Canadian Plant Disease Survey

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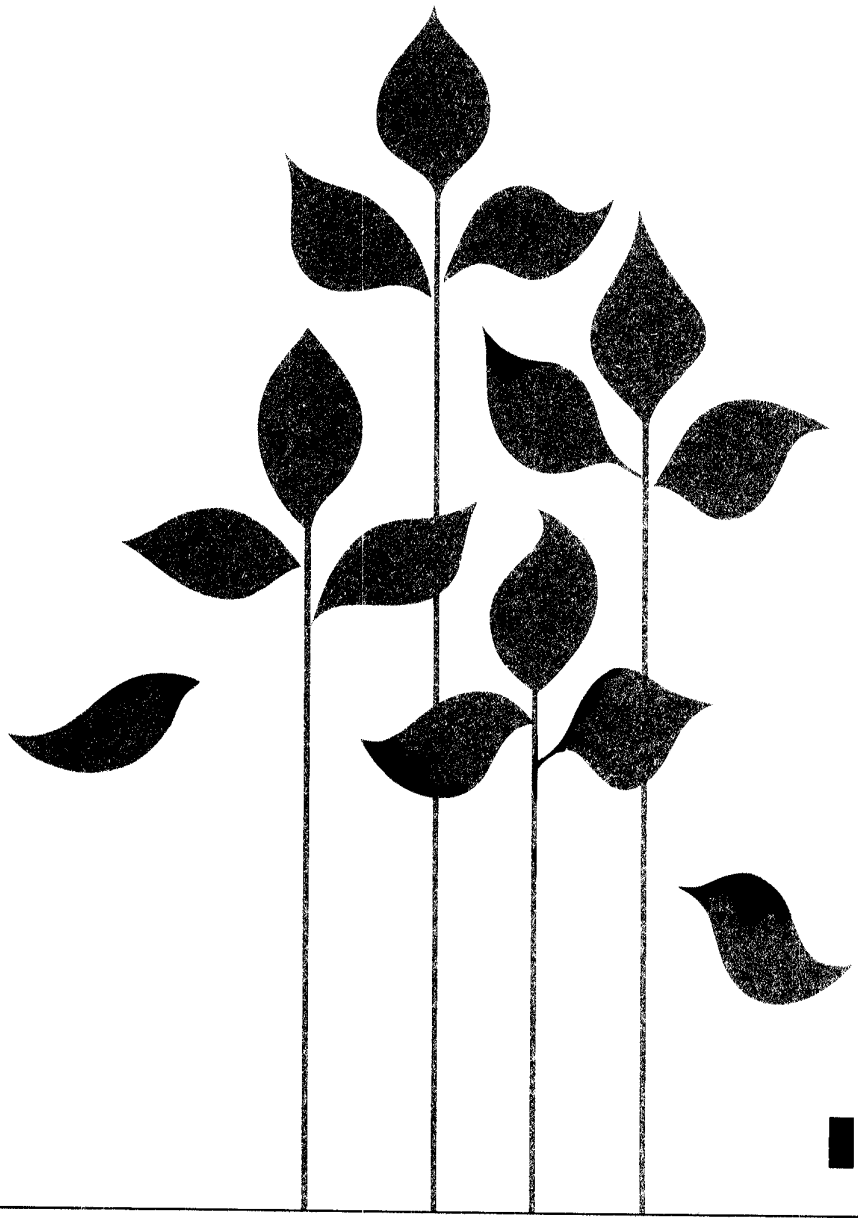

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Canadian Plant Disease Survey

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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 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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Cooperative seed treatment trials - 1975[1]

J.T. Mills

Twenty-four seed treatment chemicals were tested at two locations for their efficacy in controlling bunt of wheat [*Tilletia caries* and *T. foetida*], covered smut of oats [*Ustilago kolleri*], and covered smut of barley [*U. hordei*] and for their effects on the emergence of flax. Smut infection of untreated seed was low with the exception of 25% bunt at Brandon. Vitaflo 280 and 18 other treatments gave significantly reduced levels of bunt and of oat and barley smut at both stations. Flax emergence was significantly increased after treatment with CFG 3000. Bay-meb 6447 at the 5.00 and 10.00 g/kg and 26019 RP at the 1.50 g/kg rate reduced flax emergence.

Can. Plant Dis. Surv. 55:117-120. 1975

On a évalué à deux endroits différents l'efficacité de 24 produits de traitement des semences contre la carie du blé (*Tilletia caries* et *T. foetida*) et les charbons couverts de l'avoine (*Ustilago kolleri*) et de l'orge (*U. hordei*), ainsi que l'effet de ces produits sur la levée du lin. Les semences non traitées ont peu souffert du charbon, mais à Brandon 25% ont été attaquées par la carie. Le Vitaflo 280 et 18 autres traitements ont significativement réduit la fréquence de la carie et des charbons de l'avoine et de l'orge aux deux stations. Le traitement au CFG 3000 a fortement augmenté le taux de levée du lin, mais l'application de Bay-meb 6447 aux taux recommandés de 5.00 et 10.00 g/kg ou de 26019 RP à 1.50 g/kg l'a réduit.

In 1975, 24 seed treatment chemicals were tested for their efficacy in controlling common bunt of wheat [*Tilletia foetida* (Wallr.) Liro and *T. caries* (DC.) Tul.], covered smut of oats [*Ustilago kolleri* Wille], and covered smut of barley [*U. hordei* (Pers.) Lagerh.] and for their effects on the emergence of flax under Manitoba conditions.

Materials and methods

The chemical composition, where available, and the product name and source of the materials used are listed in Table 1. 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. 'Raja' flax (*Linum usitatissimum* L.) was used for emergence tests.

Prior to chemical treatment the cereals were inoculated with the appropriate dry smut spores at the rate of 1 g per 200 g of wheat, oats, or barley seed. 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 4 weeks before seeding.

Tests were carried out at Brandon and duplicated at Morden, Manitoba. There were four replicates 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. Emergence of flax was recorded 3-4 weeks after seeding.

At Brandon, wheat and oats were sown on May 12 and May 26 respectively and barley and flax on May 27; at Morden wheat and oats were sown on May 15 and May 22, and barley and flax on May 28.

The number of smutted heads in each row was recorded after the crop had headed and are expressed as means of the number of heads in the untreated rows. The results are given as means of four replicates, at each planting site. The "LSD-05" was determined from the means of the treatments at each station.

Results and discussion

Smut infection of untreated seed varied from 3% to 25% for wheat, from 4% to 8% for oats, and from 1% to 3% for barley.

The comparison standard Vitaflo 280 and 18 other treatments gave significantly reduced levels of bunt, and of oat and barley smut at both stations.

Phytotoxicity was observed on wheat at both stations after treatment with Bay-meb 6447 at the 5.00 and 10.00 g/kg rates.

Emergence of untreated flax varied from 48% to 59% (Table 2). Flax emergence was significantly increased

[1] *Contribution No. 684, Research Station, Agriculture Canada, Winnipeg, Manitoba R3T 2M9.*

with CFG 3000 at Morden and Brandon. Bay-meb 6447 at the 5.00 and 10.00 g/kg rates and 26019 RP at the 1.50 g/kg rate significantly reduced emergence at both stations.

Acknowledgments
The writer thanks members of the staff of the Morden and Brandon Research Stations for their cooperation and assistance.

Table 1. Seed treatment materials used in the cooperative tests

Treatment no.	Source*	Product name	Active ingredient
1		Untreated check	
2	Chemagro	Bay-meb 6447	1-(4-chlorophenoxy)-3,3-dimethyl-1(1H-1,2,4-triazol-1-yl)-2-butanone (25%)
3	Chipman	TF 3262	pyracarbolid 10% + maneb 16.7%
4	Chipman	TF 3309	maneb 25.0%
5	Ciba-Geigy	CFG 2980	identity not available
6	Ciba-Geigy	CFG 2990	identity not available
7	Ciba-Geigy	CFG 3000	identity not available
8	Ciba-Geigy	CFG 3010	identity not available
9	DuPont	DPX 12	identity not available
10	DuPont	DPX 14	identity not available
11	Interprovincial	Busan 25D	2-(thiocyanomethylthio) benzothiazole (25%)
12	Interprovincial	Busan 30L	2-(thiocyanomethylthio) benzothiazole (30%)
13	Interprovincial	BL 1794-30	identity not available
14	May & Baker	26019 RP	(1-(isopropylcarbamoyl)-3-(3,5-dichlorophenyl hydantoin)
15	Merck	Me 125	identity not available
16	Nor-Am	SN 43493	identity not available
17	Nor-Am	SN 49183	identity not available
18	Rohm & Haas	RHC 366	identity not available
19	Uniroyal	Vitaflo 280	Vitavax (carbathiin) 14.9% + thiram 13.2%
20	Uniroyal	UBI 2067	identity not available
21	Uniroyal	UBI 2078	identity not available
22	Uniroyal	UBI 2079	identity not available
23	Uniroyal	UBI 2080	identity not available
24	Uniroyal	UBI 2083	identity not available
25	Uniroyal	UBI 2085	identity not available
26		Untreated check	

*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; Interprovincial Cooperatives Ltd., Winnipeg, Manitoba; May & Baker (Canada) Ltd., Montréal, Québec; Merck Sharp and Dohme, Rahway, New Jersey; 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 and emergence of flax

