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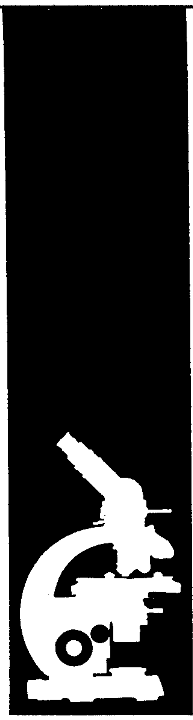
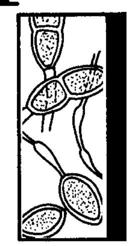
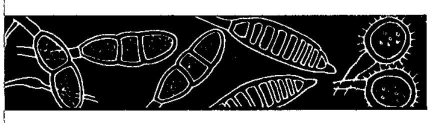


CANADIAN PLANT DISEASE SURVEY





EDITOR W.L. SEAMAN

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

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CANADIAN PLANT DISEASE SURVEY

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CONTENTS

"The Canadian Plant Disease Survey is a periodical of information and record on the occurrence and severity of plant diseases in Canada. 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. It will not accept results of original research suitable for publication in more formal scientific journals".

AIR-BORNE RUST INOCULUM OVER WESTERN CANADA IN 1967[1]

G.J. Green[2]

In these studies, urediospores of the cereal rusts are trapped mainly to learn the time of arrival and the relative amount of primary inoculum brought into Western Canada from wheat-growing areas to south. Knowledge of spore concentrations in the air during the growing season also helps in the evaluation of the seriousness of a rust threat. The date of the first appearance of rust is important because the growing season in Western Canada is short. Wheat seeded about the end of May may be ripe by mid-August and not subject to rust damage after early August. In most years rust has about 2 months in which to develop; therefore, rust appearing in early June is more apt to increase to destructive amounts in the following 8 weeks than rust appearing early in July. The amount of primary inoculum is important also because it usually determines the amount of secondary inoculum produced. The arrival of spores from the south later in the season may also increase the rate of rust development.

In 1967 spore traps were operated at Winnipeg, Morden, and Brandon in Manitoba, and at Indian Head and Regina in Saskatchewan. The vaseline-coated slides exposed at these stations were forwarded to Winnipeg for examination. Spore concentrations were similarly determined at the Canada Department of Agriculture Research Station, Saskatoon. The slides were exposed for 48-hour periods at an angle of 45° from the vertical in sheet-metal spore traps, which were oriented by a wind-vane so that the vaseline-coated surface faced into the wind. After exposure, the area under a 22 x 50-mm cover slip was examined microscopically and the number of spores per square inch determined.

Spore counts were the lowest since 1961 (Table 1) and were indicative of the scarcity of rust in Western Canada in 1967. Although few spores were present in the air during May and June, a fairly large number of leaf rust spores were caught at Winnipeg on June 10 and 11 (Table 2). This spore shower probably was responsible for the appearance of leaf rust on susceptible winter wheat in experimental plots at Winnipeg on June 26. However, spore deposition seems to have been mainly in the

Table 1. Total number* of urediospores of stem rust and leaf rust caught in spore traps in Western Canada from 1960 to 1967

	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
Year	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
1960	1,719	1,295	677	1,708	223	546	49	2,087	49	3,674	0	10,277
1961	88	153	109	212	24	80	27	71	37	101	8	246
1962	782	1,563	2,236	6,282	1,640	2,972	789	1,874	3,000	4,840	198	2,498
1963	2,544	13,685	2,477	26,612	1,722	15,210	1,597	39,785	2,008	69,681	5,571	80,657
1964	12,872	15,041	18,578	14,780	16,439	12,797	3,798	6,918	8,632	42,129	132	531
1965	4,943	9,811	5,362	25,978	2,698	16,091	10,559	66,730	31,635	227,576	1,927	77,502
1966	3,830	7,356	1,843	14,805	737	5,019	469	17,339	724	86,525	526	37,989
1967	2,498	8,997	918	6,974	72	1,107	34	454	70	473	117	344

* Expressed as spores per square inch except the data for Saskatoon for the years 1960 to 1964, where the numbers represent spores per slide.

[1] Contribution No. 294, Research Station, Canada Department of Agriculture, Winnipeg, Mani-

[2] Plant Pathologist.

Winnipeg area because no leaf rust appeared in farm fields until July 13.

Spore showers during May have little practical significance since most of the crop in Western Canada is usually planted in the latter half of the month. Spore showers in mid-June are most important, because crops usually emerge early in June and are growing rapidly by mid-month. Spore showers occurring about mid-June or earlier can cause infections that produce pustules in about 14 days. In 1967, seedling was general in Western Canada by May 20 and was nearly completed by the end of the month. According to the Telegraphic Crop Report of the Dominion Bureau of Statistics on June 21, crops were in the 2- to 5-leaf stage in Manitoba. Leaf rust found on spring wheat in farm fields on July 13 developed slowly until the crop began to mature early in August. Stem rust was first found on susceptible winter wheat varieties in experimental plots on July 11, but it was not found during the season on the resistant varieties grown by farmers in the rust area. Readily observable amounts of stem rust did not appear on susceptible wild barley (Hordeum jubatum L.) until August 3.

Because of the scarcity of rust, especially stem rust, in farm fields in Western Canada in 1967, conclusions may be drawn concerning the origin of the spores caught. It is evident that insignificant numbers of spores of leaf rust were produced in Western Canada before mid-July and of stem rust before early August. The spores caught on the slides during May, June and early July, therefore, were carried into Western Canada by air movements from the south. The influx of spores from the south continued during the latter part of July, probably until July 28, and was complemented by locally produced leaf rust spores which became more abundant during this period. During August, spores on slides

Table 2. Number of urediospores of stem rust and leaf rust per square inch caught on vaseline-coated slides exposed for 48-hour periods at three locations in Manitoba and three locations in Saskatchewan in 1967

	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
Date	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
May 15-16	0	0	0	0	0	0	0	0	0	0	0	0
17-18	0	0	0	0	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	2	0	0	0	0
25-26	1	3	0	1	0	0	0	0	0	0	0	0
27-28	0	0	0	0	0	1	0	1	0	1	0	0
29-30	0	0			0	0	0	0	0	0	0	0
May Total	1	0	2	1	0	1	0	3	0	1	0	0
May 31-June 1	0	0	0	0	0	0	0	0	0	1	0	0
2-3	0	3	0	0	0	1	0	0	0	0	0	0
4-5	0	0	0	0	0	0	0	0	0	0	0	0
6-7	0	0	0	0	0	0	0	0	0	0	0	0
8-9	4	1	4	0	3	1	0	0	0	0	0	0
10-11	2	55	0	1	1	2	0	0	0	0	0	0
12-13	0	0	0	0	0	0	0	0	0	0	0	0
14-15	0	4	0	0	0	0	0	0	0	0	0	0
16-17	0	9	0	6	0	1	0	5	0	2	0	0
18-19	0	4	0	0	0	0	0	2	0	1	0	0
20-21	2	7	0	3	0	7	0	4	0	2	0	0
22-23	0	0	0	0	0	0	0	1	0	1	0	0
24-25	0	0	0	0	0	0	0	0	0	0	0	0
26-27	0	1	0	4	0	0	0	0	0	1	0	4
28-29	0	0			0	0	0	3	0	2	0	5
June Total	8	84	4	14	4	12	0	15	0	10	0	9

Table 2 (Concluded)

Date	Winnipeg Stem rust	Winnipeg Leaf rust	Morden Stem rust	Morden Leaf rust	Brandon Stem rust	Brandon Leaf rust	Indian Head Stem rust	Indian Head Leaf rust	Regina Stem rust	Regina Leaf rust	Saskatoon Stem rust	Saskatoon Leaf rust
June 30-July 1	0	1	0	1	0	1	0	2	0	2	0	0
2-3	0	2	0	2	0	2	0	3	0	3	0	4
4-5			4	29	3	22	0	4	1	6	0	5
6-7	0	4	1	8	0	6	1	8	1	6	0	11
8-9	2	5	2	12	2	9	1	6	2	14	0	13
10-11	13	5	1	6	1	4	1	4	2	16	0	16
12-13			0	6	0	7	0	2	0	5	0	14
14-15	0	2	18	195	0	8	0	13	0	12	0	71
16-17	1	13	0	20	0	6	1	16	33	39	0	22
18-19	2	23	5	131	2	18	0	22	1	14	0	26
20-21	11	43	4	56	0	12	0	1	0	5	0	16
22-23			0	16	0	7	0	6	0	9	0	8
24-25	0	18	1	53	0	3	1	4	0	6	0	31
26-27	0	3	0	26	0	8	0	0	0	1	0	6
28-29	8	66	1	41	0	7	0	4	2	9	0	14
30-31	11	74	14	791	2	41	0	20	0	21	0	15
July Total	48	259	51	1393	10	161	5	115	42	168	0	272
Aug. 1-2	2	229	5	94	0	41	2	24	0	13	0	3
3-4	0	43	11	240	2	60	0	9	0	16	0	0
5-6	40	355	5	79	0	22	0	5	0	8	0	3
7-8	11	132	5	209	0	6	0	2	1	4	0	2
9-10	2	29	4	80	0	8	0	8	6	17	0	2
11-12	21	277	41	539	7	18	1	11	2	27	0	1
13-14	50	293	16	180	1	47	0	5	0	9	0	1
15-16	75	553	33	309	2	38	0	7	0	5	0	1
17-18	73	630	18	312	5	220	0	8	0	18	0	2
19-20	223	1164	76	451	4	66	0	70	0	16	0	11
21-22	94	366	113	481	12	66	11	64	12	56	104	6
23-24	516	1906	147	789	8	113	12	47	2	49	0	0
25-26	774	406	115	499	9	67	1	12	0	8	0	4
27-28	445	1894	159	863	5	100	0	34	2	29	9	22
29-30	115	374	115	441	3	61	2	15	3	19	4	5
Aug. Total	2441	8651	863	5566	58	933	29	321	28	294	117	63
TOTAL	2498	8997	918	6974	72	1107	34	454	70	473	117	344

were probably from both sources, but the proportions from either source cannot be determined. Appreciable numbers of the stem rust spores caught were probably brought in from the south since the only local source of inoculum was lightly infected wild barley.

Because of the unusual conditions that existed in the 1967 growing season, an attempt was made to correlate the spore trapping results with weather conditions. The climatologist of the Meteorology Branch, Canada Department of Transport, Winnipeg, provided a report (Appendix) on air movements during periods of high spore counts. It was assumed that spores brought into Western Canada originated mainly in the winter-wheat-producing areas of Kansas and Nebraska. A homogenous air mass was present from Kansas and Nebraska to Manitoba and eastern Saskatchewan during many of the selected periods. In each period, air from the south moved into Western Canada and, without exception, the air masses present were unstable. It is also evident that during the selected periods there were convection currents that could carry spores to high altitudes and bring them down again. Once aloft, the spores could be transported rapidly in the upper air currents (40-60 nautical mph.). The report further indicates that there is great opportunity for spores to become distributed more or less uniformly over large areas. This would be especially true late in season when many spores are air-borne. It is clear from the absence of rust in Western Canada early in the season and from the reports on air movements that many of the spores caught in Western Canada during the 1967 season originated in the winter wheat area of the United States and that this influx of spores continued during the growing season.

It is interesting to consider the climatologist's report for the period May 23-26 in relation to the light spore shower that was detected by the traps. In Western Canada seeding was in progress and no spores were being produced. In the winter wheat area to the south, stem rust infections were very light. Southerly winds arrived in eastern Saskatchewan about midnight of May 22 and spread eastward into Manitoba during the next morning. Two leaf rust spores were caught at Indian Head in eastern Saskatchewan during May 23-24. Strong southerly winds blew from Kansas into Manitoba on May 24 and 25 and a few spores of stem rust and leaf rust were caught at Winnipeg and Morden on May 25 and 26. Despite northerly winds that commenced on May 26 and spread arctic air into the eastern prairies, single leaf rust spores were caught at Brandon, Indian Head, and Regina during May 27-28. Evidently the flow of arctic air did not immediately remove all air-borne rust spores from the area. No spores were caught on May 29 and 30, and only one was trapped, at Regina, during the period May 31-June 1.

Acknowledgments

The cooperation of personnel of the Canada Department of Agriculture at the spore trap locations made this project possible.

Appendix

THE SYNOPTIC WEATHER SITUATIONS DURING SPORE SHOWERS, 1967[3]

May 23 - May 26

On the evening of May 22 a low-pressure system passed to the south of Winnipeg and a light northerly to northwesterly flow of air was established over the eastern prairies. A second disturbance appeared over western Montana at midnight and in advance of it southerlies developed in eastern Saskatchewan and spread as far east as Winnipeg by morning. At that time the trajectory of the wind affecting Saskatchewan and Manitoba would have been from an origin in the western Dakotas northward to the eastern prairies (assuming airmass homogeneity*). On the evening of the 23rd, a Maritime tropical airmass spread over Montana, Wyoming, the western Dakotas and gradually spread eastward to encompass most of the remainder of these states by the evening of the 24th. This airmass overran the cooler polar air over the southern prairies causing showery precipitation from Regina to Winnipeg on the 24th and over Manitoba on the 25th. The circulation on the night of the 24th and the 25th saw strong southerlies develop from Kansas into Manitoba, although winds had begun to shift in Saskatchewan into a westerly as they moved into a Maritime Arctic airmass which spread into the Winnipeg area by the evening of the 25th, ending the woutherly circulation. By the morning of the 26th, north winds and arctic air had spread into all of the eastern prairies.

