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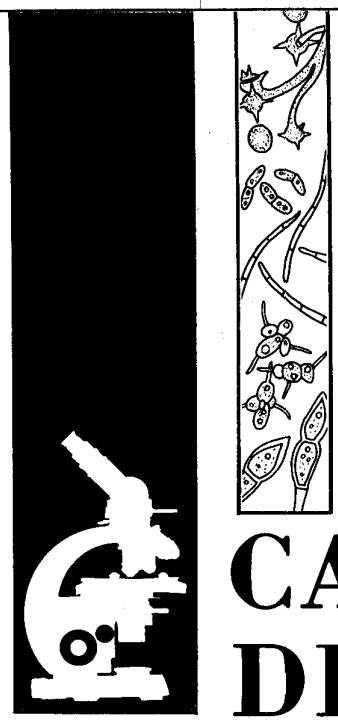

# CANADIAN PLANT DISEASE SURVEY

EDITOR W.L. SEAMAN

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

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## CONTENTS



"The Canadian Plant Disease Survey is a periodical of information and record on the occurrence and severity of plant diseases in Canada. It will also accept other original information such as the development of methods of investigation and control, including the evaluation of new materials. Review papers and compilations of practical value to phytopathologists will be included from time to time."

# NEMATODES ASSOCIATED WITH FORAGE LEGUME CROPS IN NOVA SCOTIA[1]

*C.B. Willis,[2] A.L. Henderson, D.J. Hough, and J.D. Secord* [3]

## Abstract

Nematodes belonging to the genera Pratylenchus, Meloidogyne, Heterodera, Paratylenchus, Tylenchorhynchus, Helicotylenchus, and Criconemoides were isolated from field soil and from rootlets of birdsfoot trefoil, red clover and alfalfa in Nova Scotia in 1970. Pratylenchus had the widest distribution, followed by Paratylenchus, Helicotylenchus, and Meloidogyne. Xiphenema was isolated only from soil seeded to alfalfa. A positive correlation was observed between forage legume rootlet color and Pratylenchus population density.

## Introduction

Red clover (Trifolium pratense L.), alfalfa (Medicago sativa L.) and birdsfoot trefoil (Lotus corniculatus L.) are the principal forage legume crops grown in Nova Scotia, where they are seeded in mixtures with grasses. A survey of forage growing areas in the province was carried out to determine the occurrence and population density of plant-parasitic nematodes. This paper summarizes the results of a preliminary survey of nematodes in red clover, alfalfa, and birdsfoot trefoil fields in Nova Scotia.

## Materials and methods

Soil and root samples were collected in September, October, and November 1970 from 36 fields on 20 farms located in Annapolis, Colchester, Cumberland, Hants, Kings, Lunenburg, and Pictou counties. Farms and fields were chosen without prior knowledge of nematode problems. The soils ranged from a gravelly loam to a clay loam with drainage rated from excellent to poor.

From each field, 20 soil cores (2.54 x 15.0 cm) and a minimum of 10 root systems were taken. Only the predominant forage legume was sampled in each field. Soil samples were passed through a 2 mm screen to remove rocks and larger roots. Nematodes from two 50 g subsamples from each soil sample were extracted by the modified cottonwool filter method (9). Root samples were washed and the rootlet portion was rated visually for discoloration. Rootlet color was rated as light or medium-dark (light for little or no discoloration, medium-dark for extensive brown to black discoloration). The rootlets were then trimmed from the tap roots and larger secondary roots and were cut into short pieces; a maximum of 10 g of rootlets from each root sample were extracted for 7 days by the funnel-spray method (6). Nematodes were identified visually to genus under a dissecting microscope and counts were recorded as the number of nematodes per 0.45 kg of soil (oven dry weight) and per g dry weight of rootlet. The data were compiled according to forage legume crop and to the year in which the crop was seeded.

## Results

### Frequency of occurrence

Root-lesion (Pratylenchus), root-knot (Meloidogyne), pin (Paratylenchus), cyst (Heterodera), spiral (Helicotylenchus), stunt (Tylenchorhynchus), ring (Criconemoides), and dagger (Xiphinema) nematodes were isolated (Tables 1 and 2). Root-lesion nematodes were isolated from 89% of the root samples and from 92% of the soil samples. Root-knot larvae were obtained from 36% and 33% of the root and soil samples, respectively. There were no great differences in the incidence of either nematode among the three forage legumes or among the three seeding years. Pin nematodes were the second and spiral nematodes the third most frequently recovered nematodes. Cyst nematode larvae, stunt nematodes, and ring nematodes were recovered less frequently. The dagger nematode was recovered from only 6% of the soil samples and all of these were seeded to alfafla.

### Population density

The population density of root-lesion nematodes was high in infested rootlet samples (Table 1) but was highest in soil samples (Table 1 and 2). However, the root-knot nematode was more abundant in infested rootlets, with an overall mean of 4,266 nematodes/g of rootlets, than in soil

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Table 1. Population density of root-lesion and root-knot nematodes in infested samples of rootlets and soil from 36 fields of forage legumes

| | Root-lesion nematode | | | | | | Root-knot nematode | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots | | | Soil | | | Roots | | | Soil | | |
| Forage legume and year seeded | No. of samples | Range* | Mean* | No. of samples | Range† | Mean† | No. of samples | Range* | Mean* | No. of samples | Range† | Mean† |
| Birdsfoot trefoil | 9 | 9-20,663 | 4,346 | 9 | 534-6,003 | 2,021 | 4 | 9- 1,333 | 346 | 4 | 68-1,556 | 530 |
| Red clover | 7 | 44-11,771 | 3,473 | 7 | 178-8,271 | 2,141 | 3 | 73-11,142 | 4,168 | 3 | 435- 631 | 503 |
| Alfalfa | 16 | 18-21,049 | 1,887 | 17 | 140-9,706 | 2,912 | 6 | 424-33,425 | 6,929 | 5 | 68-4,742 | 1,553 |
| All legumes | | | | | | | | | | | | |
| 1968 or earlier | 12 | 18-14,780 | 2,866 | 12 | 140-9,706 | 4,416 | 5 | 73- 4,728 | 1,593 | 5 | 442-4,742 | 1,765 |
| 1969 | 9 | 9- 2,575 | 891 | 10 | 328-8,271 | 1,716 | 5 | 9-33,425 | 9,179 | 4 | 68- 631 | 328 |
| 1970 | 11 | 44-21,049 | 4,654 | 11 | 178-3,876 | 1,139 | 3 | 12- 1,163 | 553 | 3 | 68- 869 | 418 |
| All legumes from all seeding years | 32 | 9-21,049 | 2,925 | 33 | 140-9,706 | 2,505 | 13 | 9-33,425 | 4,266 | 12 | 68-4,742 | 949 |

* Range and mean number of nematodes/g rootlets.

† Range and mean number of nematodes/0.45 kg soil.

Table 2. Population density of five nematode types in infested samples of soil from 36 fields of forage legumes

| | Pin nematode | | | Cyst nematode | | | Stunt nematode | | | Spiral nematode | | | Ring nematode | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forage legume and year seeded | No. of samples | Range* | Mean* | No. of samples | Range* | Mean* | No. of samples | Range* | Mean* | No. of samples | Range* | Mean* | No. of samples | Range* | Mean* |
| Birdsfoot trefoil | 7 | 213-5524 | 2495 | 2 | 113-1281 | 697 | 1 | | 219 | 7 | 34-1095 | 361 | 4 | 35-119 | 111 |
| Red clover | 5 | 104-1415 | 409 | 3 | 104-2321 | 1153 | 1 | | 103 | 5 | 104-1197 | 425 | 1 | | 218 |
| Alfalfa | 15 | 69-5569 | 925 | 4 | 69-1195 | 569 | 6 | 310-619 | 461 | 7 | 33-1100 | 475 | 3 | 107-548 | 356 |
| All legumes | | | | | | | | | | | | | | | |
| 1968 or earlier | 9 | 69-5114 | 1398 | 3 | 69-2321 | 995 | 3 | 310-550 | 433 | 6 | 104-1100 | 424 | 4 | 112-548 | 318 |
| 1969 | 9 | 105-5569 | 1763 | 2 | 113-1281 | 697 | 3 | 219-619 | 463 | 8 | 33-1197 | 504 | 3 | 35-218 | 117 |
| 1970 | 9 | 69-2006 | 549 | 4 | 104-1195 | 687 | 2 | 103-301 | 202 | 5 | 34- 536 | 212 | 1 | | 107 |
| All legumes from all seeding years | 27 | 69-5569 | 1237 | 9 | 69-2321 | 792 | 8 | 103-619 | 386 | 19 | 33-1197 | 402 | 8 | 35-548 | 216 |

* Range and mean number of nematodes/0.45 kg soil.

samples, which contained a mean of 949/0.45 kg soil. Mean numbers of root-lesion nematodes recovered from rootlet samples were lowest from alfalfa and highest from birdsfoot trefoil. Mean numbers of root-lesion nematodes recovered from soil samples were lowest from fields seeded in 1970 and highest from fields seeded in 1968 or earlier. Recovery of root-knot nematodes was greatest from alfalfa rootlets. The pin nematode had the second highest population mean from infested soil samples; cyst, stunt, spiral, and ring nematodes had lower means (Table 2).

The color of forage legume rootlets ranged from little or no discoloration to very dark brown or black; rootlets in the latter category were rotting and were difficult to recover in the field. The mean number of root-lesion nematodes recovered/g rootlets from samples that were classified medium-dark was much higher than from samples classified light (Table 3). More than 5X the number of root-lesion nematodes were recovered from soils from which medium-dark rootlets were recovered.

## Discussion

It is recognized that several factors contribute to the often observed depletion of the legume component in legume-grass mixtures. The root rot complex is one such factor that has been identified in the Maritime Provinces (7), and root-lesion nematodes have also been associated with forage legumes (11).

The frequency of occurrence of root-lesion nematodes in this study was similar to that reported from strawberry fields in Nova Scotia (10), but was much greater than that reported from red clover and alfalfa fields in North Carolina (2). A high population density coupled with the high frequency of occurrence and the previous demonstration (8) of forage yield reductions indicate that

Table 3. Relationship of forage legume rootlet color and number of root-lesion nematodes *(Pratylenchus)* isolated from rootlet and soil samples

| Rootlet color | No. of samples | Mean number of nematodes per sample: Rootlets (no./g) | Mean number of nematodes per sample: Soil (no./0.45 kg) |
|---|---|---|---|
| Light | 22 | 1524 (± 946)* | 883 (±136) |
| Medium-dark | 14 | 4291 (±1770) | 4520 (±869) |

* Figures in brackets are standard errors of the means.

root-lesion nematodes are economically important in forage production in Nova Scotia.

No root-knot nematodes were recovered from Nova Scotia strawberry fields (10) but they were recovered from 33% and 25% of the root and soil samples, respectively, of the fields sampled in this study. The hoot-knot nematode has also been shown to have detrimental effects on forage legumes (5), and, since it had the greatest population density in infested root samples in this study, this nematode could also be considered economically important.

Pin nematodes occurred more frequently and stunt and dagger nematodes less frequently in the present study than in the strawberry and forage surveys referred to above (2, 10). No cyst nematodes were recovered from the Nova Scotia strawberry fields (10), but were isolated from fields of each forage legume in this survey. Of these nematodes, the cyst nematode has reduced forage yields of red clover in the field (4); the stunt nematode had no effect on yield of alfalfa or red clover in greenhouse studies (1); and the dagger nematode, which was recovered from only 2 alfalfa fields in this study, has been reported to reduce alfalfa yields (3).

The positive correlation ($r = 0.6609^{**}$) observed in this study between the color of forage legume rootlets and the recovery of root-lesion nematodes from soils suggests that these nematodes are involved in the frequently observed root rot complex (7). A similar relationship between rootlet color and the prevalence of other nematode species was not observed.

The frequency of occurrence and population densities of endo- and ecto-parasitic nematodes associated with forage legume crops in Nova Scotia indicated a definite need for further research on host-parasite relationships, as well as on the economic importance of nematode infestations, and on the relationships of nematodes to the root rot disease complex.

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# LOSSES FROM FOLIAGE DISEASES OF FORAGE CROPS IN CENTRAL AND NORTHERN ALBERTA IN 1970

*B. Berkenkamp*[1]

## Abstract

An extensive survey of foliar diseases of forage crops was carried out in central and northern Alberta in 1970. Methods were devised to estimate the severity of each disease of each species, and these were used to estimate losses. A loss of 5.65% or $4.7 million was found.

## Introduction

Although it is known that diseases reduce the potential yield of forage crops, there is very little published information on the extent of this reduction or its value. There is likewise a dearth of information on methods of estimating losses. This paper outlines a method for determining losses and reports estimates of losses caused by foliage diseases of forage crops based on an extensive survey of central and northern Alberta in 1970, as a part of the National Crop Disease Loss Assessment Program.

Winter crown rot and other root and crown diseases of legumes were not surveyed due to the short period during which symptoms appear, but losses from these diseases may approach or surpass those caused by foliar diseases. Insufficient information was available on root diseases of grasses to allow a meaningful survey. One would suspect that variation in severity of various diseases would occur from year to year and attempts will be made to compare prevalence and severity over several years.

## Materials and methods

One percent of the farms growing forage crops (2) in seven of the Alberta Census Divisions (CD) 8-15 (Figure 1) were surveyed during the period June 29 to September 8. CD 9 was not included because of a sparsity of farms. Leaf and stem samples from 5,150 forage plants were collected from 305 fields and examined for disease symptoms. The fields selected were at least 2 miles apart and in each the percentage contribution of those plant species comprising at least 5% of the forage mixture was estimated. Ten shoots of each of these species were collected at 2-pace intervals starting at a point 20 paces from the edge of the field and following a line approximately 45 degrees from the edge. The plants were examined in the field or were kept for short periods in labelled plastic bags. Pastures and recently cut fields in which legumes were in a pre-bud stage or grasses in a pre-boot stage were not sampled. For each field the date of sampling, approximate location, Census Division, percentage of each forage species, presence of the various diseases and average severity of each disease were recorded.

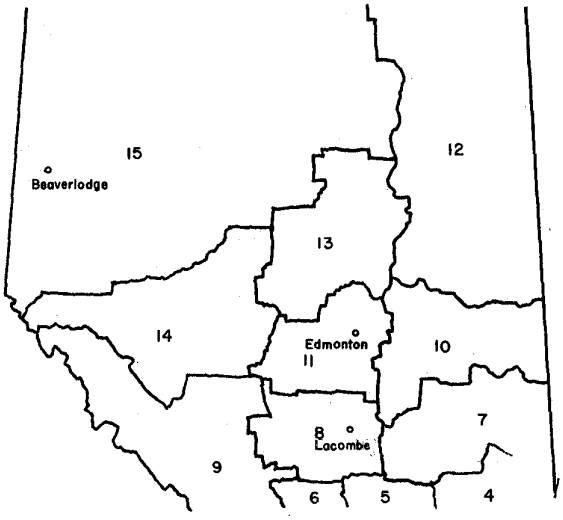


Figure 1. Map of central and northern Alberta showing Census Divisions.

A disease index based on severity was determined for each disease. Yellow leaf blotch and common leaf spot of alfalfa were assessed using the key in Figure 2.

For other foliage diseases, indices were based on the % leaves affected or on the % leaf area affected. Percentage of leaves affected was used as the basis for assessing brown stripe of creeping red fescue and stagonospora leaf spot, pepper spot, downy mildew, rust, sooty blotch, northern anthracnose, powdery mildew, and black-stem leaf spot of alfalfa and clovers. Percentage leaf area affected was used for drechslera leaf streak of timothy, using a key described by James et al. (5) and applying it to all

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the leaves present on each shoot. The leaf area affected by heterosporium leaf spot of timothy was determined by estimating the number of spots per leaf and multiplying by 0.15, the ratio of lesion-to-leaf area.

| *Disease Index* | *Symptoms* |
|---|---|
| 0.1 | Symptoms present in field. |
| 1.0 | Symptoms on more than 2 leaves per shoot but fewer than 7. Almost all plants show symptoms. |
| 5.0 | Symptoms generally restricted to the lowest quarter of shoot. |
| 10.0 | Very little defoliation. Leaves on the upper half of shoot nearly free of symptoms. |
| 25.0 | Leaf symptoms severe on the lower half of shoots. Upper leaves showing moderate symptoms but with green growing tips. |
| 50.0 | Severe leaf symptoms up to three-quarters length of shoot. Lowest quarter defoliated. |
| 75.0 | Severe symptoms on three-quarters of all leaves, only growing tips green. Up to half of stem defoliated. |

Figure 2. Key to severity of yellow leaf blotch and common leaf spot of alfalfa.

The percentage of stem area affected was determined for black stem of alfalfa and clovers and for stem eyespot of creeping red fescue.

Horsfall (4) has shown that for each percentage of diseased leaves the loss is 0.25% due to stemphylium leaf spot on red clover. This factor was applied to other crops and their diseases. He also stated that severe powdery mildew apparently reduced the crop 25-33%. Davies et al. (1) reported that spraying ryegrass affected by powdery mildew and rhynchosporium leaf blotch with a fungicide gave a yield increase of up to 25% depending on the level of infection, which was presumably near 100%. Therefore, the disease index, corresponding to percent area affected, was multiplied by 0.25 to obtain percent loss for all legumes and grasses surveyed. The validity of this factor should be verified for each disease by field tests.

The disease index for each field was calculated by multiplying the total disease index for all diseases of each species by the proportion of that species in the field and adding the indices of other species present. The average disease index for each Census Division was multiplied by 0.25 to give percent loss. Potential production is actual production plus yield loss. No adjustment was made for loss in quality (6). Acreage, yield, and actual production were derived from the survey, with assistance and data from the Alberta Marketing and Statistics Branch, (H.H. Bryce, personal communication).

## Results and discussion

Alfalfa was the species most frequently used in forage mixtures in the area surveyed (Table 1), comprising 45.5% of the total cultivated forage. These figures are somewhat biased in favor of legumes, since they recover more rapidly than grasses after cutting and make up a greater percentage of hay in second and subsequent cuttings. No allowance for seed or pasture production was made and all acreage was considered as producing hay. Since the survey was carried out over a period of 72 days, disease severity in fields sampled early in the survey was actually less than in the later samplings, but no attempt was made to adjust for this. This feature would tend to underestimate losses. Incidence and severity ratings of forage crop diseases in each Census Division are shown in Table 1.

Census figures do not report species and mixtures cultivated for forage but report all as "tame hay". Thus in estimating losses, the species and diseases were combined. Table 2 shows acreage, yield, and loss by Census Division, and totals or averages for the northern half of Alberta. The low loss in CD 14 was partially due to the common use of wheatgrass, on which disease was not estimated.

