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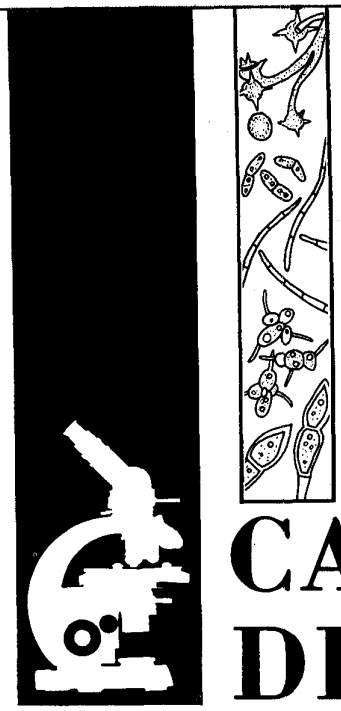

CANADIAN PLANT DISEASE SURVEY

EDITOR W.L. SEAMAN

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

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"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."

AN ILLUSTRATED SERIES OF ASSESSMENT KEYS FOR PLANT DISEASES, THEIR PREPARATION AND USAGE[1]

W. Clive James

Abstract

The percentage scale was exclusively used to define different disease severities in an illustrated series of disease assessment keys for cereal, forage, and field crops. The standard area diagrams were accurately prepared with an electronic scanner. Procedures for assessing the different diseases are outlined in order to achieve some degree of standardization in disease assessment methods.

Introduction

The main reason for measuring plant diseases is to obtain quantitative data on the occurrence and development of diseases. Such data are a vital requirement in most aspects of plant pathology and are used to assess the relative importance of different diseases by comparing their incidence and intensity on agricultural crops. These measurements are also used in conjunction with yield or quality data to determine the relationship between disease intensity and crop loss so that economic losses can be calculated from surveys conducted to assess the importance of diseases. Under certain circumstances disease measurements provide a critical tool for distinguishing treatment differences that cannot be detected by measuring yield or quality; hence use is made of disease measurements in trials conducted to test the relative efficacy of fungicides and their respective formulations, and in variety trials designed to detect small differences in disease resistance between varieties.

Diagnosis and measurement of plant diseases represent two of the basic principles practised in plant pathology. With a few exceptions, methods for identifying pathogens are standardized throughout the world as a result of taxonomic classifications which are universally accepted. However the measurement of plant diseases has received less attention and even the published methods lack consistency. The Food and Agriculture Organization of the United Nations has prepared a manual (4) in an effort to publicize and standardize methods for estimating crop losses, and since this inevitably involves disease assessment some degree of standardization will result. Large (21) reviewed many of the methods used for measuring disease that have appeared as isolated examples in the literature. However, to the author's knowledge there has been no attempt to develop or publish a series of disease assessment keys using the same guiding principles throughout. The objective of this paper is to present such a series of keys for various crops so that pathologists can use them and report on their merits and faults with a view to producing better keys for the future. The work reported here is particularly concerned with developing disease assessment methods that can subsequently be used in connection with estimates of crop loss.

Methods and discussion

Disease assessment methods fall into two categories. The first is represented by the general descriptive type of key (1, 19) in which plants with varying amounts of disease are described. Probably the best known key in this category is the one used (1) for assessing late blight of potato caused by Phytophthora infestans (Mont.) de Bary (see Key No. 3.1.2). The second category of assessment methods utilizes standard area diagrams; the first example was published in 1892 by Nathan Cobb (3), and it illustrated different severities of rust with five standard area diagrams. These standard area diagrams typified the pattern of the disease on wheat leaves where 1,5,10,20, and 50% of the leaf area was occupied by rust pustules. The assessment keys presented here are also based on standard area diagrams, although guidance notes are provided with some of the keys.

The specifications of a successful disease assessment key are very demanding; however, there are two major requirements. The first is that observers using the key on a particular group of diseased plants must be able to arrive at similar assessments consistently, and the second is that assessment be achieved simply and quickly.

The keys presented in this paper are based on a percentage scale because of the many advantages that such a scale offers. The upper and lower limits of a percentage scale are always uniquely defined, and the

[1] Contribution No. 277, Research Station, Canada Department of Agriculture, Ottawa, Ontario

scale is flexible in that it can be conveniently divided and subdivided, e.g. 50%, 10%, 1%, 0.1%. Another advantage is that it is universally known and accepted. It can be used to record the proportion of plants infected, the area damaged by a foliage or root pathogen, or the number of roots or fruits affected expressed as a percentage of the total number present. Although only a few degrees of infection are shown in the keys presented here, e.g. 1,10,20, and 50%, interpolations can be made when assessments are recorded, e.g. 3,15,40%. The extent of interpolation should be dictated by the ability of the observer to detect differences in level of infection.

In this paper, the percentage of infection noted represents the actual area covered by the pustules or lesions illustrated; for example, in the key for leaf rust of cereals 1% represents the actual area of the lamina covered by the black spots (which represent pustules) expressed as a percentage of the area of the leaf illustrated. An additional assessment is made of any chlorotic or dead tissue associated with the pustules and is added to the pustule or lesion assessment to provide an estimate of the "visible area affected"; for example if the pustule area is 1% and chlorosis 4%, the disease percentage recorded is 5%. Similarly, if a hypersensitive reaction is observed, such as the development of necrotic areas rather than sporing pustules when certain varieties of wheat are infected with stripe rust (23), the percentage of visible area affected is equivalent to that of the necrotic area. Also if it is known that a particular lesion will incapacitate a larger area than that occupied by the lesion, for example a petiole lesion may incapacitate the whole lamina, then the percentage recorded is that of the larger area. It will be appreciated that it is not possible to illustrate areas of chlorotic or dead tissue in the keys because the variability is so great. This technique for recording disease by assessing percentage leaf area affected is justifiable if the aim is to relate disease levels to losses in plant production because a measure of the pustule area plus that of any associated damage is probably a better indication of the damage caused by the disease than a measure of the pustule area alone. However, this approach could not be justified if the objective was different, for example in an epidemiological study designed to measure the number of spores in a diseased plant population. If the keys are used as suggested, it is quite possible that, in practice, levels of 100% infection may never be encountered, but this is not considered to be a disadvantage. When disease level is related to yield loss there is no reason why the maximum level of disease should be recorded as 100%. In this connection Melchers and Parker (24) modified the original Cobb Scale (3) so that the maximum area covered by rust, which was arbitrarily chosen as 37% of the leaf or stem cover, was labelled 100%. The modified Cobb Scale was expanded by Peterson et al. (26) to represent additional levels of infection, but an actual affected area cover of 37% was also labelled 100%, as in the modified Cobb Scale.

The degree of accuracy desired in disease assessment varies according to the particular objectives of a research program. Consequently, the usage of a particular disease assessment method will not be the same in all situations. This is particularly true in relation to sample size, which varies enormously, depending upon the objectives of the experiment or survey. However, it may be helpful to note some of the guiding principles that should be followed in making disease assessments, bearing in mind that each situation demands special consideration leading to modification of the specifications.

Whenever disease assessments are recorded, the growth stage should be noted, according to a published key (17), if possible. Similarly, if the assessment refers to any particular plant component, for example particular leaves, this fact should be recorded so that meaningful comparisons can be made at a later date. The method of selecting the sample for assessment should also be recorded, i.e. random or systematic sampling of single leaves, individual plants, groups of plants, length of row, area of crop, or other units. The average infection should be calculated by dividing the total disease recorded by the number of units in the sample; the average is therefore based on the healthy and infected units in the sample (see example for cereal leaf rust). An exception to this rule occurs when the average infection within foci is calculated (see the example for late blight of potato). Lack of time sometimes precludes the assessment of individual leaves or root systems, but for some diseases individual plants must be examined closely.

The simplest technique is usually the one least prone to error. The assessment of disease on individual cereal leaves is an example of a simple effective method. Each disease present is assessed individually and, because the observer is assessing one disease on one leaf at one time, the error attached to an observation is small. Additional readings are made for the percentage of green tissue remaining and the percentage of dead tissue not visually attributable to disease. When several leaves have been assessed, the information recorded can be used to calculate the mean and its standard error; the data may also be used to estimate the number of leaves required to give a disease mean with a desired standard error. The principles involved in sampling techniques have been reviewed recently by Church (2).

The notes that accompany the disease assessment keys in this paper are intended

for general guidance and can be modified to suit individual requirements. The standard area diagrams presented here have been incorporated into a disease assessment manual designed for use in the field. The manual consists of a series of disease assessment keys and growth stage diagrams of host plants. The keys have been printed on durable plastic material so that they can be used repetitively under rigorous field conditions. Each key is printed as a separate 7 x 4 inch (17.8 x 10.2 cm) pocket-size sheet, so that it can be taken out of the loose leaf folder for use; when new keys are available they will be distributed for inclusion in the manual. The manual has been prepared in an attempt to standardize disease assessment methods, and it is therefore complementary to the FAO Manual on Crop Loss Assessment Methods(4), in which only proven methods for assessing losses due to disease, rather than disease assessment keys, are published. Copies of the publication, A Manual of Assessment Keys for Plant Diseases, are available from the author.

Preparation of keys

The preparation of standard area diagrams can be laborious, especially when verification is needed that the 1% infection represented actually occupies 1% of the area on the standard area diagram. By using conventional apparatus such as a planimeter, it is very difficult to measure a small area accurately; for example, 1% on the key for leaf rust of cereals is made up of 20 unit areas. This problem was solved by using an IBM drum scanner which measures areas to within 1/62,500 sq inch. All the keys were drawn approximately 4 times larger than the size shown, thus simplifying the task of drawing the lesions, which were copied from diseased leaves. The drawings were made on 24 x 36 inch "Cronaflex" sheets, and the necessary areas were measured on the scanner.

The scanner system consists of a scan head containing a photoelectric cell that records black areas in units of 1/62,500 sq inch. The recorded information was stored on magnetic tape and then processed to determine the measurement of the area. For example, for the leaf rust of cereals key the leaf area outlined was shaded black, and the total area of the leaf measured. Similarly, the total area of the lesions representing 1% was measured (apart from the leaf outline) and expressed as a percentage of the total leaf area. After the first scan was completed, the area designated as 1% was increased or decreased as required, and rescanned to verify that the correction produced the desired effect. A 24 x 36 inch sheet can be scanned in approximately 10 minutes.

Use of disease assessment keys

A. Cereal crops (wheat, barley, oats)

Growth Stages. Use the growth stage key (17) to indicate the stage of crop growth.

Sampling. Select a random sample of fertile tillers. For plots up to 0.01 of an acre (0.004 hectare) select 10 primary fertile tillers. For larger plots and fields select up to 50 tillers at random along one diagonal or other appropriate area. Sample size is determined by the variability of disease and by the accuracy desired.

Assessing Disease. Assess the percentage visible area affected by disease on individual laminae, sheaths, or spikes. Make separate assessments if there is more than one disease present and assess the percentage area remaining green; the percentage dead tissue not associated with disease can be calculated later by subtraction, viz. 100% - (total percentage disease) - (percentage green tissue) = percentage dead tissue.

Calculate average infections for each specific group of leaves (see example).

Make estimates at various growth stages and note leaf position so that meaningful comparisons can be made for various leaves.

These keys have been specifically developed for assessing cereal diseases but they may be used for diseases of grasses if the symptoms are similar.

EXAMPLE - Assessment of cereal leaf rust.

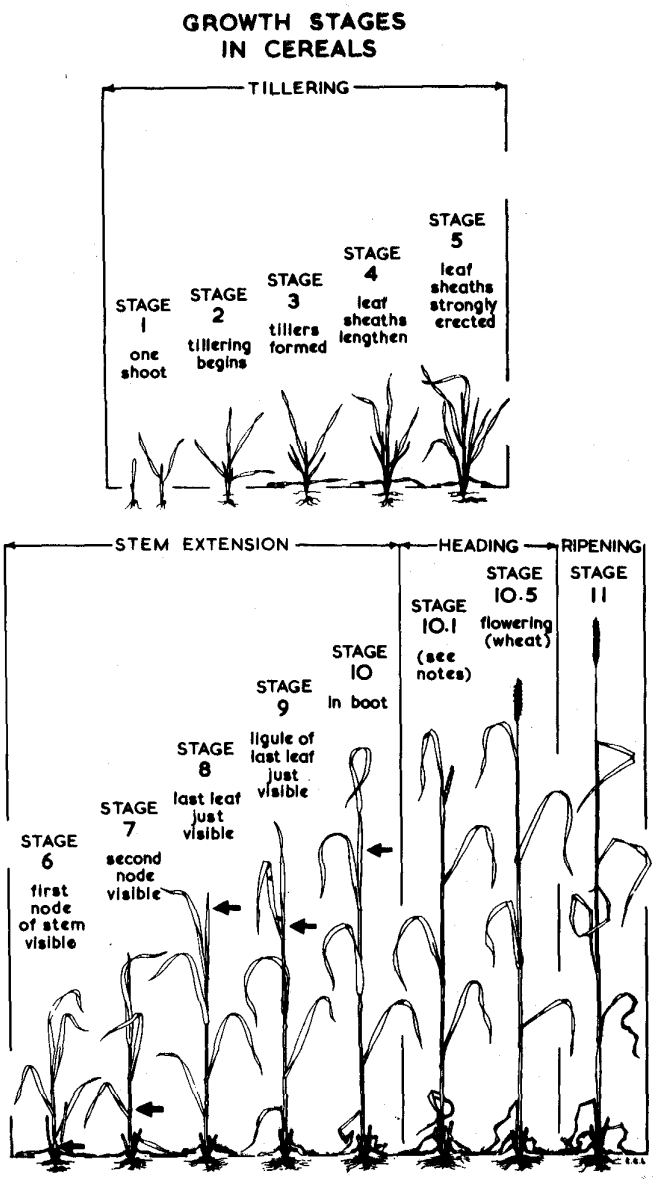
Determine percentage leaf area affected by leaf rust of cereals, based on 10 fertile tillers from a plot. Data for other diseases, green tissue, and dead tissue can be treated in a similar way.

Tiller no.	Percentage leaf (lamina) area affected: Flag leaf	Second leaf
1	5	10
2	4	8
3	0	5
4	3	7
5	4	0
6	5	4
7	0	7
8	5	0
9	5	10
10	5	10
Total	36	61
Mean	3.6	6.1
Standard Error	0.64	1.2

Growth stage key for cereals

Stage

1 One shoot (number of leaves can be added) = "brairding"
2 Beginning of tillering
3 Tillers formed, leaves often twisted spirally. In some varieties of winter wheats, plants may be "creeping" or prostrate
4 Beginning of the erection of the pseudo-stem, leaf sheaths beginning to lengthen
5 Pseudo-stem (formed by sheaths of leaves) strongly erected
6 First node of stem visible at base of shoot
7 Second node of stem formed, next-to-last leaf just visible
8 Last leaf visible, but still rolled up, spike beginning to swell
9 Ligule of last leaf just visible
10 Sheath of last leaf completely grown out, spike swollen but not yet visible
10.1 First spikes just visible (awns just showing in barley, spike escaping through split of sheath in wheat or oats)
10.2 Quarter of heading process completed
10.3 Half of heading process completed
10.4 Three-quarters of heading process completed
10.5 All spikes out of sheath
10.5.1 Beginning of flowering (wheat)
10.5.2 Flowering complete to top of spike
10.5.3 Flowering over at base of spike
10.5.4 Flowering over, kernel watery ripe
11.1 Milky ripe
11.2 Mealy ripe, contents of kernel soft but dry
11.3 Kernel hard (difficult to divide by thumb-nail)
11.4 Ripe for cutting. Straw dead



(After E.C. Large. 1954. Plant Pathol. 3:128-129)

B. Forage crops (alfalfa, clover)

Growth stages. Use the growth stage key to indicate the stage of crop growth.

Sampling. Select a random sample of plant units for disease assessment. The units may consist of individual leaves, plants, groups of plants, or all plants in a particular quadrat or area, e.g. ft^2 . yd^2 . or m^2. Calculate the average infection for the sample units employed.

Assessing Disease. Some diseases may cause defoliation when only a small percentage of the leaf area is affected. For these plants estimate the area of leaves lost by defoliation and add this to the percentage infection on the remaining leaves to obtain the required estimate of percentage leaf area affected by disease.

Growth stage key for legumes

The growth and development of legumes have been divided in five major stages, which have been numbered consecutively. Each major stage has been divided into two or more substages. If further refinement is required more substages can be added if they are adequately described.

The recording of a stage requires the use of a two digit number; for example, early bud in legumes = 21; 2 = bud, 1 = early.

This system of classification requires that half the stems in each plot must be in the stage so described.

