AN ILLUSTRATED SERIES OF ASSESSMENT KEYS FOR PLANT DISEASES, THEIR PREPARATION AND USAGE'

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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

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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.

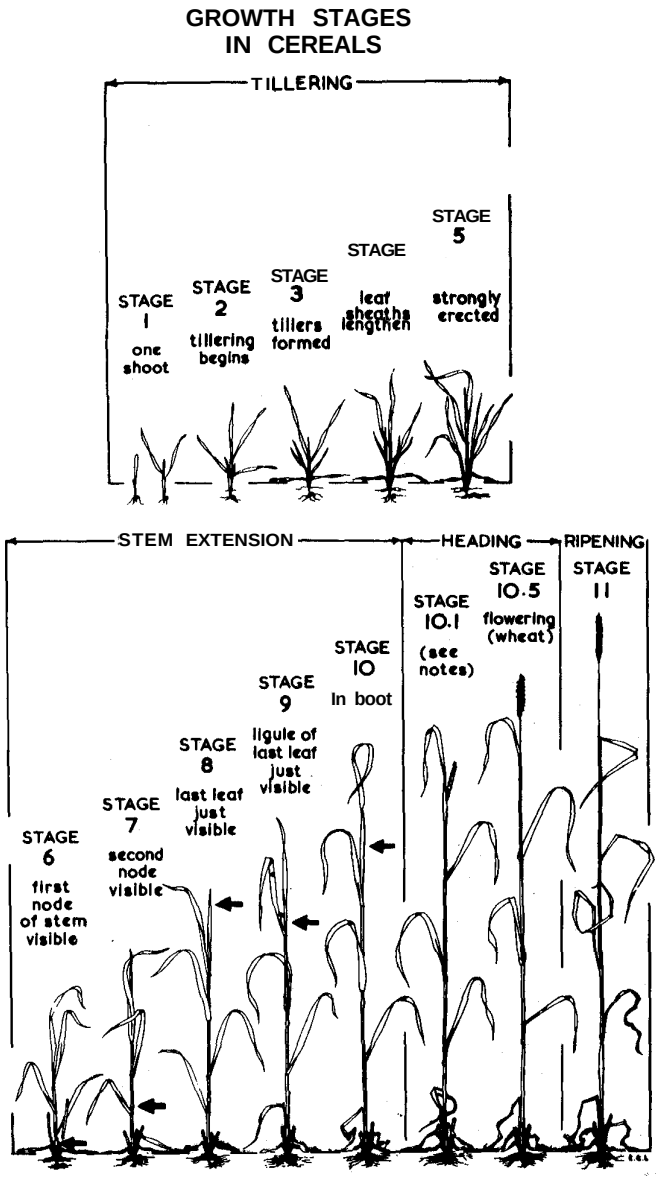
Determine percentage leaf area affected by leaf rust of cereals, based on 10 fertile tillers from a plot. Data for other diseases, green tissue, and dead tissue can be treated in a similar way.

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%

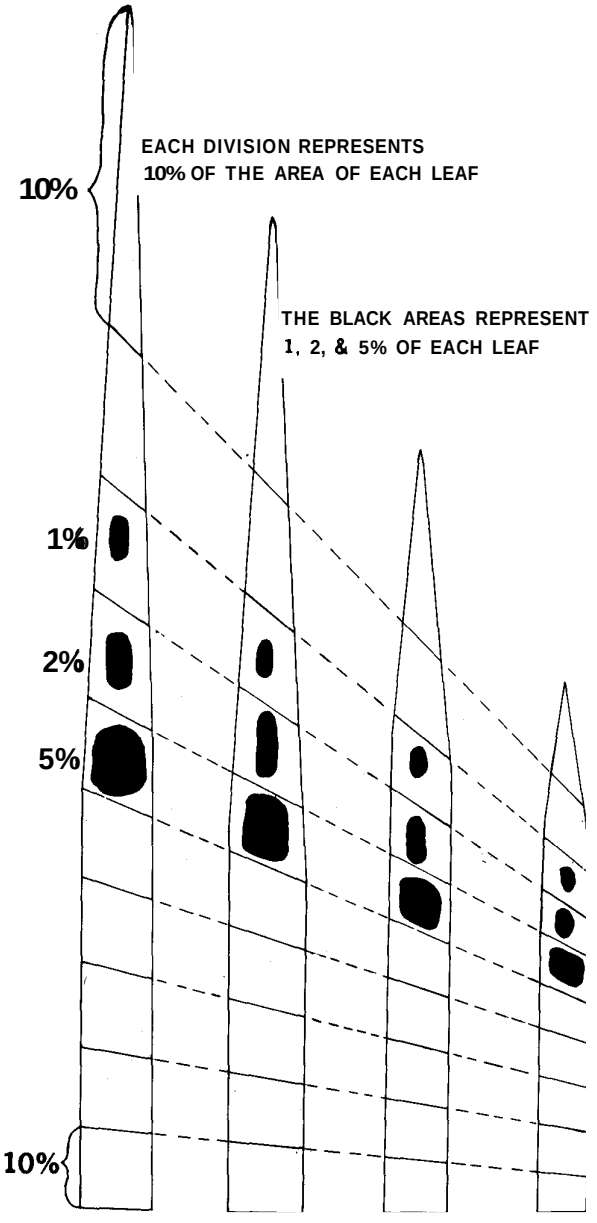
Percentage acreage affected = 15/4840
= 0.3%

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.