Treatment no.	Product name	Formulation*	Dosage (g or ml/kg)	Mean no. smutted heads† Wheat B**	Wheat M**	Oats B**	Oats M**	Barley B**	Barley M**	Emergence†† Flax B**	Flax M**
1	Untreated check			38.75	10.25	20.50	15.25	14.25	1.00	101.00	111.25
2	Bay-meb 6447	WP	5.00	0	0	0	0	0	0	72.75	82.25
			10.00	0	0	0	0	0	0	51.25	69.50
3	TF 3262	SL	1.04	0.25	0.75						
			4.12			0	0				
			2.92					0	0		
4	TF 3309	SL	1.73	0	0						
			4.50			0.75	0				
			3.22					0	0		

Table 2 (Cont'd)

Treatment no.	Product name	Formulation*	Dosage (g or ml/kg)	Mean no. smutted heads† Wheat B**	Wheat M**	Oats B**	Oats M**	Barley B**	Barley M**	Emergence†† Flax B**	Flax M**
5	CFG 2980	WP	2.08	1.25	0						
			3.67			0	0.75				
			2.60					0	0		
			4.46							117.75	146.75
6	CFG 2990	WP	2.08	1.00	0						
			3.67			1.75	0.75				
			2.60					0.75	1.75		
			4.46							112.25	122.25
7	CFG 3000	WP	2.08	1.75	0						
			3.67			1.00	1.50				
			2.60					0	0		
			4.46							130.00	143.75
8	CFG 3010	WP	2.08	1.50	0						
			3.67			0	0.50				
			2.60					0	0		
			4.46							110.75	113.00
9	DPX 12	WP	2.08	0	0						
			3.70			0	0				
			2.60					0	0		
			2.25							111.00	112.75
10	DPX 14	WP	2.08	0	0.75						
			3.70			0	0				
			2.60					0	0		
			2.25							116.25	124.75
11	Busan 25D	D	2.10	2.00	1.50						
			3.67			0	0.50				
			2.60					0	0		
			4.45							112.50	125.00
12	Busan 30L	SN	0.80	0.25	0.50						
			1.37			0	0.50				
			0.97					0.25	0		
			0.83							101.75	112.50
			1.10							102.25	109.00
13	BL 1794-30	SN	1.56	1.50	0.25						
			2.34	2.25	1.00						
			2.75			1.00	0.75				
			4.13			0.25	0				
			1.95					1.50	0		
			2.92					0	0		
			1.67							70.75	105.25
			2.79							82.50	111.00
14	26019 RP	WP	1.50	0	0					78.50	100.00
			2.00	0	0					80.25	98.00
15	Me 125	SN	0.66	11.00	1.75	9.50	13.50	8.00	2.75	80.00	104.00
			1.32	17.75	2.50	16.00	10.75	10.25	6.50	80.25	99.25
16	SN 43493	WP	2.10	0	0						
			3.90			3.00	2.25				
			2.30					6.50	1.50	104.00	116.00
17	SN 49183	WP	2.10	0	1.50						
			3.90			0.75	1.75				
			2.30					0	0	119.50	137.50
18	RHC 366	SL	0.52	0.25	0.50						
			1.04	0	0						
			2.08	0	0						
			0.92			4.00	7.75				
			1.84			0.50	4.75				
			3.68			0	0.25				
			0.66					0	0.25		
			1.31					0	0		
			2.62					0	0		
			1.12							102.00	123.25
			2.24							119.75	123.75

Table 2 (cont'd)

Treatment no.	Product name	Formulation*	Dosage (g or ml/kg)	Mean no. smutted heads† Wheat B**	Wheat M**	Oats B**	Oats M**	Barley B**	Barley M**	Emergence†† Flax B**	Flax M**
			4.48							120.50	128.25
19	Vitaflo 280	SL	1.82	0	1.00						
			3.22			0.25	0				
			2.28					0	0		
			3.90							106.50	122.50
20	UBI 2067	WP	2.75			0	0				
			1.95					0	0		
21	UBI 2078	SL	1.56	0	0						
			2.76			0	0				
			1.95					0	0		
			3.34							114.75	104.00
22	UBI 2079	SL	1.39	2.00	2.75						
			2.45			0	0.50				
			1.73					0	0		
			2.79							94.25	109.75
23	UBI 2080	SL	0.72	1.50	1.00						
			1.27			0	0				
			0.90					0	0		
			1.54							105.50	115.50
24	UBI 2083	SL	1.82	0.50	1.00						
			3.22			0	0				
			2.28					0	0		
			3.90							104.75	109.00
25	UBI 2085	SL	3.22			0	0.25				
			2.28					0	0		
26	Untreated check			46.75	12.25	16.25	18.00	10.25	2.75	97.00	118.75
LSD (0.05)				7.76	2.83	4.42	3.63	3.91	1.65	22.81	15.26
Mean no. of heads				187	447	237	357	468	557		

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

**B = Brandon
M = Morden

†% smut = $\frac{\text{mean no. smutted heads}}{\text{mean no. of heads}}$ X 100

††Flax emergence based on mean of 4 reps each having 200 seeds planted.

Prevalence of alfalfa crown and root diseases in the Peace River Region of Alberta and British Columbia[1]

J.S. McKenzie and J.G.N. Davidson

Following the 1973-74 winter, numerous alfalfa fields showed severe injury in the Peace River Region of Alberta and British Columbia. A survey of root and crown diseases was conducted in 40 2nd-year or older alfalfa (*Medicago sativa*) fields. The root/crown rot complex was divided into four principal types of symptoms: root rot, internal crown rot, external crown rot, and winter crown rot. Moderate or severe root rot occurred in 68% of the fields observed in the northern part of the region in Alberta, whereas in the remaining area only 24% of the fields had just a trace amount of root rot. Internal crown rot was prevalent throughout the survey area. External crown rot and winter crown rot were of minor significance. Twelve percent of the fields observed had no disease symptoms, 55% had only one type of symptom, and 33% had more than one.

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Un grand nombre de champs de luzerne de la région de la rivière de la Paix, en Alberta et en Colombie-Britannique, ont gravement souffert de l'hiver 1973-1974. On a conduit un relevé des types de pourridiés dans 40 luzernières (*Medicago sativa*) de deux ans ou plus. On a ainsi pu définir quatre types de pourridié selon les symptômes notés: le pourridié des racines, le pourridié interne du collet, le pourridié externe du collet et le pourridié hivernal du collet. Dans le nord de la région, en Alberta, 68% des champs examinés étaient gravement ou moyennement atteints du pourridié des racines alors que 24% des champs restants seulement ne manifestaient qu'un taux d'infestation négligeable. Le type le plus fréquent de pourridié dans toute la région est le pourridié interne du collet. Le pourridié externe du collet et le pourridié hivernal sont relativement rares. Sur les champs examinés, 12% n'en présentaient pas de symptômes, 55% n'en présentaient qu'un cas et 33%, plus d'un.

Extensive damage to perennial grasses and legumes occurred during the 1973-74 winter in the Peace River Region of Albert and British Columbia. This winter was characterized by unusually deep and prolonged snow cover. Severe injury has also been reported following the winters of 1955-56 (8), 1926-27 (2) and 1922-23 (1).

With the recent opening of five dehydration plants in this region, alfalfa(*Medicago sativa* L.) production has gained increasing importance. However, yields have been less than 1 ton per acre in some areas and an unsatisfactory level of winter survival has created additional difficulties for many growers. Hence a project was initiated to assess the extent and causes of poor winter survival and low yields in this region.

Diseases and injuries affecting the overwintering of alfalfa have been recently reviewed by Graham et al. (11), Jung and Larson (17), Kehr et al. (18), Leath et al. (19), Bolton (4), and Heinrichs (15). It has become increasingly apparent that crown rot and root deterioration is a product of an interaction of multiple factors of both the physical and biological environments. Knowledge of the pathogens and environmental factors involved is far from complete and symptoms produced by different causes overlap (19). Moreover, this problem has not been previously investigated in this region and very seldom north of the 55th parallel (25). We therefore decided to assess and describe the types of symptoms, to determine the causal factors involved, and finally to arrive at solutions to minimize occurrence. This paper documents the first phase of this project, to identify the major types of damage occurring on alfalfa in the Peace River Region, as found in surveys of 40 2nd-year or older fields in 1974.