Stages of development of legumes

Major stages		Substages	
1	Vegetative	1	Early - 4-6 inches high
		2	Medium - over 6 inches high (before any buds are detectable)
		3	Late - pre-bud (a few stems may be in early bud stage)
2	Bud	1	Early - buds minute, may be felt as an enlargement in apex of stem
		2	Medium - buds well formed and visible
		3	Late - buds visible, swollen; earliest buds showing some color at tips
3	Flower	1	10% bloom
		2	25% bloom
		3	50% bloom
		4	75% bloom
4	Full flower	1	100% bloom
		2	Flowers dying
5	Seed	1	Early - green seed pods
		2	Medium - seed in dough stage
		3	Mature - seed mature

(After a system developed by Dr. J. E. Winch, University of Guelph)

C. Field crops (potatoes, beans)

Sampling. Select a random sample for disease assessment.

Assessing Disease. Choose a unit length of row for row crops, or a small quadrat or area for other crops and assess the percentage leaf area affected. If appropriate, single leaves or plants may be assessed. Calculate average infections for the sample units employed.

If the primary stages of disease develop as foci, determine the average area of the foci and the number/acre or hectare and express as percentage acreage affected. Calculate percentage leaf area affected within the infected area, as in the following example.

EXAMPLE -
Assessment of late blight of potatoes

(a) Primary stages of epidemic - When infection is present in limited foci

Average number of foci/acre 5
Average area of foci 3 yd^2
Average percentage leaf area infected within foci 1%

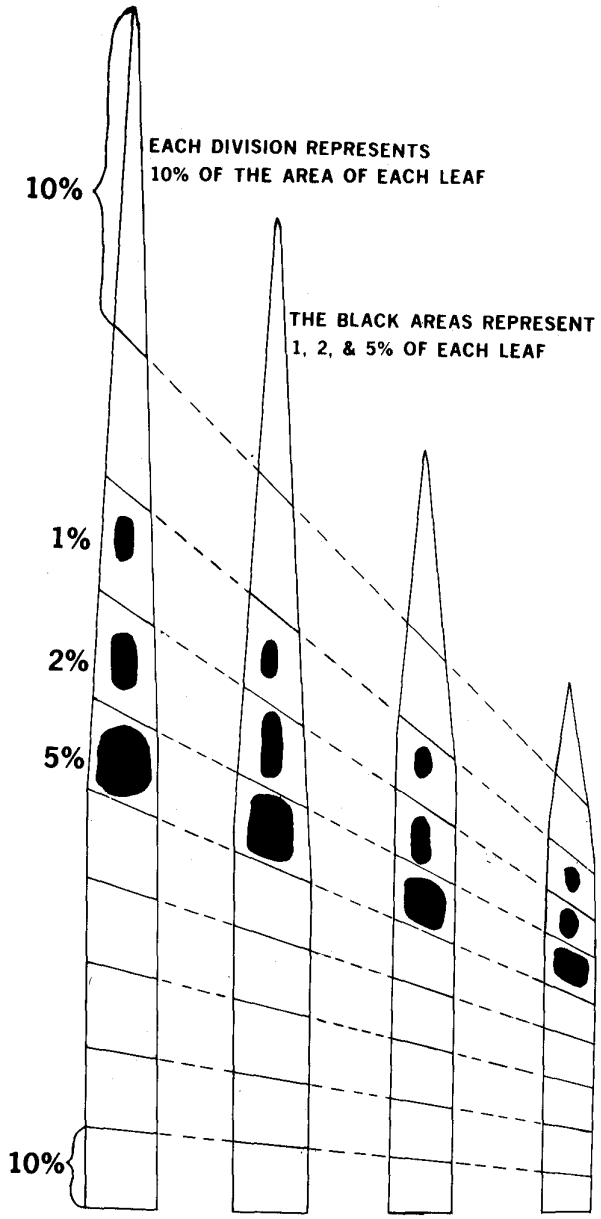
Percentage acreage affected = 15/4840
= 0.3%

Therefore 0.3% of acreage is affected, with an average infection of 1% within the foci.

(b) Later stages of epidemic - Select 10 sample areas at random in the field and assess percentage leaf area affected. Calculate average infections as for cereal disease assessments.

RHYNCHOSPORIUM LEAF BLOTCH OR SCALD OF BARLEY

Key No. 1.1



Use for:

Leaf blotch or scald (*Rhynchosporium secalis* (Oud.) Davis) of barley

Procedure:

Select a random sample of fertile tillers.

Growth stages:

Assess the percentage area affected by rhynchosporium on the upper side of the laminae of the flag and second leaves, at growth stage 11.1. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisions can be made between crops.

Assessing severity:

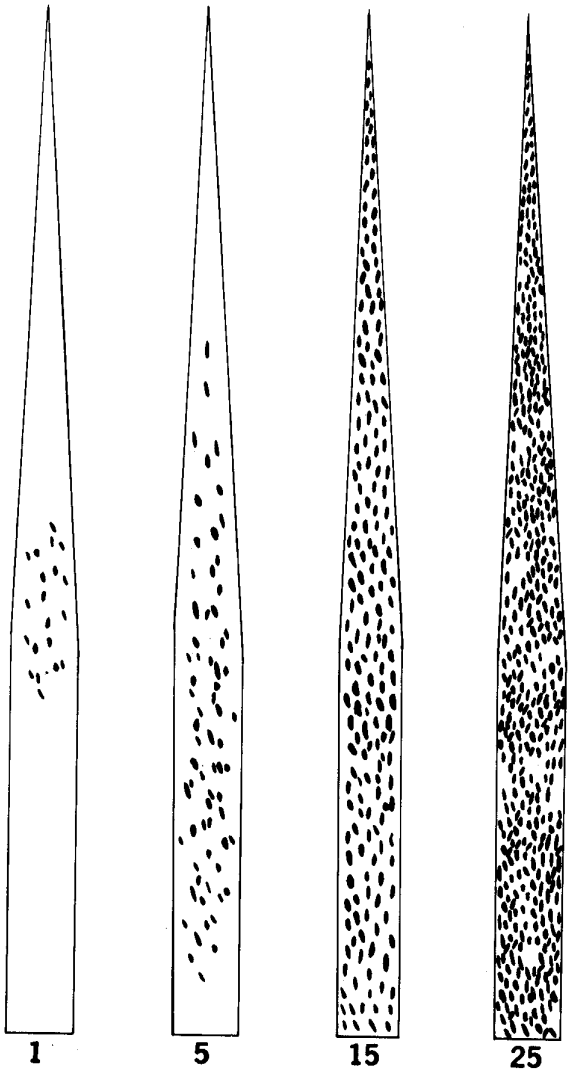
Match the leaf to one of the diagrams and use the black areas (representing 1%, 2%, and 5% of each leaf) as a guide in assessing the percentage leaf (lamina) area covered by small isolated lesions, and the 10% sections for the larger lesions that have coalesced. For the purpose of this key, affected area includes the lesions and any yellowing that appears to be associated with a lesion. Differences in disease incidence will be reflected in comparisons of either flag leaf or second leaf values, depending on the level of the infection.

References:

8, 9, 10

LEAF RUST OF CEREALS

Key No. 1.2



Use for:

Crown rust of oats (*Puccinia coronata* (Corda) Erikss. & Henn.)
Leaf rust of wheat (*Puccinia triticina* Erikss.)
Leaf rust of barley (*Puccinia recondita* Rob. ex Desm.)

Procedure:

Select a random sample of fertile tillers.

Growth stages:

Assess at growth stages 10.5 and either 11.1 or 11.2 or both. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:

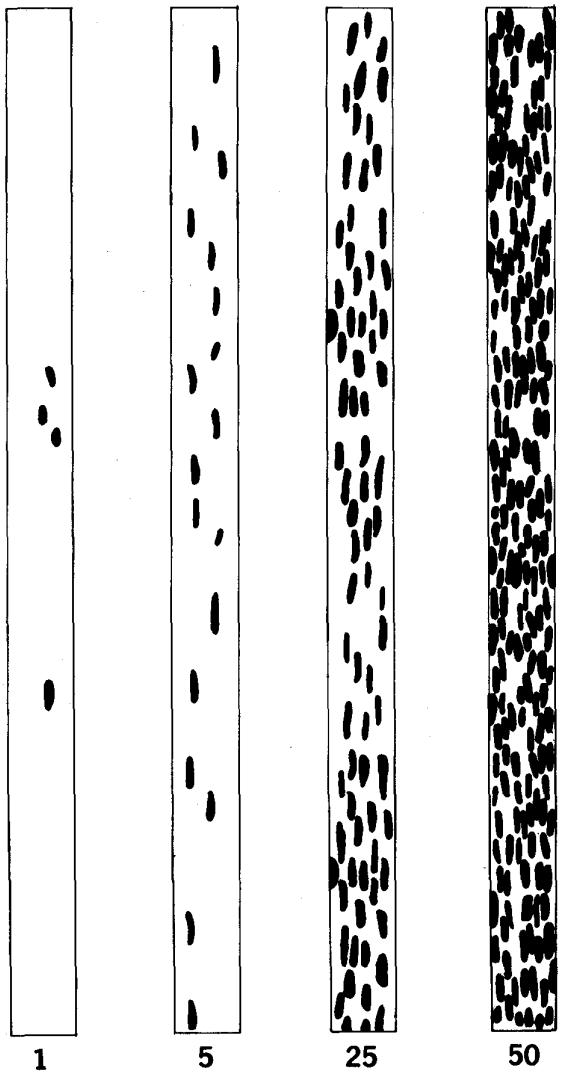
Assess percentage leaf (lamina) area affected by disease on individual top leaves.

Reference:

6

STEM RUST OF CEREALS

Key No. I.3



Use for:

Stem rust of wheat (*Puccinia graminis* Pers. f. sp. *tritici* Erikss. & Henn.)
Stem rust of oats (*Puccinia graminis* Pers. f. sp. *avenae* Erikss. & Henn.)
Stem rust of barley (*Puccinia graminis* Pers. f. sp. *secalis* Erikss. & Henn.)

Procedure:

Select a random sample of fertile tillers.

Growth stages:

Assess at growth stages 11.1 or 11.2. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisions can be made between crops.

Assessing severity:

Assess percentage leaf (sheath) area affected by disease on individual top leaves.

References:

6, 27

POWDERY MILDEW OF CEREALS

Key No. 1.4

Use for:

Powdery mildew of wheat (*Erysiphe graminis* DC. ex Mérat f. sp. *tritici* Marchal)

Powdery mildew of barley (*Erysiphe graminis* f. sp. hordei Marchal)

Powdery mildew of oats (*Erysiphe graminis* DC. ex Mérat)

Procedure:

Select a random sample of fertile tillers.

Growth Stages:

Assess at growth stage 10.5. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:

Assess percentage leaf (lamina) area affected by disease on individual top leaves.

References:

19, 20

SEPTORIA GLUME BLOTCH OF WHEAT

Key No. 1.5

PERCENTAGE SPIKE AREA COVERED

Use for:
Glume blotch of wheat (*Septoria nodorum* Berk.)

Procedure:
Select a random sample of spikes.

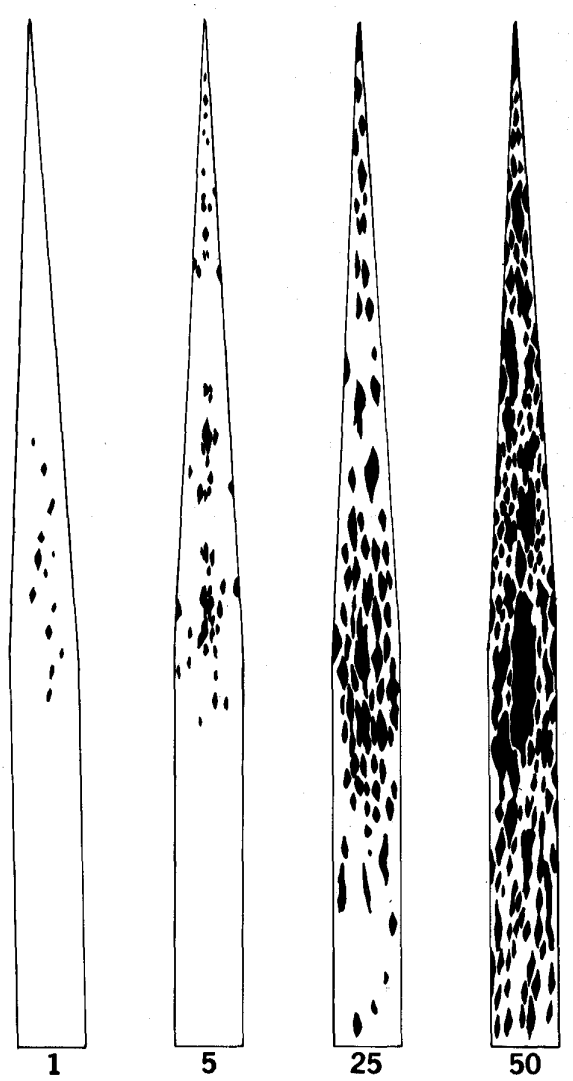
Growth stages:
Assess at growth stages 10.5 and either 11.1 or 11.2 or both.

Assessing severity:
Assess percentage spike area affected by disease.

Reference:
15

SEPTORIA LEAF BLOTCH OF CEREALS (Leaf symptoms)

Key No. 1.6.1



Use for:

Glume blotch of wheat (*Septoria nodorum* Berk.)
Speckled leaf blotch of wheat (*Septoria tritici* Rob. ex Desm.)
Leaf blotch of wheat (*Septoria avenae* Frank f. sp. *triticea* T. Johnson)
Leaf blotch and black stem of oats (*Septoria avenae* Frank f. sp. *avenae*)
Speckled leaf blotch of barley (*Septoria passerinii* Sacc.)

Procedure:

Select a random sample of fertile tillers.

Growth stages:

Assess at growth stages 10.5 and either 11.1 or 11.2 or both. The key can also be used for recording disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:

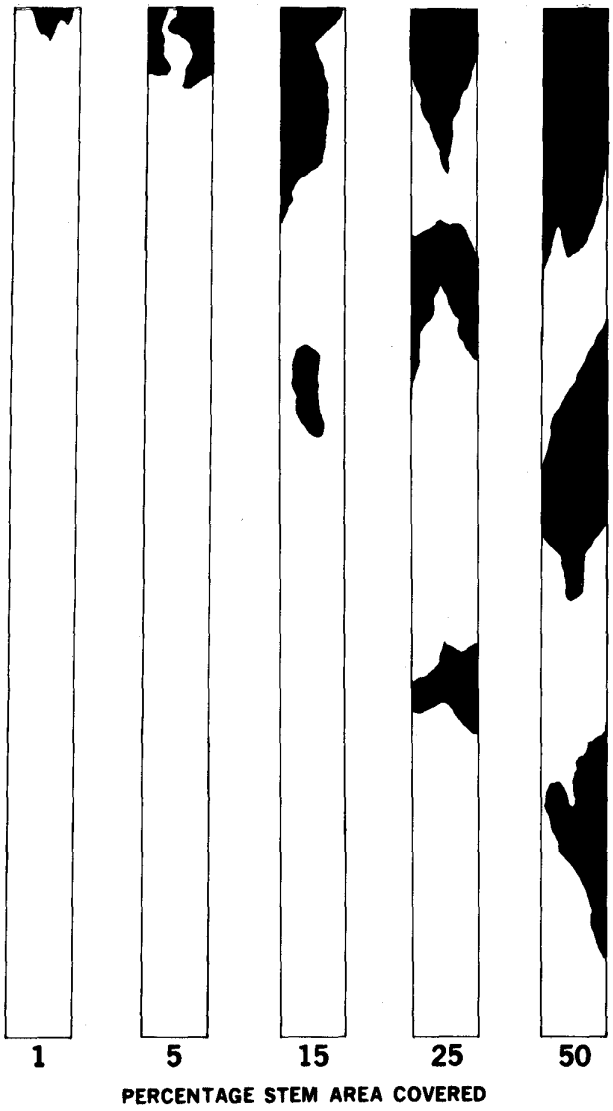
Assess percentage leaf (lamina) area affected by disease on individual top leaves.

Reference:

15

SEPTORIA LEAF BLOTCH OF CEREALS (Stem symptoms)

Key No. 1.6.2



Use for:

Glume blotch of wheat (*Septoria nodorum* Berk.)
Speckled leaf blotch of wheat (*Septoria tritici* Rob. ex Desm.)
Leaf blotch of wheat (*septoria avenae* Frank f. sp. *triticea* T. Johnson)
Leaf blotch and black stem of oats (*Septoria avenae* Frank f. sp. *avenae*)
Speckled leaf blotch of barley (*Septoria passerinii* Sacc.)

Procedure:

Select a random sample of fertile tillers.

