Distribution and severity of root and leaf diseases and cereal leaf beetle damage of barley in western Ontario

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Barley fields in western Ontario were surveyed for incidence of root rot and foliage pests from 1972 to 1975. Estimates of the effect of common root rot caused by ***Cochliobolus sativus*** on barley yields using discoloration of the subcrown internode as a measure of the amount of disease indicated that 4.3 and 0.8% of the crop was lost in 1972 and 1974, respectively. In 1973, an 8.3% increase in yield occurred in plants discolored by root rot. Because of the wide variation in yields and lack of adequate subcrown internodes it would appear that this method of determining root rot damage to barley may not be usable in Ontario. An early season survey in 1975 showed that pathogenic ***Pythium*** spp. were present in soils but there was no definite evidence of root rot damage from these species. Spot blotch *(C.* ***sativus)*** was the most severe and prevalent foliage disease of barley from 1973 to 1975. Scald ***(Rhynchosporium secalis),*** leaf rust ***(Puccinii horde,)*** and powdery mildew ***(Erysiphe graminis)*** occurred irregularly in trace amounts. Damage to the foliage caused by the cereal leaf beetle ***(Oulema melanopus)*** was minor and decreased each year of the foliage survey.

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De 1972 a 1975, des champs d'orge de l'ouest de l'Ontario ont ete examines sur la frequence d'apparition des maladies des racines et des feuilles. Les pertes de recolte dues au pietin cause par ***Cochliobolus sativus*** et mesurees d'apres la decoloration de l'entre-noeud situe sous la couronne sont estimees a 4.2 et 0.8% pour les campagnes de 1972 et 1974, respectivement. En 1973, on a note un accroissement de 8.3% chez les plantes decolorees par le pietin ce qui tient au fait que malgre la presence de souches pathogenes de ***Pythium*** spp. dans le sol au printemps 1975, elles n'ont pas provoque de symptômes convaincants de pietin. De 1973 a 1975, c'est l'helminthosporiose *(C.* ***sativus)*** qui a ete la maladie foliaire la plus répandue et la plus grave de l'orge, la tache pâle ***(Rhynchosporium secalis),*** la rouille des feuilles ***(Puccinia hordei)*** et le blanc ***(Erysiphe graminis)*** se manifestant de façon isolée et sans aucune gravite. Les dégâts occasionnes au feuillage par le criocère des cereales ***(Oulema melanopus)*** ont ete benins et ont diminué au cours de chacune des annees de la periode d'observation.

Root rot of cereals caused by the fungus ***Cochliobolus sativus*** (Ito and Kurib.) Drechsl. ex Dastur, conidial state ***Bipolaris sorokiniana*** (Sacc. in Sorok.) Shoem., Syn ***Helminthosporium sativum*** Pamm., King. and Bakke has been investigated for many years in Canada. Recent surveys in western Canada have estimated that 5.7% or 30 million bushels of wheat (4) and 10.3% or 54 million bushels of barley ***(8)*** are lost annually in that area because of root rot. These surveys employed discoloration of the subcrown internode as a measure of the root rot present.

Barley grown in pure and in mixed stands with oats is an important crop in Ontario and no surveys to estimate root rot or foliage damage have been made. For this reason, root rot surveys were carried out in western Ontario for 4 years starting in 1972. In 1973-75, surveys were conducted to determine the prevalence and severity of damage to barley foliage caused by diseases and by the cereal leaf beetle. The following report summarizes the data obtained over these 4 years.

Methods

Approximately 60% of Ontario's barley crop (0.3 **M** ha) is grown in 10 counties in western Ontario (Fig. 1) as pure and mixed stands with oats and almost 50% is concentrated in five counties [Huron, Perth, Wellington, Bruce and Grey (6)] within the larger area. In 1972 and 1973 the surveys covered the 10 counties but were restricted to the five main counties in 1974 and 1975. One field was sampled for approximately every 10,000 ha of barley grown per county (6) with 5 being done for the counties producing the most barley and fewer for those producing less barley. Townships within counties were chosen at random and one field was sampled per township. The root rot discoloration method requires barley plants that are reasonably ripe (mealy ripe) at the time of sampling. In 1972 only one survey was made in a selected field with the crop at the correct stage of growth. In subsequent years an effort was made to do the foliage disease survey and the root rot survey on the same fields. In a few cases this was not possible because of maturity problems and the root rot samples had to be obtained from the most suitable nearby field. Root rot sampling procedures in the field and assessment of plants in the laboratory were similar to those described by Ledingham ***et al.*** (4) with the exception that all sampling was done on a diagonal line rather than in quadrats and the effect on barley yield was calculated for the surveyed area rather than for individual fields. The formula for determining the effect of root rot on yield was applied as follows:

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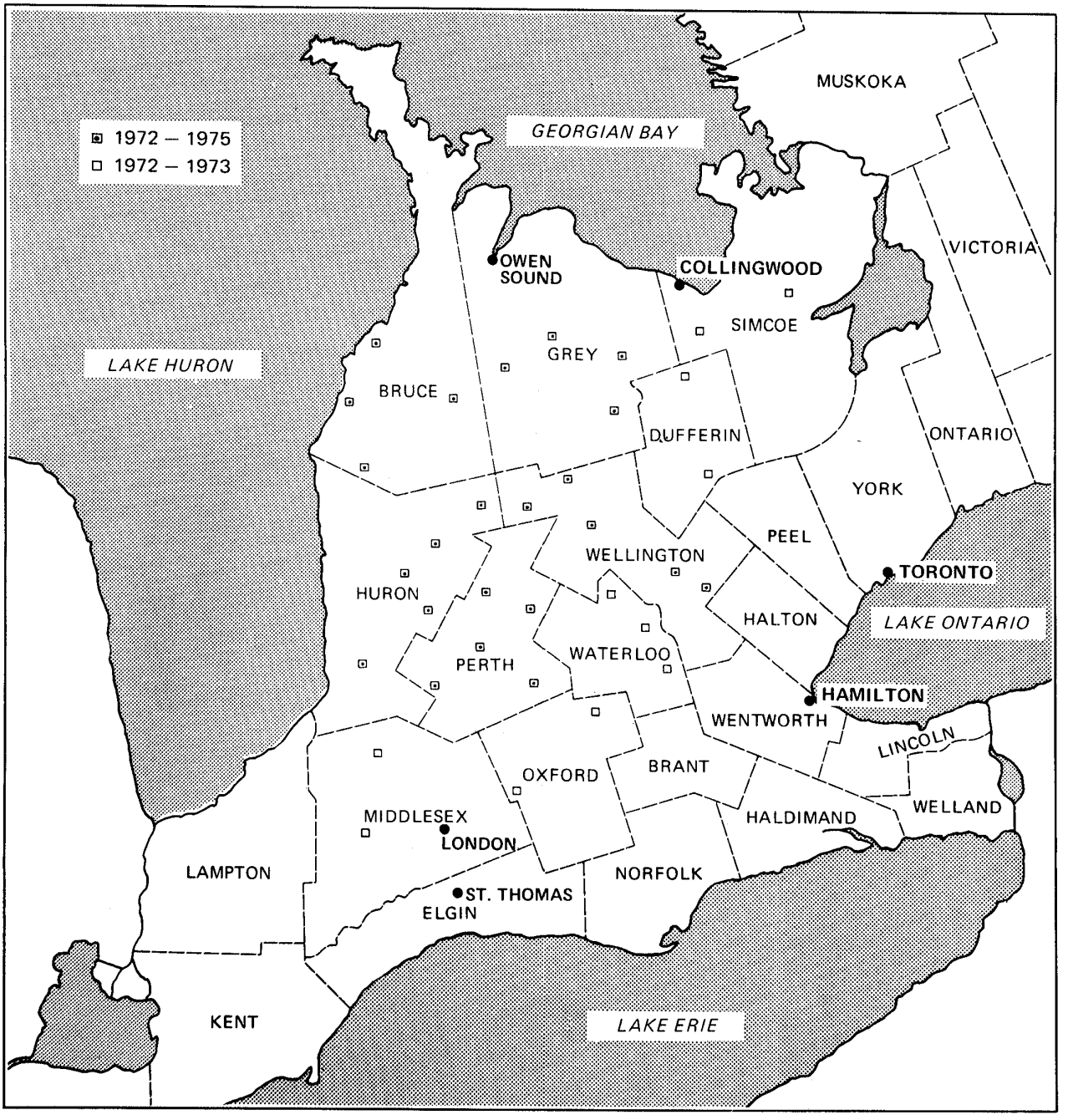

