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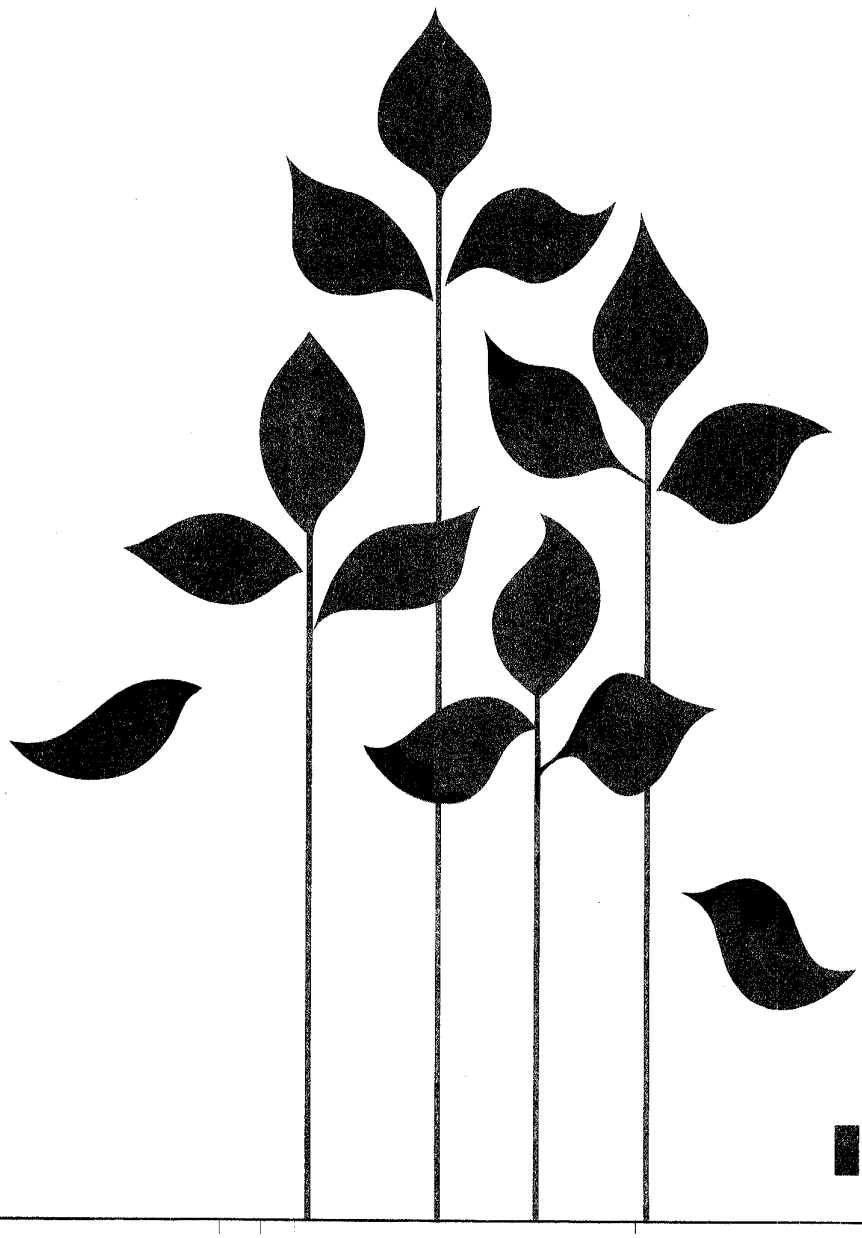

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Contents

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

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

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Anthracnose on field beans in Ontario[1]

V.R. Wallen

Anthracnose caused by *Colletotrichum lindemuthianum* was found in a Select seed plot of the white field bean (*Phaseolus vulgaris*) cv. Sanilac and in a Foundation field of Sanilac and a commercial field of Kentwood in southwestern Ontario in 1976. All cultivars grown commercially in the area are regarded as resistant to anthracnose, suggesting that a race of the fungus new to the area has been introduced.

Can. Plant Dis. Surv. 56: 109. 1976

On a constaté la présence d'anthracnose causée par *Colletotrichum lindemuthianum* dans une parcelle de semences Sélect de haricot blanc (*Phaseolus vulgaris* cv. Sanilac), ainsi que dans une parcelle de semences de fondation de Sanilac et une autre de semences commerciales de Kentwood dans le sud-ouest de l'Ontario en 1976. Tous les cultivars cultivés commercialement dans la région sont considérés comme résistants à l'anthracnose, ce qui laisse supposer l'introduction d'une race du champignon jusque-là inconnue dans la région.

During the inspection of Select white field bean plots in southwestern Ontario in August, 1976, a pod with anthracnose-like symptoms was located in one of the Sanilac plots, near Staffa, Ontario. A thorough inspection of the 1 acre plot did not reveal any further infected material at that time. Subsequently a culture of *Colletotrichum lindemuthianum* (Sacc. and Magn.) Bri. and Cav. was isolated from the infected pod. A second inspection on September 8 revealed that at least 5% of the plants were infected. Pods on infected plants were severely affected. The pattern of infection in the field was indicative of seed-borne infection with heavily infected plants surrounded by healthy plants.

An adjacent field of Foundation Sanilac was also affected at this time, also with approximately 5% of the plants infected. As most of the leaves had either fallen or were in an advanced stage of senescence, it was not possible to determine if any leaf infection had occurred. Since then a number of cultures of *Colletotrichum lindemuthianum* have been obtained from infected material from these two fields.

The staff of the London district office of Plant Products Division was notified of the finding and infected pods were subsequently forwarded from a commercial field of the variety Kentwood from the Springfield area. In this field 75% of the plants were infected. Cultures of the anthracnose organism were also isolated from two samples of Flageolet Verte beans grown in the Dublin, Ontario, area.

The principal white field bean varieties Kentwood, Sanilac, and Seafarer are regarded as resistant to anthracnose, at least to the races of anthracnose present in Ontario. This finding suggests the presence of a race new to the area. In preliminary greenhouse trials all three varieties have proven susceptible to the original two isolates, and on the basis of the reaction of differential bean cultivars, the race has been identified as delta.

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Cooperative seed treatment trials - 1976[1]

J.T. Mills,[2] J. Nielsen,[2] G. Pelletier,[3] J.G.N. Davidson,[4] and L.J. Piening[5]

Twenty-two seed treatment chemicals were tested at four stations for their efficacy in controlling bunt of wheat [*Tilletia caries* and *T. foetida*], loose smut of oats [*Ustilago avenae*], and false loose smut of barley [*U. nigra*]. Smut infection of untreated seed was high with the exception of 1.6% barley smut at Ste-Foy, Québec. Eight treatments gave significantly less control of bunt and oat smut at two stations and of barley smut at one station than the standard Vitaflo 280 but the remaining treatments were not significantly better.

Can. Plant Dis. Surv. 56; 110-113. 1976

On a évalué à quatre stations l'efficacité de vingt-deux fongicides (traitement des semences) dans la lutte contre la carie du blé (*Tilletia caries* et *T. foetida*), le charbon nu de l'avoine (*Ustilago avenae*) et le faux charbon nu de l'orge (*U. nigra*). Le taux d'infection au charbon des semences non traitées était élevé, à l'exception du charbon de l'orge à Sainte-Foy (1.6%). En ce qui a trait à la carie du blé et au charbon de l'avoine à deux stations, et au charbon de l'orge à une station, huit traitements ont donné des résultats significativement moins probants que le Vitaflo 280, mais les autres traitements n'ont pas été significativement meilleurs.

In 1976, 22 seed treatment chemicals were tested for their efficacy in controlling common bunt of wheat [*Tilletia foetida* (Wallr.) Liro and *T. caries* (DC.) Tul.], loose smut of oats [*Ustilago avenae* (Pers.) Rostr.], and false loose smut of barley [*U. nigra* Tapke]. There were two main changes in the 1976 trials as compared to those of 1975. These were the use of a vacuum inoculation technique to improve smut infection of oats and barley, and the use of a much wider range of test locations across Canada.

Materials and methods

Table 1 lists the chemical composition, where available, and the product name and source of the materials used. Vitaflo 280 was included as a comparison standard.

Seeds of 'Norteno M67' wheat (*Triticum aestivum* L.), 'Random' oats (*Avena sativa* L.), and 'Herta' barley (*Hordeum distichon* L.) were used in the smut tests.

Before treatment with chemicals, wheat was inoculated with dry bunt spores at the rate of 1 g spores per 200 g of seed. The technique for inoculation of oats and barley was described by Nielsen (1976). The chemical dosages used were those suggested by the manufacturer (Table 2). Each sample was hand-shaken in a glass jar to cover the seed uniformly with the chemical. After 3 days or more, 200 seeds were removed from each jar and placed in a paper envelope. Envelopes that contained seed of the same treatment were stored in polyethylene bags at 15°C for up to 8 weeks before seeding.

The tests on bunt were planted at Beaverlodge, Alberta, (April 30) and at Lacombe, Alberta, (May 6); those on the smuts of oats and barley at Ste. Foy, Quebec, (June 3) and Winnipeg, Manitoba (June 22). There were four replicates per test at each location. Each replicate consisted of 200 seeds planted in a row 4 m long; all rows were planted 25 cm apart; plots were arranged in a randomized block design.

The total heads in the untreated rows and the number of smutted heads in all rows was recorded after the crop had headed. The % smut in the treatment rows was obtained by dividing the mean no. of smutted heads by the mean no. of heads in untreated rows then multiplying the result by 100.