An attempt was made to determine major regional differences in frequency of symptom types. A strictly quantitative survey was not attempted. Twenty-eight alfalfa fields were surveyed throughout the region between June 16 and June 23, 1974. Seven fields were surveyed in the Beaverlodge area on May 23, and 5 fields in the Dawson Creek and Fort St. John area on August 15. Sampling was started 8–15 m (25–50 feet) from the edge of each field, and several plants were dug at each of 5 to 10 locations throughout the field. Except in the case of small patches of winter crown rot, above-ground conditions were not factors in choosing location. Roots and crowns were sliced vertically to show the type and severity of injury. Each field was rated as nil, trace, moderate, or severe for each disease symptom. The index was a qualitative evaluation of the total field sample. Fields tended to fall into one of four clear-cut groups with very little intergradation. Nil indicated that symptoms were not present. Trace indicated that early symptoms were present. Moderate indicated that some symptoms were well developed but either occurred

[1] *Contribution No. NRG 75-17, Agriculture Canada, Research Station, Beaverlodge, Alberta T0H 0C0*

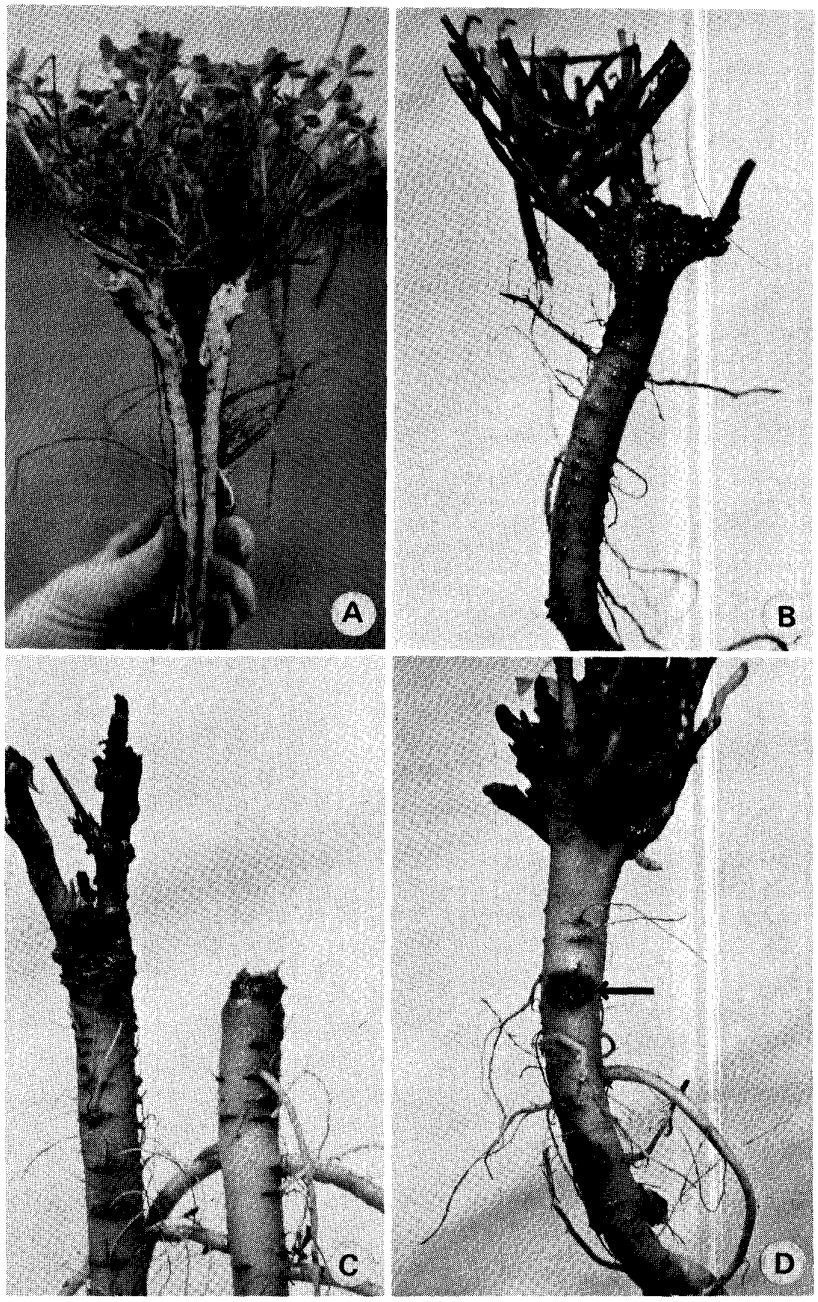

Figure 1. The four main types of crown and root disorders found in the Peace River Region in 1974.

A) Internal crown rot symptoms, indicating advanced stage where central stele of root is damaged.

B) External crown rot, showing necrosis of the root-crown cortex.

C) Winter crown rot indicating disintegration of the crown tissue.

D) Root rot (arrow) showing site of initiation where lateral roots emerge.

sporadically or appeared to cause no serious deterioration of the stand. Severe indicated that symptoms were well developed throughout the field and caused obvious deterioration of the stand.

Results

Description of symptoms

Four main types of injury occurring singly or in various combinations were distinguished.

Internal crown rot occurs frequently in older stands. Dark brown necrotic areas are iniated in the crown at the site of cut stems or in axils. The necrosis proceeds into the crown to form a wedge-shaped decayed area. This eventually progresses into the central stele of the taproot (Fig. 1A). The vigor of plants is reduced because fewer shoots originate from the reduced crown surface. Normally crown buds originate in the fall then develop rapidly in early spring, but in severely affected crowns new shoots arise only from the lower part of the crown in late spring.

External crown rot injury is characterized by necrosis in the transition zone of the crown and root cortex. It appears to begin as an external lesion which expands and results in partial girdling and partial killing of the crown and crown buds (Fig. 1B). After 2 or more seasons, girdling is complete, resulting in death of most of the crown. A marked increase in the extent of external crown rot has recently been observed in patches in one intensively monitored alfalfa field in the fall, prior to freeze-up.

Winter crown rot is a characteristic of both old and young stands. It occurs primarily in patches within a field. Crown tissues become soft and brownish yellow in appearance, then disintegrate until the whole crown is rotted off (Fig. 1C). The rot is not selective of tissues within the crown, and taproots usually are not damaged. It appears to be more common in low, wet areas and completely kills the crown, apparently in a single winter. It is associated with snow mold.

Root rot injury is characterized by blackish-brown lesions appearing on root surfaces, usually expanding from where a lateral root emerges from a taproot (Fig. 1D) or a main root. These lesions progress until they completely rot through the root.

Survey

Figure 2 outlines the Peace River Region of Alberta and British Columbia. The region is divided into two areas on the basis of where root rot appeared to be of major significance. Area 1 includes the region around Manning, Alberta, north to the Fort Vermilion, High Level districts. Area 2 includes the remaining portion of the Peace River Region in Alberta and British Columbia.

The results of the 1974 survey are given in Table 1. Root rot occurred in 68% of the fields surveyed in Area 1 and in most of those fields damage was either moderate or severe. In Area 2 only 24% of the fields had just a trace amount of root rot. Internal crown rot was slightly more prevalent in Area 2 than in Area 1 (Fig. 2). Fifty-seven percent of the 19 fields examined in Area 1 and 67% of the 21 fields in Area 2 had internal crown rot. External crown rot occurred more frequently in Area 1, while winter crown rot was more frequent in Area 2. Both external crown rot and winter crown rot were of minor occurrence in 1974. Twelve percent of the fields observed had no disease symptoms, 55% had only one type of symptom, and 33% had more than one.

A comparison of the fall samples with the spring samples is valid for all symptoms except winter crown rot. Since winter crown rot was of only minor occurrence throughout the survey, data from the fall sampling were included in the analysis.

Discussion

The four types of symptoms distinguished here do not indicate causal agents or the season in which initiation or development occurs. They resemble symptoms previously observed, and are attributed to various causes at various seasons.

Symptoms illustrated and described elsewhere that are similar to our internal crown rot type have been termed heart rot (27, 28), crown rot, or crown and root rot (4, 6, 19, 24). They have been variously attributed to environmental conditions (27), *Rhizoctonia solani* Kühn (4, 24), *Fusarium* spp. (6, 19), *Stagonospora meliloti* (Lasch) Petr. (9, 16); similar symptoms have also been produced by artifical freezing (28). The later stages of crown bud rot, which has been attributed to a complex including *R. solani, Fusarium roseum* Link sensu Snyder and Hansen [*F. avenaceum* (Fr.) Sacc., *F. acuminatum* (Ell. and Ev.) Wr.], and *Ascochyta imperfecta* Peck (*Phoma medicaginis* Malbr. & Roum.), are also similar (12, 13, 14).

External crown rot types of symptom have been termed collar rot (27), phloem injury (28), and winter crown rot in its earlier or partial stages (7). They were attributed to environmental conditions (27) and the low-temperature basidiomycete (7) and also were produced by artificial freezing (28). The greatest increase in external crown rot that we have observed, however, occurred in the fall prior to freezing or snow cover.

Winter crown rot (4, 5, 7), also termed snow mold (20), and the low-temperature basidiomycete disease (11), has so far been attributed exclusively to the low-temperature basidiomycete. Isolates of this organism are quite variable in morphology and physiology (20, 26) and may prove to be a complex of basidiomycetes. This type of symptom has also been produced by artificial freezing (28).

Similar root rot symptoms have been variously termed brown root rot attributed to *Plenodomus meliloti* Dearness and Sanford (22, 25); root or root and crown rot due to *R. solani* (11, 24), *Fusarium* spp. (6, 19), or *Phytophthora megasperma* Drechs. (*P. cryptogea* Pethy. and Laff.) (10, 21), although dissimilar symptoms were also described and shown for *P. megasperma* (11); and root canker due to *R. solani* (3, 4, 9, 23).

