A SURVEY OF FOLIAR DISEASES OF CULTIVATED STRAWBERRIES IN NOVA SCOTIA[1]

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Abstract

A survey of the foliar diseases on commercial strawberry varieties in Nova Scotia was carried out during 1962, Leaf spot caused by Mycosphaerella fragariae was the most prevalent foliage pathogen. Blotch, Gnomonia fructicola; blight, Dendrophoma obscurans; and scorch, Diplocarpon earliana, although present in most fields are not considered to be economically important pathogens of strawberry foliage in Nova Scotia, Infection suspected to be caused by a species of Gloeosporium was found on strawberry foliage for the first time in this area. The symptom expression of blotch and blight and the sporulating characteristics of D. obscurans do not agree with those already reported.

Introduction

Dominion Bureau of Statistics figures show a trend of increasing strawberry acreage and yield in Nova Scotia (Appendix 1). This increase has been particularly significant in recent years. Expanding marketing outlets for processed and frozen strawberries is expected to further enhance the economic importance of this crop to the agricultural economy of Nova Scotia.

To ascertain the incidence of foliar diseases of strawberries in Nova Scotia a survey was carried out during the summer of 1962, No comparable survey of strawberry diseases had been carried out prior to this time.

Previous Reports of Strawberry Leaf Spot Diseases in Nova Scotia

Leaf spot, caused by Mycosphaerella fragariae (Tul.) Lindau (Ramularia tulansii Sacc,), was first reported in 1925 by J.F. Hockey (6) on both cultivated and wild species throughout the province. Since then it has been reported almost every year with leaf infections up to 100 per cent and estimated reduction in yields from nil to 50 per cent.

Leaf blotch, caused by Gnomonia fructicola (Arnaud) Fall (Zythia fragariae Laibach), was first reported on strawberries in Nova Scotia in 1952 (2). Except in 1953, blotch has been reported each year with infections ranging from trace to 10 per cent on strawberry foliage. Damage to leaves was reported as nil except for 1952 when it was reported as moderate,

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Leaf blight, caused by Dendrophoma obscurans (Ell. & Ev.) H.W, And., was first reported in Nova Scotia in 1053, by C. O. Gourley (4), on most varieties grown. Since that time it has been reported every year and except for 1953 and 1954 when it was heavy and moderate, respectively, only trace infections were present. No reduction in crop yields has been recorded as a result of blight infections on the foliage.

Leaf scorch, caused by Diplocarpon earliana (Ell. & Ev.) Wolf., was reported in Nova Scotia in 1951 by D.W. Creelman (1), From 1954 through 1959 it was reported by C.O. Gourley. Infections varied from trace to 75 per cent.

Materials and Methods

A preliminary study of the organisms on overwintering strawberry leaves was carried out during May 1962 in the Kings Co. area of Nova Scotia. Leaves from all plantings in Kings Co. included in the main survey and leaves from two additional plantings were collected, washed in tap water for about 5 minutes, and placed on a moist paper towel in an 8" x 10" x 4" plastic container with a tight fitting cover. After 6 to 7 days at room temperature the leaves were examined for fungi and rated for the presence of overwintering disease organisms (See footnote, Table 1).

The main survey included 110 fields of 12 different varieties from the four main producing areas in Nova Scotia, namely Kings, Digby, Colchester and the Chester Basin area of Lunenburg Co, This included 43 newly-set fields, 56 first-year fruiting beds, 10 second-year and 1 third-year fruiting bed. A severity rating from absent to severe for each symptom was noted for each field of each variety. Samples were collected from those leaves showing symptoms whose causal agent was not known, These leaves were surface sterilized and portions of the infected areas were planted on PDA and PDA containing a decoction from boiled strawberry leaves, Streptomycin, 50 µg/ml, was added to each medium. In addition sterilized leaves were incubated in sterile moist chambers, The last of these methods was particularly important for the identification of D. earliana which was difficult to culture on the two agar media,

Results and Discussion

Throughout the survey the organisms most consistently isolated from strawberry foliage were M. fragariae, G. fructicola, Dendrophoma obscurans and Diplocarpon earliana, the causal organisms of leaf spot, leaf blotch, leaf blight, and leaf scorch, respectively, In addition, a species of Gloeosporiurri was consistently isolated, Other organisms isolated, which are probably not causal agents of leaf spots, in order of decreasing prevalence, were Botrytis cinerea Pers. ex Fr., Alternaria sp., Septoria sp., Chaetomium sp., Harknessia sp., Penicillium sp., Hormodendrum sp., Fusarium sp., Sordaria sp., Colletotrichum sp., Verticillium sp., and Gliocladium roseum Bainier, Peziza ostracoderma Kerf, Absidia sp., and Rhizopus sp.

The average severity rating of major strawberry leaf pathogens for all varieties on overwintered leaves was 7 for M. fragariae, 5 for G. fructicola and 3 for Dendrophoma obscurans. Diplocarpon earliana was not found on overwintered leaves from commercial plantations but was found on overwintered leaves from seedling plots at the Research Station. Perithecia of M. fragariae were produced in abundance on infected leaves, No perithecia of G. fructicola were found on overwintered leaves, Numerous pycnidia containing spores of Z. fragariae, the imperfect stage of G. fructicola, were present on the overwintered leaves of all varieties except Surecrop. The spores were exuded in a cream to yellowish-brown mass that became darker with age. This is considered the primary source of blotch inoculum. D. obscurans was observed in small amounts on overwintered leaves and was detected by the presence of a cream to brown pycnidial exudate darkening with age. The spores of D. obscurans were never exuded from the pycnidiurn in a horn as noted by Fall (3).

