Occurrence of a highly virulent strain of blackleg (Leptosphaeria maculans) on rape in Saskatchewan (1975-77)[1]

G.A. *Petrie*

A highly virulent form of the blackleg fungus, ***Leptosphaevia maculans,*** was found in 10 rapeseed fields in east-central Saskatchewan in 1976 and in 16 fields in 1977. These represented 10% and 17% of fields surveyed, respectively. A number of heavy infections occurred in the Melfort-Star City area. The estimated yield loss in one field as a result of basal stem canker alone was 20%. Severe blackleg occurred only where rape residues from the previous year bearing ascocarps of L. ***maculans*** were present in an adjacent field or in the same field. The virulent strain was isolated more frequently from dark-colored lesions on stubble than from those light in color.

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Une forme tres virulente du champignon de la jambe noire, ***Leptosphaeria maculans,*** a ete constatee dans dix champs de colza du centre-est de la Saskatchewan en 1976 et dans seize champs en 1977, soit respectivement 10 et 17% des champs visités. Plusieurs fortes infestations se sont produites dans la region de Melfort-Star City. Dans un champ, les pertes de rendement dues au seul chancre de la tige ont ete evaluees a 20%. Des symptômes graves de jambe noire n'ont ete observes que lorsqu'il y avait des residus de culture de ***Brassica*** dans le même champ ou dans un champ voisin. La souche virulente a ete isolée plus fréquemment sur les lesions de couleur foncee que sur celles de couleur pâle.

Two strains of ***Leptosphaeria maculans*** (Desm.) Ces. & de Not. [imperfect state, ***Phoma lingam*** (Tode ex **Fr.)** Desm.] occur widely on ***Brassica*** spp., one considerably more virulent than the other. Recently, severe outbreaks of the virulent type have occurred in Australia on rape ***(Brassica napus*** **L.)** and turnip rape ***(B. campestris*** **L.)** cultivars of Canadian origin (1, 4) and in the United States on cabbage (2). In Western Canada blackleg has been of minor importance for many years, as strains of relatively low virulence occurred sporadically on cruciferous weeds, rape and mustards (6, 7). However, in 1975 a virulent strain identical to that occurring in parts of the United States and similar to the one found in Australia was isolated from rape stubble from two fields in east-central Saskatchewan (5). In light of the Australian experience, its discovery in the heart of the rape-growing area is viewed as a potentially serious threat to Canadian rape production. This paper describes the results of blackleg surveys made in 1976 and 1977, and discusses possible control measures.

Methods

Stubble fields of rape and mustard were sampled in the fall or early spring. The spring, 1976, survey took in areas not covered the preceding fall (5). In 1977, the survey of that year s crop was begun in mid-July. On the basis of the extensive survey conducted in the fall of 1975 (5) and earlier surveys, the area receiving closest attention consisted of Saskatchewan crop districts ***8*** and 6. The incidence of blackleg in each field was rated "nil", "slight", "moderate" or "heavy" and notes were taken on severity of infection. The incidence ratings corresponded to 0, trace-9%, 10-39%, and 40% or more of the plants infected, respectively. In many instances, samples consisting of 20-25 plants each were pulled at intervals of 25 paces along a diagonal across the field. Material collected at several sites per field was retained for purposes of isolation, for the virulent and avirulent strains cannot be distinguished in the field on the basis of symptom type.

A 0.5 x 1 cm piece was excised from the lesioned part of each stem; pieces were plated after surface sterilization as previously described (6). Preliminary experiments had shown that two types of lesion consistently yielded *L.* ***maculans,*** whitish lesions bearing numerous pycnidia and slate-grey to black areas bearing relatively few inconspicuous pycnidia. Where both lesion types were abundant in a field, they were segregated and plated separately. In 1977, the sources of several heavy infections noted around Star City were sought by examining surrounding fields for evidence of rape residues. Samples of residues were removed to the laboratory and checked periodically for sporulation in ascospore liberation tunnels using a method similar to that of McGee (3).

