037	10828	DURUM WH	D.T. 388	GLUME	5898	X.T.CEREAL.	5899	X.T.CEREAL.	
70023	10/ 8/70			DAUPHIN	MAN	5109	10003	WHEAT	NEEPAWA	LEAF	5900	X.T.CEREAL.	5901	X.T.CEREAL.	5900
70024	12/ 8/70	01	N	PIPESTONE	MAN	4934	10058	WHEAT	NEEPAWA	LEAF	5891	X.T.CEREAL.	5892	X.T.CEREAL.	
70025	12/ 8/70	08	N	PIPESTONE	MAN	4934	10058	WHEAT		GLUME	5906	X.T.CEREAL.	5907	X.T.CEREAL.	5906
70026	21/ 8/70			WINNIPEG	MAN	4953	9709	BEAN		POD	5916	COR.FLACC.	5921	COR.FLACC.	
71009	13/ 7/71			WINNIPEG	MAN	4953	9709	WHEAT		LEAF	6001	X.T.UNDULO			
71010	13/ 7/71			WINNIPEG	MAN	4953	9709	BARLEY		LEAF	6003	X.T.H-AV.			
71012	5/ 8/71			GLENBORO	MAN	4932	9915	WHEAT	MANITOU	LEAF	6023	X.T.UNDULO			
71015	5/ 8/71			OAK LAKE	MAN	4947	10038	BARLEY		LEAF	6019	X.T.H-AV.	6020	X.T.H-AV.	
71017	4/ 8/71			ALEXANDER	MAN	4950	10017	BARLEY	SIX ROW	LEAF	6030	X.T.H-AV.			
71018	4/ 8/71			CARBERRY	MAN	4952	9920	WHEAT	MANITOU	LEAF	6026	X.T.UNDULO			
71019	4/ 8/71			ALEXANDER	MAN	4950	10017	WHEAT	MANITOU	LEAF	6033	X.T.CEREAL.			
71024	10/ 8/71	07	W	KEYES	MAN	5014	9907	WHEAT		HEAD	6006	X.T.UNDULO	6007	X.T.UNDULO	
71025	10/ 8/71	02	W	KEYES	MAN	5014	9907	WHEAT		LEAF	6040	X.T.CEREAL.			
71028	26/ 7/71			RATHWELL	MAN	4940	9832	BARLEY		LEAF	6042	X.T.H-AV.			
71029	26/ 7/71	04	S	TREHERNE	MAN	4938	9841	WHEAT		LEAF	6044	X.T.UNDULO			
71033	4/ 8/71	01	SW	KILLARNEY	MAN	4912	9942	WHEAT		LEAF	6048	X.T.CEREAL.			
71037	10/ 8/71	01	SE	KEYES	MAN	5014	9907	WHEAT		LEAF	6054	X.T.CEREAL.			
71039	10/ 8/71	01	SW	KEYES	MAN	5014	9907	WHEAT		LEAF	6056	X.T.CEREAL.			
71040	13/ 8/71			GLENLEA	MAN	4938	9709	WHEAT	NEEPAWA	LEAF	6058	X.T.UNDULO			
71041	14/ 8/71	02	S	MACDONALD	MAN	5003	9828	WHEAT	NEEPAWA	LEAF	6061	X.T.CEREAL.			
71043	17/ 8/71	03	W	HOBSON	MAN	5003	9820	WHEAT		LEAF	6065	X.T.CEREAL.			
71045	17/ 8/71	02	S	TOWNLINE	MAN	5004	9819	WHEAT		LEAF	6068	X.T.CEREAL.			
71046	17/ 8/71			GENEST	MAN	5000	9825	WHEAT		LEAF	6070	X.T.CEREAL.			
71049	17/ 8/71	04	S	MACDONALD	MAN	5003	9828	WHEAT		GLUME	6076	X.T.CEREAL.			
71051	3/ 9/71			SHOAL LAKE	MAN	5026	10034	WHEAT	NEEPAWA	GLUME	6081	X.T.UNDULO			

* Distance (miles) and † direction from designated location.

ABBREVIATIONS USED IN TABLE 4

AGP RPNS = *Agropyron repens* (L.) Beauv.;
AGRO TUMEF = *Agrobacterium tumefaciens* (Smith and Townsend) Conn. 1942;
BELLE PLAI = Belle Plaine;
CALAPPROVED = Giant Stringless Greenpod bean;
CHARLOTTET = Charlottetown;
COR = *Corynebacterium* Lehmann & Neumann 1896;
COR FLACC = *Cor. flaccumfaciens* (Hedges) Dowson 1942;
COR INSID = *Cor. insidiosum* (McCulloch) Jensen 1934;
COR MICH = *Cor. michiganense* (Smith) Jensen 1934;
COR SEPED = *Cor. sepedonicum* (Spieckermann and Kotthoff) Skaptason & Burkholder 1942;
CRYSTAL CI = Crystal City;
CYRPUS RIV = Cypress River;
DARLINGFOR = Darlingford;
DELW COMMDO = Delwiche Commando;
ER = *Erwinia* Winslow et al. 1920;
ER AMYLOV = *Er. amylovora* (Burrill) Winslow et al. 1920;
ER UREDOV = *Er. uredovora* (Pon et al.) Dye 1963;
FANNYSTELL = Fannystelle;
FIELD PE = Field peas;
FORT SIMPS = Fort Simpson;
GAINSBOROU = Gainsborough;
G STRLS GPD = Giant Stringless Greenpod bean;
GILBERT PL = Gilbert Plains;
HALO = Producing a chlorotic halo in oats;
HED HELX = *Hedera helix* L.;
IRRI 422 ETC = International Rice Research Institute 442-2-50-2-2-3;
KAPUSKASIN = Kapuskasing;
LATH VEN = *Lathyrus venosa* Muhl.;
LIMA BN = Lima bean;
LTH 4363-32 = Lethbridge, AB 36-1991 × Titan;
LTH 5134-4 = Lethbridge, Harlan × Montcalm;
L 50824-12-5 = Lacombe, 508-24-12-5;
MTCLM X ANOID = Montcalm × Anoidium;
MTN = Mountain;
P = *Pseudomonas* Migula 1894;
P.C. = *Pseudomonas coronafaciens* (Elliott) Stevens 1925;
P.C. NO HALO = *Pseudomonas coronafaciens*, lesions lacking chlorotic halo;
P. STRIAF = *Pseudomonas striafaciens* (Elliott) Starr & Burkholder 1942;
P. GLYCINEA = *Pseudomonas glycinea* Coerper 1919;
PIGEON LAK = Pigeon Lake;
PILOT MOUN = Pilot Mound;
P. LACHRY = *Pseudomonas lachrymans* (Smith and Bryan) Carsner 1918;
PS ATROFAC = *Pseudomonas atrofaciens* (McCulloch) Stevens 1925;
POPLAR POI = Poplar Point;
P. PHASEOL = *Pseudomonas phaseolicola* (Burkholder) Dowson 1943;
P. TOMATO = *Pseudomonas tomato* (Okabe) Alstatt 1944;
PORTAGE LA = Portage la Prairie;
P. PISI = *Pseudomonas pisi* Sackett 1916;
QUACK GR = *Agropyron repens* (L.) Beauv.;
R RK X MINHDY = Red Rock × Minhardy;
SEDDONS CR = Seddons Corner near Buchan, Man.;
ST. EUSTACH = St. Eustache;
ST. FRANCOI = St. Francois;
STE ROSE = Ste. Rose du Lac;
TX K-SG = *Taraxicum Kok-saghz* Rod.;
ST. JEAN BT = St. Jean Baptist;
UNIDENT PP = Unidentified bacterial plant pathogen;
UNION POIN = Union Point;
VANKLEEK H = Vankleek Hill;
VCT X GN R 578 = Victory × Green Russian, strain 578;
WHEAT = Spring Wheat (bread wheat);
WINNIPEG B = Winnipeg Beach;
X = *Xanthomonas* Dowson 1939;
X. CAMPEST = *X. campestris* (Pammel) Dowson 1939;
X. CAROTAE = *X. carotae* (Kendrick) Dowson 1939;
X. HEDERAE = *X. hederae* (Arnaud) Dowson 1939;
X. PHASEOLI = *X. phaseoli* (Smith) Dowson 1939;
X.T. = *Xanthomonas translucens* (Jones, Johnson and Reddy) Dowson 1939;
X.T. CER = *X. t.* f. sp. *cerealis* Hagborg 1942;
X.T. H = *X. t.* f. sp. *hordei* Hagborg 1942;
X.T. H-A = *X. t.* f. sp. *hordei-avenae* Hagborg 1942;
X.T. SECAL = *X. t.* f. sp. *secalis* (Reddy, Godkin and Johnson) Hagborg 1942;
X.T. UNDULO and XTU = *X. t.* f. sp. *undulosa* (Smith et al.) Hagborg 1942;
X. VESICAT = *X. vesicatoria* (Doidge) Dowson 1939.