Figure 1. Approximate location of barley fields in western Ontario sampled for root rot and foliage pests from 1972-1975.

$$\text{Effect of yield in \%} = 100 - \left(\frac{\Sigma W}{\Sigma W_1 \times N} \times 100\right)$$

where W is the total weight of grain of all plants rated; W_1, the average weight of grain per plant of all clean plants rated; and N, the total number of plants rated.

In 1975, fields were surveyed in mid-June at the 3-5 leaf growth stage (3) for the presence of disease symptoms that might be caused *Pythium* spp. Sampling was done on a diagonal path starting 25 paces from the edge of each field and an examination of plants was made at 5-pace intervals for 25 times using the plants at the toe of the right foot in each case. Some root

Table 1. The effect of root rot on the yield of barley and barley-oat mixtures grown in western Ontario during 1972 to 1974 using discoloration of the subcrown internode to rate root rot severity

Year	No. of Counties	No. of Fields	No. of Plants examined	% unclassified subcrowns	Yield % Loss	Yield % increase
1972	10	31	5139	45.6	4.3	
1973	10	34	6263	36.7		8.3
1974	5	25	5166	61.8	0.8	

Table 2. The effect of root rot severity on number of heads and yield per plant (g) of barley in the subcrown internode disease categories employed in a survey in western Ontario 1972 to 1974.

	Clean		Slight		Moderate		Severe		Unclassified [1]	
Year	heads	yield	heads	yield	heads	yield	heads	yield	heads	yield
1972	2.5	1.9	2.2	1.7	2.2	1.8	2.3	1.5	2.4	1.8
1973	2.7	1.8	2.7	2.1	2.7	2.3	2.8	2.4	2.4	2.1
1974	2.6	1.7	2.6	1.7	2.6	1.7	2.5	1.5	2.4	1.4
Mean	2.6	1.8	2.5	1.9	2.5	1.9	2.5	1.8	2.4	1.8

[1]Subcrown internode too short to classify.

samples from diseased plants were plated on agar (1) in the field while some yellowed plants and soil were transplated to flats and plated later in the laboratory. A composite soil sample from each field was assessed in the laboratory for the presence of ***Pythium*** spp. by a bait-plant technique (1).

The foliage disease and cereal leaf beetle surveys were carried out on barley plants from fields that ranged from approximately late-flowering to the milky-ripe stages of growth on the Feekes' scale (3). The fields were sampled as described for the 1975 Pythium survey with one main tiller collected at each 5-pace stop. The top 3 leaves of the 25 tillers per field were examined and the percent leaf area covered by diseases was recorded using the septoria leaf blotch disease key (2) as a guide for estimating the amount of infection.

Results and discussion

Common root rot

The subcrown internode technique was unsuitable for determining damage caused by common root rot in Ontario because the results ranged from a 4.3% yield loss in 1972 to an 8.3% yield increase in 1973 (Table 1). The individual variation in effect of root rot on yield as determined by the yield loss formulae from field to field each year ranged from approximately a 30% decrease to a 30% increase. The yearly figure for effect of root rot on yield had to be determined on bulked samples from all fields because a number of fields each year had no plants in the clean category. The number of plants that had no subcrown internode or one too short to classify was extremely high each year ranging from 37% in 1973 to 62% in 1974 (Table 1). Much of the success of the subcrown internode method for rating root rot depends on the presence of a high percentage of plants from each field having internodes that can be rated. Deep seeding, which is necessary in western Canada, results in the development of long subcrown internodes.