For a particular crop and location the mean of the total heads in the treated rows was assumed to be the same as the mean of the total heads in the untreated rows. The results are given as means of four replicates at each planting site. Significance at the 0.95 level was determined from the means of the treatments at each station.

Results and discussion

Smut infection of untreated seed was 1.6% in barley and varied from 16.1% to 35.8% in wheat, and from 12.9% to 13.9% in oats.

Eight treatments gave significantly less control of bunt and oat smut at two stations and of barley smut at one station than the standard Vitaflo 280 but the remaining treatments were not significantly better (Table 2). The barley test at Winnipeg was lost because of flooding.

No obvious symptoms of phytotoxicity were observed in plants originating from treated seeds at any of the test locations.

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Table 1. Seed treatment materials used in the cooperative tests

Treatment no.	Source*	Product name	Active ingredient
1		Untreated check	
2	ACP	AG 304	identity not available
3	Chemagro	Bay–meb 6447	1–(4–chlorophenoxy)–3,3–dimethyl–1 (1H–1,2,4–triazol–1–yl)–2–butanone (25%)
4	Chipman	TF 3350	identity not available
5	Chipman	TF 3355	identity not available
6	Ciba–Geigy	A 5581A	identity not available
7	Dupont	DPX 14	identity not available
8	Dupont	DPX 1991 T	benomyl 30% + thiram 30%
9	FMC	Polyram liquid	metiram 22.5%
10	FMC	BEG 3	identity not available
11	FMC	BEG 4	identity not available
12	Interprovincial	Busan 30	2–(thiocyanomethylthio) benzothiazole (30%)
13	Nor–Am	SN 43410	identity not available
14	Rohm & Haas	RH 2161	identity not available
15	Uniroyal	Vitaflo 280	carbathiin 14.9% + thiram 13.2%
16	Uniroyal	UNI 2036	identity not available
17	Uniroyal	UNI 2067	identity not available
18	Uniroyal	UBI 2078	identity not available
19	Uniroyal	UBI 2085	identity not available
20	Uniroyal	UBI 2099	identity not available
21	Uniroyal	UBI 2100	identity not available
22	Uniroyal	UBI 2101	identity not available
23	Uniroyal	UBI 2102	identity not available

* ACP Ltd., London, Ontario; Chemagro Ltd., Mississauga, Ontario; Chipman Chemicals Ltd., Hamilton, Ontario; Ciba–Geigy Canada Ltd., Cambridge (Galt), Ontario; E.I. DuPont de Nemours & Co. Inc., Wilmington, Delaware; FMC of Canada Ltd., Burlington, Ontario; Interprovincial Cooperatives Ltd., Winnipeg, Manitoba; Nor–Am Agricultural Products Inc., Woodstock, Illinois; Rohm & Haas Co. of Canada Ltd., West Hill, Ontario; Uniroyal Chemical Division, Elmira, Ontario.

Table 2. Effects of seed–treatment chemicals on smuts in wheat, oats and barley at Beaverlodge (B), Lacombe (L), Ste. Foy (SF), and Winnipeg (W)

Treatment no.	Product name	Formulation*	Dosage g or ml/kg	% smutted heads + Wheat B	Wheat L	Barley SF	Oats SF	Oats W
1	Untreated check			35.8	16.1	1.6	12.9	13.9
2	AG 304	SL	2.00	1.2	1.4	1.5		
3	Bay–meb 6447	WP	5.00	0.0	0.0	0.0	0.0	0.1
			10.00	0.3	0.0	0.0	0.0	0.0
4	TF 3350	SN	0.50	3.9	1.2			
			0.94			0.0		
			1.30				1.8	0.3
5	TF 3355	SL	1.82	6.4	0.1			
			3.25			0.0		
			4.60				0.0	0.4
6	A 5581A	SL	1.60	1.5	0.4			
			1.80	1.4	0.7			
			2.00			0.0		
			2.30			0.0		
			2.80				0.4	0.0
			3.20				0.9	0.0
7	DPX 14	WP	2.10	0.2	0.0			
			2.60			0.0		
			3.70				0.1	0.7

Table 2. (Cont.)

Treatment no.	Product name	Formulation*	Dosage g or ml/kg	% smutted heads + Wheat B	Wheat L	Barley SF	Oats SF	Oats W
8	DPX 1991 T	WP	2.10	0.3	0.0			
			2.60			0.0		
			3.70				0.0	0.0
9	Polyram liquid	SL	3.10	4.7	0.3			
			3.90			0.4		
			4.20	1.6	0.0			
			5.20			0.1		
			5.50				9.5	0.4
			7.40				11.3	0.1
10	BEG 3	SL	3.10	1.7	0.4			
			3.90			0.0		
			5.50				1.6	0.0
11	BEG 4	SL	3.10	4.6	2.4			
			3.90			0.0		
			5.50				0.7	0.0
12	Busan 30	SN	0.39	1.8	0.8			
			0.48			0.0		
			0.68				0.2	0.0
			0.78	1.8	1.6			
			0.97			0.0		
			1.37				0.2	0.0
13	SN 43410	SN	0.68	18.6	4.2			
			0.85			1.0		
			1.28				5.6	0.0
			1.36	12.4	6.6			
			1.70			0.2		
			2.55				3.8	0.0
14	RHC 2161	SN	0.33	19.6	6.3			
			0.41			0.1		
			0.58				7.7	2.1
			0.66	13.8	1.8			
			0.82			0.0		
			1.16				4.8	1.1
			1.30	5.9	2.2			
			1.63			0.0		
			2.29				1.4	0.0
15	Vitaflo 280	SL	1.82	1.5	0.1			
			2.28			0.0		
			3.22				1.6	0.0
16	UNI 2036	WP	1.56	0.9	0.1			
			1.95			0.0		
			2.75				0.6	0.0
17	UNI 2067	WP	1.56	0.4	0.0			
			1.95			0.0		
			2.75				0.6	0.4
18	UBI 2078	SL	1.56	0.1	0.0			
			1.95			0.0		
			2.75				0.3	0.0
19	UBI 2085	SL	3.22				0.9	0.0
20	UBI 2099	WP	1.56	0.2	0.0			
			1.95			0.0		
			2.75				0.2	0.0
21	UBI 2100	SN	1.82	1.2	0.3			
			2.28			0.0		
			3.22				0.3	0.0
22	UBI 2101	SN	2.08	0.2	0.0			
			2.61			0.0		
			3.68				0.0	0.0

Table 2. cont.

Treatment no.	Product name	Formulation*	Dosage g or ml/kg	% smutted heads +				
				Wheat		Barley	Oats	
				B	L	SF	SF	W
23	UBI 2102	SN	2.08	0.7	0.0			
			2.61			0.0		
			3.68				0.1	0.0
Upper significance limit (0.95)**				4.4	0.7	0.3	3.4	0.4
Mean no. of heads				276	190	395	239	186

* Formulation code: SN = solution, SL = slurry, WP = wettable powder

$$+\,\%\ \text{smut} = \frac{\text{mean no. of smutted heads}}{\text{mean no. of heads in untreated rows}} \times 100$$

** Treatments significantly inferior to Vitaflo 280 have values higher than the upper significance limit.

Acknowledgments

The writers thank the technical staff of the Beaverlodge, Lacombe, Ste. Foy, and Winnipeg Research Stations for their assistance.

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Nielsen, J. 1976. Note on a method of artificial inoculation of oats and barley for seed treatment trials on seedling-infecting smuts. Can. Plant Dis. Surv. 56: 114-116.

A method for artificial inoculation of oats and barley for seed treatment trials on seedling-infecting smuts[1]

J. Nielsen

A method was developed to inoculate bulk amounts of seed of oats and barley for trials on the efficacy of seed-treatment fungicides in controlling the seedling-infecting smuts *Ustilago avenae, U. kolleri, U. nigra,* and *U. hordei*. The method is based on the partial vacuum principle, with the seed in a desiccator being evacuated before the spore suspension (100-200 mg spores/litre water) is introduced. It is suggested that this method be adopted as a standard for such trials in Canada. Since these four smuts have the same biology, it may be possible to use only *U. avenae* on oats as the test organism.

Can. Plant Dis. Surv. 56: 114 - 116. 1976

On a élaboré une technique d'inoculation de semences d'avoine et d'orge en vrac en relation avec des essais sur l'efficacité de certains fongicides (traitement des semences) dans la lutte contre les charbons des plantules (*Ustilago avenae, U. kolleri, U. nigra*, et *U. hordei*). La méthode s'inspire du principe du vide partiel selon lequel la semence est mise dans un dessicateur et en est retirée avant l'inoculation avec la suspension de spores (100 à 200 mg de spores par litre d'eau). On recommande l'adoption de cette méthode comme étalon pour ce type d'essai au Canada. Puisque ces quatre espèces de charbon ont les mêmes propriétés biologiques, il serait possible de n'utiliser que *U. avenae* comme organisme-test sur l'avoine.

Field trials for testing the efficacy of fungicides to control the seedling-infecting smuts of oats and barley [*Ustilago avenae* (Pers.) Rostr., *U. kolleri* Wille, *U. nigra* Tapke, and *U. hordei* (Pers.) Lagerh.] should ideally be done on naturally infested seed. However, such seed is now very hard to obtain, and even if grain that is visibly contaminated by spores can be procured, infection of hulled cultivars of oats and barley is often very low. These two factors have forced most workers to use some form of artificial contamination or inoculation of the seed with spores. Such a method of artificial inoculation should fulfil the following requirements: 1) it should approach natural conditions as much as possible; 2) it should be reliable and reproducible, so that results of tests done in different areas or years are comparable; and 3) it should be easy to perform.