PRELIMINARY STUDIES TO DETERMINE EFFECT OF SOUTHERN LEAF BLIGHT ON YIELD OF CORN IN EASTERN ONTARIO

A.T. Bolton [2]

Abstract

Effect on yield of plant age at time of infection with Helminthosporium maydis was determined using the corn (Zea mays) hybrid Warwick SL209 containing Texas male sterile cytoplasm. At Ottawa, corn plants inoculated July 15 developed symptoms within 4 days and exhibited a yield reduction of 50%. Plants inoculated August 1 showed some stunting and yield loss, but the disease was less severe. Plants inoculated August 15 and September 1 exhibited fewer severe symptoms but a statistically significant yield loss. Infection of the lower leaves of the corn plants did not affect yield but infection of the upper leaves including the ear caused considerable yield loss. The results of these preliminary experiements suggest that, in eastern Ontario, natural infection of corn susceptible to H. maydis occurs too late in the season to cause yield losses of more than 10%.

Résumé

On a déterminé l'effet sur le rendement du stade de croissance au moment de l'infection par Helminthosporium maydis, en utilisant le maïs hybride Warwick SL209 portant la stérilité cytoplasmique mâle Texas. A Ottawa, les plants de maïs inoculés le 15 juillet ont manifesté des symptômes en moins de 4 jours et ont accusé une réduction de rendement de 50%. Les plants inoculés de 1er août ont manifesté une certaine atrophie et une perte de rendement, mais à un moindre degré. Sur les plants inoculés de 15 août et le 1er septembre les symptômes graves étaient moins nombreux mais la baisse de rendement a été statistiquement significative. L'infection des feuilles supérieures, n'a pas influé sur le rendement, mais celle des feuilles supérieures, y compris l'épi, a provoqué une baisse de rendement considérable. Les résultats de ces expériences préliminaires portent à croire que dans l'est de l'Ontario, l'infection naturelle du maïs susceptible à H. maydis se produit trop tard dans la saison pour causer des baisses de rendement de plus de 10%.

Southern leaf blight was found on corn (Zea mays L.) in eastern Ontario in 1970. Although the disease caused serious losses in areas of the United States as well as in a few fields in southwestern Ontario, the damage caused in eastern Ontario was negligible (2).

The pathogen Helminthosporium maydis Nisikado [stat. perf. Cochliobolus heterostrophus (Drechs.) Drechs.] race T overwintered in eastern Ontario during the winter 1970-71 but did not appear on corn plants in the area until September. As a result, losses were only slight in spite of the fact that in many fields lesions covered a high percentage of leaf area of most plants (1).

In 1972, field experiments were carried out at Ottawa to determine if an epidemic could be initiated earlier in the season and to assess the effect on yield of early infection. A study also was made of the effect on yield of inoculation of different plant parts.

Materials and methods

To determine the effect on yield of plant age at time of infection with H. maydis, the Zea mays L. hybrid Warwick SL209 containing

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Texas male sterile cytoplasm was used. Each plot consisted of three 8-plant rows with plants 30 cm apart in rows 1 m apart. Eight plots of each of the five treatments were located 4 m apart in all directions. Plants in the center row of each plot were inoculated with H. maydis 7, 9, 11, and 13 weeks after planting beginning with the first inoculation July 15. H. maydis isolated from corn near Ottawa in September 1971 was used in the inoculations.

To determine the effect on yield of the amount of foliage infected, eight additional plots per treatment were laid out as described above, and plants were inoculated 11 weeks after seeding, as follows: 1) the first five leaves from the base of the plant; 2) the first six leaves, including the first ear; 3) the first eight leaves and ears; 4) the entire plant.

To prepare large quantities of inoculum, the fungus was grown at 22-25 C on autoclaved corn kernels in 2-liter erlenmeyer flasks containing 800 g corn and 300 ml distilled water. Six to 8 days after seeding with conidia of H. maydis the infested kernels were removed from the flask and spread out on paper towels to dry. The dried infected corn was stored in paper bags until required. To prepare inoculum, the kernels were placed in large plastic bags along with sufficient sterile water to maintain humidity at 100%, spread out to a depth of about 2 cm, and placed under fluorescent lights (about 500 ft-c) for 8-9 days. At that time the surface of the kernels was covered with spores. To make the spore suspension, water was added and the mixture strained through several layers of cheesecloth. A suspension of 10,000 to 12,000 spores per ml was applied to the corn foliage at the rate of 1 liter to eight plants. Inoculations were made during the late evening to avoid rapid drying of the leaves. During the following 10 days the plants were moistened at half-hour intervals during the day using mist nozzles.

All plots were harvested October 3, and the weights of cobs and foliage were recorded.

Results

Corn plants inoculated July 15 at the 7-week stage developed symptoms within 4 days. Plants inoculated after July 15 required a longer time to produce disease symptoms. At harvest, however, symptoms were quite severe on all but those plants inoculated September 1. The latter exhibited extensive lesions in the ear area, especially on the husks. By harvest a few spores had spread to the check plots, but only a few lesions were present on the upper leaves of these plants.

Approximately 50% of the plants inoculated at the 7-week stage were stunted. Many of the stunted plants produced cobs that were less than one-half normal size while non-stunted plants appeared to produce normal cobs. A few plants inoculated August 1 were stunted, but no definite stunting occurred in plants inoculated later. However, the August 15 and September 1 infections caused some loss of vigor and plants were shorter than the uninoculated checks.

Although there was considerable variation within plots receiving the same treatment, differences in yield between treatments were significant at the 5% level using Duncan's multiple range test (Table 1). Plants

Table 1. Effect on grain yield and total (fodder) yield of plant age at time of inoculation with southern leaf blight[1]

Age at inoculation[2]	Total yield[3] (kg/ha)	Grain yield (kg/ha)
Check	33,047 a[4]	10,180 a
13 weeks	28,500 b	9,180 b
11 weeks	26,414 c	8,600 b
9 weeks	24,023 d	7,740 c
7 weeks	17,180 e	5,380 d

[1] Average of eight plots.

[2] Calculated from germination.

[3] Weight of foliage plus cobs.

[4] Values followed by the same letter are not statistically different at the 5% level according to Duncan's multiple range test.

Table 2. Effect on grain yield and total (fodder) yield of area of plant affected with southern leaf blight[1]

Area inoculated[2]	Total yield[4] (kg/ha)	Grain yield (kg/ha)
Check	23,671 a[5]	9,960 a
5 leaves	20,531 ab	9,760 a
6 leaves[3]	18,234 b	8,920 b
8 leaves[3]	18,140 b	7,820 c
All leaves[3]	16, 594 b	7,500 c

[1] Average of eight plots.

[2] Calculated upward from the lowest true leaf.

[3] Including ear.

[4] Weight of foliage plus cobs.

[5] Values followed by the same letter are not statistically different at the 5% level according to Duncan's multiple range test.

inoculated July 15 yielded approximately 50% as much grain and foliage as uninoculated plants.

Plants with the lower five leaves inoculated at the 11-week stage did not show a significant reduction in yield. However, if the infected area included an ear and ear leaf, a significant yield loss resulted (Table 2). Increasing the infected area to include the 8 lower leaves or the entire plant caused a reduction in grain but not in foliage production.

Discussion

Gates et al. (2) reported that a yield loss of about 10% resulted from removal of the two leaves below the ear leaf 2-3 weeks after mid-silk and that removal of all the leaves below the ear leaf resulted in a loss of 15%. They also reported that removal of the ear leaf and all the leaves above it resulted in a yield reduction of 45%.

In the investigations reported in this paper, the first inoculation was made 3 weeks before the mid-silk stage and by the time those plants were past mid-silk most leaves were about 60% necrotic. It is, therefore, reasonable to conclude that yield was reduced about 50% due to destruction of green leaf tissue. Later infections produced less necrotic tissue and yields were correspondingly greater.