We have, therefore, been careful to separate symptoms from causes, and in this report the attempt has been made to distinguish the main types of symptoms that

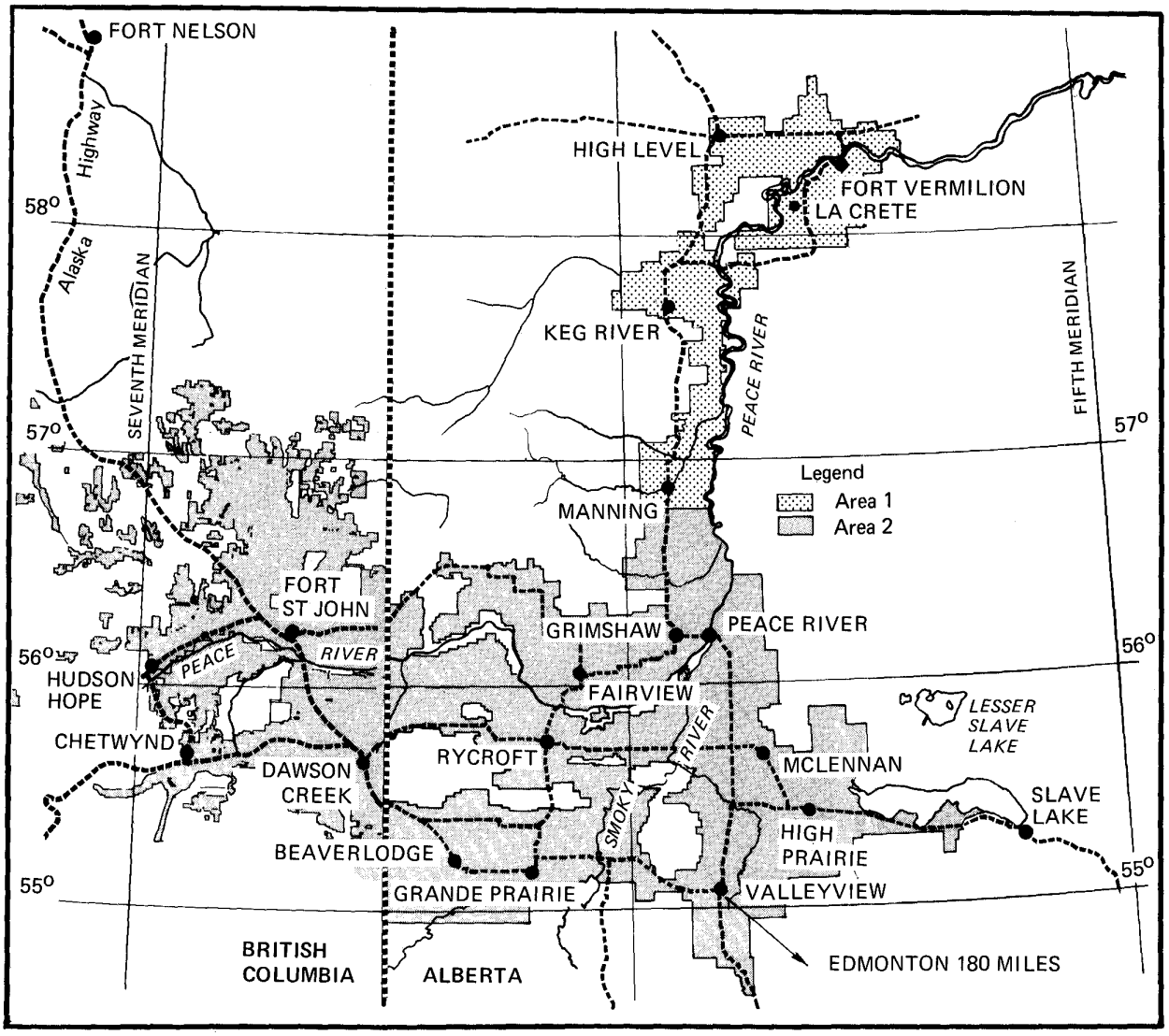

Figure 2. The agricultural area of the Peace River Region in Alberta and British Columbia. Area 1 extends from 10 miles south of Manning, Alberta, north to the High Level and Fort Vermilion area. Area 2 consists of the remaining parts of the Peace River Region.

occur in the Peace River Region before investigating causes and interactions. Descriptions of the symptoms of crown and root disorders of alfalfa and their relative distribution in the region were developed from the results of the survey for one season. The cultivars Beaver, Grimm, Rambler, and Roamer predominate in the region, but no attempt was made to identify cultivars or to specify the particular soil type in which a disorder was found. The prevalence of root rot in Area 1 and its minor significance in Area 2 may be important in understanding the disease and environmental relationships in these areas. Studies are continuing to identify the causes of these symptoms, the organisms involved, and to assess management practices that may reduce severity.

Acknowledgments

The technical assistance of Gordon McLean and Colin Brodie is gratefully acknowledged.

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Table 1. Percentage of alfalfa fields observed to have disease symptoms† in two areas of the Peace River Region of Alberta and British Columbia in 1974

Area*	No. fields observed	Internal crown rot			External crown rot			Winter crown rot			Root rot		
		T	M	S	T	M	S	T	M	S	T	M	S
1	19	32	15	10	11	5	0	0	5	0	0	53	15
2	21	33	24	10	5	0	0	5	5	0	24	0	0

* See Figure 2.

† T = trace; M = moderate; S= severe.

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Potato seed-piece decay: a bibliography, 1930–1975

Compiled by J. P. Miska and G. A. Nelson[1]

Can. Plant Dis. Surv. 55:126-146. 1975

Contents

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This world bibliography is intended to provide information to research workers on potato seed-piece decay. It lists scientific and technical papers published in periodicals relating to plant pathology and mycology. The compilation was developed from a card index maintained by Dr. G. A. Nelson and has been enlarged to include titles cited since 1930 in journals and by potato disease abstracting services.

Citations are arranged first by subject heading, then alphabetically by author. All titles are given in English. The entries are numbered consecutively and each gives author, date, title, source, and language of publication. Citations appearing under more than one subject heading are cross referenced and an author index appears at the end of the bibliography. The subject headings are worded according to *Review of Applied Mycology*, now *Review of Plant Pathology*. Entries in the Addendum are chiefly of the 1970's and are listed alphabetically by author; they are cited by numbers (prefix A) at the end of the appropriate subject heading.

The potato is one of our most important vegetable crops. A bibliography on decay of potato seed pieces will be a valuable source for scientists who wish to study seed-piece decay further.

Not all the titles in this bibliography are available in this library. For further information please contact Librarian, Research Station, Agriculture Canada, Lethbridge, Alberta, Canada T1J 4B1

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Author index

Resistance of turfgrasses to low-temperature-basidiomycete snow mold and recovery from damage[1]

J. Drew Smith

Most strains of *Poa pratensis, Festuca rubra,* and *Festuca ovina* were heavily damaged in tests at Saskatoon when turf plots were inoculated with cultures of the nonsclerotial low-temperature basidiomycete, LTB, grown on sterile rye grain. Suscepts included several of the cultivars favoured for use in other climatic regions where the range of snow molds and other turf pathogens is different from that on the prairies. No strains completely resistant to the LTB were found, but some new introductions, selections and established cultivars showed low initial damage and/or rapid recovery. Cultivars require regional testing for disease resistance, especially snow mold resistance, before being recommended for use. Varietal descriptions should specify resistance to a particular snow mold pathogen or pathogens not to "snow mold" since the spectrum of these varies greatly from region to region.

Can. Plant Dis. Surv. 55:147-154. 1975

L'inoculation d'un basidiomycète psychrophile sans sclérotes (LTB) cultivé sur des grains de seigle stériles à des parcelles de gazon a fortement endommagé la plupart des lignées de *Poa pratensis, Festuca rubra* et *Festuca ovina* utilisées dans des essais réalisés à Saskatoon. Plusieurs des cultivars sensibles sont ceux qu'on utilise de préférence dans les régions climatiques où les moisissures nivéales et les autres organismes pathogènes du gazon diffèrent de ceux des Prairies. Aucune lignée n'a manifesté une résistance complète au LTB, mais quelques nouvelles sélections et quelques cultivars établis ont montré peu de dégâts initiaux et (ou) se sont rétablis rapidement. Pour pouvoir être recommandé, les cultivars doivent subir des essais multilocaux de résistance à la moisissure nivéale. Les descriptions de variété devraient spécifier les types de pathogène de la moisissure nivéale auxquels les cultivars sont résistants étant donné que les pathotypes de ces dernières varient beaucoup d'une région à l'autre.

Snow mold caused by an unidentified, non-sclerotial low-temperature basidiomycete, LTB, is widespread on domestic lawns and other amenity turf in the lower snowfall regions of western Canada and may cause considerable damage in some years (4, 5). LTB snow mold may be controlled by applications of nonmercurial fungicides made before the development of a permanent snow cover. However, severe attacks on susceptible cultivars may require the use of mercurous/mercuric chloride mixtures (6).

Few studies have been made on the resistance to the LTB of cultivars of *Poa pratensis* L., *Festuca rubra* L. and *Festuca ovina* L. The first two species are the most common components of domestic lawns and other amenity turfs in the prairies. Cormack (1) found that *P. pratensis* had moderate to high resistance and that *F. rubra* and *F. ovina* had low resistance under the conditions of southern Alberta. In order to improve control of this disease and reduce the need to rely on fungicides, many introductions and local selections of *P. pratensis* and fine-leaved *Festuca* spp. were screened for resistance and recovery following artificial inoculation with cultures of the fungus grown on sterile grain. The results of field tests in 1974 are presented here.