The legumes were found to be more seriously affected by diseases than grasses and were infected by a larger number of different diseases. Red clover sustained the greatest percentage loss, 7.28%, composed mostly of powdery mildew, 3.04%; stagonospora, 2.17%; and northern anthracnose, 1.11%. Alsike clover had a total loss of 7.03%, composed chiefly of powdery mildew, 3.54% and stagonospora, 2.83%. Alfalfa, the most common forage crop, sustained a disease loss of 5.81%, most of it caused by yellow leaf blotch, 2.87; black stem, 1.45%; and common leaf spot, 1.3%. Harding (3) reported a similar relationship in Saskatchewan in 1967. Only one major disease was found on brome, drechslera leaf blotch causing 2.56% loss, and on timothy, drechslera leaf streak, causing 1.46% loss.

As suggested, the loss figures of $4.6 million or 5.65% could be an underestimate. As this loss is from leaf and stem diseases only, it is obvious that when root and crown disease losses are added the loss of potential forage yield due to disease is very substantial.

Table 1. Incidence and severity of foliage diseases of forage crops in central and northern Alberta, 1970

1. ALFALFA (*Medicago sativa* L.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Yellow leaf blotch | Black stem | Stagon-ospora | Pepper spot | Downy mildew | Common leaf spot |
|---|---|---|---|---|---|---|---|---|
| 8 | 148.0 | 29 | 21/ 9.87** | 22/8.22 | 10/0.04 | 0/0 | 6/0.02 | 11/ 0.92 |
| 10 | 142.1 | 47 | 43/11.44 | 46/5.46 | 19/0.15 | 12/0.06 | 5/0.26 | 39/ 4.52 |
| 11 | 177.2 | 36 | 33/14.11 | 31/3.37 | 16/0.20 | 5/0.40 | 0/0 | 32/ 6.23 |
| 12 | 147.7 | 21 | 7/ 0.58 | 20/5.02 | 9/2.34 | 1/1.43 | 2/0.01 | 19/10.68 |
| 13 | 175.4 | 31 | 26/10.33 | 26/8.89 | 11/0.64 | 0/0 | 1/0 | 17/ 5.17 |
| 14 | 0.5 | 1 | 0/0 | 0/0 | 1/0.10 | 0/0 | 0/0 | 1/ 0.10 |
| 15 | 186.7 | 18 | 18/24.40 | 13/3.48 | 1/0.01 | 0/0 | 1/0.01 | 8/ 5.88 |
| Total | 977.6 | 183 | 148/11.49 | 158/5.79 | 67/0.46 | 18/0.26 | 15/0.07 | 127/ 5.21 |

* Causal fungi: Yellow leaf blotch, *Leptotrochila medicaginis* (Fckl.) Schuepp; black stem, *Ascochyta imperfecta* Pk.; stagonospora, *Leptosphaeria pratensis* Sacc. and Briard; pepper spot, *Pseudoplea trifolii* (Rostr.) Petr.; downy mildew, *Peronospora trifoliorum* de Bary; common leaf spot, *Pseudopeziza trifolii* f. sp. *medicaginis-sativae* Schmiedeknecht.

** Number of fields affected/disease index.

2. RED CLOVER (*Trifolium pratense* L.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Powdery mildew | Northern anthracnose | Black stem | Black-stem leaf spot | Stagon-ospora |
|---|---|---|---|---|---|---|---|
| 8 | 46.0 | 8 | 2/ 2.51 | 6/3.97 | 3/0.51 | 0/0 | 5/19.14 |
| 10 | 4.0 | 4 | 2/11.75 | 1/9.50 | 1/0.25 | 0/0 | 0/0 |
| 11 | 86.6 | 22 | 11/14.23 | 9/8.65 | 11/2.35 | 0/0 | 4/ 5.16 |
| 12 | 6.1 | 2 | 1/ 6.00 | 0/0 | 0/0 | 0/0 | 0/0 |
| 13 | 91.2 | 17 | 12/15.97 | 5/3.01 | 8/6.00 | 1/0.06 | 10/ 6.79 |
| 14 | 1.3 | 2 | 0/0 | 1/1.00 | 0/0 | 0/0 | 0/0 |
| 15 | 185.3 | 18 | 8/12.43 | 7/0.61 | 8/1.59 | 6/5.19 | 14/14.03 |
| Total | 420.5 | 73 | 36/12.16 | 29/4.44 | 31/2.57 | 7/1.29 | 33/ 8.69 |

* Causal fungi: Powdery mildew, *Erysiphe polygoni* DC. ex Mérat; northern anthracnose, *Kabatiella caulivora* (Kirchn.) Karak.; black stem, *Ascochyta meliloti* (Trel.) Davis; stagonospora, *Stagonospora recedens* (O. Massal.) Jones and Weimer.

3. ALSIKE CLOVER (*Trifolium hybridum* L.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Powdery mildew | Black stem | Stagon-ospora | Pepper spot | Rust | Sooty blotch |
|---|---|---|---|---|---|---|---|---|
| 8 | 46.8 | 11 | 6/10.39 | 3/0.84 | 6/ 8.12 | 0/0 | 0/0 | 0/0 |
| 10 | 12.4 | 6 | 4/35.17 | 0/0 | 3/ 7.02 | 0/0 | 0/0 | 1/0.02 |
| 11 | 42.5 | 16 | 4/ 8.01 | 3/0.07 | 11/10.09 | 4/0.76 | 0/0 | 0/0 |
| 12 | | 0 | | | | | | |
| 13 | 24.0 | 6 | 4/21.70 | 1/4.67 | 6/20.55 | 0/0 | 0/0 | 1/6.33 |
| 14 | 2.6 | 3 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 15 | 85.6 | 10 | 4/15.31 | 2/0.02 | 10/17.20 | 0/0 | 1/5.00 | 0/0 |
| Total | 213.9 | 52 | 22/14.17 | 9/0.74 | 36/11.31 | 4/0.23 | 1/0.96 | 2/0.73 |

* Causal fungi: Powdery mildew, *Erysiphe polygoni* DC. ex Mérat; black stem, *Ascochyta meliloti* (Trel.) Davis; stagonospora, *Leptosphaeria pratensis* Sacc. and Briard; pepper spot, *Pseudoplea trifolii* (Rostr.) Petr.; rust, *Uromyces trifolii* (Hedw. f. ex DC.) Lév.; sooty blotch, *Cymadothea trifolii* (Pers. ex Fr.) Wolf.

Table 1 (Cont'd.)

4. SWEET CLOVER (*Melilotus alba* Desr. and *M. officinalis* (L.) Lam.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Black stem | Downy mildew | Stagonospora |
|---|---|---|---|---|---|
| 8 | 7.7 | 1 | 0/0 | 1/0.10 | 0/0 |
| 10 | 4.0 | 1 | 0/0 | 1/0.10 | 1/0.10 |
| 11 | 8.0 | 3 | 0/0 | 0/0 | 1/0.03 |
| 12 | 8.5 | 1 | 1/13.40 | 0/0 | 1/2.70 |
| 13 | 7.3 | 1 | 0/0 | 0/0 | 1/0.10 |
| 14 | 1.1 | 1 | 0/0 | 0/0 | 1/0.10 |
| 15 | 46.3 | 4 | 0/0 | 0/0 | 0/0 |
| Total | 82.9 | 12 | 1/ 1.12 | 2/0.02 | 5/0.26 |

* Causal fungi: Black stem, *Ascochyta meliloti* (Trel.) Davis; downy mildew, *Peronospora trifoliorum* de Bary; stagonospora, *Leptosphaeria pratensis* Sacc. and Briard.

5. WHITE CLOVER (*Trifolium repens* L.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Pepper spot | Stagonospora | Rust |
|---|---|---|---|---|---|
| 8 | 3.3 | 2 | 0/0 | 2/0.10 | 1/0.05 |
| 10 | | 0 | | | |
| 11 | 1.2 | 1 | 0/0 | 0/0 | 1/0.10 |
| 12 | | 0 | | | |
| 13 | | 0 | | | |
| 14 | 0.5 | 1 | 0/0 | 0/0 | 0/0 |
| 15 | | 0 | | | |
| Total | 5.0 | 4 | 0/0 | 2/0.05 | 2/0.05 |

* Causal fungi: Pepper spot, *Pseudoplea trifolii* (Rostr.) Petr.; stagonospora, *Leptosphaeria pratensis* Sacc. and Briard; rust, *Uromyces trifolii* (Hedw. f. ex DC.) Lév.

6. BROME (*Bromus inermis* Leyss.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Brown leaf spot | Selenophoma | Scald |
|---|---|---|---|---|---|
| 8 | 30.3 | 10 | 9/ 5.87 | 2/0.07 | 0/0 |
| 10 | 51.3 | 24 | 24/ 8.57 | 10/0.12 | 4/0.05 |
| 11 | 30.9 | 13 | 13/ 7.36 | 2/0.13 | 1/0.16 |
| 12 | 9.8 | 4 | 4/10.90 | 1/0.02 | 0/0 |
| 13 | 36.7 | 8 | 8/23.01 | 1/0.01 | 1/0.27 |
| 14 | 3.1 | 2 | 2/ 7.00 | 0/0 | 0/0 |
| 15 | 65.3 | 8 | 7/13.27 | 5/0.06 | 1/0.01 |
| Total | 227.4 | 69 | 67/10.26 | 21/0.09 | 7/0.08 |

* Causal fungi: Brown leaf spot, *Drechslera bromi* (Died.) Shoem.; selenophoma, *Selenophoma bromigena* (Sacc.) Sprague and Johnson; scald, *Rhynchosporium secalis* (Oud.) J.J. Davis.

7. TIMOTHY (*Phleum pratense* L.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Eyespot | Leaf streak |
|---|---|---|---|---|
| 8 | 71.3 | 26 | 25/0.39 | 25/ 6.11 |
| 10 | 4.7 | 4 | 4/0.35 | 4/ 4.17 |
| 11 | 48.9 | 24 | 22/0.40 | 20/ 5.40 |
| 12 | 10.4 | 4 | 3/0.14 | 3/ 7.30 |
| 13 | 47.9 | 13 | 12/0.98 | 12/ 3.47 |
| 14 | 11.3 | 3 | 3/0.02 | 2/ 0.67 |
| 15 | 27.4 | 5 | 2/0.07 | 5/15.82 |
| Total | 221.9 | 79 | 71/0.44 | 71/ 5.83 |

* Causal fungi: Eyespot, *Heterosporium phlei* Gregory; leaf streak, *Drechslera phlei* (Graham) Shoem.

8. FESCUE (*Festuca rubra* L.)

| Census Division | Acres grown ('000) | No. fields sampled | Diseases assessed* Brown stripe | Stem eyespot |
|---|---|---|---|---|
| 8 | 3.3 | 1 | 0/0 | 0/0 |
| 10 | | 0 | | |
| 11 | | 0 | | |
| 12 | 2.1 | 1 | 1/10.00 | 0/0 |
| 13 | | 0 | | |
| 14 | | 0 | | |
| 15 | 103.9 | 9 | 5/ 0.06 | 5/4.44 |
| Total | 109.3 | 11 | 6/ 0.95 | 5/3.64 |

* Causal fungi: Brown stripe, *Passalora graminis* (Fckl.) Höhn; stem eyespot, *Phleospora idahoensis* Sprague.

* *Note*: For each disease assessed incidence and severity ratings show no. fields affected/disease index.

Table 2. Losses from foliage diseases of forage crops in Alberta Census Divisions 8 to 15

| Census Division | No. of fields sampled | Acreage of forage crops ('000) | Yield (tons/acre) | Loss (%) | Actual production ('000 tons) | Potential production ('000 tons) | Loss ('000 tons) | Loss* ($'000) |
|---|---|---|---|---|---|---|---|---|
| 8 | 47 | 365.4 | 2.03 | 4.03 | 741.8 | 772.93 | 31.13 | 560.34 |
| 10 | 56 | 222.0 | 1.71 | 4.82 | 379.6 | 398.81 | 19.21 | 347.78 |
| 11 | 60 | 400.8 | 2.03 | 5.99 | 813.6 | 865.40 | 51.80 | 932.40 |
| 12 | 22 | 189.4 | 1.81 | 4.47 | 342.8 | 358.82 | 16.02 | 288.36 |
| 13 | 53 | 386.3 | 1.81 | 7.15 | 699.2 | 753.08 | 53.88 | 969.84 |
| 14 | 6 | 61.8 | 1.81 | 0.16 | 111.9 | 112.07 | 0.17 | 3.06 |
| 15 | 61 | 702.0 | 1.75 | 6.55 | 1228.5 | 1314.60 | 86.10 | 1549.80 |
| Total | 305 | 2327.7 | 1.85 | 5.65 | 4317.4 | 4575.71 | 258.31 | 4651.58 |

* Based on a farm value of $18 per ton of forage.

## Acknowledgments

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# A DISEASE SURVEY OF CEREALS IN CENTRAL AND NORTHERN ALBERTA, 1970

*L.J. Piening* [1]

## Introduction

One of the objectives of the CDA research establishments in Alberta is to develop cereal varieties with greater yields, along with other desirable agronomic features. To implement such a programme it is desirable to be aware of the diseases occurring on cereals in Alberta and if possible to obtain some indication of yield losses. The report by McDonald et al. (2) indicated the presence of cereal diseases on the eastern prairies, many of which are generally not important in Alberta. McDonald et al. also indicated the losses from cereal diseases and the value of disease resistance in Manitoba. The development of resistant varieties has reduced the occurrence of epidemics in cereals, and the value of such varieties is obviously great. However, since the causal agents are also subject to environmental pressures, the development of pathogens virulent to hitherto resistant varieties is omnipresent and constant vigilance in the form of disease surveys is necessary to detect them.

This paper reports the occurrence of cereal diseases in northern and central Alberta in 1970 and provides an estimate of losses from the major diseases of cereals in central Alberta.

## Materials and methods

More than 100 fields of cereals were surveyed during the third week of July along a route north from Beaverlodge, east to Sexsmith and north through Spirit River and Fairview to a point 20 miles north of Peace River. The survey continued south from Peace River to High Prairie via McLennan, west to Wanham, south to Grande Prairie and east to Valleyview. No attempt was made to calculate losses on cereals in northern Alberta because the survey was made earlier than desired and the incidence of disease was low in this area. Scald or net blotch on the upper two leaves of barley were found in only 5 of 60 fields.

In central Alberta the survey was conducted in Crop Districts 8, 10, 11, and 13 (Table 1). Crops were not examined in Crop District 9 because few cereals are grown in this area, and a lack of time prevented the surveying of fields in Crop District 12. Flax and rye were rarely seen in central Alberta and were not considered in the survey of this region.

The selection of fields for survey and the methods of assessing disease incidence and loss were essentially similar to those used by McDonald et al.(2). The following scale was used for assessing the severity of leaf diseases:

Trace - one or two lesions on 1 of 10 plants;
Slight - one or two lesions on one half of the plants;
Moderate - several lesions on all lower leaves of all plants;
Severe - lesions on all leaves of all plants, the lower leaves totally diseased and the disease present on all upper leaves.

The incidence of smut and ergot was measured by counting the numbers of affected heads in 100-head samples at several locations in a field. An average of less than one affected head per field was considered trace infection; one and two affected heads were considered slight and moderate, respectively.

Root rot intensity was rated by noting the amount of tissue discoloration at the subcoronal internode (4).

## Results

NORTHERN ALBERTA

The crops in the west and south of the area surveyed were more mature than in the northeast where rainfall was more abundant. The low rainfall was associated with a low incidence of leaf diseases, whereas root rot of barley was more evident in the areas of low rainfall.

Barley

Table 2 illustrates the intensities of the various diseases. Scald caused by Rhynchosporium scalis (Oud.) Davis was found more frequently than net blotch (Drechslera teres [Sacc.] Shoem.) on barley in 1970. Smut (loose and covered) was found in 14% of the fields visited.

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Table 1. Number of farms growing wheat, oats, or barley and percentage of farms surveyed in four crop districts in central Alberta in 1970

| Crop District | Wheat | | Oats | | Barley | |
|---|---|---|---|---|---|---|
| | No. of farms* | % farms surveyed | No. of farms* | % farms surveyed | No. of farms* | % farms surveyed |
| 8 | 1700 | 0.7 | 3500 | 0.5 | 4500 | 1.0 |
| 10 | 8000 | 0.3 | 7000 | 0.05 | 5000 | 0.2 |
| 11 | 3400 | 0.5 | 5300 | 0.5 | 4800 | 0.4 |
| 13 | 4000 | 0.1 | 4000 | 0.1 | 4700 | 0.3 |

* Data supplied by the Alberta Department of Agriculture, Economics Division.

Table 2. Percentage of 60 barley fields showing various intensities of five diseases in northern Alberta, 1970

| Intensity of disease | Net blotch | Scald | Root rot | Loose smut | Covered smut |
|---|---|---|---|---|---|
| 0 | 23 | 9 | 35 | | |
| Trace | 54 | 49 | 32 | 5 | 9 |
| Slight | 7 | 19 | 16 | | |
| Moderate | 12 | 17 | 14 | | |
| Severe | 4 | 6 | 3 | | |

Fifty-five percent of the barley examined was sown on summerfallow and 45% on stubble. The incidence of moderate and severe root rot was greater on summerfallow-sown barley than on stubble. Approximately 35% of fields of barley from both stubble and fallow were free from root rot.

Wheat

Spring wheat was found to be relatively free from disease. Leaf and stem rust as well as head diseases such as ergot, smut, and bacterial black chaff were not found in the 25 fields of wheat examined. Approximately one-half of all wheat plants examined had considerable powdery mildew (Erysiphe graminis D.C. ex Merat) on the lower leaves. Septoria leaf spot was found in about 10% of the fields and a slight incidence of common root rot (Bipolaris sorokiniana [Sacc. in Sorok.] Shoem. and Fusarium sp.) occurred in 75% of all wheat examined.

Oats

One third of the oats examined had 1 to 2% of the kernels missing. This is probably a physiological condition called blast. Gray speck caused by manganese deficiency was observed in about 10% of all oats seen and was restricted to about 5% of the total leaf area. No other diseases were seen.

Flax

No diseases were observed in the six fields of flax inspected.

Rye

Powdery mildew was seen on the lower leaves of all of the rye inspected. Scald (Rhynchosporium secalis [Oud.] Davis) was found on the lower leaves from one field, as was bacterial leaf stripe (Xanthomonas translucens [Jones, Johnson & Reddy] Dows.). No rust or ergot was observed.

CENTRAL ALBERTA

A more intensive survey of cereal crops was conducted in central Alberta during the period August 10 to August 31 when most of the crops were in the soft dough stage.