The Maritime tropical airmass referred to above was very unstable therefore strong convective currents would be present in it, which would carry particulate matter aloft to considerable heights.

Precipitation fell on 24th and 25th from an unstable airmass which had passed through the Kansas, Nebraska area. Had spores been available in these areas they would readily have been transported aloft into the airmass by strong convective currents and deposited in Saskatchewan in precipitation and in Manitoba by precipitation or by moderate south winds blowing from southern regions on the night of the 24th and on the 25th. An upper air sounding made at Bismark, North Dakota was representative of this airmass and showed possible convective currents to 33,000 feet during the afternoons.

June 2 - 3

The airmass was homogenous from Kansas and Colorado-Utah to eastern Saskatchewan-Manitoba. Strong southerly to south-southwesterly winds persisted in these areas until the passage of a cold front shifted the winds to strong northwest in Saskatchewan, the western Dakotas and northwestern Nebraska during the late morning and early afternoon of the 3rd and over Manitoba during the late afternoon.

The airmass south of Saskatchewan was quite unstable on June 2 and 3 but Nebraska - North Dakota soundings indicated that convection would be cut off at about 5,000 ft on June 2. On the 3rd, however, these soundings had warmed to the extent that very strong convection currents would be present.

Conditions were ideal for transfer of spores Saskatchewan on the 2nd and early morning of the 3rd, and into Manitoba on the 3rd.

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3 Contributed by P. J. Pender, Climatologist, Meteorology Branch, Canada Department of Transport, Winnipeg, Manitoba.

* Homogeneity of airmass here implies the same airmass over the eastern prairies as over the Kansas - Nebraska areas.

June 8 - 11

In this period the airmass was again generally homogeneous. There was a light easterly circulation, which became a little south of east on the 11th in eastern Saskatchewan and Manitoba. A weak cold front changed the winds to west at Regina early on the morning of the 11th, but it did not advance much further eastward that day.

The Bismarck sounding was chosen as representative of the airmass. Instability was present on June 8, 9, and 10, with maximum convective currents to 23,000 on the afternoon of the 9th. By the afternoon of the 11th it had become quite stable.

June 14 - 20

From June 14 to 17, winds on the eastern prairies were northerly to easterly as disturbances moving from Kansas to the Upper Great Lakes avoided this area. On the 17th a new storm track became established south of the eastern prairies from west to east through the Dakotas. Winds continued easterly to northeasterly until a major system moving into western Saskatchewan on the afternoon of the 17th initiated south to southeast winds in eastern Saskatchewan, the Dakotas, Nebraska and Kansas. Strong southerlies developed in Manitoba by mid-morning on the 18th and swept up from the Nebraska-Kansas areas. At the same time, they had begun to shift into the northwest at Regina and by evening all of Saskatchewan had northwest winds. By evening on the 19th the wind shift had spread to Winnipeg and northwesterlies prevailed across the eastern prairies.

Bismarck and Shilo soundings on the 18th indicated convection to 30,000 feet during the period of strong southerly winds.

June 26 - 27

Conditions were almost identical to those on June 2 - 3 except that winds were not as strong. Considerable convection indicated by cumulus cloud and thundershowers scattered throughout the airmass.

July 10 - 21

This period began with strong northwest winds over the area following the passage of a cold front. A high-pressure system then pushed down from the Northwest Territories and maintained north winds at Regina until the evening of the 12th when they became light easterly. As the high turned eastward, winds shifted behind it into the east and finally into the south. Moderate southerlies had developed at Regina by the evening of the 13th. Weak southerlies reached as far east as Winnipeg by morning of the 14th and freshened by afternoon. However, a second cold front had now moved through Saskatchewan and here winds were back to the north. By noon on the 15th, northwest winds had returned to Winnipeg as the cold front continued eastward. Another high followed. Southerlies developed in Saskatchewan on the morning of the 17th as a weak low moved into western sections of that province and spread to Manitoba during the afternoon. The disturbance then turned northward into northern Manitoba, maintaining southerlies at Regina till the morning of the 19th when another weak cold front moved through the areas and reached Winnipeg late in the evening on the 20th. A light west to northwest circulation was then established.

In each of the above cases convection occurred during southerly circulations, and the southerly circulation extended far enough south to include the Kansas - Nebraska area. The southerlies were not particularly strong at any time except on July 17 over Eastern Saskatchewan.

LEAF RUST OF WHEAT IN CANADA IN 1967[1]

D.J. Samborski [2]

Disease development and crop losses in Western Canada

Development of leaf rust on the United States winter wheat crop was limited by drought and an extended period of low temperatures. Consequently, only small numbers of spores of Puccinia recondita Rob. ex Desm. were carried into Western Canada, where dry weather further delayed rust development. In some areas of Manitoba considerable leaf rust was present on 'Selkirk' wheat at maturity, but the rust developed too late to reduce yields.

Leaf rust in the rust nurseries

Although severe infections of leaf rust occurred in a number of nurseries (Table 1), it must be emphasized that these infections do not necessarily represent the severity of infections in commercial fields. In some nurseries plants were examined when they were nearly ripe, while in others observations were made at an earlier stage of plant development. 'Frontana', which was highly resistant in all the nurseries, has been extensively used in breeding programs, and 'Chris' and 'Manitou', which

Table 1. Percentage infection by Puccinia recondita on 15 wheat varieties in uniform rust nurseries at 22 locations in Canada in 1967

Locality	Lee	Thatcher	Selkirk	Red Bobs	Manitou	Marquis	Kenya Farmer	McMurachy	Ramsey	Mindum	Stewart 63	D. T. 184	Thatcher^{6}x Transfer	Exchange	Frontana
Saanichton, B.C.	5	25	0	25	0	40	5	40	0	0	0	0	0	0	0
Creston, B.C.	tr*	25	tr	25	tr	25	2	20	0	0	0	0	0	0	0
The Pas, Man.	20	80	40	70	2	40	20	20	tr	0	0	0	0	0	0
Morden, Man.	70	90	70	100	5	80	50	80	0	0	0	0	0	0	0
Winnipeg, Man.	40	50	40	70	5	50	40	50	0	0	0	0	0	0	0
Glenlea, Man.	30	40	20	60	3	40	20	30	0	0	0	0	0	0	0
Verner, Ont.	30	90	30	90	5	90	35	90	tr	0	tr	tr	0	0	0
Williamstown, Ont.	10	50	10	50	5	50	15	50	0	0	0	0	0	0	0
Douglas, Ont.	10	75	10	75	5	75	10	70	0	0	0	0	0	0	0
Alfred, Ont.	20	75		75	10	75	20	75	0	0	0	0	0	0	0
Kemptville, Ont.	15	75	15	80	5	75	15	80	0	0	0	0	0	0	0
Fort William, Ont.	15	30	10	35	5	30	15	30	0	0	0	0	0	0	0
Guelph, Ont.	20	70	10	70	2	65	15	65	0	10	10	tr	0	0	0
Ottawa, Ont.	25	70	40	75	10	75	25	65	10	20	10	0	0	0	0
Appleton, Ont.	20	85	20	90	10	85	20	85	0	0	0	0	0	0	0
St. Catherines, Ont.	20	65	5	70	5	70	10	65	1	1	0	1	0	0	0
La Pocatière, Que.	5	35	5	35	tr	35	15	35	0	0	0	0	0	0	0
Quebec, Que.	10	10	5	10	0	10	5	10	0	0	0	0	0	0	0
Macdonald College, Que.	5	60	5	50	0	60	5	65		10	tr		0	0	0
Lennoxville, Que.	5	50	10	50	10	60	5	50	tr	tr	0	0	0	0	0
L'Assomption, Que.	20	85	35	85	10	80	30	80	tr	tr	1	5	0	0	0
Kentville, N.S.	10	65	5	80	5	65	10	65	0	0	0	0	0	0	0

* tr=trace

1 Contribution No. 298, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba.

2 Plant Pathologist.

have adult plant resistance inherited from 'Frontana', are being widely grown in the spring wheat area of North America.

Distribution of physiologic races

Studies on the inheritance of resistance in the standard differential varieties and on the inheritance of virulence on these varieties have indicated that a comparable differentiation of the leaf rust population in Canada could be obtained by using genes Lr1, Lr2, $Lr2^4$ and Lr3 (1, 4). Backcross lines containing these genes for leaf rust resistance have been developed and they were used in the 1967 leaf rust survey. The distribution of isolates that were virulent on these single-gene lines is shown in Table 2. Virulence formulae (2) were used to describe virulence combinations obtained in the 1967 survey. Avirulence on genes Lr1, Lr2 and $Lr2^4$, and virulence on Lr3 is predominant in the rust population.

Table 2. Virulence of isolates of *Puccinia recondita* on backcross lines containing genes Lr1, Lr2, $Lr2^4$ and Lr3 for resistance to leaf rust in Canada in 1967

Virulence formula (effective/ineffective host genes)	Typical race	Number of isolates from: Maritimes	Ont. & Que.	Man.	Sask.	B.C.	Total isolates	% total isolates
1, 2, 2^4/3	15	7	25	72	44	3	151	63.5
1, 2, 3/2^4	11	1				2	3	1.3
1, 2/2^4, 3	58 or 161	8	42		14	11	75	31.3
2, 2^4/1, 3	5		1	2			3	1.3
2/1, 2^4, 3	126		3				3	1.3
/1, 2, 2^4, 3	30		3				3	1.3
							238	100.0

Table 3. Distribution by geographic area of NA65 races of *Puccinia recondita* isolated in Canada in 1967

Race	Number of isolates from: Maritimes	Que. & Ont.	Man.	Sask.	B.C.
1	1				2
3	13	57	5	22	11
7		3			
9		4	35	13	1
10	2	9	33	23	
11		1	1		2

Only three cultures in 1967 were virulent on the backcross line containing gene Lr2.

All cultures of leaf rust isolated in 1967 were tested on the NA65 supplementary differential varieties, and the distribution of NA65 races is shown in Table 3. The survey data from each area are also expressed as the percentage of isolates virulent on the individual supplementary differential varieties (Table 4). The results are very similar to those obtained in 1966, and no important shift in virulence occurred on these varieties in 1967.

A number of highly resistant varieties (3) were inoculated with bulked collections of uredospores to detect scarce or new virulent strains in the rust population. Susceptible-type pustules were obtained only on 'Maria Escobar' and 'Klein Titan'. This type of virulence is normally present in the leaf rust population.

Table 4. Percentage of isolates of Puccinia recondita studied in Canada in 1967 virulent on each of the NA65 differential wheat varieties

Geographic area	Dular	Waban	Lee	Sinvalocho	Exchange
Maritimes	0	0	12.5	81.3	12.5
Que. & Ont.	0	4.0	17.7	82.4	12.2
Man.	0	0	93.2	8.0	44.7
Sask.	0	0	62.0	38.0	40.0
B.C.	0	0	19.0	81.2	0.0

Acknowledgments

I am grateful for assistance given by the cooperators in the care of the rust nurseries and the collection of rust specimens. Mr. W. O. Ostapyk performed the technical operations needed for identifying the physiologic races.

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STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1967[1]

G.J. Green [2]

Prevalence and importance in Western Canada

In 1967, wheat stem rust caused by Puccinia graminis Pers. f. sp. tritici Erikss. and Henn. was first found in Western Canada at Winnipeg, Manitoba. A few pustules were observed in experimental plots of winter wheat on July 11, but the disease could not be found on the susceptible spring wheat varieties 'Marquis' and 'Red Bobs' in experimental plots at Morden on July 13. Stem rust was not found on the resistant varieties grown in the rust area, although observations were made continuously during the growing season. Trace amounts could not be found readily on susceptible wild barley (Hordeum jubatum L.) throughout the rust area until August 3. Stem rust developed late in August in late-sown plots of susceptible varieties in rust nurseries located in the rust area. On August 15 there was only 1% stem rust on the very susceptible 'Red Bobs' at Brandon, Manitoba, but on August 30 40% of the plants of this variety were infected at The Pas, Manitoba. At Regina, Saskatchewan on July 24, stem rust could not be found on the susceptible spring wheat varieties 'Red Fife', 'Marquis', and 'Saunders' or on the susceptible winter wheat variety 'Kharkov'. On August 3, it was found in trace amounts at Fleming, Saskatchewan, on the Manitoba border, but it was not found at Alameda, Arcola, Aylesbury, Kelliher, Torquay, Radville, Viceroy, Langenburg, and Yorkton. The weather was dry at all locations except Fleming and Langenburg. Not a single pustule could be found at Swift Current in western Saskatchewan on August 7.

Probably the main factor limiting rust development was the extremely dry season. Average precipitation from April 1 to September 11 was 8.97 inches normal 12.25) in Manitoba, 4.55 inches (normal 9.80) in Saskatchewan, and 7.29 inches (normal 10.57) in Alberta. The development of stem rust on susceptible varieties late in the season in Manitoba indicated that rust development was limited by the resistance of the cultivated varieties and by the small amount of primary inoculum carried into Western Canada.

Stem rust of wheat, barley, and rye in the rust nurseries

The amount of stem rust in the Western Canadian nurseries was much less than usual. No rust developed on wheat in nurseries in Saskatchewan, Alberta, or British Columbia. At Brandon in western Manitoba stem rust infection was 1% on 'Red Bobs' on August 15 (Table 1). The rust nurseries at The Pas, Morden, and Glenlea, Manitoba, were examined in late August and early September, but rust development was heavy only at Morden. Rust occurred in all nurseries in Ontario but the intensities varied greatly. Barberry may have contributed to rust development in some areas. Rust was less common in Quebec than in Ontario, and none was found in nurseries east of Quebec.