[1] *Contribution No. 592, Research Station, Agriculture Canada, 107 Science Crescent, Saskatoon, Saskatchewan S7N 0X2.*

Materials and methods

Plant materials

Tests 1,2, and 3 included 99 accessions of *P. pratensis* cultivars and selections from many countries and the prairies of Canada. Test 1 comprised 65 accessions replicated six times in random fashion. In test 2, 17 lines were similarly replicated four times. In Test 3, 17 lines were replicated only twice. The numbers of replicates and the seeding rate were governed mainly by availability of seed. Seed was sown with a multiple belt seeder on 3 June 1971. Row spacing was 22.5 cm, row length 3.2 m, with four rows per plot. When established, the grasses were mown at 5 cm height, at first with a rotary mower mounted under a garden tractor and then with tractor-drawn reel mowers. Clippings were returned. Irrigation was supplied when needed. Plots were top-dressed in midsummer with a soil/sand/peat mixture to encourage turf formation. Although tests indicated adequate soil phosphate levels, 3 kg of 16-20-0 and 3 kg of 33-0-0 fertilizer per 100 m^2 were applied per annum.

Test 4 comprised 12 commercial cultivars and 12 selections of *Poa pratensis* in 1 m^2 plots replicated four times in a randomized block arrangement. Seeding rate depended on amount of seed available. Seed was sown by hand broadcasting in June 1972. Fertilization was similar to Tests 1, 2, and 3; mowing was done with a domestic rotary or small, self-propelled reel mower to 5 cm height. Clippings were returned.

Test 5 comprised 6 cultivars and 10 selected lines of *F. rubra* (56-and 42-chromosome types) and 3 lines of *F. ovina* in 1 m^2 plots replicated four times in a randomized block arrangement. Seeding, fertilization and mowing were identical with that in Test 4.

Test 6. Where seed was in shorter supply than in Test 5, it was only possible to sow duplicate plots of a further 12 lines of *F. rubra* and four of *F. ovina*. Seeding, mowing and fertilizing were the same as in Tests 4 and 5.

Tests 7 and 8. Where seed from only a few plants was available or that available was of poor germination, it was sown in soil in 30 X 42 cm greenhouse flats. This sowing was done in late winter; when coherent turf was available in spring, it was removed from the flat and laid on a levelled soil bed. With suitable topdressing and judicious mowing, a well-grown turf became available for testing in the fall of the same year. Test 7 comprised 48 lines of *P. pratensis*. Test 8 comprised 37 lines of *F. rubra* and 7 of *F. ovina*. In both tests, each line was replicated three times.

Inoculation

The LTB isolate Ju714a used to establish an epidemic was derived from diseased patches of *Agrostis* sp. from the sixth green at the Golf and Country Club, Moose Jaw, Saskatchewan, in spring 1971. It had been proved highly pathogenic on *P. pratensis* and *F. rubra* in seasons previous to 1973 (6). It was grown on sterile, moist rye grain in 1.14 liter milk bottles at 6°C for 3 months, air-dried, crushed, and stored at -10°C until required. Seventeen kilograms of the dried inoculum was applied to 2125 m^2 (8 g/m^2) of the test areas by hand broadcasting in several directions on 5 and 7 September 1973.

Rating for disease

This was done on 23 April and 6, 15, and 24 May 1974. The percentage area affected by the disease was recorded.

Results

Susceptible strains of *P. pratensis*, and *F. rubra*, and *F. ovina* were heavily damaged by the LTB isolate in all tests (Tables 1 to 8 and Figs. 1, 2, & 3). Many of the *F. rubra* and some of the *F. ovina* strains showed more than 80% damage (Tables 5, 6, & 8 and Fig. 1) on 23 and 29 April, 2 and 3 weeks respectively after the snow cover had gone. However *P. pratensis* strains (Tables 1, 2, 3, 4, & 7 and Fig. 1) generally did not show as much initial damage and they recovered more rapidly from damage. This is apparent when percent damage for the *P. pratensis* strains on 15 May (Tables 1, 2, 3, & 4) is compared with that for *F. rubra* and *F. ovina* on the same date (Tables 5 & 6). Similar differences in rate of recovery are apparent when data for *P. pratensis, F. rubra* and *F. ovina* are compared in the microplot tests (Tables 7 & 8, and Fig. 3). In some tests, a strain was entered twice with seed from different lots; for example IH 2079, Primo (Table 1), Reptans (Table 5), Olds (Table 6), Dawson, Boreal, Goldfrood, Reptans, and Olds (Table 8). Differences between ratings of the same cultivar were not significant. None of the strains were completely resistant to the LTB, but the *P. pratensis* lines S-7763 (Table 1), S-8606 (Table 2), K35584 and K35605 (Table 7) showed high resistance and, except for K35605, rapid recovery from damage. *F. rubra* line S-1765 (Tables 6 & 8) and *F. ovina* lines 2069 (Table 5), 2065 (Table 6), S-1758, S-1733, S-1792, and S-3482 (Table 8) were outstanding in resistance. In some of the moderately resistant *P. pratensis* strains, eg. in those with initial ratings of less than 40% infection (Table 1), recovery was generally rapid.

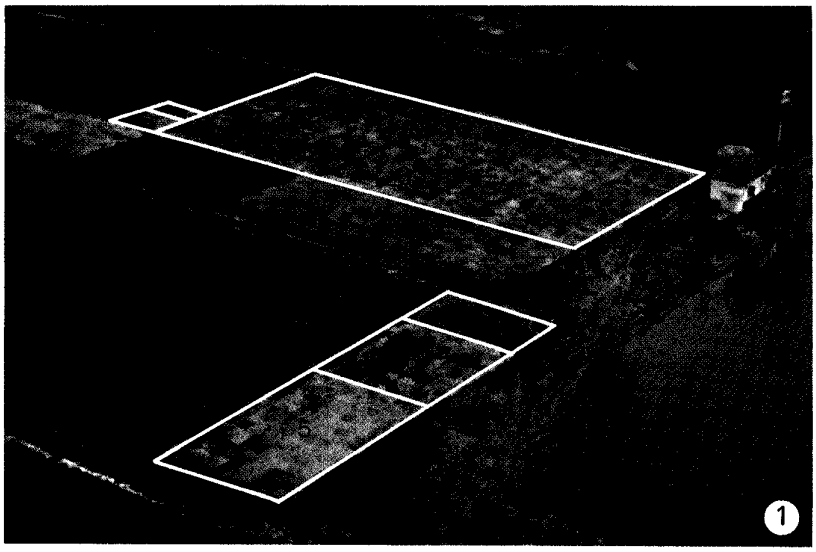
Discussion

The considerable differences in susceptibility to the LTB snow mold found among strains of *P. pratensis, F. rubra*, and *F. ovina* and in rate of recovery from damage suggest that field pathogenicity tests of the kind employed are suitable for the selection of disease resistant lines. The row method of seeding employed in Tests 1, 2, and 3 permitted additional data to be obtained on susceptibility of entries to powdery mildew [*Erysiphe graminis* DC. ex Mérat] and rust [*Puccinia poae-nemoralis*, Otth.]; in the central prairie region these diseases are much more prevalent on *Poa pratensis* in spaced rows than in mown turf. Row seeding also allows the formation of turf from smaller amounts of seed than conventional broadcast sowing. Additional data may also be obtained on rapidity of turf formation by selections. The knitting together of turf may be encouraged by top-dressing. However, mature turf suitable for inoculation and disease studies may require several years to develop. Both the row seeding and the microplot method (Tests 7 and 8) minimized risk of test failures due to "washout", common in this region, and eliminated the need to await calm conditions necessary for successful multiple plot seedings. The microplot technique provided a very effective rapid screening

Figure 1. Aerial view of low-temperature basidiomycete (LTB) test plots on 29 April 1974, about 3 weeks after snow melt. Some recovery is apparent in *Poa pratensis* lines in particular (Tests 1–4). Key to test plots: 1–4, 7 *Poa pratensis*; 5,6,8 *Festuca rubra* and *F. ovina*.

Figure 2. LTB test plots, 8 May 1974. *Poa pratensis* plots (Test 4) below line; *Festuca* spp. plots (Tests 5 and 6) above line. Considerable recovery has taken place in several *P. pratensis* lines, less frequently in fescues.