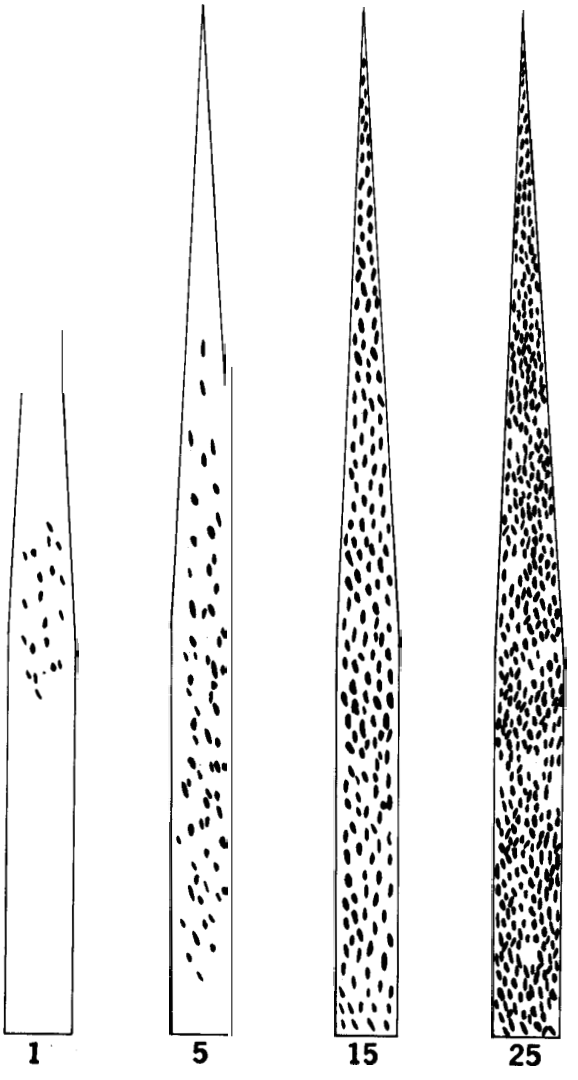
Growth stages:
Assess the percentage area affected by rhynchosporium on the upper side of the laminae of the flag and second leaves, at growth stage 11.1. The key can also be used for recording the disease at earlier growth stages, but the growth stage and leaf position (top leaf = leaf 1) should be 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



PERCENTAGE LEAF AREA COVERED

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:

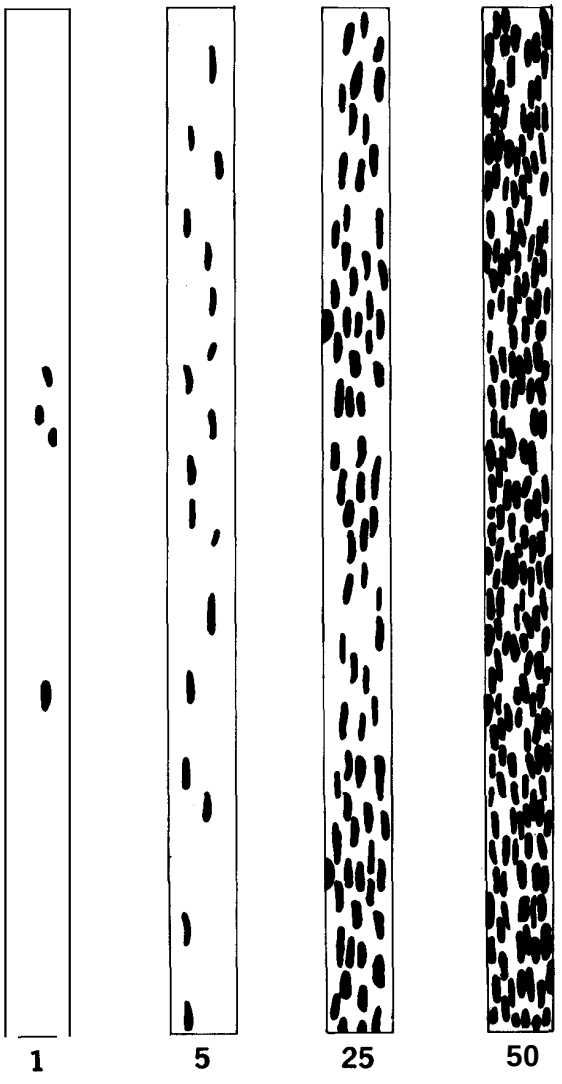
Assess percentage leaf (lamina) area affected by disease on individual top leaves.

Reference:

6

STEM RUST OF CEREALS

Key No. 13



PERCENTAGE STEM AREA COVERED

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:

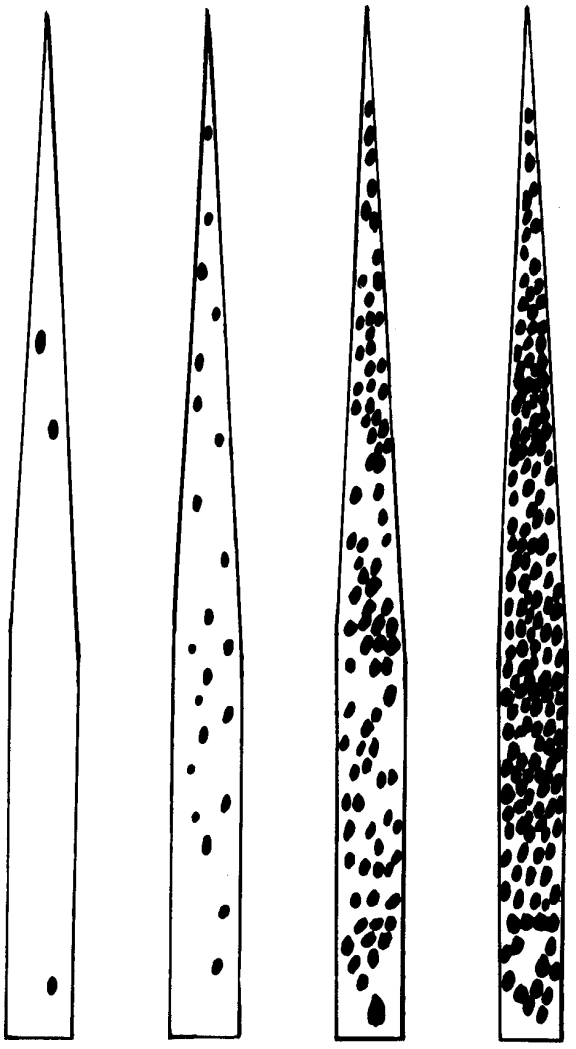
Assess percentage leaf (sheath) area affected by disease on individual top leaves.

