Prevalence of six fungal pathogens associated with seeds of rape and turnip rape in Western Canada in 1976[1]

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Commercial seed lots of rape ***(Brassica napus)*** and turnip rape (B. ***campestris)*** from the year 1976 were examined for six fungal pathogens and the results compared with those of an earlier study conducted between 1967 and 1973. The six species were ***Alternaria brassicae, A. raphani, Fusarium roseum, Botrytis cinerea. Sclerotinia sclerotiorum,*** and ***Albugo candida (A. cruciferarum).*** The prevalence and incidence of all these, with the exception of ***A. brassicae,*** were higher in 1976 than in 1967-73. A considerable increase in ***A. raphani*** occurred on seed from southern Alberta and from Manitoba but levels of ***A. brassicae*** remained relatively static or even declined, except in the Peace River area of Alberta. ***B. cinerea*** occurred in 74% of seed samples from northern Alberta, indicating the possibility of an increase in seedling emergence problems. In that area also there was a large increase in S. ***sclerotiorum*** occurring in or on the seed itself, as opposed to its occurrence as sclerotia mixed with the seed. Oospores of ***A. candida*** were found in a much higher percentage of Alberta and Saskatchewan samples of ***B. campestris*** in 1976 than in 1967-73; mean infestation levels, as spores per g of seed, and the proportion of heavily infested samples also increased.

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Nous avons examine la mycoflore pathogene de lots de semences de colza ***(Brassica napus)*** et de navette ***(B. campestris)*** de la campagne 1976, et compare les résultats avec ceux d'une etude anterieure realisee entre 1967 et 1973. Nos travaux recherchaient particulierement six espèces: ***Alternaria brassicae, A. raphani, Fusarium roseum. Botrytis cinerea, Sclerotinia sclerotiorum*** et ***Albugo candida (A. cruciferarum).*** La frequence et la densité d'infestation de chacune de ces espèces *se* sont revelees plus fortes que dans la periode d'observation precedente. sauf dans le cas de ***A. brassicae.*** On a note une nette recrudescence de ***A. raphani*** dans les semences en provenance du Manitoba et du sud de l'Alberta, mais la frequence de ***A. brassicae*** est demeuree relativement stationnaire, et a même baisse, sauf dans la zone de la riviere de la Paix en Alberta. ***B. cinerea*** a ete trouve sur 74% des echantillons du nord de l'Alberta, ce qui laisserait prévoir une augmentation des troubles de levee des semis. Cette region accuse aussi un fort accroissement de S. ***sclerotiorum*** a la surface ou a l'intérieur des graines, plutôt que sous forme de sclerotes melanges a la semence. Les oospores de ***A. candida*** étaient beaucoup plus frequents dans les echantillons de ***B. campestris*** de l'Alberta et de la Saskatchewan que dans la periode 1967-1973; les taux moyens d'infestation, établis d'apres le nombre de spores par gramme de semences, ont egalement augmente, de même que la proportion d'échantillons fortement infestés.

The results of a survey of seed-borne fungi of oilseed crops in Western Canada conducted between the years 1967 and 1973 have been published recently (5, 6). This paper reports the results of a similar study in which seed lots of rape ***(Brassica napus*** L.) and turnip rape (***B. campestris*** L.) from the year 1976 were examined for pathogenic fungi as part of an ongoing periodic investigation of levels of pathogens in crucifer seed in the Prairie Provinces. Data for the following six pathogens will be presented; the diseased caused by each follows its Latin binomial: ***Alternaria brassicae*** (Berk.) Sacc. (alternaria black spot), ***A raphani*** Groves & Skolko (alternaria black spot), ***Fusarium roseum*** Lk. emend. Snyder & Hansen (mostly 'Acuminatum') (seedling blight and footrot), ***Botrytis cinerea*** Pers. ex Fr. (damping-off and seedling blight), ***Sclerotinia sclerotiorum*** (Lib.) de Bary (sclerotinia stem rot), and ***Albugo candida*** (Pers. ex Lev.) Ktze. ***(A. cruciferarum*** S. F. Gray) (white rust and staghead).

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Materials and methods

Seed lots of approximately 15 g each drawn at random from country grain elevators throughout the Prairie Provinces were obtained from the Canadian Grain Commission. On a provincial basis, total numbers of samples were as follows: 205 from Saskatchewan, 173 from Alberta, and 57 from Manitoba. Distribution of samples by crop district or agricultural reporting area is shown in Table 1. The crop districts recognized were those illustrated by Williams (9).

Subsamples of 200-300 seeds were plated on an agar medium as previously described (8) and, in the case of the lots of ***B. campestris*** seed, 5 g subsamples were also examined for oospores of ***Albugo candida*** by means of a washing and filtration technique (6).