In nature, infection by the seedling-infecting smuts of oats and barley is caused by spores that lodge between hull and karyopsis (Kitunen 1937, Rusch 1957, Thiede 1963). Spores of loose smut of oats and false loose smut of barley are deposited between these structures at or shortly after flowering; spores of the covered smuts find their way under the hull at threshing or during other agitation of the grain. Any method of artificial inoculation should also attempt to deposit the spores under the hull, but it is immaterial when and how this is done. When dry spores are dusted on to the seed, some of them will in fact find their way under the hull. However, the number of spores deposited in this space, and consequently the level of infection, depends on how tightly the hull encloses the karyopsis. Seed samples and cultivars differ in this characteristic, and this difference is largely responsible for the variability between tests, making this method of inoculation unreliable.

A dependable method to bring spores under the hull was developed by Zade (1928/29). The spores were suspended in water, the seed immersed in this suspension, and the mixture subjected to a partial vacuum. The air that was removed from between hull and karyopsis was replaced by spore-suspension when the system was returned to atmospheric pressure. The seed was then dried. This method, in one modification or other, has been routinely used for testing of cultivars of oats and barley for their reaction to smut (Fischer and Holton 1957). Generally a spore-concentration of 1 g/litre water was used. The method has also been used to inoculate seed for seed-treatment trials, but the control by chemicals of smut on seed inoculated in this way appeared to be less effective than in tests with naturally infested seed (Leukel 1937, Purdy 1958). Purdy concluded "that artificial inoculation by the vacuum method produces unnatural and unnecessarily difficult problems of smut control by seed treatment", and "that testing of new materials should be done with naturally infested seed since it more closely represents the conditions encountered in commercial treating than does artificially inoculated seed". Purdy's data show that artificial inoculation with the vacuum method indeed produced an unnatural and unnecessarily difficult problem of smut control: his untreated check had up to 89% infection, a level that is never found under natural conditions. It is caused by an excess of spores on the seed. This, however, is not a flaw of the vacuum method, since any other method that introduced such a high spore load between hull and karyopsis would have

[1] *Contribution No. 772, Agriculture Canada, Research Station, 195 Dafoe Road, Winnipeg, Manitoba R3T 2M9*

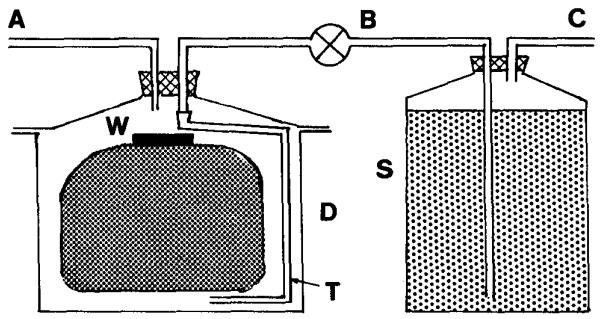

Figure 1. Diagram of the apparatus used to inoculate bulk amounts of seed of oats or barley with spores of *Ustilago* spp.

the same effect. The spore-concentrations of 1 or 2 g/litre water as used by Leukel (1937) and Purdy (1958) were the same as those used in tests of resistance or susceptibility of oat or barley cultivars to smut. In such experiments, maximum infection is desired. For seed-treatment trials, the concentration should obviously be much lower. To determine the concentration, and with it the spore-load that approaches natural conditions one should, in my opinion, be guided by the highest level of infection likely to be found in farmers' fields, because this is the level of infection that seed treatment with a fungicide should be able to prevent. Thus, an infection level of between 10% and 15% appears to be desirable. Since a certain number of spores between hull and karyopsis will cause a certain level of infection, regardless of how the spores get there, the vacuum method should provide the desired level of infection if the appropriate spore concentration is used. Thiede (1963) showed that in oats there is a linear correlation between spore-load and level of infection and established that with the partial vacuum method an infection of 10% to 15% was obtained with a concentration of 100 mg spores/litre water. Thiede's study also showed that when the spore-load was adjusted to give a natural level of infection, there was no difficulty in controlling smut by fungicides that were known to be effective. No similar study has been done with barley, but we found in our own trials that it is necessary to increase the spore-concentration to at least 200 mg/litre to obtain a similar level of infection. This difference between oats and barley is most likely due to the fact that in barley the hull adheres much tighter to the karyopsis than it does in oats.

Using partial vacuum and a low spore concentration, natural conditions are approached as closely as possible, and the tests become reliable and reproducible, fulfilling two of the three requirements mentioned above. The following description will show that the technique is also easy to use.

Seed, 3.5 kg of oats or 4 kg of barley, in a bag of loosely woven fabric was placed in a 25 cm diam desiccator (Fig. 1D) fitted with a cover with a rubber stopper. A weight (W) of about 2 kg was placed on the bag to prevent it from floating. The inoculum was prepared by suspending spores in part of the required amount of water, using a Waring Blendor running at approximately 2000 rpm for 1 min. The final concentration of the inoculum was 100 mg (oats) or 200-300 mg (barley) spores/litre water, and enough was prepared each time to fill the sturdy polyethylene storage bottle (S), which had a capacity of about 8 to 10 litres.

Valve B was closed when seed and spore-suspension were in place, and suction was applied at A until the vacuum reached about 600 to 650 mm. While evacuation continued, valve B was opened slightly to draw in spore suspension through rubber tube T until the inoculum covered the seed to a depth of about 5 cm. Evacuation continued for a further 10 min, after which the vacuum was released. The inoculum was transferred back into the storage vessel by applying gentle suction at C. The recovered inoculum could be used for successive inoculations done the same day. Excess inoculum was removed from the seed by draining the bag for 30 min. The seed was then spread in a layer about 1 cm thick and dried quickly and thoroughly with a fan before it was treated with fungicide.

For maximum infection, the tests should be seeded after the soil has warmed up. Spores for the following year's trials should be obtained by harvesting infected heads in paper bags just after heading and preferably before they have been subjected to rain. After drying the infected heads at room temperature for 2 weeks, the spores are separated by passage through a 40 sieve, sometimes after cutting up the dry heads in a blender. The spores are stored in a glass jar at about 5°C, where they remain viable for at least 2 years. Generally, however, it is advisable to use the freshest spores available.

To compare results of seed-treatment trials conducted at different times and at different geographical locations across Canada, it is desirable to standardize the methods used in such trials. The method of inoculation described here should be part of this standardization. Since loose and covered smuts of oats have the same biology, and false loose and covered smut of barley have the same biology, trials on only one of the smuts on each crop are needed. It is convenient to use loose smut of oats and false loose smut of barley, because they are easy to recognize in the field, and because spores of these smuts disperse more readily when the inoculum is prepared. A further aspect should also be considered, particularly in preliminary tests of a large number of prospective fungicides. Decades of past trials have shown that whenever a fungicide at a certain dosage was effective against the smuts of oats, it was also effective at this dosage against the seedling-infecting smuts of barley. Since there is no difference in biology of these smuts, and since they appear to react similarly to fungicides, it is possible that the required information can be obtained by testing prospective fungicides with only one species of smut, and with only one of the two crops. Oats would

be preferable, because it is less prone to attack by other diseases, and it is less susceptible to adverse weather and soil conditions.

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Air-borne rust inoculum over western Canada in 1976[1]

G.J. Green

A few urediospores of leaf rust [*Puccinia recondita*] and stem rust [*P. graminis*] were carried into western Canada early in the growing season but rust development was limited by dry weather and the total numbers of spores present were much smaller than the 11-year mean. There were more spores over Saskatchewan than over Manitoba.

Can. Plant Dis. Surv. 56: 117 - 118. 1976

Quelques urédiospores de rouille de feuilles (*Puccinia recondita*) et de rouille de la tige (*P. graminis*) ont été transportés en suspension dans l'air dans l'ouest du Canada au début de la saison de végétation, mais le temps sec a limité le développement de la rouille et le nombre total de spores en suspension a été beaucoup plus faible que la moyenne des 11 années précédentes. Il y avait plus de spores en suspension en Saskatchewan qu'au Manitoba.

The numbers of air-borne urediospores of *Puccinia recondita* and *P. graminis* over western Canada in 1976 were estimated by the same methods described in previous reports of this study published annually in the Canadian Plant Disease Survey.

A few urediospores of leaf rust and stem rust were carried into western Canada in late May and early June. Presumably they initiated infections that, along with additional spores from the south, resulted in increasing numbers of spores being caught after mid June (Table 1). More spores were present over Saskatchewan than over Manitoba, presumably because there was more moisture there.

The mean number of spores found in the spore traps (Table 2) was much smaller than the 1966-76 mean. The small number of spores probably resulted from the very dry condition on the prairies after mid July that limited rust development.

Table 1. Number of urediospores of stem rust and leaf rust per square inch (6.5 cm^2) observed on vaseline–coated slides exposed for 72–hour periods at three locations in Manitoba and three locations in Saskatchewan in 1976

Date	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
	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 28 – June 1	2	0	0	0	0	0	0	0	0	0	0	0
June 1 – 4	0	0	0	0	0	0	0	2	0	2	0	0
4 – 7	0	0	0	0	0	0	0	0	0	0	0	0
7 – 10	0	0	0	0	0	0	0	0	0	1	0	0
10 – 13	0	0	0	0	0	0	0	0	0	0	0	9
13 – 16	0	0	1	0	0	0	0	0	0	0	3	7
16 – 19	0	0	3	1	0	0	0	0	2	1	6	12
19 – 22	1	0	0	3	0	1	0	2	0	2	0	3
22 – 25	1	2	3	9	6	1	0	0	1	0	0	3
25 – 28	0	1	0	4	0	3	0	3	0	0	2	5
28 – July 1	0	7	0	1	0	0	0	1	0	2	3	34
June total	4	10	7	18	6	5	0	8	3	8	14	73
July 1 – 4	1	4	2	11	0	2	0	5	0	14	2	31
4 – 7	1	22	4	22	1	12	1	2	2	5	5	30
7 – 10	1	16	0	15	5	19	1	10	0	12	1	4
10 – 13	2	28	2	89	0	39	0	7	1	14	2	8

[1] *Contribution No. 780, Research Station, Agriculture Canada, 195 Dafoe Road, Winnipeg, Manitoba R3T 2M9.*

Table 1. cont.