Barley

Losses caused by the major leaf and head diseases in barley in central Alberta were estimated at 9.91% of potential yield. The two leaf diseases, scald (Rhynchosporium secalis) and net blotch (Drechslera teres) were generally not found associated in the same field. Scald was more severe than net blotch in 1970 and was most prevalent in Crop Districts 10 and 13 in the northeast area of the central region (Table 3).

Leaf spot (Septoria spp.) was found in trace amounts in 9% of the fields, and bacterial leaf stripe Xanthomonas translucens in slight amounts in 4.5% of the fields; spot blotch (Bipolaris sorokiniana) and ergot (Claviceps purpurea [Fr.] Tul.) were observed in trace amounts in 1% of the fields. These diseases were not considered to cause a significant loss in yield.

Common root rot was recorded in 74.4% of all fields seen and was estimated to have

Table 3. Yield losses from diseases of barley in central Alberta, 1970

| Crop District† | | Yield losses from Scald | Net blotch | Smut | Total | Average yield (bu/acre)* | Potential yield (bu/acre)* | Acres ('000)* | Potential yield production ('000 bu) |
|---|---|---|---|---|---|---|---|---|---|
| 8 | Range (%) | 0-32 | 0-41 | 0-5 | | | | | |
| | Mean (%) | 5.1 | 2.03 | 0.28 | 7.41 | 41.6 | 44.9 | 616 | 27,658 |
| | Bu ('000) | 1410.6 | 516.4 | 77.4 | 2004.4 | | | | |
| | % fields with disease | 91.3 | 65 | 40 | | | | | |
| 10 | Range (%) | 0-58 | 0-3.2 | 0-1.0 | | | | | |
| | Mean (%) | 10.4 | 0.35 | 0.5 | 11.25 | 43.1 | 48.6 | 490 | 24,014 |
| | Bu ('000) | 2476.6 | 83.35 | 138.6 | 2698.6 | | | | |
| | % fields with disease | 88 | 66 | 78 | | | | | |
| 11 | Range (%) | 0-30 | 0-6 | trace | | | | | |
| | Mean (%) | 7.0 | 0.55 | trace | 7.55 | 42.7 | 46.2 | 444 | 20,513 |
| | Bu ('000) | 1435.9 | 112.8 | trace | 1548.7 | | | | |
| | % fields with disease | 90 | 68 | 47 | | | | | |
| 13 | Range (%) | 0-58 | 0-10.8 | trace | | | | | |
| | Mean (%) | 14.4 | 6.54 | trace | 20.94 | 35.0 | 44.3 | 400 | 17,720 |
| | Bu ('000) | 2551.7 | 1159.9 | trace | 3711.6 | | | | |
| | % fields with disease | 91 | 91.7 | 16 | | | | | |

* Data supplied by the Alberta Department of Agriculture, Economics Division.

† The total number of barley fields examined in each Crop District (CD) was as follows: CD 8, 46; CD 10, 10; CD 11, 19; CD 13, 12.

reduced yields by approximately 20% (unpublished data).

Wheat

Only two diseases of wheat were considered important enough to reduce yield. Common root rot was estimated to have reduced yield by 6% (R.J. Ledingham, unpublished data). A head blight that has been observed during the past 5 years, causing the neck, rachis, and glumes to become dark brown or purple, was responsible for severe losses in Crop District 11 where an 18% yield reduction was estimated (Table 4). This condition was noticed in 23% of the fields visited. The causal agent has not been discovered, although a similar condition referred to as pseudo black chaff has been described by Ausemus et al. (1) who regarded it as a physiological condition occurring under certain conditions of heat and humidity. This condition appeared in large patches in the field, in some cases affecting nearly all plants. Affected heads yielded only a few small shrivelled kernels. Yield losses were estimated after examining affected heads and grain from many sites in a field.

Ergot (Claviceps purpurea) was more abundant this year in wheat than in previous years (Table 4). Quality was affected more than quantity.

Leaf diseases such as septoria (Septoria spp.), powdery mildew (Erysiphe graminis) and leaf rust (Puccinia recondita Rob. ex Desm.) were restricted chiefly to the lower leaves. These diseases appeared late in the season.

Oats

Very little disease was found in oats in 1970. Blast (possibly a physiological condition) was found in 75% of all oats examined, preventing approximately 5.3% of the kernels from developing. Several plants were affected by barley yellow dwarf virus. Several cases of halo blight (Pseudomonas coronafaciens [Elliott] Stev.) and loose or covered smut were seen. Leaf spot (Drechslera avenacea [Curt. ex Cke.] Shoem. was seen in about 12% of all fields, but incidence was rated at trace.

## Discussion

This survey was made in an attempt to measure the severity of some of the common diseases of cereals. The percentage of farms surveyed (Table 1) was generally less than desired but it was felt that the number of samples obtained was sufficient to give some indication of loss. Major epidemics of diseases such as leaf rust are rarely seen in Alberta, possibly because rust resistant varieties are grown througout the prairies. Smut diseases of barley are also kept to a minimum because of the large acreage sown to 'Conquest' barley and because of the use of

Table 4. The distribution of diseases and yield losses in 49 fields of wheat inspected in central Alberta, 1970

| Disease | Percentage of fields with disease | Distribution and losses due to disease |
|---|---|---|
| Common root rot | 29 | Slight occurrence in all Crop Districts. Losses estimated at over 6%. |
| Take-all | 14 | Slight occurrence in Crop Districts 8 (10 fields) and 11 (14 fields). One field with 1% loss. |
| Leaf spot (*Septoria* sp.) | 40 | Of moderate occurrence in all Crop Districts. Disease restricted to lower leaves. One field with estimated loss of 5%. |
| Ergot | 31 | Of moderate occurrence in Crop District 11 (14 fields). One field with ergot in one quarter of all heads. Quality losses greater than yield loss. |
| Mildew | 6 | Of moderate occurrence in Crop Districts 8 and 11. One field seen with mildew on upper leaves as well as lower leaves. |
| Leaf rust | 14 | Present only on lower leaves in Crop Districts 8 and 11. |
| Head discoloration (black chaff) (pseudo black chaff) | 58 | Melanosis of the head was severe in Crop District 11 (14 fields), where 18% loss in yield was calculated. Losses in two individual fields were calculated at 80%. A condition suspected to be black chaff was found in about one third of all fields seen, where it did not cause appreciable damage. |

seed dressings. Smut was not seen in wheat. The relative freedom of wheat from diseases may be due to the relatively small acreage of wheat in northern and central Alberta as compared to barley and oats.

The loss of yield in a crop from a disease, as shown in Tables 3 and 4, is the cumulative value of all diseases in the crop. Under certain conditions this estimate of loss might be too high. An example is the loss suffered by barley affected with two major diseases such as root rot (20%) and leaf diseases (9.6%), where the actual reduction in yield would probably be less than the 29.6% calculated.

McDonald et al. (2) stated that the methods of relating disease intensity to yield losses selected from the literature are subject to more variability than other phases of a survey. This is especially the case where comparable losses in leaf area from barley plants grown under high and low fertilizer regimes have quite different losses in yield (3). If the sample is large enough, however, such variation should be minimized.

The loss in yield due to root rot in wheat and barley appears to be of significant importance. The rather high loss in barley might stimulate research into the development of varieties resistant to this disease.

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# LOSSES FROM CEREAL DISEASES AND VALUE OF DISEASE RESISTANCE IN MANITOBA AND EASTERN AND NORTHERN SASKATCHEWAN IN 1970[1]

*W.C. McDonald, J.W. Martens, J. Nielsen, G.J. Green, D.J. Samborski, G. Fleischmann, C.C. Gill, A.W.Chiko, and R.J. Baker*

Data on the losses caused by specific plant diseases and on gains in productivity from the use of disease control measures are necessary for the efficient management of the limited research resources available to solve disease problems.

Obtaining the data, however desirable they may be, presents many problems. The pathologists must be familiar with many fungal, bacterial, viral, and physiologic diseases on a number of crops; there must be research to establish the losses caused by various levels of infection at different stages of crop development so that field observations can be related to loss; and large areas must be surveyed at a time when the research and development disease nurseries require the most attention.

Until 1969, pathologists in Manitoba relied on limited field surveys and yield trials in experimental plots to assess the importance of the various diseases. This approach was adequate for its time and served to identify the most important diseases which were then given a high priority in cereal breeding programs. However, except for the rusts, very little specific disease data were generated; less obvious diseases received scant attention; and there was inadequate information to redirect or initiate research and control programs.

Similarly, the advantages of new, disease resistant varieties have been so obvious that no need was felt to provide extensive data on their value to growers or to those providing funds for research.

To provide additional much needed information, an extensive survey was done in Manitoba in 1969, estimating the losses caused by the major diseases of wheat, oats, and barley (1). This paper reports a similar survey, extended to include parts of Saskatchewan, conducted in 1970.

## Materials and methods

The methods used were similar to those developed in 1969 (1) with slight modifications. Eight survey routes were mapped to cover all of the crop districts in Manitoba and four in eastern and northern Saskatchewan. The routes through Manitoba, two for each crop, were designed to pass through the areas in which over 75% of the specific crop was grown; the Saskatchewan routes were intended to cover all cereal crops. The length of specific routes varied from 370 to 1600 miles covering a total of 6000 miles and 689 fields in 41 man days.

The optimum **number** of survey sites in each crop district was arbitrarily set at 1% of the farms growing the specific crop and this figure was usually achieved or exceeded, except in the case of wheat (Table 1). The number of farms, rather than the number of acres in a district, was used because management practices such as seed treatment, crop rotation, and other disease control measures were assumed to be uniform on a particular farm regardless of the size of fields. The sites were marked on the route maps at 15- to 20-mile intervals and the field closest to each site on the route was surveyed. Although each route was designed to survey a specific crop, some sites for the other two crops were also included. Disease incidence in each field was assessed on 25 plants, one collected every 2 paces along a traverse 50 **yards** long and 50 yards in from the edge of the field. Disease ratings and information on stage of growth, location, etc. were recorded on crop-specific survey forms.

The surveys were conducted during the period of July 28 to Aug. 12 when most of the crop was in the soft dough stage. For the final analysis of the data the 14 crop districts were grouped into five areas based on previous knowledge of the general distribution of diseases. For Saskatchewan existing crop districts were used.

The range and mean percentage loss for each disease were determined and the potential average **yield** in each area was found by multiplying the average yield by 100 and dividing by 100 minus the percentage loss

[1] Contribution No. 469, Research Station, Canada Department of Agriculture, Winnipeg 19, Manitoba.

Table 1. Number of farms with specific crops, number of survey sites, and percentage of farms surveyed in Manitoba and in eastern and northern Saskatchewan

| Area and Crop District | Wheat | | | Oats | | | Barley | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of farms* | Farms surveyed (No.) | (%) | No. of farms* | Farms surveyed (No.) | (%) | No. of farms* | Farms surveyed (No.) | (%) |
| *MANITOBA* | | | | | | | | | |
| East | | | | | | | | | |
| 4 | 513 | 6 | | 605 | 15 | | 403 | 4 | |
| 5 | 1750 | 12 | | 1880 | 20 | | 843 | 16 | |
| 6 | 96 | | | 189 | 3 | | 29 | | |
| 12 | 600 | | | 728 | 1 | | 321 | | |
| Total | 2959 | 18 | 0.6 | 3402 | 39 | 1.1 | 1596 | 20 | 1.2 |
| Central | | | | | | | | | |
| 3 | 3723 | 25 | 0.7 | 3204 | 33 | 1.0 | 1649 | 26 | |
| Southwest | | | | | | | | | |
| 1 | 1544 | 14 | | 1207 | 7 | | 586 | 6 | |
| 2 | 2335 | 12 | | 1913 | 12 | | 994 | 11 | |
| 7 | 1422 | 11 | | 1299 | 8 | | 632 | 13 | |
| Total | 5301 | 37 | 0.7 | 4419 | 27 | 0.6 | 2212 | 30 | 1.4 |
| West-central | | | | | | | | | |
| 8 | 1541 | 11 | | 1427 | 13 | | 571 | 12 | |
| 9 | 1360 | 11 | | 1276 | 15 | | 571 | 13 | |
| 10 | 2543 | 15 | | 1852 | 18 | | 1465 | 16 | |
| 14 | 599 | 2 | | 630 | 2 | | 273 | | |
| Total | 6043 | 39 | 0.6 | 5185 | 48 | 0.9 | 2880 | 41 | 1.4 |
| Northwest | | | | | | | | | |
| 11 | 1818 | 8 | | 1489 | 8 | | 810 | 10 | |
| 13 | 932 | 4 | | 656 | 4 | | 702 | 4 | |
| Total | 2750 | 12 | 0.4 | 2145 | 12 | 0.6 | 1512 | 14 | 0.9 |
| TOTAL | | 131 | | | 159 | | | 131 | |
| *SASKATCHEWAN* | | | | | | | | | |
| Southeast (1) | | 26 | | | 20 | | | 13 | |
| East-central (5) | | 37 | | | 24 | | | 35 | |
| Northeast (8) | | 19 | | | 13 | | | 20 | |
| Northwest (9) | | 26 | | | 9 | | | 26 | |
| TOTAL | | 108 | | | 66 | | | 94 | |

* Manitoba Agriculture Yearbook, 1969.

from all diseases. The loss in bushels from individual diseases was calculated by multiplying the mean percentage loss from a disease by the potential yield and by the acreage.

The methods of assessing losses from individual diseases were similar to those used the previous year (1). The gain in wheat production from the use of stem- and leaf-rust resistant varieties was obtained by comparing the average yield of 'Manitou" (resistant to stem rust and moderately resistant to leaf rust), 'Thatcher' (susceptible to leaf rust) and 'Marquis' (susceptible to both rusts) in the 1970 Western Wheat Co-operative Tests. The mean yields in cwt/acre from seven stations in the 1970 rust area (Brandon, Portage la Prairie, Morden, Indian Head, Melfort, Regina and Saskatoon) were: 'Manitou', 25.7; 'Thatcher', 23.7; and 'Marquis', 21.2. The mean yields from ten stations in the adjoining rust-free areas of Saskatchewan and Alberta (Cabri, Kindersley, Scott, Swift Current, Acme, Beaverlodge, Edmonton, Evansburg, Lacombe, and Lethbridge) were: 'Manitou', 26.5; 'Thatcher', 25.7; and 'Marquis', 24.2 cwt/acre. The gain in production from leaf rust resistance was calculated from the difference in yield between 'Manitou' and 'Thatcher' as a percentage of the yield of 'Manitou'; and from stem rust resistance, the difference between 'Thatcher' and 'Marquis' yields as a percentage yield advantage of 'Manitou' and 'Thatcher' under rust-free conditions.

Table 2. Yield losses from disease in wheat in Manitoba, 1970

| Area (Crop District) | | Yield losses from: Leaf rust | Leaf spot | Virus | Root rot | Total | Average yield (bu/ac) | Potential avg yield (bu/ac) | Acres ('000) | Potential production ('000 bu) |
|---|---|---|---|---|---|---|---|---|---|---|
| East | Range (%) | T* - 20 | 0-25 | 0-T | 0-0 | | 18.3 | 19.8 | 234 | 4,633.2 |
| (4, 5, 6, 12) | Mean (%) | 2.6 | 4.7 | 0 | 0 | 7.3 | | | | |
| | Bu† ('000) | 120.5 | 217.8 | 0 | 0 | 338.2 | | | | |
| Central | Range (%) | T-10 | 0-17 | 0-3 | 0-0 | | 19.3 | 20.7 | 297 | 6,147.9 |
| (3) | Mean (%) | 0.8 | 2.0 | 0.1 | 0 | 2.9 | | | | |
| | Bu ('000) | 49.2 | 123.0 | 6.1 | 0 | 178.2 | | | | |
| Southwest | Range (%) | 0-35 | 0-25 | 0-4 | 0-1 | | 22.2 | 23.8 | 418 | 9,948.4 |
| (1, 2, 7) | Mean (%) | 3.2 | 3.2 | 0.1 | 0.1 | 6.6 | | | | |
| | Bu ('000) | 318.3 | 318.3 | 9.9 | 9.9 | 656.6 | | | | |
| West-central | Range (%) | T-20 | 0-15 | 0-T | 0-T | | 22.8 | 24.3 | 307 | 7,460.1 |
| (8, 9, 10) | Mean (%) | 5.1 | 1.2 | 0 | 0 | 6.3 | | | | |
| | Bu ('000) | 380.5 | 89.5 | 0 | 0 | 470.0 | | | | |
| Northwest | Range (%) | T-35 | 0-32 | 0-0 | 0-10 | | 24.1 | | 144 | 4,665.6 |
| (11, 13, 14) | Mean (%) | 17.4 | 6.7 | 0 | 1.5 | 25.6 | | 32.4 | | |
| | Bu ('000) | 811.8 | 312.6 | 0 | 70.0 | 1,194.4 | | | | |
| Total ('000 bu) | | 1,680.3 | 1,061.0 | 16.0 | 79.9 | 2,837.4 | 21.6 | 23.5 | 1,400 | 32,855.2 |
| % of potential production | | 5.11 | 3.23 | 0.05 | 0.24 | 8.64 | | | | |

* T = trace

† Bu = bushels

Table 3. Yield losses from disease in oats in Manitoba, 1970

| Area (Crop District) | | Yield losses from: Crown rust | Stem rust | Virus | Leaf spot | Blast | Total | Average yield (bu/ac) | Potential avg yield (bu/ac) | Acres ('000) | Potential production ('000 bu) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| East | Range (%) | 0-50 | 0-56 | 0-14 | 0-5 | 0-0 | | | | | |
| (4, 5, 6, 12) | Mean (%) | 14.8 | 17.3 | 0.8 | 0.3 | 0 | 33.2 | 35.9 | 53.7 | 328 | 17,613.6 |
| | Bu ('000) | 2,606.8 | 3,047.2 | 140.9 | 52.8 | 0 | 5,847.7 | | | | |
| Central | Range (%) | T-34 | 0-40 | 0-8 | 0-5 | 0-1 | | 39.2 | 51.0 | 203 | 10,353.0 |
| (3) | Mean (%) | 9.8 | 12.8 | 0.3 | 0.2 | 0 | 23.1 | | | | |
| | Bu ('000) | 1,014.6 | 1,325.1 | 31.1 | 20.7 | 0 | 2,391.5 | | | | |
| Southwest | Range (%) | 0-16 | 0-15 | 0-4 | 0-8 | 0-3 | | 43.4 | 45.4 | 275 | 12,485.0 |
| (1, 2, 7) | Mean (%) | 2.2 | 1.6 | 0.2 | 0.3 | 0.1 | 4.4 | | | | |
| | Bu ('000) | 274.7 | 199.8 | 25.0 | 37.5 | 12.5 | 549.3 | | | | |
| West-central | Range (%) | 0-20 | 0-15 | 0-3 | 0-2 | 0-5 | | 48.0 | 50.2 | 289 | 14,507.8 |
| | Mean (%) | 3.7 | 0.4 | 0.1 | 0.1 | 0.1 | 4.4 | | | | |
| | Bu ('000) | 536.8 | 58.0 | 14.5 | 14.5 | 14.5 | 638.3 | | | | |
| Northwest | Range (%) | 0-10 | 0-2 | 0-2 | 0-32 | 0-5 | | 44.8 | 47.7 | 165 | 7,870.5 |
| (11, 13, 14) | Mean (%) | 2.3 | 0.1 | 0.3 | 2.9 | 0.5 | 6.1 | | | | |
| | Bu ('000) | 181.0 | 7.9 | 23.6 | 228.2 | 39.3 | 480.1 | | | | |
| Total ('000 bu) | | 4,613.9 | 4,638.0 | 235.1 | 353.7 | 66.3 | 9,906.9 | 41.9 | 49.9 | 1,260 | 62,829.9 |
| % of potential production | | 7.34 | 7.38 | 0.37 | 0.56 | 0.10 | 15.76 | | | | |