References:

6, 27

POWDERY MILDEW OF CEREALS

Key No, 1.4



PERCENTAGE LEAF AREA COVERED

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 caretully 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.

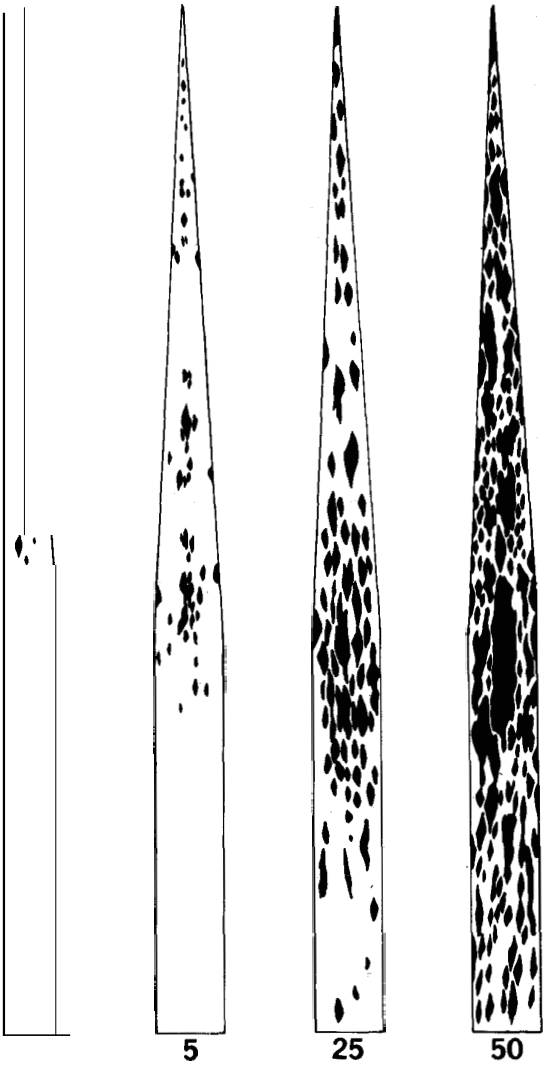
Growth stages:
Assess at growth stages 10.5 and either 11.1 or 11.2 or both.

Assessing severity:
Assess percentage spike area affected by disease.

Reference:
15

SEPTORIA LEAF BLOTCH OF CEREALS (Leaf symptoms)

Key No. 1.6.1



PERCENTAGE LEAF AREA COVERED

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:

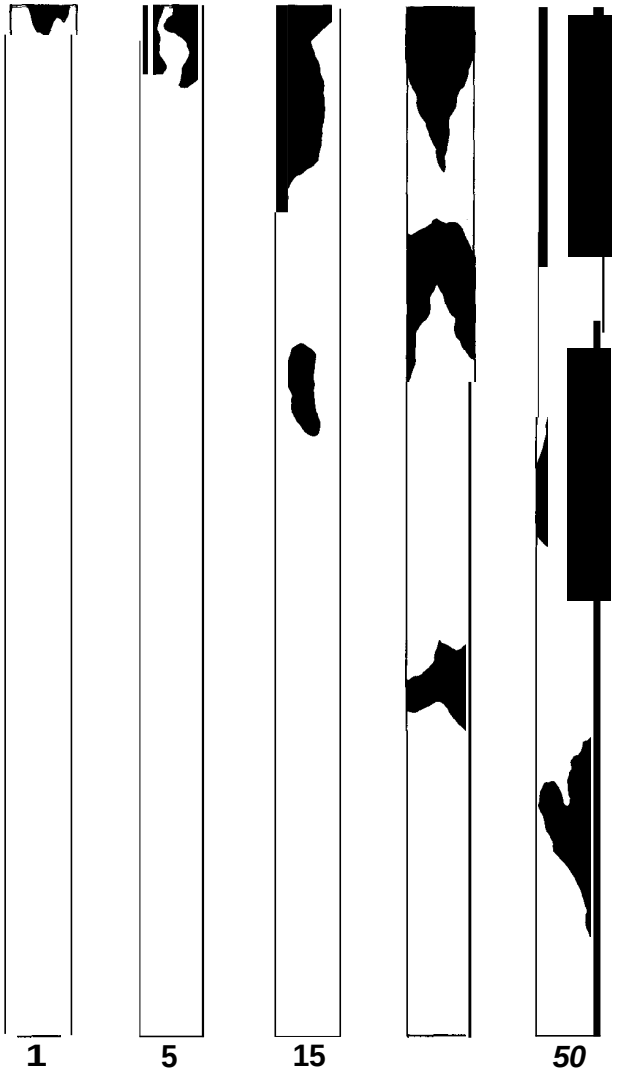
Assess percentage leaf (lamina) area affected by disease on individual top leaves.

