Oat yield losses from septoria leaf blotch at four locations in eastern Canada[1]

R. V. Clark[2], C. O. Gourley[3], H. W. Johnston[4], L. J. Piening[5], G. Pelletier[6], J. Santerre[6], and H. Genereux[6]

In a 3-year field plot experiment, natural infection of oats, *Avena sativa,* by *Leptosphaeria avenaria* f. sp. *avenaria* was most severe at Charlottetown, P.E.I., followed by La Pocatiere, Que., Kentville, N. S., and Ottawa, Ont. At Charlottetown in 1970 a 50% increase in seed yield was obtained when plants were protected regularly with foliar applications of maneb, and the average increase for the 3 years, 1970-72 was 15%; at La Pocatiere the largest increase in yield of maneb treated plants amounted to 13% with an average increase of 7% for 3 years. At Kentville and Ottawa septoria infection was light and fungicide sprays had little effect on yields over the 3 years. Although increases in yield were substantial at Charlottetown and La Pocatiere. no consistent signficant improvement was found at either location over the 3-year period. This probably was due to changes in the environment from year to year, affecting disease prevalence and severity, cultivar response, and disease control. Spraying regularly with maneb increased kernel weight and percent protein and decreased percent hull of the seed at Charlottetown, indicating additional losses due to this disease.

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Dans une experience de 3 ans en parcelles, l'infection naturelle de l'avoine *(Avena sativa)* par *Leptosphaeria avenaria* f. sp. *avenaria* a ete la plus virulente a Charlottetown (île-du-Prince-Edouard), suivie dans l'ordre par La Pocatiere (Quebec); Kentville (Nouvelle-Ecosse) et Ottawa (Ont.). A Charlottetown en 1970, on a obtenu une hausse du rendement en grain de 50% lorsque les plants ont ete regulierernent proteges au moyen d'applications foliaires de manebe, et la hausse rnoyenne des 3 annees (1970 a 1972) a ete de 15%; a La Pocatiere, la plus forte hausse de rendement des plants traites au manebe a atteint 13%. et la hausse moyenne des 3 ans a ete de 7%. A Kentville et a Ottawa, l'infection par la septoriose a ete faible et les pluvérisations de fongicides ont eu peu d'effet sur les rendements au cours des 3 annees. Même si les augmentations de rendement ont ete substantielles a Charlottetown et a La Pocatiere, on n'a constaté aucune hausse constante significative a aucun des deux endroits durant la periode de 3 ans. Ce phenomene est probablement attribuable a des modifications du milieu d'annee en année, qui ont influé sur la frequence et la gravite de la maladie, la reaction des cultivars et la lutte contre les maladies. A Charlottetown, les pulverisations regulieres au manebe ont accru le poids des grains et leur teneur en proteines, et diminué le pourcentage de balle, ce qui prouve par consequent que les pertes attribuables a cette maladie ont été considerables.

Septoria leaf blotch incited by *Leptosphaeria avenaria* Weber f. sp. *avenaria* (imperfect state *Septoria avenae* Frank f. sp. *avenae)* is a prevalent and serious disease of oats *(Avena sativa* L.) in eastern Canada. The causal fungus attacks leaves, stems, and seed; infection is initiated in the early summer, primarily by ascopores that develop on overwintered straw and stubble. As the disease progresses, pycnidia develop in infected leaves and sheaths and pycnidiospores provide the inoculum for the secondary spread of the disease. By maturity most of the aboveground parts of host plants are diseased and in some instances considerable stem break and lodging occur (1).

In earlier studies at Ottawa (2) it was found that yield increases of up to 20% could be obtained by applying fungicides such as maneb to the oat foliage a number of times during the summer. A number of new oat cultivars have been introduced since then and as the septoria disease is prevalent throughout eastern Canada it is important to establish the yearly progress of the disease and to determine crop losses at several locations. This paper reports the results of a 3-year cooperative study initiated in 1970 with tests located at Ottawa, Ont.; La Pocatiere, Que.; Kentville, N.S.; and Charlottetown, P.E.I. In 1971 and 1972 the test was carried out also at Lacombe, Alta., a location usually free from the septoria disease.