Growth stages:

Assess at growth stages 10.5 and either 11.1 or 11.2 or both. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:

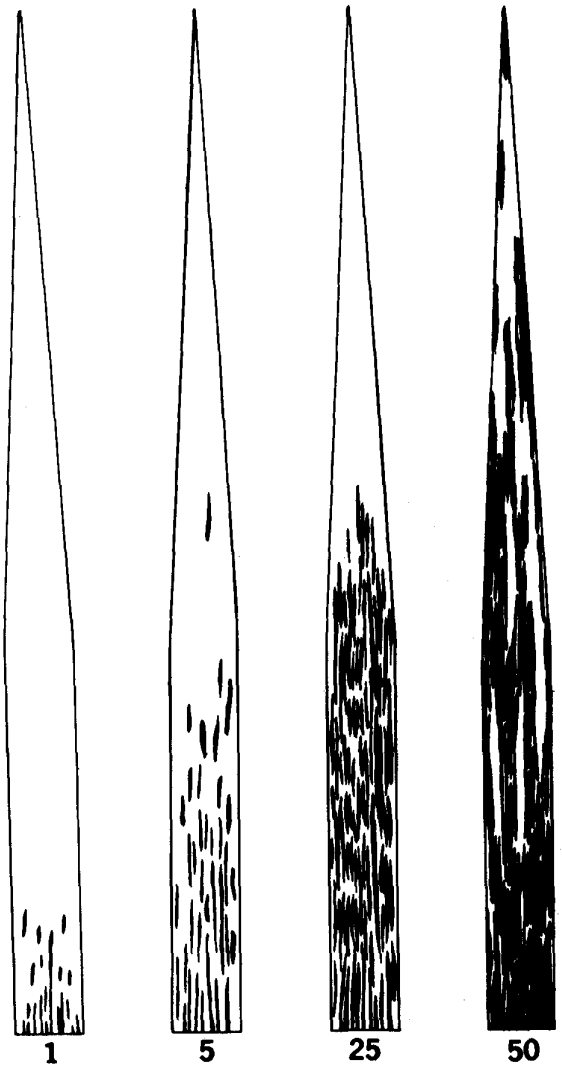
Assess percentage leaf (sheath) area affected by disease on individual top leaves.

Reference:

15

DRECHSLERA LEAF BLOTCH OR STRIPE OF CEREALS

Key No. 1.7



Use for:

Leaf blotch or stripe of oats (*Drechslera avenacea* (Curt. ex Cke.) Shoem. (*Helminthosporium avenae* Eidam; stat. perf. *Pyrenophora chaetomioides* Speg., *P. avenae* Ito & Kurib.))

Leaf blotch of wheat (*Drechslera tritici-repentis* (Died.) Shoem. (*Helminthosporium t.-r.* Died.))

Procedure:

Select a random sample of fertile tillers.

Growth stages:

Assess at growth stages 10.5 and either 11.1 or 11.2 or both. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:

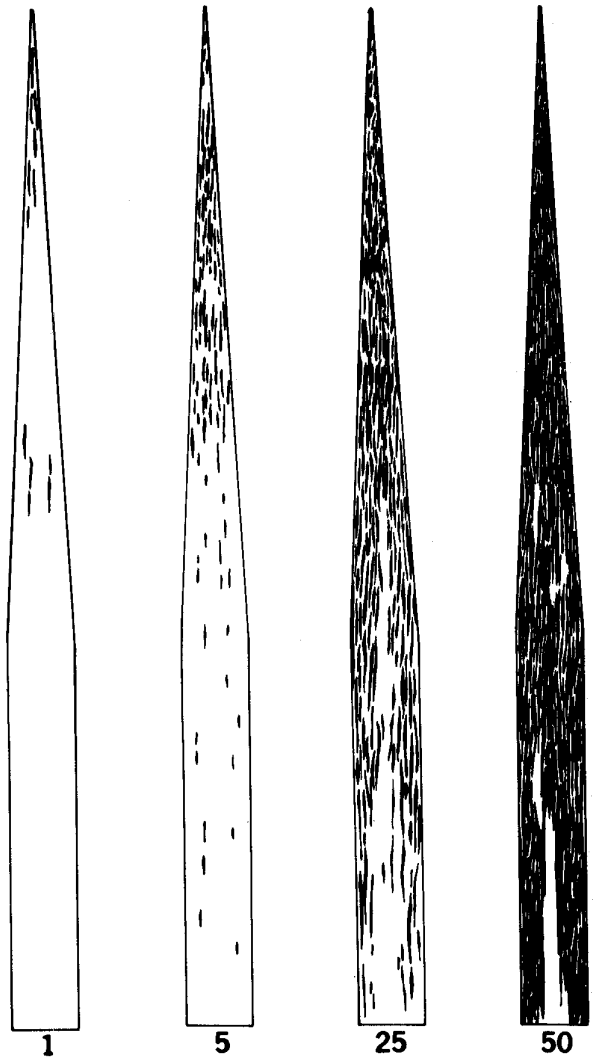
Assess percentage leaf (lamina) area affected on individual top leaves.

References:

5, 28

SPINDLE STREAK MOSAIC OF WHEAT

Key No. 1.8



PERCENTAGE LEAF AREA COVERED

Use for:
Spindle streak mosaic of wheat (wheat spindle streak mosaic virus)

Procedure:
Select a random sample of individual fertile tillers or unit lengths of row.

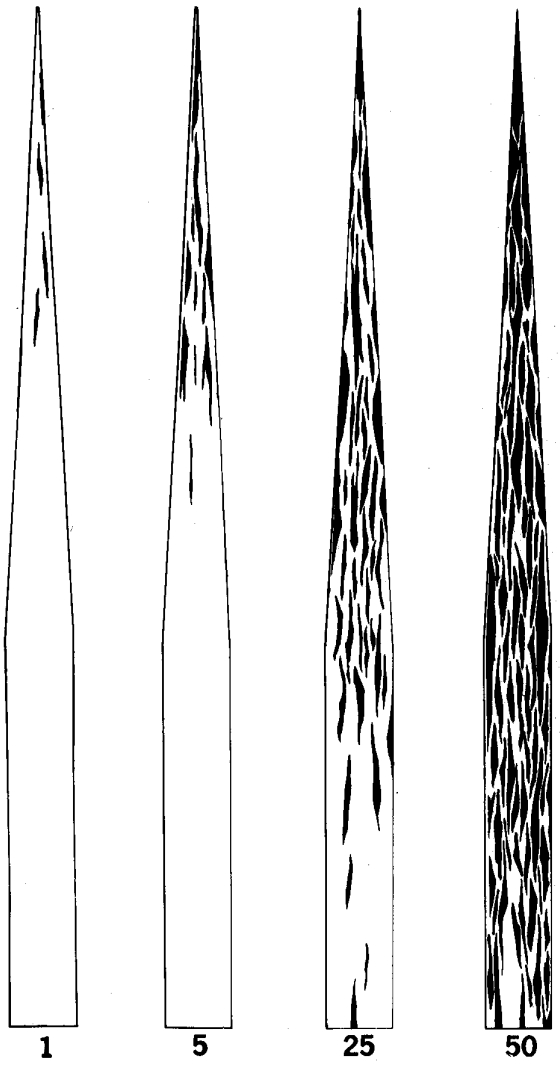
Growth stages:
Assess at growth stages 8, 9, and 10. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:
Estimate proportion of fertile tillers infected and express as percentage. Assess the percentage leaf (lamina) area affected by disease of individual top leaves.

References:
5, 28

BACTERIAL BLACK CHAFF OF WHEAT

Key No. 1.9



Use for:
Bacterial black chaff of wheat (*Xanthomonas translucens* (Jones, Johnson & Reddy) Dowson)

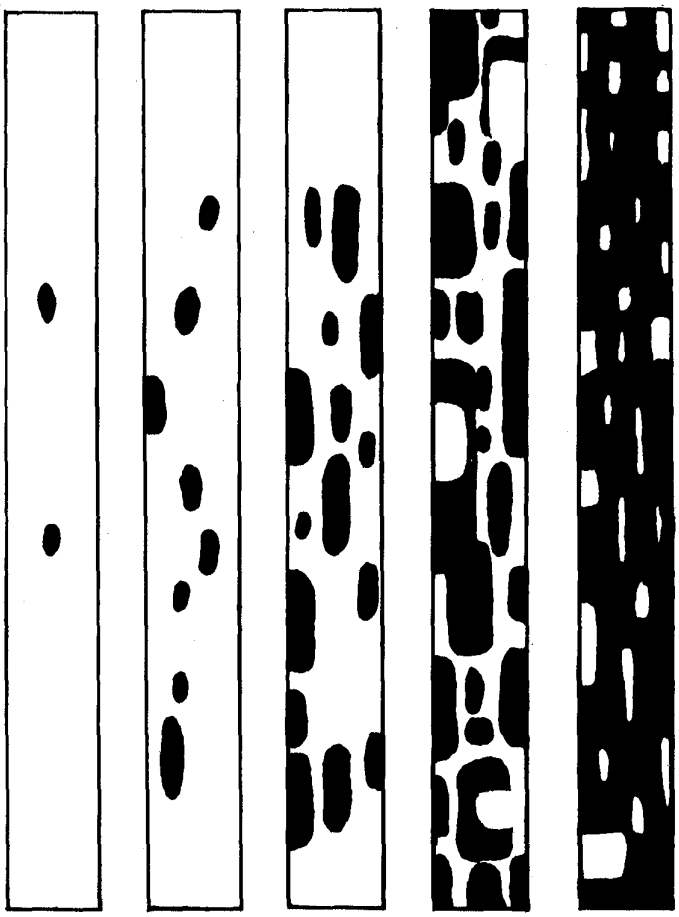
Procedure:
Select a random sample of fertile tillers.

Growth stages:
Assess at growth stages 10.5 and either 11.1 or 11.2 or both. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:
Assess percentage leaf (lamina) area affected on individual top leaves.

BLACK STEM OF ALFALFA (Stem symptoms)

Key No. 2.1.1



Use for:
Black stem of alfalfa (on stems) (*Phoma medicaginis* Malbr. & Roum.)

Procedure:
Assess individual stems or plants, or plants in small sample areas (ft^2, yd^2, m^2).

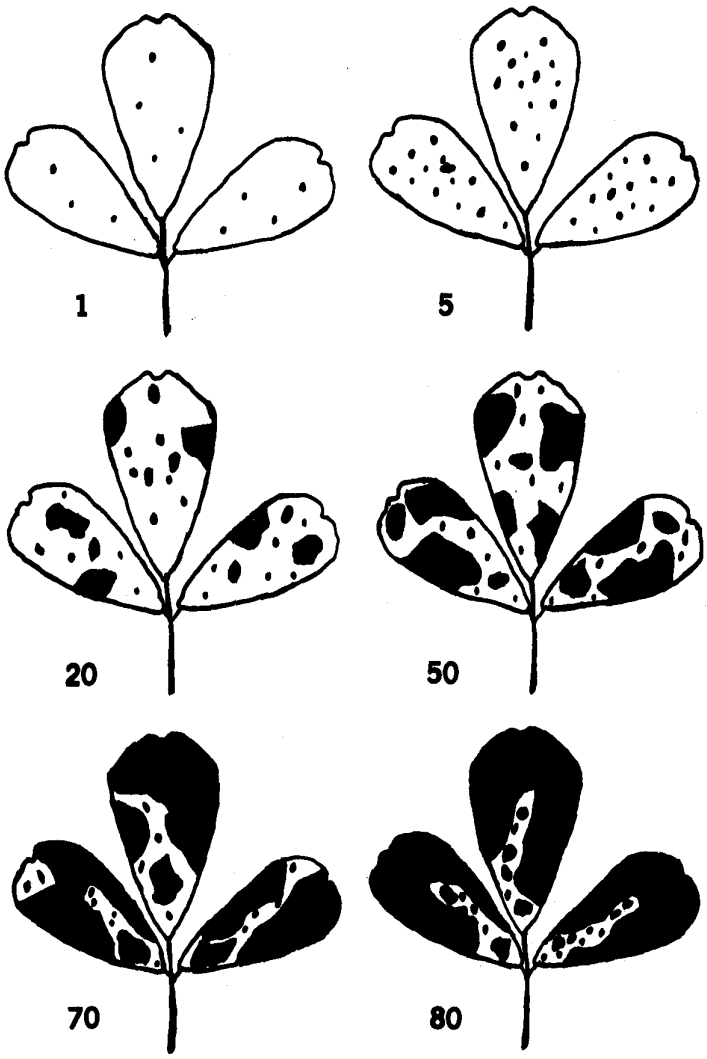
Growth stages:
Before first and second cuts and at any other appropriate stages (see growth stage key).

Assessing severity:
Assess percentage stem area affected.

References:
7, 29

BLACK STEM OF ALFALFA (Leaf symptoms)

Key No. 2.1.2



PERCENTAGE LEAF AREA COVERED

Use for:
Black stem of alfalfa (on leaves) (*Phoma medicaginis* Malbr. & Roum.)

Procedure:
Assess individual leaves or plants, or plants in small sample areas (ft^2, yd^2, m^2).

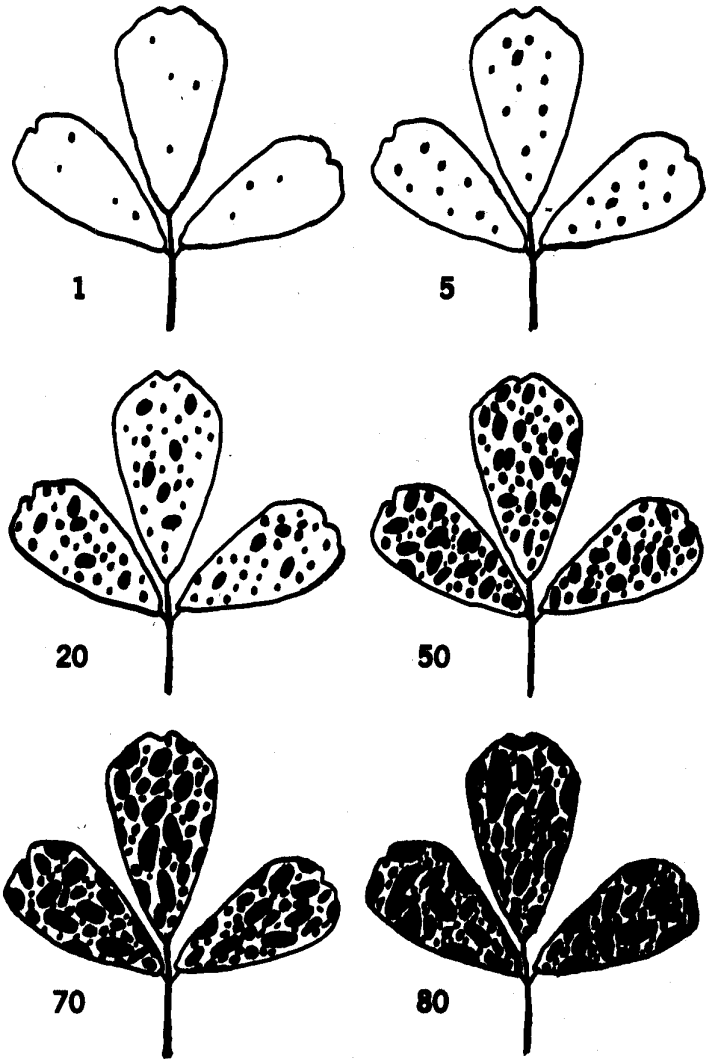
Growth stages:
Before first and second cuts and at any other appropriate stages (see growth stage key).

Assessing severity:
Assess percentage leaf area affected (including defoliation due to disease, if any).

References:
7, 29

COMMON LEAF SPOT OF ALFALFA

Key No. 2.2



PERCENTAGE LEAF AREA COVERED

Use for:
Common leaf spot of alfalfa (*Pseudopeziza trifolii* (Biv.-Bern. ex Fr.) Fckl. f. sp. *medicaginis-lupulinae* Schmied.)

Procedure:
Assess individual leaves or plants, or plants in small sample areas (ft^2, yd^2, m^2).