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:

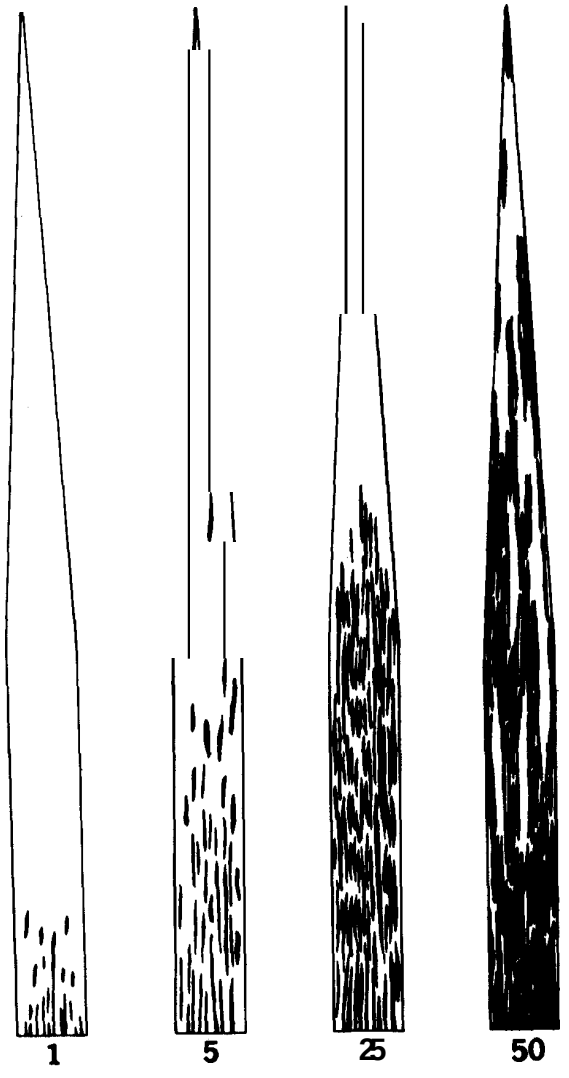
Assess percentage leaf (sheath) area affected by disease on individual top leaves.

Reference:

15

DRECHSLERA LEAF BLOTCH OR STRIPE OF CEREALS

Key No. 1.7



PERCENTAGE LEAF AREA COVERED

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:

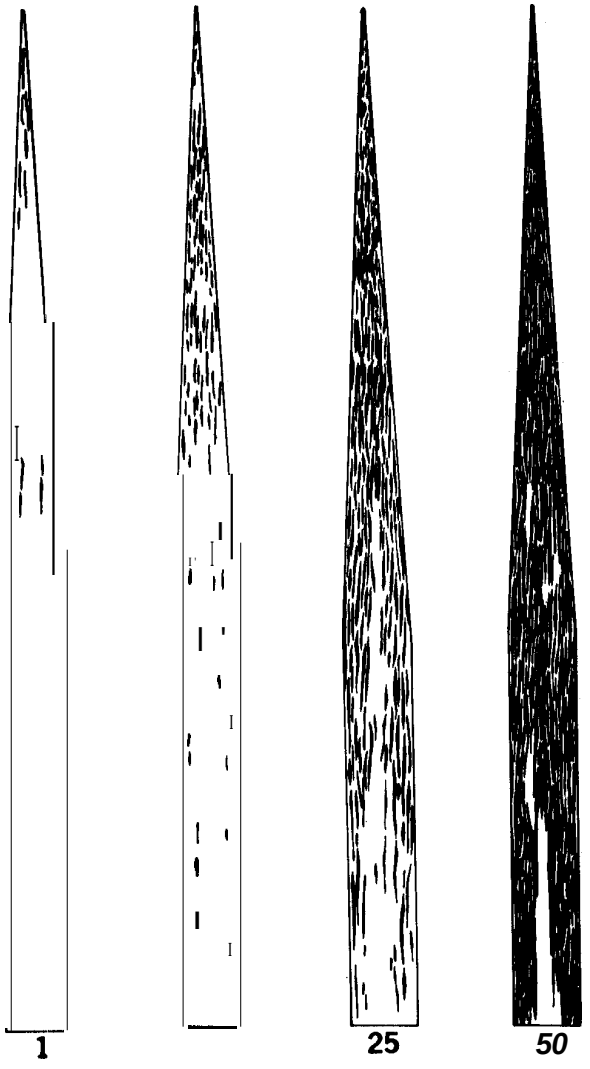
Assess percentage leaf (lamina) area affected on individual top leaves.

References:

5, 28

SPINDLE STREAK MOSAIC OF WHEAT

Key No. **1.8**



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:

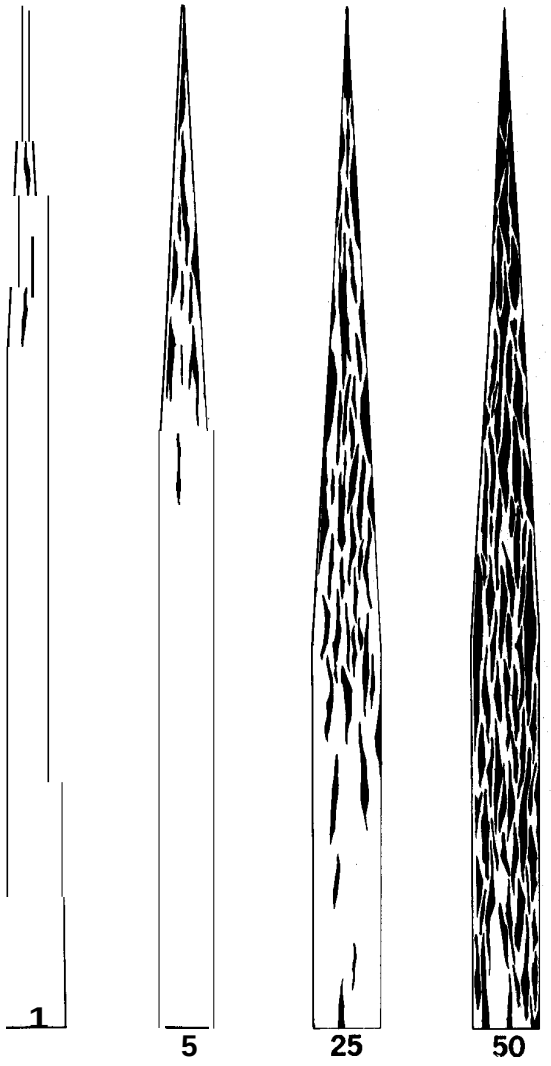
Estimate proportion of fertile tillers infected and express as percentage. Assess the percentage leaf (lamina) area affected by disease of individual top leaves.