Experiments under artificial conditions in the greenhouse have shown (unpublished results) that corn plants reach a very susceptible stage between the sixth and seventh week after germination and that they very rapidly develop resistance to infection after the seventh week. This would explain the fact that the plants inoculated July 15 (at the 7-week stage) were variable in their reaction to inoculation. If all plants in this group had been stunted, the yield loss might have reached 90%.

In the Ottawa area, H. maydis that had overwintered on corn debris such as stalks, stored cobs, and leaf material produced viable spores from late May to the end of June (1). If weather conditions were conducive to infection at that time, an epidemic could result. However, during that period temperatures are usually low and rainfall is generally light. Conditions in eastern Ontario are more conducive to development of southern leaf blight in August and September but by then corn has passed the susceptible stage and losses of more than 10% are not likely to occur. Late infection, although causing considerable necrosis, does not appear to bring about serious losses.

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FUNGI ASSOCIATED WITH SEEDS OF RAPE, TURNIP RAPE, FLAX, AND SAFFLOWER IN WESTERN CANADA, 1968-73[1]

G. Allan Petrie

Alternaria brassicae and A. raphani were the only important pathogenic Alternaria spp. isolated from seeds of oleiferous Brassica spp. cultivated in western Canada. In 4 of 5 years, 95% or more of Saskatchewan seed samples of B. campestris (turnip rape) were infested by one or both of these pathogens, and levels within samples increased from 3.6% in 1969 to 9.0% in 1972. B. campestris samples had higher levels of A. brassicae than of A. raphani. B. napus (rape) seed contained considerably lower levels of both Alternaria species. The highest infestation levels occurred in seed from northern Alberta, northern and eastern Saskatchewan, and northwestern Manitoba. In heavily infested seed of B. campestris 73% of the A. brassicae and 90% of the A. raphani occurred on the seed surface. Storage of infested seed for 6-8 months at 25 C reduced the levels of infestation by more than 50%. There appeared to be no correlation between amount of seed infestation and reduction in seedling stand in laboratory or greenhouse tests. Fusarium roseum 'Acuminatum' and Botrytis cinerea were less prevalent than the Alternaria spp. on Brassica seed. Polyspora lini was the most abundant pathogen on flax (Linum usitatissimum) seed, but Alternaria linicola, F. roseum 'Acuminatum', and B. cinerea were also important. A. raphani and A. brassicae, although non-pathogenic on flax seedlings, were found in 20-30% and 1-3% respectively of the Saskatchewan flax seed samples. In safflower (Carthamus tinctorius) samples, Alternaria carthami occurred on up to 95% of untreated seed and 76% of surface-disinfested seed; Botrytis cinerea and F. roseum were found on up to 20% of the seeds in some samples, and A raphani was found in two of seven lots.

Alternaria brassicae et A. raphani ont été les seuls champignons pathogènes importants du genre Alternaria isolés des graines de crucifères (Brassica spp.) oléagineuses cultivées dans l'ouest du Canada. Quatre années sur cinq, au moins 95% des échantillons de graines de B. campestris (navette) provenant de la Saskatchewan ont été infestés par l'un de ces champignons pathogènes ou les deux à la fois, et les niveaux d'infestation des échantillons ont passé de 3.6% en 1969 à 9% en 1972. Les échantillons de B. campestris étaient davantage infestés par A. brassicae que par A. raphani. Les graines de B. napus (colza) étaient beaucoup moins infestées par les deux espèces d'Alternaria. On a trouvé les plus forts niveaux d'infestation dans les graines provenant du nord de l'Alberta, du nord et de l'est de la Saskatchewan et du nord-ouest du Manitoba. Dans les graines fortement infestées de B. campestris, on a trouvé 73% de A. brassicae et 90% de A. raphani sur les téguments des graines. L'entreposage des graines infestées pendant 6 à 8 mois à 25°C a réduit les niveaux d'infestation de plus de 50%. Il semble n'y avoir aucune corrélation entre l'importance de l'infestation des graines et la réduction des peuplements des plants susmentionnés dans les essais en laboratoire ou en serre. Fusarium roseum "Acuminatum' et Botrytis cinerea étaient moins abondants que Alternaria spp. sur les graines de Brassica. Polyspora lini était le champignon pathogène le plus répandu sur les graines de lin (Linum usitatissimum), mais Alternaria linicola, F. roseum "Acuminatum' et B. cinerea étaient également abondants. Même s'ils n'infestaient pas les plants de lin, on a trouvé A. raphani et A. brassicae dans 20 à 30% et 1 à 3% respectivement des échantillons de graines de lin provenant de la Saskatchewan. Dans les échantillons de carthame (Carthamus tinctorius), on a trouvé Alternaria carthami sur près de 95% des graines non traitées et sur 76% des graines désinfectées en surface; on a trouvé Botrytis cinerea et F. roseum sur près de 20% des graines de certains échantillons, et A. raphani dans 2 lots sur 7.

There are few recent papers in the literature which describe in detail the extent to which fungal pathogens are transmitted with seed of rape, turnip rape, flax, or safflower in western Canada. Vanterpool (15) reported Alternaria brassicae (Berk.) Sacc. as the only pathogen isolated from rapeseed samples produced in Saskatchewan in 1948. However, by 1959 the list of species obtained from this source had grown appreciably and included species of Alternaria, Botrytis cinerea Pers., Fusarium

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acuminatum Ell. & Ev., Mycosphaerella brassicicola (Duby) Lind., Rhizoctonia spp. and Rhizopus spp. (16, 17). Four years later it was reported (18) that seed from the 1963 rape crop carried "unusually high" levels of A. brassicae and lesser amounts of A. raphani Groves & Skolko. McDonald (7) isolated A. brassicae from 14 of 25 samples of registered rapeseed grown in Manitoba in 1956. The highest level of infection found in any sample was 4%. The most recent study of pathogens found on flax seed in western Canada was the 1971 report of Henry and Ellis (5) from Alberta, which dealt exclusively with Polyspora lini Laff.

The work described here was undertaken to determine the extent and significance of infestation of rape and turnip rape seed by fungi. It was started in 1968 and later expanded to include an examination of seed of flax and safflower, cruciferous weeds, and garden crucifers. The occurrence of Alternaria spp. on garden crucifer seed entering Canada's prairie provinces from British Columbia and abroad (11) and the transmission of Leptosphaeria maculans (Desm.) Ces & Not. on crucifer seed (12) have been reported previously.

Materials and methods

Samples of rape (Brassica napus L.) and turnip rape (B. campestris L.) seed were obtained from the Plant Products Division of Agriculture Canada and from the Canadian Grain Commission. A large proportion of samples in the first group represented Foundation or Certified seed, whereas those in the second were drawn from growers' commercial seed entering country elevators. The seed originated in all parts of the rape-growing area of western Canada. Over 100 samples were plated each year from 1968 to 1971, with over 1000 being examined in 1970 (Table 1). Relatively few were plated in 1972 and 1973. Five years' data were obtained from Saskatchewan farm samples, four for those from Alberta, and three for those from Manitoba. The cultivars of rape and turnip rape changed during the course of the study with the advent of low erucic acid types. By 1970, Echo and Target had become the established cultivars of turnip rape and rape, respectively. Small amounts of several additional ones were grown in 1971. In 1972, however, an abrupt change to the low erucic types Span (B. campestris) and Zephyr (B. napus) took place (14).

Seed from the 1973 western Canadian cooperative rapeseed varietal tests was also secured to permit a closer comparison of seed infestation of the different cultivars. Data from five regional cooperative tests in Saskatchewan crop districts 5, 8 and 9 provided a comparison of fungal infestation levels on the B. campestris cultivars Echo, Span, and Torch, and the B. napus cultivars Target, Zephyr, and Midas for 1973. In some instances seed of the turnip rape line R-500 ('Yellow Sarson') was also plated for comparison.

Flax (Linum usitatissimum L.) samples grown in Saskatchewan and Alberta were obtained from the Plant Products laboratories at Saskatoon and Edmonton. Three years' data were obtained for Saskatchewan, with Alberta samples being limited to 27 from 1969. A total of seven safflower (Carthamus tinctorius L.) seed samples were secured from several sources, including plants pulled in a farmer's field. Flax cultivars plated were principally Noralta and Redwood 65, with smaller numbers of Norland, Raja, and others. The safflower samples were not identified to cultivar.