The damage by root rot on the barley plants that could be classified was minimal (Table 2). Only in 1972 was there any measurable decrease in the number of heads and yield per plant due to root rot. In 1973 there was a sizable increase in yield per plant in the diseased categories and those rated as severely diseased had the greatest yield increase. Furthermore, in that year, 63% of the plants had classifiable subcrown internodes so most samples were of a reasonable size. Every year several surveyed fields had no plants with subcrown internodes long enough to classify, probably as a result of shallow seeding.

The above results indicate, that in Ontario, there is a wide variation between barley fields with respect to development of subcrown internodes and response to root rot as determined by the discoloration of internodes. Recent surveys of wheat (4) and barley (8) have been

Table 3. Kinds and frequency of isolation of ***Pythium*** spp. from plant and soil samples collected in western Ontario in 1975 using both barley and oats as host receptors (1)

Barley		Oats	
P. arrhenomanes	(7) [1]	*P. aristosporurn*	(5)
P. aristosporum	(7)	*P. volutum*	(2)
P. tardicrescens	(1)	*P. arrhenomanes*	(1)
Pythium spp.	(3)	*P. irregulare*	(1)
		P. torulosum	(1)
		P. tardicrescens	(1)
		Pythium spp.	(2)

[1]Comparative frequency of isolation.

done in western Canada using the same method for rating root rot and a similar wide variation was present in the results from Manitoba, especially with barley. There, the calculated effects on yield based on an average 2-3 fields per crop district also ranged from a 35% decrease to a 26% increase (8). However, their results were determined on individual field samples whereas the Ontario samples had to be bulked, as noted previously. Because of the wide variation in yields within and between surveys, the reliability of the root rot data and the use of the subcrown internode method for rating disease in barley in Ontario and probably Manitoba is questionable. Furthermore, it is quite possible that the principal fungus causing root rot of barley in Ontario may be different to that causing it in Saskatchewan and Alberta.

A sizeable portion of the barley crop in Ontario is grown as mixtures with oats and in a few cases a small percentage of wheat also is included. Only two mixed fields were surveyed in 1972 but 20 and 35% of the fields surveyed in 1973 and 1974 contained mixtures. The estimated effects of root rot on yield of barley from these fields were yield increases of 15.1 and 3.8% respectively, indicating that root rot behaviour in mixed stands of grain may differ from that in pure stands of barley. This may be an added complicating factor in the use of the subcrown internode method for determining root rot damage and yield loss of barley in Ontario.

Pythium root rot

In 1975, twenty-four fields were surveyed for Pythium root rot and particular attention was paid to symptoms such as yellowing and stunting. Yellowing of leaves was observed in 11 fields, principally in trace amounts on the bottom leaf. However, it was general on all leaves in 3 late-seeded fields where the plants were in the 3rd leaf stage when surveyed. Transplants of these yellowed plants did not produce ***Phythium*** spp. It was concluded that the symptoms produced in these 3 fields were caused by a corn herbicide applied to the fields the previous year. ***Pythium*** spp. were isolated from plant and root material obtained from 5 of the remaining 8 fields having plants with yellow leaf symptoms. These plants were found mostly in a few low areas in the fields; in one case the crop was growing next to a swamp with an obviously high water table.

The leaf yellowing was at times associated with dark brown spotting of the leaves and dark brown lesioning of the crown areas of the barley plants. These symptoms were largely due to ***C. sativus.*** Plants with such symptoms were collected from 8 fields and 5 of them were infected with the above fungus when samples were placed in a humidity chamber. In general, it was concluded that Pythium-like symptoms were not prevalent in the field and where they were present they were associated with high moisture levels.

The soil sample collected from each of the above fields was assayed for pathogens using both barley and oat test plants (1). A number of ***Pythium*** spp. were isolated from 14 of the samples and P. ***aristosporum*** Vanterpool and ***P. arrhenomanes*** Drechsler occurred most frequently (Table 3). Obviously ***Pythium*** spp. are plentiful in the soil in these fields and possibly could have caused damage during extended periods of excessive moisture in poorly drained soil. McKeen (5) has suggested that Pythium root rot damage may be of major importance in barley in southwestern Ontario. Our results do not support this suggestion. However, additional surveys are needed, especially during a wet season, to determine whether ***Pythium*** root rot is an important disease of barley in this area.