The reaction of the varieties at locations where rust developed followed the pattern of former years. The susceptible varieties 'Red Bobs' and 'Marquis' were most heavily rusted; the varieties 'Lee' and 'Thatcher', which are susceptible to subraces of 15B but resistant to many other races, were lightly rusted at most locations; and the resistant varieties 'Selkirk', 'Manitou', 'Kenya Farmer', 'Stewart 63', and 'D. T. 184' had little or no infection.

Stem rust on barley and rye was also light. 'Prolific' rye was infected at only 10 of the 36 nurseries (Table 2), and apparently rye stem rust (Puccinia graminis Pers. f. sp. secalis Erikss. and Henn.) developed too late to infect the barley varieties. 'Montcalm' barley is susceptible to both wheat stem rust and rye stem rust, but it is evident that wheat stem rust was the cause of most of the infection on it because 'Parkland' and 'C. I. 10644', which are resistant to wheat stem rust but susceptible to rye stem rust, were not attacked.

Distribution of physiologic races

In 1967 the isolates of wheat stem rust obtained in Canada were classified into 9 virulence formulas or 6 physiologic races. The virulence formula system (2) has been used since 1965, and the physiologic races were identified by the methods described by Stakman et al. (3), except that only the varieties 'Marquis', 'Reliance', 'Arnautka', 'Mindum', 'Einkorn' and 'Vernal' were used as differential hosts.

The virulence formulas now in use (Table 3) differ from those listed earlier (2) mainly in that Sr1 has been added to some of the formulas. Several years ago Dr. Knott of the University of Saskatchewan provided seed of a backcross line of 'Marquis' (Marquis ^{6} x H-24-44) carrying a gene from 'H-44-24' presumed to be Sr1 that had been named many years ago (1). This line has been used regularly in the physiologic race survey for 3 years and considerable data is now available on its performance. It seems advisable to accept this gene as Sr1, although it confers seedling resistance to a

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Table 1. Percent infection of stem rust of wheat (Puccinia graminis f. sp. tritici) on 14 wheat varieties in uniform rust nurseries at 19 locations* in Canada in 1967

Locality	Common wheat										Durum wheat			
	Red Bobs	Marquis	Lee	Thatcher	Selkirk	Manitou	Kenya Farmer	McMurachy	Exchange	Frontana	Mindum	Ramsey	Stewart 63	D. T. 184
Brandon, Man.	1	tr**	tr	0	0	0	0	0	0	0	0	0	0	0
The Pas, Man.	40	10	tr	10	tr	0	0	0	tr	0	tr	0	0	0
Morden, Man.	80	70	20	20	0	0	0	0	1	tr	3	0	0	0
Glenlea, Man.	30	30	1	1	tr	tr	tr	0	1	1	10	tr	0	tr
Fort William, Ont.	70	40	5	tr	0	0	tr	0	tr	0	0	0	0	0
Kapuskasing, Ont.	5	tr	tr	tr	0	0	0	0	0	0	0	0	0	0
St. Catharines, Ont.	20	1	0	0	0	0	0	0	0	0	1	0	0	0
Guelph, Ont.	90	80	50	20	0	0	0	10	25	tr	50	0	0	0
Kemptville, Ont.	50	30	5	tr	0	0	0	0	tr	0	10	0	0	0
Appleton, Ont.	50	25	1	tr	0	0	tr	0	tr	0	5	0	0	0
Williamstown, Ont.	50	15	25	10	1	0	0	0	0	0	5	0	0	0
Alfred, Ont.	10	5	5	10	0	0	0	tr	0	0	tr	0	0	0
Verner, Ont.	40	5	0	0	0	0	0	)	tr	0	0	0	0	0
Douglas, Ont.	70	70	25	10	0	0	1	1	1	0	25	5	0	0
Ottawa, Ont.	35	40	30	5	0	0	0	10	20	tr	20	0	0	0
Macdonald College, Que.	50	20	1	tr	0	0	0	0	0	tr	15	0	0	0
Lennoxville, Que.	1	tr	0	1	0	0	0	0	0	0	tr	0	0	0
La Pocatière, Que.	25	10	20	20	0	0	1	0	0	tr	tr	0	0	0
L'Assomption, Que.	25	5	0	0	0	0	0	0	0	0	0	0	0	0

* No rust was observed in nurseries at 17 other locations: Saanichton, Agassiz and Creston, B. C.; Edmonton, Beaverlodge, Lacombe and Lethbridge, Alta.; Scott, Melfort and Indian Head, Sask.; Quebec and Normandin, Que.; Kentville and Truro, N. S.; Fredericton, N. B.; Charlottetown, P. E. I.; and St. John's, Nfld.

** tr = trace

number of races, whereas Srl was originally identified by a study of the inheritance of adult plant resistance. Some formulas that do not have Srl were written before the Marquis-Srl line became available and have not been found since. Other formulas such as Cl, C2, and C24 do not contain Srl because this gene appeared to differentiate between cultures of these formulas, and supporting evidence is needed before new formulas can be written. Two cultures of Cl (17) were identified in 1967, but isolates with the other two formulas were not found. Cultures with these formulas do not appear to be important, and it does not seem worthwhile to carry out a special study to demonstrate that they include cultures virulent or avirulent on Srl. One new formula, C32, was differentiated in 1967.

The number of isolates identified in 1967 is smaller than usual because of the scarcity of rust in Canada. The prevalence of race C18 (15B-IL) (Table 4) increased from 68.1% in 1966 to 77.3% in 1967, while race C17 (56) decreased from 5.5% in 1966 to 2.4% in 1967. These changes follow a trend that began in 1964. Races C18 (15B-IL) and C17 (56) have no practical importance in Canada because all varieties produced for commercial use are resistant to them. The most virulent race found in 1967, C20 (11), increased from 2.5% of the isolates in 1966 to 13.0%. It can attack seedlings of 'Selkirk' and it is moderately avirulent on 'Manitou' (infection type; to 2CN). However, it is not as virulent as the races C22 (32) and C25 (38) that were present in 1965 and 1966 and that have now disappeared from Western Canada. Race C20 (11) does not appear to threaten the varieties now grown in the rust area of Western Canada. Races C14 (38), C19 (38), C29 (17) and C32 (32) were found rarely in Ontario, and may have originated on barberry. Race Cl (17) was found once in Manitoba and once in Saskatchewan. Only races C18 (15B-IL), C17 (56), and C20 (11) were found in both Eastern and Western Canada. Nearly all rust collections were obtained from susceptible varieties or susceptible wild grasses.

Table 2. Percent infection of stem rust (Puccinia graminis) on three varieties of barley and one variety of rye in uniform rust nurseries at 14 locations* in Canada in 1966

Locality	Barley			Rye
	Montcalm	Parkland	C. I. 10644	Prolific
Creston, B. C.	0	0	0	20
The Pas, Man.	5	0	0	0
Morden, Man.	30	0	0	0
Glenlea, Man.	2	0	0	0
Guelph, Ont.	0	0	0	30
Kemptville, Ont.	0	0	0	1
Appleton, Ont.	tr	0	0	30
Williamstown, Ont.	0	0	0	5
Alfred, Ont.	0	0	0	25
Verner, Ont.	tr	0	0	tr
Douglas, Ont.	5	tr	0	0
Ottawa, Ont.	tr	0	0	10
Macdonald College, Que.	0	0	0	15
Kentville, N. S.	0	0	0	20

* No rust was observed at 22 other locations: Saanichton and Agassiz, B. C.; Edmonton, Beaverlodge, Lacombe, and Lethbridge, Alta.; Indian Head, Scott, and Melfort, Sask.; Brandon, Man.; Kapuskasing, Fort William, and St. Catharines, Ont.; La Pocatière, Quebec, Lennoxville, L'Assomption, and Normandin, Que.; Kentville, N. S.; Frederiction, N. B.; Charlottetown, P. E. I.; and St. John's, Nfld.

The protection afforded by the identified resistance genes (Table 5) was similar to 1966. Genes Sr6, Sr8, Sr9a, and Sr9b continued to be the most effective, each conferring resistance to over 80% of the isolates. The other genes are relatively ineffective because they do not condition resistance to race C18 (15B-IL).

Composite collections of all cultures identified in 1967, in groups of about 20 cultures, were used to inoculate the highly resistant varieties 'Kenya Varmer' (R. L. 2768. 1), 'Mida-McMurachy-Exchange II-47-26', 'Frontana-K58-Newthatch II-50-17', 'Justin', 'Chris', 'C. T. 282', C. T. 296', 'Nd 60-54', 'St 464', 'C. I. 8155', 'R. L. 4204. 2', 'D. T. 191', 'D. T. 199', 'D. T. 316', 'D. T. 188', and 'Tobari 66'. No new combinations of virulence genes were revealed.

Acknowledgments

Thanks are due to the members of universities and those of the Canada Department of Agriculture who cared for the rust nurseries, and to many others who collected the rust used in the physiologic race survey. Mr. J. H. Campbell carried out the technical work of the program.

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Table 3. Virulence formulas, formula numbers, and equivalent physiologic race numbers of wheat stem rust used in 1967

Formula Number	Virulence formula (effective/ineffective host genes)	Physiologic race
C1	5, 6, 7, 9a, 9b, 10, 11/8	17
C2	5, 6, 7, 9a, 9b, 10/8, 11	17A
C3	5, 6, 9a, 11/7, 8, 9b, 10	29-4 (Can.)
C4	5, 6, 11/7	23
C5	5, 9a, 9b, 11/6, 7, 8, 10, GB*	29-1 (Can.)
C6	5, 9a, 9b, 11, GB/6, 7, 8, 10	29-2 (Can.)
C7	5, 11, GB/6, 7	48
C8	5, 11/6, 7, GB	48A
C9	6, 7, 8, 9a, 9b, 10/1, 5, 11	15B-1L (Can.)
C10	6, 7, 8, GB/1, 5, 9a, 9b, 10, 11	15B-1 (Can.)
C11	6, 7, 8/5, 9a, 9b, 10, 11, GB	15B-4 (Can.)
C12	6, 7, 9a, 9b, 10, 11/5, 8	11
C13	6, 7, 10, 11/1, 5, 8, 9a, 9b	32, 113
C14	6, 7, 10, 11/5	14, 38
C15	6, 7, 10/5, 8, 9a, 9b, 11	11, 32, 113
C16	6, 7, 11/5	39
C17	1, 6, 8, 9a, 9b, 11/5, 7, 10	11, 56
C18	6, 8, 9a, 9b/1, 5, 7, 10, 11	15B-1L (Can.)
C19	1, 6, 10, 11/5, 7	10, 38
C20	1, 7, 8, 11/5, 6, 9a, 9b, 10	11, 87
C21	9a, 11/5, 6, 7, 8, 9b, 10	32
C22	1, 9a/5, 6, 7, 8, 9b, 10, 11	32
C23	/5, 6, 7	38
C24	5, 7, 9a, 9b, 10/6, 8, 11	17
C25	/5, 6, 7, 10, 11	38
C26	6, 7, 8, 9b/5, 9a, 10, 11	15B-4 (Can.)
C27	6, 11/5, 7, 10	33, 59
C28	1, 6, 8, 9b, 11/5, 7, 9a, 10	18, 54
C29	1, 5, 6, 7, 9a, 10, 11/8, 9b	17
C30	1, 9a, 9b/5, 6, 7, 8, 10, 11	29
C31	5, 6, 7, 10, 11/	27
C32	1, 9a, 9b, 11/5, 6, 7, 8, 10	32

* GB = Golden Ball.

Table 4. Distribution by provinces of physiologic races of *Puccinia graminis* f. sp. *tritici* collected on wheat, barley, and grasses in 1967

Virulence formula number	Physiologic race number	Number of isolates from: Que.	Ont.	Man.	Sask.	Total no. of isolates	Percent of total isolates
C1	17	0	0	1	1	2	1.0
C9	15B-IL	1	2	0	0	3	1.4
C14	38	0	1	0	0	1	0.5
C17	56	0	4	1	0	5	2.4
C18	15B-IL	9	57	79	15	160	77.3
C19	38	0	7	0	0	7	3.4
C20	11	1	12	12	2	27	13.0
C29	17	0	1	0	0	1	0.5
C32	32	0	1	0	0	1	0.5
		11	85	93	18	207	100.0

Table 5. Percentage of total isolates avirulent on single identified resistance genes

Resistance genes	Avirulent isolates (%)
Sr 1	19.8
Sr 5	1.5
Sr 6	86.5
Sr 7	16.4
Sr 8	94.1
Sr 9a	83.1
Sr 9b	82.6
Sr 10	6.8
Sr 11	21.3

CROWN RUST OF OATS IN CANADA IN 1967 [1]

George Fleischmann [2]

Disease development and crop losses in Western Canada

In 1967 oat crown rust caused by Puccinia coronata Cda. f. sp. avenae Erikss. was first found in the vicinity of Winnipeg on July 17. Only traces of crown rust were found on oats in the Red River Valley of Manitoba as late as August 4. There was a slight increase in the intensity of the disease in this region during August. The occurrence of crown rust diminished rapidly west of the Red River Valley and no infections occurred on susceptible varieties grown in the Saskatchewan rust nurseries. Development of crown rust in Western Canada in 1967 was the lightest in recent years due to unfavorable moisture conditions early in the season, and as a result losses to the oat crop were negligible.