Materials and methods

Uniform methods of field plot layout and maintenance, disease assessment, and yield determination were employed. A randomized block design of four replicates and three or four fungicide regimes and at least three cultivars (Dorval, Garry, and Russell) were used. Oat seed of good size and condition was obtained at each location and planted with a mechanical plot seeder at the rate of 76 kg/ha (2 bu/ac) as close as possible to the recommended seeding date. Row lengths of 3 m (10 ft) with 10 rows per plot or 3.6 m (12 ft) with 8 rows per

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[2-6] *Research Station, Agriculture Canada, bttawa, Ont., [2]Kentville. N.S., [3]kharlottetown, P.E.I., [4]Lacombe, Alta., [6]Ste-Foy and La Pocatiere, Que.*

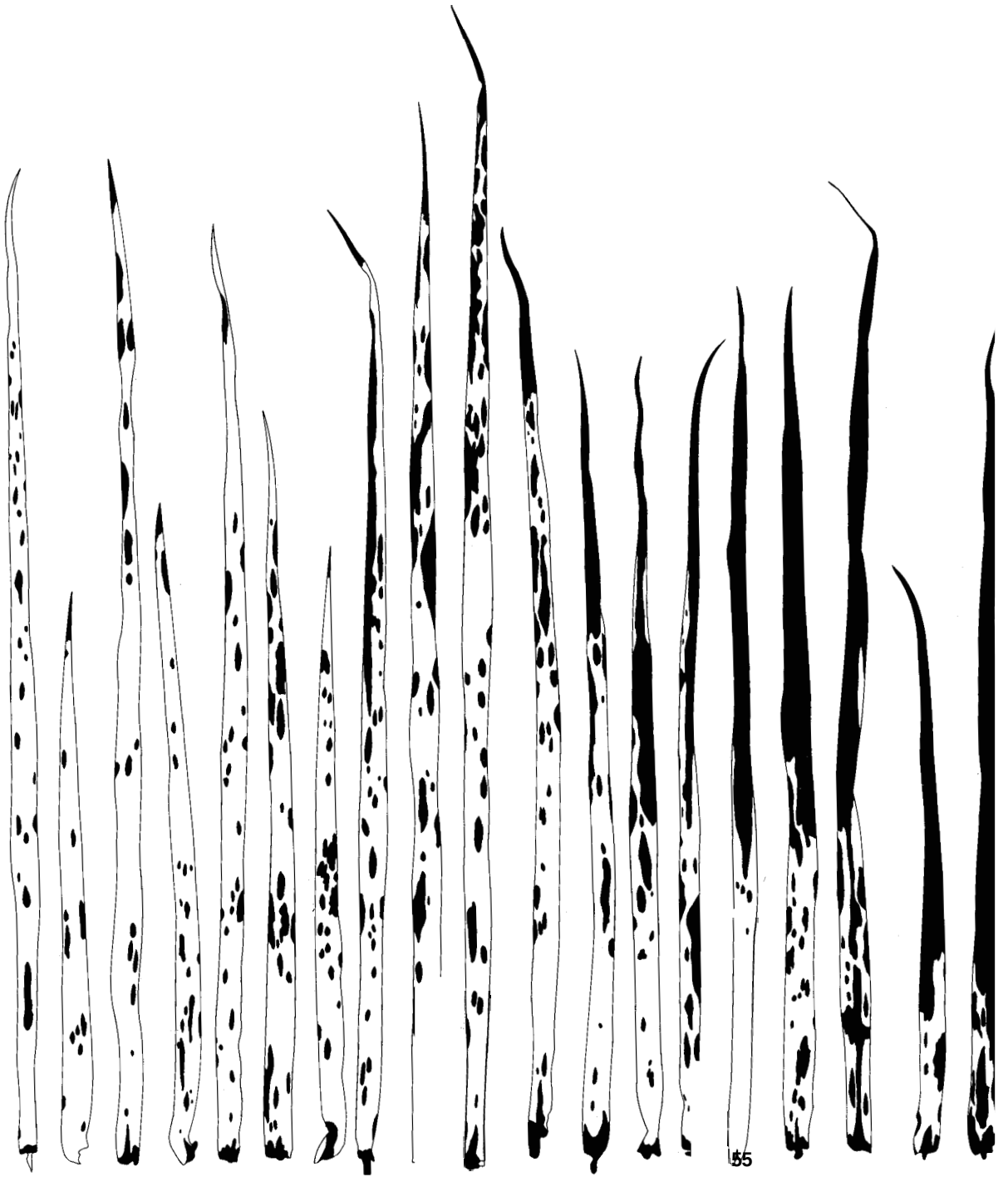

Figure 1. Disease assessment key for the septoria leaf blotch of oats. The percentage involved on each leaf was determined by A) the scatter point method and B) the drum scanner technique.