References:

5, 28

BACTERIAL BLACK CHAFF OF WHEAT

Key No. 1.9



PERCENTAGE LEAF AREA COVERED

***Use** for:*

Bacterial black chaff of wheat *(Xanthomones translucens* (Jones, Johnson & Reddy) Dowson)

Procedure:

Select a random sample of fertile tillers.

Growth stages:

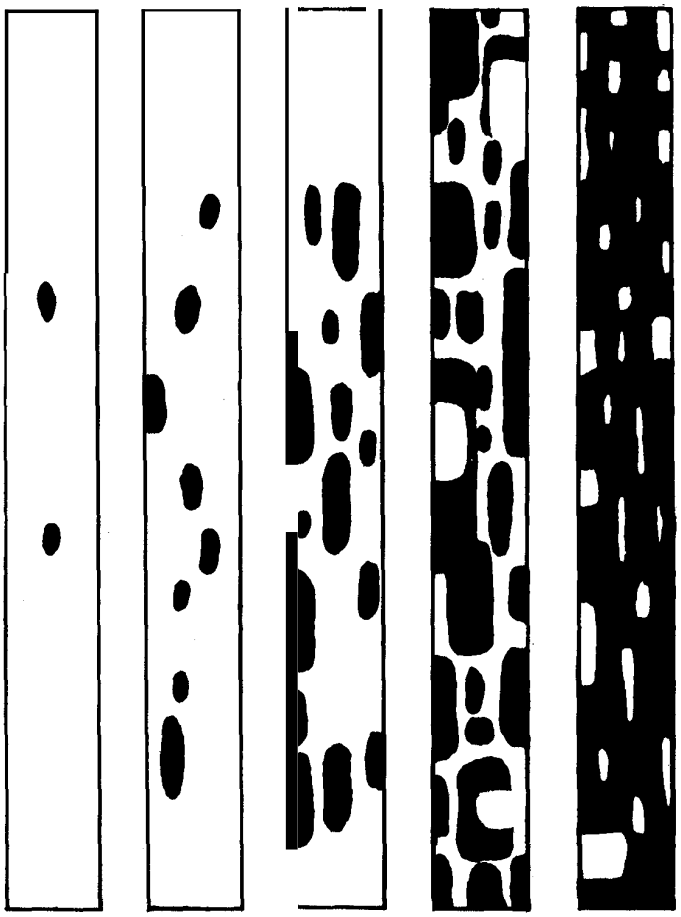
Assess at growth stages **10.5** and either 11.1 or **11.2** or both. The key can also be used for recordinq the disease at earlier growth stages, out the growth stage and leaf position (top leaf = leaf **1)** should be carefully noted, so that valid comparisons can be made between crops.

Assessing severity:

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

BLACK STEM OF ALFALFA (Stem symptoms)

Key No. 2.1.1



PERCENTAGE STEM AREA COVERED

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

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

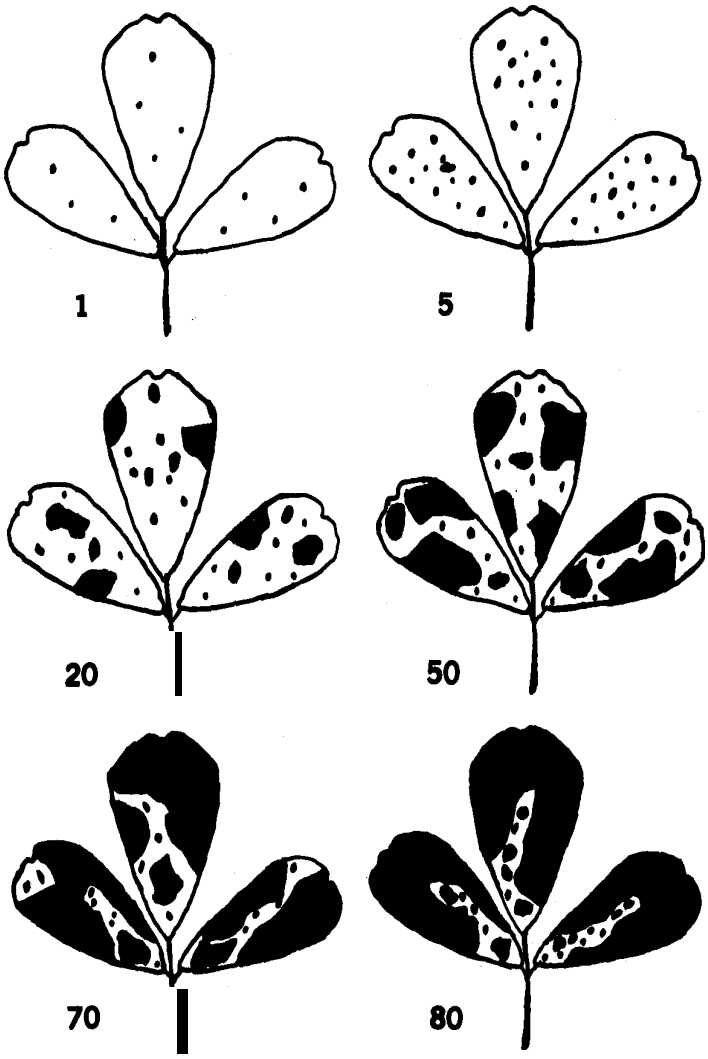
Growth stages:
Before first and second cuts and at any other appropriate stages (see growth stage key).