Disease ratings in the rust nurseries

Ratings of crown rust intensity on 10 oat varieties grown at nurseries in Manitoba, Ontario, Quebec and Prince Edward Island are presented in Table 1. Omitted from this table are those nurseries in which no crown rust was found on any of the 10 oat varieties, as well as a few nurseries in which rust intensity could not be estimated because of the shrivelled or mildewed condition of the leaves.

No crown rust occurred on oats from any nursery west of Morden, Manitoba, and the small percentage infection on oats grown at Morden is indicative of the light attack of crown rust which occurred in Western Canada in 1967.

Heavy crown rust infections occurred on oats grown in the vicinity of dense buckthorn infestations in Eastern Canada. The nurseries in eastern Ontario (Kemptville, Appleton, Ottawa) received the highest crown rust intensity ratings. 'Rodney ABDH', a backcross line containing additional stem rust resistance, also appears to afford some degree of crown rust resistance as reflected by the lower intensities on it than on ordinary 'Rodney' oats at nearly all of the locations.

Table 1. Percentage infection of crown rust on 10 oat varieties at 13 locations in Canada

Locality	Bond	Trispernia	Landhafer	Ceirch du Bach	Saia	Rodney ABDH	C. I. 3034	Rodney	Garry	C. I. 4023
Morden, Man.	10	0	tr*	tr	0	5	0	5	5	5
Williamstown, Ont.	5	0	0	0	0	0	0	5	5	5
Alfred, Ont.	0	1	1	0	0	10	0	10	10	5
Kemptville, Ont.	25	tr	tr	5	tr	20	40	50	50	40
Fort William, Ont.	5	1	2	tr	0	tr	0	0	tr	5
Ottawa, Ont.	40	3	0	5	0	15	10	40	40	15
Appleton, Ont.	60	2	tr	0	0	10	5	40	40	40
La Pocatière, Que.	10	0	tr	0	0	0	0	tr	tr	tr
Quebec, Que.	5	0	0	0	0	tr	0	1	1	tr
Macdonald Coll., Que.	80	2	5	tr	0	40	20	80	70	70
Lennoxville, Que.	5	0	0	0	0	0	0	5	0	5
L'Assomption, Que.	25	0	0	0	tr	10	tr	20	25	20
Charlottetown, P.E.I.	15	0	0	0	0	tr	0	10	10	5

* tr = trace infection, less than 1%.

Distribution of physiologic races

The frequency of occurrence and distribution of 37 physiologic races of crown rust identified from 197 Canadian isolates is presented in Table 2. The

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sparsity of crown rust in the west is reflected by the reduced number of isolates identified from this region in comparison to previous years. There was again considerable diversity in the physiologic races comprising the crown rust population in the west, though two races, 295 and 326, made up one third of the isolates identified. Most of the races identified from Manitoba in 1967 attacked the differential varieties 'Landhafer' and 'Santa Fe'.

A wide spectrum of physiologic races was also identified from isolates made in Eastern Canada. The 'classical' Victoria-virulent races 203, 210 and 216 continued to comprise a substantial portion (40%) of the population, but other races, particularly race 341, were also abundant.

Four races with previously undescribed combinations of virulence on the differential varieties

Table 2. Distribution of physiologic races of crown rust in Canada, 1967

Physiologic race	West		East		W & E Totals	
	Number isolates	% of all isolates	Number isolates	% of all isolates	Number isolates	% of all isolates
202	0	0	2	1.4	2	1.0
203	2	3.7	19	13.3	21	10.5
207	0	0	1	0.7	1	0.5
209	0	0	3	2.1	3	1.5
210	0	0	18	12.6	18	9.0
211	0	0	2	1.4	2	1.0
216	2	3.7	21	14.7	23	11.5
226	0	0	1	0.7	1	0.5
228	1	1.9	7	4.9	8	4.0
230	0	0	1	0.7	1	0.5
239	1	1.9	2	1.4	3	1.5
241	0	0	2	1.4	2	1.0
258	0	0	1	0.7	1	0,5
259	0	0	3	2.1	3	1.5
264	5	9.2	1	0.7	6	3.0
272	0	0	1	0.7	1	0.5
274	0	0	2	1.4	2	1.0
276	2	3.7	0	0	2	1.0
295	7	13.0	1	0.7	8	4.0
297	0	0	4	2.8	4	2.0
320	0	0	2	1.4	2	1.0
325	2	3.7	0	0	2	1.0
326	11	20.3	7	4.9	18	9.0
327	2	3.7	0	0	2	1.0
330	1	1.9	6	4.2	7	3.5
332	0	0	5	3.5	5	2.5
333	2	3.7	0	0	2	1.0
341	6	11.1	24	16.8	30	15.0
342	0	0	3	2.1	3	1.5
345	0	0	1	0.7	1	0.5
363	0	0	1	0.7	1	0.5
365	4	7.4	0	0	4	2.0
446	1	1.9	3	2.1	4	2.0
New races	5*	9.2	1**	0.7	10	5.0
Total-Races	18		29		37	
Total-Isolates	54		143		197	
Race: Isolate Ratio	1:3.0		1:4.9			

* Five isolates representing three new races.

** One isolate representing one new race.

were discovered in Canada during the 1967 survey. The race numbers and resistance formulae of these races are: race 450 = 1, 2, 3, 4, 9, 10; race 451 = 1, 2, 3, 7, 8, 9, 10; race 452 = 1, 2, 3, 7, 10; and race 453 = 1, 3, 10.

Virulence on the differential varieties

The virulence of Canadian crown rust isolates on the sources of resistance represented by the differential varieties is presented in Table 3. The situation in Eastern Canada was much the same as in 1966 (1).

In Manitoba there was a marked increase in virulence on the varieties 'Landhafer', 'Santa Fe', 'Trispernia' and 'Bondvic'. The two first-mentioned varieties were attacked by two-thirds of the crown rust isolates identified in 1967 but by less than one-quarter of the isolates the previous year. 'Trispernia' and 'Bondvic' were attacked by one-quarter of the crown rust isolates compared with only 2% of the isolates in 1966. The virulence of the crown rust population on all four of these varieties was greater in 1967 than had been reported since these differentials were first used in 1952 (2). The present situation undermines the utilization of these sources of resistance in a breeding program.

Table 3. Virulence of Canadian crown rust biotypes, 1966 and 1967, on the differential varieties

	Anthony	Victoria	Appler	Bond	Landhafer	Santa Fe	Ukraine	Trispernia	Bondvic	Saia
Western Canada: (Manitoba)										
No. virulent isolates (1967)	39	32	39	48	37	37	43	13	17	7
% virulent isolates (1967)	72	59	72	89	68	68	80	24	31	13
% virulent isolates (1966)	66	58	62	82	24	23	83	2	2	4
Eastern Canada:										
No. virulent isolates (1967)	67	77	72	123	14	15	136	3	2	18
% virulent isolates (1967)	47	54	50	86	10	11	95	2	1	13
% virulent isolates (1966)	51	45	30	77	9	9	85	0	0	9
Canada - Total										
No. virulent isolates (1967)	106	109	111	171	51	52	179	16	19	25
% virulent isolates (1967)	53	54	55	85	25	26	90	8	9	12
% virulent isolates (1966)	61	54	53	80	20	20	82	2	2	6

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STEM RUST OF OATS IN CANADA IN 1967[1]

J.W. Martens[2]

Disease development and crop losses in Western Canada

Stem rust of oats caused by Puccinia graminis Pers. f. sp. avenae Erikss. and Henn. was less prevalent in Western Canada in 1967 than in any other year since 1961. Stem rust was first found in Manitoba on July 17. It developed slowly, and very few fields suffered significant losses in yield. No rust was found in Alberta or Saskatchewan.

Uniform rust nurseries

Rust nurseries consisting of 10 oat varieties were grown at 36 locations across Canada (Table 1) by cooperators at universities and Canada Department of Agriculture stations. The plants were sent to Winnipeg to be rated for disease. No stem rust was observed on nurseries west of Manitoba or east of Quebec. In Manitoba plants at only one nursery showed light infections. In Ontario and Quebec

Table 1. Percentage infection by Puccinia graminis f. sp. avenae on 10 oat varieties at 10 uniform rust nurseries* in Canada, 1967

Locality	Bond	Trispernia	Landhafer	Ceirch du Bach	Saia	Rodney ABDH	C. I. 3034	Rodney	Garry	C. I. 4023
Morden, Man.	15	10	tr**	tr	0	0	0	0	tr	0
Alfred, Ont.	10	0	0	0	0	0	0	tr	0	0
Kemptville, Ont.	tr	0	0	0	0	0	0	tr	0	0
Fort William, Ont.	tr	0	0	0	0	0	0	0	0	0
Guelph, Ont.	20	60	25	20	0	1	3	3	tr-1	1
Ottawa, Ont.	2	0	0	0	0	tr	0	tr	2	0
Appleton, Ont.	tr	0	0	0	0	0	0	0	tr	0
St. Catherines, Ont.	0	0	tr	0	0	1	0	0	0	0
La Pocatière, Que.	5	15	5	5	0	0	0	2	0	0
Macdonald College, Que.	25	5	5	0	0	5	0	5	5	0

* No rust was observed in 26 other nurseries located at Agassiz, Creston, and Saanichton, B.C.; Beaverlodge, Edmonton, Lacombe, and Lethbridge, Alta.; Indian Head, Melfort and Scott, Sask.; Brandon, Glenlea, The Pas and Winnipeg, Man.; Verner, Williamstown, Douglas and Kapuskasing, Ont.; Quebec, Lennoxville, L'Assomption and Normandin, Que.; Kentville and Truro, N.S.; Fredericton, N.B.; and St. John's, Nfld.

** tr = trace infection

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plants in six nurseries showed trace to light infections, and plants in two others had light to moderate infections.

Identification and distribution of physiologic races

Physiologic races were identified by their reactions on inoculated seedlings of the varieties 'Richland' (rust resistance gene Pg-2), 'Rodney' (Pg-4), 'Minrus' (Pg-1), 'Jostrain' (Pg-3), 'Eagle[2] x C.I. 4023' (pg-8), and 'C.I. 5844-1' (pg-9). The designation of races by formula number (Table 2) follows the system of nomenclature now in use in Canada (1, 2). The alphabetical designations formerly used for stem rust resistance genes have been changed to conform to the standardized system proposed by Simons et al. (3). Both the old and the new designations for physiologic races of the pathogen and for resistance genes in the host are shown in Table 2.

A supplementary set of differential hosts composed of the varieties 'Rosen's Mutant', 'Saia', and 'C.I. 3034' was also used. The rust reactions of 'Rosen's Mutant' were similar to those of 'C.I. 5844-1' but were slightly more resistant. 'Saia' was resistant to all collections except one from Ontario. Reactions of 'C.I. 3034' in the seedling stage were similar to those of 'Minrus'.

Physiologic race C10 continues to predominate (66% of isolates) in Western Canada; races C3 (20%) and C5 (14%) comprised the remainder (Table 2). In Eastern Canada the race distribution changed relatively little during the period 1958 to 1966, when C9 and closely related races were prevalent. A shift appears to have occurred in 1967. In Ontario C9 was still the most prevalent race, but 47% of the isolates were of western affinity (races C3, C5, and C10). The shift, if it occurred, may have resulted from the barberry eradication program in Ontario. However, the population sample is too small to demonstrate conclusively that a major shift has occurred.

Virulence range of the pathogen population

Most of the pathogen population carries virulence capabilities that are apparently not necessary for the survival of the fungus in North America (Table 3). For instance, over 95% of the population is virulent on gene Pg-3 resistance, but significant amounts of this type of resistance are not known to have been present at any time in the host population in Canada or in the primary inoculum area to the south. Similarly, over half the pathogen population is able to attack pg-8 resistance, a form not known to have occurred in the host population. Virulence on pg-8 resistance does not appear to be associated with factors essential to survival, because races C3 (avirulent on pg-8) and C5 (virulent on pg-8) have coexisted for many years. Also, there is no obvious reason why 70% of the rust population in Eastern Canada is virulent on pg-9 resistance, because there has been no selection pressure for virulence to pg-9. While races capable of overcoming only the Pg-2 and Pg-4 types of resistance would be

Table 2. Distribution by provinces of physiologic races of Puccinia graminis f. sp. avenae isolated in Canada in 1967

Race: Formula no.	Race: Former designation	Virulence formula (effective/ineffective host genes): Pg gene designation	Virulence formula: Alphabetical gene designation	Number of isolates from: Manitoba	Ontario	Quebec	Total isolates	Percentage of total isolates
C3	7A-12A	2, 8/1, 3, 4, 9	AF/BDEH	12	1	0	13	16.5
C5	6F	4, 9/1, 2, 3, 8	BH/ADEF	8	2	0	10	12.6
C6	8A-10A	1, 8/2, 3, 4, 9	DE/ABEH	0	1	0	1	1.3
C9	6A-13A	8/1, 2, 3, 4, 9	F/ABDEH	0	7	4	11	13.9
C10	6AF	9/1, 2, 3, 4, 8	H/ABDEF	39	4	0	43	54.4
C17	11A	1, 3, 8/2, 4, 9	DEF/ABH	0	0	1	1	1.3
Total				59	15	5	79	

Table 3. Frequency of virulence in the stem rust population on various types of resistance in Canada in 1967

Geographic area	Percentage of isolates virulent on host varieties that have the following genes* for resistance: Pg-1 (D)	Pg-2 (A)	Pg-3 (E)	Pg-4 (B)	pg-8 (F)	pg-9 (H)	Total no. isolates	Mean virulence capability**
Eastern Canada	90	95	95	90	30	70	20	4.70
Western Canada	100	79.6	100	86.4	79.6	20	59	4.65

* The letters in brackets represent the designations for stem rust resistance genes used before the present standardized system of nomenclature (Simons et al., 1966) was adopted.