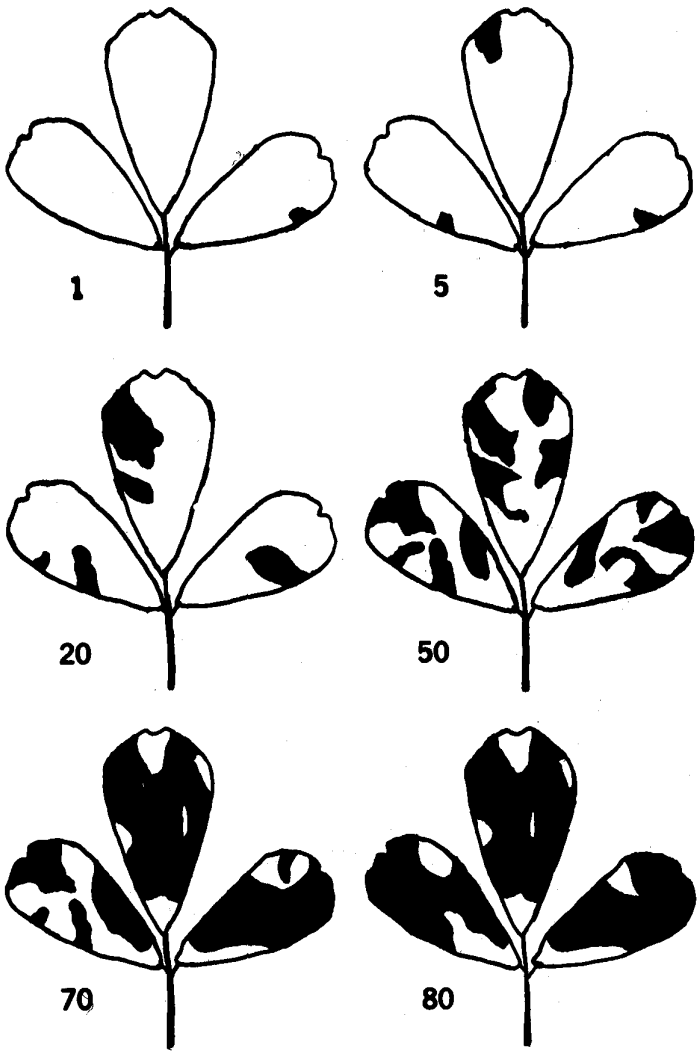
Growth stages:
Before first and second cuts and at any other appropriate stages (see growth stage key).

Assessing severity:
Assess percentage leaf area affected (including defoliation due to disease, if any).

Reference:
7

YELLOW LEAF BLOTCH OF ALFALFA

Key No. 2.3



PERCENTAGE LEAF AREA COVERED

Use for:
Yellow leaf blotch of alfalfa (*Leptotrochila medicaginis* (Fckl.) Schuepp)

Procedure:
Assess individual leaves or plants, or plants in small sample areas (ft^2, yd^2, m^2).

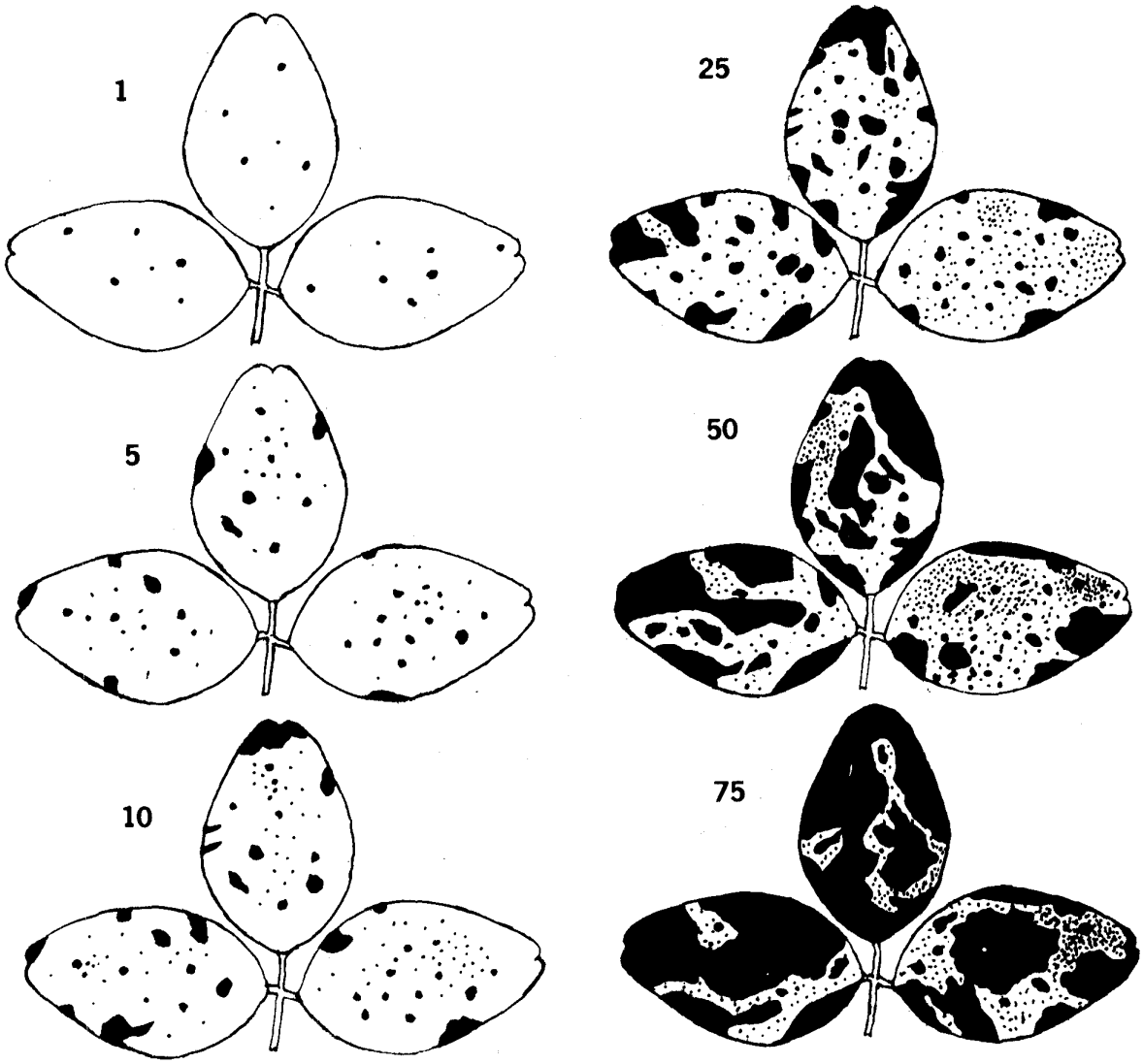
Growth stages:
Before first and second cuts and at any other appropriate stages (see growth stage key).

Assessing severity:
Assess percentage leaf area affected (including defoliation due to disease, if any).

Reference:
7

STEMPHYLIUM LEAF SPOT OF RED CLOVER

Key No. 2.4



PERCENTAGE LEAF AREA COVERED

Use for:

Leaf spot of red clover (*Stemphylium botryosum* Wallr.)

Target spot of red clover (*Stemphylium sarcinaeforme* (Cav) Wiltshire).

Procedure:

Assess individual leaves or plants or plants in small sample areas (ft^2, yd^2, m^2).

Growth stages:

Before first and second cuts and at any other appropriate stages (see growth stage key).

Assessing severity:

Assess percentage leaf area affected (including defoliation due to disease, if any).

LATE BLIGHT OF POTATOES

Key No. 3.1.1

PERCENTAGE LEAF AREA COVERED

Use for:

Late blight of potatoes (*Phytophthora infestans* (Mont.) de Bary)

Procedure:

Use Key No. 3.1.1 when infection is limited to foci in the primary stages of the epidemic. Survey the crop for foci of infection. A special effort should be made to record the date of initial infection and the early part of the disease progress curve. Use Key No. 3.1.2 for the later stages of the epidemic when infection is widespread.

Growth stages:

Assess at regular intervals (such as one week) after the epidemic has started.

Assessing severity:

1 Survey the crop and estimate the average number of foci per acre or hectare.
2 Determine the average area of the foci.
3 Express (1) and (2) as percentage acreage affected (see example for late blight of potatoes).
4 Use Key No. 3.1.1 to assess percentage leaf area affected within the foci.

References:

1, 12, 13, 14, 16, 25

LATE BLIGHT OF POTATOES

Key No. 3.1.2

Blight (%)	Nature of infection
0.0	No disease observed
0.1	A few scattered plants blighted; no more than 1 or 2 spots in 12-yard radius
1.0	Up to 10 spots per plant; or general light infection
5.0	About 50 spots per plant; up to 1 in 10 leaflets infected
25	Nearly every leaflet infected, but plants retain normal form; plants may smell of blight; field looks green although every plant is affected.
50	Every plant affected and about 50% of leaf area destroyed; field appears green, flecked with brown
75	About 75% of leaf area destroyed; field appears neither predominantly brown nor green
95	Only a few leaves on plants, but stems green
100	All leaves dead, stems dead or dying

(After British Mycological Society, 1947)

Use for:
Late blight of potatoes (*Phytophthora infestans* (Mont.) de Bary)

Procedure:
Use the key when the disease is widespread in the plot or crop. Select random sample areas along a diagonal or in accordance with other sampling schemes.

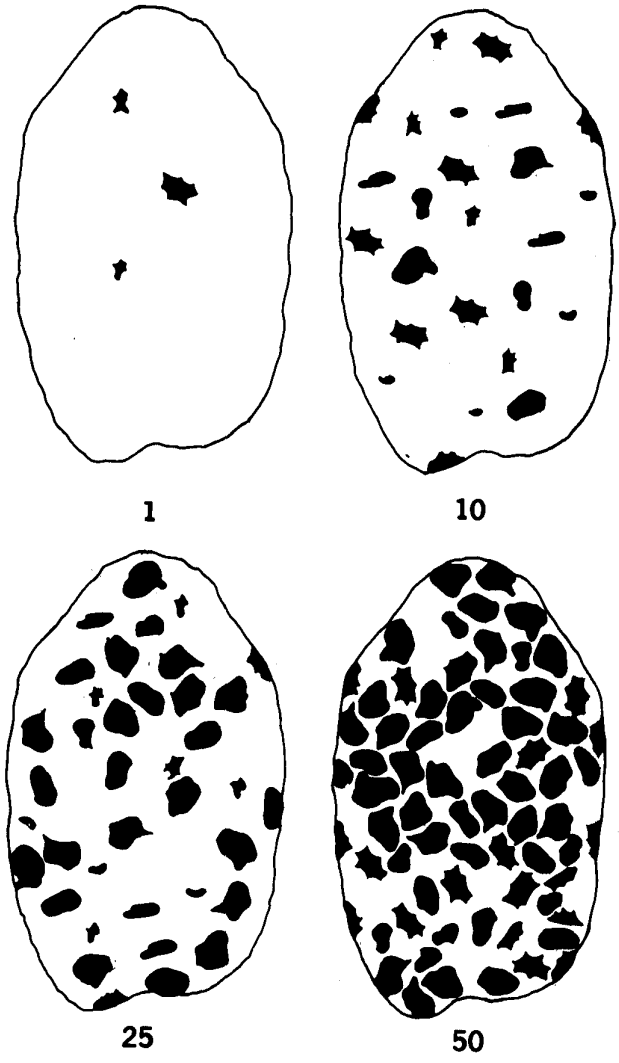
Growth stages:
Assess at regular intervals (such as one week) after the epidemic has started.

Assessing severity:
Assess percentage leaf area affected by blight.

References:
1, 12, 13, 14, 16, 25

COMMON SCAB OF POTATOES

Key No. 3.2



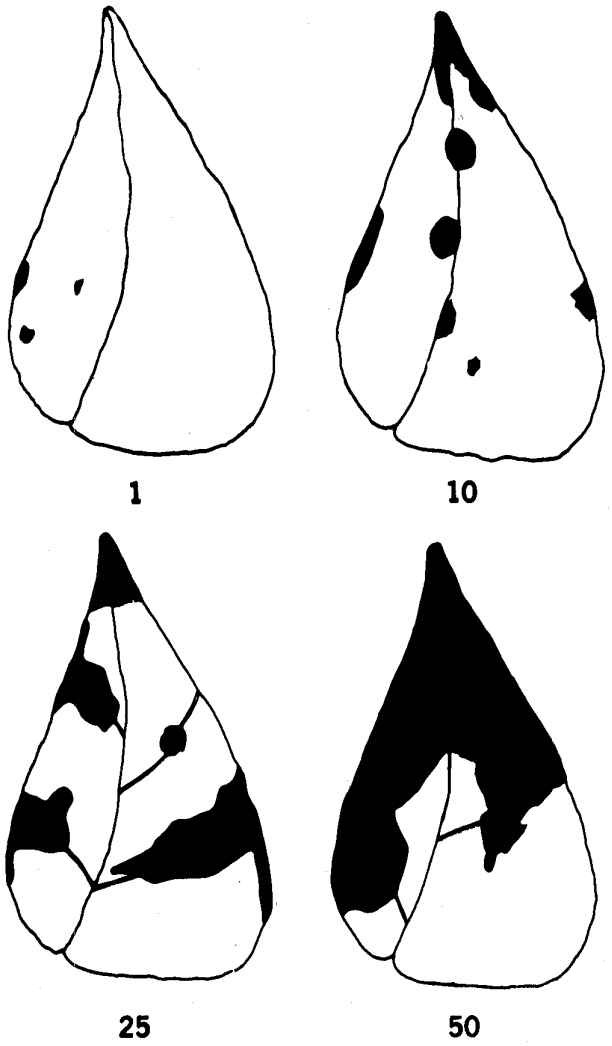
Use for:
Common scab of potatoes (*Streptomyces scabies* (Thaxt.) Waksm. & Henrici)

Procedure:
Assess percentage surface area covered by scab on samples of tubers.

References:
18, 22

COMMON BACTERIAL BLIGHT OF BEANS (Leaf symptoms)

Key No. 3.3.1



Use for:

Common bacterial blight (*Xanthomonas phaseoli* (E.F.Sm.) Dowson) of beans (*Phaseolus vulgaris* L.)

Procedure:

Primary stages (infection in foci)

1 Survey the crop for foci.
2 Estimate average number of foci per acre or hectare.
3 Determine average area of foci.
4 Express (2) and (3) as percentage acreage affected (see instructions).
5 Use the key to estimate the percentage leaf area affected.

Later stages (infection widespread)

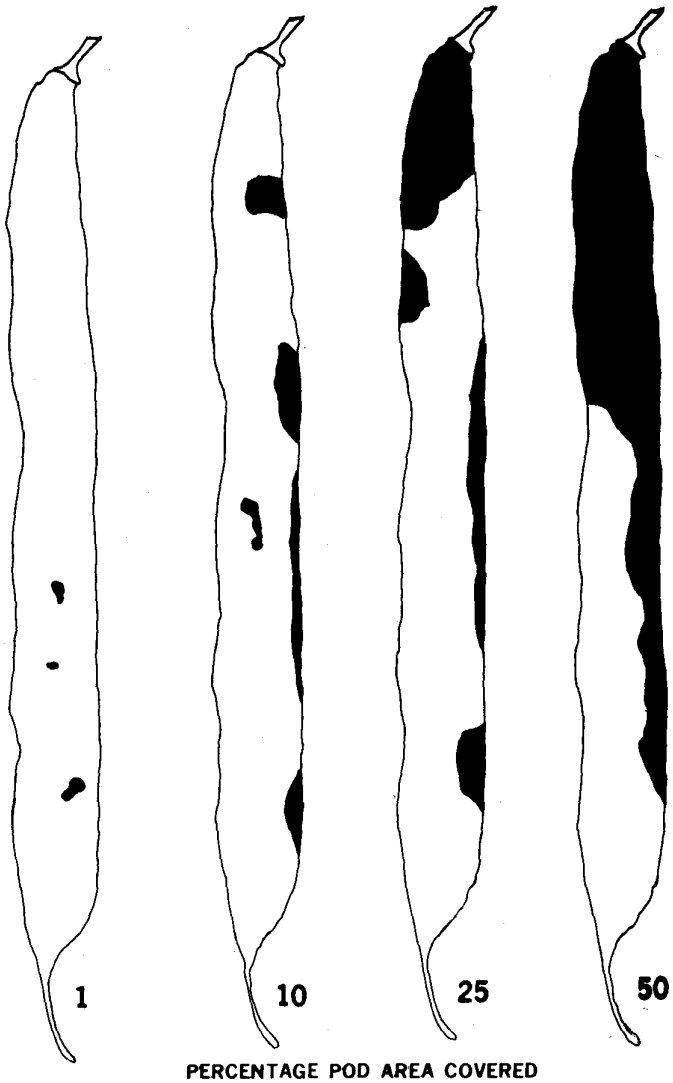
1 Select 10 random samples along a diagonal, each sample constituting two adjacent rows with 25 plants in each row (total of 50).
2 Use the key to assess percentage leaf area affected and calculate average for the 10 samples.

Growth stages:

Make the assessment when plants are fully mature but still green. In southern Ontario this stage generally occurs between August 15 and 20.

COMMON BACTERIAL BLIGHT OF BEANS (Pod symptoms)

Key No. 3.3.2



PERCENTAGE POD AREA COVERED

Use for:

Common bacterial blight (*Xanthomonas phaseoli* (E.F.Sm.) Dowson) of beans (*Phaseolus vulgaris* L.)

Procedure:

Primary stages (infection in foci)

1 Survey the crop for foci.
2 Estimate average number of foci per acre or hectare.
3 Determine average area of foci.
4 Express (2) and (3) as percentage acreage affected (see instructions for late blight of potatoes).
5 Use the key to estimate the average percentage pod area affected.