Table 1. Number and source of growers' seed samples plated for detection of pathogenic fungi

	Turnip rape *(Brassica campestris)*			Rape *(Brassica napus)*			Total *Brassica*		
Year	Sask.	Alta.	Man.	Sask.	Alta.	Man.	samples	Flax	Safflower
1968	36	47	6	22	0	30	141	0	0
1969	172	48	0	133	0	0	353	144*	0
1970	513	200	19	264	3	28	1,027	107	6
1971	219	11	34	0	0	19	283	0	1
1972	10	0	0	22	0	0	32	61	0
	B. campestris			*B. napus*					
Totals	1,315			520			1,836	312	7

* Includes 27 Alberta samples.

With the exception of those of safflower which were plated with forceps, untreated seeds were picked up 15 or 20 at a time by means of a vacuum plate seeder and deposited on V8 juice agar containing 40 ppm rose bengal and 100 ppm streptomycin sulfate. For each of the first few hundred samples, 300 seeds were plated but this was reduced to 200 for the remaining ones. The apparatus was disinfected with alcohol halfway through each sample and between samples. After 7 to 10 days' incubation under diffuse light at room temperature, a record was made of the fungi present. Colonies were routinely examined microscopically at a magnification of 40X. Fresh subsamples from seed lots yielding high levels of certain fungi were surface disinfested in 10% Javex (0.6% available chlorine on dilution) for 20 min and plated to determine levels of internal infection.

The effect of storage of Brassica seed on survival of the two principal Alternaria pathogens was also studied. Sixty-six heavily infested samples were plated a second time 6 to 8 months following the first plating. In the interval, the samples were stored at room temperature in the laboratory.

In order to obtain an indication of the effect of seed-borne fungi on emergence, naturally infested seed was plated untreated on moist filter paper and was also sown in pots of sand or sandy loam soil, 20 seeds to a plate or pot, with at least five replicatons. The plates were assessed at 10 days, whereas pots were usually kept for 2 to 3 weeks and seedling stand counts made at least once a week. For comparison with naturally infested seed, samples of Span and Zephyr rape were heavily inoculated with spore suspensions of Alternaria spp. and sown in soil. Pots were moistened to field capacity from reservoirs below as required.

Results

1. Saprophytic fungi encountered

The most common 10 or 12 saprophytes in the rape, turnip rape, flax and safflower samples were remarkably similar. Alternaria alternata (Fries) Keissler, Cladosporium spp. and Penicillium spp. were, with a few exceptions, the most prevalent, usually occurring in over 80%, and often over 90%, of the samples plated in a given year. Epicoccum sp., Arthrinium sp., Rhizopus sp. (and related genera), Stemphylium spp., miscellaneous pycnidial fungi, Fusidium spp., Gonatobotrys sp. and a few others normally were found less often, but the first two occasionally appeared in over 70% of a year's seed lots. Rhizopus and related genera were usually found in from 1/3 to 1/2 of the samples.

2. Pathogenic Alternaria species

Those parasitizing Brassica spp. were limited to A. brassicae and A. raphani; A. brassicicola (Schw.) Wiltshire was not recovered from any of the more than 1800 samples. An interesting saprophytic Alternaria which somewhat resembled A. brassicicola occurred in crucifer, flax and safflower samples.

Each year, with the exception of 1969, 95% or more of the Saskatchewan B.

Table 2. Prevalence of *Alternaria brassicae (A.b.)* and *A. raphani (A.r.)* in seed samples of *Brassica* spp. produced in Saskatchewan

	% of samples infested			% of seeds infested per sample					
				Average			Highest recorded infestation		
Year	*A.b.*	*A.r.*	One or both	*A.b.*	*A.r.*	Total	*A.b.*	*A.r.*	One or both
				Brassica campestris					
1968	88.9	86.1	97.2	2.9	3.3	6.2	10.0	15.7	23.7
1969	85.7	63.4	87.4	2.3	1.3	3.6	18.0	13.0	28.7
1970	92.4	71.5	96.3	5.2	1.2	6.4	27.5	11.0	29.0
1971	91.3	72.2	94.5	5.6	2.1	7.7	25.2	49.1	55.3
1972	90.0	100.0	100.0	5.9	3.1	9.0	11.4	8.1	12.9
				Brassica napus					
1968	86.4	68.2	90.9	1.0	0.8	1.8	6.7	4.0	10.4
1969	53.7	61.9	76.9	0.6	0.9	1.5	4.7	10.7	12.4
1970	63.3	62.5	80.7	1.1	0.9	2.0	18.0	10.0	19.0
1972	36.4	68.2	77.3	0.4	1.1	1.5	3.3	13.3	13.3

Table 3. Prevalence of *Alternaria brassicae* and *A. raphani* in *Brassica campestris* seed samples produced in Alberta

Year	% of samples infested			% of seeds infested per sample					
				Average			Highest levels		
	A.b.	*A.r.*	One or both	*A.b.*	*A.r.*	Total	*A.b.*	*A.r.*	One or both
1968	51.1	55.3	68.1	0.9	1.1	2.2	10.5	10.0	16.2
1969	66.7	72.9	81.3	2.5	4.4	6.9	15.0	29.0	41.3
1970	70.9	69.0	84.2	3.4	1.8	5.2	25.5	22.0	28.0

Table 4. Prevalence of *Alternaria brassicae* and *A. raphani* in *Brassica* seed samples produced in Manitoba

Year	% of samples infested			% of seeds infested per sample					
				Average			Highest levels		
	A.b.	*A.r.*	One or both	*A.b.*	*A.r.*	Total	*A.b.*	*A.r.*	One or both
				Brassica campestris					
1968	83.3	33.3	83.3	3.8	0.3	4.1	10.7	1.3	10.9
1970	79.0	42.1	79.0	2.1	0.4	2.5	7.5	1.5	9.0
1971	76.5	53.0	85.3	2.3	0.8	3.1	11.9	8.1	15.3
				Brassica napus					
1968	36.7	10.0	43.3	0.1	0.1	0.2	0.7	1.0	1.3
1970	10.7	25.0	32.1	0.1	0.2	0.3	1.5	1.3	1.5
1971	15.8	15.8	26.3	0.1	0.1	0.2	0.5	1.2	1.2

campestris samples were infested with one or both pathogenic Alternaria spp. (Table 2). Fewer of the B. napus samples were affected, the decrease being more pronounced in the incidence of A. brassicae. Results on a "seeds per sample" basis followed a similar trend. Total infestation of B. napus seed lots remained consistently low, whereas after an initial decrease, a trend toward higher levels was evident in the turnip rape samples. In the most heavily diseased sample, a 1971 lot of turnip rape, 55.3% of the seeds yielded a pathogenic Alternaria. In Alberta seed, the incidence of A. brassicae was much lower relative to A. raphani and to the Saskatchewan samples (Table 3). Nevertheless, a pathogenic Alternaria was recovered from over 80% of the seed lots in 2 of the 3 years. The Manitoba data are presented in Table 4.

In Table 5, all the Saskatchewan samples are grouped into five arbitrary infestation severity categories. The distribution of B. napus samples having A. brassicae and A. raphani were remarkably alike, in about 3% of them more than 5% of the seeds were affected. B. campestris seed lots carrying A. raphani had heavier infestations; 7% of these were in the two higher categories. However, none of the preceding pairings approached the B. campestris - A. brassicae combination in this regard; in over 35% of these 5% or more of the seeds yielded the pathogen.

Next to Polyspora lini, Alternaria linicola Groves & Skolko was the major pathogen on flax seed in Saskatchewan (Table 11). Nevertheless, its importance declined considerably over the period of study (Table 6). The prevalence of A. raphani and A. brassicae in flax samples was surprising. Although the latter was uncommon, the former occurred at low levels in over 30% of the 1970 seed lots and in 27% of those from 1969 (Table 6). Although highly virulent on Brassica spp., isolates of these two species did not cause appreciable damage to flax

Table 5. Percentage of *Brassica* seed samples in each of five infestation severity categories (Saskatchewan samples)

Alternaria species	*Brassica* species	Categories (% of seeds infested per sample) 0	<1	1-4.9	5-9.9	10 and over
A. brassicae	*B. campestris*	9.2*	10.1	45.3	21.2	14.2
	B. napus	39.8	26.6	30.5	2.7	0.2
A. raphani	*B. campestris*	29.0	23.3	40.7	5.0	2.0
	B. napus	37.1	29.9	30.3	2.3	0.5

* Figures represent all samples plated from 1968 to 1972 inclusive.