Whenever isolations were made, identity as to strain was determined by cultural studies (5) and pathogenicity tests. In the latter, seeds of ***B. napus*** cv. Midas were

[1] ***Contribution No. 694, Research Station, Agriculture Canada, Saskatoon, Saskatchewan, S7N 0X2.***
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Table 1. Results of blackleg surveys conducted in northeastern Saskatchewan, 1976-77

Time surveys conducted	No. of fields entered	Total blackleg incidence				Virulent strain"	
		% of fields with infections rated				% of fields infected	% of fields rated Mod-Heavy
		Nil	Slight	Moderate	Heavy		
Spring 1976	35	8.6	51.4	28.6	11.4	2.9	0.0
Fall, 1976 and Spring, 1977	76	4.0	61.9	26.3	7.9	11.8	1.3
Midsummer, 1977	92	71.7	17.4	4.4	6.5	17.4	6.5

"Presence confirmed following isolation.

Table 2. Amount of blackleg infection in representative fields rated ''slight'' "moderate" and "heavy"

Field no.	Field rating	% of stems infected by *L.* rnaculans	%of sampling" sites having *L.* maculans	Range of infected stems at different sites (%)
61	slight	1.3	20.0	0.0 - 10.0
69	moderate	21.0	80.0	0.0 - 50.0
74	heavy	55.6	100.0	33.3 - 73.1

*As a rule, 20 to 25 stems were pulled at each of 10 sampling sites.

inoculated with a conidial suspension and sown in vermiculite. Ten to 14 days following seedling emergence, isolates were classified on the basis of virulence and symptom type (8). For convenience, the virulent strain will hereafter be referred to as the "Wisconsin" (W) strain and the weakly virulent type, as the "Puget Sound" (PS) strain (8).

Results

A total of 203 fields were surveyed; blackleg occurred in 94.5% of the 1975-76 fields and in 28.3% of the 1977 fields (Table 1). However there was an increase in percentage of fields having the virulent strain. Forty percent of the 1975 fields rated "moderate" or "heavy", as did 34% of the 1976 fields and 11% of 1977 fields. Examples of levels of infection typified by the ratings "slight", "moderate" and "heavy" may be seen in Table 2, as may an indication of disease distribution within fields. In 1975 and 1976, the most heavily infected fields occurred near Humboldt, Lake Lenore, Cudworth, Vonda, St. Benedict, Waldheim, and Saskatoon. Most of the symptoms resulted from late season infection by the PS strain. In midsummer, 1977, several severely diseased fields were located around Star City in northeastern Saskatchewan. These had obviously been infected considerably earlier by a much more virulent strain

The virulent W strain was detected in 11 of the 111 1975-76 fields (10%) when isolations were made (Table 3). It was present in from 1.0% to 94.5% of the stems from which L. *maculans* was isolated. In the field near Star City from which over 94% of the blackleg infections consisted of the virulent strain, the incidence rating was "moderate". This strain, although well distributed throughout some fields, was only found in others at a single sampling site, as in field 81 (Table 3). In 1977, the W strain occurred in 16, or 17.4%, of the fields and accounted for six of the 10 in which the blackleg incidence was "moderate" or higher (Table 1). All of the fields having high levels of the W type were located in the Melfort-Star City area (Table 4). These were the only fields entered during the two-year period in which ratings for severity in addition to incidence were high. In field 138 near Naisberry, 100% of the plants were infected in the portion of the field sampled. All infections had been caused by the W strain. A field 1 km south of no. 138 had only a trace of infection. Another, no. 148, located close to 1976 field 109, had been seeded on stubble infected by the W strain. In this field severe basal cankers were common and often accompanied by severing of the upper taproot. When the method of McGee and Emmett (4) was used to calculate loss in yield, a minimum loss figure of 20% was obtained for field 148. In no other field was basal cankering this severe.

Table 3. Results of isolations of L. ***maculans*** from ***Brassica*** stubble from Saskatchewan rape fields **(1976)** in which the virulent strain was found

Field no.	Location	No. stems yielding *L. rnaculans*	% of blackleg-infected stems yielding W strain"	% of blackleg-infected stems yielding PS strain"*
23	Rosthern	50	2.0	98.0
78	Humboldt	101	1.0	99.0
81	Marysburg site 1	102	0.0	100.0
	Marysburg site 2	31	0.0	100.0
	Marysburg site 3	233	34.8	65.0
81E	Marysburg	59	27.1	74.6
87	Lake Lenore	241	12.9	87.1
104	Melfort	11	18.2	81.8
105	Melfort	46	6.5	93.5
107	Star City	47	23.4	78.7
108	Star City	80	2.5	97.5
109	Star City	91	94.5	8.8
112	Tarnopol	3	33.3	66.7