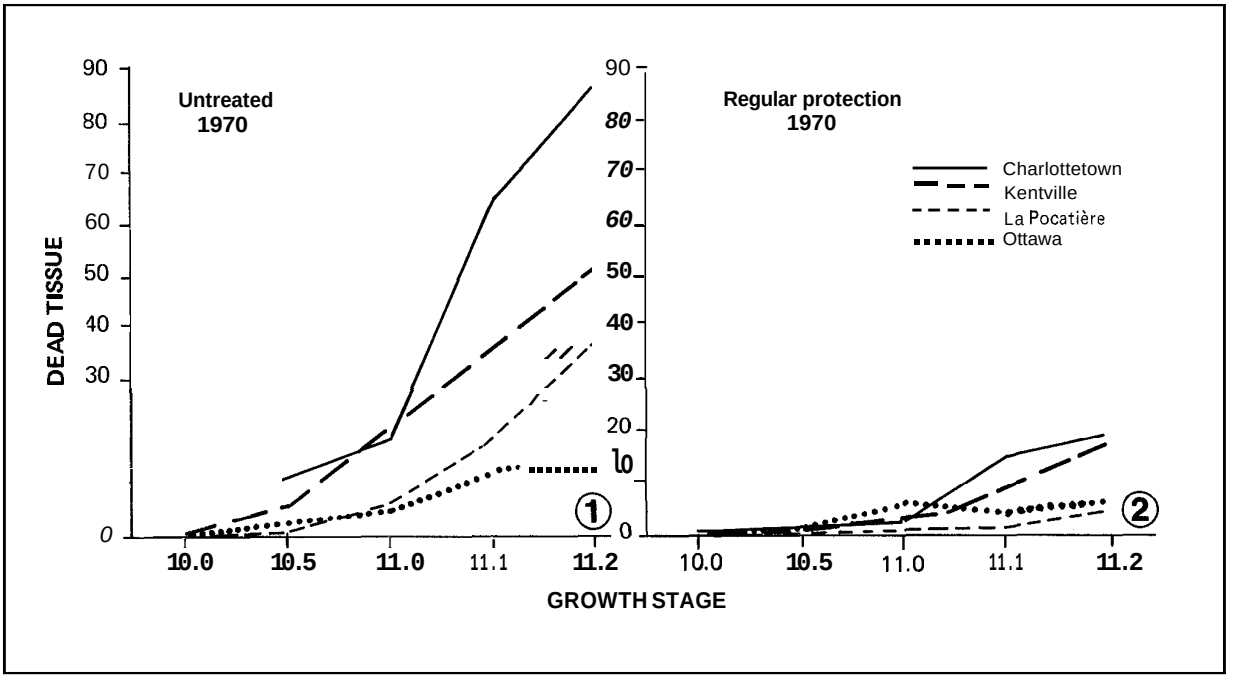

Figure 2. Oat septoria progress curves for Charlottetown, Kentville, La Pocatière, and Ottawa for the years 1970-72. 1-21 Curves for the four locations for 1970 on the untreated and regular spray applications, with disease severity based on 2 – 4 leaves per plant.

plot were used depending on location. At maturity 18.2 m (60 ft) of row per plot were harvested for yield determinations leaving the two outside rows and ends as border material. Four buffer rows of barley were planted between each oat plot to allow for spray drift and to reduce disease spread and interplot interference. Recommended fertilizer applications for each area and weed control (MCPA) practices were followed at all locations. When necessary, plots were sprayed for aphid control with endosulfan.