Table 6. Extent of infestation of Saskatchewan flax seed samples by selected fungi

Year	Fungal species *Alternaria linicola*	*Alternaria raphani*	*Alternaria brassicae*	*Fusarium roseum*	*Botrytis cinerea*
			% of samples infested		
1969	49.6	27.4	0.9	27.4	8.6
1970	41.5	30.2	2.8	34.0	18.9
1972	24.6	19.7	1.6	23.0	13.1
			% of seeds per sample infested (avg)		
1969	5.5	0.2	<0.1	0.3	0.1
1970	3.7	0.3	<0.1	0.3	0.2
1972	0.5	0.2	<0.1	0.2	0.2
			highest infestation recorded (% of seeds infested)		
1969	72.0	2.0	0.5	5.0	1.5
1970	46.0	4.5	1.0	2.0	2.0
1972	5.0	1.6	0.5	1.3	4.0

seedlings in pathogenicity tests. Both were also found in 1969 flax samples from Alberta (Table 7). A. linicola was much less prevalent in that province as a whole than it was in Saskatchewan in 1969.

Isolates resembling A. linicola in cultural and conidial morphology occurred in both rape and turnip rape seed lots from Saskatchewan. In 1968, 3.4% of Brassica samples yielded such isolates, and in 1969 and 1970, respectively, 2.6% and 1.0% were infested. Generally 0.5% or less of the seeds in a sample bore the fungus. It was not detected in 1971 or 1972 seed. Inoculation tests were not conducted to confirm the identity of this species.

The levels of Alternaria carthami Chowdhury encountered in some safflower samples were indeed striking (Table 8). In 1970 leaf lesioning caused by this Alternaria was general and severe throughout Saskatchewan. A. raphani was isolated from two of the seven seed lots but A. brassicae was not detected.

The 1969 and 1970 data for turnip rape seed infestation by Alternaria spp. in Alberta are grouped in Table 9 according to agricultural reporting area (ARA). The south to north progression is perhaps not surprising. However, the sharp decrease in A. brassicae in the Peace River region (ARA 7) should be noted. This was again observed

Table 7. Infestation of 27 Alberta 1969 flax seed samples by fungal pathogens of flax and rape

Agricultural reporting area	*Alternaria linicola*	*Alternaria raphani*	*Alternaria brassicae*	*Fusarium roseum*	*Botrytis cinerea*
		% of samples infested			
1-3	0.0	0.0	6.7	6.7	13.3
4-7	41.7	25.0	8.3	58.3	58.3
1-7	18.5	11.1	7.4	29.6	33.3
		% of seeds per sample infested (avg)			
1-3	0.0	0.0	<0.1	<0.1	0.1
4-7	3.1	0.1	<0.1	0.7	1.0
1-7	1.4	0.1	<0.1	0.3	0.5
		highest infestation level recorded (% of seeds infested)			
1-3	0.0	0.0	0.5	0.5	1.0
4-7	23.5	0.5	0.5	2.5	6.0
1-7	23.5	0.5	0.5	2.5	6.0

Table 8. Pathogenic fungi present in Saskatchewan safflower seed samples, 1970-71

Sample and locality	Treatment*	Fungi present and % of seeds affected per sample			
		Alternaria carthami	*Alternaria raphani*	*Botrytis cinerea*	*Fusarium roseum*
C-1 (Rosthern)	SD	36.7	0.0	3.3	0.0
	UT	94.7	0.0	8.3	2.0
C-2 (Saskatoon)	UT	4.5	0.5	4.5	20.0
C-3 (Saskatoon)	UT	26.0	0.0	5.3	0.0
C-4 (Elrose)	SD	2.0	0.0	10.5	0.0
	UT	19.5	1.5	17.5	0.0
C-5 (Briercrest)	UT	3.6	0.0	0.0	11.8
C-6 (Balcarres)	SD	76.0	0.0	0.5	0.0
	UT	95.0	0.0	0.5	0.5
C-7 (Lake Lenore)	SD	51.7	0.0	0.0	0.0
	UT	71.7	0.0	0.0	0.0

* SD = surface-disinfested; UT = untreated.

in the few 1971 samples examined. The average infestation levels in three Peace River samples were A. brassicae 0.7%, and A. raphani 14.3%. In contrast the averages for eight samples from ARA 6 were 9.0% and 4.0%, respectively. In Saskatchewan the incidence of Alternaria on Brassica seed increased along an approximate southwest to northeast axis (Table 10). The trends for the flax samples for the two provinces may be seen in Tables 7 and 11. Brassica seed lots from southern Manitoba were largely free of pathogenic fungi but infestation was appreciably higher in the northwest (crop districts 10 to 14).

High levels of A. brassicae and A. raphani occurred in samples from the 1973 cooperative varietal tests that had been located in crop districts 5, 8, and 9 in

Table 9. Average infestation levels of *Alternaria brassicae (A.b.)* and *A. raphani (A.r.)* in seed samples of *Brassica campestris* from Alberta

Agricultural reporting area	Average % of seeds infested per sample					
	1969			1970		
	A.b.	*A.r.*	Total	*A.b.*	*A.r.*	Total
1-2	0.6	0.2	0.8	0.3	0.2	0.5
3	1.1	0.6	1.7	0.9	0.2	1.1
4	1.0	2.1	3.1	4.2	1.1	5.3
5	3.1	1.3	4.4	3.6	1.4	5.0
6	8.3	9.7	18.0	9.6	2.3	11.9
7	0.9	9.3	10.2	1.1	3.2	4.3
Provincial avg	2.5	4.4	6.9	3.4	1.8	5.2

Table 10. Average infestation levels of *Alternaria* spp. in Saskatchewan seed samples of *Brassica campestris* by geographical area

Region	Crop district	Avg % of seeds per sample infested by both *A. brassicae* & *A. raphani*		
		1969	*1970*	*1971*
South	1-4		2.9	0.4
West central	7	0.6	1.8	2.4
Central	6*	1.9	2.7	4.7
	8B**	1.5	4.6	9.6
East central	5A*		4.4	4.0
	5B**	4.4	4.1	9.8
Northeast	8A	4.7	7.7	11.4
North central and northeast	9A	4.6	10.0	6.3
Northwest	9B		4.7	7.0
Provincial avg		3.6	6.4	7.7

* Southern part of the region.

** Northern part of the region.

Saskatchewan (Table 12). More A. raphani was found on B. campestris than on B. napus. The same was true of A. brassicae, although the differences were much less marked. The results agreed with those obtained for the farm samples (Table 1), with the exception of the wide differences here in amounts of A. brassicae and A. raphani found on B. napus. Had the B. campestris entries in Table 12 included the line R-500 ('Yellow Sarson') the overall species average would have been considerably higher, for R-500 seed carried substantially greater amounts of Alternaria. Differences in levels of infestation between the standard cultivars of each Brassica species occurred but they were not consistent from station to station.

Table 13 shows the effect of surface disinfestation on levels of Alternaria in 151 Brassica seed samples, most of which were B. campestris. On an average, 72.8% of the A. brassicae and 90.0% of the A. raphani occurred on the seed surface. After 6 to 8 months storage of seed an average of 47.2% of the original A. brassicae and 51.1% of the A. raphani remained.

Seed germination and seedling emergence apparently were not directly related to total seed infestation by pathogenic Alternaria species. Twenty-six samples naturally infested with A. brassicae, A. raphani, or both were plated without pretreatment on filter paper moistened with sterile water. On an average, 17.9% of the seeds per sample carried a pathogenic Alternaria, the range being 10-27%. Considering all samples, an average of 94.6% of the seeds germinated, 3.2% of the seedlings subsequently died, and 16.2% either died before or after emergence or exhibited disease symptoms but survived until the test was concluded. When the amount of Alternaria in each sample was matched with the number of seedlings of that sample killed or exhibiting some disorder, no correlation could be recognized. Again, when naturally infested seed was sown in sand or soil, seedling emergence and survival appeared to be completely unrelated to level of Alternaria in the sample. In the soil tests, amounts of infestation ranged from 1.9% to 27.0% and with the exception of a few samples, final emergence was generally close to 90%. When seeds of rape and turnip rape were heavily inoculated with spores of A. raphani or A. brassicae and sown in soil, the reduction in stand due to A. raphani in a representative experiment was approximately 15% in both B. campestris and B. napus; A. brassicae reduced the stand by no more than 8%.