Table 4. Yield losses from disease in barley in Manitoba, 1970

| Area (Crop District) | | Yield losses from: Virus | Leaf spot | Thrips | Leaf rust | Stem rust | Smut | Root rot | Total | Average yield (bu/ac) | Potential avg yield (bu/ac) | Acres ('000) | Potential production ('000 bu) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| East (4, 5, 6, 12) | Range (%) | 0-29 | 0-17 | 0-5 | 0-3 | 0-0 | 0-11 | 0-0 | T-42 | 27.6 | 32.0 | 242 | 7,744.0 |
| | Mean (%) | 7.8 | 4.5 | 0.2 | 0.2 | 0 | 1.1 | 0 | 13.8 | | | | |
| | Bu ('000) | 604.0 | 348.5 | 15.5 | 15.5 | 0 | 85.2 | 0 | 1,068.7 | | | | |
| Central (3) | Range (%) | 0-28 | 0-11 | 0-5 | 0-6.4 | 0-17.5 | 0-4.0 | 0-0 | 0-43.1 | 29.9 | 32.4 | 275 | 8,910.0 |
| | Mean (%) | 3.8 | 1.3 | 0.9 | 0.4 | 1.2 | 0.2 | 0 | 7.8 | | | | |
| | Bu ('000) | 338.6 | 115.8 | 80.2 | 35.6 | 106.9 | 17.8 | 0 | 694.9 | | | | |
| Southwest (1, 2, 7) | Range (%) | 0-15 | T-15 | 0-10 | 0-4.8 | 0-0 | 0-10 | 0-T | T-30.0 | 36.1 | 38.0 | 399 | 162.0 |
| | Mean (%) | 1.3 | 1.7 | 1.5 | 0.3 | 0 | 0.3 | 0 | 5.1 | | | | |
| | Bu ('000) | 197.1 | 257.1 | 227.4 | 45.5 | 0 | 45.5 | 0 | 773.3 | | | | |
| West-central (8, 9, 10, 14) | Range (%) | 0-6 | 0-20 | 0-10 | 0-13.5 | 0-0 | 0-5 | 0-T | 0-33.5 | 39.5 | 41.6 | 331 | 769.6 |
| | Mean (%) | 0.2 | 2.1 | 1.9 | 0.7 | 0 | 0.1 | 0 | 5.0 | | | | |
| | Bu ('000) | 27.5 | 289.2 | 261.6 | 96.4 | 0 | 13.8 | 0 | 688.5 | | | | |
| Northwest (11-13) | Range (%) | 0-1.2 | T-8.5 | 0-10 | 0-7 | 0-0 | 0-T | 0-12 | T-30.6 | 34.9 | 37.9 | 253 | 588.7 |
| | Mean (%) | 0.1 | 1.9 | 3.2 | 1.1 | 0 | 0 | 1.7 | 8.0 | | | | |
| | Bu ('000) | 9.6 | 182.2 | 306.8 | 105.5 | 0 | 0 | 163.0 | 767.1 | | | | |
| Total ('000 bu) | | 1,176.8 | 1,192.8 | 891.5 | 298.5 | 106.9 | 162.3 | 163.0 | 3,992.5 | 34.1 | 36.8 | 1,500 | 55,174.3 |
| % of potential production | | 2.13 | 2.16 | 1.61 | 0.54 | 0.20 | 0.30 | 0.30 | 7.24 | | | | |

## Results

### Wheat

Losses from the major diseases of wheat that occurred in Manitoba and eastern and northern Saskatchewan amounted to 2.8 and 4.3 million bu or 8.6 and 8.1%, respectively, of the potential yield without disease (Tables 2 and 5). The value of rust and smut resistance for Manitoba was estimated at 3.4 million bu. or $4.8 million (Table 8).

Most of the wheat varieties grown in the area surveyed are resistant to stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks. and E. Henn.) and losses were not significant. Leaf rust (*Puccinia recondita* Rob. ex. Desm.) was the single most important disease in Manitoba, causing losses of 1.7 million bu or 5.1% of the potential production. Saskatchewan losses amounted to 1.9 million bu or 2.6% of the potential production.

All of the common wheat varieties grown in Manitoba are resistant to loose smut caused by *Ustilago tritici* (Pers.) Rostr.; only trace infections occurred in both common and durum wheats in 1970.

Leaf spot diseases caused by *Drechslera tritici-repentis* (Died.) Shoem., *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. and *Septoria avenae* Frank f. sp. *triticea* T. Johnson caused losses of 1.0 and 2.2 million bu or 3.2 and 4.2% of the potential production for Manitoba and the Saskatchewan area respectively.

Losses caused by virus diseases and root rot were slight in all areas surveyed.

### Oats

Losses from diseases in oats amounted to 9.9 and 0.8 million bu or 15.8 and 1.4% of the potential production for Manitoba and the Saskatchewan areas respectively (Tables 3 and 7). Crown rust (*Puccinia coronata* Cda. f. ap. avenae Eriks.) and stem (*Puccinia graminis* Pers. f. sp. *avenae* Eriks. and E. Henn.) were the most destructive diseases of oats in Manitoba, causing losses of $4.6 million. Abundant inoculum combined with a considerable acreage of late-seeded oats resulted in the most severe epidemic and the greatest yield loss since 1955.

Most of the oat varieties grown in the area surveyed are resistant to the prevalent races of smut; only trace infections of loose and covered smut were found in Manitoba and mean levels of up to 0.1% were present in only one district in Saskatchewan. The gain in production form the use of smut resistant varieties in Manitoba amounted to 0.6 million bu or $0.3 million. In the area surveyed, virus diseases and leaf spot diseases caused by *Drechslera avenacea* (Curt. ex Cke.) Shoem. and *Septoria avenae* Frank f. sp. *avenae* caused only slight losses.

### Barley

Losses caused by the major diseases and by thrips in barley totalled 4.0 and 6.1 million bu or 7.2 and 7.6% of the potential production for Manitoba and the Saskatchewan area, respectively (Tables 4 and 6).

Thrips were the most important cause of crop damage in the Saskatchewan area, causing losses of 3.5 million bu or 4.3% of potential yield; Manitoba losses from this cause were

Table 5. Yield losses from disease in wheat in eastern and northern Saskatchewan, 1970

| Area (Crop District) | | Yield losses from: Leaf rust | Leaf spot | Virus | Root rot | Total | Average yield (bu/ac) | Potential avg yield (bu/ac) | Acres ('000) | Potential production ('000 bu) |
|---|---|---|---|---|---|---|---|---|---|---|
| Southeast (1) | Range (%) | 0-3 | 0-8 | 0-T | 0-5 | T-9 | 21.7 | 22.1 | 463 | 10,232.3 |
| | Mean (%) | 1.1 | 0.4 | 0 | 0.3 | 1.8 | | | | |
| | Bu ('000) | 112.6 | 40.9 | 0 | 30.7 | 184.2 | | | | |
| East-central (5) | Range (%) | 0-35 | 0-27 | 0-T | 0-T | T-42 | 26.4 | 29.4 | 668 | 19,639.2 |
| | Mean (%) | 7.2 | 2.9 | 0 | 0 | 10.1 | | | | |
| | Bu ('000) | 1,414.0 | 569.5 | 0 | 0 | 1,983.6 | | | | |
| Northeast (8) | Range (%) | 0-3 | T-25 | 0-T | 0-12 | T-29 | 27.2 | 29.1 | 358 | 10,417.8 |
| | Mean (%) | 0.6 | 4.9 | 0 | 1.0 | 6.5 | | | | |
| | Bu ('000) | 62.5 | 510.5 | 0 | 104.2 | 677.1 | | | | |
| Northwest (9) | Range (%) | 0-20 | 0-38 | 0-2 | 0-1 | T-50 | 29.2 | 33.0 | 375 | 12,375.0 |
| | Mean (%) | 2.6 | 8.7 | 0.1 | 0.2 | 11.6 | | | | |
| | Bu ('000) | 321.7 | 1,076.6 | 12.4 | 24.8 | 1,435.5 | | | | |
| Total ('000 bu) | | 1,910.8 | 2,197.5 | 12.4 | 159.7 | 4,280.4 | 25.9 | 28.3 | 1,864 | 52,664.3 |
| % of potential production | | 3.63 | 4.17 | 0.02 | 0.30 | 8.13 | | | | |

Table 6. Yield losses from disease in barley in eastern and northern Saskatchewan, 1970

| Area (Crop District) | | Yield losses from: Virus | Leaf spot | Thrips | Leaf rust | Smut | Root rot | Total | Average yield (bu/ac) | Potential avg yield (bu/ac) | Acres ('000) | Potential production ('000 bu) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast (1) | Range (%) | 0-4 | T-1.3 | 0-1.0 | 0-4 | 0-3 | 0-0.2 | | 41.6 | 42.3 | 277 | 11,717.1 |
| | Mean (%) | 0.7 | 0.2 | 0.1 | 0.4 | 0.3 | 0 | 1.7 | | | | |
| | Bu ('000) | 82.0 | 23.4 | 11.7 | 46.9 | 35.1 | 0 | 199.2 | | | | |
| East-central (5) | Range (%) | 0-0.1 | T-23.0 | 0-10 | 0-0.1 | 0-3 | 0-20 | | 42.5 | 45.4 | 521 | 23,653.5 |
| | Mean (%) | 0 | 1.5 | 4.0 | 0 | 0.4 | 0.6 | 6.5 | | | | |
| | Bu ('000) | 0 | 354.8 | 946.1 | 0 | 94.6 | 141.9 | 1,537.5 | | | | |
| Northeast (8) | Range (%) | 0-0.1 | T-14 | 0-10 | 0-0.1 | 0-4 | 0-5 | | 40.4 | 43.8 | 406 | 17,782.8 |
| | Mean (%) | 0 | 2.3 | 4.8 | 0 | 0.4 | 0.3 | 7.8 | | | | |
| | Bu ('000) | 0 | 409.0 | 853.6 | 0 | 71.1 | 53.3 | 1,387.1 | | | | |
| Northwest (9) | Range (%) | 0-10 | 0-20 | 0-10 | 0-0 | 0-8 | 0-4 | | 44.2 | 49.6 | 556 | 27,577.6 |
| | Mean (%) | 1.3 | 2.4 | 6.1 | 0 | 0.9 | 0.2 | 10.9 | | | | |
| | Bu ('000) | 358.5 | 661.9 | 1,682.2 | 0 | 248.2 | 55.1 | 3,005.9 | | | | |
| Total ('000 bu) | | 440.5 | 1,449.1 | 3,493.6 | 46.9 | 449.0 | 250.3 | 6,129.7 | 42.4 | 45.9 | 1,760 | 80,730.9 |
| % of potential production | | 0.54 | 1.79 | 4.33 | 0.06 | 0.56 | 0.31 | 7.59 | | | | |

0.9 million bu or 1.6% of potential production.

Virus diseases and the foliage diseases spot blotch (Cochliobolus sativus [Ito & Kurib.] Drechs. ex Dastur, imperfect state Bipolaris sorokiniana [Sacc. in Sorok.] Shoem.); net blotch (Pyrenophora teres (Died.) Drechs., imperfect state Drechslera teres [Sacc.] Shoem.); and septoria leaf blotch (Septoria passerinii Sacc.), combined, caused losses of 2.4 and 1.9 million bu or 4.3 and 2.3% of the potential yield for Manitoba and the Saskatchewan area, respectively.

Most of the six-rowed varieties grown are resistant or moderately resistant to the prevalent races of smut and the value of this resistance was estimated at 0.6 million bu or $0.5 million. Smuts caused by Ustilago nuda (Jens.) Rostr., U. nigra Tapki, and U. hordei (Pers.) Lagerh. occurred mainly on 2-rowed varieties and on a small acreage of susceptible, but not recommended, 6-row varieties. Combined losses for the entire area surveyed were 0.6 million bu or 0.9% of the potential yield.

Table 7. Yield losses from disease in oats in eastern and northern Saskatchewan, 1970

| Area (Crop District) | | Yield losses from: Crown rust | Virus | Leaf spot | Smut | Blast | Total | Average yield (bu/ac) | Potential avg yield (bu/ac) | Acres ('000) | Potential production ('000 bu) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast | Range (%) | 0-T | 0-4 | 0-T | 0-0 | 0-1 | 0-4 | 52.7 | 52.9 | 200 | 10,580 |
| (1) | Mean (%) | 0 | 0.2 | 0.1 | 0 | 0 | 0.3 | | | | |
| | Bu ('000) | 0 | 21.2 | 10.6 | 0 | 0 | 31.7 | | | | |
| East-central | Range (%) | 0-8 | 0-2 | 0-T | 0-T | 0-1 | 0-8 | 55.4 | 56.0 | 388 | 21,728.0 |
| (5) | Mean (%) | 0.6 | 0.2 | 0.1 | 0 | 0.1 | 1.0 | | | | |
| | Bu ('000) | 130.4 | 43.4 | 21.7 | 0 | 21.7 | 217.3 | | | | |
| Northeast | Range (%) | 0-0 | 0-1 | 0-T | 0-0 | 0-5 | 0-5.1 | 52.3 | 52.7 | 175 | 9,222.5 |
| (8) | Mean (%) | 0 | 0.2 | 0.1 | 0 | 0.5 | 0.8 | | | | |
| | Bu ('000) | | 18.4 | 9.2 | 0 | 46.1 | 73.8 | | | | |
| Northwest | Range (%) | 0-0 | 0-8 | 0-1 | 0-1 | 0-0 | 0-8 | 59.3 | 60.9 | 329 | 20,036.1 |
| (9) | Mean (%) | 0 | 2.4 | 0.2 | 0.1 | 0 | 2.7 | | | | |
| | Bu ('000) | 0 | 480.9 | 40.0 | 20.0 | 0 | 541.0 | | | | |
| Total ('000 bu) | | 130.4 | 563.9 | 81.5 | 20.0 | 67.8 | 863.8 | 55.6 | 56.4 | 1,092 | 61,566.6 |
| % of potential production | | 0.21 | 0.92 | 0.13 | 0.03 | 0.11 | 1.40 | | | | |

Table 8. Value of disease resistance in cereal varieties grown in Manitoba in 1970

| Crop | Disease | Loss in susceptible varieties (%) | Acreage of resistant varieties (%) | Total production ('000 bu) | Gain in production ('000 bu) | Price ($/bu) | Value ($'000) |
|---|---|---|---|---|---|---|---|
| Common wheat | Stem rust | 4.0 | 100 | 30,223.7 | 1,208.9 | 1.40 | 1,706.5 |
| | Leaf rust | 7.8 | 77.7 | | 1,831.5 | 1.40 | 2,564.1 |
| | Loose smut | 1.3 | 100 | | 392.9 | 1.40 | 550.1 |
| | Total | | | | 3,433.3 | | 4,820.7 |
| Oats | Smut | 1.2 | 99.0 | 52,805.4 | 628.4 | 0.50 | 314.2 |
| Barley | Smut | 2.1 | 60.4 | 51,195.8 | 650.2 | 0.75 | 487.6 |
| Total | | | | | 4,711.9 bu | | $5,622.5 |

## Discussion

The estimates of disease loss and the value of resistance calculated for 1970 are probably conservative. The assessment did not take into account actual and potential losses in quality of the crop.

The methods used for this survey are, of course, open to criticism; more fields, more samples per field, or simply more resource imput would have been desirable. However, we believe a survey of this nature to be adequate for the purposes intended; the economic reality of plant disease losses and the justification for control research are clearly indicated. Research resources should not be diverted to large scale precise determination of disease losses when they could be used to control the losses.

## Acknowledgments

Acreage and yield data were supplied by M. Daciw, Manitoba Department of Agriculture, and by the Saskatchewan Department of Agriculture.

## Literature cited

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# DISTRIBUTION OF BARLEY STRIPE MOSAIC VIRUS IN MANITOBA IN 1970[1]

*Arthur W Chiko*

## Abstract

An intensive survey for barley stripe mosaic virus (BSMV) was made throughout most of the barley growing region in southern Manitoba. The virus was transmitted from field samples to 'Black Hulless' barley and subsequently identified by its reaction with BSMV antiserum. BSMV was detected in 22 and 4%, respectively, of the 2- and 6-row barley fields sampled. The incidence of diseased plants in these fields varied from a trace to about 50%. No evidence was obtained of widespread masked infection in barley. However, in a few fields where the disease was detected, some symptomless plants were also infected.

Attempts to differentiate field-collected BSMV isolates using five barley varieties and 'Clintland' oats were unsuccessful.

## Introduction

Although barley stripe mosaic (BSM) was not reported to be caused by a seed-borne virus until 1951 (10), the disease was probably observed in Manitoba as early as 1924 (3, 5). Since then, reports of its presence in Manitoba and elsewhere in Canada have appeared frequently (2). Some of these reports, however, suggest that the disease is mainly of consequence in experimental barley plots and that its occurrence in farmers' fields is relatively rare. By contrast, the disease has previously been reported to occur quite commonly in several regions of the United States (1,6,8,13,15). In North Dakota, Timian and Sisler (15) observed BSM in 93% of the barley fields examined in 1954. In 1954 and 1955 BSM was not reported in Manitoba barley fields and annual Canadian plant disease survey reports (2), generally indicate that the incidence of the disease in this province has never remotely approached that in North Dakota. The reason for this apparent disparity is not clear since climates in the two regions are similar and no effort has been made to control the disease in Manitoba. Furthermore, although varietal tolerances vary considerably, all major commercial barley varieties grown in Manitoba are susceptible to barley stripe mosaic virus (BSMV) (Chiko, unpublished).