Later stages (infection widespread)

1 Select 10 random samples along a diagonal, each sample constituting two adjacent rows with 25 plants in each row (total of 50)
2 Use the key to assess percentage pod area affected and calculate average for the 10 samples

Growth stages:

Make the assessment when plants are fully mature but still green. In southern Ontario this stage generally occurs between August 15 and 20.

Acknowledgments

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DISEASES OF VEGETABLES IN ORGANIC SOILS OF SOUTHWESTERN QUEBEC IN RELATION TO CLIMATE IN 1969 AND 1970

René Crête,[1] Leon Tartier,[2] and Thomas Simard[3]

Abstract

In 1969 and 1970, foliar diseases of carrot and onion were observed in late August and early September, but they did not develop to epidemic proportions. A new root disease of carrot caused by Rhizoctonia sp. was observed for the first time in 1969 and again in 1970. Onion smut was observed on 48% of the farms surveyed in 1970. In general, diseases of vegetables grown in organic soil were less severe in 1970 than in 1969. This is attributed to climatic conditions characterized in 1970 by a lower than normal precipitation for the months of June, July, and August.

Résumé

En 1969 et 1970, les brûlures foliaires de la carotte et de l'oignon sont apparues à la fin d'août et au début de septembre mais n'ont pas atteint le seuil épidémique. Une maladie nouvelle sur la carotte causée par Rhizoctonia sp. fut observée pour la première fois en 1969 puis en 1970. Le charbon de l'oignon fut observée sur 48 pour cent des fermes visitées en 1970. En general, la sévérité des maladies de legumes cultivés en sol organique a été moins accentuée en 1970 qu'en 1969. Ceci est attribuable aux conditions climatiques caracterisées par une pluviosité nettement au-dessous la normale pour les moins de juin, juillet et août.

Introduction

This survey has been conducted annually since 1959 (3) to determine the occurrence, distribution, and severity of diseases on the main vegetable crops grown in organic soils in southwestern Quebec (4). In 1963 (5), the object was extended to study the annual development of foliar diseases, such as blights of carrot, onion, and potato, in relation to climatic conditions, especially precipitation.

Methods

The surveys began in 1969 at the end of August, and in 1970 during the second week of September. The general method described previously was followed, and the diseases were evaluated according to an index devised in 1961 (4) and modified in 1966 (6). The pertinent meteorological data recorded at Ste. Clothilde, Que., (Table 1) were obtained from Mr. C. Péron, CDA Research Station, St. Jean, Que.

Results and discussion

The prevalence of diseases in 1969 was noticeably greater than in 1970 (Table 2). Carrot blights caused by Alternaria dauci (Kuhn) Groves & Skolko and Cercospora carotae (Pass.) Solh.; onion leaf blight caused by Botrytis squamosa Walker, purple blotch of onion caused by Alternaria porri (Ell.) Cif., and late blight of potato caused by Phytophthora infestans (Mont.) de Bary developed earlier and were more severe in 1969 than in 1970. Late blight was severe in unsprayed early crops of potato in 1969, whereas in 1970 the disease was insignificant in both early and late crops. Lettuce diseases were also more important in 1969, especially early in the season. Late blight of celery (Septoria apiicola Speg.), with light to moderate infections in 1970, had not been observed since 1966 (6). White rot of onion, Sclerotium cepivorum Berk., was again recorded for both years in the same fields, while onion smut (Urocystis magica Pass. ap. Thum.), seemed to be increasing in 1969. Therefore in June 1970 an extensive onion smut survey was conducted in 44 fields representing 60% of the onion growers and 70%

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of the onion producing area. The results are published elsewhere (1). A new root disease of carrot was observed for the first time in 1969 and again in 1970 in the same field. The causal agent was tentatively identified as Rhizoctonia sp. The symptoms greatly resembled those of rhizoctonia crown rot and cavity spot of muck-grown carrots described by Mildenhall and Williams in 1970 (2). The cavity spots were the most conspicuous symptoms observed.

In general, the results of 1969 and 1970 presented similarities with those of 1963 and 1964 (5). In these years foliage diseases developed about 1 month later than in 1961, when epidemics of foliage diseases of carrot, onion, and potato appeared early in the season (4). The years 1964 and 1970 were characterized by notably lower than average rainfall in June, July, and August, and it was during those years that disease development and intensity were the least serious. In 1969 the June rainfall was well above the long-term average but half of this amount fell during the last week of the month. The month of July was dry and did not permit an extensive build-up and spread of inoculum. Therefore the disease intensity was less than expected. Early and repeated fungicide applications following our recommendations may also have contributed to keeping the foliar diseases at a low level, thus preventing serious economic losses.

Table 1. Total precipitation (inches) and mean temperatures (°F) from May to September at Ste. Clothilde, Châteauguay Co., Québec

	May		June		July		August		September	
Year	P	T	P	T	P	T	P	T	P	T
1969	2.12	51.9	5.70	63.4	2.27	66.2	4.36	67.4	2.69	57.3
1970	3.16	54.3	2.03	63.5	2.23	70.1	3.15	68.4	4.40	58.8
31-year average	3.24	53.8	3.40	63.8	3.56	67.8	3.40	65.6	3.16	57.2

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Table 2. Diseases of vegetables grown in the organic soils of southwestern Québec in 1969 and 1970

			Area affected			
			1969		1970	
Crop	Diseases and causal agent	Disease rating*	Fields	Acres	Fields	Acres
CABBAGE	Black rot *(Xanthomonas campestris)*	4	1	3		
	Clubroot *(Plasmodiophora brassicae)*	2	1	5	1	5
SWEDE TURNIP** (Rutabaga)	Mosaic (Virus)	1	4	92		
		2	2	30		
		3	4	109		
		4	5	41		

Table 2 (Cont'd)

Crop	Diseases and causal agent	Disease rating*	Area affected 1969 Fields	1969 Acres	1970 Fields	1970 Acres
CARROT	Foliar blights	0	1	5		
	(Alternaria dauci and/or	1	9	102	6	80
	Cercospora carotae)	2	4	54	4	118
		3	3	27	1	3
		4	5	26	1	10
	Rhizoctonia crown rot and cavity spot *(Rhizoctonia* sp.*)*	1	1	10	3	25
	Aster yellows (Mycoplasma)	1	4	32	9	197
	Nematode root knot	1	3	16	1	8
	(Meloidogyne hapla)	3			1	12
CELERY	Late blight	1			1	20
	(Septoria apiicola)	3	1	1	1	5
	Pink rot *(Sclerotinia sclerotiorum)*	1	3	22	1	10
	Aster yellows (Mycoplasma)	1	4	60	4	60
	Mosaic (Virus)	1			4	60
	Mn deficiency	1	1	4	4	40
LETTUCE	Downy mildew *(Bremia lactucae)*	1	4	14	2	9
	Drop	1	3	7	2	9
	(Sclerotinia sclerotiorum)	2	1	4		
	Bottom rot	1	3	10	2	7
	(Rhizoctonia solani)	3	1	1		
	Aster yellows (Mycoplasma)	1	8	24	3	11
	Mosaic (Virus)	1			3	11
	Tip burn	1	1	2	1	2
	Chemical injury	3	1	6		
		4	1	3		
ONION	Leaf blight	1	13	175	6	86
	(Botrytis squamosa)	2	4	18	2	20
		3	1	28		
	Botrytis sp. (on spanish onions)	1			1	3
	Purple blotch	1	11	130	6	86
	(Alternaria porri)	2			1	10
		3	2	25	1	10
	Fusarium bulb rot *(Fusarium oxysporum* f. *cepae)*	1			2	13

Table 2 (Cont'd)

Crop	Diseases and causal agent	Disease rating*	Area affected 1969 Fields	1969 Acres	1970 Fields	1970 Acres
ONION (Cont'd)	White rot *(Sclerotium cepivorum)*	1	3	25	3	25
	Smut *(Urocystis magica)*	0	2	55	23	797
		1	2	45	19	449
		2	1	8	2	136
		3	1	10		
		4	1	1	1	1
	Calcium deficiency	1	1	10		
	Herbicide damage	4	1	6		
	Wind damage	1			1	50
PEPPER	Early blight *(Alternaria solani)*	1	1	3		
		3	1	3		
	Sun scald	3			1	3
	Blossom-end rot	2			1	3
POTATO						
Early crop	Late blight *(Phytophthora infestans)*	4	3	3		
Late crop	Late blight *(Phytophthora infestans)*	1	4	18		
		4	1	8		
	Early blight *(Alternaria solani)*	1	3	20	2	20
	Fusarium wilt *(Fusarium oxysporum f. tuberosi)*	2			1	10
	Rhizoctonia *(Rhizoctonia solani)*	1			1	10
	Gray mold *(Botrytis cinerea)*	1			1	10
	Leaf roll (Virus)	1	4	25	1	2
		2	1	10		
	Simple mosaic (Virus)	1			2	20
	Purple top (Virus)	1	2	15		
SPINACH	Downy mildew *(Peronospora effusa)*	1	1	10		
		3	2	20		
TOMATO	Bacterial speck *(Pseudomonas tomato)*	1	1	3		
	Leaf mold *(Cladosporium fulvum)*	3	4	30 x 100 ft greenhouse		
	Blossom-end rot	1	1	3		

* Footnotes on following page

Table 2 (Concluded)

* Disease ratings of 0 to 4 indicate disease severity classes representing % affected plants in the case of virus or soil-borne diseases, or the % leaf area affected by foliar diseases.

Rating	Disease severity (%)
0	0
1	1- 10
2	10- 30
3	30- 60
4	60-100

** In L'Assomption Co., north of Montreal, no survey of swede turnips was made in 1970, but mosaic was as prevalent as in 1969.

INFLUENCE OF CHEMICAL FUNGICIDE TREATMENT OF OAT SEED ON SEEDLING EMERGENCE, SEED YIELD, AND KERNEL WEIGHT[1]

R. V. Clark[2]

Abstract

Treating sound seed of five oat (Avena sativa) varieties with six fungicide chemicals in field trials over a period of 3 years resulted in seed yields and kernel weights not significantly different from those of the untreated controls. Seedling emergence was increased slightly. Average seed yields were significantly different over the 3-year period but kernel weights were not. Varietal seed yields and kernel weights were significantly different each year and this difference was entirely attributable to variable responses of the varieties to the numerous environmental factors involved each year.

Introduction

The benefits from the treatment of diseased and damaged seed with fungicides have been recognized for many years (1). It is particularly important to treat diseased cereal seed since many cereal diseases are seed-borne and their control must be achieved by seed treatment rather than by foliage treatment later in the growing season as no practical foliar treatments are presently available. Therefore considerable emphasis is placed on treating all cereal seed regardless of condition. In recent years some people have questioned the value of treating healthy cereal seed. It has been suggested that treatment of sound seed provides little or no protection against soil organisms and no increase in yields. Rawlinson and Colhoun (8) recently found that the only beneficial effects of treating uncontaminated cereal seed occurred with oats and this happened only when the crop was grown under natural or simulated winter conditions and subjected to periods of frost.

Field trials were conducted for three years to determine the effects of treatment of sound oat seed with chemical fungicides on seedling emergence, seed yield, and kernel weight.

Materials and methods

Samples of oat (Avena sativa L.) seed were treated with mercury compounds at the following rates, Ceresan M (7.7% ethyl mercury p-toluene sulfonanilide) 0.5 oz/bu; Liqui-San 10L (1.9% methyl mercury 2-3 dihydroxy propyl mercaptide and 0.42% methylmercurie acetate) 0.75 oz/bu; and Pandrinox Liquid Combination (0.75% methylmercuric dicyandiamide and 2 5/8 lb heptachlor/imp gal) 2.0 oz/bu. The nonmercury fungicides Chemagro 4497 (50% bis [1, 2, 3-trichloroethyl sulfoxide]) and HRS-1591A (ethylene bis [tetrahydrothyophenonium] dibromide were applied at the rate of 3 oz/100 lb of seed. A 3% solution of methyl cellulose (Methocel) was applied as a sticker with each of the fungicides[3] at the rate of 1 part sticker to 15 parts seed by weight. Controls included untreated seed and seed treated with methyl cellulose sticker alone.

Sound seed of uniform size of the varieties Stormont, Dorval, Russell, Garry and Rodney was treated each year. All the seed was produced at Ottawa the season prior to planting; on the basis of plating tests the seed used was free from seed-borne pathogens. In one or two cases 1- and 2-year old seed was bulked to provide a large enough sample to treat. A minimum of 0.33 lb of seed was used each time a sample was treated. A rotary type treater having a tumbling action was used to apply the fungicides and sticker to the seed uniformly.

Four replicates of 4-row plots with 100 seeds per row were planted for each treatment. The rows were 10 ft long and 12 inches apart. Seedling emergence counts were taken on the two center rows of each plot approximately 1 month after planting. At

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[1] Contribution No. 276. Ottawa Research Station, Research Branch, Canada Department of Agriculture.

[2] Research Station, Canada Department of Agriculture, Ottawa, Ontario.

[3] Ceresan M was supplied by Dupont of Canada Ltd., Toronto, Ontario; Liqui-San 10L by Green Cross Products, Montreal, Quebec; Pandrinox Liquid Combination by Morton Chemical Co. of Canada Ltd., Winnipeg, Manitoba; Chemagro 4497 by Chemagro Limited, Toronto, Ontario; HRS-1591A by Hooker Chem. Corp., Niagara Falls, New York; and Methocel by Dow Chemical Co., Midland, Michigan.

maturity the same two rows of each plot were harvested and the seed yield and 1000-kernel weight data were determined. The entire two center rows were harvested the first year but in the two following years a 1-ft portion was removed from the ends of each row before the remainder was harvested. Threshing was done with a cyclone thresher.

Results

In tests with cereals, seed yields serve as a means of comparing the overall performance of the crop while emergence and 1000-kernel weight data provide a means of comparing early seedling growth and the final condition of the harvested seed. In the present tests oat seed yields and kernel weights were obtained for 3 years and seedling emergence for 2 years. The data on seed yield and 1000-kernel weight were analyzed statistically, both separately and combined. Some adjustments had to be made to the yield data for the combined analysis as larger plots were employed in the first year, and only three replicates were suitable for use in the third year.

The relative seed yields (Table 1) showed that no fungicide gave a consistent increase or decrease during the 3-year period. The combined analysis and the individual analyses (Table 2) showed that the yields of plants from fungicide treated seed were not significantly different from the controls. Yields were variable each year and, as a result, the coefficient of variation was high (approximately 30%). Treatment of the seed with the methyl cellulose sticker increased yields in 2 of the 3 years (Table 1) and produced a more consistent improvement in yield than the fungicidal chemicals. There were no consistent differences between the mercury and nonmercury chemicals in regard to their increase or decrease of yields.

Seed yields were significantly different from year to year (Table 2). They were highest the first year of the tests and lowest the third year. The yields of the varieties were significantly different each year but in the combined analysis the differences were not significant (Table 2). The two first order interactions between years X varieties and years X treatments were significant also. The treatment X variety interaction was not significant so the various treatments behaved the same way regardless of variety.

Seedling emergence data were obtained for the first 2 years and, in general, emergence of the treated seed was slightly better than that of the controls (Table 3). Seedling emergence was very poor the first year due to dry weather at the time of seeding and a second planting was done later in the season in the same field. Emergence was much improved in the later seeding and seedling counts among treatments were more or less in the same order as in the first planting. Because of extensive tillering, the low emergence levels did not reduce seed yields.

Kernel weight data were obtained on bulked samples the first year, so only the results of the second and third years' tests could be included in the combined analysis (Table 2). The analysis showed that treatment of the seed with chemicals did not significantly change the kernel weight of the subsequent crop. As was the case with the seed yields, the kernel weights of the varieties were significantly different in the 2 years the analysis was done but the differences were not significant in the combined analysis. Comparing the relative kernel weights of the seed from the three tests (Table 4) shows that they were lowest in Test 1 and highest in Test 3. This was the reverse of the seed yields for these tests.

Table 1. Effects of seed treatment on oat seed yields over a 3-year period

Treatment*	1965† Yield (g)	Rank	1966 Yield (g)	Rank	1967 Yield (g)	Rank	Average Yield (g)	Rank
Control (untreated)	437.3	4	304.9	5	232.9	2	325.0	3
Methocel (sticker)	455.7	2	320.5	1	209.0	6	328.4	2
Ceresan M	430.8	5	316.1	2	213.6	5	320.1	5
Chemagro 4497	426.0	6	288.7	7	233.6	1	316.1	7
HRS-1591A	463.1	1	310.0	3	214.2	4	329.1	1
Liqui-San	423.2	7	300.4	6	230.1	3	317.9	6
Pandrinox	449.0	3	306.5	4	205.2	7	320.2	4

* Fungicides were applied to seed following treatment with Methocel.

† Data adjusted for plot size.