Figure 3. LTB test plots, 8 May 1974. Microplots of *Festuca* spp. (Test 7) below line; microplots of *Poa pratensis* (Test 8) above line. Considerable recovery has occurred in most *P. pratensis* lines and in some *Festuca* spp. lines.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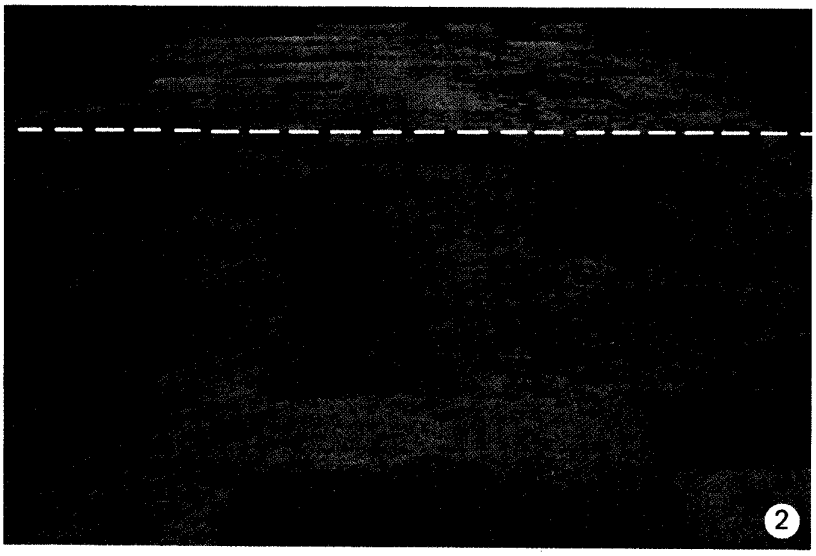
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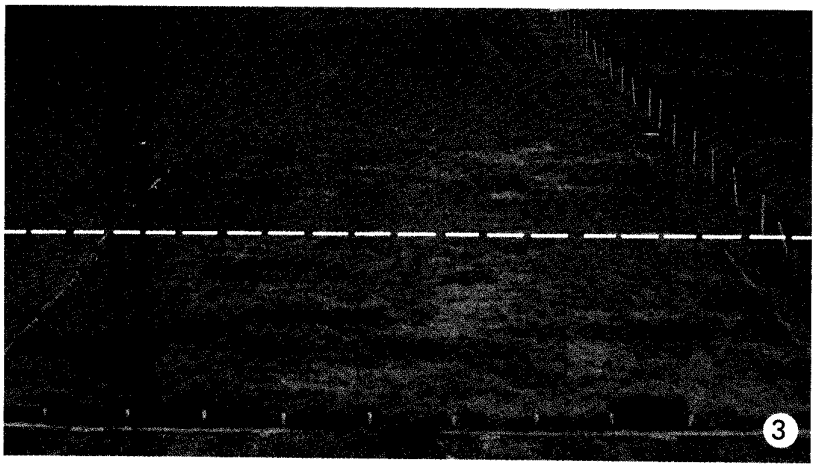
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Table 1. Resistance and recovery of *Poa pratensis* lines from LTB snow mold, 1974: Test 1 (6 replicates)

Cultivar or line	Origin[1]	Percent area of turf affected			
		23 Apr	6 May	15 May	Avg
S-7763	USSR	16	7	1	8
S-7766	Canada	27	19	5	17
Park	USA	29	18	8	18
Norma Øtofte	Denmark	27	24	7	19
Mostovskij	USSR	38	18	3	19
Hunsballe	Denmark	30	25	4	20
Captan	Neth.	41	16	3	20
S-7759	Canada	38	21	2	20
S-7764	Canada	31	24	6	20
IH 2079	Canada	34	22	5	20
EFS64	Denmark	34	25	5	21
Kahnstein	Germany	33	24	8	22
Skandia II	Sweden	35	25	6	22
Delta	USA	32	25	10	22
K22011	USSR	43	23	6	23
S-7760	Canada	38	30	3	23
S-8598	Canada	30	26	19	25
S-7762	Canada	37	29	9	25
S-7767	Canada	40	29	8	26
Delft	Neth.	36	28	15	26
IV-89-61	Hungary	33	32	16	26
S-8595	Canada	33	27	19	26
S-7765	Canada	41	28	13	27
Line 59	Neth.	29	32	22	27
Adorno	Neth.	38	27	18	27
S-8596	Canada	46	30	8	28
IH 2079	Canada	36	34	7	28
K35603	Estonia	40	34	13	29
Troy	USA	51	28	9	29
S-8597	Canada	41	27	12	30
S-8599	Canada	34	32	13	30
Atlas	Sweden	39	33	18	30
Golf	Sweden	42	35	17	31
SK 46	Poland	41	30	13	31
Tygera	USSR	30	33	32	31
S-8600	Canada	40	37	18	32
Kentucky	USA	37	36	23	32
K 31808	Latvia	43	33	23	33
S-8611	Hungary	48	35	18	33
S-7758	Canada	48	33	21	34
Steinacher	Germany	49	41	13	34
RVP	Belgium	44	40	25	36
MLM 18006	Unknown	36	48	26	37
Arista	Neth.	45	43	23	37
Baron	Neth.	36	41	27	38
Windsor	USA	44	44	25	38
Primo	Sweden	41	40	33	38
S-8601	Canada	48	48	18	38
Monarch	England	42	42	32	39
S-7761	Canada	41	48	28	39
Nike Daehnfeldt	Denmark	49	47	22	39
Newport	USA	45	44	31	40
Sydsport	Sweden	43	49	35	42
Nugget	USA	48	43	38	43
S-8591	Canada	48	44	40	44
Primo	Sweden	50	52	33	45
S-8592	Canada	53	51	32	45
S-7756	Canada	54	51	40	48
Fylking	Sweden	55	47	46	49
S-5894	Canada	61	51	39	50
S-7768	USSR	65	58	32	51
MLM 18005	Unknown	63	48	41	51
S-7757	Canada	53	51	32	52
IV-89-24	Hungary	61	55	43	53
Barkenta	Neth.	65	64	56	62
LSD 1%		30	29	21	

[1]Neth = The Netherlands

method for lines where seed supply was short. Turf can be produced in the winter for planting the following spring. The method probably suffers from deficiencies inherent in very small plot studies; there is an "edge effect" and great heterogeneity in resistance and susceptibility between adjacent components in a small area. This probably affects the progress of the infection. So far no satisfactory laboratory or greenhouse technique has been developed which can satisfactorily simulate the conditions of turf under a snow cover, which is necessary for this disease to develop. In culture the LTB isolate used produces hydrocyanic acid, which is probably important in pathogenesis.

Of the *P. pratensis* strains tested, S-7763, an introduction from the Murmansk region of the USSR, showed high resistance and recovery in the row-seeded (Table 1) and broadcast (Table 4) tests. This strain in these, and other tests, shows early winter dormancy and more rapid spring regrowth than any other strain so far tested at Saskatoon. These are probably desirable characters for this region. It shows high resistance to *E. graminis* and moderate resistance to *P. poae-nemoralis* in seed rows (unpublished). It is an excellent seed producer and highly apomictic. Other lines showed considerable resistance and quick recovery from damage or, while apparently susceptible to attack, showed quick recovery from damage. For example, in the broadcast seeded plots an introduction from Italy, S-8606, rated significantly better in both characters than the cultivars Prato, Cougar, and Fylking (Table 2). In the microplot tests (Table 7), K35584 from the USSR was outstanding in resistance and recovery from damage, but six other lines from the USSR, Canada, and the USA, namely K35605, 19, C68-79, 2, K28704, and 145, had fair resistance, and, except for K35605, good recovery.

The poor resistance and slow recovery of many well known *P. pratensis* strains, some of which are commonly sold for turf formation in the prairies, are major findings

Table 2. Resistance and recovery of *Poa pratensis* lines from LTB snow mold, 1974: Test 2 (4 replicates)

Cultivar or line	Origin	Percent area of turf affected			
		23 Apr	6 May	15 May	Avg
S-8606	Italy	20	6	3	10
S-8604	Italy	26	13	5	15
S-8605	Italy	30	13	8	17
170	England	24	18	11	18
K28704	USSR	31	16	6	18
K27874	USSR	49	19	5	24
IV-89-59	Hungary	36	25	18	26
K27307	USSR	44	25	13	27
C68-79	USA	43	26	13	27
S-8602	USSR	46	33	19	33
Rogue	Canada	44	34	21	33
Dasas	Denmark	56	36	15	36
K35602	Estonia	54	45	30	43
K35604	Estonia	58	49	39	48
Prato	Neth.	65	45	41	50
Cougar	USA	64	53	48	55
Fylking	Sweden	64	49	53	55
LSD 1%		43	32	23	

Table 3. Resistance and recovery of *Poa pratensis* lines from LTB snow mold, 1974: Test 3 (2 replicates)

Cultivar or line	Origin	Percent area of turf affected			
		23 Apr	6 May	15 May	Avg
S-7831	Unknown	28	23	6	19
S-8603	England	50	23	11	28
S-8741	Unknown	40	23	23	28
S-7840	Unknown	33	23	38	31
S-7835	Unknown	35	28	35	33
S-7839	Unknown	55	33	20	36
S-7830	Unknown	70	35	6	37
Stensballe	Denmark	65	33	15	38
S-7837	Unknown	60	43	18	40
S-8609	Canada	76	35	10	40
Merion	USA	55	40	28	41
S-7834	Unknown	63	38	33	44
S-8610	Canada	65	50	16	44
S-7832	Unknown	73	50	33	52
S-7838	Unknown	68	45	43	52
S-7836	Unknown	63	58	40	53
S-7833	Unknown	83	65	30	59

of the tests. Many of these were developed for use in turf or pastures elsewhere. Barkenta, Fylking, Primo, Nugget, Sydsport, Windsor, and Baron (Table 1); Fylking and Cougar (Table 2); Merion (Table 3); and Cougar, Merion, Baron, Arista, Fylking, Barenta, Nugget, Primo, and Sydsport (Table 4) performed poorly. Some of these have received good ratings for resistance to certain diseases (2) that do not usually cause significant damage in the Saskatoon region or in adjacent areas with similar climatic conditions. On the other hand, the superior performance of Park (Tables 1 & 4), Captan (Table 1), and Delta (Table 4) is apparent.