Foliage diseases

The foliage disease surveys of barley were done on the same fields as the root rot surveys wherever possible. Spot blotch caused by ***C. sativus*** was consistently the most prevalent disease occurring in all fields sampled each year (Table 4). There were wide annual variations in severity with 26.2, 2.8 and 5.6% of leaf area infected from 1973 to 1975 respectively. There was also a wide variation in severity from field to field (Table 5) partly influenced by the age of the plants and partly by environmental conditions. Spot blotch developed very quickly toward maturity when wet weather prevailed (Table 5) and fields with slightly older plants had considerably more disease present as recorded in 1973. Variable weather also affected the severity of disease development as frequent heavy rainstorms occurred

Table 4. The number of fields with infected plants and % severity of damage to foliage of barley caused by diseases and insects in western Ontario 1973-75 [1]

Diseases	1973 No. of Fields	1973 % severity	1974 No. of Fields	1974 % severity	1975 No. of Fields	1975 % severity
Spot blotch (*Cochliobolus sativus*)	34	26.2	25	2.8	25	5.6
Scald (*Rhynchosporium secalis*)	6	Tr	11	2.3	7	Tr
Septoria (*Septoria passerinii*)	2	Tr	5	Tr	7	Tr
Leaf rust (*Puccinia horde,*)	15	1.3	7	Tr		
Mildew (*Erysiphe graminis*)	4	Tr				
Leaf Beetle (*Oulema melanopus*)	34	2.1	20	1.4	10	Tr

[1]Number of fields surveyed 1973 - 34, 1974 - 25, and 1975 - 25

Table 5. The range and average spot blotch (C. *sativus*) infection in percent between individual fields and age of barley surveyed in western Ontario 1973-75

Year	No. of Fields	Range of infection%	Average infection%	Host maturity[1]
1973	34	2.1 - 68.8	26.2	11.0
1974	25	0.3 - 11.1	2.8	10.8
1975	25	0.2 - 23.7	5.6	10.9

[1]'Feekes' host maturity scale (3).

throughout the survey area during July each year. Their occurrence was quite intermittent and very localized resulting in wide differences in the duration of leaf wetness which caused wide differences in spot blotch severity regardless of age or host.

Plant samples having dark brown crowns and lower leaf tissues were collected occasionally during the foliage surveys. Subsequent isolation and sporulation tests on agar showed that the spot blotch fungus was present on most tissues indicating an abundance of secondary inoculum.

Pure and mixed barley and oat stands and different barley cultivars also appeared to affect the severity of spot blotch (Table 6). The reduced development of spot blotch in barley grown in mixed stands with oats is possibly one reason why much of the barley in western Ontario is grown in mixed stands. Mixed barley and oats outyielded 'both pure barley and pure oats in western Ontario each year over the five year period 1971-75 by an average 13% and 10%, respectively (7).

Other leaf diseases were observed only in trace amounts. In 1973, leaf rust (*Puccinia horde;* Otth) was widespread while in 1974 scald [*Rhynchosporium secalis*, (Oud.) Davis] was found in half of the fields surveyed (Table 4). The minor diseases occurred regionally to some extent with scald and septoria (*S. passerinii* Sacc.) being found in cooler areas close to Lake Huron and in the northern counties of Bruce and Grey. Leaf rust was found more frequently in southern fields which accounted for its apparent prevalence in 1973 as more southern fields were sampled that year. Powdery mildew (*Erysiphe graminis* DC ex Merat.) was restricted to a

Table 6. The range and average spot blotch (C. ***sativus***) infection in percent in fields of mixed barley and oats and of 3 cultivars of pure barley in western Ontario in 1975

Cultivar	No. of Fields	Range of infection %	Average infection %
Herta (mixed)	11	1.1 - 11.0	4.5
Herta (pure)	6	6.2 - 23.7	11.3
Conquest (pure)	4	0.2 - 1.3	0.7
Trent (pure)	2	1.2 - 11.5	6.3

small area in eastern Wellington county around Guelph. Damage by the cereal leaf beetle (***Oulema melanopus*** L.) was widespread each year but it never occurred in more than trace amounts and the damage decreased in prevalence each year of the survey (Table 4).

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