Table 2. Combined analysis and individual analyses of variance on 3 years of yield and 2 years of kernel weight data

Source of variation	Seed yield df	Seed yield MS	Seed yield F	Kernel weight df	Kernel weight MS	Kernel weight F
Combined						
Years	2	1483277	11.7**	1	14.4	2.6
Reps/years	8	126815		5	5.6	
Treatments	6	2073	0.17	6	5.6	2.2
Varieties	4	55804	1.87	4	20.9	0.9
Years x treat	12	11860	2.7**	6	2.6	1.2
Years x var	8	29908	6.9**	4	21.9	10.6**
Treat x var	24	5575	1.3	24	3.4	1.6*
Treat x var x years	48	2451	0.5	24	2.9	1.4
Error (pooled)	272	4283		170	2.1	
Test 1						
Treatments	6	4767	0.7			
Varieties	4	18650	2.9*			
Treat x var	24	6973	1.1			
Error	102	6339				
Test 2						
Treatments	6	2189	0.7	6	2.8	1.1
Varieties	4	15496	5.2**	4	22.8	8.7**
Treat x var	24	3604	1.2	24	2.9	1.1
Error	102	2989		102	2.6	
Test 3						
Treatments	6	2171	0.7	6	3.1	2.4*
Varieties	4	56344	17.9**	4	16.5	13.2**
Treat x var	24	4089	1.3	24	3.9	3.1**
Error	68	3140		68	1.2	

* Significant 5% level.

** Significant 1% level.

Diseases such as septoria leaf blotch (Septoria avenae Frank f.sp. avenae) and crown rust (Puccinia coronata Cda.) were present in the plots each year but there was no indication that the rates of infection varied among treatments or varieties. Some variation in crown rust development was noted among replicates. The incidence of both of these diseases varied from year to year.

Discussion

There has been controversy over the years on the value of treating cereal seed with chemical fungicides. In some areas much of the cereal grain seeded is treated with fungicides whether it is known to be diseased or not. This is done frequently as a safety precaution to avoid possible losses from seedand soil-borne pathogens. There are numerous examples of seed-borne diseases of cereals that have been controlled by treatment of the seed with fungicidal chemicals (1), but in most instances the effects of such treatment on seed yields have not been determined. In cases where data are available (2, 3) the results indicate that with the exception of the cereal smuts significant yield increases often do not occur, even when the seed is heavily infected by a pathogen such as Cochliobolus sativus.

With the exception of the recent paper by Rawlinson and Colhoun (8) there are very few reports on the effect on yield of treating sound seed with fungicides. Most unpublished data that the writer has seen from several sources suggest that significant yield increases do not occur; the present work agrees with this. The relative yields of the five fungicidal treatments compared over the 3 years show an increase over the controls six times and a decrease nine times. The main problem in this work was the variability encountered in the yield data and this is, no doubt, one of the reasons why few published reports are available. Because of the amount of labor involved, small plots have been employed in tests of this type, usually using a randomized block design. As more mechanized equipment becomes available

Table 3. Effects of seed treatment on oat seedling emergence for 2 years

Treatment	1965* Emergence (%)	1965* Rank	1965† Emergence (%)	1965† Rank	1966 Emergence (%)	1966 Rank
Control (untreated)	47	7	89	6	79	7
Methocel (sticker)	52	2			82	6
Ceresan M	49	5	92	1	85	1
Chemagro 4497	53	1	89	5	85	2
HRS-1591A	52	3	90	3	83	4
Liqui-San	49	6	91	2	83	5
Pandrinox	51	4	90	4	84	3

* First seeding.

† Second seeding (for emergence data only).

Table 4. Effects of seed treatment on the 1000-kernel weight of oat seed over a 3-year period

Treatment	1965† Weight (g)	1965† Rank	1966 Weight (g)	1966 Rank	1967 Weight (g)	1967 Rank	Average Weight (g)	Average Rank
Control (untreated)	29.5	3	31.4	7	31.9	7	30.9	7
Methocel (sticker)	30.1	1	32.0	3	32.0	6	31.3	3
Ceresan M	28.9	7	31.7	5	32.8	3	31.1	4
Chemagro 4497	29.1	5	31.8	4	32.2	5	31.0	5
HRS-1591A	29.3	4	32.1	2	32.9	2	31.4	2
Liqui-San	29.0	6	31.4	6	32.5	4	31.0	6
Pandrinox	29.9	2	32.3	1	33.2	1	31.8	1

† 1965 kernel weight data not included in the statistical analysis.

for plot work, larger plots can be employed, possibly using improved sampling designs to minimize within-test variability. Even though the within-test variability was large, varietal response was in agreement with other oat yield tests grown at Ottawa and at other locations in Ontario during these years (4, 5, 6). However the variability in varietal response over the 3 years was also large, as can be seen by the fact that differences among varieties in both seed yield and kernel weight were significant each year but when subjected to the combined analysis were not (Table 2). This varietal variability was due to variable yearly responses, which no doubt resulted because of the presence each year of different uncontrolled environmental factors, such as temperature, rainfall, and foliage diseases.

Treatment of the seed improved seedling emergence slightly. However at the seeding rates currently recommended, improved emergence appears to be of little importance, as it has been found that more than a 50% reduction in emergence is needed before a significant decrease in yield will occur (2, 3). A recent study by Pelton (7) shows that in Western Canada under conditions of moisture stress, low seeding rates of wheat (0.3 and 0.6 bu/ac) produced significantly more grain than the higher rates generally used. In such a situation maximum emergence could be important.

Kernel weights were low in the first test and higher in the next two (Table 4). A decrease in kernel weight is usually associated with an increase in the number of tillers produced; this occurred in the first test, where poor emergence resulted in widely spaced plants that tillered profusely. This decrease in plants and increase in tillers did not lower grain yield but it did reduce kernel weight.

Acknowledgments

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SEED INFESTATION OF FLAX IN ALBERTA WITH THE FUNGUS CAUSING BROWNING OR STEM-BREAK

A. W. Henry[1] *and C. Ellis*[2]

Abstract

Seed samples of four varieties of flax (Linum usitatissimum L.) from different parts of Alberta were examined by artificial culture on potato sucrose agar for the presence of the browning or stem-break fungus Polyspora lini. Infestation was detected in seed of each of the four varieties Noralta, Raja, Redwood, and Redwing, with the incidence of infested samples ranging from 16 to 40%. Clean samples were obtained from widely separated parts of the province but most commonly from the drier areas.

Introduction

Browning or stem-break of flax has been known for about half a century. It was first reported in Ireland by Lafferty in 1921 (6). He described the disease and proved it was caused by a fungus. In North America it would appear that the disease has been present for as long a period as in Europe, though not recognized as the same until after Lafferty's report from Ireland. It was first reported in Canada from Saskatchewan in 1923 (1) though collected there as early as 1920 (3); it was reported in Alberta in 1926 (7). Additional early reports from Canada and the United States may be found in references by Flor (2) and Henry (2,3,4).

The dual name which Lafferty gave the disease indicates the two types of symptoms produced. Browning refers to brown blotches which develop on all above-ground parts and which are most conspicuous while the plants are still green. Stem-break on the other hand indicates a tendency of some affected plants to break over just above the soil surface. Brown lesions tend to develop most prominently on stems and leaves but they may also be found on floral parts, such as sepals and seed capsules. In fact the seed itself may be attacked, contaminated and damaged in varying degrees. It is with this latter effect that we are chiefly concerned here.

CAUSE AND METHODS OF TRANSMISSION

The causal organism was described by Lafferty (6) as an imperfect fungus which he named Polyspora lini n. gen. n. sp. in 1921. Recently (1965) the perfect state of this fungus was found in New Zealand by Sanderson on wild Australian flax, Linum marginale A. Cunn. (8). He described this as a new ascomycete which he named Guignardia fulvida Sanderson sp. nov. He also found that cultures from ascospores were similar to those from conidia and could infect cultivated flax and produce symptoms similar to those resulting from conidial infections.

The conidial or imperfect stage of the fungus is the one commonly found in North America on cultivated flax (Linum usitatissimum L.) It is characterized by an abundance of single-celled hyaline oval to cylindric conidia in tiny creamy masses on the surface of the brown lesions on the host. Diseased tissues plated on potato sucrose agar normally yield white yeast-like colonies which soon turn shiny black. These colonies produce a great abundance of conidia but only a limited amount of mycelium. Occasionally variant colonies consisting mainly of mycelium are formed in culture but these are not the typical form of the fungus (4).

Transmission of the causal fungus from year to year is made possible mainly by the use of infested seed or by establishing a crop in close association with diseased residues of a previous crop. Primary infection is initiated by inoculum on or in such seed or residues and is followed by the production of conidia which produce secondary infections during wet periods throughout the growing season. Conidia are dispersed by various agents such as wind, drifting rain and insects to living flax plants in the vicinity. Under favorable weather conditions the disease tends to become more severe as the season advances due to the continued production of conidia and possibly to an increase in susceptibility of the host with age.

IMPORTANCE OF SEED INFESTATION

Seed-borne inoculum is in an especially favorable position for establishing infection

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in a new crop started from infested seed. However much of the inoculum on the surface of the seed may fail to initiate infection because it is inactivated (5) by soil microorganisms or by chemical action if the seed is treated with fungicides. However internally-borne inoculum is often present in contaminated seed and is likely to survive and prove effective in disease initiation. The pathogen can survive in infested seed for at least 3-4 years under farm storage conditions. Therefore the use of infested seed is an efficient means of establishing numerous infection centers from which secondary spread throughout a crop may occur. Moreover the distribution of infested seed through commercial channels is bound to occur and this can result in the rapid and serious spread of the pathogen over a wide area.

The direct loss from seed infestation may be substantial. Not only is the yield of the crop grown from such seed likely to be reduced but its quality as well. The seed from a diseased crop is likely to be infested and its value for propagative purposes lowered appreciably. The main purpose of the present study was to determine the extent of infestation of Alberta flax seed with Polyspora lini.

Materials and methods

The seed examined consisted of 118 samples; 28 were obtained from several Alberta Municipal Seed Cleaning Plants and 90 from the Federal District Seed Analyst, Plant Products Division, CDA, Edmonton, Alberta. These samples were from widely scattered districts of Alberta and included seed of four varieties, most of them (82%) being of the Noralta variety.

Polyspora lini was detected by plating 100 untreated seeds from each sample on acidified potato sucrose agar. When infested or surface contaminated seeds are incubated on this medium for 5-7 days typical colonies (Figure 1) of P. lini are produced that can usually be identified without the aid of a microscope.

Results

The results of the survey are given in Tables 1 and 2 and are illustrated in Figure 2. They show that flax seed from widely separated parts of Alberta was infested with the browning or stem-break fungus, the percentage of infested samples per variety ranging from 16.6% to 40%. As indicated by the map, infestation was most common in samples from western and central Alberta and least common in the dry southeastern part. In the western part it was noted in samples as far south as Claresholm and as far north as Falher in the Peace River area.

The percentage of infested seed per sample was not particularly high but if only 1% of the seeds in a sample were infested, such a seed lot could establish a very large number of infection centers per acre.

However clean samples were obtained from all parts of the province surveyed (Figure 2) and all samples received from some areas were found to be clean.

Discussion

The most alarming fact brought out by the data in Tables 1 and 2 was that a high percentage of samples of seed of all four major varieties tested, namely Noralta, Raja, Redwood, and Redwing, proved to be infested with Polyspora lini.

With the exception of Redwing these are relatively new varieties which have become widely grown and distributed in Alberta, this being especially true of Noralta. Moreover the seed samples tested are believed to have originated on Alberta farms. It is possible therefore that the use of seed of any of these varieties that was not tested and found free from Polyspora lini could result in the wider distribution of the pathogen.

Table 1. Incidence of *Polyspora lini* in flax seed samples supplied by five Alberta Municipal Seed Cleaning Plants*

Flax variety	No. of samples	No. of samples yielding *P. lini*	Samples infested (%)	Range of infestation (%)
Noralta	20	5	25.0	0-20
Raja	6	1	16.6	0- 2
Redwood	2	0		
Total	28	6		

* Located at Alliance, Blackie, Falher, Nanton, and Pembina.

Table 2. Incidence of *Polyspora lini* in flax seed samples supplied by the Federal District Seed Analyst in Edmonton

Flax variety	No. of samples	No. of samples yielding *P. lini*	Samples infested (%)	Range of infestation (%)
Noralta	55	17	31.0	0-9
Raja	16	6	37.5	0-2
Redwing	5	2	40.0	0-3
Redwood	14	3	21.4	0-1
Total	90	28		

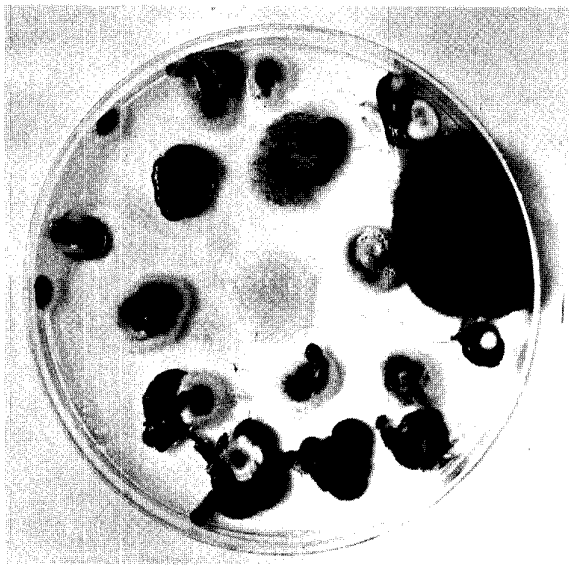

Figure 1. Isolates of *Polyspora lini* from infested seed of Noralta flax growing on potato sucrose agar. The shiny black colonies are typical of the pathogen.

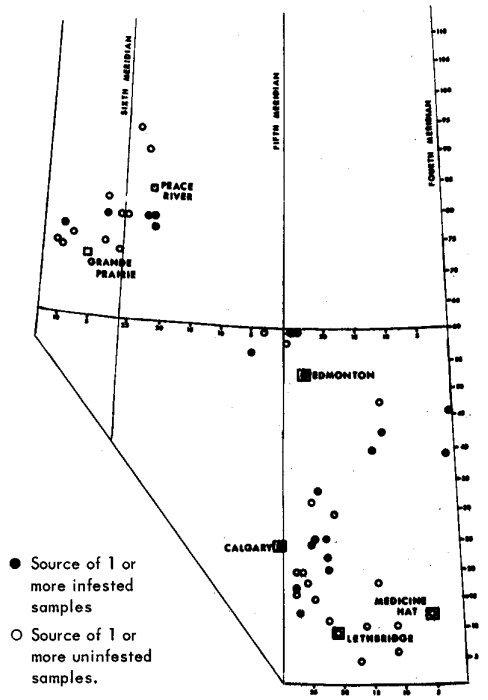

Figure 2. Distribution of Alberta flax seed samples examined for infestation with *Polyspora lini*.

While the data do not show differences in reactions to P. lini among the four varieties reported on here we have reason to believe that such differences exist. Field observations for instance indicate that Noralta is highly susceptible and that Raja possesses some resistance. It must be recognized however that P. lini is a variable fungus (4), probably consisting of many different races, so that resistance to one race may not necessarily mean resistance to all races. Among other varieties it has been noted that extreme reactions have been reported, e.g. Bison as highly susceptible and Rio as highly resistant.

It might be noted that three of the varieties examined here, Noralta, Raja, and Redwood possess considerable resistance to rust and wilt fungi. It would seem that the browning and stem-break fungus has become sufficiently important in Alberta to warrant the incorporation of resistance to it in new varieties that may be developed.

USE OF UNINFESTED SEED IN THE CONTROL OF THE DISEASE

The use of clean seed can play a major role in the control of the browning and stem-break disease. While our investigations show that many samples of Alberta farmers' seed are infested with the causal fungus, they also show that the majority are clean. Hence it is possible to obtain clean seed in Alberta.

If a farmer has to purchase seed to establish a crop he should be sure that he obtains clean seed. He should then be able to grow his own seed for an indefinite period with the expectation of producing crops free from this disease.

If, on the other hand, a farmer has infested seed he would be well advised to sell it for commercial purposes and buy clean seed with which to start his next crop.

Clean seed is more likely to be obtainable from areas which have a dry rather than a moist climate.

Visual examination of flax seed is not sufficient to detect infestation with P. lini. A cultural test such as that used in this investigation is necessary and could be made quite readily if seed testing laboratories were provided with the necessary equipment and qualified personnel.

ADDITIONAL CONTROL MEASURES

The use of clean seed is an essential control measure and might in certain circumstances be sufficient by itself, but other supplemental measures, such as crop rotation, seed treatment, and the growing of resistant varieites when suitable ones are available should be practised.