Date	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
July 13 – 16	0	35	0	43	2	25	0	8	2	10	0	14
16 – 19	4	170	4	38	0	19	2	3	1	8	6	33
19 – 22	2	67	3	22	1	72	1	10	1	28	0	17
22 – 25	1	128	13	229	3	101	0	30	0	39	0	5
25 – 28	0	334	19	169	5	196	4	98			9	80
28 – 31	0	12	4	132	1	147	0	4	2	25	1	12
July total	12	816	51	770	18	632	9	177	9	155	26	234
July 31 – Aug. 3	0	0	0	54	0	30	1	57	0	125	5	153
Aug. 3 – 6	12	112	9	254	1	71	1	136	2	205	4	199
6 – 9	10	90	11	14	6	135	6	240	6	495	15	372
9 – 12	8	23	10	6	4	15	1	124	4	338	12	235
12 – 15	4	5	7	8	0	0	1	29	15	614	81	3018
August total	34	230	37	336	11	251	10	589	27	2011	117	3977
1976 Total	50	1056	95	1124	35	888	19	774	39	2174	157	4284
1975 Total	319	1271	240	1809	36	496	4	335	15	962	210	1439

Table 2. Mean number of urediospores of stem rust and leaf rust observed on slides exposed for 48–hour periods at six locations from July 1 to August 15 for the years 1966 to 1976*

Year	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon		Mean	
	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
1976	2	47	4	50	2	39	1	34	2	96	4	109	3	63
1975	14	57	9	82	2	21	1	13	1	43	10	64	6	47
1974**	1	4	1	7	1	5	1	5	1	12	1	47	1	13
1973	16	249	4	136	1	242	2	629	2	1449	7	179	5	481
1972	16	277	24	696	16	645	12	1515	23	6566	3	528	16	1705
1971	38	497	14	404	4	114	5	125	5	172	7	87	12	233
1970	56	252	73	649	12	235	8	173	12	480	2	197	27	331
1969	5	41	5	62	1	29	1	8	1	6	2	24	3	28
1968	3	225	5	219	1	47	1	24	1	23	1	15	2	92
1967	9	81	6	122	1	16	1	8	2	11	0	12	3	42
1966	23	145	17	239	4	11	13	702	6	618	3	1296	11	502
1966–76 Mean	16.6	170.5	14.7	242.4	4.0	127.6	4.2	294.2	5.1	861.5	3.6	232.5	8.1	321.5

* 1976 data converted from 72–hour exposures

** July 1 to August 5

Stem rust of wheat, barley, and rye in Canada in 1976[1]

G.J. Green

Stem rust development was slowed by dry weather after mid July, but moderate to severe infections developed by early August in plots of susceptible varieties in southern Manitoba and southeastern Saskatchewan. There was virtually no stem rust in farm fields of resistant varieties. Stem rust was common on susceptible varieties in rust nurseries grown at locations from eastern British Columbia to eastern Ontario. Twenty-three physiologic races were identified in 1976 indicating that the wheat stem rust population continues to be as variable as in the previous 2 years. Race C33 (15B-1L) continued to predominate and two closely related races, C49 (15) and C53 (15B-1L), increased in prevalence. There was little change in the virulence of the rust population on identified resistance genes.

Can. Plant Dis. Surv. 56: 119 - 122. 1976

Le temps sec a ralenti le développement de la rouille de la tige (*Puccinia graminis*) après la mi-juillet, mais des infections allant de modérées à graves se sont manifestées au début d'août en parcelles de variétés sensibles dans le sud du Manitoba et le sud-est de la Saskatchewan. La maladie était virtuellement absente des champs de ferme semés en variétés résistantes. Elle était cependant répandue en parcelles d'observation de variétés sensibles cultivées à certains endroits échelonnés de l'est de la Colombie-Britannique à l'est de l'Ontario. Vingt-trois races physiologiques ont été identifiées en 1976, ce qui indique que les populations de rouille de la tige du blé demeurent aussi variables qu'au cours des deux années précédentes. La race C33 (15B-1L) a continué de dominer, et deux races étroitement apparentées, soit C49 (15) et C53 (15B-1L), ont acquis plus d'importance. La virulence des populations de rouille à l'égard des gènes de résistance identifiés n'a pratiquement pas changé.

Prevalence and importance in western Canada

In 1976 wheat stem rust [*Puccinia graminis* Pers. f. sp. *tritici* Eriks. and E. Henn.] was first observed in western Canada on a susceptible variety at Morden, Manitoba, on June 25. It increased quickly during early July but dry conditions later in the month and during August slowed development. Despite the dry weather, stem rust was severe (70-80%) on susceptible *Triticum aestivum* L. cv. Klein Titan at Morden, Manitoba, in early August, moderate (20-40%) at Brandon, Manitoba, and Indian Head, Saskatchewan, and light (10%) at Regina, Saskatchewan. By mid October stem rust was easily found on susceptible wild barley (*Hordeum jubatum* L.) from the Red River Valley of Manitoba to Cardston, Alberta.

Stem rust resistant wheat varieties recommended for the rust area of western Canada continued to show excellent resistance in 1976 and were not damaged. The recommended varieties of six-row barley are resistant to wheat stem rust and only traces of rust were observed on susceptible two-row barley.

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

Uniform rust nurseries consisting of 20 varieties of wheat, 3 varieties of barley, 1 variety of rye, and 1 variety of triticale were planted by cooperators at 32 locations across Canada in 1976. The varieties included in the nurseries (Tables 1 and 2) have been described previously (1).

Wheat stem rust occurred on susceptible varieties in 17 nurseries from British Columbia to eastern Ontario. The heaviest infections occurred in Manitoba and at Thunder Bay, Ontario (Table 1). The incidence of stem rust in 1976 was much higher than in 1975, returning to the level of earlier years when rust was common.

The widely grown common wheat varieties Neepawa, Napayo, and Sinton were highly resistant at all locations as were the durum wheat varieties Hercules, Wascana, Macoun, and Wakooma. The moderate amount of rust on Kenya Farmer at Thunder Bay was unexpected. Kenya Farmer has been resistant since it was first grown in the nurseries in 1954 and the infection at Thunder Bay this year was probably caused by favorable weather for rust development and moderately avirulent races.

Stem rust occurred on barley and rye at 14 locations (Table 2). Although rye stem rust attacks barley varieties resistant to wheat stem rust, heavy infection of rye was not associated with heavy infection of barley, except at Creston, B.C. Presumably the barley ripened before rust could develop. Much of the rust on barley at Manitoba locations seems to have been wheat stem rust.

Physiologic specialization

Physiologic races were identified by the methods used previously (1) with the addition of the varieties Agent with *Sr24* and Eagle with *Sr26*. Six hundred and two isolates of wheat stem rust were identified. This is a much larger number than usual and it was made

[1] *Contribution No. 779, Research Station, Agriculture Canada, Winnipeg, Manitoba R3T 2M9*

Table 1. Percent infection of stem rust *(Puccinia graminis* f. sp. *tritici)* on 20 wheat varieties in uniform rust nurseries at 17 locations in Canada in 1976

	Red Bobs	Lee	Pitic 62	Neepawa	Napayo	Sinton	Kenya Farmer	C.I. 8154 X Frocor[2]	Glenlea	Norquay	Exchange	Frontana	Thatcher[6] X Transfer	R.L. 4255	Agatha	Hercules	Mindum	Wascana	Macoun	Wakooma
Creston, B.C.	10	0	0	0	0	0	0	0	0	0	tr	0	0	0	0	0	0	0	0	0
Lacombe, Alta.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Edmonton, Alta.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lethbridge, Alta.	tr	0	0	0	0	0	0	0	0	0	tr	0	0	tr	0	0	0	0	0	0
Melfort, Sask.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0
Indian Head, Sask.	10	10	0	0	0	0	0	0	0	0	tr	0	0	tr	0	0	tr	0	0	0
Brandon, Man.	70	50	tr	tr	0	0	0	0	0	0	40	0	20	10	5	0	25	tr	0	tr
Durban, Man.	60	40	tr	tr	0	tr	0	0	0	0	5	tr	50	10	25	0	40	tr	0	0
Morden, Man.	30	tr	0	0	0	0	0	0	0	0	tr	0	tr	0	tr	0	0	0	0	0
Glenlea, Man.	60	30	tr	2	tr	tr	1	tr	tr	tr	10	tr	30	31	10	tr	5	tr	tr	1
Thunder Bay, Ont.	90	80	15	tr	0	0	35	0	0	0	25	0	20	1	30	0	30	0	0	0
Kapuskasing, Ont.	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guelph, Ont.	60	tr	0	0	0	0	0	0	0	0	tr	0	tr	0	0	0	tr	0	0	0
Ottawa, Ont.	10	tr	0	0	0	0	0	0	0	0	0	0	tr	0	0	0	1	0	0	0
Appleton, Ont.	30	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunbury, Ont.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vineland, Ont.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

No rust was observed in nurseries at 15 locations: Agassiz, B.C.; Beaverlodge, Alta.; Scott, Sask.; New Liskeard and Kemptville, Ont.; Macdonald College, Normandin, Lennoxville, Quebec, and La Pocatière, P.Q.; Truro and Kentville, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; and St. John's, Nfld.