Results

Percentages of samples infested by all of the pathogens except ***Albugo candida*** are presented in Table 1. The average % of seeds infested per sample for the two ***Alternaria*** species is given in Table 2 and these data for ***Botrytis cinerea, Fusarium roseum*** and ***Sclerotinia sclerotiorum*** in Table 3. Manitoba results were not

Table 1. Percentages of rapeseed samples from Saskatchewan, Alberta, and Manitoba infested by five fungal pathogens of rape in 1976

Province & C. D. or A. R. A.*	No. of samples plated		Pathogen					
			Alternaria brassicae	*Alternaria raphani*	One or both**	*Botrytis cinerea*	*Fusarium roseum*	*Sclerotinia sclerotiorum*
Saskatchewan								
1-3	10		**10.0**	70.0	70.0	10.0	30.0	***0.0***
5	24		41.7	79.2	79.2	12.5	29.2	0.0
6	22		9.1	54.6	54.6	4.6	9.1	0.0
7	18		27.8	94.4	100.0	11.1	11.1	0.0
8A	23		69.6	95.7	100.0	8.7	39.1	4.4
8B	34		20.6	70.6	73.5	14.7	50.0	0.0
9A	33		66.7	60.6	84.8	3.0	30.3	0.0
9B	41		48.8	70.7	90.2	4.9	34.1	0.0
Provincial total	205	Av.	40.5	73.2	82.4	8.4	31.2	0.5
Alberta								
1	1		0.0	0.0	0.0	0.0	0.0	0.0
2	20		20.0	100.0	100.0	25.0	35.0	0.0
3	6		33.3	83.3	83.3	33.3	33.3	0.0
4	65		56.9	75.4	78.5	32.3	43.1	1.5
5	30		80.0	93.3	93.3	50.0	53.3	1.3
6	16		87.5	87.5	93.8	50.0	75.0	12.5
7	35		91.4	100.0	**100.0**	74.3	54.3	14.3
Provincial total	173	Av.	65.3	87.3	89.0	44.5	48.6	5.2
Manitoba								
1+2	9		0.0	22.2	22.2	0.0	11.1	***0.0***
7-9	10		**10.0**	40.0	40.0	0.0	40.0	*0.0*
3-6	12		8.3	25.0	25.0	8.3	8.3	***0.0***
10+11	17		11.8	47.1	47.1	0.0	11.8	***0.0***
12-14	9		66.7	88.9	100.0	22.2	77.8	***0.0***
Provincial total	57	Av.	17.5	43.9	45.6	5.3	26.3	***0.0***

* Crop district or agricultural reporting area (Alberta).
** Refers to *Alternaria* spp.

included in Table 3 due to the rather sporadic low levels of infestation found.

A large majority of the samples from Saskatchewanwere B. ***napus.*** The 1976 results for ***Alternaria*** spp. were similar to those recorded between 1968 and 1972 for this crop species [ref. (5), Table 2], with the exception that the levels of A. ***raphani*** were higher in 1976 than in any of the years covered in the earlier study. This increase in ***A. raphani*** was even more marked in Alberta samples, which were almost entirely ***B. campestris*** [comparing Tables 1 and 2 with ref. (5), Table 3]. Much heavier infestations of both ***A. brassicae*** and ***A. raphani*** occurred in the Peace River area (A.R.A. 7) in 1976 than in either 1969 or 1970 [ref. (5), Table 9], but much lower levels of ***A. brassicae*** were found in A.R.A. 6 in 1976. A large increase in ***A. raphani*** in A.R.A.'s 2 and 3 was also noted in that year. Manitoba samples were largely B. ***napus.*** A large increase in 1976 in the levels of ***A. raphani*** was noted here as well [comparing Tables 1 and 2 and ref. (5), Table 4].

Fusarium roseum occurred in a relatively large number of Saskatchewan samples, comparable to the high levels of 1972 [Table 1 and (5), Table 14]. It was much more prevalent in Alberta and Manitoba samples than in previous years [Table 1 and ref. (5), Table 15]. The infestation levels within samples (Table 3) are averages for infested samples only and are not directly comparable with those reported in the earlier paper. However,

Table 2. Mean % seeds infested per sample by *Alternaria* spp.; 1976 seed lots from Saskatchewan, Alberta, and Manitoba