** Mean virulence capability = frequency of virulence on Pg-1 +...+ pg-9/total number of isolates.

highly successful in North America, the prevailing population is maintaining the ability to attack an average of more than four types of resistance.

Crop loss hazard

The predominant races of stem rust in both Eastern and Western Canada are capable of attacking all commercial oat varieties, and varieties resistant to the prevailing races will not be available in the immediate future. Therefore, stem rust continues to present a serious threat to oat production in Canada. Under favorable epidemiological conditions, heavy losses could occur. However, continued barberry eradication will reduce primary inoculum and minimize the chances of loss in Eastern Canada. Growers in Western Canada can minimize losses by planting their oat crops early.

Acknowledgments

The assistance of cooperators who cared for the rust nurseries and submitted rust collections from various parts of Canada is gratefully acknowledged. Mr. Peter K. Anema performed the technical operations necessary for the identification of physiologic races.

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A SURVEY OF DISEASES OF VEGETABLE CROPS IN SOUTHERN ONTARIO IN 1967

A.A. Reyes, J.R. Chard, A. Hikichi, W.E. Kayler, K.L. Priest, J.R. Rainforth, I.D. Smith and W.A. Willows[1]

There has been no recent comprehensive survey of the common diseases of vegetables in southern Ontario, although observations of diseases reported by scientists or extension specialists in the province have been compiled annually (3-9). A systematic survey of vegetable crops was conducted in this region in 1967 to determine the identity and prevalence of diseases. The survey did not include diseases caused by viruses and nematodes.

The counties surveyed were Brant, Elgin, Essex, Haldimand, Kent, Lambton, Lincoln, Middlesex, Norfolk, Oxford, Welland, and Wentworth. Each county was visited on a weekly rotational basis from early May to early October. Disease identification was based primarily on symptomatology (1), but whenever possible the diagnosis was confirmed by microscopic examination and by isolation of the causal organism from diseased specimens. The prevalence of each disease in greenhouse or field was determined by the method used by Simard et al. (10, 11) in Quebec.

The majority of the diseases observed were on tomato, onion, cauliflower, pepper, and cucumber (Table 1). The least number of diseases were on asparagus and eggplant. Most diseases were caused by fungi. Diseases caused by environmental or physiological disorders, such as air pollution damage to lima beans and frost and hail damage to tomatoes, were noted occasionally.

A review of the literature (2-9) indicates that most of the diseases that occurred most frequently in 1967 also have been at relatively high levels in previous years. Similarly, those diseases that occured at the trace level in 1967 also occurred at this level in other years.

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Table 1. Incidence of diseases of vegetable crops in southern Ontario in 1967

Crop	Disease and cause	Prevalence* and county
Asparagus	Root rot or wilt (Fusarium spp.)	Tr. 1/1** field (Kent), sl. 1/1 field (Norfolk)
Bean, lima	Bronzing (ozone damage)	Tr.-mod. 2/3 fields (Kent)
Bean, snap	Cottony soft-rot (Sclerotinia sclerotiorum)	Sl. 2/3 fields (Kent), sev. 1/4 fields (Brant)
	Root rot (Fusarium spp.)	Tr. 1/1 field (Norfolk), tr.-sl. 2/4 fields (Brant)
	Stem canker (Rhizoctonia solani)	Tr. 1/1 field (Norfolk)
Beet	Damping-off (Pythium spp., Fusarium spp.)	Tr. 2/3 fields (Kent)
	Leaf spot (Cercospora beticola, Alternaria tenuis)	Sl. 3/3 fields (Kent)
	Root rot (Botrytis cinerea, Fusarium spp.)	Tr. 1/3 fields (Kent)
Cabbage	Clubroot (Plasmodiophora brassicae)	Tr. 1/1 field (Lambton), sl. 1/1 field (Essex)
	Drop (Sclerotinia sclerotiorum)	Tr. 2/4 fields (Welland)
	Yellows (Fusarium oxysporum f. conglutinans)	Tr. 1/2 fields (Norfolk)
Cauliflower	Black rot (Xanthomonas campestris)	Tr.-mod. 3/7 fields (Oxford), mod. 1/1 field (Welland), mod. 3/3 fields (Essex)
	Clubroot (Plasmodiophora brassicae)	Tr. 1/3 fields (Lincoln), sl. 1/3 fields (Essex), mod. 1/1 field (Welland)
	Damping-off (Pythium spp., Fusarium spp.)	Tr. 1/3 fields (Lincoln), tr. 1/1 field (Norfolk)
	Drop (Sclerotinia sclerotiorum)	Tr. 1/7 fields (Oxford), tr. 1/1 field (Welland)
	Leaf spot (Alternaria brassicae)	Tr. 1/1 field (Brant), sev. 1/1 field (Norfolk)

* Tr.(trace)=1-10% of plants affected in the greenhouse or field, sl.(slight)=10-30% 30%, mod. (moderate)=30-60%, sev. (severe)=60-100%.

** Number of fields or greenhouses in which the disease was found/number of fields or greenhouses inspected.

Table 1 (Continued)

	Leaf spot (cause undetermined, bacteria isolated)	Mod. 1/1 field (Wentworth)
	Root rot (Fusarium spp.)	Tr. 1/1 field (Brant)
	Wire stem (Rhizoctonia solani)	Tr. 1/7 fields (Oxford), tr. 1/1 field (Norfolk)
Corn, sweet	Root rot (Fusarium spp.)	Tr. 1/1 field (Norfolk)
	Smut (Ustilago maydis)	Tr. 1/1 field (Oxford), tr. 2/3 fields (Essex), mod. 1/1 field (Norfolk)
Cucumber	Angular leaf spot (Pseudomonas lachrymans)	Sl. 1/7 fields (Norfolk), sl.-sev. 2/4 fields (Kent), mod. 6/6 fields (Essex), mod.-sev. 2/2 fields (Oxford)
	Bacterial wilt (Erwinia tracheiphila)	Tr.-sl. 4/4 fields (Kent), tr.-sl. 2/2 fields (Oxford), tr.-sl. 2/4 fields (Welland), tr.-sl. 5/7 fields (Norfolk)
	Damping-off (Pythium spp., Rhizoctonia solani, Fusarium spp.)	Tr. 1/7 fields (Norfolk), tr. 1/4 fields (Welland), sev. 3/6 fields (Essex)
	Leaf blight (Alternaria cucumerina)	Sl.-mod. 2/2 fields (Oxford)
	Powdery mildew (Erysiphe cichoracearum)	Mod. 1/1 greenhouse (Essex), sev. 1/2 fields (Oxford), sev. 2/7 fields (Norfolk)
	Scab (Cladosporium cucumerinum)	Mod. 2/6 fields (Essex)
Eggplant	Wilt (Verticillium dahliae)	Tr. 1/1 field (Norfolk), sl. 1/1 field (Essex), sev. 1/2 fields (in each of Lincoln, Oxford)
Lettuce	Drop (Sclerotinia sclerotiorum)	Tr. 1/1 field (Lambton)
	Gray mold (Botrytis cinerea)	Tr. 3/3 fields (Essex)
Muskmelon	Bacterial wilt (Erwinia tracheiphila)	Tr. 1/2 fields (Oxford)
	Leaf blight (Alternaria cucumerina)	Sl. 1/1 field (Norfolk)
	Powdery mildew (Erysiphe cichoracearum)	Sev. 2/4 fields (Essex)
	Scab (Cladosporium cucumerinum)	Sev. 1/1 field (Norfolk)
Onion	Basal rot (Fusarium spp.)	Sl. 1/6 fields (Essex)
	Bulb rot (Penicillium spp.)	Tr. 1/6 fields (Essex)

Table 1 (Continued)

	Damping-off (*Fusarium* spp.)	Tr. 1/6 fields (Essex)
	Leaf blight (*Botrytis* spp.)	Mod.-sev. 2/4 fields
	Neck rot (*Botrytis allii*)	Mod. 1/6 fields (Essex)
	Pink root (only *Fusarium* spp. isolated)	Sl. 1/2 fields (Lincoln), mod. 1/6 fields (Kent), mod. 1/2 fields (Welland)
	Purple blotch (*Alternaria porri*)	Sev. 1/6 fields (Kent)
	Smut (*Urocystis cepulae*)	Tr. 1/6 fields (Essex), tr. 1/2 fields (Lincoln)
	Tip burn (physiological)	Sl. 1/4 fields (Lambton), mod. 3/6 fields (Kent)
Pea	Root rot (*Fusarium* spp.)	Tr.-sl. 3/4 fields (in each of Kent, Haldimand, Norfolk)
	Stem canker (*Rhizoctonia solani*)	Tr. 1/4 fields (in each of Kent, Norfolk)
Pepper	Blossom-end rot (physiological)	Tr. 1/6 fields (in each of Essex, Lincoln)
	Damping-off (*Pythium* spp., *Rhizoctonia solani*, *Fusarium* spp.)	Tr. 1/1 greenhouse (Essex), tr. 1/2 greenhouses (Norfolk), sl. 2/2 greenhouses (Elgin), tr. 1/6 fields (Lincoln)
	Early blight (*Alternaria solani*)	Tr. 1/6 fields (Lincoln), sl. 3/6 fields (Essex)
	Fruit rot (*Phoma destructiva*)	Tr. 1/6 fields (Essex)
	Soft rot (*Pythium* spp.)	Tr. 1/1 field (Brant)
	Wilt (*Verticillium dahliae*)	Tr. 1/6 fields (in each of coln), mod.-sev. 3/6 fields (Essex)
Potato	Blackleg (*Erwinia atroseptica*)	Tr. 1/3 fields (Lambton), tr. 1/2 fields (Oxford), sl. 2/3 fields (Kent)
	Scab (*Streptomyces scabies*)	Sl. 1/2 fields (Oxford)
	Stem canker (*Rhizoctonia solani*, *Fusarium* spp.)	Tr. 1/3 fields (in each of Elgin, Essex, Kent, Lambton, Welland)
Spinach	Bacterial soft rot (*Erwinia* spp.)	Mod. 1/1 field (Kent)
	Gray mold (*Botrytis cinerea*)	Tr. 1/1 field (Kent)
Squash, summer	Soft rot (*Rhizopus* sp.)	Tr. 1/1 field (Kent)

Table 1 (Concluded)

Tomato	Anthracnose (Colletotrichum sp.)	Tr. 1/1 truckload (400 hampers) (Kent), tr. 1/3 fields (Norfolk), tr. 3/6 fields (Essex)
	Bacterial canker (Corynebacterium michiganense)	Mod.-sev. 2/3 greenhouses (Essex), tr. 1/4 fields (Kent), tr. 3/6 fields (Essex)
	Bacterial speck (Pseudomonas tomato)	Tr. 2/6 fields (Essex), tr.-sl. 1/4 fields (Kent)
	Bacterial spot (Xanthomonas vesicatoria)	Mod. 1/3 fields (Norfolk)
	Bacterial wilt (Pseudomonas solanacearum)	Tr. 1/4 fields (Kent)
	Blotchy ripening (physiological)	Tr. 1/1 greenhouse (Lincoln), tr. 2/3 greenhouses (Essex), tr. 3/6 fields (Essex), sl. 3/4 fields (Kent)
	Damping-off (Pythium spp., Rhizoctonia solani, Fusarium spp.)	Tr. 1/5 greenhouses (Norfolk), tr. 1/3 greenhouses (Oxford)
	Early blight (Alternaria solani)	Tr. 1/1 greenhouse (in each of Elgin, Lincoln), tr. 1/4 greenhouses (Brant), tr.-sl. 3/3 fields (Norfolk), sl. 1/6 fields (in each of Essex, Lincoln), mod. 1/3 fields (Wentworth), mod. 3/4 fields (Kent)
	Frost damage	Tr. 2/4 fields (Kent)
	Gray mold (Botrytis cinerea)	Tr. 1/4 greenhouses (Brant), tr. 1/1 greenhouse (Elgin), tr. 1/5 greenhouses (Norfolk), sl. 1/1 greenhouse (Lincoln), mod.-sev. 2/3 greenhouses (Essex)
	Hail damage	Sl. 1/4 fields (Kent)
	Leaf spot (Septoria lycopersici)	Tr. 1/3 greenhouses (Essex), sl. 1/3 fields (in each of Wentworth, Norfolk)
	Root rot (Fusarium spp., Pythium spp.)	Tr. 1/4 fields (Kent), tr. 1/6 fields (in each of Lincoln, Welland), tr. 1/3 fields (Norfolk)
	Wilt (Fusarium oxysporum f. lycopersici)	Tr. 1/6 fields (Essex), tr. 2/6 fields (Lincoln), tr. 1/2 fields (Oxford)
	Wilt (Verticillium dahliae)	Tr. 1/6 fields (Essex), sl. 3/4 fields (Kent)

DISEASES OF CRUCIFERS IN SASKATCHEWAN IN 1967

G. Allan Petrie[1] and T.C. Vanterpool[2]

In 1967 the total rapeseed production in Saskatchewan decreased to 11.5 million bushels from the 12.7 million in 1966. The decrease was mainly due to a reduction in acreage. Despite one of the driest growing seasons on record (1), the yield per acre in 1967 has been estimated at 17.0 bushels, compared with 17.4 bushels in 1966.