Table 2. Percent infection of stem rust *(Puccinia graminis)* on three varieties of barley and one variety each of rye and triticale in uniform rust nurseries at 14 locations in Canada in 1976

	Montcalm	Conquest	Wpg. M7118–13	Prolific	Rosner
Creston, B.C.	50	tr	10	50	0
Lacombe, Alta.	0	0	0	50	0
Lethbridge, Alta.	0	0	0	tr	0
Brandon, Man.	15	0	0	5	0
Durban, Man.	5	0	0	tr	0
Glenlea, Man.	5	1	1	tr	1
Thunder Bay, Ont.	tr	tr	0	0	0
Guelph, Ont.	0	0	0	10	0
Ottawa, Ont.	0	0	0	40	0
Appleton, Ont.	0	0	0	40	0
Sunbury, Ont.	tr	0	tr	60	0
Macdonald College, P.Q.	0	0	0	5	0
Lennoxville, P.Q.				60	
Kentville, N.S.	0	0	0	70	0

No rust was observed in nurseries at 18 locations: Agassiz, B.C.; Beaverlodge and Edmonton, Alta.; Scott, Melfort and Indian Head, Sask.; Morden, Man.; New Liskeard, Vineland, Kemptville, and Kapuskasing, Ont.; Normandin, Quebec and La Pocatière, P.Q.; Truro, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; and St. John's, Nfld.

Table 3. Distribution by provinces of physiologic races of *Puccinia graminis* f. sp. *tritici* on wheat, barley and grasses, and of *Puccinia graminis* f. sp. *secalis* on barley and grasses in 1976

Virulence formula and (race) number	Virulence formula (effective/ineffective host genes)	Number of isolates from:					Total number of isolates	Percent of total isolates
		Ont.	Man.	Sask.	Alta.	B.C.		
C17 (56)	6,8,9a,9b,9d,9e,11,13,17,22,24,26,Tt1,Tt2/5,7a,10,14,15	1					1	0.2
C18 (15B–1L)	6,8,9a,9b,13,15,17,22,24,26,Tt2/5,7a,9d,9e,10,11,14,Tt1		11	2	1		14	2.3
C25 (38)	9a*,9e,22,Tt1,Tt2/5,6,7a,8,10,11,15		1		1		2	0.3
C33 (15B–1L)	6,9a,9b,13,15,17,22,24,26,Tt2/5,7a,8,9d,9e,10,11,14,Tt1	6	194	93	29		322	53.4
C33 (15B–1L)	6,9a,9b,13,15,17,22,24,26,Tt2/5,7a,8,9d,9e,10,11*,14,Tt1		23	13	2		38	6.3
C33 (115)	6,9a,9b,15,17,22,24,26,Tt2/5,7a,8,9d,9e,10,11,Tt1			9			9	1.5
C35 (32–113)	9d,9e,10,11,13,17,22,24,26,Tt2/5,6,7a,8,9a,9b,14,15,Tt1	1	20	1	2		24	3.9
C35 (32–113)	9d,9e,10,11*,13,17,22,24,26,Tt2/5,6,7a,8,9a,9b,14,15,Tt1		1				1	0.2
C41 (32–113)	9d,9e,10,13,17,22,24,26,Tt2/5,6,7a,8,9a,9b,11,14,15,Tt1		1				1	0.2
C42 (15)	6,8,9a,9b,11,13,15,17,22,24,26,Tt2/5,7a,9d,9e,10,14,Tt1		1				1	0.2
C44 (15B–1L)	6,9a,9b,13,17,22,24,26,Tt2/5,7a,8,9d,9e,10,11,14,15,Tt1			1			1	0.2
C46 (15B–1L)	6,8,9a,9b,13,15,22,24,26,Tt2/5,7a,9d,9e,10,11,14,17,Tt1		2				2	0.3
C49 (15)	6,9a,9b,11,13,15,17,22,24,26,Tt2/5,7a,8,9d,9e,10,14,Tt1		36	20	8		64	10.6
C53 (15B–1L)	6,9a,9b,13,15,22,24,26,Tt2/5,7a,8,9d,9e,10,11,14,17,Tt1	1	63	27	7		98	16.3
C53 (15B–1L)	6,9a,9b,13,15,22,24,26,Tt2/5,7a,8,9d,9e,10,11*,14,17,Tt1		1				1	0.2
C56 (38)	6,7a,8,9e,11,Tt1,Tt2/5,9a,15			1			1	0.2
C59 (31)	9d,9e,13,22,24,26,Tt1,Tt2/5,6,7a,8,9a,9b,10,11,14,15,17		2	1			3	0.5
C65 (39)	6,8,9e,11,17,Tt1,Tt2/5,7a,9a,10,15					1	1	0.2
C66 (15)	6,9a,9b,11,13,15,22,24,26,Tt2/5,7a,8,9d,9e,10,14,17,Tt1	1	9	2			12	1.9
C67 (38)	9e,Tt1,Tt2/5,6,7a,8,9a,10,11,15,17				1		1	0.2
C68 (33)	6,8,9a,9e,11,17,Tt1,Tt2/5,7a,10,15				1	2	3	0.5
C69 (113)	6,9e,10,11,Tt2/5,8,9a,15,17,Tt1		1				1	0.2
C70 (23)	6,8,9a,9e,11,17,Tt1,Tt2/5,7a,10,15			1			1	0.2
Total wheat stem rust isolates		10	366	171	52	3	602	100.0
Rye stem rust isolates		2	26	16	52		96	

* Intermediate infection type

possible by planting plots of the susceptible variety Klein Titan at Morden and Brandon, Manitoba, and at Indian Head and Regina, Saskatchewan, and making 187 collections from the Manitoba locations and 104 collections from the Saskatchewan locations. The remaining 311 collections were mainly from wild barley in the prairie provinces and from susceptible varieties in experimental plots. More collections were obtained from western Saskatchewan and southern Alberta than in previous years but there were few collections from eastern Canada and British Columbia.

The Canadian rust population continued to show the wide variability observed in 1974 and 1975. Twenty-three races including five new virulence combinations were found. The virulence formulas for the new races, C66 to C70, and formulas for the other races identified (Table 3) include resistance genes *SrTt1, SrTt2, Sr24,* and *Sr26* that were not included in the previous list of formulas (2).

Although race C33 continued to predominate, as it has since 1970, there were sharp increases in the prevalence of two related races (Table 3). Race C53 which comprised only 0.3% of the 1975 isolates increased to 16.3% in 1976, and race C49 that comprised 4.8% of the 1975 isolates increased to 10.6%. Race C53 is like race C33 except that it is virulent on varieties with resistance gene *Sr17*. Race C49 also is like race C33 except that it is avirulent on *Sr11*. The most common of the new races, C66, is like race C49 except that it is virulent on resistance gene *Sr17*. Race C35 was more common than in 1975 but it was the only strain of the old race 11-32 group found in 1976. This group includes potentially dangerous virulence combinations. There was a sharp decline in the prevalence of race C25 that had shown moderate virulence on Neepawa and Manitou, the main varieties of the rust area. Fourteen other races were found rarely at scattered locations in the prairie provinces and a single isolate of race C17, the old race 56, was obtained from Ontario. Although some interesting changes seem to be taking place in the Canadian stem rust population, they do not appear to threaten the resistant varieties now grown in the rust area.

The prevalence of rye stem rust was investigated by inoculating both wheat and rye with 240 collections of rust on barley and wild barley. Ninety-six collections were, or included, rye stem rust, indicating that rye stem rust was prevalent but not nearly as prevalent as wheat

Table 4. Percent of total isolates and races avirulent on single identified resistance genes in 1976 and (1975)

Resistance gene	Avirulent isolates % 1976 (1975)	Avirulent races % 1976 (1975)
Sr5	0 (0.3)	0 (4)
Sr6	94.7 (85.8)	74 (58)
Sr7a	0.2 (3.9)	4 (23)
Sr8	4.1 (7.8)	30 (35)
Sr9a	94.4 (93.1)	65 (58)
Sr9b	93.4 (93.6)	52 (56)
Sr9d	5.2 (6.4)	26 (50)
Sr9e	6.3 (16.0)	52 (65)
Sr10	4.5 (2.7)	17 (19)
Sr11	18.3 (10.5)	48 (52)
Sr13	98.2 (97.6)	61 (81)
Sr14	0 0	0 0
Sr15	93.0 (82.5)	40 (27)
Sr17	79.7 (90.2)	57 (63)
SrTt1	2.3	35

No data for races C25 (38), C56 (38), C65 (39), C67 (38), C68 (33), C69 (113), and C70 (23) on *Sr9b* and *Sr9d*.

stem rust. The 291 collections from Klein Titan in Manitoba and Saskatchewan were identified as 12 races, and 21 races were identified from collections on wheat, barley, and wild barley. Races C44 and C56 were found only on Klein Titan at Regina, and eight rare races from the prairie provinces were not found on Klein Titan. The four main races (C33, C53, C49, and C33 *Sr11* Int.) that comprised 86.6% of the isolates were found in all four plots of Klein Titan in about the same frequency as for the total survey. Evidently collections from the plots of Klein Titan were good indicators of the prevalence of the main races, but they failed to reveal a number of rare rust strains.