3. Fusarium roseum, Botrytis cinerea and other species

Fusarium roseum Lk. emend. Snyder & Hansen (largely 'Acuminatum') was found, usually at low levels, in 20.3% of all the Saskatchewan turnip rape samples and in 13.6% of those of rape plated from 1968 to 1972 (Table 14). It was somewhat more common in flax seed lots (Table 6). Three years' data for Brassica seed from Alberta and Manitoba are presented in Table 15. F. roseum occurred in 58.3% of the flax samples from Alberta ARA's 4 to 7 in 1969 (Table 7). It was found in four of seven safflower samples from Saskatchewan (Table 8); in samples from Saskatoon and Briercrest, 20.0 and 11.8% of the seeds were infested, respectively.

A few fusaria isolated from seed were used to inoculate rape and flax. Some of the flax isolates infected Brassica spp. in addition to flax, while others were not very virulent on either. Cultures from seed of

Table 11. Prevalence and incidence of infestation of Saskatchewan flax seed samples by rape and flax pathogens; 3-year averages (1969, '70, '72) by crop district

Crop district	*Polyspora lini*	*Alternaria linicola*	*Alternaria raphani*	*Alternaria brassicae*	*Fusarium roseum*	*Botrytis cinerea*
			Percentages of seed samples infested (avg)			
1	80.0	44.2	24.2	0.0	40.8	3.3
2	75.9	11.9	24.7	2.2	29.6	1.9
3-4	66.7	5.6	22.2	0.0	16.7	0.0
5	88.0	53.0	26.6	0.0	15.5	13.7
6	76.1	36.1	16.3	2.8	17.9	12.4
7	89.0	37.7	26.9	0.0	20.7	14.5
8	85.2	67.5	18.4	4.8	26.7	31.2
9	100.0	60.7	39.3	0.0	32.2	14.3
Overall	81.0	48.5	25.8	1.8	28.1	13.5
			Average infestation levels			
1	2.9	2.0	0.2	0.0	0.4	0.1
2	1.6	1.5	0.2	<0.1	0.2	0.1
3-4	2.2	<0.1	0.3	0.0	0.1	0.0
5	2.8	3.8	0.2	0.0	0.1	0.1
6	2.4	0.3	0.1	<0.1	0.1	0.1
7	3.2	0.2	0.4	0.0	0.2	0.1
8	2.8	8.6	0.1	<0.1	0.3	0.7
9	5.3	7.5	0.3	0.0	0.2	0.1
Overall	2.6	3.3	0.2	<0.1	0.2	0.2

rape and turnip rape frequently attacked flax.

Botrytis cinerea Pers. isolates, whether from Brassica, flax, or safflower seed were highly virulent on crucifer and flax seedlings. The percentages of Saskatchewan Brassica seed samples naturally infested in the 4 years 1968-71 were 1.7, 3.0, 1.2 and 1.4, respectively. The highest percentage of flax samples affected was 18.9 in 1970, and the lowest, 8.6 in 1969 (Table 6). Generally, the levels of infestation within samples were low. In 1969, over 58% of the flax seed lots from more northerly parts of Alberta had Botrytis, with up to 6% of the seeds yielding the pathogen (Table 7). Safflower too often carried considerable Botrytis, much of which was within the seed coat (Table 8).

Sclerotinia sclerotiorum (Lib.) de Bary was an infrequent contaminant of Brassica seed lots and was not found in those of flax or safflower. Only five samples, all of which were B. napus, yielded Sclerotinia out of a total of over 1800. Three of these

Table 12. Extent of *Alternaria brassicae* and *A. raphani* infestation of *Brassica* seed from five Saskatchewan regional varietal tests, 1973*

Brassica species and cultivar	*A. brassicae*	*A. raphani*	Total
B. campestris (avg)	10.8	6.4	17.2
Torch	10.5	8.3	18.8
Echo	11.1	5.0	16.1
Span	10.8	5.9	16.7
B. napus (avg)	9.6	1.9	11.5
Target	9.5	1.8	11.3
Zephyr	11.1	2.0	13.1
Midas	8.2	1.9	10.1

* The five locations were Melfort, Parkside, Lake Lenore, Kelvington and Somme. The seed was plated untreated.

Table 13. Effect of surface-disinfestation on levels of *Alternaria* in 151 *Brassica* seed samples

Treatment	Average % of seeds with *Alternaria* spp.		
	A. brassicae	*A. raphani*	Total
Untreated	8.1	4.9	13.0
Disinfested*	2.2	0.4	2.6
% of total *Alternaria*			
Within the seed coat	27.2	10.0	20.0
On the seed surface	72.8	90.0	80.0

* 10% Javex (0.6% available Cl on dilution), 20 min.

Table 14. Prevalence of *Fusarium roseum* in turnip rape and rape seed samples produced in Saskatchewan

Year	*Brassica campestris*			*Brassica napus*		
	% of samples infested	Infestation level (%)		% of samples infested	Infestation level (%)	
		Avg	Highest		Avg	Highest
1968	19.4	0.1	1.0	13.6	<0.1	0.3
1969	11.1	0.1	3.3	9.0	<0.1	1.0
1970	20.3	0.2	6.0	14.8	0.1	1.0
1971	26.5	0.2	2.9			
1972	50.0	0.3	1.0	32.0	0.2	1.0
Overall	20.3	0.2	6.0	13.6	0.1	2.5

represented 1968 seed from Saskatchewan. In four of the five instances, the fungus grew out from a seed, rather than originating from a sclerotium in the sample. As no intensive search for sclerotia was undertaken, it is possible that the amount of Sclerotinia present might have been considerably underestimated. However, most sclerotia likely were removed when the seed was cleaned.

The results from the 1973 rapeseed varietal tests for Fusarium, Botrytis and Sclerotinia were as follows: S. sclerotiorum grew from 0.5% of the seeds from one of the 53 seed lots, a Winnipeg sample. No significant infestation by the other two pathogens was detected in samples from Winnipeg, Saskatoon, and Beaverlodge. However, striking amounts occurred in some of these from five regional tests in Saskatchewan (Table 16). A sample of Span from Kelvington carried 17.4% Fusarium, and one of Torch, 7.5%. A Torch sample from Lake Lenore had 6.0% infested seed. Levels approaching these were rarely encountered in growers' seed during 5 years of plating. Few samples of B. napus were infested. Botrytis was also much more common than usual, occurring in high percentages of seed lots of both species (Table 16). Surface-disinfestation eliminated almost all of the Fusarium and Botrytis.

Polyspora lini occurred in 67.5%, 88.7%, and 86.9% of the Saskatchewan flax samples from 1969, 1970, and 1972, respectively. The corresponding average levels of infestation per sample were 1.1%, 4.2%, and 2.6% and the highest levels encountered in any seed lot, 14.5%, 22.5%, and 14.7%. Of the samples from Alberta, 33.3% of those from ARA's 1 to 3 and 91.7% of those from ARA's 4 to 7 carried P. lini. Slightly more than 58% of all the seed lots were infested. About 29% of those plated by Henry and Ellis (5) had the pathogen. Presumably their samples were produced in 1970.

Table 15. Prevalence of *Fusarium roseum* in *Brassica* seed samples produced in Alberta and Manitoba

Year	Alberta			Manitoba		
	% of samples infested	Infestation level (%)		% of samples infested	Infestation level (%)	
		Avg	Highest		Avg	Highest
1968	8.5	<0.1	0.3	2.8	<0.1	0.2
1969	31.3	0.1	0.7			
1970	26.7	0.8	2.5	13.0	0.1	1.0
1971				9.4	<0.1	1.0

Table 16. Extent of seed infestation with *Fusarium roseum* and *Botrytis cinerea* in Saskatchewan rapeseed varietal tests, 1973 (avg of 5 locations*)

Brassica species and no. samples plated	Fungal species	% samples infested	Infestation level (%)	
			Avg	Highest
B. campestris (14)	*F. roseum*	78.6	3.2	17.4
	B. cinerea	50.0	0.6	3.0
B. napus (13)	*F. roseum*	7.1	<0.1	0.5
	B. cinerea	42.9	0.4	1.5

* The data for three cultivars were averaged for each of the two species at each location (see text).