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, yd², m²).

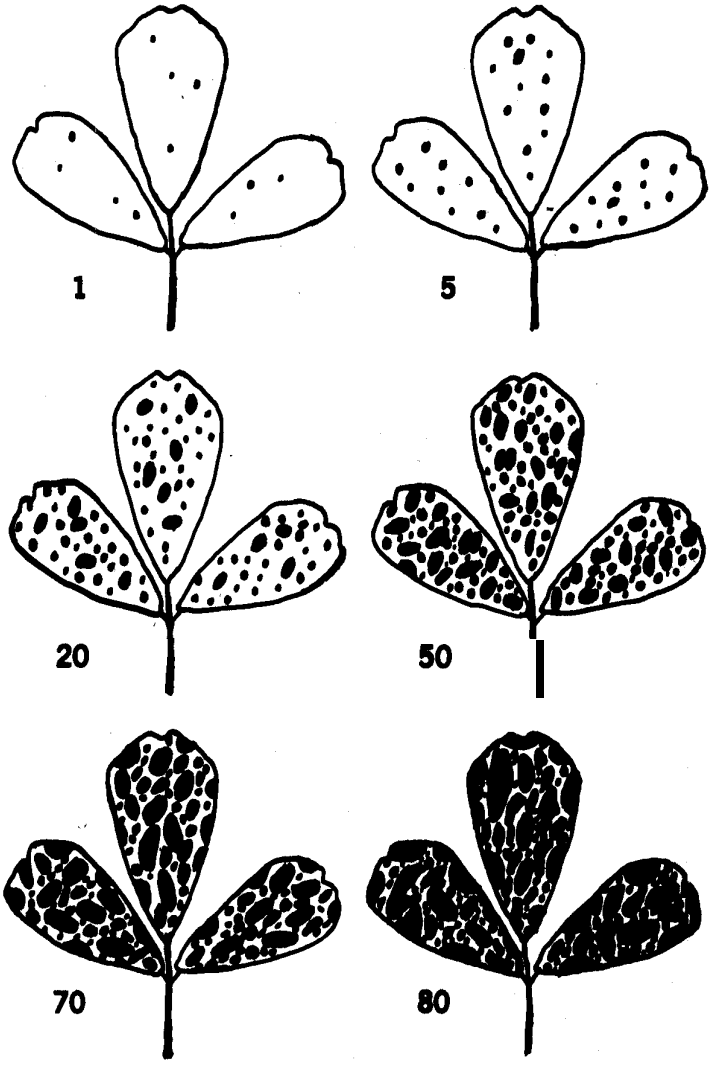
Growth stages:
Before first and second cuts and at any other appropriate stages (see growth stage key).

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 (ff, yd^2, m^2).

Growth stages:

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

Assessing severity:

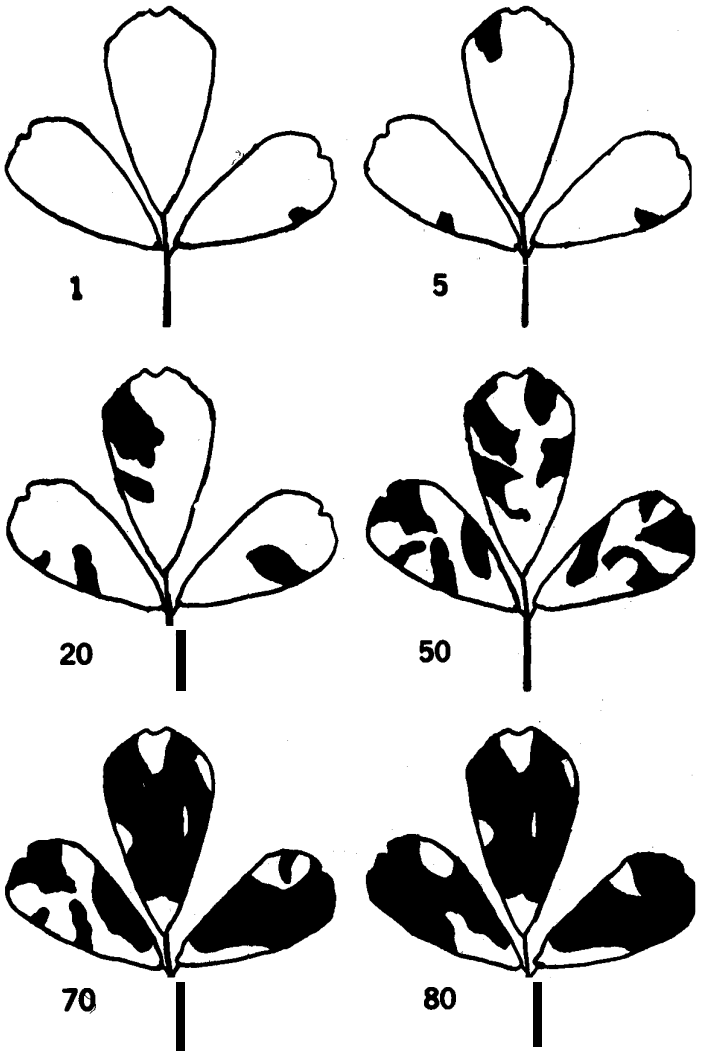
Assess percentage leaf area affected (including defoliation due to disease, if any).

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).