The percentages of isolates and races avirulent on varieties with *Sr* genes (Table 4) has not changed much in recent years. Since 1972 there has been a slight trend to increased virulence on genes *Sr5, Sr7a, Sr8, Sr9d, Sr10, Sr11*, and *Sr17* and decreased virulence on *Sr6, Sr9a, Sr9b*, and *Sr15*. These trends are mainly due to changes in the prevalence of race C33 and related races. The main differences between 1976 and 1975 were reduced virulence on *Sr6, Sr11*, and *Sr15*, and increased virulence on *Sr9e* and *Sr17*. These changes do not affect resistant Canadian wheats or most sources of resistance used in breeding programs. Resistance genes *Sr22, Sr24, Sr26*, and *SrTt2* were effective against all rust isolates.

Essentially the same group of highly resistant varieties used in 1975 (1) were inoculated with composite collections of urediospores from all isolates. Varieties that were resistant to the inoculum were: Agatha, Bonny, C.I. 8154 X Frocor[2], D.T. 411, Era, Esp 518/9, Glenlea, Hercules, Frontana-K58-Newthatch II-50-17, Macoun, Norquay, N.D. 499, N.D. 506, (P X Mq[8])[6] X (Rsc X Etoile de Choisy), Romany, R.L. 4308, R.L. 5405, St 464, Tama, Waskana, Wakooma, and WRT 240. Varieties that segregated or had a few susceptible infections were: Chris, Kenya Farmer, Mida-McMurachy-Exchange II-47-26, R.L. 4320, Sinton, and Webster.

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The staffs at various Universities and Agriculture Canada Research Stations made much of the work reported here possible by planting and harvesting the rust nurseries and sending rust collections for race identification. Mr. J.H. Campbell carried out all technical work of the physiologic race survey and recorded rust intensities in the nurseries.

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Leaf rust of wheat in Canada in 1976[1]

D. J. Samborski

Hot dry weather on the Prairies in July and August limited rust development and there was little damage in this area from leaf rust [*Puccinia recondita*] in 1976. The leaf rust race survey was carried out with 18 single gene backcross lines for resistance as differential varieties. Genes *Lr11, Lr19* and *Lr21* were resistant to all isolates in 1976 and only a few isolates were virulent on *Lr9, Lr16* and *Lr17*.

Can. Plant Dis. Surv. 56: 123 - 125, 1976

Le temps chaud et sec qu'ont connu les Prairies en juillet et en août a restreient le développement de la rouille des feuilles (*Puccinia recondita*), limitant les dégâts causés par la maladie dans cette région en 1976. Un relevé des races de rouille a été effectué utilisant 18 lignées de blé issues de rétrocroisements à gène unique de résistance comme variétés différentielles. Les gènes *Lr11, Lr19* et *Lr21* se sont montrés réristants à tous les isolats en 1976, et seuls quelques isolats ont manifesté de la virulence sur les gènes *Lr9, Lr16* et *Lr17*.

Disease development and crop losses in western Canada

Leaf rust of wheat [*Puccinia recondita*] was first found in Manitoba on June 18. It was widespread by early July in Manitoba and eastern Saskatchewan and moderate infections developed on the bread wheat varieties Neepawa, Napayo, and Manitou. However, hot dry weather in July and August limited rust development and there was little damage from leaf rust in 1976. The new commercial variety Sinton was resistant in the field, and Glenlea was highly resistant.

Physiologic specialization

Field collections of leaf rust were established on Little Club wheat (*Triticum aestivum* L.) in the greenhouse, and one single-pustule isolate was taken from each collection. Urediospores from the remaining pustules were collected and bulked with other collections from each geographic area to give composites that were used to inoculate a group of highly resistant varieties of wheat.

A total of 264 cultures were established in 1976. Most of the collections in Manitoba, Saskatchewan, and Alberta were obtained from commercial fields of wheat varieties that do not possess any genes for seedling resistance to leaf rust.

The single-gene backcross lines listed in Table 1 have been described previously (1, 2, 3). Genes *Lr1, Lr2a, Lr2b, Lr2c, LrB, Lr3*, and *Lr11* were isolated from the eight standard leaf rust differential varieites and appear to be all the genes in these differentials that are detectable with North American isolates of leaf rust. This permits survey data from earlier studies using these differentials to be interpreted in terms of specific gene interactions.

Four exotic genes are shown in Table 1: *Lr9* (*Aegilops umbellulata*), *Lr19* (*Agropyron elongatum*), *Lr21* (*Aegilops squarrosa*) and *Lr24* (*Agropyron elongatum*). Genes *Lr9* and *Lr24* have been used in breeding programs and varieties possessing these genes are in commercial production. Cultures of leaf rust virulent on genes *Lr9* and *Lr24* have been isolated in North America and virulence on *Lr24* is especially prevalent. Gene *Lr19* is highly resistant to all isolates of leaf rust. A range of infection types were obtained on *Lr21* with different isolates of leaf rust although no compatible interactions have been observed.

All cultures of leaf rust virulent on *Lr9* isolated in Canada have the same avirulence/virulence formula (1,2a,2b,16,17,24/2c,B,3,3ka,9,10,18). This pattern is characteristic of the leaf rust population in eastern Canada. Virulence on *Lr24* occurred in cultures that were virulent on only *Lr3* of the resistance genes from the standard differential varieties (Table 2). This type of culture, previously identified as race 15, has long been characteristic of the leaf rust population in the Great Plains of North America. Most of the cultures virulent on *Lr24* were avirulent on *Lr10* but this is probably because there is at present little selection pressure in this area for virulence on *Lr10*.

Twenty-two virulence combinations on twelve genes for resistance were obtained in 1976. These virulence patterns again show three leaf rust populations in North America that are quite distinct, although some mixing does occur. In Canada, these rust populations occur in: 1) British Columbia and southern Alberta; 2) Manitoba, Saskatchewan, and northern Alberta; 3) eastern Canada including Ontario, Quebec, and the Maritime Provinces.

Composite collections of leaf rust were used to inoculate a number of highly resistant varieties of wheat. A number of single-pustule isolates were studied but all were similar to cultures already described (Table 2).

[1] *Contribution No. 778, Research Station, Agriculture Canada, Winnipeg, Manitoba R3T 2M9.*

Table 1. Virulence of isolates of *Puccinia recondita* on backcross lines containing single genes for resistance to leaf rust in Canada in 1976

Resistance genes	No. of virulent isolates from: B.C.	Alta.	Sask.	Man.	Ont. & Que.	Total no. of virulent isolates	% total isolates
Lr1	1	2	0	5	3	11	4.2
Lr2a	0	0	4	15	0	19	7.2
Lr2b	0	0	4	16	5	25	9.5
Lr2c	4	9	5	16	16	50	18.9
LrB	3	7	0	1	16	27	10.2
Lr3	2	25	86	112	23	248	93.9
Lr9	0	0	0	0	3	3	1.1
Lr10	4	29	59	73	11	176	66.7
Lr11	0	0	0	0	0	0	0
Lr14a	4	23	87	111	12	237	89.8
Lr16	0	0	1	0	0	1	0.4
Lr17	1	2	0	0	0	3	1.1
Lr18	3	7	2	7	16	35	13.3
Lr19	0	0	0	0	0	0	0
Lr21	0	0	0	0	0	0	0
Lr24	1	1	24	39	6	71	26.9
Lr3ka	0	1	0	2	12	15	5.7
LrT	0	0	1	3	8	12	4.6

Table 2. Virulence combinations of *Puccinia recondita* isolates on backcross lines containing single genes for resistance to leaf rust in Canada in 1976

Avirulence/virulence formula	No. of isolates from: B.C.	Alta.	Sask.	Man.	Ont. & Que.	Total no. of isolates
1,2a,2b,2c,B,3ka,10,16,17,18,24/3	0	2	4	5	0	11
1,2a,2b,2c,B,3ka,16,17,18,24/3,10	0	19	52	44	5	120
1,2a,2b,2c,B,3ka,10,16,17,18/3,24	1	1	24	32	3	61
1,2a,2b,2c,B,3ka,16,17,18/3,10,24	0	0	0	6	3	9
1,2a,2b,2c,B,10,16,17,18,24/3,3ka	0	0	0	0	1	1
1,2a,2b,2c,B,16,17,18,24/3,10,3ka	0	1	0	1	0	2
1,2a,2b,2c,B,3ka,17,18,24/3,10,16	0	0	1	0	0	1
1,2a,2b,2c,B,3ka,16,17,24/3,10,18	0	0	1	4	0	5
1,2a,2b,2c,B,3ka,10,16,17/3,18,24	0	0	0	1	0	1
1,2a,2b,B,3,3ka,16,17,24/2c,10,18	0	0	1	0	0	1
2a,2b,2c,B,3ka,16,17,18,24/1,3,10	0	0	0	3	0	3
1,2a,2b,3,3ka,16,17,24/2c,B,10,18	3	5	0	0	0	8
1,2a,2b,B,3ka,16,18,24/2c,3,10,17	0	2	0	0	0	2
1,2a,2b,3,3ka,16,17,24/2c,B,10,18	0	0	0	0	5	5
1,B,3ka,16,17,18,24/2a,2b,2c,3,10	0	0	4	14	0	18
2a,2b,3,3ka,16,17,24/1,2c,B,10,18	0	2	0	0	0	2
1,2a,2b,16,17,24/2c,B,3,10,18,3ka	0	0	0	0	3	3
2a,2b,3ka,B,16,18,24/1,2c,3,10,17	1	0	0	0	0	1
2a,2b,10,16,17,24/1,2c,B,3,18,3ka	0	0	0	0	3	3
1,2a,10,16,17,24/2b,2c,B,3,18,3ka	0	0	0	0	5	5
B,10,16,17,24,3ka/1,2a,2b,2c,3,18	0	0	0	1	0	1
2a,16,17,24/1,2b,2c,B,3,10,18,3ka	0	0	0	1	0	1

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Stem rust of oats in Canada in 1976[1]

J.W. Martens and R.I.H. McKenzie

Stem rust [*Puccinia graminis* f. sp. *avenae*] was first found on oats (*Avena sativa*) in Manitoba in mid July. Light infections developed throughout Manitoba and a large part of Saskatchewan, but dry weather arrested disease development and there were no crop losses except in small areas of central and eastern Manitoba and northeastern Saskatchewan. Races C10 and C23 continued to predominate in western Canada while race C9 predominated in eastern Canada. Virulence on resistance conferred by gene Pg 13 was again found in both areas of the country. Several new races were also isolated.