In Montana, Eslick (4) observed wide annual variation in BSM symptoms in 'Glacier' barley plants derived from infected seed that was continually obtained from the previous year's crop. He also noted that relatively high yield losses occurred during a year when symptoms were almost nonexistent. A latent strain of BSMV was subsequently isolated and described by McKinney and Greeley (12).

The possible masking of BSM symptoms, the former apparent disparity in BSM incidence between North Dakota and Manitoba, and the apparent lack of any previous systematic survey for BSM in Manitoba prompted the survey work reported here. The objectives of this survey were (1) to determine the possible occurrence of masked BSMV infection and (2) to estimate the frequency and distribution of symptomatic BSMV infection in Manitoba barley fields. Preliminary results of attempted varietal differentiation of field-collected BSMV isolates are also reported.

## Materials and methods

Survey routes and sampling procedures - The perimeter of the BSMV survey was delimited by a route similar to that described by McDonald et al. (9) for barley disease loss surveys in Manitoba. This route passes through crop districts in which over 75% of the Manitoba barley crop is grown. Several routes within this perimeter were also surveyed and a total of approximately 1600 miles was covered between July 6 and July 23, 1970. Fields of barley in the early tillering to boot stages were inspected and sampled at preselected intervals of about 4-12 miles, the interval generally depending on the length of the particular survey route. Near points of intersecting survey routes, intervals were occasionally shorter than 4 miles, and they were sometimes considerably longer than 12 miles due to the absence or inaccessibility of barley fields.

In each field sampled, regardless of the presence or absence of plants with suspected BSM symptoms, leaves were collected from 10 apparently healthy barley plants. Beginning 20 paces in from one edge of a field, leaves from five healthy plants were sampled at five pace intervals along two traverses 10 paces apart and perpendicular to the edge of the

[1] Contribution No. 476, Research Station, Canada Department of Agriculture, Winnipeg 19, Manitoba.

field. Two to four apical leaves were selected from one tiller of each plant sampled. When plants with suspected BSM symptoms were observed, leaves from about 10 of these plants were also sampled. Each sample was placed in a tightly sealed polyethylene bag and stored in a cooler with ice-packs until delivered to the laboratory and assayed for infectivity (1-3 days after sampling).

Infectivity assay - Each sample of leaves was ground in a mortar with 2 ml of distilled water and the extract was filtered through cheesecloth. 'Black Hulless' barley (Hordeum vulgare L.) was used as an indicator plant for BSMV. Seedlings in the 1-2 leaf stage were dusted with corundum and sample extract was applied to leaves by a finger-wiping method. Each leaf was rubbed five times and 11-16 indicator plants were inoculated with each sample extract. The presence or absence of symptoms was recorded 7-12 days after inoculation.

Serological procedures - An isolate of BSMV was obtained from Dr. C.C. Gill, Research Station, CDA, Winnipeg. 'Fergus' barley (H. distichum L.), inoculated at about the 2-leaf stage, was used as a propagation host for the virus. Infected leaves were harvested 10-14 days after inoculation and the leaf extract was clarified by the chloroform-charcoal method of Timian and Savage (14), except that the extract was cooled to 0-1 C only at the start of the procedure and was not centrifuged before adding chloroform. The virus was subsequently purified by two cycles of high (70,000 g, 2 hr) - low (5,000 g, 15 min) speed centrifugation. Prior to the final low speed centrifugation, the virus pellet was resuspended in a volume of 0.01 M phosphate buffer, pH 6.5, equal to 1/20 the volume of chloroform-charcoal clarified extract. Virus preparations purified by this procedure were infectious and exhibited strong anisotropy of flow.

A rabbit was given four weekly intravenous injections of 0.5 ml of freshly purified BSMV suspension. Serum obtained from the rabbit 2 weeks after the final injection reacted with chloroform-charcoal clarified extract from BSMV-infected, but not from healthy, 'Fergus' barley. The titer of the BSMV antiserum was 1/512.

Serological reactions were determined using a slide precipitation test. Two drops each of test antigen preparation and antiserum were delivered from Pasteur capillary pipettes into a well of a serological slide plate and incubated 15 min on a platform rotator at 120 rpm. The presence of a precipitate was detected by viewing the slide plate in a dark room under a stereoscopic microscope with indirect light at a magnification of 50X. All dilutions for serological tests were made with normal saline (0.14 M NaCl).

Isolates from the field which induced chlorotic symptoms in 'Black Hulless' barley were each transferred to about 15 seedlings of this variety. After 11-13 days, extract from each group of infected plants was clarified by the chloroform-charcoal method. Each extract was tested undiluted against BSMV antiserum diluted 1/16.

BSMV isolate differentiation - Isolates of BSMV collected from widely separated areas in Manitoba were maintained in 'Black Hulless' barley. 'Clintland' oats (Avena sativa L.) and five barley varieties in the 1-2 leaf stage were inoculated with each isolate as previously described. Three of the barley varieties tested ('Conquest' (H. vulgare), 'Herta' (H. distichum), and 'Fergus') are currently grown commercially in Manitoba. Test plants were grown in the greenhouse under supplemental fluorescent light (15 hr photoperiod) at a mean daily temperature of 25.0 ± 1.4 C.

## Results and discussion

Each field-collected isolate which induced chlorotic symptoms in 'Black Hulless' barley also reacted with BSMV antiserum. Chloroform-charcoal clarified extract from uninoculated 'Black Hulless' plants (control) did not react with BSMV antiserum.

BSMV was detected most commonly in southeastern Manitoba where it was distributed fairly consistently throughout the range of 2-row barley (Fig. 1). Although symptoms were most pronounced in 6-row barley, few fields with infected plants were encountered.

BSMV was detected in 22% and 4%, respectively, of the 2- and 6-row barley fields sampled (Table 1). The approximate incidence of plants with BSM symptoms in these fields was as follows: trace - 4 fields; 1-5% - 5 fields; 25% - 1 field; and 50% - 1 field. It should be emphasized that this was a systematic survey. Therefore, the number of fields indicated as having BSMV-infected plants present should not be construed as the total number of fields in

Table 1. Occurrence of barley stripe mosaic virus in fields of 2- and 6-row barley in southern Manitoba in 1970

| Type of barley | Fields | | |
|---|---|---|---|
| | No. sampled | No. with BSMV* | % with BSMV |
| 2-row | 41 | 9 | 22.0 |
| 6-row | 50 | 2 | 4.0 |
| 2- and 6-row | 91 | 11 | 12.1 |

* Transmitted to 'Black Hulless' barley and reacted with BSMV antiserum.

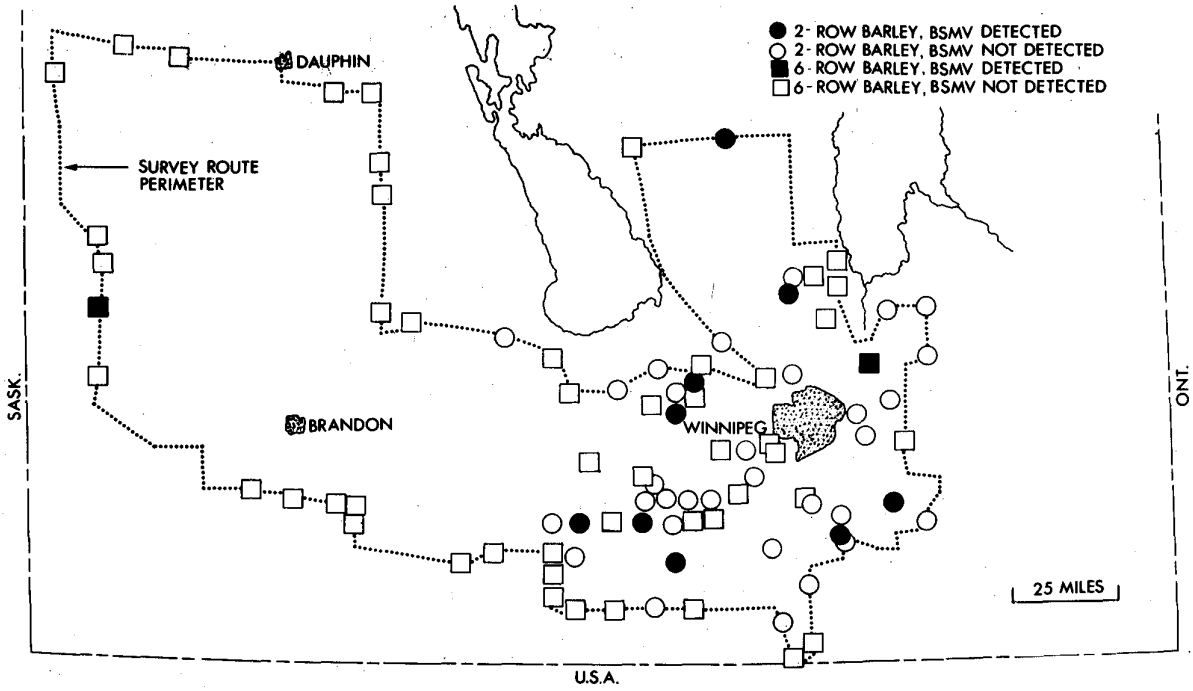


Figure 1. Distribution of barley stripe mosaic virus in fields of 2- and 6- row barley in southern Manitoba in 1970.

Table 2. Symptom severity indices of five barley varieties inoculated with 10 field isolates of barley stripe mosaic virus

| Variety | Symptom severity index* for isolate: 1 | 2† | 3 | 4 | 5 | 6† | 7 | 8 | 9 | 10 | Avg severity index for all isolates | Apparent transmission†† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *6-row* | | | | | | | | | | | | |
| Black Hulless | 3.8 | 3.5 | 3.9 | 3.7 | 4.0 | 4.0 | 3.7 | 3.0 | 3.0 | 4.1 | 3.7 | 115/143 |
| Conquest | 2.2 | 2.5 | 2.8 | 2.1 | 1.7 | 1.9 | 1.7 | 1.4 | 2.5 | 2.0 | 2.1 | 125/150 |
| *2-row* | | | | | | | | | | | | |
| Herta | 1.0 | 2.0 | 1.5 | 1.0 | 1.0 | 1.3 | 1.4 | 1.0 | 1.5 | 1.2 | 1.3 | 58/150 |
| Fergus | 2.0 | 1.4 | 2.2 | 1.6 | 1.2 | 1.3 | 1.7 | 1.0 | 1.0 | 1.2 | 1.5 | 68/148 |
| Betzes | 1.8 | 1.5 | 1.7 | 1.8 | 1.3 | 1.4 | 1.4 | 1.0 | 2.0 | 1.3 | 1.5 | 93/150 |

* Avg rating for each variety 13 days after inoculation of 11-15 plants with each isolate. Individual plants were rated as follows: 1, 2, 3, and 4 = 1, 10, 25, and 50% or more chlorosis, respectively, on systemically infected leaves and 5 = dead or dying. Plants without symptoms (rated 0) were not used in computing the index.

† These isolates were from 6-row barley; all other isolates were from 2-row barley.

†† Total no. plants with symptoms/total no. plants inoculated.

which the disease was observed. For instance, near one sampling point five fields were observed in each of which the incidence of diseased plants was about 50%. Similar but less extreme situations were noted near most other sampling points where the disease was detected.

BSMV was not isolated from any of the leaf samples obtained from 80 fields in which plants with BSM symptoms were not observed. It thus seems unlikely that any widspread masked or latent form of the virus was present in fields of barley in Manitoba. The virus was, however, detected in symptomless leaf samples from 2 of 11 fields in which plants with BSM symptoms were observed. Both samples were from 2-row barley.

Symptoms of BSM in 2-row barley were often very mild or inconspicuous. Chlorosis and mosaic were generally absent, the most

apparent symptoms being brown stripes on lower leaves. The length, frequency and color intensity of the stripes varied widely. In several fields, symptoms were so mild that the disease could easily be overlooked and at time of heading the brown stripes might be interpreted as natural senescence.

The symptomatic reactions of five barley varieties to 10 BSMV isolates, each of which induced symptoms in the field, are summarized in Table 2. Each isolate generally incited milder symptoms in the 2-row varieties than in the 6-row varieties. Some differences in varietal response to different isolates were occasionally observed but these were not sufficiently characteristic or uniform to serve as a basis for isolate differentiation. Symptoms induced in the five barley varieties by two isolates from symptomless 2-row barley (data not shown in Table 2) were generally similar to those incited by field-collected isolates obtained from plants with BSM symptoms. The percentage of 2-row barley plants that failed to develop symptoms (51%) in this test was considerably higher than the percentage of symptomless 6-row plants (18%). Therefore, a number of inoculated 2-row plants of the varieties 'Fergus' and 'Herta' were individually assayed for BSMV on 'Black Hulless' barley. The virus was transmitted from 49 of 50 'Herta' and 46 of 46 'Fergus' barley plants showed symptoms ranging from doubtful to severe. In addition, the virus was also transmitted from 32 of 70 (46%) 'Herta' and 24 of 71 (34%) 'Fergus' barley plants which showed no apparent symptoms of infection.

Two attempts were made to differentiate field-collected BSMV isolates using 'Clintland' oats. In one test, 3 of 11 isolates were transmitted to oats but the percentage of plants infected by each of these isolates was low (20% or less). When the test was repeated with the same isolates, only one isolate was transmitted to oats but this isolate was not one of those transmitted in the first test. Although 'Cherokee' oat plants have previously been reported for differentiating BSMV strains (13), 'Clintland' oats did not appear to have any similar value.

The results of this survey suggest that BSM is more common in 2-row barley fields in Manitoba than most previous surveys (2) indicate. Although the frequency of the disease was considerably less than that previously reported in North Dakota (15), the estimate for the percentage of fields with infected plants in Manitoba is considered to be conservative. This is because only a small portion of each field was inspected and trace infections might easily have been overlooked. No explanation can presently be advanced for the large differences encountered in the percentages of 2- and 6-row barley fields with BSM.

Masking of BSM symptoms under greenhouse conditions can probably be attributed to inadequate light intensities (6,7,11). Whether or not the same factor is responsible for masked infection in the field is not known. The extent of symptomless infection would have to be estimated to obtain meaningful yield loss data for BSMV in farmers' fields.

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# SCLEROTINIA IN SASKATCHEWAN IN 1970

*L. J. Duczek and R. A. A. Morrall* [1]

## Abstract

*Sclerotinia* was recorded on 18 plant species in Saskatchewan in 1970. New Canadian records were on *Solidago canadensis* var. *salebrosa*, *Linum usitatissimum*, and *Lens culinaris*. The average provincial infection rate of rape (*Brassica campestris* and *B. napus*), based on a stubble survey of 94 fields in Crop Districts 5 to 9, was 0.53%. It appears that the distribution of sclerotinia stem rot has increased steadily since 1957 in the major rapeseed growing areas of Saskatchewan.

## Introduction

The principal purpose of this work was to make a quantitative survey of sclerotinia stem rot of rapeseed in Saskatchewan. The incidence of this disease was studied in earlier general surveys of rape diseases by Vanterpool and Petrie (2,3,4,6,7) but quantification of severity was imprecise. The ratings that they employed, namely trace, slight, moderate and severe, serve a limited purpose since they tend to be meaningful only to the investigators concerned. Furthermore, their surveys were, of necessity, conducted in restricted parts of fields which were easily accessible on foot from adjacent roads (Vanterpool, personal communication). Our work employed a technique which, despite some limitations, gave rates of infection based on measurements all around the fields.

Earlier reports (1) and preliminary data from 1969 indicated that several other plant species are hosts of *Sclerotinia* in Saskatchewan. Thus, some attempt was made to extend the survey to other host species, though in most cases quantitative study was impossible in the time available.

Stem rot of rape is usually thought to be caused by *Sclerotinia sclerotiorum* (Lib.) de By. However, there is some dispute in the literature concerning the classification of this and other species of the genus. Conners (1) does not accept Purdy's (5) "broader concept of *S. sclerotiorum*", which includes *S. sclerotiorum* (Lib.) de By., *S. trifoliorum* Eriks., *S. minor* Jagger, *S. sativa* Drayt. & Groves, and *S. intermedia* Ramsey. Though work is currently in progress in this laboratory on variability of *Sclerotinia*, and isolations were made from many collections, no attempt was made in the survey to differentiate species or strains of the fungus from different hosts or geographic locations. However, it is likely that most of the plants were infected with *S. sclerotiorum sensu stricto*. Similarly, owing to the state of the crops at sampling (see Methods), *Brassica campestris* L. (Polish rape) and *B. napus* L. (Argentine rape) were not distinguished in the survey.

The weather in the 1970 growing season in central Saskatchewan was marked by abnormally low rainfall in May, followed by up to 6 inches by the end of June in most districts. Such conditions might be expected to have favored apothecium production by overwintered sclerotia of *Sclerotinia* at a critical time in the development of susceptible crops and, therefore, to have enhanced infection. However, our knowledge of the behaviour of the fungus under field conditions in Saskatchewan is insufficient to allow more than this vague statement concerning the relationships between weather and the severity of disease.

## Methods

### Rape

Ninety-four fields, mostly in Crop Districts 8 and 9, the major rapeseed growing areas of Saskatchewan, were visited between late August and early October. Only swathed or combined fields were surveyed since sampling necessitated driving into the fields. The numbers of diseased plants were recorded in five 1-$m^2$ quadrats in each field and mean numbers of infected plants per $m^2$ were calculated. Plants were considered diseased if the remaining stems were bleached and shattered and/or contained sclerotia. The quadrats were placed 10-30 m from the edge of a field, usually at each of the four corners and halfway down one side. The survey deviated from this standard pattern in nonrectangular fields, but in all cases quadrat samples were widely dispersed in each field. In the main rapeseed growing areas fields were surveyed approximately 10 miles

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Table 1. Incidence of *Sclerotinia* in rape fields in Saskatchewan, 1970

| Crop District and area | No. of fields surveyed | Rapeseed acreage* (X $10^3$) | Relative intensity of survey index** | Percentage of fields sampled in 6 infection categories based on numbers of infected plants per $m^2$ | | | | | | Mean number of infected plants per $m^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | Tr*** | 0.20-0.99 | 1.00-9.99 | 10.00-19.99 | >20.00 | |
| 1, 2, 3, 4 Southern Saskatchewan | 0 | 25.5 | 0 | | | | | | | |
| 5 Yorkton-Wynyard | 12 | 460.1 | 0.5 | 83 | 0 | 17 | 0 | 0 | 0 | 0.07 |
| 6 Saskatoon | 12 | 100.8 | 2.5 | 75 | 0 | 25 | 0 | 0 | 0 | 0.05 |
| 7 Wilkie-Kindersley | 3 | 57.7 | 1.1 | 67 | 33 | 0 | 0 | 0 | 0 | 0 |
| 8 Tisdale-Nipawin | 38 | 665.3 | 1.2 | 32 | 6 | 41 | 15 | 3 | 3 | 2.00 |
| 9 Meadow Lake-Prince Albert | 29 | 690.6 | 0.9 | 52 | 7 | 31 | 10 | 0 | 0 | 0.22 |
| Total (whole province) | 94 | 1999.5 | 1.0 | 51 | 5 | 32 | 10 | 1 | 1 | 0.87 |

* Dominion Bureau of Statistics, July 1970 estimate.