"The virulent "Wisconsin" strain.
*"The weakly virulent "Puget Sound" strain

Table **4.** Occurrence of the virulent W strain of L. ***maculans*** in Saskatchewan rape fields sampled in **1977**

Field	Location	Incidence	Severity
138	Naisberry	heavy (100%)	moderate-severe
139	Naisberry	slight	slight
141	Star City	slight	slight
142	Star City	slight	slight
145	Star City	moderate	moderate
146	Star City	heavy	moderate
147	Star City	slight	slight
148	Star City 5W	heavy	severe
176	Star City	heavy	severe
177	Star City	heavy	severe
151	Wakaw 12E	slight	mod-severe premature ripening
154	Tarnopol	slight	mod-severe premature ripening
155	Tarnopol 10N	slight	slight
158	Meskanaw	moderate	moderate
169	Brooksby 12N	slight	slight-moderate
204	Vonda	moderate	slight-moderate

In almost every instance in which **1977** fields had ratings of "moderate" or higher, rape residues bearing ascocarps of the W strain were found in an adjacent field, or in the same field in the case of no **148.** Although the material was often partially covered by soil as a result of frequent rains, ascospore discharge occurred when samples were tested in the laboratory. Discharge was particularly abundant in the case of the material collected adjacent to field **138.** Invariably barley was the **1977** crop under which the rape residues were located. Infection in many of the rape fields was uniform and heavy close to the source of inoculum, with frequently a rather sharp line of demarcation setting off the less heavily diseased remainder of the field. One example was field **177** which lay north of the inoculum source, a large barley field. A large, yellowed, semicircular zone several meters across, in which the loss was estimated at 50%, lay adjacent to the barley; other large yellow patches could be seen throughout the field. In field **176,** 2 km north of no. **177,** infection occurred in small patches up to 1 m across, in which 50% or more of the plants were severely diseased or dead. It appeared that the primary inoculum source was again the barley field south of field **177.** The patches apparently resulted from secondary infection by rain-splashed conidia. Another heavily infected field **(1**46) lay across the road to the east of the same barley field. Spores from residues in the latter were therefore responsible for severe infection in at least three **1977** fields.

Table 5. Recovery of the virulent "W" strain and weakly virulent "PS" strain of ***Leptosphaeria maculans*** from light- and dark-colored stem lesions from four rape fields

Field no.	Rep. no	Stem lesion color	No. of stems yielding *L. maculans*	% of stems yielding W strain	% of stems yielding PS strain
81E		"Dark"	16	81.3	25.0
		"Light"	16	6.3	93.8
		mixed"	27	7.4	92.6
87	1	"Dark"	22	31.8	68.2
	2	"Dark"	21	38.1	61.9
	1	"Light"	15	6.7	93.3
	2	"Light"	25	8.0	92.0
	1	mixed*	23	43.5	56.5
2	2	mixed*	135	3.0	97.0
86		"Dark"	85	0.0	100.0
		"Light"	46	0.0	100.0
130		"Dark"	54	0.0	100.0
		"Light"	49	0.0	100.0

"Isolations from bulk sample without regard to lesion color.

Fields lightly infected by the W strain were scattered between Saskatoon and the Melfort area (Table 4). In the Wakaw and Meskanaw fields, blackleg-infected and footrot-infected* plants had completely ripened off well in advance of the remainder of the crop. Premature ripening to this degree was much less common in the Star City area, probably due to more moist conditions in the northeast. The well-developed center of virulent blackleg infection observed in the Lake Lenore-Marysbury area in **1976** had all but disappeared in **1977.** Indeed, there was very little blackleg in this area in August, probably due once again to conditions being relatively dry.

In **1977,** rape had been seeded adjacent to both of the **1975** fields in which the virulent strain was found initially (5). In both instances, however, no blackleg was detected in **1977.** Both of the original fields were cropped to cereals in **1976;** one was fallowed in **1977** and the other was again in cereal.