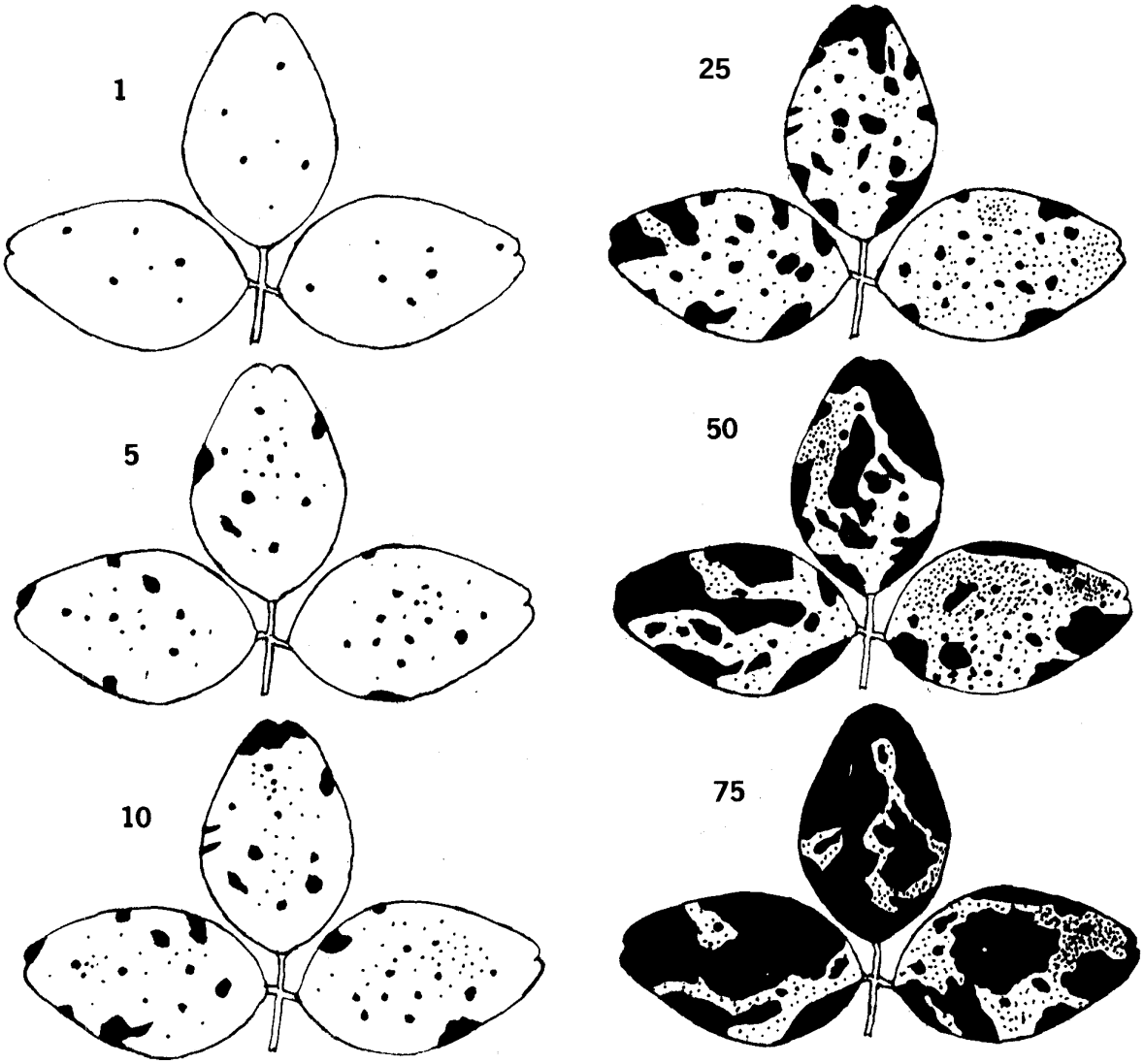
Growth stages:
Before first and second cuts and at any other appropriate stages (see growth stage key).

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:

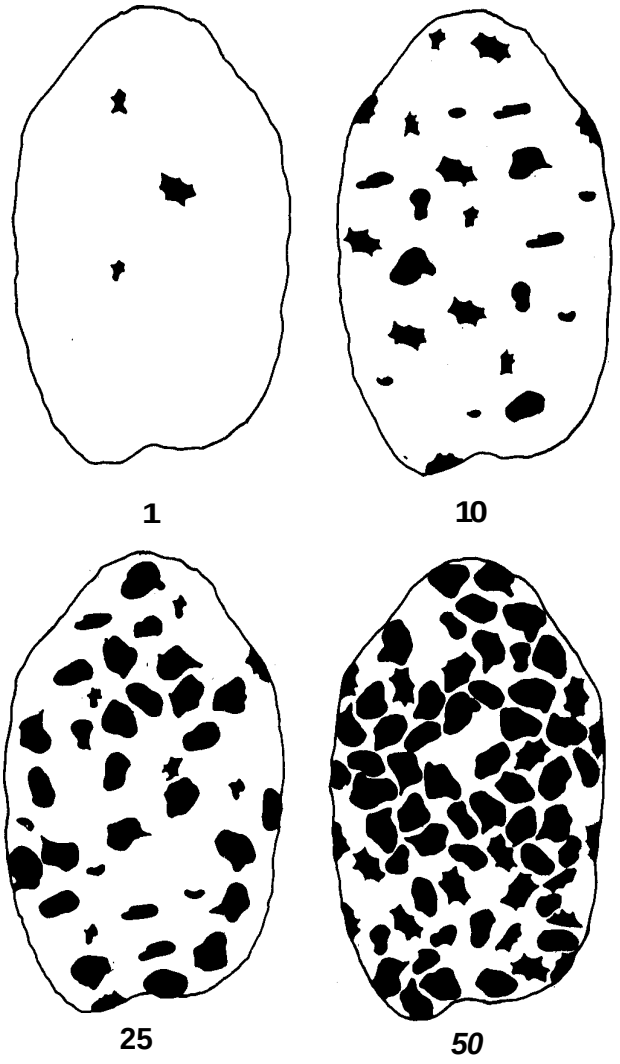
Assess percentage leaf area affected by blight.