Twenty-eight fields of rape (Brassica napus L.) and mustard (Brassica hirta Moench) were rated for disease in late August and early September (Table 1).

Table 1. Ratings of disease in 28 fields of rape and mustard in Saskatchewan, 1967

Disease organism	Disease rating* 0	1	2	3	4	% of total fields infected
Albugo cruciferarum	28.5**	53.6	14.3	3.6	0.0	71.5
Sclerotinia sclerotiorum	67.9	17.9	7.2	7.2	0.0	32.1
Alternaria brassicae	57.1	25.0	14.3	3.6	0.0	42.9
Mycosphaerella brassicicola	28.5	67.9	3.6	0.0	0.0	71.5
Aster yellows virus (callistephus virus 1)	96.4	3.6	0.0	0.0	0.0	3.6
Plenodomus lingam (brassica strain)	85.6	7.2	3.6	3.6	0.0	14.4

* Where 0 = no symptoms observed and 4 = severe disease.

** Figures are % of total fields sampled.

Most of the principal diseases of crucifers were less severe in 1967 than they were in 1966, although the percentage of fields infected by certain pathogens was higher than in 1965 (2, 3). A comparison of average disease severity ratings of rape fields for the last three years is given in Table 2.

The generally dry atmospheric conditions in 1967 restricted the development of leaf and stem pathogens, and in many northern rape fields the straw was unusally clean. Peronospora parasitica (Pers. ex Fr.) Fr. was not observed during this year's survey, and aster yellows virus infections were seen extremely rarely. Mycosphaerella brassicicola (Duby) Lind. was much less severe than in previous years. Although alternaria leaf, stem, and pod spots, caused mainly by Alternaria brassicae (Berk.) Sacc., were generally less severe than in 1966, some very severe large black stem lesions were found on rape in the Bresaylor area.

Table 2. Average severity ratings* of diseases in rape fields in Saskatchewan, 1965-1967

Disease organism	1965	1966	1967
Albugo cruciferarum	1.3	2.0	1.2
Peronospora parasitica	0.3	0.5	0.0
Sclerotinia sclerotiorum	0.6	1.4	1.2
Alternaria brassicae	0.4	1.8	1.2
Mycosphaerella brassicicola	1.7	1.6	1.0
Aster yellows virus (callistephus virus 1)	0.4	1.2	0.1
Total rating 0 - 24 scale	4.7	8.5	4.7
0 - 100 scale	20	35	20

* Where 0 = no symptoms and 4 = severe disease.

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Of the chief diseases, only blackleg, caused by Leptosphaeria maculans (Desm.) Ces. & de Not., imperfect state: Plenodomus lingam (Tode ex Fr.) Hohn., was much more severe in 1967 than it had been in previous years. The brassica strain of the fungus (2) extended its range from the Saskatoon-Humboldt-Naicam region north to the Melfort area. It was also found for the first time on Brassica kaber (DC.) L. C. Wheeler var. pinnatifida (Stokes) L. C. Wheeler near Lake Lenore and Melfort. A summary of the results of special surveys conducted apart from the main survey over the past 5 years in east-central Saskatchewan is given in Table 3.

Table 3. Occurrence of Leptosphaeria maculans (Plenodomus lingam) on rape and mustard in east-central Saskatchewan, 1963-1967

Year	% of fields infected	Av. severity rating*
1967	83	1.3
1966	71	0.5
1965	60	<0.5
1963-64	25	<0.5

* Where 0 = no symptoms and 4 = severe disease.

Ascocarps of Leptosphaeria maculans bearing mature ascospores were collected on Thlaspi arvense L. in May and June at two locations near Saskatoon. Single ascospores isolated from this material developed into cultures typical of the thlaspi strain (2) of Plenodomus lingam. A more detailed report dealing with L. maculans from Thlaspi will be published later.

Several miscellaneous collections were made during 1967. The oospore stage of Albugo cruciferarum S. F. Gray was collected on pods of Brassica kaber var. pinnatifida (Fig. 1). The symptoms differed from those typical of infections on rape in the absence of any conspicuous hypertrophy. Albugo was also found on Sisymbrium altissimum L. (conidial and oospore states), Capsella bursa-pastoris (L.) Medic. (conidial state) and Descurainia sp. (conidial state).

Mycosphaerella brassicicola was found for the first time as an epiparasite on albugo rape stem enlargements near Brooksby and Delmas.

A salmon-colored fungus with both verticillate and penicillate conidiophores was isolated from the stem bases of two rape plants at Saskatoon at harvest time. It proved to be slightly pathogenic on rape seedlings. In the absence of the perfect state, it is provisionally identified as Gliocladium roseum (Link) Bainier. This is a first report for this fungus on rape in Saskatchewan.

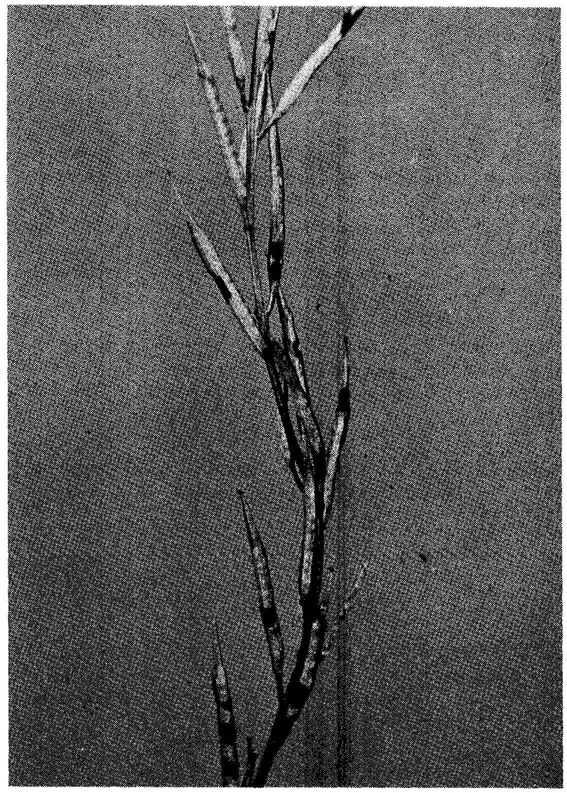

Figure 1. Pod lesions on *Brassica kaber* var. *pinnatifida* caused by *Albugo cruciferarum.*

A species of Septoria was obtained in culture from rape collected near Brooksby. It was only mildly pathogenic in a rape seedling test.

Rape plants showing traces of late root rot were collected at Saskatoon. Two species of Fusarium were isolated from the roots and both showed slight to moderate pathogenicity to rape seedlings.

Powdery mildew (Erysiphe polygoni DC.) was observed in plots of late-maturing rape at Saskatoon.

Severe basal enlargements caused by accidental 2,4-D spraying in June occurred on rape collected at Rosthern.

The rape yield per acre in 1967 was only 1.7% less than that in 1966. Diseases in 1967 reduced rape yields appreciably in some areas. At Swan River, Manitoba, where Alternaria was extremely severe in 1966, the average yield was 8.8 bu/acre and summer rainfall measured 10.2 inches. In 1967, however, with a summer rainfall of 4.1 inches and a very low incidence of disease, the average yield has been estimated to be 18 bu/acre. Because rape is not considered to be a drought-tolerant plant, a lower yield would have been expected this year, other things being equal. It would seem, therefore, that the reduced incidence of disease is one important factor that accounts for the unexpectedly high yields of rape in 1967.

Acknowledgments

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ESTIMATES OF CROP LOSSES FROM DISEASES IN THE LOWER FRASER VALLEY OF BRITISH COLUMBIA, 1966[1]

H.N.W. Toms[2]

Favorable conditions for the build-up of diseases were not present in the lower Fraser Valley in 1966, and there was a low incidence of foliar diseases such as blights, molds, rusts, and mildews.

Percentages of crop losses (Table 1) are based on a combination of field observations and estimates of the value of produce down-graded or rejected by processors and the local vegetable marketing board. A summary of acreages and estimated losses for each crop for 1965 and 1966 is given in Table 2. Values are based on the price received by the farmer. Although the loss figures for the 1966 potato crop are 50% higher than those for 1965, they do not imply an increase in disease incidence but are rether a more accurate estimate of total loss.

1966 was notable for increased production of small fruits from recent plantings, but the rise in strawberry acreage to 1250 acres from 300 in 1965 is deceptive. The lower acreage in 1965 was caused by the heavy losses that resulted from an unexpected freeze in mid-December 1964, before the plants had hardened off. A large acreage was killed and had to be replanted. The replants came into bearing in 1966. Fortunately, little loss occurred with raspberry plantings in the same freeze. The increased fruit loss in raspberry in 1966 was due to a heavy attack by gray mold under favorable weather conditions at the time of fruit maturity. The apparent decrease in cranberry acreage is the result of listing the acreage of bearing plants rather than total plantings.

Vegetable acreage and production in 1966 were about the same as in 1965. The general background for horticultural crops in this area was given previously in some detail (1). In that report it was stated that "since the war there has been a noticeable decrease in local vegetable production on the periphery of the metropolitan area owing both to the rising cost of land and to the conversion of farm and market garden land to residential and industrial uses." This statement applies only to the outskirts of Vancouver. In rural districts there has been a considerable increase in vegetable acreage since 1950.

Acknowledgments

Grateful acknowledgment is made to horticulturists of the British Columbia Department of Agriculture and to an official of the B.C. Coast Vegetable Co-operative Association for supplying data.

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1 Contribution No. 140, Research Station, Canada Department of Agriculture, Vancouver, British Columbia.

2 Plant Pathologist.

Table 1. Estimated losses due to disease in vegetable and fruit crops in the lower Fraser Valley of British Columbia in 1966

Crop and disease	Acres planted	Crop value* (thousands of dollars)	Estimated loss (% of value)	Estimated loss (thousands of dollars)
VEGETABLES				
BEANS - Includes processing	1,755	$699.0		
Gray mold (Botrytis cinerea)			5	$34.9
Root rots (Sclerotinia etc.)			5	34.9
Boron deficiency			2	13.9
BROCCOLI - Includes processing	278	165.1		
Bacterial soft rot (Erwinia carotovora)			2	3.3
Downy mildew (Peronospora parasitica)			2	3.3
Clubroot (Plasmodiophora brassicae)			8	13.2
Boron deficiency			1	1.6
BRUSSELS SPROUTS - Includes processing	140	93.3		
Bacterial soft rot (Erwinia carotovora)			15	14.0
Downy mildew (Peronospora parasitica)			2	1.8
Clubroot (Plasmodiophora brassicae)			2	1.8
Boron deficiency			3	2.8
CABBAGE	426	273.5		
Clubroot (Plasmodiophora brassicae)			3	8.2
CAULIFLOWER - Includes processsing	414	240.2		
Bacterial curd rot (Erwinia carotovora)			2	4.8
Downy mildew (Peronospora parasitica)			2	4.8
Clubroot (Plasmodiophora brassicae)			5	12.0
Boron deficiency			2	4.8
Seedling troubles (Rhizoctonia, etc.)			1	2.4
CUCUMBERS				
Field:	313	98.6		
Root rot (Fusarium sp.)			2	1.9
Scab (Cladosporium cucumerinum)			5	4.9
Leaf spot (Alternaria cucumerina and A. tenuis)			2	1.9
Greenhouse:		204.0		
Wilts (Misc. soil fungi)			10	20.4
LETTUCE		391.1		
Spring crop				
Sclerotinia rot, drop (Sclerotinia sclerotiorum)	125		15	16.3
Summer crop				
Bottom rot (Rhizoctonia complex)	175		10	15.2
Late crop				
Bacterial soft rot (Erwinia carotovora)	150		10	13.1

Table 1. (continued)

Crop and disease	Acres planted	Crop value* (thousands of dollars)	Estimated loss (% of value)	Estimated loss (thousands of dollars)
ONIONS				
Bunching:	50	63.0		
Smut (Urocystis magica)			1	0.6
Downy mildew (Peronospora destructor)			2	1.2
Bulb crop	120	180.3		
Neck rot (Botrytis spp.)			15	27.0
PEAS- Table and processing	5,215	1,017.4		
Downy mildew (Peronospora viciae)			1	10.0
Root rot (Fusarium complex)			8	81.4
POTATOES	5,000	1,443.0		
Black leg (Erwinia atroseptica)			1	14.4
Common scab (Streptomyces scabies)				1.5
Pink rot (Phytophthora erythroseptica) and Late blight (P. infestans)			6	86.6
Bacterial soft rot (Erwinia carotovora)			10	144.3
Bacterial ring rot (Corynebacterium sepedonicum)				3.5
Storage dry rots (Fusarium spp.)			2	29.0
Tuber net necrosis (Leafroll virus)			4	33.7
Misshapen tubers (Various causes)			20	288.6
SPINACH - Spring crop	12	7.7		
Downy mildew (Peronospora farinosa)			15	1.2
SQUASH - Winter stored	142	64.5		
Black rot (Mycosphaerella melonis)			15	9.6
TOMATOES				
Field	10	6.0		
Early and late blights			20	1.2
Blossom-end rot			5	0.3
Greenhouse		252.3		
Leaf mold (Cladosporium fulvum)			5	12.6
Tobacco mosaic virus			10	25.2
Verticillium wilt (V. dahliae)			5	12.6
TURNIPS AND RUTABAGAS	107	71.5		
Boron deficiency			2	1.4
TREE FRUITS				
ITALIAN PRUNE	300	60.0		
Black knot (Apiosporina morbosa)			20	12.0
SMALL FRUITS				
BLUEBERRY				
Field	1,400	807.1		
Cane canker (Godronia cassandrae)			15	90.0
Blossom blight and mummy berry (Monilinia vaccinii-corymbosi)			15	90.0

Table 1 (Concluded)

Crop and disease	Acres planted	Crop value* (thousands of dollars)	Estimated loss (% of value)	Estimated loss (thousands of dollars)
Nursery propagation beds				
Twig and fruit rots (various causes)		40.0	25	10.0
CRANBERRY	450	287.5		
Cotton ball (*Sclerotinia oxycocci*)			trace	0.1
Fruit rots (various organisms)			1	2.9
RASPBERRY	2,000	2,672.0		
Fruit rot (*Botrytis cinerea*)			20	534.4
Root rots			10	267.2
STRAWBERRY	1,250	2,834.0		
Fruit rot (*Botrytis cinerea*)			5	141.7
Red stele (*Phytophthora fragariae*)			5	141.7
Powdery mildew (*Sphaerotheca macularis*)			2	56.7
Root rot complex			3	85.0
Estimated total losses $2,454,000				

* Based on price received by the farmer.