** The index indicates the coverage in a crop district relative to a standard of one for the whole province, based on the assumption that the mean size of fields surveyed was the same in each crop district.

$$\text{Index} = 1 \times \frac{\text{No. of fields surveyed}}{94} \times \frac{1999 \times 10^3}{\text{acreage of rapeseed}}$$

*** Trace indicates fields in which disease was found only outside the quadrats. This represents an infection rate of <0.20 plants/$m^2$.

apart along arbitrarily chosen roads traversing the area. The total number of plants in the quadrats was counted in approximately every 6th field as a basis for calculating a mean number of plants per $m^2$ for Saskatchewan and, hence, a percentage infection rate. Where infected plants did not occur in the quadrats but were seen elsewhere in the field, the infection was rated as a trace.

Other host species

Those other crops and plants examined for Sclerotinia infection were determined largely by serendipity during traverses of rapeseed growing areas. However, some fields of sunflowers, peas, and lentils were deliberately included on advice from agricultural representatives in the province. A single field of yellow mustard was surveyed by the same method as for rapeseed. All the plants in garden plots, and several representative rows in the fields of sunflower were counted to determine percentage infections. The common and scientific names of the host plants examined are listed in Table 4.

## Results

Rape

The per $m^2$ infection rates of the fields were grouped into six arbitrary categories (Table 1). The intensity of the survey in each crop district varied and an index was calculated according to the total acreage and the number of fields sampled. For example, Crop Districts 5 and 6 were surveyed respectively 0.5 and 2.5 times as intensely as the average for the province. No fields were surveyed in Crop Districts 1 to 4 because of the low acreage of rapeseed in these areas.

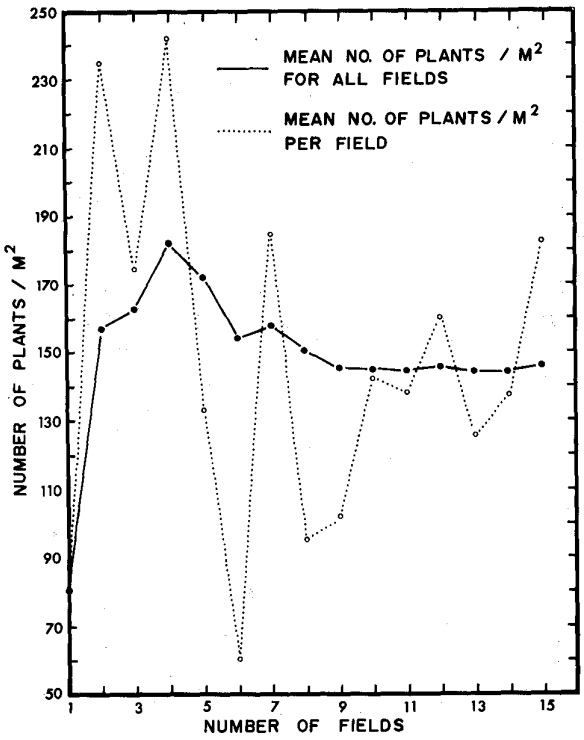


Figure 1. Mean number of plants/$m^2$ for each field and for all fields.

$$\text{Mean no. plants/m}^2 \text{ for all fields} = \frac{\Sigma \text{ mean no. plants/m}^2 \text{ for n fields}}{n}$$

Crop Districts 5, 6, and 7 had Sclerotinia in 33% or less of the fields, each with less than 1 infected plant per $m^2$. The average infection rates in these districts were 0.07 plants per $m^2$ or less. The heaviest infection rate for a district, 2.00 plants per $m^2$, occurred in Crop District 8, where 68% of the fields were infected. However, 48% of the fields were in the trace-0.99 plants per $m^2$ infection categories. In Crop District 9, where 48% of the fields were infected, the average infection rate was 0.22 plants per $m^2$, and in 38% of the fields the infection rate was in the trace-0.99 plants per $m^2$ range

Figure 1 shows that the total numbers of plants per $m^2$ in rapeseed fields varied widely, for a low of 60.2 to a high of 242.0. However, by including progressively larger numbers of fields in the calculation, the mean for all fields counted levelled off at about 145. This would be a reasonably reliable estimate of the average numbers of plants per $m^2$ for Saskatchewan. While the variation between fields did not permit the calculation from our data of reliable percentage infection rates of individual fields, the figure of 145 plants per $m^2$ was used to calculate a percentage infection rate for the whole province that was considered to be reasonably reliable. Using the figure in Table 1 of 0.87 infected plants per $m^2$, which was the average of all fields sampled, calculation gave a provincial infection rate of 0.60%. However, this figure was biased by the relative intensity of survey in different crop districts, and a more reliable calculation was made by taking into account the relative acreages in different crop districts. The mean infection rates in each of Crop Districts 5 to 9 (Table 1) were multiplied by the respective acreages for the districts. These products were then added and the sum divided by the total acreage in those crop districts. This gave a mean provincial infection rate of 0.77 plants per $m^2$ or 0.53%.

In all fields with Sclerotinia in Crop Districts 5, 6, and 7 the disease was recorded in only one quadrat, or as a trace (Table 2). This means that the disease was probably prevalent in only one area of each field. Fields in Crop Districts 8 and 9 tended to have more uniform infection, but most still had disease in only one or two quadrats. Most fields in the province with the disease appearing in less than three quadrats had an infection rate of less than 1.00 plant per $m^2$, while fields with disease appearing in three to five quadrats usually had an infection rate greater than 1 plant per $m^2$ (Table 3). In the only field that had more than 20 infected plants per $m^2$, disease occurred in all five quadrats.

A stubble survey with quadrats has advantages over previous surveys (2, 3, 4, 6, 7). Rating over the entire field is clearly more realistic than surveying along one edge, since in 58% (46+10) of infected fields in this survey the disease occurred at only one locus (Table 2). Moreover, numerical infection rates are more meaningful statistically than disease categories. By concentrating on the plants inside a quadrat,

Table 2. Uniformity of *Sclerotinia* distribution in rape fields by crop districts

| Crop District | No. of fields with disease | Percentages of infected fields where *Sclerotinia* occurred in various numbers of quadrats | | | | | |
|---|---|---|---|---|---|---|---|
| | | Tr† | 1 | 2 | 3 | 4 | 5 |
| 5 | 2 | 0 | 100 | 0 | 0 | 0 | 0 |
| 6 | 3 | 0 | 100 | 0 | 0 | 0 | 0 |
| 7 | 1 | 100 | 0 | 0 | 0 | 0 | 0 |
| 8 | 26 | 8 | 35 | 23 | 11 | 8 | 15 |
| 9 | 14 | 14 | 50 | 29 | 0 | 0 | 7 |
| Total | 46 | 10 | 46 | 22 | 6 | 4 | 11 |

† Tr = trace, indicating fields in which the disease was found only outside the quadrats.

Table 3. Uniformity of *Sclerotinia* in rape fields relative to disease ratings

| No. of quadrats with disease per field | No. of fields | Percentages of fields with *Sclerotinia* in 6 infection categories based on numbers of infected plants per $m^2$ | | | | |
|---|---|---|---|---|---|---|
| | | Trace* | 0.20-0.99 | 1.00-9.99 | 10.00-19.99 | >20.00 |
| Trace* | 5 | 100 | 0 | 0 | 0 | 0 |
| 1 | 22 | 0 | 100 | 0 | 0 | 0 |
| 2 | 9 | 0 | 67 | 33 | 0 | 0 |
| 3 | 3 | 0 | 67 | 33 | 0 | 0 |
| 4 | 2 | 0 | 0 | 100 | 0 | 0 |
| 5 | 5 | 0 | 0 | 60 | 20 | 20 |
| Total | 46 | 11 | 65 | 20 | 2 | 2 |

* Trace indicates fields in which the disease was found only outside the quadrats.

infected specimens were noted which normally would have been missed in scanning because they lacked stereotyped disease symptoms, although containing sclerotia inside the stems. Nevertheless the stubble-quadrat technique probably slightly underestimates infection rates, because stubble is crushed by machinery and some infected plants may be missed. Also, as noted earlier on mustard (3), and observed by us in 1970 on rape, some Sclerotinia infections occur higher up on the stem and do not extend to the base. A survey of stubble will exclude such plants.

There is some disadvantage to using infection rates per unit area, rather than percentage infection rates, when there is a wide fluctuation in the total number of plants per unit area. However, this is compensated for by the fact that numbers of infected plants per unit area are a direct measurement of the total amount of disease, whereas percentage infection rates are not. Frequently the latter are quoted in the literature without reference to total numbers of plants in the area. Particularly in the case of diseases like sclerotinia stem rot, an appreciation of disease spread is dependent on a knowledge of the actual density of diseased plants. A given amount of inoculum could cause a similar number of plant infections in two fields, which, because of differing plant densities, might differ in percentage infection rates by a factor of 2 or more. An apparent twofold difference such as that could be quite misleading in assessing the disease potential of the two areas, and relating the severity of disease to weather conditions. Hence, surveys which rely on assessing diseases on a fixed number of plants collected in each field have important limitations from the epidemiologist's viewpoint.

Other host species

Sclerotinia disease was found on a number of other crops, common weeds, and garden plants (Table 4). Most disease occurred as basal stem rot except on tomato, vegetable marrow, buttercup squash, and pumpkin, where it also occurred in the fruit. Three dryland sunflower fields in Crop District 2 were surveyed but showed no evidence of Sclerotinia. However, a 1.7 acre irrigated plot of sunflower near Saskatoon had 14% infection, while six gardens in Crop Districts 6 and 8, with plots of 100 to 600 plants, had respectively 0, 7, 8, 33, 36, and 51% infection. This survey was somewhat prejudiced as usually only gardens with wilted plants were examined closely. Sclerotinia was found on other garden plants including lettuce, squash, pumpkin, bean, peas, tomato, and hollyhock from widely dispersed points in Crop Districts 5 to 9. The disease was found on minor legume field crops in Crop District 8 (Melfort-Nipawin) in fields of seed sweet clover, seed alfalfa, field peas, and lentils. Specimens on flax and Canadian goldenrod were also found in this district. The prevalence of Sclerotinia on Canada thistle and perennial sow thistle throughout the province stresses the importance of weed control in slough areas, roadsides, and fenceways (2,3).

## Discussion and conclusions

Since Conner's compendium (1) no reports of Sclerotinia on new host species in Canada have appeared in the Canadian Plant Disease Survey or elsewhere, to our knowledge. Thus, Sclerotinia on Solidago canadensis L. var. salebrosa (Piper) Jones, Linum usitatissimum

Table 4. Host plants on which *Sclerotinia* was found in Saskatchewan in 1970

| Common name | Scientific name | Remarks |
|---|---|---|
| Rape a) polish<br>b) argentine | *Brassica campestris* L.<br>*Brassica napus* L. | See text. |
| Mustard, yellow | *Brassica hirta* Moench 'yellow' | One field, 0.3% infection, surveyed same as rape. |
| Canadian goldenrod | *Solidago canadensis* L.* var. *salebrosa* (Piper) Jones | Specimens in field of seed sweetclover. |
| Canada thistle | *Cirsium arvense* (L.) Scop.** | In three locations, two in rape fields, one near heavily infected sunflower. |
| Perennial sowthistle | *Sonchus arvensis* L. | In seven locations, five associated with rape or sunflower. |
| Sunflower | *Helianthus annuus* L. | See text. |
| Lettuce | *Lactuca sativa* L. | In three garden locations. |
| Squash-vegetable marrow | *Cucurbita pepo* L.** | All in same market garden; infection extensive on all 3 hosts. |
| Pumpkin | *Cucurbita pepo* L.** | |
| Buttercup squash | *Cucurbita maxima* Duchesne** | |
| Lentils | *Lens culinaris* Medik.*** | In one field. |
| Alfalfa | *Medicago sativa* L. | In one field. |
| Sweetclover, yellow | *Melilotus indica* (L.) All. | In three fields. |
| Bean | *Phaseolus vulgaris* L. | In one garden. |
| Pea | *Pisum sativum* L.** | In one field and one garden. |
| Flax | *Linum usitatissimum* L.* | In one field. |
| Hollyhock | *Althaea ficifolia* (L.) Cav.** | In one garden. |
| Tomato | *Lycopersicon esculentum* Mill.** | In one garden. |

* New Canadian record, not listed in Conners (1).

** New Saskatchewan record, not listed in Conners (1).

*** New Canadian record, host not listed in Conners (1).

L., and Lens culinaris Medik. are new records for Canada. Similarly several new records for Saskatchewan are indicated in Table 4.

Previous survey reports (3,7) have mentioned the possibility of an increase of common rapeseed diseases over the years in Saskatchewan. Although it is not possible to compare the quantitative data of 1970 with data for previous years (see Results), it is possible to compare the relative percentages of fields with Sclerotinia present (Table 5). Surveys before 1970 were conducted almost entirely in Crop Districts 8 and 9, so that in Table 5 the 1970 figures are taken only from these districts. The data indicate that Sclerotinia is probably becoming increasingly widespread. It is likely that the apparent increase in infected fields in 1970 is partly due to more careful surveying. The possibility that earlier surveys missed fields with low levels of infection because they covered only parts of the fields is emphasized in Table 3, which indicated that in most such fields Sclerotinia was found in only one quadrat. On the other hand, part of this effect may have been offset by the stubble survey missing infections restricted to areas higher on the plant stems.

The above discussion suggests the need for future surveys of Sclerotinia, though perhaps not always on an annual basis. Inoculum may become generally distributed in Crop Districts 8 and 9, and perhaps elsewhere, in 5 to 10 years. Increased sales and continuing markets have already established rapeseed as a major crop in Saskatchewan and the acreage in the province

Table 5. *Sclerotinia* infection on rapeseed as recorded in disease surveys since 1957 in Saskatchewan Crop Districts 8 and 9

| Year of survey | Acreage in province* ($10^3$) | Fields surveyed (no.) | Fields infected (%) | Reference |
|---|---|---|---|---|
| 1957 | 520 | 38 | 5.3 | Vanterpool (6) |
| 1962 | 167 | n.a.** | trace | Vanterpool (7) |
| 1965 | 555 | 40 | 27.5 | Petrie and Vanterpool (2) |
| 1966 | 731 | 52 | 39.0 | Petrie and Vanterpool (3) |
| 1967 | 600 | 28† | 32.1 | Petrie and Vanterpool (4) |
| 1969 | 1000 | 40 | 2.5 | Crop Districts 7 and 9, (Petrie, pers. comm.) |
| 1970 | 2000 | 67 | 59.7 | In text |

* Reference: Saskatchewan Dep. Agr. 1969. Annual Report.

** n.a. = figures not available.

† Includes rapeseed and mustard.

quadrupled from 1968 to 1970. If production continues with varieties exhibiting little disease resistance, inoculum will increase locally in favorable years and will become more widely distributed. There will then be the potential for widespread epidemics in some years, instead of the localized severe outbreaks observed in 1970 (Table 1). Since most of the new crops being grown in Saskatchewan, in particular sunflower, field peas, and safflower, are known hosts of Sclerotinia, the risk is not confined to rapeseed. It remains for plant breeders and pathologists to incorporate into their programs means to attack this possible threat.

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# FUNGICIDES FOR PREVENTING CLUBROOT OF CAULIFLOWER IN LOAM AND PEAT SOILS[1]

*D.G. Finlayson and C.J. Campbell*

## Abstract

Peat and sandy loam soils infested with Plasmodiophora brassicae were treated in the greenhouse with Benlate, calomel, $NH_4OH$, and quintozene. Blocks were seeded 0, 14, and 28 days after treatment. Fourteen days after seeding, emergence was recorded and 42 days after seeding the incidence of clubroot was assessed. $NH_4OH$ at the highest rate seriously reduced emergence and caused severe stunting. In peat, calomel and $NH_4OH$ reduced clubroot. In sandy loam all the treatments except the two lowest rates of Benlate reduced clubroot. $NH_4OH$ effectively decreased acidity of the soils for about 28 days.

## Introduction

Experiments from 1962 to 1965 (5) produced methods and rates of application for several insecticides to protect stem crucifers (cabbage, cauliflower, broccoli and Brussels sprouts) from damage by cyclodiene-resistant cabbage maggots, Hylemya brassicae (Bouché). During this period no attempt was made to prevent clubroot infection by Plasmodiophora brassicae Wor. In 1966 experiments were initiated to determine if the recommended chemicals for preventing clubroot and maggot damage could be applied together and still remain compatible. The following year a large field experiment was conducted to assess fungicides, insecticides, and starter solutions applied in the transplant water (2). Several incompatibilities were noted and further work was conducted to assess pesticides applied prior to seeding of cauliflower (3). There were no apparent interactions in the combined chemicals but it was obvious that the compounds applied prior to seeding did not prevent clubroot infection. In 1969 greenhouse and field experiments were conducted to investigate the action of $NH_3$, $NH_4OH$, quintozene, and calomel (mercurous chloride) on clubroot in direct-seeded cauliflower (4). Some reduction in clubroot was noted and further experiments were conducted in the greenhouse to determine the feasibility of further field work. Cauliflower is the most sensitive of the stem brassicas to chemical treatments.

## Materials and methods

Samples of clubroot-infested sandy loam and peat soils from untreated blocks of the 1969 experiments were taken in late September, held at approximately 5C for 4 months, sifted, and air-dried in the greenhouse for 24 hr before treating. Subsamples of 4,000 g sandy loam or 3,200 g peat, sufficient to fill seven 10-cm plastic pots, were treated with Benlate (50% benomyl [methyl 1-(butylcarbomoyl)-2-benzimidazole-carbamate], Dupont of Canada Ltd., Toronto, Ont.), calomel, or quintozene (Terraclor, 75% pentachloronitrobenzene, Olin Mathieson Chemical Corp., Little Rock, Arkansas) at various rates (Table 1). The soil samples were layered with the powdered fungicides in a plastic basin, mixed, poured into a plastic bag, thoroughly tumbled, and divided equally amongst the pots. $NH_4OH$ (28-30% $NH_3$) was injected with a No. 20 hypodermic needle 4 cm below the surface of untreated soil in pots in 3 equal portions at the points of an equilateral triangle of approximately 3-cm sides in the center of the pots. Each of the 14 treatments was replicated 21 times for each soil type, i.e. 7 replicates in each of 3 blocks for sandy loam and peat. Each block was randomized so that each of the 7 rows contained every treatment. Block I was seeded 0 days after treatment; Block III, 14 days after treatment; and Block II, 28 days. Each pot received 6 seeds (cv. Snowball Y), 2 in the center of the pot and 1 in each of the four quadrants 3 cm from the center at diagonal right angles. The emerged seedlings were counted 14 days after seeding and thinned at that time to give a maximum of 3 seedlings per pot, one of which was in the center. Captan was applied to all blocks as a dust on the surface to prevent damping-off. Water was added topically as needed.