References:

1, 12, 13, 14, 16, 25

COMMON SCAB OF POTATOES

Key No. 3.2



PERCENTAGE TUBER AREA COVERED

Use for:

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

Procedure:

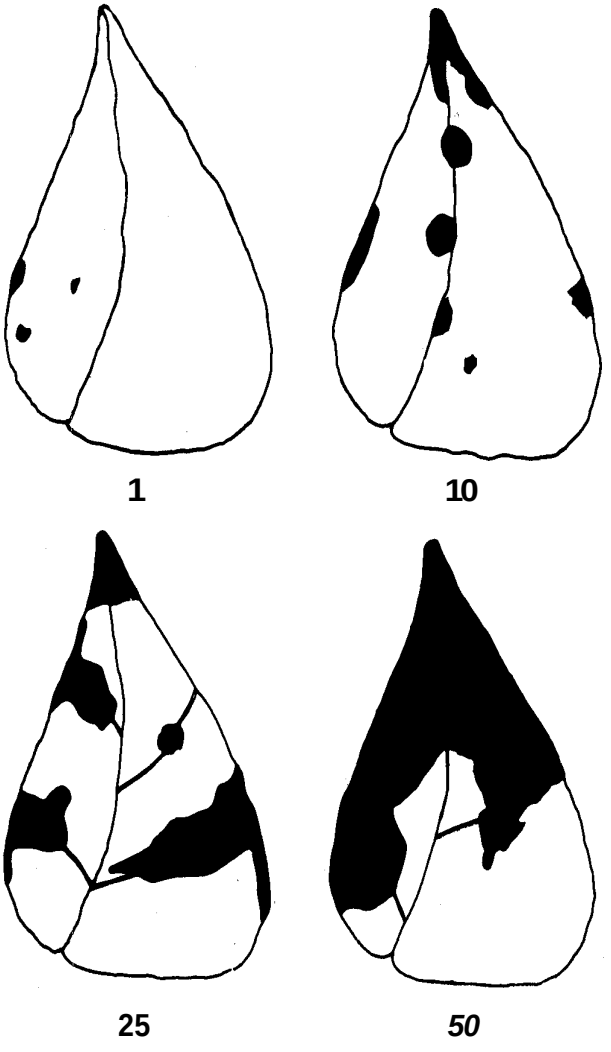
Assess percentage surface area covered by scab on samples of tubers.

References:

18, 22

COMMON BACTERIAL BLIGHT OF BEANS (Leaf symptoms)

Key No. 3.3.1



PERCENTAGE LEAF 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).
5 Use the key to estimate the percentage leaf area affected.

Later stages (infection widespread)

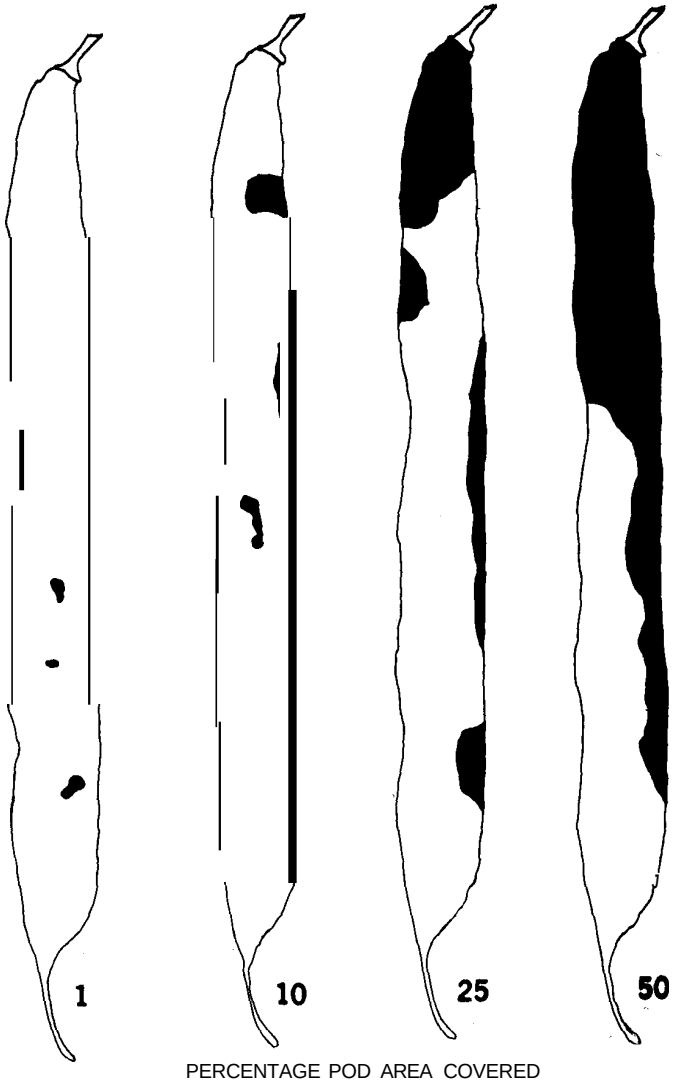
1 Select 10 random samples along a diagonal, each sample constituting two adjacent rows with 25 plants in each row (total of 50).
2 Use the key to assess percentage leaf area affected and calculate average for the 10 samples.

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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