All *F. rubra* strains tested (Tables 5, 6, and 8), except S-1765 (Tables 6 and 8), a 1947 introduction from Kazakstan in the USSR, showed heavy damage following snow melt. The only cultivar which approached S-1765 in resistance was Arctared, but strains K34675, K25236, and K22609 (Talbe 5) showed a significantly faster rate of recovery than any other strains in Test 5, including all Canadian cultivars.

The *F. ovina* L. var. *saximontana* Rydb. entries 2069 (Table 5) and 2065 (Table 6), which were Saskatchewan selections from the Cypress Hills, S-1758, S-1733, and S-1792 from Kazakstan in the USSR, and S-3482, a hard fescue, *F. ovina* var. *duriuscula* L., of unknown origin (Table 8) showed considerably greater resistance to LTB damage than the remainder. The cultivar Barenza and the strain 2107 (Tables 6 & 8) suffered severe damage which resulted in death of most of the turf on these plots.

Of the winter diseases, snow mold caused by the LTB is probably the most prevalent in the prairies on bluegrass/fescue turf commonly used in the formation of domestic lawns and other irrigated amenity turf. It is also the most difficult to control. Particularly in a cool, dry spring following heavy damage recovery is slow and turf may be severely thinned out. Observations of field cases suggest that the prolongation of vegetative growth into late fall by heavy or late summer nitrogen applications increases turf susceptibility to LTB, as with disease caused by *Fusarium nivale* (3). Winter dormancy is a mechanism related to the survival of the perennial grasses through an unfavorable period when turf is prone to attacks of psychrophilic fungal pathogens. The onset of this dormancy is signaled by a slowing of leaf production and by leaf death and attendant chlorophyll loss, which may be referred to as "browning off". *P. pratensis, F. ovina*, and *F. rubra*, cool season grasses, do not have a complete winter dormant period and are capable of growth during the winter in mild, bright periods, for example, in midwinter thaws in "chinook" regions. However, the earliness and completeness of the "browning off" process in early winter varies from strain to strain. Since it is thought that pathogenesis in the LTB is related to tissue damage from hydrocyanic acid production (7), it is possible that this production is dependent on the chemical composition or condition of the substrate (the turf grass plant), which may influence the amount of plant damage caused. Early and deep dormancy may also conserve soil nitrogen and husband stored plant food reserves which allows rapid "take-off"

Table 4. Resistance and recovery of *Poa pratensis* lines from LTB snow mold, 1974: Test 4 (4 replicates)

Cultivar or line	Origin	Percent area of turf affected			
		23 Apr	6 May	15 May	Avg
S-7763	USSR	28	6	0	11
IH 2079	Canada	29	26	4	20
S-7760	Canada	39	23	8	23
S-7759	Canada	39	24	13	25
Delta	USA	40	26	15	27
Park	USA	48	31	15	31
K35603	Estonia	61	25	9	32
S-8596	Canada	45	15	9	33
K35602	Estonia	60	45	28	44
Sydsport	Sweden	50	58	46	51
Primo	Sweden	55	56	43	51
Steinacher	Germany	73	55	35	54
Nugget	USA	61	53	51	55
Barkenta	Neth.	81	68	49	59
K35604	USSR	69	73	45	62
S-8591	Canada	68	62	58	62
Fylking	Sweden	65	66	58	63
Arista	Neth.	69	70	55	65
Baron	Neth.	68	74	66	69
Merion	USA	78	73	65	72
S-7756	Canada	75	71	70	73
Line 59	Neth.	84	78	70	77
S-7757	Canada	88	80	76	78
Cougar	USA	83	83	83	83
LSD 1%		50	44	44	

Table 5. Resistance and recovery of *Festuca rubra* and *Festuca ovina* lines from LTB snow mold, 1974: Test 5 (4 replicates)

Cultivar or line	Origin	Percent area of turf affected				
		23 Apr	6 May	15 May	24 May	Avg
F. rubra						
K34675	Latvia	90	38	9	13	27
K25236	USSR	80	30	10	4	31
K22609	USSR	83	53	19	9	41
K27390	Lithuania	79	68	39	35	55
K31197	USSR	90	79	48	40	64
Olds	Canada	88	81	58	63	69
S-7850	Canada	83	81	63	54	70
Reptans	Neth.	80	79	73	64	74
Reptans	Neth.	78	78	74	68	74
Durlawn	Canada	88	89	79	50	76
Dawson	England	94	86	76	53	77
Baron	Neth.	63	85	74	78	77
K35599	Estonia	95	89	70	61	79
Pennlawn	USA	88	91	83	76	84
Canada No. 1 (S-7374)	Canada	90	91	86	76	86
K31286	Latvia	99	94	91	63	87
MLM 15010	Unknown	91	93	92	92	92
F. ovina						
2069	Canada	4	33	3	8	12
1811-456	Armenia	45	40	29	25	35
562	Germany	97	92	86	68	86
LSD 1%		38	40	33	39	

Table 6. Resistance and recovery of *Festuca rubra* and *Festuca ovina* lines from LTB snow mold, 1974: Test 6 (2 replicates)

Cultivar or line	Origin	Percent area of turf affected				
		23 Apr	6 May	15 May	24 May	Avg
F. rubra						
S-1765	U.S.S.R.	15	15	15	15	15
Sceempter	Neth.	65	75	60	60	65
1081	Canada	70	85	55	60	68
1079	Canada	85	90	70	50	74
Duraturf	U.S.A.	100	93	70	55	79
Olds(1098)	Canada	100	90	80	50	80
Oasis	Neth.	100	97	78	55	82
1120	Canada	90	93	85	87	86
1118	France	90	93	88	75	86
1111	Canada	95	93	85	75	87
KL257	Unknown	95	95	85	80	89
Olds(1084)	Canada	100	95	88	75	89
F. ovina						
2065	Canada	13	10	8	10	10
2066	Canada	28	70	40	30	42
2107	Neth.	95	98	85	85	91
Barenza	Neth.	90	98	93	95	94
LSD 1%		55	35	49	51	

in growth and hence recovery from disease damage in spring when favorable climatic conditions occur.

Because of different climatic conditions and a different range of snow mold and other pathogens, including the LTB and a highly pathogenic *Typhula* sp. at present designated *Typhula* FW (6), *P. pratensis*, *F. rubra*, and *F. ovina* cultivars recommended for use elsewhere should not be employed for turf formation on the prairies on a large scale without adequate regional testing. Varietal descriptions may be faulty when the generic term "snow mold" is used to indicate disease resistance without specifying which pathogen is concerned.

Acknowledgments

I am indebted to W. W. Reiter, W. Leonard, and C. Tennant for valuable technical assistance.

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Table 7. Resistance and recovery of *Poa pratensis* lines from LTB snow mold 1974: Test 7 (Microplot, 3 replicates)

Cultivar or line	Origin	Percent area affected		
		24 Apr	6 May	Avg.
K35584	USSR	5	0	2
K35605	USSR	10	7	8
19	Canada	18	3	11
C68-79	U.S.A.	17	5	11
2	Canada	20	3	12
K28704	U.S.S.R.	18	7	12
14	Canada	18	10	14
21	Canada	23	10	16
K27307	U.S.S.R.	22	17	19
K27397	U.S.S.R.	30	10	20
18	Canada	25	15	20
145	Canada	37	7	22
74	England	27	20	23
S-8610	Canada	22	25	23
16	Canada	33	15	24
23	Canada	38	13	26
73	England	27	27	27
20	Canada	38	17	27
17	Canada	40	15	28
15	Canada	40	17	28
S-7844	Canada	42	18	30
K28748	U.S.S.R.	38	22	30
1	Canada	40	20	30
22	Canada	40	22	31
IV-89-59	Hungary	40	22	31
K28748	U.S.S.R.	43	22	32
80	U.S.S.R.	37	28	32
72	England	43	28	36
Dasas	Denmark	43	28	36
S-7845	Canada	48	23	36
K27874	Lithuania	47	27	37
Fylking	Sweden	43	33	38
9	Canada	47	32	39
141	Hungary	43	37	40
83	U.S.S.R.	43	43	43
81	U.S.S.R.	50	42	46
71	Hungary	60	37	48
79	U.S.S.R.	53	47	50
78	U.S.S.R.	57	52	54
Stensballe	Denmark	63	45	54
IV-89-24	Hungary	60	52	56
S-8609	Canada	67	53	60
136	Hungary	70	53	62
85	U.S.S.R.	70	60	65
Prato	Neth.	77	57	66
82	U.S.S.R.	75	63	70
131	U.S.S.R.	77	68	72
77	U.S.S.R.	82	70	76
LSD 1%		47	38	

Table 8. Resistance and recovery of *Festuca rubra* and *Festuca ovina* lines from LTB snow mold, 1974: Test 8 (microplots, 3 replicates)