Discussion

Several examples have been provided of the high prevalence and incidence of certain pathogenic Alternaria spp. often encountered on seed of oilseed crops, of which Alternaria carthami on safflower is perhaps the most striking. By its very abundance, seed infestation would seem to be strongly implicated as a prime source of early spring infections in the field. This may be the case, but conclusive proof has yet to be obtained. In addition, certain factors which would tend to minimize the harmful effects of seed contamination have been identified. By simply storing Brassica seed from one crop year to the next one may reduce the viable inoculum by 50% or more under certain conditions. However, the rates of decline of infestation levels may be much less at temperatures below 25°C, the approximate average temperature prevailing during the present experiment. From the seed storage results it is also apparent that the tabulated infestation data underestimate the levels present when the seed was harvested. A few months delay between harvest and the time the seed was plated was unavoidable. It may also be noted that routine cleaning of the seed probably eliminated a considerable proportion of the more severely diseased seeds in many samples.

Another important consideration is the fate of seed-borne inoculum after the seed is sown in soil. It would appear from the few experiments conducted that the levels of Alternaria naturally occurring on Brassica seed may frequently be suboptimal for the induction of symptoms and that the soil microflora might reduce the inoculum's effectiveness. The latter appears to happen in the case of Polyspora lini on flax seed (4). The results of Richardson's study (13) of Alternaria brassicicola and A. brassicae in this regard is even more pertinent. He concluded from the results of a field trial that natural seed infestation had no effect upon emergence in the case of either pathogen. It is felt that the effect of seed infestation upon establishment of Alternaria in the subsequent crop requires considerable further study.

The effect of fungicidal treatment of Brassica seed was not examined, but as the bulk of the Alternaria inoculum was superficial, it would be readily accessable to chemicals. Mills and Wallace (8) included rapeseed in an evaluation of a number of fungicidal formulations. The production of clean seed in areas such as southern Manitoba which have been producing relatively disease-

free seed is another possibility to be considered. The development of cultivars resistant to alternaria black spot is a worthwhile objective. B. napus appears to possess greater resistance to the disease than B. campestris (2, 3, 6, 9), and it certainly had less Alternaria seed contamination in this study. The saprophytic development of some pathogens, particularly A. raphani, in association with nonsusceptible hosts may also be a factor in their dissemination worthy of consideration.

The apparent increase in Fusarium roseum on Brassica seed (Tables 14 and 16) and its consistently wide prevalence on flax seed may be significant. Footrot of crucifers in which the 'Acuminatum' type of F. roseum is also a major participant, showed a substantial increase between 1970 and 1972 (10) and Fusarium-Rhizoctonia root rot of flax has been the main problem causing inquiries in the spring from farmers in recent years. It also has been shown that at least a few variants of F. roseum 'Acuminatum' have wide host ranges among oilseed crops grown on the Canadian prairies.

It is thought that Botrytis cinerea has great potential importance in some areas due to its high virulence on all the oilseed crops studied and the fact that it can be widespread in some years (Tables 7 and 16). In Europe it is a major cause of seedling losses in flax (1). Although Rhizopus was grouped with the saprophytic species in this paper, it too can cause an important seed and pre-emergence seedling rot of rape, as Vanterpool (16) has pointed out.

Acknowledgments

The author wishes to thank Mrs. Jean Key and Mrs. Marjorie Richardson for technical assistance. He is also grateful to staff members of the Saskatoon, Edmonton, and Winnipeg laboratories of the Plant Products Divison of Agriculture Canada, in particular Mr. F. W. S. Dale, District Seed Analyst, Saskatoon. Thanks are also due staff members of the Canadian Grain Commission for supplying seed samples and to Professor R. A. A. Morrall, Department of Biology, University of Saskatchewan for providing safflower specimens.

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MICROFUNGI ASSOCIATED WITH DIEBACK OF NATIVE CUPRESSACEAE IN BRITISH COLUMBIA

A. Funk[1]

Abstract

A total of 12 microfungi were recorded on three native Canadian species of Cupressaceae in British Columbia, associated with a dieback disease that flared up in 1969-1970. Damage occurred both in natural forest and in nursery plantings. The disease has now subsided in all areas.

Résumé

L'auteur signale 12 micro-champignons dans trois espèces indigènes canadiennes de Cupressacées en Colombie-Britannique, associés au Dépérissement qui sévit en 1969-1970 dans les forêts naturelles et dans les pépinières. La maladie s'est maintenant résorbée aux deux endroits.

Pathological dieback of young native cedars (Cupressaceae) is rare in natural forests; Boyce (1961) lists no diseases in this class and my own observations during 16 years in British Columbia indicate that it is very infrequent. The outbreaks recorded here began in 1969-1970 in natural regeneration of western red cedar (Thuja plicata Donn) on Vancouver Island, and simultaneously on native cedars in nurseries and ornamental plantings in the Fraser Valley (Funk and Molnar 1972) (Fig. 1). Because of the high value of these trees, as timber and ornamental species, a study was made of the microfungi associated with the condition. Many of these fungi were proven pathogens of other species of conifers; some were new host records or first reports from Canada.

It seems likely that there were special predisposing factors in 1969-1970 that triggered the widespread outbreak of the disease. These factors have not been identified with certainty, but the unusually low temperatures of the previous winter are suspected as one of the probable causes. However, for the same period no increase was noted in dieback of other coniferous groups in B.C.; but in Europe and the U.K. (Morelet 1970; Strouts 1973), as well as in other parts of western North America (Davison and

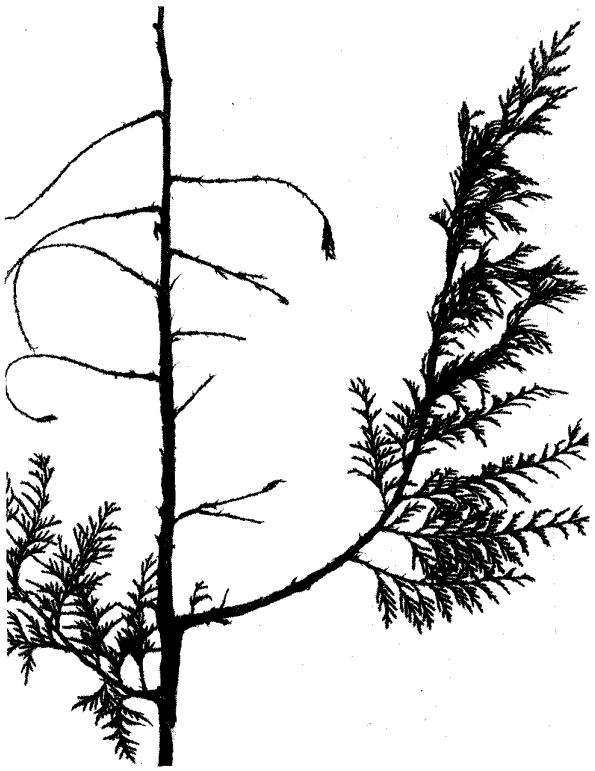

Figure 1. Dieback of yellow cedar.

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Davidson 1973), there was increased dieback in Cupressaceae. Since then, there has been a general decline of disease incidence in the species mentioned, although the leaf blight caused by Seiridium cardinale is still quite common.

Observations

Records of the microfungi are given in an annotated list under the heading of the host species. Numbers refer to specimens deposited in Herb DAVFP, Victoria; some specimens contain more than one fungus. The fungi considered most important in the causation of disease are listed first.

WESTERN RED CEDAR (Thuja plicata Donn)

1. Diaporthe lokoyae Funk (19438, 19456). A pathogen of conifers, found in natural regeneration and a forest nursery.

Figure 2. *Seiridium cardinale,* conidia.

2. Seiridium cardinale (Wagener) Sutton & Gibson (19439) (Fig. 2). Leaf and shoot pathogen, found in natural tree regeneration.

3. Kabatina thujae Schneider & v. Arx (no specimen). A pathogen, found only on T. plicata f. atrovirens, an ornamental form, in Fraser Valley.

4. Velutarina rufo-olivacea (Alb. & Schw. ex Fr.) Korf (19436, 19441). Common wherever dieback occurred. Saprophyte, comes in after primary pathogens.

YELLOW CEDAR [Chamaecyparis nootkatensis (D. Don) Spach]

Dieback occurred only in horticultural varieties growing in ornamental nurseries of the Fraser Valley.