Manzate D (80% maneb, Du Pont of Canada, Toronto) at concentrations of 3.3 kg/ha the first year and 6.7 kg/ha the second and third year was applied to the oat foliage starting at the late tillering stage. Sprays were applied with knapsack type sprayers until runoff and care was taken to avoid drift and to obtain maximum coverage. If a heavy rain washed the fungicide off a few hours after the original application, then a second spray was applied. The following regimes were employed applying sprays every 10 days: 1) untreated, no protection; 2) regular protection, with applications from late tillering until maturity; 3) early protection, with applications from late tillering until midheading stage; 4) late protection, with applications from midheading stage until maturity.

Septoria leaf blotch severity was assessed by estimating the percentage of leaf area affected, using an infection key prepared by the senior author (Fig. 1). The leaf area diagrams were based on a range of leaf sizes and infection percentages of naturally infected oat leaves. The percent infection on the individual leaves in the key was established by both a scatter point method and an IBM drum scanner technique (4). With the scatter point method the amount of surface area representing disease was determined by overlaying leaves in the key with scatter point paper (Bruning Areagraph Chart No. 4850), and the number of dots in both the diseased and healthy areas were counted and then used to calculate the percentage of healthy and diseased areas involved. This procedure was repeated a number of times and the results were averaged.

Beginning at early heading stage, disease assessments were made on 10 main tillers selected at random from the rows within each plot. The tillers were removed carefully so that those remaining on each plant were left to mature. Early in the growing season, when septoria symptoms were scarce, only one or two replicates were assessed and tillers where chosen from the border rows. Disease was recorded in 1970 as the percent damage per plant based on 2-4 leaves and in the following 2 years as the percent damage per leaf using the 2 top leaves. Other diseases present were also noted. At times it was difficult to differentiate the cause of specific necrotic leaf areas because of the presence of a number