Cultivar or line	Origin	Percent area of turf affected		
		24 Apr	6 May	Avg.
F. rubra				
S-1765	U.S.S.R.	2	10	6
Arctared	U.S.A.	30	20	25
Oasis (1108)	Neth.	32	23	28
Boreal (1105)	Neth.	50	33	42
Duraturf	U.S.A.	47	38	43
1084	Canada	58	33	46
Dawson (1133)	England	52	40	46
1120	Canada	53	42	48
Golfrood (1079)	Neth.	53	43	48
Dawson (1104)	England	60	38	49
S59	U.K.	62	38	50
Pennlawn (1087)	U.S.A.	60	43	52
Sceempter	Neth.	67	38	53
Pennlawn (1078)	U.S.A.	68	38	53
1101	U.S.A.	60	48	54
1114	Canada	60	53	57
Polar	U.S.A.	70	43	57
Golfrood (1103)	Neth.	62	53	58
Boreal (1106)	Canada	67	48	58
1108	Neth.	67	48	58
1112	Canada	62	53	58
1102	Canada	70	50	60
1111	Canada	73	52	63
S-7374	Canada	67	60	63
KL257	Unknown	73	55	64
Fallade	Neth.	72	57	64
Brabantia	Neth.	77	60	68
Ruby	U.S.A.	72	63	68
Reptans (1095)	Sweden	78	61	70
Reptans (1098)	Sweden	82	63	73
Agio	Neth.	80	65	73
Olds (1097)	Canada	77	70	73
Olds (1098)	Canada	70	67	73
1118	France	85	63	74
MSG Flevo-2	Neth.	82	67	74
Novorubra	Neth.	90	67	78
Highlight	Neth.	90	77	83
F. ovina				
S-1758	U.S.S.R.	2	0	1
S-1733	U.S.S.R.	2	5	3
S-1792	U.S.S.R.	3	7	5
Durar	U.S.A.	7	13	10
Biljart	Neth.	27	23	25
Barenza	Neth.	65	65	65
2107	Neth.	70	65	68
LSD 1%		44	49	

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Ergot tolerance in spring rye

Frank Sosulski[1] *and C.C. Bernier*[2]

In field plots in Saskatchewan, spring rye flowered later and showed higher levels of ergot infection than fall rye. Among three spring rye cultivars tested, Gazelle was consistently lower in percentage by weight of ergot sclerotia in seed samples, as well as being substantially higher in seed yield. Floret inoculation tests demonstrated that Gazelle does not possess physiological resistance to ergot. Gazelle showed less infection probably because the florets were pollinated more rapidly and more completely than those of the other cultivars.

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En parcelles d'essais installées en Saskatchewan, le seigle a fleuri plus tard et a été plus gravement touché par l'ergot [*Claviceps purpurea*] que le seigle d'automne (*Secale cereale*). Des trois cultivars testés, c'est Gazelle qui a montré le plus faible pourcentage de sclérotes d'ergot par poids dans les échantillons de grain, ainsi qu'un rendement en grain sensiblement plus élevé. Les épreuves d'inoculation des florules révèlent que Gazelle ne possède pas de résistance physiologique à l'ergot et s'il a été moins atteint, c'est que sa pollinisation a été plus rapide et plus complète que chez les autres cultivars.

Ergot, a common disease of cereals and grasses, is especially prevalent in rye. The causal fungus *Claviceps purpurea* (Fr.) Tul. infects the florets, prevents seeds from developing, and replaces some kernels with a large sclerotium or ergot body (Seaman 1971). In addition, alkaloids in ergot sclerotia may cause poisoning when ingested by animals, poultry, and humans. The concentrations of poisonous alkaloids in ergot sclerotia vary among strains and samples but as little as 0.1% ergot in the feed or diet is considered to be potentially hazardous to health. The Canada Grain Act specifies that the highest grades of rye intended for milling should be free from ergot. Rye containing more than 0.33% ergot sclerotia by weight is graded ergoty.

After the initial infection of florets by ascospores from overwintering sclerotia, the fungus produces conidia, which are spread by rain and insects to later-flowering suscepts. Therefore, late maturing, naturally cross-pollinated cereals and grasses may show high levels of ergot infection. Spring rye, in particular, flowers later than fall-sown rye and may be severely infected by conidia from neighboring fields of fall rye or perennial grasses. Seed treatment with fungicides does not control ergot, and there are no resistant cultivars of spring or fall rye (Seaman 1971). Therefore, control methods must be designed to limit the availability of spores of the pathogen and to grow crops that flower at the same time and for as short a period as possible.

Platford and Bernier (1970) reported that a cultivar of spring wheat and another of durum wheat possessed significant degrees of resistance to ergot. Recently a new, high yielding cultivar of spring rye named Gazelle appeared to be less susceptible to ergot infection than other cultivars of spring rye (Sosulski and Curran 1975). The present study was undertaken to determine the level of ergot contamination in seed samples of spring rye cultivars grown in field experiments during 1973 and 1974 in Saskatchewan. These results were compared with the percentages of ergot in seed samples of fall rye cultivars.

Materials and methods

Three spring rye cultivars were grown in replicated yield trials at three locations in 1973 and at four locations in 1974. The entries included Gazelle, a single plant selection from German ryes; S6204, a yellow-seeded genotype developed by Watkins and White (1964); and Prolific, the only commonly grown cultivar of spring rye in western Canada. In addition, five fall rye cultivars were grown in yield trials at Saskatoon in 1973 and 1974.

At harvest, plants from each plot were threshed in the field with a Vogel thresher which has only a minimal cleaning capacity. Loose straw was removed by hand and the seed samples were bagged and weighed. Seed from the four replications in each test was bulked before storage. Ergot sclerotia were separated by hand from the 2 to 3 kg of seed of each cultivar in each test, and the ergot content reported as the weight of sclerotia expressed as a percentage of the total sample weight.

Results and discussion

Fall rye from the 1973 and 1974 replicated field trials had a low incidence of ergot infection. The cultivars Antelope, Cougar, Frontier, Kodiak, and Puma contained between 0.01% and 0.10% ergot in the two experi-

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Table 1. Relationship between percentage of ergot sclerotia and seed yield of spring rye cultivars in experimental plots at four locations in Saskatchewan

Spring rye cultivar	1973			1974				1973–74 Average
	Saskatoon	Indi	Aberdeen	Saskatoon	Indi	Indian Head	Arcola	
	Percentage by weight of ergot sclerotia in seed samples							
Gazelle	0.04	0.00	0.01	0.65	0.41	0.57	0.01	0.24
Prolific 1	0.16	0.68	0.21	1.70	0.53	1.23	0.04	0.65
Prolific 2	0.13	0.88	0.16	1.82	0.68	1.66	0.05	0.77
S6204	0.14	0.51	0.33	1.46	0.93	2.10	0.06	0.79
	Seed yield, quintals per hectare							
Gazelle	31.4	28.9	30.5	28.4	14.7	25.0	26.9	26.5
Prolific 1	22.6	23.6	24.7	21.1	12.2	25.1	21.6	21.6
Prolific 2	23.6	24.6	24.9	21.0	12.2	19.9	21.4	21.1
S6204	23.0	25.1	24.4	15.8	11.7	12.8	18.3	18.7
LSD 0.05	4.2	2.4	2.4	1.5	2.1	–*	4.0	

* Due to flooding, only one replicate was harvested at Indian Head.

ments. The fall rye cultivars headed during the first week of June and the seed was mature about 1 month later.

The cultivars of spring rye headed after June 20 and ripened 1 to 2 weeks after the fall ryes. The percentages of ergot bodies in the spring rye samples were much greater than for fall rye in six of the seven tests grown in 1973 and 1974 (Table 1). The percentages of ergot were particularly high at Saskatoon, Indi, and Indian Head in 1974 when several samples contained over 1.0% ergot. The Arcola test in 1974 showed a low level of infection in the three cultivars.

In all spring rye tests the percentage of sclerotia in seed samples of Gazelle was lower than in those of the other cultivars (Table 1). The average ergot level in the seed samples of Gazelle was only one-third that of Prolific and S6204. The consistency of the differences in each test suggested that Gazelle contained specific tolerance or resistance to ergot infection of the florets or to the formation of ergot bodies after infection.

However, in subsequent single-floret inoculation tests in the greenhouse, Gazelle was found to be as susceptible to ergot as Stewart 63, a nonresistant cultivar of durum wheat (Platford and Bernier 1970). No differences were observed between the rye and the wheat cultivars in amount of honeydew produced and in number and final size of sclerotia formed. It appears that GAzelle does not possess physiological resistance to ergot.

Gazelle yielded about 24% more seed than Prolific in the 1973-74 series of tests (Table 1) and this factor may have accounted for the lower incidence of ergot sclerotia. Presumably Gazelle florets were pollinated more rapidly and more completely than those of the other cultivars, thus limiting the opportunity for ergot infection. Gazelle headed on the same date as Prolific (avg 48 days after seeding) and the seeds matured in 98 days for both cultivars (Sosulski and Curran 1975), so that a difference in date of flowering was not a factor.

Conclusions

Spring rye cultivars showed higher levels of ergot infection than fall ryes, which was probably due to their later period of flowering. Ergot infection of some spring rye plots exceeded 1.0% because of small plot size and close proximity to roadways sown to perennial grasses. It appears that natural infections in experimental plot areas are sufficient to demonstrate differences in tolerance or resistance to ergot by spring rye cultivars.

Gazelle spring rye was consistently lower in percentage of ergot sclerotia in seed samples from plots grown at seven locations in 1973 and 1974. Single floret inoculation tests demonstrated that Gazelle lacked physiological resistance to ergot. The lower incidence of ergot observed in this cultivar in the field was apparently due to a better flowering habit which allowed Gazelle to escape infection to a greater degree than other spring cultivars.

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