Province & C. D. or A. R. A.*	All samples			Infested samples only		
	Alternaria brassicae	*Alternaria raphani*	One or both	*Alternaria brassicae*	*Alternaria raphani*	One or both
Saskatchewan						
1-3	0.1	0.9	0.9	0.5	1.2	1.3
5	0.4	1.9	2.3	0.9	2.4	2.9
6	0.2	0.7	0.9	2.3	1.3	1.7
7	0.3	1.3	1.6	1.0	1.4	1.6
8A	0.8	2.1	2.9	1.2	2.2	2.9
8B	0.1	1.2	1.3	0.5	1.7	1.7
9A	1.5	1.9	3.5	2.3	3.2	4.1
9B	0.7	1.4	2.1	1.4	2.0	2.3
Provincial average	0.6	1.5	2.1	1.4	2.0	2.5
Alberta						
2	0.2	5.6	5.8	0.8	5.6	5.8
3	0.3	5.3	5.5	0.8	6.3	6.6
4	1.2	1.8	3.0	2.1	2.4	3.8
5	2.3	2.2	4.4	2.8	2.3	4.7
6	1.5	8.8	10.3	1.7	10.0	10.9
7	6.0	21.0	26.9	6.6	21.0	26.9
Provincial average	2.2	6.9	9.1	3.4	7.9	10.3
Manitoba						
1+2	0.0	0.1	0.1	0.0	0.5	0.5
7-9	0.1	0.2	0.3	0.5	0.5	0.6
3-6	< 0.1	0.2	0.2	0.5	0.7	0.8
10+11	0.1	2.2	2.3	1.0	4.7	4.9
12-14	2.1	4.6	6.6	3.1	5.1	6.6
Provincial average	0.4	1.5	1.9	2.1	3.3	4.0

'Crop district or agricultural reporting area (Alberta).

most *Fusarium* infestations of farm seed samples encountered since 1968 have been light.

Considerably more *Botrytis cinerea* occurred in Alberta samples in 1976 than in those from the other two provinces (Tables 1 and 3). Levels of infestation in Manitoba samples were comparable to those in seed lots from Saskatchewan. Over 74% of samples from the Peace River area of Alberta were infested by this species. Infested samples from Saskatchewan were more prevalent in 1976 than in four previous years [Table 1 and ref. (5)].

Sclerotinia sclerotiorum was not detected in Manitoba samples and rarely detected in those from Saskatchewan. However, it was found in over 5% of Alberta seed lots, including 12.5% of those from A.R.A. 6 and 14.3% of those from A.R.A. 7 (Table 1). The average infestation level for samples from A.R.A. 7, considering infested samples only, was 1.2% (Table 3). This is a substantial increase over earlier years. Most of this represented infestation of the seed itself as opposed to the occurence of sclerotia in the samples (see 4). Recently sclerotia have been found commonly in newly harvested rapeseed (3). However, results reported here and earlier (4, 5) indicate that they are much less common following commercial cleaning of the seed and those present are relatively small, as one would expect.

Oospores of *Albugo candida* were found in a much higher percentage of samples of B. *campestris* in 1976 than in almost all other years for which data are available, both in the case of Saskatchewan and Alberta seed [Table 5 and ref. (6), Tables 7 & 8]. The average infestation level for 1976 for Saskatchewan (28 spores per g of seed) was higher than in any of six previous years, with the exception of 1968 in which it was 41

Table 3. Mean % seeds infested per sample by ***Botrytis cinerea, Fusarium roseum,*** and ***Sclerotinia sclerotiorum;*** seed lots from Saskatchewan and Alberta"

Province & C. D. or A. R. A. **	Fungal pathogens		
	Botrytis cinerea	***Fusarium roseum***	***Sclerotinia sclerotiorum***
Saskatchewan			
1-3	0.5	0.6	0.0
5	0.5	1.4	0.0
6	0.5	0.5	0.0
7	0.5	0.5	0.0
8A	1.7	0.6	0.5
8B	0.3	0.6	0.0
9A	0.5	0.9	0.0
9B	0.5	0.6	0.0
Provincial average	0.6	0.7	0.5
Alberta			
2	0.5	0.6	0.0
3	0.5	0.5	0.0
4	1.0	1.4	0.5
5	1.5	1.1	0.5
6	1.3	3.3	0.5
7	4.7	1.6	1.2
Provincial average	2.3	1.6	0.9

* Infested samples only
** Crop district or agricultural reporting area (Alberta).

Table 4. Oospores of Albugo ***candida*** detected in seed lots of ***Brassica campestris*** grown in Saskatchewan, Alberta, and Manitoba in 1976

Province & C. D. or A. R. A.*	No. of samples washed	Oospores per g of seed	
		Av.	Max.**
Saskatchewan			
1-3	5	24.6	49
5	11	56.7†	509
6	5	15.3	40
7	9	47.7#	354
8	13	33.4	116
9A	12	11.6	43
9B	17	10.1	31
Provincial average (72 samples)		27.7	509
Alberta			
1&3	7	116.4††	598
2	17	38.1	397
4	53	46.1	519
5	27	37.2	186
6	16	39.7	342
7	32	172.6	1964
Provincial average (152 samples)		72.8	1964
Manitoba			
Provincial average (29 samples)		6.9	52

* Infested samples only
** Crop district or agricultural reporting area (Alberta).
Max. = highest no. oospores in any sample.
† Omitting highest value, mean no. oospores = 11.5 per g.
†† Omitting highest value, mean no. oospores = 9.4 per g.
# Omitting highest value, mean no. oospores = 36.1 per g.

spores per g [Table 4 and ref. (6), Table 4]. The same was true of Alberta, except that the 1969 value of 92 spores per g of seed exceeded the 73 spores per g recorded in 1976 [Table 4 and ref. (6), Table 5].