The seedlings were examined for clubroot 42 days after seeding. The pots were up-ended, and the soil was carefully shaken from the roots, which were then washed in clean water, and the incidence of clubroot was recorded. The index of infection was: no clubroot, 0; slight clubbing, 1; moderate, 2; severe, 3; and very severe, 4 (Fig. 1). Plants treated with Benlate and quintozene and untreated plants were placed in frozen storage for residue studies. To determine the effects of $NH_4OH$ on the acidity of soils

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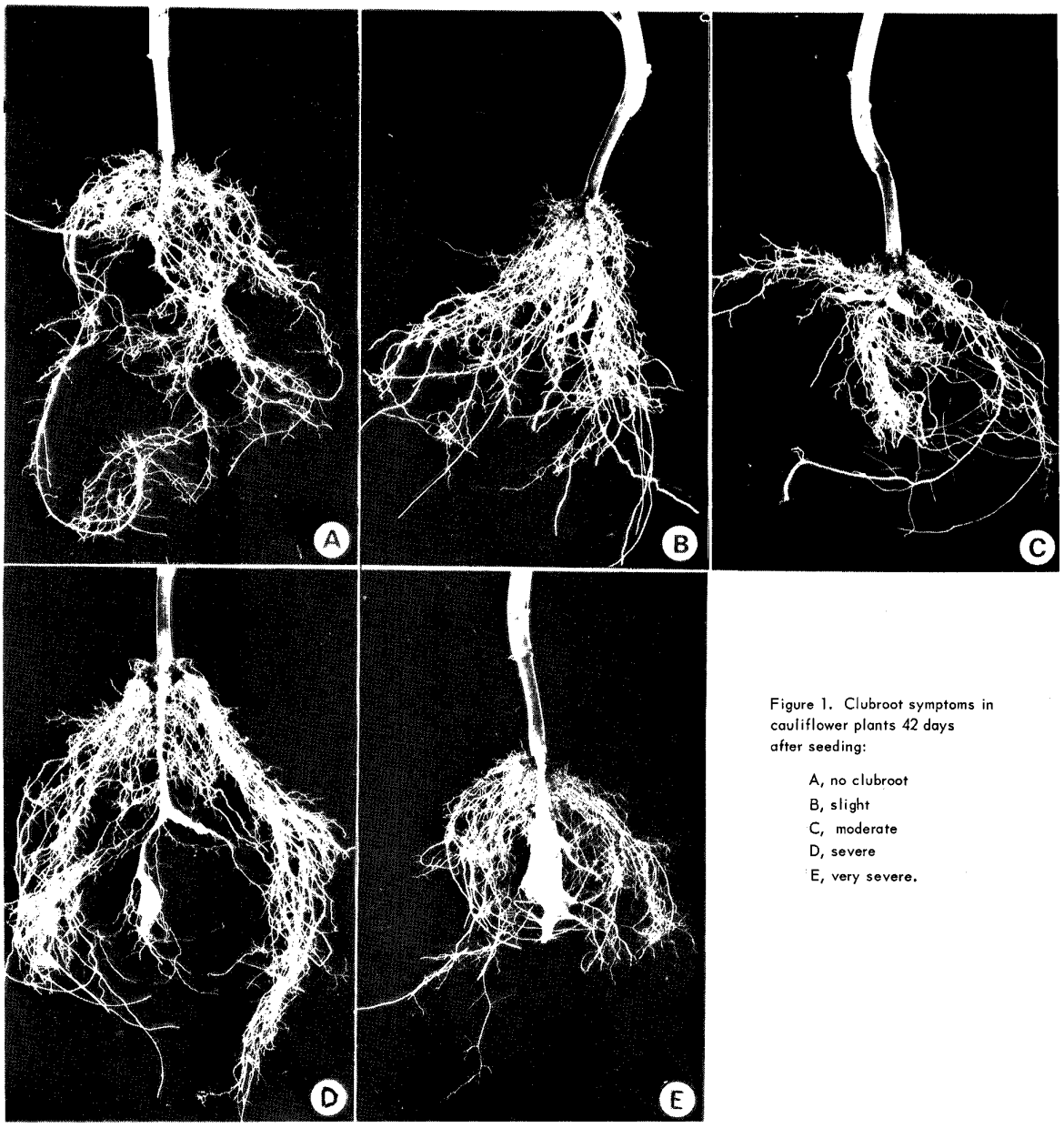


Figure 1. Clubroot symptoms in cauliflower plants 42 days after seeding:

A, no clubroot
B, slight
C, moderate
D, severe
E, very severe.

not containing plants, additional pots were treated with the 1.5 and 3.0 ml rates of $NH_4OH$ and the pH was determined 1, 3, 5, 7, 14, and 28 days after injection.

The values for seedling emergence, and severity of clubroot (expressed as percentages of the maximum index and transformed using angle = arc sin $\sqrt{\text{percentage}}$) were examined by the analysis of variance and compared according to Duncan (1).

## Results and discussion

Values for seedling emergence and clubroot infection are shown in Table 1. In both soils there was a significant reduction in the number of emergent seedlings when the pots were seeded immediately after treatment. The most severe reduction occurred in pots treated at the highest rate of $NH_4OH$, which also caused significant reductions in sandy loam when the values were averaged across the

Table 1. Average number of emergent seedlings per pot seeded 0, 14, and 28 days after fungicide treatment and average percentage clubroot assessed 42 days after seeding in sandy loam and peat soils

| Treatment and rate (ppm active) | | Number of seedlings | | | | Percentage clubroot* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 14 | 28 | Avg | 0 | 14 | 28 | Avg† |
| *Sandy loam soil* | | | | | | | | | |
| Benlate | 20 | 4.3 | 5.3 | 5.6 | 5.1 | 80.0 | 59.5 | 62.5 | 67.3 a |
| Benlate | 40 | 3.7 | 5.9 | 5.7 | 5.1 | 62.5 | 72.6 | 54.8 | 63.3 a |
| Benlate | 80 | 2.6 | 5.4 | 5.7 | 4.6 | 41.1 | 2.4 | 0.0 | 14.3 bc |
| Benlate | 160 | 2.1 | 5.4 | 5.4 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 c |
| Calomel | 10 | 3.4 | 5.3 | 5.7 | 4.8 | 5.9 | 0.0 | 0.0 | 2.0 c |
| Calomel | 20 | 4.0 | 4.7 | 5.6 | 4.8 | 0.0 | 0.0 | 0.0 | 0.0 c |
| $NH_4OH$** | 0.75 | 3.1 | 5.0 | 5.4 | 4.5 | 47.2 | 0.0 | 14.3 | 20.5 b |
| $NH_4OH$ | 1.50 | 3.3 | 5.9 | 4.3 | 4.5 | 33.3 | 0.0 | 4.2 | 12.5 bc |
| $NH_4OH$ | 3.0 | 1.0 | 4.9 | 1.4 | 2.4†† | 8.3 | 0.0 | 6.3 | 4.9 bc |
| Quintozene | 40 | 4.0 | 5.7 | 5.6 | 5.1 | 5.3 | 2.4 | 2.4 | 3.4 b |
| Quintozene | 80 | 3.9 | 5.6 | 5.4 | 5.0 | 1.3 | 0.0 | 0.0 | 0.4 c |
| Quintozene | 160 | 4.6 | 4.7 | 5.9 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 c |
| Quintozene | 320 | 4.3 | 5.1 | 4.9 | 4.8 | 0.0 | 0.0 | 0.0 | 0.0 c |
| Untreated | | 3.9 | 5.6 | 4.9 | 4.7 | 78.8 | 30.9 | 41.7 | 50.5 a |
| Avg† | | 3.4 a | 5.3 b | 5.1 b | | 26.0 a | 12.0 b | 13.3 b | |
| *Peat soil* | | | | | | | | | |
| Benlate | 25 | 2.7 | 5.6 | 5.7 | 4.7 | 64.7 | 65.5 | 20.2 | 50.1 a |
| Benlate | 50 | 3.4 | 5.9 | 5.6 | 5.0 | 68.4 | 67.9 | 17.8 | 51.4 a |
| Benlate | 100 | 3.6 | 5.4 | 5.4 | 4.6 | 53.8 | 64.3 | 8.3 | 42.1 a |
| Benlate | 200 | 2.1 | 5.9 | 5.6 | 4.5 | 64.6 | 32.1 | 0.0 | 32.2 ab |
| Calomel | 12.5 | 4.4 | 5.7 | 5.7 | 5.3 | 33.3 | 33.3 | 11.9 | 26.2 abc |
| Calomel | 25.0 | 4.1 | 5.7 | 5.6 | 5.1 | 0.0 | 15.5 | 3.6 | 6.4 bcd |
| $NH_4OH$** | 0.75 | 4.1 | 5.0 | 5.7 | 4.9 | 0.0 | 14.3 | 0.0 | 4.8 cd |
| $NH_4OH$ | 1.5 | 4.0 | 5.4 | 5.3 | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 d |
| $NH_4OH$ | 3.0 | 1.9 | 5.2 | 3.9 | 3.7 | 0.0 | 0.0 | 0.0 | 0.0 d |
| Quintozene | 50 | 3.9 | 5.3 | 5.9 | 5.0 | 72.4 | 14.3 | 14.3 | 33.7 ab |
| Quintozene | 100 | 3.9 | 5.4 | 5.4 | 4.9 | 60.7 | 2.4 | 9.5 | 24.2 abc |
| Quintozene | 200 | 4.7 | 5.0 | 5.7 | 5.1 | 52.4 | 22.6 | 11.9 | 29.0 abc |
| Quintozene | 400 | 4.1 | 5.4 | 6.0 | 5.2 | 29.8 | 23.8 | 0.0 | 17.9 abcd |
| Untreated | | 4.3 | 5.7 | 5.6 | 5.2 | 61.9 | 40.5 | 3.6 | 35.3 ab |
| Avg† | | 3.7 a | 5.5 b | 5.5 b | | 40.1 a | 28.3 a | 7.2 b | |

* Average percentage of the maximum index.

** Rates of $NH_4OH$ are expressed in ml per 10-cm pot.

† Averages followed by the same letter are not significantly different at the 5% level (1).

†† This was the only significantly different value in the column.

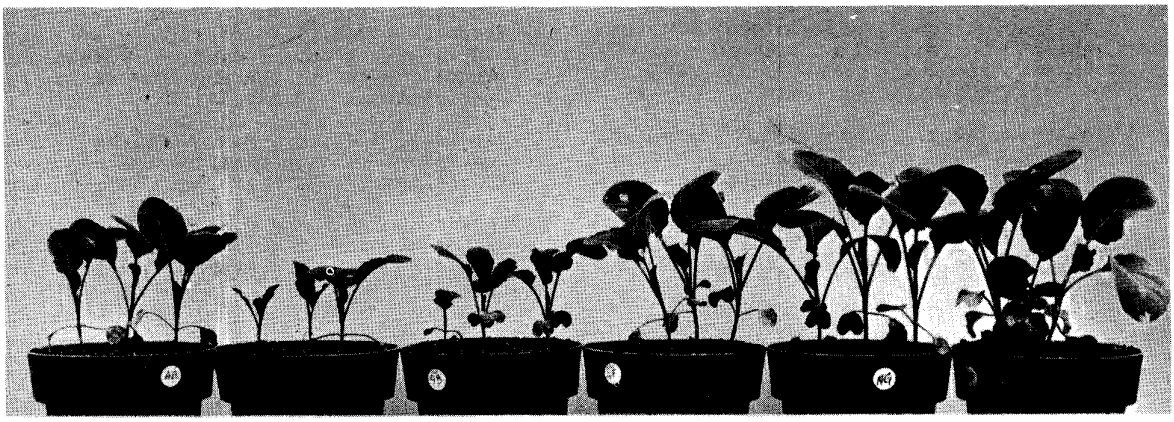


Figure 2. Effects of soil fungicide treatments on growth of cauliflower plants.

three seeding periods. In sandy loam and in peat the average number of seedlings in pots treated with 3.0 ml $NH_4OH$ was 2.4 and 3.7 respectively, compared with the overall average of 4.6 in sandy loam and 5.0 in peat. At 1.5 ml $NH_4OH$, the average number of seedlings was about normal. Growth was retarded in seedlings grown in soil treated with 20 ppm calomel or 3.0 ml $NH_4OH$ (Fig. 2).

There was significantly more clubroot in the plants when they were seeded in pots immediately after treatment than when they were seeded 28 days after treatment. However, the amount of clubroot infection in the untreated blocks also decreased during the waiting period, and this was more evident in the peat soil than in the sandy loam. In peat only the higher rate of calomel and the three rates of $NH_4OH$ effectively reduced the incidence of clubroot. In sandy loam all treatments except the two lowest rates of Benlate reduced the amount of clubroot. This is contrary to reports by Jacobsen and Williams (6) who reported that cabbage plants grown in soil freshly mixed with benomyl (Benlate) at 0.1 to 1.6 g active material/litre of soil were free of clubroot for 35 days. Quintozene was very effective at all rates in sandy loam but was no better than the untreated controls in peat soil. Systemic clubroot, as described by Kavanagh and Williams (7), was observed in the cauliflower experiment, but it was not included in the results.

Treatment with $NH_4OH$ decreased the acidity of the soils (Table 2). In peat the pH increased from 4.9 to 7.5 when 1.5 ml $NH_4OH$ were used and to 8.1 when 3.0 ml were used. By 28 days the pH values were approaching those of the untreated soil. In sandy loam 1.5 and 3.0 ml of $NH_4OH$ changed the pH from 5.5 to 8.4 and 8.9 one day after treatment; 28 days after treatment soil treated at the lower rate was back to normal, but at the 3.0 ml rate the pH was 6.7. If addition of lime to soil to decrease acidity has any bearing on lowering the incidence of clubroot, then the addition of $NH_4OH$ merits further investigation because not only does it lower the acidity, but it also adds nitrogen to the soil through the breakdown of $NH_3$.

Table 2. Average pH of sandy loam and peat soils 1, 3, 5, 7, 14, and 28 days after injection with 1.5 and 3.0 ml $NH_4OH$ per 10-cm pot

| | *Sandy loam* | | | *Peat* | | |
|---|---|---|---|---|---|---|
| | Rate $NH_4OH$ (ml) | | | Rate $NH_4OH$ (ml) | | |
| Days after treatment | 0 | 1.5 | 3.0 | 0 | 1.5 | 3.0 |
| 1 | 5.5 | 8.4 | 8.9 | 4.9 | 7.5 | 8.1 |
| 3 | 5.4 | 8.1 | 8.4 | 4.9 | 7.2 | 7.9 |
| 5 | 5.4 | 7.9 | 8.2 | 4.9 | 7.1 | 7.9 |
| 7 | 5.1 | 7.9 | 8.4 | 4.8 | 6.5 | 7.8 |
| 14 | 4.8 | 7.0 | 7.9 | 4.7 | 6.0 | 6.6 |
| 21 | 5.2 | 6.1 | 7.2 | 4.8 | 5.5 | 6.4 |
| 28 | 5.2 | 5.4 | 6.7 | 4.9 | 5.1 | 6.0 |

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# PLANT-PARASITIC NEMATODE GENERA ASSOCIATED WITH CROPS IN ONTARIO IN 1970

F. Marks, J.L. Townshend, J.W. Potter, Th.H.A. Olthof[1], and A. Cornelisse[2]

The number of samples processed through the Ontario Nematode Diagnostic and Advisory Service totalled 980 (Table 1) in 1970, a 20% increase over that of 1969. Excluding soil samples from nematicide trials by chemical companies, a total of 329 samples were submitted; 37% of the samples were from tobacco, 16% from forages and small grains, 16% from ornamentals, 13% from fruits, 8% from vegetables, and 10% from miscellaneous crops, as compared to 48, 12, 9, 10, 4, and 17% from these crops in 1969.

There was a trend towards a wider usage of the Service by growers and extension personnel, as evidenced by the fact that samples were submitted from 45 crops as compared to 28 in 1969. There was also a trend towards the submission of more research samples (597) and fewer service (paid) samples (383) by extension personnel in 1970, indicating that the Nematode Diagnostic Service is becoming an increasingly important tool for diagnosing or confirming diagnoses of complex soil problems affecting crop production. Since many of the indications of nematode damage are quite similar to nutritional problems, it would be helpful with certain key crops on light soils to collect samples for both nematode diagnosis and soil analysis.

One noteworthy and unusual series of samples was submitted by Charles Warner, Instructor at New Liskeard College of Agricultural Technology. These samples were taken from hay and pasture, corn, and mixed oats and barley fields in Nipissing, Parry Sound, and Thunder Bay Districts, respectively, in northern Ontario. Seven genera of nematodes: root-lesion (Pratylenchus sp.), pin (Paratylenchus sp.), dagger (Xiphinema sp.), spiral (Helicotylenchus sp., stunt (Tylenchorhynchus sp.), root-knot (Meloidogyne sp.), and cyst (Heterodera sp.) nematodes, were extracted from the samples. Two types, the root-lesion and pin nematodes from hay samples, averaged 4400 and 2150 per pound of soil, respectively; the highest populations of these two genera were 13,100 and 6,400 per pound, respectively. These population densities are much greater than those usually found in cultivated soils in southern Ontario. These results were unexpected as it had been considered that the northern Ontario winter climate was too harsh to allow sizeable populations of nematodes to survive. Therefore, the results indicate the possibility that nematodes have deleterious effects on crop production in Canada's northern farming areas.