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On a commencé à observer la présence de rouille de la tige (*Puccinia graminis* f. sp. *avenae*) chez l'avoine (*Avena sativa*) au Manitoba, à la mi-juillet. De faibles infections se sont produites dans cette province et dans une grande partie de la Saskatchewan, mais le temps sec a stoppé l'évolution de la maladie, laquelle ne s'est traduite par aucune perte de récolte, à l'exception de régions restreintes du centre et de l'est du Manitoba et du nord-est de la Saskatchewan. Les races C10 et C23 ont continué de dominer dans l'ouest du Canada, alors que la race C9 était la plus répandue dans l'est. Elles se sont montrées virulentes à l'égard du gène de résistance Pg 13 dans les deux régions du pays. On a également isolé plusieurs nouvelles races du champignon.

Prevalence and crop losses in western Canada

Stem rust of oats (*Avena sativa* L.) caused by *Puccinia graminis* Pers. f. sp. *avenae* Eriks and E. Henn. was first observed in southern Manitoba in mid July. By mid August light infections occurred throughout Manitoba and in Saskatchewan as far west as Swift Current and north to Prince Albert, but disease development was arrested by a hot dry summer. The rust caused no crop losses except in small areas in central and eastern Manitoba and in northeastern Saskatchewan where a few fields developed moderate levels of infection and sustained some losses.

Uniform rust nurseries

Rust nurseries comprising the oat cultivars Fraser, Hudson, Rodney, and the lines C.I. 3034, C.I. 4023, C.I. 9139, R.L. 2924, R.L. 2925, R.L. 2926, and R.L. 3062 were grown at 30 locations across Canada. Trace to moderate infections of stem rust were observed at Kentville, N.S., Lennoxville and Macdonald College, Quebec; Appleton, Kemptville, Ottawa, and Thunder Bay, Ontario; and Brandon, Durban, and Morden, Manitoba. Heavy infections were observed at Sunbury, Ontario. No rust infections were observed on nurseries grown at St. John's West, Newfoundland; Charlottetown, Prince Edward Island; Truro, Nova Scotia, Fredericton, New Brunswick, La Pocatière, Normandin, and Quebec, Quebec; Guelph, New Liskeard and Vineland, Ontario; Indian Head, Melfort, and Scott, Saskatchewan; Beaverlodge, Edmonton, Lacombe, and Lethbridge, Alberta; and Agassiz and Creston, British Columbia.

Physiologic specialization

Rust isolates obtained from wild oats (*A. fatua* L.), commercial oat fields, and the uniform rust nurseries were established on the susceptible cultivar Victory and virulence combinations were determined by the infection types produced on seedlings of "Rodney O" single-gene backcross lines as indicated in Table 1. The oat line Rodney O^2 X C.I. 9139 (*Pg X*), an undetermined genotype thought to have *Pg 12* plus one or more other resistance genes, was also used as a supplementary differential. All 218 field cultures were avirulent on the *Pg X* differential. Races C10 (U.S. 31) and C23 (U.S. 61) continued to predominate in western Canada and comprised 57% and 39% of all field isolates, respectively (Table 1). This is similar to the most recently published results in the United States (3). Several uncommon races were identified and a new virulence combination, C32, was isolated from wild oats near Woodside, Manitoba. Race C31 (U.S. 77), with virulence on *Pg 13* resistance, was first found in Manitoba in a trap nursery in 1975 and was isolated from two field collections in 1976. This race has previously been reported in the United States (3). A separation of cultivars by origin (Table 1, B and C) demonstrates the bias introduced by collections from commercial cultivars with some stem rust resistance. Results from susceptible host cultures indicate that race C23 is in fact the dominant race in western Canada.

In eastern Canada, race C9 (U.S. 87) and the closely related C30 (U.S. 87) with virulence on *Pg 13* resistance, continued to predominate. The frequency of virulence on lines with single genes for resistance (Table 2) has not changed significantly from the previous year except for increased (from 8% to 20%) virulence on *Pg 13* resistance in eastern Canada. With the exception of

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Table 1. Virulence combinations of oat stem rust field isolates on backcross lines with single–gene resistance to stem rust in Canada in 1976

Designation	Avirulence/virulence formula	No. of isolates from: Ont. & Que.	Man.	Sask. & Alta.	Total isolates	Percentage of total isolates
A. Combined isolates from all hosts						
C9	8/1,2,3,4,9	9			9	4
C10	9/1,2,3,4,8	4	80	33	117	53.7
C18	2,4,8,9,/1,3		2	1	3	1.4
C23	2,4,9,13/1,3,8	3	41	37	81	37.2
C26	1,2,3,4,8,9,13/		1		1	0.5
C30	8/1,2,3,4,9,13	4			4	1.8
C31	1,2,4,8/3,9,13		2		2	0.9
C32	2,3,4,9,13/1,8		1		1	0.5
Total					218	
B. Isolates from cultivars with some stem rust resistance						
C9		6			6	6
C10		4	44	22	70	69
C18			1		1	1
C23			12	8	20	20
C30		4			4	4
Total					101	
C. Isolates from wild oats and cultivars with no stem rust resistance						
C9		3			3	2.6
C10			36	11	47	40.2
C18			1	1	2	1.7
C23		3	29	29	61	52.1
C26			1		1	0.9
C31			2		2	1.7
C32			1		1	0.9
Total					117	

Table 2. Frequency of virulence in the oat stem rust population on various types of resistance in eastern and western Canada in 1974

Source of isolates	Percentage of isolates virulent on cultivars with the following genes for resistance: *Pg 1*	*Pg 2*	*Pg 3*	*Pg 4*	*Pg 8*	*Pg 9*	*Pg 13*	*Pg (X)* (C.I. 9139)	Total no. isolates	Mean virulence capability*
East	100	85	100	85	35	65	20	0	20	4.9
West	98.5	57.1	99.0	57.1	97.0	1.0	1.0	0	198	4.1

* Mean virulence capability = No. of isolates virulent on *Pg 1+... Pg 13*/total no. of isolates.

races C9 and C30, none of the races so far identified presents a threat to the cultivar Hudson which combines resistance conferred by genes *Pg 2, Pg 4,* and *Pg 9*.

In an effort to detect the evolution of new virulence combinations in the rust population, a natural-infection trap nursery consisting of breeding material and various other genotypes has been planted at Glenlea, Manitoba, for the past 3 years. The isolates obtained (Table 3) from this material, usually by culturing small "resistant" type pustules, have been interesting both from the standpoint of detecting new virulence combinations and in terms of the races identified, relative to those isolated from "field" cultures. Even though many of the field cultures

Table 3. Virulence combinations of 1974, 1975, and 1976 oat stem rust trap nursery isolates on backcross lines with single–gene resistance to stem rust

Designation	Avirulence/rirulence formula	1974		1975		1976	
		No. of isolates	% total	No. of isolates	% total	No. of isolates	% total
C1	1,2,3,4,8/9	35	23.3	18	10.1	2	1.0
C2	1,2,4,8/3,9			6	3.4	5	2.4
C8	3,8/1,2,4,9					1	0.5
C9	8/1,2,3,4,9					4	1.9
C10	9/1,2,3,4,8	90	60.0	99	55.6	101	48.8
C19	1,2,4,8,9/3			1	0.6	5	2.4
C23	2,4,9,13/1,3,8	18	12.0	47	26.4	79	38.2
C24	1,2,8/3,4,9,13	7	4.7	3	1.7	1	0.5
C26	1,2,3,4,8,9,13/					3	1.4
C30	8/1,2,3,4,9,13					2	1.0
C31	1,2,4,8/3,9,13			4	2.2	4	1.9
Total		150		178		207	

are obtained from wild oats (no resistance) or cultivars that have no known stem rust resistance, the full range of variability present in nature is not being detected with the field collections. In 1974 only two virulence combinations were isolated from 125 Manitoba field collections (1) vs. four from the naturally-infected trap nursery at Glenlea (Table 3). In 1975 nine virulence combinations were isolated from 160 Manitoba field cultures (2) vs. seven for the trap nursery, but the latter produced four isolates of a race (C31, U.S. 77) virulent on *Pg 13* resistance and not previously found in Canada. This race was reported from Texas, Florida, and South Carolina in 1975 (3). However, the widely virulent race C14 was not found in the trap nursery but was isolated six times from field collections in 1975. In 1976 field collections produced six virulence combinations (Table 1) vs. 12 from the trap nursery.

Variability in oat stem rust appears to be increasing and changes being observed are not readily explained in terms of host population changes on the continent.

Acknowledgments

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

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Crown rust of oats in Canada in 1976[1]

D.E. Harder

Oat crown rust [*Puccinia coronata* f. sp. *avenae*] did not cause significant crop losses in western Canada in 1976. There was little increase in virulence from previous years on the cultivar Hudson. Hudson is currently the most crown rust resistant cultivar in Canada, although it is susceptible to a large number of isolates from eastern Canada. The combination of genes *Pc 38* and *Pc 39* still provides effective resistance to all crown rust isolates in Canada. Virulence combinations were determined using a set of 12 oat lines carrying substituted single genes (*Pc*) for crown rust resistance. The 280 isolates from western Canada and 94 isolates from eastern Canada comprised 37 and 22 virulence combinations respectively. There was little change from 1975 in the levels of virulence on the *Pc* genes in western Canada, but in eastern Canada there were increases in virulence on genes *Pc 45* and *Pc 56*.