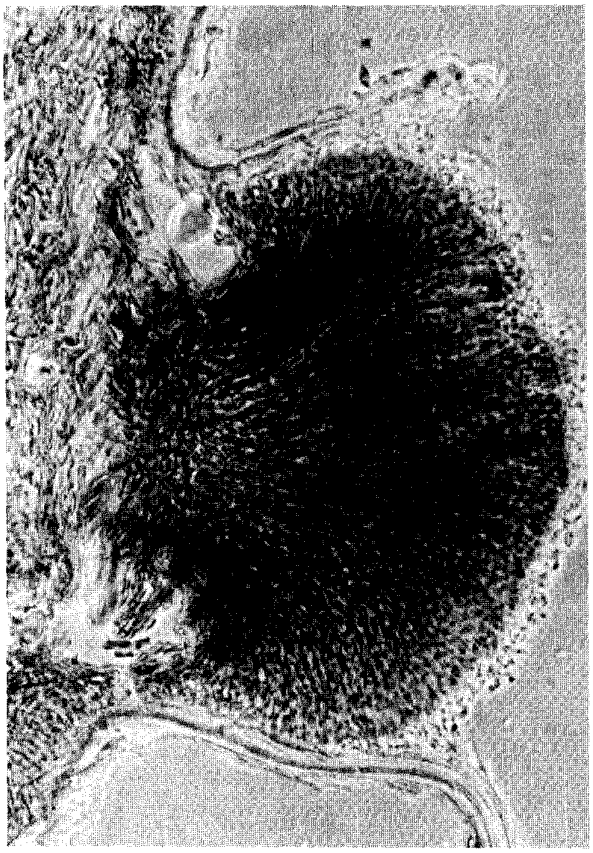

Figure 3. *Kabatina thujae,* erumpent fruiting body.

1. Kabatina thujae Schneider & v. Arx (19218-19222 incl.) (Fig. 3). A primary pathogen causing serious shoot mortality.

2. Cytospora abietis Sacc. (19205, 19207). A facultative parasite on weakened trees.

3. Pleospora laricina Rehm (19210, 19213). Probably saprophytic on killed branches.

4. Pestalotia funerea Desm. (19208, 19212). Saprophyte.

5. Pestalotia thujae Sawada (19204). Probably saprophytic.

EASTERN WHITE CEDAR (Thuja occidentalis L.)

This species is native to eastern Canada but is grown ornamentally in B.C.

1. Phomopsis juniperivora Hahn (19214). A virulent pathogen of junipers, first host record for B.C.

2. Micropera sp. (19215). Status unknown.

3. Seiridium sp. (19216). Status unknown.

Discussion

The outbreak of dieback in natural stands of western red cedar has been short-lived but intense and has revealed that several native fungal pathogens are able to inflict considerable damage under certain conditions in this species. In the Kabatina dieback of yellow cedars, the disease was so persistent that, in spite of fungicidal spraying in the nursery, the trees had to be destroyed. Fortunately there has been no recurrence or spreading of any of these diseases and the picture at present is good for these native Cupressaceae.

Sporadic diseases of forest and ornamental trees, such as these on native Cupressaceae, are completely unpredictable but have a considerable impact on the development and growth of new stands. Because they are short-lived, it may be difficult to determine the causal organisms with certainty if detection is delayed. This report is intended to aid in the assessment of damage in this class of diseases.

Acknowledgments

I thank members of the Mycology Section, Biosystematics Research Institute, Ottawa, for identifying some of these fungi, and members of the Forest Insect & Disease Survey, Victoria, for making collections.

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* Distance (miles) and † direction from designated location.

ABBREVIATIONS USED IN TABLE 4

AGP RPNS = *Agropyron repens* (L.) Beauv.;
AGRO TUMEF = *Agrobacterium tumefaciens* (Smith and Townsend) Conn. 1942;
BELLE PLAI = Belle Plaine;
CALAPPROVED = Giant Stringless Greenpod bean;
CHARLOTTET = Charlottetown;
COR = *Corynebacterium* Lehmann & Neumann 1896;
COR FLACC = *Cor. flaccumfaciens* (Hedges) Dowson 1942;
COR INSID = *Cor. insidiosum* (McCulloch) Jensen 1934;
COR MICH = *Cor. michiganense* (Smith) Jensen 1934;
COR SEPED = *Cor. sepedonicum* (Spieckermann and Kotthoff) Skaptason & Burkholder 1942;
CRYSTAL CI = Crystal City;
CYRPUS RIV = Cypress River;
DARLINGFOR = Darlingford;
DELW COMMDO = Delwiche Commando;
ER = *Erwinia* Winslow et al. 1920;
ER AMYLOV = *Er. amylovora* (Burrill) Winslow et al. 1920;
ER UREDOV = *Er. uredovora* (Pon et al.) Dye 1963;
FANNYSTELL = Fannystelle;
FIELD PE = Field peas;
FORT SIMPS = Fort Simpson;
GAINSBOROU = Gainsborough;
G STRLS GPD = Giant Stringless Greenpod bean;
GILBERT PL = Gilbert Plains;
HALO = Producing a chlorotic halo in oats;
HED HELX = *Hedera helix* L.;
IRRI 422 ETC = International Rice Research Institute 442-2-50-2-2-3;
KAPUSKASIN = Kapuskasing;
LATH VEN = *Lathyrus venosa* Muhl.;
LIMA BN = Lima bean;
LTH 4363-32 = Lethbridge, AB 36-1991 × Titan;
LTH 5134-4 = Lethbridge, Harlan × Montcalm;
L 50824-12-5 = Lacombe, 508-24-12-5;
MTCLM X ANOID = Montcalm × Anoidium;
MTN = Mountain;
P = *Pseudomonas* Migula 1894;
P.C. = *Pseudomonas coronafaciens* (Elliott) Stevens 1925;
P.C. NO HALO = *Pseudomonas coronafaciens*, lesions lacking chlorotic halo;
P. STRIAF = *Pseudomonas striafaciens* (Elliott) Starr & Burkholder 1942;
P. GLYCINEA = *Pseudomonas glycinea* Coerper 1919;
PIGEON LAK = Pigeon Lake;
PILOT MOUN = Pilot Mound;
P. LACHRY = *Pseudomonas lachrymans* (Smith and Bryan) Carsner 1918;
PS ATROFAC = *Pseudomonas atrofaciens* (McCulloch) Stevens 1925;
POPLAR POI = Poplar Point;
P. PHASEOL = *Pseudomonas phaseolicola* (Burkholder) Dowson 1943;
P. TOMATO = *Pseudomonas tomato* (Okabe) Alstatt 1944;
PORTAGE LA = Portage la Prairie;
P. PISI = *Pseudomonas pisi* Sackett 1916;
QUACK GR = *Agropyron repens* (L.) Beauv.;
R RK X MINHDY = Red Rock × Minhardy;
SEDDONS CR = Seddons Corner near Buchan, Man.;
ST. EUSTACH = St. Eustache;
ST. FRANCOI = St. Francois;
STE ROSE = Ste. Rose du Lac;
TX K-SG = *Taraxicum Kok-saghz* Rod.;
ST. JEAN BT = St. Jean Baptist;
UNIDENT PP = Unidentified bacterial plant pathogen;
UNION POIN = Union Point;
VANKLEEK H = Vankleek Hill;
VCT X GN R 578 = Victory × Green Russian, strain 578;
WHEAT = Spring Wheat (bread wheat);
WINNIPEG B = Winnipeg Beach;
X = *Xanthomonas* Dowson 1939;
X. CAMPEST = *X. campestris* (Pammel) Dowson 1939;
X. CAROTAE = *X. carotae* (Kendrick) Dowson 1939;
X. HEDERAE = *X. hederae* (Arnaud) Dowson 1939;
X. PHASEOLI = *X. phaseoli* (Smith) Dowson 1939;
X.T. = *Xanthomonas translucens* (Jones, Johnson and Reddy) Dowson 1939;
X.T. CER = *X. t.* f. sp. *cerealis* Hagborg 1942;
X.T. H = *X. t.* f. sp. *hordei* Hagborg 1942;
X.T. H-A = *X. t.* f. sp. *hordei-avenae* Hagborg 1942;
X.T. SECAL = *X. t.* f. sp. *secalis* (Reddy, Godkin and Johnson) Hagborg 1942;
X.T. UNDULO and XTU = *X. t.* f. sp. *undulosa* (Smith et al.) Hagborg 1942;
X. VESICAT = *X. vesicatoria* (Doidge) Dowson 1939.