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Table 1. Plant parasitic nematodes identified from soil samples processed by the Ontario Nematode Diagnostic and Advisory Service, 1970

| Crop | No. of samples | Nematode | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cyst lesion | Root knot | Root lesion | Spiral | Stunt | Pin | Dagger | Ring | Lance | Stubby root |
| Alfalfa | 1 | | | | | | 1200/1 | | | | |
| Apple | 4 | 50/1** | | 1413/4 | | 325/2 | 50/1 | | | | |
| Asparagus | 1 | | | 3000/1 | | 800/1 | 1100/1 | | | | |
| Barley | 6 | 50/1 | | 4150/5 | 863/4 | 683/3 | 1463/4 | | | | |
| Buckwheat | 1 | | | 550/1 | | | 50/1 | | | | |
| Carrot | 2 | | 1150/1 | | | 50/1 | 125/2 | | | | |
| Cherry | 10 | | | 1730/10 | | 167/3 | 450/3 | 10/1 | | 257/7 | |
| Clover (red) | 1 | | | | 3500/1 | 1200/1 | | | | | |
| Corn | 15 | 350/3 | | 1475/14 | 170/5 | 83/3 | 459/11 | | 50/1 | | |
| Fallow | 4 | | | 613/4 | 50/1 | 50/2 | 325/2 | 150/2 | | | |
| Flowers (misc) | 3 | | | 533/3 | | 150/2 | 625/2 | | | | |
| Geranium | 1 | | | | | | | | | | |
| Grain (mixed) | 1 | | | 5000/1 | | | 1800/1 | | | | |
| Grasses (mixed) | 7 | 150/1 | 1600/1 | 3800/7 | 300/1 | | 2158/6 | 100/1 | | | |
| Grass (Sudan) | 1 | | | 1400/1 | 400/1 | | | 10/1 | | | |
| Lawn | 2 | 600/1 | | 1100/1 | 200/1 | 525/2 | 100/1 | | | | |
| Lettuce | 1 | | | | | | | | | | |
| Mums (cuttings) | 3 | | | | | | | | | | |
| Mums (potted) | 1 | | | | | | | | | | |
| Mushroom | 2 | | | | | | | | | | |
| Oats | 5 | 200/1 | 300/1 | 3383/3 | 400/1 | 125/2 | 500/3 | | | | |
| Onion | 3 | | | | | 50/1 | | | | | |
| Peach | 15 | | 300/1 | 2688/12 | 50/1 | 375/2 | 2423/11 | 225/2 | 200/1 | | |
| Pear | 6 | | | 1720/5 | | 75/2 | 250/3 | | | | |
| Potato | 3 | | | 1220/3 | | 50/1 | 267/3 | | | | |
| Rhubarb | 7 | 2800/1 | | 3038/4 | | | 5368/6 | | | | |
| Rose | 21 | | | 1267/15 | 10/1 | | 150/1 | | | | |
| Rye | 24 | | | 643/18 | | 175/10 | 372/9 | | | | |
| Shrubs (cedar) | 3 | | | | 5300/1 | | | | | | |
| Shrubs (Deciduous, misc) | 1 | | | 700/1 | | | 50/1 | | | | |
| Shrubs (Evergreens, misc) | 5 | | | 217/3 | | 50/1 | 171/4 | | | | |
| Shrubs (Flowering, misc) | 6 | | 13300/2 | 16300/2 | 30/1 | 965/4 | 800/1 | | 1275/2 | | 163/4 |
| Shrubs (Andorra juniper) | 5 | | | 1375/2 | | 50/1 | 1200/1 | | | | |
| Shrubs (Blue Pfitzer juniper) | 1 | | | 16000/1 | | | | | | | |
| Shrubs (Blue Danube juniper) | 1 | | | | | 50/1 | | | | | |
| Shrubs (Meyer juniper) | 1 | | | 600/1 | | | | | | | |
| Shrubs (Savin juniper) | 1 | | | 2500/1 | | | 200/1 | | | | |
| Soybean | 1 | | | 1750/1 | | | 50/1 | | | | |
| Squash | 2 | | | 50/1 | | | 305/2 | | | | |
| Strawberry | 7 | | 450/1 | 558/6 | 50/1 | 300/1 | 50/1 | | | | |
| Tobacco | 121 | 50/1 | 100/2 | 1328/80 | 288/4 | 175/18 | 247/43 | | | | |
| Tobacco* | 651 | | | | | | | | | | |
| Tomato | 7 | | | 2250/3 | | 50/1 | 700/2 | | | | |
| Turnip | 1 | | | | | | | | | | |
| Vegetables (misc) | 4 | | | 2250/1 | | 300/2 | 1200/2 | | | | |
| Water cress | 1 | | | | | | | | | | |
| Wheat | 10 | 1500/1 | 200/1 | 705/10 | 150/1 | 200/2 | 1156/9 | | | | |
| Total | 980 | | | | | | | | | | |

* Samples from nematicide trials - averages are not included because treatments render them invalid.

** Average number of nematodes per lb of soil/number of samples containing the nematode.

# SUSCEPTIBILITY OF SOME STRAWBERRY CULTIVARS TO GREEN PETAL[1]

*C.O. Gourley, G.W. Bishop, and D.L. Craig*

## Abstract

Of 13 cultivars and selections of strawberry exposed to natural infection in a field test at Oxford, Nova Scotia, the cultivars Redcoat and Elista and the Kentville selection K63-280 were the least affected by green petal. Variation in disease incidence may have occurred because of a difference in vector preference for different cultivars, and not primarily as a cultivar resistance to green petal.

## Introduction

Green petal, a virus-like disease of strawberries, occurs sporadically and in varying intensities in different areas of the Maritime Provinces (13). Chiykowski (3) showed that the green petal pathogen also causes clover phyllody. Observations made by Stultz and MacNab (13) and the transmission studies of Chiykowski (5) indicated that, in addition to clover, other plants may be reservoirs for this disease causing entity. The infectious agents appear to be mycoplasma-like bodies transmitted by leafhoppers (1,2,4,7,8,12).

In 1955, green petal was first reported in Nova Scotia on the cultivars Catskill, Senator Dunlap, and Temple (9). Since that time it has been found on most of the strawberry cultivars grown in the Maritime Provinces (6,10,11,13).

In 1967, a single row of 100 virus free plants for each of 13 cultivars or seedlings, was set out in a strawberry yield trial at Oxford, Cumberland County, Nova Scotia. Rows were set in an east-west direction and cultivars in the order arranged in the table from 'K63-280' on the north to 'Acadia' on the south side. The planting was bounded by a hedgerow on the south, by strawberry and raspberry plantings on the east and west ends, respectively, and on the north by a field of grass and clover. Phyllody was not observed on clover plants in this field.

## Observations and discussion

In 1968, a high incidence of green petal occurred in this trial and during harvest each mother plant of each cultivar was examined for symptoms of disease. The incidence of green petal was recorded as follows:

| Cultivar | % mother plants diseased |
|---|---|
| K63-280† | 5 |
| Tioga | 56 |
| Talisman | 13 |
| Senga Sengana | 18 |
| Sparkle | 24 |
| Raritan | 16 |
| Elista | 5 |
| Redcoat | 4 |
| Vesper | 20 |
| K60-98† | 14 |
| Midway | 12 |
| Gorella | 12 |
| Acadia | 11 |

† Kentville seedling.

More green petal occurred in Sparkle than in Redcoat, two cultivars commonly grown in Nova Scotia. In the Oxford area, the incidence of green petal has been higher in commercial plantings than in other areas of the province (13), and observations suggest that Sparkle has been more seriously affected than Redcoat. Collins and Morgan (6) observed similar cultivar resistance to strawberry green petal, and reported Sparkle to be more susceptible than Redcoat. They indicated that although the strawberry was not a preferred host for the leafhopper vector, it was a suitable one. However, they believed that the disease was aster yellows and therefore assumed that the vector was Macrosteles fascifrons (Stål). More recent work has shown that the disease is distinct from aster yellows and that green petal may be transmitted by several species of leafhopper (1,2,3,4,8).

The work of Collins and Morgan (6) indicated that the vectors are slow moving and that this may have accounted for the higher incidence of green petal along the sides of plantations bordering on source

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fields. In the Oxford trial the incidence of green petal varied and was not always highest in those cultivars nearest source fields. There may be a difference in vector preference for different cultivars, and this may have been responsible for the difference in the incidence of green petal among the cultivars in this trial.

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# INFLUENCE OF VITAVAX SEED TREATMENT AND LOOSE SMUT INFECTION ON YIELDS OF BARLEY AND WHEAT[1]

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## Abstract

Vitavax seed treatments at 4 and 8 oz per 100 lb of seed gave complete control of the loose smuts of barley and wheat. The 4 oz rate gave the highest yields in most cases, and the 8 oz rate reduced the yield of some seed lots. Levels of embryo smut infection ranging from 4 to 13% caused yield reductions, the highest level reducing yield by approximately 10%. In addition, although loose smut was controlled by treatment with Vitavax, the yield potential of the infected barley seed was not as high as that of smut-free seed.

## Introduction

The control of loose smuts of cereals where infection takes place during flowering has been difficult and uncertain until the recent appearance of oxathiin fungicides, of which Vitavax appears to be the most effective (1,4). There is little doubt about the efficacy of these chemicals in controlling cereal smuts. However, further information is necessary on the influence of internal smut infection of seed and Vitavax treatment on specific crops and varieties. The work reported here concerns greenhouse and field experiments with samples of barley and wheat seed infected with various levels of the loose smut fungi Ustilago nuda (Jens.) Rostr. and U. tritici (Pers.) Rostr., respectively.

## Materials and methods

Three seed lots of 'York' barley, Hordeum vulgare L., infected with 3.5, 13.5 and 5.4% loose smut, as determined by the embryo test, were used in this study. The seed was grown at Ottawa and represented successive crops from one original smaple. An additional sample of 'York' barley from another source was included for comparative purposes. Two samples of 'Opal' spring wheat seed with a light infection of loose smut (less than 1% head infection in the field) were obtained from Charlottetown, P.E.I., and Kentville, N.S., and were compared with an Ottawa sample from a plot free from smutted heads. One-lb portions of seed from each lot were treated with Vitavax (75% carboxin [2,3-dihydro-5-carboxanilido-6-methyl-1,4 oxathiin]; Uniroyal Ltd., Elmira, Ontario) at the rates of 4 and 8 oz per 100 lb (113 and 227 g per 45.4 kg) of seed. Treated and untreated samples of barley and wheat were sown in the greenhouse and in the field in 1970. The barley greenhouse test was sown twice and all others once. In the greenhouse seeding was done in beds, one row per treatment replicated four times. In one barley test and in the wheat test 20 seeds were planted per row 1 inch (2.5 cm) apart, while in the second barley test 25 seeds were planted approximately 1 inch apart. Rows were spaced approximately 12 inches (30.5 cm) apart. All plants were harvested at maturity. In the field seeding was done in 4-row plots with the rows 7 inches (17.8 cm) apart and 11.5 ft (3.5 m) long; each plot was replicated four times. Ten-foot (3-m) sections of the two center rows of each plot were harvested for yield and 1000 kernel weight determinations. A randomized block design was used in both the greenhouse and field.

Plant and head counts were made in all rows in the greenhouse and head counts on all four rows of each plot having loose smut in the field. Emergence counts were made on the two center rows of each field plot. Smut counts were taken when the plants were fully headed and percentages were determined on the basis of head counts.

## Results and discussion

Vitavax completely controlled the loose smuts of barley and wheat at the two concentrations used (Tables 1,2, and 3). Because the amount of loose smut present in the barley seed lots had been determined by the embryo test prior to seeding, these figures could be compared with the amount that actually appeared in the resulting plants. The average smut infection in the untreated seed in the greenhouse and in the field amounted to only 40% of that indicated by the embryo test, and the highest infection was only 54%. Thus the smutted head counts were considerably lower than the embryo

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Table 1. Effect of Vitavax seed treatment on control of loose smut and on number of plants, heads, and seed yield of York barley grown in the greenhouse from seed lots containing different levels of loose smut infection*

| Seed Lot No. | Embryo infection (%) | Vitavax (8 oz/100 lb) | | | | Vitavax (4 oz/100 lb) | | | | Untreated | | | | Mean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plants (no.) | Heads (no.) | Yield (g) | Smut (%) | Plants (no.) | Heads (no.) | Yield (g) | Smut (%) | Plants (no.) | Heads (no.) | Yield (g) | Smut (%) | Plants (no.) | Heads (no.) | Yield (g) |
| 1 | 3.5 | 20.3 | 57.1 | 55.2 | 0 | 20.9 | 69.1 | 57.9 | 0 | 20.7 | 71.7 | 54.2 | 1.9 | 20.6 | 65.9 | 55.8 |
| 2 | 13.5 | 18.6 | 52.2 | 49.0 | 0 | 18.7 | 60.8 | 56.3 | 0 | 21.1 | 62.5 | 48.8 | 5.8 | 19.4 | 58.5 | 51.3 |
| 3 | 5.4 | 20.1 | 56.3 | 51.2 | 0 | 20.6 | 65.3 | 57.1 | 0 | 17.4 | 60.0 | 53.9 | 1.2 | 19.4 | 60.4 | 54.1 |
| | Mean | 19.7 | 55.2 | 51.8 | 0 | 20.1 | 65.1 | 57.1 | 0 | 19.7 | 64.6 | 52.3 | 3.0 | 19.8 | 61.6 | 53.6 |

* Average of two tests.

counts and this was consistent in the two greenhouse tests and in the one field test. Russell and Popp (2) found that in general there was a good correlation between the embryo test percentage and the subsequent smut percentage in the field, but occasionally the field infection was considerably lower. However, Stokes and Dewey (3) recently found that smut counts in barley were generally slightly higher in the field than was indicated by the embryo count. In the tests reported here the seed lots of York barley were identical except for their age and level of smut infection. The low levels of smut present in the greenhouse and field tests with the three lots of barley indicate that the embryo test provides an overestimate of the amount of smut likely to occur in a subsequent crop of this variety.

Also the amount of smut present in a parent crop as measured by head counts apparently has little bearing on the percentage of smut in the next crop. When barley Seed Lot 2 was produced approximately 20% of the heads were affected with loose smut in the field, and according to the embryo test 13.5% of the seed from that crop (Tables 1 and 2) were infected. The crop grown from Seed Lot 2 had 12% of the heads affected by smut in the field but the embryo test indicated that only 5.4% of the seeds were infected. As suggested by Russell and Popp (2), the amount of loose smut in the succeeding crop is largely controlled by weather conditions at the time the parent crop is in flower. If it is unfavorable and inoculum is sparce then the new crop will have a lower percentage than the parent crop.

The yields of the untreated barley samples (Tables 1 and 2) indicate that the highest level of embryo infection reduced yields by 5-10%, and that lower levels of smut reduced yields by lesser amounts. Considering the relatively low levels of smut - the highest infection that occurred in the field amounted to 7% (Table 2) - the yield reductions appeared to be substantial. However, none of the barley yields were significantly different and co-efficients of variation ranged from 10 to 20%. Stokes and Dewey (3) found that low levels of smut caused significant yield reductions of about the same magnitude as those in the present experiments. In this work treatment of the seed with Vitavax at 4 oz/100 lb gave the highest yield in the greenhouse, while in the field the highest yield occurred at the 8 oz rate. Control samples of York barley were included in the two greenhouse tests (Table 1), but emergence of the untreated seed was extremely poor both times so it was not a legitimate comparison and the data were not included. The results of our greenhouse tests with barley agree with those of Reinbergs et al. (1) who also found that there was some yield reduction with the 8 oz concentration of Vitavax.

The barley seed with the highest embryo smut infection (Seed Lot 2) produced the fewest plants and heads in the greenhouse and had the lowest yield in both tests even though the smut was completely controlled at both treatment levels (Table 1). This was also true for yields at the 4 oz rate in the field, and only one seed lot (No. 3) yielded less at the 8 oz rate (Table 2). Therefore the seed with the highest smut infection produced plants with less vigor and consequently less yield. In the field test there appeared to be no change in kernel weight due to the Vitavax treatment or to smut infection.

Levels of smut infection in samples of Opal wheat seed were very low. No smut developed in untreated seed in the greenhouse. However, Vitavax treatment did give some improvement in yield. In the field a small amount of loose smut was present in the untreated plots of the Charlottetown and Kentville samples but it had no influence on yield (Table 3). No smut appeared in plants grown from seed treated with either level of Vitavax. The Ottawa sample showed a considerable yield benefit from treatment with Vitavax, but this was obviously due to factors other than smut control.

Table 2. Effect of Vitavax seed treatment on control of loose smut and on seed yield and 1000-kernel weight of York barley grown in the field from seed lots containing different levels of loose smut infection

| Seed Lot No. | Embryo infection (%) | Vitavax (8 oz/100 lb) | | | Vitavax (4 oz/100 lb) | | | Untreated | | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Seed yield (g) | 1000-k weight (g) | Smut (%) | Seed yield (g) | 1000-k weight (g) | Smut (%) | Seed yield (g) | 1000-k weight (g) | Smut (%) | Seed yield (g) | 1000-k weight (g) |
| 1 | 3.5 | 335.5 | 30.9 | 0 | 326.1 | 32.6 | 0 | 288.6 | 31.7 | 1.1 | 316.7 | 31.7 |
| 2 | 13.5 | 302.8 | 31.6 | 0 | 220.6 | 32.6 | 0 | 283.6 | 31.5 | 7.1 | 269.0 | 31.9 |
| 3 | 5.4 | 265.0 | 32.0 | 0 | 314.4 | 31.7 | 0 | 296.9 | 32.2 | 1.3 | 292.1 | 31.9 |
| 4 | Control | 352.0 | 32.4 | 0 | 315.2 | 32.0 | 0 | 307.6 | 32.4 | 0 | 324.9 | 32.2 |
| | Mean | 313.8 | 31.7 | 0 | 294.1 | 32.2 | 0 | 294.2 | 31.9 | 3.2 | | |

Table 3. Effect of Vitavax seed treatment on control of loose smut and on seed yield and 1000-kernel weight of Opal wheat grown in the field from seed from three locations

| Seed source | Vitavax (8 oz/100 lb) | | | Vitvax (4 oz/100 lb) | | | Untreated | | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seed yield (g) | 1000-k weight (g) | Smut (%) | Seed yield (g) | 1000-k weight (g) | Smut (%) | Seed yield (g) | 1000-k weight (g) | Smut (%) | Seed yield (g) | 1000-k weight (g) |
| Charlottetown | 313.7 | 36.1 | 0 | 325.2 | 36.1 | 0 | 357.8 | 36.2 | 0.33 | 332.2 | 36.1 |
| Kentville | 315.5 | 32.1 | 0 | 316.7 | 31.9 | 0 | 339.3 | 32.3 | 0.68 | 323.8 | 32.1 |
| Ottawa | 316.5 | 32.2 | 0 | 357.8 | 32.5 | 0 | 271.5 | 32.1 | 0 | 315.2 | 32.2 |
| Mean | 315.2 | 33.4 | 0 | 333.2 | 33.5 | 0 | 322.8 | 33.5 | 0.33 | | |

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