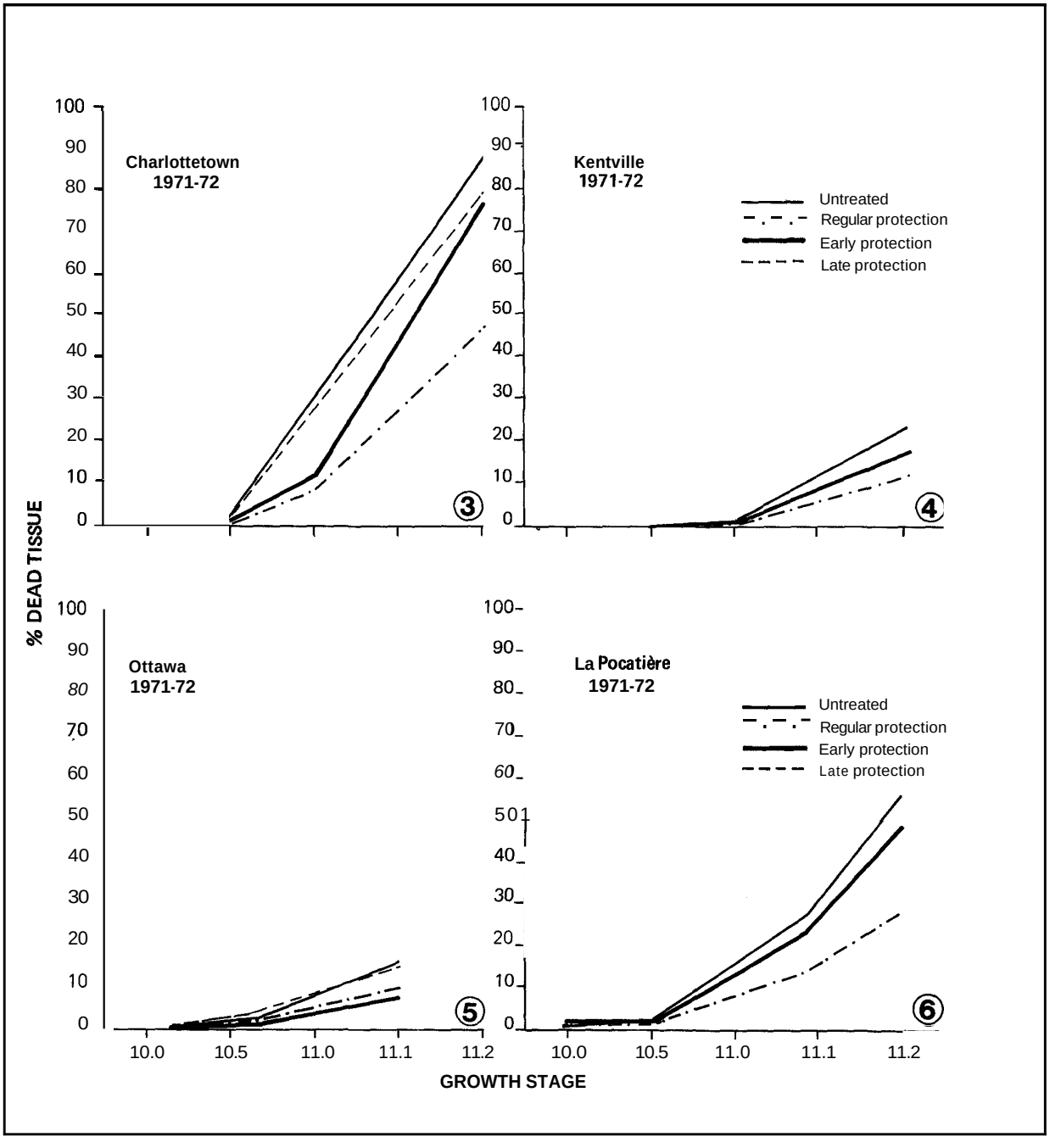

Figure 2. (continued). 3-6) Curves for the same treatments for 1971-72 at the four locations, with disease severity based on the flag and second leaves.

of diseases. However, since by far the majority of the dead tissue resulted from infection by Septoria, assessments were done on the basis of the total chlorotio and necrotic areas present. In the last assessment each year (mealy ripe stage) the amount of septoria black stem infection was recorded. Each time a disease assessment was made the average growth stage of each cultivar was recorded according to the Feekes scale (6). Grain yields

and 1000-kernel weights were obtained at all locations, and percent hull, bushel weight, and percent protein at Charlottetown. The protein content of the seed was measured by determining grain N content using an automated kjeldahl digest method and then multiplying by a factor of 6.25 (3, 5). The various data were subjected to individual and, in some cases, combined analyses of variance.

Results

Disease data

Septoria leaf blotch was the principal disease each year at the four locations in eastern Canada. Other diseases developed in lesser amounts; these included barley yellow dwarf, drechslera leaf blotch [*Drechslera avenacea* (Curt. ex Cke.) Shoem.], and crown rust [*Puccinia coronata* Cda. f. sp. *avenae* Erikss. & Henn.]. Barley) yellow dwarf occurred sporadically at all four locations most years, usually only on plants at the edge of the plots. The use of endosulfan to control aphids once barley yellow dwarf symptoms were noted did not always stop the development of the disease as it was prevalent at both Charlottetown and La Pocatiere in 1971. Drechslera leaf blotch occurred in trace amounts at the four locations, but because symptoms are very similar to those of septoria the two diseases were difficult to separate. Crown rust occurred regularly at Ottawa, mostly in trace amounts, and rarely at the other locations.

The scatter point technique of determining leaf surface area on the key generally overestimated the amount of the infected area on most leaves when compared with the electronic drum scanner method (Fig. 1). The overestimate amounted to 3 or 4% on most leaves but did go as high as 7%. The greatest differences between the two techniques occurred on leaves with numerous small lesions and these no doubt could be more accurately measured by the scanner. However, both techniques are probably within the accuracy limits of visual estimates. This key is superior to others (4) in that it contains various sized leaves showing a range of typical septoria lesions.

In 1970, disease ratings were done on a per plant basis (Fig. 2, 1-2) and, by maturity, septoria was most severe at Charlottetown and lightest at Ottawa with intermediate levels at the other locations. At Charlottetown that year regular applications of maneb every 10 days reduced average leaf area affected per plant to 20% from 90% in the untreated plots. In 1971 and 1972 assessments were based on the average leaf area affected on the top (flag) and second leaves. In both years the severity of septoria was lower at Kentville. Maneb applications were less effective in controlling septoria at Charlottetown and La Pocatiere, resulting in smaller differences at maturity between the untreated and regular application curves (Fig. 2, 3-6). These variations may have resulted from the change in the way disease assessments were made or from the influence of seasonal changes in local environments and disease syndromes.