Acknowledgments

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ECONOMICALLY IMPORTANT NEMATODES IN CONTRACTED ACREAGE OF PROCESSING PEAS IN EASTERN ONTARIO

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Abstract

Helicotylenchus digonicus, Tylenchorhynchus brevidens, Pratylenchus minyus and Paratylenchus projectus were the predominant species of economically important nematodes, occurring in 90, 80, 70, and 55% respectively, of the pea fields surveyed in Eastern Ontario. Xiphinema americanum, Criconemoides curvatum, Meloidogyne hapla, and Heterodera avenae occurred in 30, 25, 25, and 15% respectively, of the fields surveyed.

Information on the occurrence and prevalence of economically important species of nematodes in agricultural crops grown in Canada is scanty. Some surveys of this nature have been undertaken in the past, especially in Ontario (e.g., Townshend, 1967; Bird and Boekhoven, 1968). This paper summarizes the results of a survey for nematodes done on contracted acreage for processing peas in eastern Ontario, in cooperation with plant pathologists of the Ottawa Research Station who were undertaking a pea disease survey in the summer of 1970.

Materials and methods

By means of a table of random numbers, 20 pea fields located in the Bloomington, Cherry Valley, Cordington, Hillier, Richmond Hill, Wellington, Waupoos, and Whitby areas of eastern Ontario were selected. These fields totaled 384 acres or 6.1% of the contracted acreage for processing peas in eastern Ontario. Soil and root samples were taken from the fields June 22-27, 1970, approximately 1 week before harvest. Samples consisting of a portion of plant roots with adhering soil were taken from sites along the arms of an imaginary 'W' pattern over the total area of each field. Collections from 5-8 adjoining sites were mixed together to form a composite sample. Thus a total of 680 sites were sampled to form 114 composite samples from the 20 fields.

The samples were stored in polyethylene bags at 38-40F (3.3-4.4C) for not more than 3 months before processing. Nematodes were extracted from soil by the sugar flotation technique (Jenkins, 1964), relaxed by gentle heat, fixed in 5% formalin, and processed in cotton blue lactophenol. Roots stained in a 0.05% solution of acid fuchsin in lactophenol were teased in lactophenol to extract endoparasitic nematodes of the genera Meloidogyne and Heterodera. Identification of specimens was made by the nematologists at the Entomology Research Institute, Ottawa.

Results

Helicotylenchus digonicus was found in 18 fields. No other species of Helicotylenchus was encountered.

Tylenchorhynchus sp. occurred in 16 fields. Of the two species encountered, T. brevidens was more common than T. maximus.

Pratylenchus sp. occurred in 14 fields. P. minyus was the prevalent species, although P. crenatus also occurred in some fields.

Paratylenchus sp. occurred in 11 fields, P. projectus being the main species identified from six fields.

Xiphinema sp. occurred in six fields, X. americanum being the main species encountered.

Criconemoides sp. occurred in five fields, C. curvatum being the main species encountered in three fields.

Meloidogyne hapla occurred in five fields, both adult females and juveniles occurring inside the roots.

Heterodera avenae was found in three fields. Cysts and juvenile stages occurred inside the roots.

The distribution of these eight genera of economically important nematodes is shown in Table 1. In addition to these, species of the following genera were also encountered in the soil samples.

Acrobeloides Cephalobus

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Diplogaster	Tylenchus
Rhabditis	Psilenchus
Plectus	Ditylenchus
Wilsonema	Aphelenchus
Dorylaimus	Aphelenchoides
Neotylenchus	Mylonchulus

The role of species of some of these genera, e.g., Aphelenchus avenue (encountered in 75% of fields), Aphelenchoides parietinus (found in one field), Tylenchus sp., and Psilenchus sp., in relation to plant damage, is not clearly understood at present.

Discussion

This survey indicates that a number of potentially plant-parasitic nematode species occur on peas in eastern Ontario. It is quite possible that they cause economic damage to this crop themselves. There is also a distinct possibility of relationships between some of the pea diseases found in the surveyed acreage and the plant-parasitic nematodes associated with plants grown in the same acreage. As shown in Table 1, species of Helicotylenchus, Tylenchorhynchus and Pratylenchus occurred in 90, 80, and 70% of the total number of fields surveyed. The preliminary results of the 1970 pea disease survey (P. K. Basu, personal communication) also indicate the predominance of fusarium root rot in the acreage surveyed. The role of species of Pratylenchus in causing necrosis of plant roots, their involvement in root-rot complexes and in establishment of root-rotting fungi in plant roots has been shown by various workers (Mountain, 1954, 1961; Graham, 1951; Slootweg, 1956). Species of Tylenchorhynchus have also been shown to facilitate establishment of fusarium wilt in plants (Holdeman, 1956). An increase in incidence of certain bacterial wilts in the presence of Helicotylenchus sp. has been reported (Libman and Leach, 1962). It may be useful to mention here that species of Helicotylenchus appear to be very common in cultivated acreages in Ontario. Towshend and Potter (unpublished data) found Helicotylenchus sp. to be the most common spiral nematode in forage crop soils in central and southwestern Ontario. It is realized that quantitative data on the plant-parasitic nematodes found in these pea fields would be of considerable value in ascertaining the role of these nematodes in plant damage. Unfortunately, such data could not be compiled for this survey. However the qualitative data present herein does show the prevalence of species of Helicotylenchus, Tylenchorhynchus and Pratylenchus in the surveyed acreage. It would be useful, to investigate further the role of these nematodes in root rot and other bacterial and fungal diseases found by plant pathologists in the pea crop surveyed in eastern Ontario. Also, the role of nematodes such as Xiphinema americanum, although found in only 30% of the fields, should not be underestimated since these nematodes could serve as vectors of certain plant viruses.

Acknowledgments

I wish to thank Dr. P. K. Basu, Plant Pathologist, Ottawa Research Station, for his generous help and cooperation in the course of this survey, and my colleague, Mr. R. H. Mulvey, for assisting in the collection of samples.

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Table 1. Distribution of eight nematode genera in pea acreage surveyed in eastern Ontario

Nematode	No. of fields	Acreage	% of total acreage surveyed	% of total no. of fields surveyed	Location
Helicotylenchus sp.	18	362	94.27	90	B, C, CN, H, R, W, WP, WY
Tylenchorhynchus spp.	16	257	66.92	80	B, C, CN, H, R, W, WP, WY
Pratylenchus spp.	14	295	76.82	70	B, C, CN, H, R, W, WP, WY
Paratylenchus sp.	11	204	53.12	55	B, C, CN, R. W, WP, WY
Xiphinema sp.	6	84	21.87	30	B, W, WY
Criconemoides sp.	5	76	19.79	25	B, C, R, WP
Meloidogyne sp.	5	78	20.31	25	B, C, CN, R, WY
Heterodera sp.	3	44	11.45	15	R, WY

Total number of fields surveyed: 20; total acreage surveyed: 384 acres; key to locations: B - Bloomfield; C - Cherry Valley; CN - Cordington; H - Hillier; R - Richmond Hill; W - Wellington; WP - Waupoos; WY - Whitby.

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OCCURRENCE OF TUBERCULINA MAXIMA ON PINE STEM RUSTS IN WESTERN CANADA

J. M. Powell[1]

Abstract

The purple mold Tuberculina maxima Rost. has been collected in western Canada on Cronartium coleosporioides Arth. infecting Pinus contorta Dougl.; on Cronartium comandrae Pk. infecting Pinus banksiana Lamb., Pinus contorta and Pinus sylvestris L.; on Cronartium comptoniae Arth. infecting Pinus banksiana and Pinus contorta; on Cronartium ribicola J.C. Fisch. infecting Pinus monticola Dougl.; and on Endocronartium harknessii (J.P. Moore) Y. Hiratsuka infecting Pinus contorta. There are no records of T. maxima on any of these rusts from Saskatchewan and Manitoba. In southern Alberta, T. maxima was found at nearly all locations where C. comandrae occurred.

Introduction

The purple mold Tuberculina maxima Rost. was first recorded on pine stem rust cankers in British Columbia in 1926(5), but not in Alberta until 1964(7). Additional information has now been obtained by personnel of the Forest Insect and Disease Survey, Canadian Forestry Service, about the distribution and occurrence of the purple mold on pine stem rusts in western Canada. Other collections have been made by the author in southern Alberta and adjacent areas of British Columbia. Information was also obtained from serveral herbaria, but only the following herbaria contained T. maxima on pine stem rusts from western Canada: CFB, DAOM, DAVFP, NY, OSC (Herbarium codes follow Lanjouw and Stafleu [4]).

Records of Tuberculina maxima on pine stem rust

Figure 1 shows the collection locations of the following records of T. maxima on the various pine stem rust cankers in western Canada.

Cronartium coleosporioides Arth.

Powell and Morf (7) found T. maxima on stalactiform rust cankers on Pinus contorta Dougl. var. latifolia Engelm. at three locations in Alberta. This included specimens found on C. coleosporioides f. album Ziller. One collection has been taken from C. coleosporioides infecting P. contorta var. contorta on Vancouver Island, British Columbia (DAVFP 15469).

Cronartium comandrae Pk.

In Alberta, Powell and Morf (7) found T. maxima on cankers of comandra blister rust affecting P. contorta at 11 locations, and at one location affecting Pinus sylvestris L. Since 1964, T. maxima has been found on C. comandrae cankers affecting P. contorta at 14 other locations in Alberta, and at 2 locations in British Columbia (CFB 7583, DAVFP 17248) and 1 in the Yukon (CFB 8937). Several collections were also made from cankers on P. banksiana Lamb. at one location in the Northwest Territories (1).

Cronartium comptoniae Arth.

Mielke (5) first reported T. maxima on sweetfern blister rust affecting P. contorta in British Columbia. More recently, another collection was made in this province (DAVFP 12908). It has also been collected on this rust affecting P. banksiana (CFB 9054) and a natural P. banksiana x P. contorta hybrid (CFB 7736), both from the Northwest Territories.

Cronartium ribicola J.C. Fisch.

Mielke (5) reported the occurrence of T. maxima on white pine blister rust affecting P. monticola Dougl. from seven locations in British Columbia, and Hubert (3) added another location. There are also six collections from other British Columbia locations in DAVFP, and another in OSC(27,699).

Endocronartium harknessii (J.P. Moore) Y. Hiratsuka

One specimen of T. maxima was collected on western gall rust affecting P. contorta (CFB 6895) in Kootenay National Park, British Columbia, in 1965.

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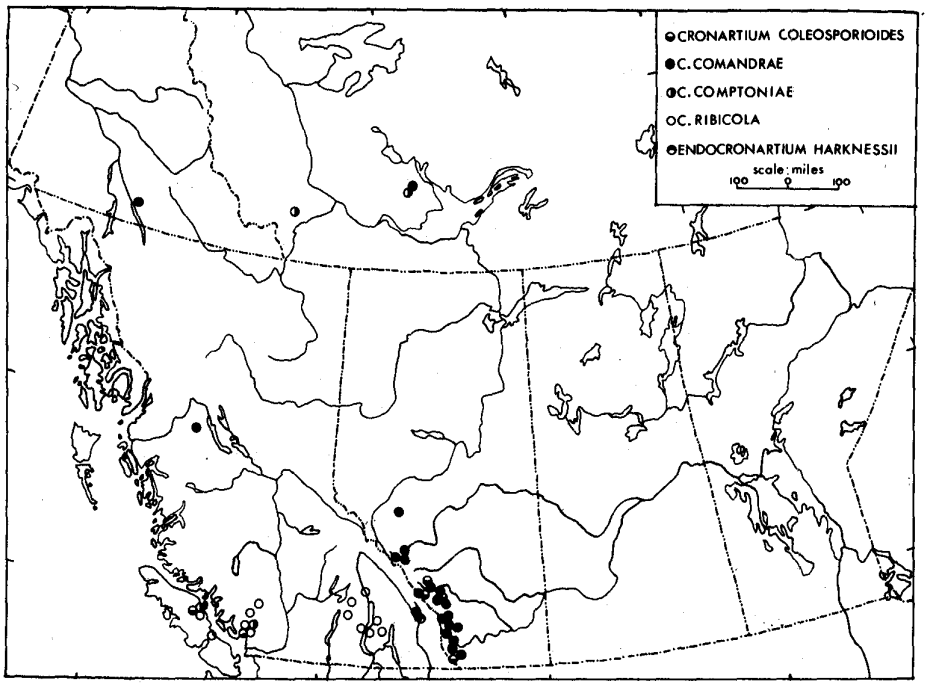

Figure 1. Distribution of *Tuberculina maxima* on pine stem rusts in Western Canada.

Discussion

The occurrence of T. maxima on pine stem rusts in western Canada is probably more widespread than the collections indicate. The known distribution of T. maxima is only a reflection of the specific surveys performed to date, with the real distribution probably closely related to the range of the pine stem rusts. Intensive surveys conducted in southwestern Alberta indicate that it could be found at nearly all the locations where the host, C. comandrae, was found. To date there are no records of T. maxima from Saskatchewan and Manitoba, or on rusts infecting P. banksiana in Alberta, although cankers of Cronartium and Endocronartium occur throughout these provinces. There are also no reports or collections of T. maxima on C. ribicola occurring on Pinus albicaulis Engelm. and Pinus flexilis James in Alberta or British Columbia, although the rust is common on the latter host (2). Similarly, there are no reports of T. maxima on the three pine stem rusts that occur on Pinus ponderosa Laws. in British Columbia.

Molnar et al. (6) indicated that T. maxima is known on 15 species of tree rusts in British Columbia; however, there has been some question about the taxonomy of the Tuberculina occurring on gymnosperm and angiosperm hosts. Dr. J.L. Cunningham (personal communication, 1970) considers the Tuberculina on Cronartium spp. in western North America to be T. maxima.

Acknowledgments

I am grateful to Dr. W.G. Ziller, Canadian Forestry Service, Victoria, B.C., for information on the DAVFP material; to Dr. K.R. Shea, U.S. Forest Service, Forestry Sciences Laboratory, Corvallis, Oregon, for information on the collections made by Mielke and others now held in the OSC herbarium; and to Dr. J.L. Cunningham, American Type Culture Collection, Rockville, Maryland, for information on the New York material and for comments on the taxonomy of Tuberculina species.

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ADDITIONAL RECORDS OF MYCODIPLOSIS LARVAE (DIPTERA: CECIDOMYIIDAE) FEEDING ON RUST FUNGI

J. M. Powell[1]

Abstract

Mycodiplosis larvae were found feeding on various spore states of the following rust fungi: Chrysomyxa pirolata Wint., Chrysomyxa woroninii Tranz., Coleosporium asterum (Diet.) Syd., Coleosporium vernoniae Berk. & Curt., Cronartium coleosporioides Arth., Cronartium comandrae Pk., Endocronartium harknessii (J.P. Moore) Y. Hiratsuka, Melampsora epitea Thüm., Puccinia caricis-shepherdiae J.J. Davis, Pucciniastrum epilobii Otth., and Pucciniastrum sparsum (Wint.) E. Fisch. The larvae occurred on the pine stem rusts Cronartium coleosporioides and Cronartium comandrae on pine as well as on alternate hosts and appeared to markedly reduce the amount of rust inoculum available for dispersal.

A list of rusts and other fungi that are attacked by Mycodiplosis spp. was recently published (3). Only two of these records pertained to reports of Mycodiplosis spp. on rusts from North America. Berkenkamp (1) recently reported Mycodiplosis impatientis Felt feeding on the uredospores of Uromyces trifolii (Hedw. f. ex. DC) Lev. on various species of clover (Trifolium) in central and northern Alberta, but I am unaware of any other report of Mycodiplosis spp. feeding on rust fungi in Canada, other than that briefly mentioned in a paper by the author (4).

During surveys for pine stem rust fungi between 1965 and 1967 in southern Alberta, over 25 collections were made of Mycodiplosis larvae feeding on spores of the pine stem rusts. After receiving a comment from R.J. Gagne (personal communication, 1970) that all true Mycodiplosis feed on rusts, I made a preliminary search for other Mycodiplosis larvae in some of the rust material held in the mycological herbarium of the Canadian Forestry Service, Edmonton (CFB).

Table 1 lists Mycodiplosis material from 11 different rust fungi, in some cases on several host plants, none of which are recorded by Nijveldt (3). Mycodiplosis were collected on the spermogonial and aecial states of Cronartium coleosporioides and Cronartium comandrae on Pinus contorta, and on the uredial and telial states of these rusts on the alternate hosts. Most larval collections on the pine stem rusts were made in July and August, although some were collected as early as June 12 and others as late as September 28. Collections on the other rusts were made over a similar period of the year (Table 1).