In June and July, lesions caused by the W strain were invariably light in color and bore conspicuous pycnidia. By fall, both light and dark-colored lesions occurred on stubble. When isolations were made from both lesion types from stubble collected in late **1976** and early **1977** it was found that the W strain was associated much more frequently with dark-colored lesions (Table 5). The PS strain, in the absence of the other, occurred in both types of lesion. Almost without exception, the two strains did not occur at the same site on a stem (Tables **3** and **5).** Samples yielding the W strain almost never yielded the PS strain as well. By late **1977,** all the **1976** material incubated out-of-doors had become dark in color and bore ascocarps of L. ***maculans.***

* ***Footrot is caused by Rhizoctonia sp. and Fusarium spp.***

Discussion

In recent years, blackleg has been prevalent on rape by late fall throughout central Saskatchewan. In a considerable proportion of infected stubble fields incidence has also been high. Most of this reflects late development of the weakly virulent strain. Incidence of this strain recorded in late fall has increased sharply since the **1963-67** period **(7).** The lower values reported for **1977** are no doubt due to the survey having been largely completed by late August, rather than late October as was previously the case. The **1977** data may be compared to those from the **1970-72** period (6). An increase in prevalence and incidence is indicated here as well, due in part to the recent appearance of the virulent strain.

Plentiful blackleg infections of a severity not seen in Western Canada prior to **1976** were consistently associated with the Occurrence nearby of abundant rape residues bearing ascocarps of the virulent strain. McGee and Emmett (4) reported that crop failures due to blackleg in Australia were directly associated with the occurrence of infected residues in adjacent fields or in the same fields. In northeastern Saskatchewan incidence of infection often decreased markedly when one travelled a short distance from an inoculum source. In a few cases this decrease appeared to be influenced by the occurrence of shelter belts between an inoculum source and a field.

Dry conditions in areas in which an abundance of inoculum should have been present appeared to be the factor responsible for the virtual disappearance of a few well-established pockets of infection. Original sources of

inoculum also appeared ineffective after 2 years of non-host crops.

By late fall the virulent strain was much more frequently associated with dark-colored than with light-colored stem lesions. This was not true of the PS strain. Ascocarps of L. maculans form following blackening of stem tissues. As the perfect state of the W strain develops much earlier in the season than does that of the PS strain (unpublished data) blackening of tissues would be expected to proceed more rapidly in the case of the W strain.

Until other control measures are available, management practices will be the key to holding the disease in check. Fields only a relatively short distance from infected trash of the preceding crop had considerably less blackleg than those adjacent to source of ascospore inoculum. Burial of infected residues is an effective means of reducing this inoculum (unpublished data). Seed treatment with an appropriate fungicide can reduce spread into uninfected areas. The extent of the occurrence of the W strain in seed is under investigation. Sources of resistance have been identified (5); it remains to incorporate these into agronomically suitable cultivars. Vigilance and attention to control measures on the part of the growers and a major research effort on the part of scientists will be required to contain the potential destructiveness of the virulent strain of blackleg.

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Literature cited

1. Bokor, A., M. J. Barbetti, A. G. P. Brown, G. C. Mac Nish, and P. McR. Wood. 1975. Blackleg of rapeseed. J. Agric. West. Austr. 16: 7-10.
2. Gabrielson, R. L., M. W. Mulanax, K. Matsuoka, P. H. Williams, G. P. Whiteaker, and J. D. Maguire. 1977. Fungicidal eradication of seedborne *fhoma lingam* of crucifers. Plant Dis. Rep. 61: 118-121.
3. McGee, D. C. 1977. Black leg *(Leptosphaeria maculans* (Desm.) Ces et de Not.) of rapeseed in Victoria: Sources of infection and relationships between inoculum, environmental factors and disease severity. Austr. J. Agric. Res. 28: 53-62.
4. McGee, D. C., and R. W. Emmett. 1977. Black leg *[Leptosphaeria maculans* (Desm.) Ces. et de Not.] of rapeseed in Victoria: Crop losses and factors which affect disease severity. Austr. J. Agric. Res. 28: 47-51.
5. McGee, D. C., and G. A. Petrie. 1978. Variability of *Leptosphaeria maculans* in relation to blackleg of rapeseed. Phytopathology, 68: in press.
6. Petrie, G. A. 1973. Herbicide damage and infection of rape by the blackleg fungus, *Leptosphaeria maculans.* Can. Plant Dis. Surv. 53: 26-28.
7. Petrie, G. A., and T. C. Vanterpool. 1968. Diseases of crucifers in Saskatchewan in 1967. Can. Plant Dis. Surv. 48: 25-27.
8. Pound, G. S. 1947. Variability in *fhoma lingam.* J. Agric. Res. 75: 113-133.