Table 1. Septoria development on stems of oats treated with maneb sprays for 2 years at Charlottetown and Kentville (1971-72) and 1 year at La Pocatière (1971) and Ottawa (1972)

Location	Fungicide application*			
	Untreated	Regular	Early	Late
Charlottetown	8.4 †	2.0	2.5	5.8
Kentville	39.6	21.6	22.8	
La Pocatiere	51.3	6.1	11.4	
Ottawa	1.8	1.5	1.5	1.5

* Maneb application regimes regular, every 10 days from late tillering to maturity; early, every 10 days from late tillering to mid-heading; late, every 10 days from mid-heading to maturity.

† Average infection per stem in centimeters.

An effort was made to utilize the septoria assessment data recorded for the various growth stages and treatment regimes for 1971 and 1972 to extrapolate yield losses for a particular disease severity. Unfortunately the data were not suitable for processing so this could not be done. However, the progress curves (Fig. 2, 3-6) show that septoria develops very little until the flowering stage (10.5) but from then on increases uniformly until the crop is ripe. The regular application of maneb every 10 days reduced septoria severity by approximately 50% at all locations. At maturity early and late applications of maneb showed little effect in reducing the disease.

Infection of oat stems in the latter part of the growing season is often an important feature of the septoria disease. In these studies, black stem development varied among locations (Table 1) and from year to year. Black stem severity and leaf blotch severity did not necessarily follow the same order, especially at Charlottetown. The regular and early spray applications of maneb reduced the amount of black stem but did not eliminate it.

Yield data

Seed yields at the five locations varied considerably from year to year (Table 2). Significant increases in yield were obtained with plants receiving regular maneb applications compared with plants receiving no treatment in 2 of 3 years at Charlottetown and La Pocatiere; however, there was no yield response from maneb at Kentville and Ottawa. At Lacombe in 1971 a significant difference in yield occurred as the regular maneb applications gave an increased yield over the controls while the early applica-

Table 2. Individual and combined seed yields (g) of oats treated with maneb sprays at five locations for 3 years

Location	Fungicide application †	1970 Yield (g)	1970 % of untreated	1971 Yield (g)	1971 % of untreated	1972 Yield (g)	1972 % of untreated	1970-72 Yield (g)	1970-72 % of untreated
Charlottetown	Untreated	889		1108		1441		1146	
	Regular	1273**	149	1216**	110	1480	103	1323	115
	Early	1105**	124	1253**	113	1525*	106	1294	113
	Late			1258**	113	1455	101		
Kentville	Untreated	1560		1365		1606		1510	
	Regular	1585	102	1393	102	1662	103	1547	102
	Early	1578	101	1367	100	1618	101	1521	101
	Late					1585	98		
La Pocatière	Untreated	1244		1242		1365		1284	
	Regular	1326**	107	1233	99	1550**	113	1370	107
	Early	1303**	105	1228	98	1479	108	1337	104
	Late					1550**	113		
Ottawa	Untreated	1100		208		858		1055	
	Regular	1095	99	271	105	830	97	1065	101
	Early	1030	94	233	102	827	96	1030	98
	Late			306	108	862	100		
Lacombe	Untreated			727		1130		929	
	Regular			755**	104	1150	102	953	102
	Early			702	96	1133	100	917	99
	Late					1140	101		

* Significant at P = 0.05.

** Significant at P = 0.01.

† See text for schedule.

tions resulted in a reduced yield. Injury from hail storms occurred that year and this may have had a differential effect. A combined analysis of yearly data for each location indicated that yield differences were significant for years but not for maneb applications. Treatment × variety interactions were not significant but a number of the interactions with years were significant, especially at Charlottetown. At Charlottetown and La Pocatiere, on occasion, early and late applications of maneb increased yields considerably.

Yields of individual cultivars varied considerably among locations and years. Significant differences in cultivar yields were obtained with 8 of 14 location-years when individually analyzed but no significance was found when the yearly data were combined for each location. The three cultivars differed in their response to the maneb applications, with the yield of Dorval being increased by an overall average of only 2% while Garry and Russell were increased by an average of 7%. Maneb applications did not reduce percent leaf area infection on Dorval but possibly resulted in slightly less black stem on this cultivar. Thus Dorval benefited less than the other cultivars from spraying with maneb, indicating that this cultivar has considerable tolerance to septoria leaf blotch.