Table 2. Vegetable and fruit crop acreages and estimated losses from disease in the lower Fraser Valley of British Columbia in 1965 and 1966

Crop	Acreage planted 1965	Acreage planted 1966	Estimated loss (thousands of dollars)* 1965	Estimated loss (thousands of dollars)* 1966	Crop	Acreage planted 1965	Acreage planted 1966	Estimated loss (thousands of dollars)* 1965	Estimated loss (thousands of dollars)* 1966
Beans	1,777	1,755	45	84	Spinach***	12	12	1	1
Broccoli	325	278	51	21	Squash	100	142	8	10
Brussels sprouts	160	140	39	20	Tomatoes**	15	10	43	52
Cabbage	400	426	8	8	Turnips	90	107	1	1
Cauliflower	425	414	56	29	Italian prune	300	300	12	12
Cucumbers**	315	313	43	29	Blueberry	1,300	1,400	160	190
Lettuce	450	450	39	45	Cranberry	500	450	3	3
Onions	195	170	31	29	Raspberry	1,700	2,000	264	802
Peas	5,280	5,215	59	92	Strawberry	300	1,250	81	425
Potatoes	5,000	5,000	398	602					
					Total	18,644	19,832	1,342	2,455

* Based on the price received by the farmer. ** Including greenhouse production, not expressed as acreage.

*** Only the spring planting was diseased.

THE RELATIVE IMPORTANCE OF SPRING AND SUMMER CANKER PHASES OF BACTERIAL SPOT OF PEACH IN SOUTHWESTERN ONTARIO

B.N. Dhanvantari[1]

Abstract

Twigs of the previous year's growth of peach trees that had been severely affected by Xanthomonas pruni in 1966 developed spring cankers at the internodes and apices when the twigs were brought into the greenhouse in March, 1967, and held under warm, humid conditions for a week. Similar spring canker symptoms appeared in the orchard in April and May. Summer cankers were not found in southwestern Ontario in 1965, 1966, or 1967.

Introduction

The symptoms of bacterial spot of peach caused by Xanthomonas pruni (E. F. Sm.) Dows. are leaf and fruit spots, defoliation, and spring and summer cankers on twigs (1). The importance of these different phases in the epidemiology of this disease in southwestern Ontario has been under investigation and the results of studies made in 1965 and 1966 have been reported (4). This paper reports the observations and results obtained in 1967.

Materials and Methods

In March, twigs on which cankers were not visible were removed from trees severely affected with the disease in the previous summer and fall and were held in moist chambers for a week or more to see if spring cankers would develop.

From late April till early June, twigs on which spring cankers appeared in the orchard were brought into the laboratory. The outer bark from the margins of the cankers was peeled away with sterile forceps, and pieces of underlying cortical tissue were removed aseptically and dropped into test tubes containing sterile distilled water. Bacteria were allowed to exude into the water for 15-20 min. and then drops of the suspension were streaked on potato-dextrose-peptone agar (PDPA). The plates were incubated at room temperature (23 ± 2C) for a few days and isolates of X. pruni were identified by the characteristic morphology and color of the colonies on PDPA. The identifications were supported by sensitivity tests with a bacteriophage isolated by Dr. M. D. Sutton, Cell Biology Research Institute, Ottawa, from the soil of a peach orchard at Harrow, Ontario, in 1966. Phage sensitivity was tested by the spot test method (6) by placing a drop of phage suspension at the routine test dilution on soft agar layer plates seeded with cells of the bacterial isolates. The plates were examined for zones of lysis after incubation for 24 hours at 28C.

Results and discussion

Cuttings of the past year's growth sampled in March developed cankers at internodes and twig apices 7 to 10 days after being placed in moist chambers. The purplish-black cankers at the internodes were somewhat depressed, 3 to 4 cm long, and had diffuse margins. Cankers at the twig apex completely girdled the stem, but those at the internodes did not. Similar symptoms were observed in the orchard from late April till June (Fig. 3). Lesions that developed in the moist chamber as well as those that formed under orchard conditions showed blister-like openings. X. pruni was isolated

Table 1. Frequency of isolation of Xanthomonas pruni from cankered twigs of peach in southwestern Ontario in the spring of 1967

Cultivar	Locality	Date	No. of cankers* sampled	No. of cankers yielding X. pruni
Kalhaven	Harrow	April 28	97	35
Kalhaven	Colchester	May 12	44	15
Kalhaven	Harrow	May 12	11	4
Sunhaven	Ruthven	May 17	10	0
Kalhaven	Harrow	May 17	35	4
Babygold-7	Ruthven	May 17	10	10
Early Elberta	Colchester	June 1	7	7

* Cankers formed during the spring on growth produced the previous season.

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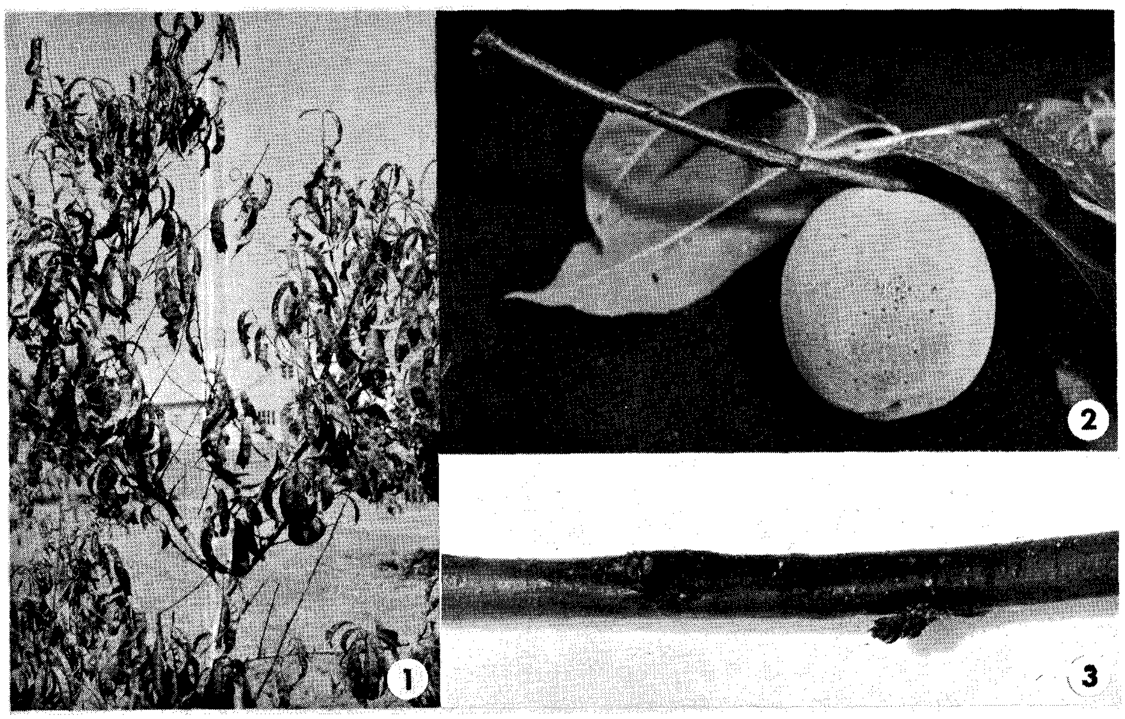

Figures 1–3. Symptoms of bacterial spot of peach caused by *Xanthomonas pruni*, showing (1) defoliation of a 'Washington' peach tree in late August, 1967; (2) fruit spot of 'Washington' peach; (3) spring canker on an internode of the previous year's growth of 'Kalhaven'.

from many of these cankers (Table 1). Some cankers remained sterile while others yielded divers organisms, including some common saprophytic bacteria and fungi.

The spring canker phase was followed by the development of leaf spots, the earliest of which appeared during the first week of June. Defoliation (Fig. 1) occurred during July, August, and September. Fruit spots (Fig. 2) were not common but occurred on the cultivars 'Kalhaven' and 'Washington'. Summer cankers were not found even on severely affected trees. Summer cankers are found in abundance in Illinois (1); they also occur in New Jersey (3) and South Carolina (5) and are considered by Klos (personal communication) to be relatively scarce in Michigan. In Canada, Kelly (2) reported the occurrence of numerous lesions of bacterial spot on fruits and young bark of peach trees in Lincoln County, Ontario. The latter were presumably summer cankers. Although Thornberry and Anderson (7) were unable to recover viable bacteria from summer cankers after the first of December in Illinois, X. pruni is reported to overwinter in such cankers in southern New Jersey (3) and South Carolina (5), and the summer cankers are considered to be an important source of primary inoculum the following spring. In southwestern Ontario, summer cankers have not been found in 1965, 1966, or 1967. However, the spring canker phase does occur, and it is an important source of primary inoculum at the beginning of the growing season.

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BIPOLARIS SOROKINIANA ON SNAP BEANS IN NOVA SCOTIA[1]

C.O. Gourley[2]

Abstract

A severe infection of leaves, pods and stems caused by Bipolaris sorokiniana (Sacc. in Sorok.) Shoemaker was found in 10 acres of snap beans (Phaseolus vulgaris) in Nova Scotia. The symptoms of the disease differ from those previously described for B. sorokiniana on beans in New Brunswick. Lesions on leaves, petioles, and stems were similar to those described for Bipolaris victoriae on beans in North Carolina, but pod lesions were distinctive in the Nova Scotia material. The fungus failed to sporulate on diseased beans in the field. An adjacent field of infected oats (Avena sativa) was considered to have been the source of inoculum.

Introduction

In August, 1967, 'Tendercrop' snap bean (Phaseolus vulgaris L.) plants in a 10-acre field in Kings County, Nova Scotia, were severely infected with what was at first considered to be bacterial blight. However, a species of the fungus Bipolaris was the dominant organism isolated from the leaves, petioles, pods, and stems of infected bean plants. The fungus was identified by Dr. R. A. Shoemaker as Bipolaris sorokiniana (Sacc. in Sorok.) Shoemaker and the specimen was filed as DAOM 117217.

Bipolaris victoriae (Meehan and Murphy) Shoemaker was reported by Winstead and Hebert (under the name Helminthosporium victoriae Meehan and Murphy) to be the causal agent of a similar disease of beans in North Carolina (2). Graham et al. (1) reported B. sorokiniana on the green-podded snap bean varieties 'Tendercrop' and 'Bush Blue Lake' in New Brunswick and stated that the symptoms of this disease were distinct from those reported for B. victoriae. In Nova Scotia bean leaves infected with B. sorokiniana showed interveinal symptoms similar to those reported from New Brunswick, but the symptoms on the leaf veins, petioles and stems were more characteristic of those caused by B. victoriae (2). The symptoms of B. sorokiniana infections on pods were distinctive from those caused by the same species in New Brunswick (1) and from symptoms of B. victoriae on pods in North Carolina (2).

A brief account of the symptoms of the disease found in Nova Scotia, the isolation of the fungus, and the source of inoculum is given in this paper.

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Symptoms

More than 90% of the pods over 3 inches long were infected with B. sorokiniana and as many as 275 lesions were counted on a single pod (Fig. 1). Pod lesions consisted of a small, black, crusty, central spot surrounded by a narrow band of water-soaked tissue, around which was a broader reddish-colored area (Fig. 2). The circular lesions on the pods were slightly depressed and as large as 5mm in diameter, and they often coalesced to form extended areas of infection. Lesions were not found on pods less than 3 inches long.