Up to 250 Mycodiplosis larvae were often present on individual cankers of C. comandrae. Between 25 and 75% of the cankers at two locations south of the Kananaskis Forest Experiment Station, near Seebe, Alberta, contained Mycodiplosislarvae in the years 1965 to 1968. The larvae were observed eating large numbers of spores and often caused the aeciospores to become aggregated in a mass of fine silk, which gave a mealy bleached appearance to the spores. The larvae took on the color of the spores. The larvae found on C. coleosporioides f. album were white, but they were various shades of orange and yellow when feeding on spores of C. coleosporioides, C. comandrae, E. harknessii and P. caricis-shepherdiae. The larvae did not pupate on the rusts but in the soil or duff layers. Rearings from duff material, collected around the base of C. comandrae-infected trees at one location, produced adults of Mycodiplosis fungiperda Felt and M. sp. nr. tsugae Felt, which suggests a specific connection with the larvae on the cankers of pine stem rusts.

Larvae of Mycodiplosis spp. appear to be important agents in reducing the amount of pine stem rust inoculum available for dispersal, and presumably play a similar role on the other rusts. Golenia (2) surmised that Mycodiplosis spp. may play a part in the biological control of Puccinia menthae Pers. and Uromyces valerianae Fuck. Nijveldt (3) stated that more investigation is needed to establish the value of gall midge larvae in the control of fungi. Most cecidomyiids, whose larvae are associated with fungi and especially the rusts, belong to the genus Mycodiplosis (3). Further investigation would probably show that larvae of this genus may be associated with many more rust fungi in North America.

Acknowledgments

I wish to thank R.J. Gagne, Systematic Entomology Laboratory, U.S. Department of Agriculture, U.S. National Museum,

[1] Research Scientist, Canadian Forestry Service, Department of Fisheries and Forestry, Edmonton, Alberta.

Washington, D.C., for identifying the larvae and adults as Mycodiplosis and for information on the genus.

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Table 1. Rust fungi and plant hosts from which larvae of *Mycodiplosis* were collected

Rust	Host	Spore state*	Collections	
			Location	Date
Chrysomyxa pirolata Wint.	*Pyrola asarifolia* Michx.	II	Alta.; Yukon	June 15, 23
Chrysomyxa pirolata	*Pyrola virens* Schweigg.	II	Alta.	June 21
Chrysomyxa woroninii Tranz.	*Ledum groenlandicum* Oeder	III	Yukon	July 27
Coleosporium asterum (Diet.) Syd.	*Aster conspicuus* Lindl.	II, III	Alta.	Aug. 19
Coleosporium asterum	*Aster* sp.	II, III	Alta.	Aug. 17, Sept. 17
Coleosporium asterum	*Solidago decumbens* Greene	II	N.W.T.	July 28
Coleosporium vernoniae Berk. & Curt	*Vernonia ?altissima* Nutt.	II, III	Ohio	Sept. 1
Cronartium coleosporioides Arth.	*Castilleja miniata* Dougl.	II, III	Alta.	Aug. 13
Cronartium coleosporioides	*Pinus contorta* Dougl. var. *latifolia* Engelm.	0 , I	Alta.	June 19-July 11
Cronartium coleosporioides f. *album* Ziller	*Pinus contorta* var. *latifolia*	I	Alta.	July 11
Cronartium comandrae Pk.	*Comandra umbellata* (L.) Nutt. ssp. *pallida* (A.DC.) Piehl	II, III	Alta.; B.C.	Aug. 17-Sept. 10
Cronartium comandrae	*Pinus contorta* var. *latifolia*	0 , I	Alta.	June 19-Sept. 28
Endocronartium harknessii (J.P. Moore) Y. Hiratsuka	*Pinus contorta* var. *latifolia*	III^I	Alta.	June 12
Melampsora epitea Thüm.	*Salix* sp.	II	Alta.	July 20-Aug. 30
Puccinia caricis-shepherdiae J.J. Davis	*Shepherdia canadensis* (L.) Nutt.	I	Alta.	July 30
Pucciniastrum epilobii Otth.	*Epilobium angustifolium* L.	II, III	Alta.	Aug. 11
Pucciniastrum epilobii	*Epilobium glandulosum* Lehm.	II, III	Alta.	July 29
Pucciniastrum sparsum (Wint.) E. Fisch.	*Arctostaphylos rubra* (Rehd. & Wils.) Fern.	II	N.W.T.	July 27

* 0 = spermogonial; I = aecial; II = uredial; III = telial; III^I = aecidioid teliospores.

PREVALENCE OF ONION SMUT, UROCYSTIS MAGICA, AND LOSSES IN ORGANIC SOILS OF SOUTHWESTERN QUEBEC IN 1970

R. Crête[1] *and L. Tartier*[2]

Abstract

A field survey revealed that onions (Allium cepa) grown on 21 of 44 farms (48%) inspected in southwestern Quebec were affected by smut. The area affected comprised 585 of the 1382 acres surveyed or 42%. The mean smut infection was 4.3%. In 1970 losses due to onion smut were evaluated at $55,000 to $60,000. The main pesticides used to control onion maggot or smut were diazinon 5-G. and ethion-thiram 5-G.

Résumé

Cette enquête a révélé la présence du charbon de l'oignon sur 21 des 44 fermes visitées, soit 48 pour cent. La superficie affectée par le charbon était de 585 acres sur 1382 acres échantillonnées, soit 42 pour cent. L'infection moyenne du charbon était de 4.3 pour cent. En 1970 les pertes causées par cette maladie ont été évaluées entre $55,000 et $60,000. Les principaux pesticides employés pour réprimer la mouche ou le charbon ont été le diazinon 5-G et l'éthion-thirame 5-G.

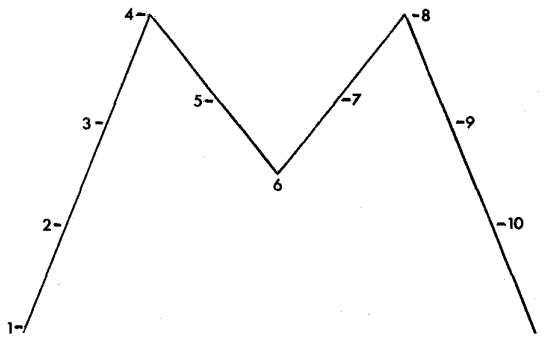
Introduction

Onion smut caused by Urocystis magica Pass. ap. Thum. was reported to be destructive in truck gardens around Montreal in 1922 and 1923 (1). In the Ste. Clothilde area smut was reported in 1960 (4), and in the period 1965-70 it has become increasingly prevalent (3,5,6,7). The importance of this disease may have been underestimated in the past because losses caused by smut have not been evaluated.

In 1970 a systematic survey was undertaken to determine the prevalence, distribution, and losses due to onion smut in the organic soils of Quebec, and to collect data related to onion production, such as acreage in culture, varieties grown, and pesticides employed for the control of onion maggot and smut.

Materials and methods

Previous observations and experiments (2) indicated that the most appropriate time to begin the survey was 6 or 7 weeks after seeding. At this time emergence of onions (Allium cepa L.) is complete and the stand has not yet been affected by smut. Forty-four onion growers were selected, representing 60% of the growers throughout the organic soil area. Close to 70% (1382 acres) of the onion producing area was surveyed, beginning on June 10. For each 10- to 15-acre field, a group of 10 samples was taken following an inverted W pattern:



The sampling sites were approximately equidistant from each other along the sampling pathway; at each site all the plants in 1 ft of row were carefully uprooted and placed in a numbered paper bag. The 10 bags from each field were placed in a plastic bag and kept in a portable cooler. For each grower, the surveyor immediately completed a form recording the name, address, onion varieties grown, acreage in culture, and pesticide treatments used for the control of

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maggot or smut. The onion samples were then taken to the laboratory and each plant was examined by transparency for smut infection.

Results

The data recorded are summarized in Tables 1 to 4. In a few cases estimates are given because precise figures could not be obtained. The large number (21) of varieties or hybrids grown is somewhat unusual. Due to the limited seed supplies of the main variety, Autumn Spice, in 1970 many growers were forced to use other varieties.

More onion growers used a furrow treatment than a seed treatment, and the most commonly used pesticides were diazinon 5-G and ethion-thiram 5-G (Table 3).

Smut was found on 21 of the 44 farms (48%), totalling 585 acres or 42% of the 1382 acres surveyed (Table 4). The mean smut infection was 4.3%.

Losses:

At the time the survey was carried out the mean number of onion plants per foot of row was 13, representing approximately 400,000 plants per acre. Based on our results, the losses may be calculated as follows:

No. of plants per acre	400,000
No. of acres affected by smut	585
Mean smut infection (%)	4.3
No. of bulbs per lb (approx.)	5
Estimated farm value[3] ($/lb)	0.03

Estimated loss:

$$\frac{400{,}000 \times 585 \times 4.3}{5 \times 100} = 1{,}993{,}680 \text{ lb}$$

$$1{,}993{,}683 \times \$0.03 = \$59{,}810$$

Using the actual % smut infection figures for the fields surveyed, the total loss in those fields amounted to 1,885,920 lb or $56,577.

Conclusions

Onion smut constitutes an increasing threat to onion growers in the organic soils of southwestern Quebec. In 1970 smut affected 48% of the farms or 42% of the area surveyed and caused losses estimated at $55,000 to $60,000.

The survey also permitted other noteworthy observations: some growers were uncertain about the acreage in culture, the rate of seeding, the rate of pesticide treatment used, and the purpose of such treatment. There is a strong indication that growers prefer furrow treatments to seed treatments because of convenience of application, not because of greater efficacy of the treatment. A great number of onion growers are not aware of the smut problem.

Table 1. Distribution and acreage of onion varieties grown in organic soils in southwestern Quebec in 1970

Number of growers	Variety	Approximate acreage
37	Autumn Spice	776
7	Copper Gem	145
7	Nugget	107
6	Epoch	45
6	Trapp No. 2 & No. 6	64
4	Autumn Splendor	45
3	Aristocrate	39
3	Sunburst	6
2	Yellow Globe	45
2	Mustang	36
2	Premier	22
2	Pronto	13
1	Buccaneer	10
1	Rocket	5
1	Encore	3
1	Fiesta	3
1	Exporter	3
1	Spartan Era	3
1	White Spanish	3
3	Red onions	9
		1382

Table 2. Distribution of onion growers according to acreage in culture in 1970

Number of growers (approx)	Number of growers surveyed	Number of acres in culture
40	17	1- 10
14	8	11- 25
15	15	26- 50
2	2	51-100
2	2	101 or more
73	44	

Acknowledgments

The authors gratefully acknowledge the assistance of G. Samoisette, J. Daneau, D. Gagnon, L. Morency, T. Simard, and P. Sauriol.

[3] K.M. Hunter, CDA Production and Marketing Branch, Ottawa, personal communication.

Table 3. Distribution of growers and acres treated with pesticides to control onion maggot or smut in 1970

No. of growers	Acres treated	Treatment	Smut observed: No. of growers	Smut observed: Acres affected	Smut observed: Mean % smut
		A - *Seed treatments* *			
3	57	Thiram 75-W + diazinon 50-W	3	57	7.0
4	119	Thiram 75-W (seed) + diazinon or Dasanit granular (furrow)	2	25	2.1
3	19	Diazinon 50-W	0	0	0.0
		B - *Furrow treatments*			
12	375	Diazinon 5-G	5	95	4.0
6	168	Dasanit 15-G	4	146	1.5
8	326	Ethion-thiram, 5-G	4	156	14.7
8	169	VC-13, 5-G, or VC-13, 5-G + thiram 10-G	2	15	0.2
1	80	Diazinon 50-EC	1	50	1.2
		C - *Treatment unknown*			
4	61		2	41	4.8
		D - *No treatment*			
1	8		0	0	0.0

* Most of the onion seed sold in the area is treated with thiram 75-W at 1 or 2 tablespoons/lb. A number of growers use this treatment if the seed has not been treated.

Table 4. Distribution of onion growers in relation to smut severity and acres affected in 1970

Number of growers	Smut (%)	Acres (No.)	Acres (%)
23	0	797	58
7	<1	131	10
6	1- 5	200	14
6	6-10	118	8
0	11-20	0	0
2	21-30	136	10

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MARSSONINA LEAFSPOT OF APPLE[1]

J. A. Parmelee[2]

Abstract

A leaf spot on apple caused by Marssonina coronaria (Ellis & J.J. Davis) J.J. Davis is reported for the first time in Canada from a bulk collection by John Dearness. The nomenclature and taxonomy of the fungus is discussed.

Bulk collections of miscellaneous parasitic fungi collected by John Dearness, and recently received from the Montreal Botanic Garden, are being examined by mycologists of the Plant Research Institute and prepared for general exchange. Some of this material was distributed by Ellis and Everhart in Fungi Columbiani; Ellis in North American Uredinales; and Sydow in Uredineen; and in Fungi Exotici Exsiccati; but for many of the specimens there is no record of previous distribution. One collection of rusted leaves of crabapple (Gymnosporangium juniperi-virginianae Schw. on Malus coronaria (L.) Mill.) carried abundant acervuli of "Marsonia coronaria Sacc. & Dearn." This leafspot fungus is not represented in accessioned specimens in the National Mycological Herbarium and is not recorded in An Annotated Index of Plant Diseases in Canada (Conners, 1967). It is listed from the mid-west in the Index of Plant Diseases in the United States (USDA, 1960). Ascochyta mali Ell. & Ev., on twigs of apple (M. sylvestris Mill.), is distinct. It is therefore expedient to record the occurrence in Canada of M. coronaria and to report my findings of its taxonomy and history.

The fungus compares favorably with the description by Saccardo and Dearness, although I find the spores to be slightly larger. My observations are: acervuli amphigenous, more conspicuous on upper leaf surface, subcuticular, ± circular on small (1-2 mm diam) coalescing dark spots. Conidia hyaline 2-celled, ellipsoid, slightly to conspicuously curved by the upper cell being usually larger and variously offset, each cell with 1-2 guttulae, 16-24 x 5-6.5 (-8)μ ; conidiophores simple, hyaline, 3-8μ long.

This and the Saccardo-Dearness description compare well with Ascochyta coronaria Davis, and from letters in the Dearness Herbarium, Davis saw this similarity and (in lit. to J. Dearness) indicated that Marssonina Magn. not Marssonia Fischer was the acceptable generic disposition. In 1914 he made the combination Marssonina coronaria (Ell. & J.J. Davis) J.J. Davis. This combination was made two years later than the one by Saccardo and Dearness but has precedence with the acceptance of Marssonina over Marssonia.

In the course of a literature search, another name of interest was found -- Marsonia mali P. Henn. described on Malus silvestris from Japan. The accompanying description is much like that for the Dearness material. Japanese specimens have not been seen but a specimen labelled Marssonina mali (P. Henn.) Ito from Romania was examined and could not be distinguished from North American material. My findings on the Romanian sample are: acervuli light brown, becoming darker and more conspicuous on the upper leaf surface, on small coalescing dark spots. Conidia hyaline long-ellipsoid, slightly curved, 2-celled, upper cell occasionally noticeably larger, 16-19.5 x 5-7μ ; conidiophores hyaline, simple, ca. 5-6μ long. Some of the narrower spores germinate from each cell with sterigma-like projections to produce microconidia: bacillar, hyaline ca. 3 x 1μ .

It therefore appears that Marssonina leaf spot of apple occurs in North America, Europe and Asia. Its perfect state is unknown: possibly a discomycete related to Diplocarpon, which has Actinonema and Marssonina imperfect states (Ainsworth, 1963) and which matures in the spring following the season of conidial production. One of the Dearness specimens (coll. 13 Sept. 1924) bears the annotation "... Strung the collection on a thread and put under the hedge" [script Dearness]. No result was given to this obvious attempt to overwinter the fungus and the specimen itself is the September collection.

NOMENCLATOR:

Marssonina coronaria (Ell. & J.J. Davis) J.J. Davis, Trans. Wisc. Acad. 17:881. 1914.

≡ Ascochyta coronaria Ell. & J.J. Davis, Trans. Wisc. Acad. 14:94. 1903.

= Marsonia coronaria Sacc. & Dearn. in Sacc., Ann. Myc. 10:313. 1912.

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[2] Mycologist.

= Marssonina mali (P. Henn.) Ito, Bot. Mag. Tokoyo 32:206. 1918.

≡ Marssonia mali P. Henn. Engl. Jahrb. 37:164. 1905.

SPECIMENS EXAMINED:

On Malus coronaria (L.) Mill.: as Ascochyta coronaria Ell. & J.J. Davis: Racine, Wisc. 15 Sept. 1912, (F. Col. 1807); as Marsonia coronaria Sacc. & Dearn.: London, Ont. Aug. 1910 (F. Exot. Exs. 93), isotype and 8 packets in Herb. Dearn. no. 3287, all from vicinity of London, Ont. and collected between 1910 and 1924; as Marssonina coronaria (Ell. & J.J. Davis) J.J. Davis: London, Ont. July-Aug. 1910-11 (F. Col. 5032); Port Frank, Lambton Co., Ont. 10 Aug. 1912 (DAOM 133730) intermixed with G. juniperi-virginianae.

Literature cited

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Conners, I.L. 1967. An annotated index of plant diseases in Canada. Can. Dep. Agr. Publ. 1251. 381 p.

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