Table 3. Thousand kernel weights (g) of seed of three oat cultivars treated at three locations with maneb sprays

Fungicide application	Charlottetown	Kentville	Ottawa	Mean
Untreated	31.0	35.2	29.8	32.0
Regular	32.7	36.3	30.1	33.0
Early	32.1	35.4	29.7	32.4
Late	32.1		29.4	
	N.S.	N.S.	N.S.	

N.S. = No significance.

Table 4. Hull and protein content (%) of seed of four oat cultivars treated at Charlottetown with maneb sprays

Fungicide application	Cultivar								Mean	
	Dorval		Garry		Russell		Cabot			
	Hull	Protein	Hull	Protein	Hull	Protein	Hull	Protein	Hull	Protein
Untreated	25.6	12.1	30.9	14.0	26.2	12.7	27.8	12.2	27.6	12.7
Regular	24.6	12.4	25.9	13.5	23.2	13.5	24.4	13.4	24.5**	13.2
Early	25.0	12.8	26.8	13.9	23.8	13.6	24.9	13.0	25.1**	13.3
Mean	25.1	12.4	27.9	13.8	24.4	13.3	25.7	12.9	25.8	13.1

** Significant at P = 0.01.

Significant increases in kernel weight from applications of maneb occurred each year at Charlottetown but not at the other locations (Table 3). However, treatment differences were not significant in the combined analysis of kernel weights for Charlottetown as cultivar, year, and location differences were sizeable.

Percent hull and percent protein were determined at Charlottetown (Table 4). Percent hull was significantly decreased by applications of maneb; the mean percent protein was slightly increased.

Discussion

Most of the variability in the yearly agronomic data obtained at each location in this study probably was due to changes in environmental conditions over the 3 years which in turn influenced the prevalence and severity of diseases. A 50% increase in yield from regular applications of maneb was obtained in 1970 at Charlottetown, with a 15% average increase over the 3 years. This increase was obtained with partial control of the disease, and the best results occurred in 1970. It is obvious from these tests that septoria leaf blotch can be a very devastating disease at Charlottetown and to a lesser extent at La Pocatiere. However, due to the variability in weather conditions and their effect on plant development, disease prevalence, and fungicide performance, a significant consistent effect was not found. Also some improvement in yield may have resulted from the application of manganese to the plants by use of the maneb fungicide (7). At Lacombe where little or no septoria occurred there was a small but consistent increase in yield from the regular applications of maneb. Manganese deficient soils are common in the Lacombe area so that applications of manganese to the oat foliage could result in increased yields.

No consistent yield increases from applications of maneb were obtained at Kentville and Ottawa. This is a change from previous studies done at Ottawa (2). However, field observations over the last few years in eastern Ontario by the senior author indicate that septoria is not as prevalent or severe at it was 15 years ago.

Data on a number of environmental factors at the four eastern research stations for the months of June, July, and August 1970-72, recorded in the Canadian Weather Review, and Daily Agrometeorological Data, Environment Canada, may explain the differences in septoria development and yield response obtained at Kentville and Ottawa as compared with Charlottetown and La Pocatiere. Average monthly maximum temperatures were high at Kentville and Ottawa, 23.7°C and 24.4°C, respectively, and low at Charlottetown and La Pocatiere, 21.8°C and 21.9°C. Average mean daily temperatures showed the same relationship for the four locations but the comparison was not as good because mean low temperatures differed considerably. High maximum temperatures would shorten the length of time required for the oat crop to reach maturity which is the case at Kentville and Ottawa. The considerably longer period of maturity at La Pocatiere and Charlottetown would favor septoria development, and the disease progress curves show that the major development takes place after the flowering stage. The overall importance of septoria in eastern Canada may be greater than these tests indicate since only partial control was achieved with regular applications of maneb.

Acknowledgments

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Correction

The title of the article by J. Drew Smith and R.P. Knowles, volume 54 number 4, page 108, should read ''Alternaria flower-stalk rot in Bromus inermis"