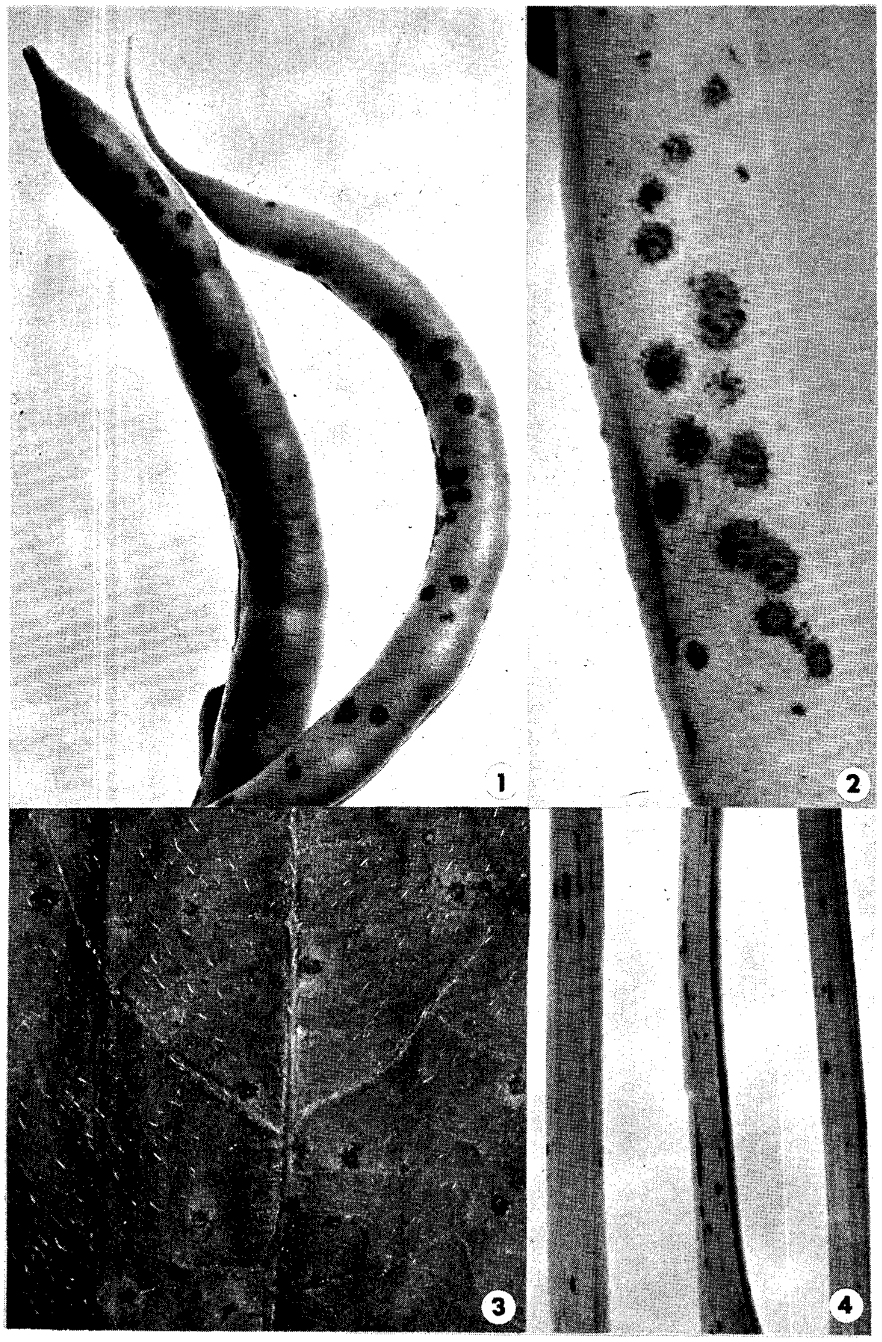
Numerous lesions were found on even the youngest expanded leaves, and the oldest leaves were almost completely necrotic. Lesions between the veins were different from those on the veins. Interveinal spots appeared first as small, chlorotic areas, the centers of which soon became brown and necrotic (Fig. 3). The necrotic areas enlarged as the lesions developed and became darker around the outer edge than in the center but did not exceed 1.5 mm in diameter. Infections on the leaf veins were similar to those found on the petioles and stems (Fig. 4). They were linear, black, not more than 3 to 5 mm long, and usually less than 1 mm wide. Lesions on the ridges of petioles and stems often developed a light-colored center and frequently coalesced to form linear areas of infection (Fig. 4 - B, C).

Isolation of the causal fungus

Infected tissue was surface sterilized in a 1:1000 $HgCl_2$ solution, rinsed in two changes of sterile water, and plated on potato-dextrose agar. The yield of B. sorokiniana was 100% from infected leaf tissue, 40% from pods, and 75% from lesions on leaf veins, petioles, and stems.

Discussion and conclusions

In New Brunswick B. sorokiniana was reported to cause the same type of lesion on both pods and stems of beans (1). These infections were first evident as black pinpoints with water-soaked halos.



Figures 1–4. Symptoms on 'Tendercrop' bean *(Phaseolus vulgaris)* caused by natural infection with *Bipolaris sorokiniana*. Figures 1 and 2. Pods showing circular, reddish-brown, water-soaked lesions with central black necrotic spots. Figure 3. Leaf lesions. Figure 4. Narrow black streaks on A) and C) stems, and B) petiole.

Mature lesions were lenticular, crateriform, brown to black, and 1 to 5 mm in size. Similar symptoms were described for B. victoriae infections on pods in North Carolina, but the lesions were only about 1 mm in diameter (2). In Nova Scotia the circular, reddish-brown areas surrounding the dark central portion of B. sorokiniana lesions on pods were quite distinctive from those caused by the same fungal species in New Brunswick and from B. victoriae spots on pods in North Carolina. The interveinal spots on bean leaves in Nova Scotia were similar to those reported from New Brunswick, but they were larger and more prominent than the small dark spots on infected leaves in North Carolina. The shothole effect reported from New Brunswick did not occur in Nova Scotia. The small, narrow, black lesions on the leaf veins, petioles and stems of infected bean plants in Nova Scotia were quite different from those on the pods. A similar type of lesion was reported on stems in New Brunswick (1) and on leaf veins, petioles, and stems in North Carolina (2). The differences in symptoms of B. sorokiniana on the same variety of snap bean may have been due to more favorable climatic conditions for fungus development in Nova Scotia in 1967 than in New Brunswick in 1963. The 1967 season appeared to be ideal for the development of B. sorokiniana.

The source of inoculum of B. victoriae on beans in North Carolina was traced to an adjacent field of 'Victorgrain' oats heavily infected with victoria blight (2). In New Brunswick the probable source of B. sorokiniana inoculum was reported to be in adjacent fields containing infected cereals or cereal stubble (1). In Nova Scotia only a ditch separated the infected bean field from a 5-acre field of oats (Avena sativa L.). At the time of examination, the oats had been harvested, but the stubble and volunteer oat seedlings were severely infected with B. sorokiniana. Couch grass (Agropyron repens L.) growing in the oat field was also severely infected. Numerous conidia of the pathogen were present on infected oat seedlings and couch grass as well as on the inner and outer surfaces of the hollow oat straw stubble. Since B. sorokiniana failed to sporulate on infected beans in the field, the inoculum apparently originated in the adjoining oat field. The bean field was directly in the path of the prevailing west winds that blew across the oat field, and the bean plants farthest away from the oats were as severly infected as those nearest the oats.

B. sorokiniana has not been heretofore reported as the cause of a disease of beans in Nova Scotia, although cereals are often the preceding crop in the rotation. The disease is not considered important and probably would not have occurred had the bean planting not been adjacent to the oat field and in the direct path of the air-borne inoculum.

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BRIEF ARTICLES

OCCURRENCE OF PYTHIUM APHANIDERMATUM ON TABLE BEETS IN BRITISH COLUMBIA[1]

B.B. Till[2]

In June 1967, large areas of a 30-acre field of table beet, Beta vulgaris L. 'Detroit Dark Red', near Armstrong, British Columbia, contained fewer plants than the average number throughout the field. Plants in these portions of the field were stunted and had yellow leaves and small roots. Plants in the rest of the field appeared normal. The soil of this area, which had been reclaimed from swamp 15 years previously, was black and high in organic matter. Crops that had preceded the beets included timothy, potatoes, parsnips, carrots, and oats. The grower stated that in 1966, the first year when table beets were grown, the crop had shown similar unsatisfactory growth in certain areas. In 1966, and again in 1967, many plants in the affected areas had died shortly after emergence, while the survivors had grown slowly to display the effects that were observed. Affected plants had scurfy black lesions on the roots at the soil level, but attempts to isolate pathogens from such lesions failed to yield any organisms deemed likely to be responsible for the disorder.

Subsequently, soil was collected from the areas of the field that were most affected and was sown with seed of 'Detroit Dark Red' beets in flats in a greenhouse that was maintained at 21 C. Seedlings emerged after 5 days, but most of them collapsed within a few hours of emergence. Wilted seedlings had conspicuous, black, wet lesions that girdled the plants at the soil level. Pure cultures of a rapidly growing fungus were consistently isolated on Difco corn meal agar from such lesions. The fungus was identified on the basis of Middleton's description (2) of Pythium aphanidermatum (Edson) Fitzp.

The pathogenicity of the fungus was confirmed in greenhouse tests at 21 C. A homogenate, prepared by blending four petri-dish cultures of the fungus, in 100 ml water, was applied to three 2-ft rows of newly emerged 'Detroit Dark Red' seedlings growing in steamed potting soil in flats. Seedlings in a second flat were similarly treated with a fungus-free homogenate of corn meal agar. Thirty hours after inoculation, seedlings began to collapse in the flat to which inoculum had been added and additional plants were affected during the next 3 days. Pure cultures of P. aphanidermatum were readily recovered from affected seedlings.

From the evidence obtained, it has been established that P. aphanidermatum was present in the soil of the problem portions of the field, and that this pathogen causes damping-off of table beet seedlings. It has not been established with certainty that stunting and scurfy root lesions were due to infection by P. aphanidermatum. It is however conceivable that these symptoms were caused by chronic attacks by the pathogen on plants that had grown beyond the stage at which they succumb completely to damping-off.

P. aphanidermatum, although known to cause damage to sugar beets in Ontario (1), has not been recorded previously on table beets in Canada.

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[2] Plant Pathologist. Present address, Wolverhampton College of Technology, Wolverhampton, Staffs., England.

OBSERVATIONS ON THE GERMINATION OF THE OOSPORES OF PHYTOPHTHORA CITRICOLA

A.W. Henry and D. Stelfox[1]

The observations reported here are preliminary ones having to do mainly with the germination of the oospores of Phytophthora citricola Saw., which is associated with a shoot blight of lilac (Syringa vulgaris L.) and a crown rot of elder (Sambucus sp.) in Alberta (4). P. citricola is homothallic and it produces oospores rapidly and abundantly on slants of lima bean agar in test tubes. In its sexual state, particularly, it closely resembles Phytophthora cactorum (Leb. & Cohn) Schroet. (6).

About 1 week after the initiation of a new colony of P. citricola on Difco lima bean agar (ph 5.8), numerous oospores may be formed under ordinary laboratory conditions at 70-75 F (21-24° C). The first

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isolate of the fungus that we examined was obtained in 1965 from the stem of a blighted lilac. It produced oospores regularly on lima bean agar, but none were observed to germinate over a two-year period. In 1967, three isolates of the fungus were obtained from other sources, two from elders affected with crown rot, and one from soil under diseased lilacs. Germinating oospores were soon found in cultures of all three isolates. Eventually, in the same year, the original isolate from lilac gave rise to oospores in which the percentage germination was even higher than in those of the other three isolates.

The time that elapsed between the starting of the cultures and the observation of the first germinating oospores varied from about 3 to 6 weeks. Allowing about 1 week for oospore formation, this indicates that at least some of the spores were able to germinate without a long period of dormancy. In view of the experience of other workers with the oospores of other species of Phytophthora, these results seem somewhat unusual, especially since they were obtained without special treatment of the oospores to stimulate germination. Germination of the oospores of P. cactorum has been induced with difficulty, but according to Miss Blackwell (3), special methods such as chilling "shortened the requisite time to two months" for the germination of month-old oospores of this species.

The most common method of germination of the oospores of P. citricola that we have observed is

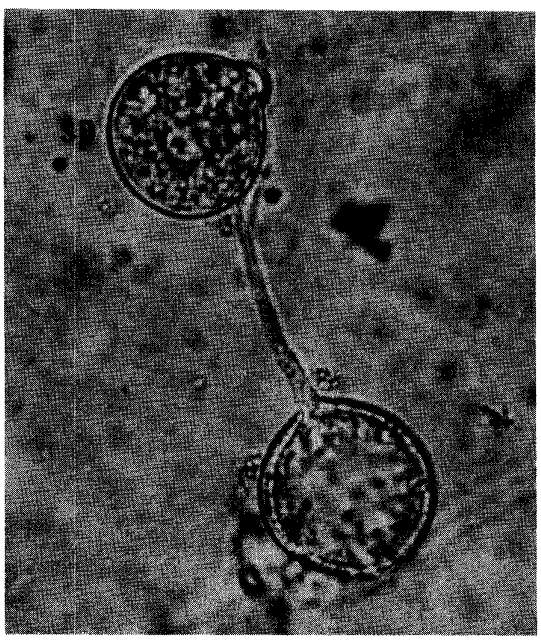

Figure 1. Oospore of *Phytophthora citricola* within an oogonium, germinating by a germ tube bearing a single sporangium (sp) following partial disintegration of the inner wall of the oospore.

characterized by the formation of a germ tube that terminates in a single sporangium (Fig. 1). Frequently this may simply be an initial stage in the process. Quite often a chain of two or more sporangia forms from the apex of the germ tube. On one occasion a branched sporangiophore bearing sporangia was seen arising from an oospore. Before the appearance of a germ tube, marked striation and other changes in the inner wall of the oospore were noted regularly. These changes probably result from a process of digestion, as has been suggested for P. cactorum (2).

Germination of the oospores that we have observed in P. citricola has occurred under quite ordinary conditions in the laboratory. Germination was first observed in cultures contaminated with bacteria, but it has since occurred in pure cultures. Moreover it has taken place under widely different light conditions, and sometimes it has occurred under limited light supply, as has been noted for P. cactorum (1, 5). Studies have been initiated to determine more precisely the effects of variations in light and other environmental factors on the germination of these spores.

Acknowledgments

Our thanks are extended to Mrs. J. Latham for photographic and other technical assistance.

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