Relatively low levels of oospore inoculum were detected in Manitoba samples in previous years and 1976 was no exception (Tables 4 and 5). Mean infestation levels for the various crop districts in Saskatchewan (Table 4) were similar, if extremely high values at variance with those for other samples in the district were omitted (see footnote, Table 4). The same was true for agricultural reporting areas in Alberta (Table 4).

The percentages of samples in each of 10 infestation severity categories are presented in Table 5. When these data are compared with those in Tables 7 and 8 of the earlier paper (6), it is apparent that with few exceptions a considerably larger number of heavily infested samples occurred in 1976 than in the years from 1967 to 1973. Most samples had fewer than 43 spores per gram of seed. If one arbitrarily considers samples with 44 or more spores per gram as being heavily infested, then 12.5% of the 1976 Saskatchewan seed lots and 25.7% of those from Alberta were in this category. The 1967-73 averages for Saskatchewan showed 6.5% of the samples heavily infested; the comparable figure for Alberta was 13.1%. Manitoba samples did not exhibit this increase [Table 5 and ref. (6), Table 9]. The highest level of infestation found in any 1976 seed lot was 1964 spores per g in a sample from Donnelly, Alberta (A.R.A. 7). The most heavily infested Saskatchewan sample was one from Margo in C.D. 5 with 509 spores per g. A seed lot from Inglis with 52 spores per g was the most heavily infested one originating in Manitoba.

Discussion

It is quite apparent that the prevalence and incidence of almost all of the fungal species considered here were higher in 1976 than in the earlier study (5, 6), at least over large portions of the rape-growing area. A considerable increase in ***Alternaria raphani*** was noted on seed

Table 5. Oospores of *Albugo candida* in seed samples of ***Brassica campestris*** from the three Prairie Provinces in 1976 - Percentage of 253 samples in each of 10 infestation severity categories

Province	No. of oospores per g of seed									
	0	Tr-3	4-11	12-43	44-86	87-129	130-323	324-645	646-1290	Over 1290
Saskatchewan	1.4	26.4	23.6	36.1	8.3	1.4	0.0	2.8	0.0	0.0
Alberta	2.0	16.5	16.5	39.5	9.2	4.0	5.9	5.3	0.7	0.7
Manitoba	10.4	55.2	17.2	13.8	3.5	0.0	0.0	0.0	0.0	0.0
3-province average*	2.8	23.7	18.6	35.6	8.3	2.8	3.6	4.0	0.4	0.4

*Values for all samples in each category

originating in southern Alberta and in Manitoba, whereas levels of A. ***brassicae*** remained relatively static or even declined, with a few exceptions such as A.R.A. 7 in Alberta. There is increasing evidence that A. ***raphani*** is a less serious pathogen than A. ***brassicae.*** A. ***raphani*** can produce rather superficial infections on some species of ***Brassica*** which are only slightly affected by A. ***brassicae,*** and it is better able to survive saprophytically on non-host species (1, 5).

It should be noted that the common occurrence of ***Botrytis cinerea*** on seed from the Peace River area of Alberta could contribute substantially to seedling emergence problems and post-emergence damping-off in the absence of seed treatment. The increased levels of A. ***candida*** oospore infestations in seed lots is also worthy of re-emphasis. Recent data (Verma and Petrie, unpublished) indicate that seed-borne oospores can substantially increase the percentage of plants with systemic infections of the inflorescence.

In certain areas, timely rainfall may have contributed to the higher levels of pathogens on seed in 1976. For example, many reporting stations in Alberta recorded above normal precipitation in August, but the reverse was true in Saskatchewan (2). Another factor to be considered, however, is the progressive build-up of inoculum of a wide array of disease-causing fungi in the soil and on weed species with the continued intensive cultivation of rape on the prairies. A good example of a wild crucifer species which now appears to function efficiently as a reservoir for a number of fungi attacking rape is wild mustard, ***[Brassica kaber*** (DC.) Wheeler var. ***pinnatifida*** (Stokes) Wheeler]. In addition, there have been recent examples of the rather sudden advent of serious new races or strains of some pathogens, often with unfortunate results [ref. (7) and unpublished data].

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