Can. Plant Dis. Surv. 56: 129 - 131. 1976

En 1976, la rouille couronnée de l'avoine (*Puccinia coronata* f. sp. *avenae*) n'a pas causé de pertes de récolte significatives dans l'ouest du Canada. On n'a observé qu'un léger accroissement de virulence sur le cultivar Hudson par rapport aux années précédentes. Hudson est généralement le cultivar le plus résistant à la maladie au Canada, bien qu'il soit sensible à un grand nombre d'isolats provenant de l'est du pays. La combinaison génique Pc 38 et Pc 39 assure encore une résistance efficace à tous les isolats de rouille couronnée au pays. On a déterminé les combinaisons de virulence au moyen d'une série de 12 lignées d'avoine porteuses de gènes uniques substitués (Pc) de résistance à la maladie. Les 280 isolats provenant de l'ouest du pays et les 94 provenant de l'est comprenaient respectivement 37 et 22 combinaisons de virulence. On n'a observé que peu de changement par rapport à 1975 dans les taux de virulence à l'égard des gènes Pc dans l'Ouest, contraitement à l'Est où l'on a enregistré des accroissements de virulence sur les gènes Pc 45 et Pc 56.

Occurrence in western Canada

Oat crown rust caused by *Puccinia coronata* Cda. f. sp. *avenae* Eriks. did not cause significant losses in oat crops in most localities in 1976. Due to a dry spring infection of buckthorn (*Rhamnus cathartica* L.) was light, and general infection of oats did not occur until mid July. Continued dry weather throughout most of the growing season limited the spread of crown rust.

Physiologic specialization

All isolates of crown rust from eastern Canada were obtained from uniform rust nurseries grown at Macdonald College, Quebec City, Lennoxville, La Pocatière, and St. Anne de Bellevue, Québec; Sunbury, Ottawa, Guelph, Thunder Bay, and Appleton, Ontario. In western Canada the isolates were obtained from field surveys throughout Manitoba and eastern Saskatchewan.

In 1976 all crown rust isolates were assessed using a series of backcross lines of *Avena sativa* L. cv. Pendek carrying single genes derived from *Avena sterilis* L. The 280 isolates from western Canada and 94 isolates from eastern Canada comprised 37 and 22 virulence combinations respectively (Table 1). In western Canada there was little change from 1975 in the number of isolates avirulent on the lines with single *Pc* genes, but in eastern Canada a general increase in crown rust virulence was indicated by a relative decrease in the number of avirulent isolates in 1976 (Table 2). As in previous years (1, 2), virulence predominated on genes *Pc 35* and *Pc 40* in western Canada, and on gene *Pc 35* in eastern Canada (Table 2). In western Canada there were no large scale changes in virulence on the *Pc* genes. The origin of the virulence noted on genes *Pc 39, Pc 47, Pc 48,* and *Pc 55* is not certain. An isolate with the same virulence formula as the last one in Table 1 is at times used in greenhouse experiments, and contamination cannot be ruled out. In eastern Canada there were substantial increases in virulence on genes *Pc 45* and *Pc 56* (Table 2). If these genes are to be used in crown rust resistance breeding, they will need to be carefully combined with complementary resistance genes.

Genes *Pc 38* and *Pc 39* are currently being combined to provide crown rust resistance in the oat breeding program at Winnipeg, and to date no crown rust isolates have been found that are virulent on this gene combination. In western and eastern Canada, respectively, 10% and 28% of isolates were virulent on Hudson, which is presently the most crown rust resistance commercial oat cultivar in Canada. This level of virulence on Hudson is relatively unchanged from previous years.

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The cooperators who cared for rust nurseries and submitted rust collections from the various locations in Canada are thanked. Mr. W.L. Timlick carried out all technical operations.

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Table 1. Virulence combinations of *Puccinia coronata* on backcross lines of *Avena sativa* cv. Pendek containing single *(Pc)* genes for crown rust resistence

Virulence formula effective/ineffective Pc genes	Eastern Canada		Western Canada	
	No. of isolates	% of isolates	No. of isolates	% of isolates
35,38,39,40,45,46,47,48,50,54,55,56/	17	18.1	60	21.4
38,39,40,45,46,47,48,50,54,55,56/35	9	9.6	32	11.4
35,39,40,45,46,47,48,50,54,55,56/38	0	0	7	2.5
35,38,39,45,46,47,48,50,54,55,56/40	3	3.2	59	21.1
35,38,39,40,46,47,48,50,54,55,56/45	13	13.8	1	0.4
35,38,39,40,45,47,48,50,54,55,56/46	3	3.2	10	3.6
35,38,39,40,45,46,47,48,54,55,56/50	1	1.1	3	1.1
35,38,39,40,45,46,47,48,50,55,56/54	0	0.0	6	2.1
35,38,39,40,45,46,47,48,50,54,55/56	13	13.8	6	2.1
39,40,45,46,47,48,50,54,55,56/35,38	0	0.0	1	0.4
38,39,45,46,47,48,50,54,55,56/35,40	0	0.0	25	8.9
38,39,40,46,47,48,50,54,55,56/35,45	1	1.1	1	0.4
38,39,40,45,47,48,50,54,55,56/35,46	2	2.1	2	0.7
38,39,40,45,46,47,50,54,55,56/35,48	0	0.0	2	0.7
38,39,40,45,46,47,48,54,55,56/35,50	2	2.1	3	1.1
38,39,40,45,46,47,48,50,55,56/35,54	0	0.0	5	1.8
38,39,40,45,46,47,48,50,54,55/35,56	17	18.1	2	0.7
35,38,39,46,47,48,50,54,55,56/40,45	0	0.0	2	0.7
35,38,39,45,47,48,50,54,55,56/40,46	0	0.0	8	2.9
35,38,39,45,46,47,48,54,55,56/40,50	0	0.0	6	2.1
35,38,39,45,46,47,48,50,55,56/40,54	0	0.0	10	3.6
35,38,39,45,46,47,48,50,54,55/40,56	1	1.1	3	1.1
35,38,39,40,47,48,50,54,55,56/45,46	1	1.1	0	0.0
35,38,39,40,46,47,48,54,55,56/45,50	1	1.1	0	0.0
35,38,39,40,46,47,48,50,55,56/45,54	1	1.1	0	0.0
35,38,39,40,45,47,48,54,55,56/46,50	0	0.0	1	0.4
35,38,39,40,45,47,48,50,55,56/46,54	0	0.0	1	0.4
35,38,39,40,45,47,48,50,54,55/46,56	1	1.1	0	0.0
35,38,39,40,45,46,47,48,54,55/50,56	1	1.1	1	0.4
39,45,46,47,48,50,54,55,56/35,38,50	0	0.0	2	0.7
38,39,46,47,48,50,54,55,56/35,40,45	0	0.0	1	0.4
38,39,45,47,48,50,54,55,56/35,40,46	0	0.0	2	0.7
38,39,45,46,47,48,54,55,56/35,40,50	0	0.0	4	2.1
38,39,45,46,47,48,50,55,56/35,40,54	0	0.0	2	0.7
38,39,45,46,47,48,50,54,55/35,40,56	1	1.1	1	0.4
38,39,40,46,47,48,54,55,56/35,45,50	1	1.1	0	0.0
38,39,40,46,47,48,50,54,55/35,45,56	2	2.1	0	0.0
38,39,40,45,47,48,54,55,56/35,46,50	0	0.0	1	0.4
38,39,40,45,47,48,50,54,55/35,46,56	1	1.1	0	0.0
38,39,40,45,46,47,48,55,56/35,50,54	0	0.0	2	0.7
38,39,40,45,46,47,48,54,55/35,50,56	2	2.1	0	0.0
35,38,39,45,46,47,48,54,55/40,50,56	0	0.0	1	0.4
35,38,39,45,46,47,48,50,55/40,54,56	0	0.0	2	0.7
35,38,39,47,48,54,55,56/40,45,46,50	0	0.0	1	0.4
35,38,50,56/39,40,45,46,47,48,54,55	0	0.0	1	0.4
Total	94		280	

Table 2. Distribution of virulence of isolates of *Puccinia coronata* in 1976 on backcross lines carrying single crown rust resistance genes

Resistance genes	Eastern Canada		Western Canada	
	No. of virulent isolates	% of isolates	No. of virulent isolates	% of isolates
Pc 35	38	40.4	90	32.1
Pc 38	0	0.0	10	3.6
Pc 39	0	0.0	2	0.7
Pc 40	5	5.3	133	47.5
Pc 45	20	21.3	8	2.6
Pc 46	8	8.5	28	10.0
Pc 47	0	0.0	2	0.7
Pc 48	0	0.0	4	1.4
Pc 50	8	8.5	25	8.9
Pc 54	1	1.1	30	10.7
Pc 55	0	0.0	2	0.7
Pc 56	39	41.5	15	5.4

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Recommandations aux auteurs

Les articles et les communiqués sont publiés en anglais ou en français. Les manuscrits (l'original et une copie) et toute le correspondance qui s'y rapporte doivent être envoyées au Rédacteur M. W. L. Seaman, à la Station de recherches d'Ottawa, ministère de l'Agriculture du Canada, Ottawa (Ontario) K1A 0C6.

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

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

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

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

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

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

Instructions to authors

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

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

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