The field survey (Table I) showed that M. fragariae was the most prevalent and destructive foliage pathogen of strawberries in Nova Scotia. Prior to July the incidence of leaf spot caused by this fungus was greater on fruiting beds than on new plantings, probably because of the abundance of overwintering inoculum in the older plantings, The first infections of M. fragariae on new foliage were noted early in June as small red spots on Cavalier and Redcoat, Some difficulty was experienced in isolating the organism from these immature spots. Later in the season new infections often began as small, tan spots. The difference in early symptom expression is suspected to be a reaction to different races of M. fragariae rather than a varietal reaction since both incipient red and tan spots were noted on almost all varieties in the survey, The red spots enlarged to about 3 to 4 mm in diameter with the center of the infected area becoming light in color, The small tan spots enlarged up to approximately 5 mm in diameter and were surrounded by a red peripherial zone which gradually faded into the surrounding green tissue, Thus, the final mature spots of both types were variable in size, being from 3 to 8 mm in diameter, red in color, with a variable white to tan dead center area.

M. fragariae was quite prevalent in all areas surveyed. The varieties in order of decreasing susceptibility are shown in Table 1. It is important to note that for some varieties only a few fields were available for inclusion in the survey.

Table I. Incidence of *infection* in relation to varieties

Varieties	Total No. of fields sampled	Total No. of observations	Average rating of all sampling dates, areas, and age plantings				
			Mycosphaerella fragariae	Gnomonia fructicola	Dendrophoma obscurans	Diplocarwon earliana	Gloeosporium sp.
Cavalier	23	82	8.0[a]	2.4	.3	.1	.2
Seedling #K53-1-77	2	7	7.4	24	0	0	1.7
Sparkle	27	96	6.5	2.9	3.6	.3	.6
Catskill	7	21	6.4	2.0	0	.4	trace
Robinson Beauty	7	19	6.4	2.5	0	1.4	.1
Redcoat	22	87	5.4	3.3	.2	.1	.1
Early Dawn	3	10	5.3	13	.2	0	0
Senator Dunlap	4	14	5.1	3.3	.1	0	0
Premier	6	22	4.4	1.5	0	0	.7
Surecrop	6	22	43	20	.1	0	.4
Guardsman	2	9	4.1	2.3	0	0	0
Grenadier	1	5	2.4	3.6	0	0	0

(a) The actual ratings were absent, trace, light, moderate, heavy and severe. For tabular use these were changed to the numerals 0,2,4,6,8, and 10, respectively.

The visual severity rating in July was less than in June (Table 2) because of the increase in the amount of new foliage, An increase in M. fragariae spots occurred toward the end of July and throughout August. Because infection takes place from 7 to 12 days prior to visual symptom expression (3), the first extensive infections began in July.

Table 2 Incidence of infection in relation to date of sampling

	Average of all areas, varieties and years of planting				
	Sampling period				
Organism	up to 24-6-62	25-6-62 to 9-7-62	10-7-62 to 24-7-62	25-7-62 to 8-8-62	9-8-62 to 25-8-62
Mycosphaerella	6.4	5.0	5.7	6.7	7.1
Gnomonia	0	0.3	2.6	3.6	4.9
Dendrophoma	0	0	0.2	0.4	0.2
Diplocarpon	0	0	0.1	0.1	0.6
Gloeosporium	0	0.1	0.5	0.3	0.5

Blotch caused by G. fructicola, was generally the second most prevalent foliar disease in the areas surveyed in Nova Scotia. In late June and early July blotch infections began to appear and by July 15 were quite prevalent on most fruiting beds in all areas, It was not found on new plantings until mid-July on Senator Dunlap. The disease ratings in Table 2 show the gradual increase during the latter part of July and throughout August. Commonly grown varieties which appear to be most highly susceptible, in order of decreasing susceptibility, are Senator Dunlap, Redcoat, Sparkle, Robinson Beauty, and Cavalier. Grenadier was more heavily infected than any other variety but only one field was examined. Even though spores of Z. fragariae, the conidial stage of G. fructicola, are present as early in the spring as the conidia of Ramularia tulasnii, the imperfect stage of M. fragariae, infection apparently occurs later in the season or a Longer incubation period is required. Age of the leaf may also be a factor,

Blotch was usually confined to mature leaves and symptoms first appeared as a red to purple area which often involved up to one-half the leaf. At this stage a blotch infection could easily be mistaken for a mineral deficiency. As the infections enlarge, the centers of the reddish-purple areas dry out to an orange-brown color. The Redcoat and Sparkle varieties in particular exhibit this sequence in symptom expression. G. fructicola has also been isolated from small red spots that could be mistaken for early symptoms initiated by many strawberry leaf pathogens. In the late summer G. fructicola was often isolated along with M. fragariae

from tan spots described as caused. by the latter fungus, In these cases G. fructicola was suspected to be a secondary organism in the spot since M, fragariae was always present. The presence of different symptom expressions, caused by the blotch fungus, may be influenced by different races of G. fructicola. as well as by different varieties of strawberries,

No definite blight symptoms caused by Dendrophoma obscurans were noted in the field. Severity ratings were made from plating and moist chamber material. Many times, on leaves incubated in the moist chamber, D. obscurans was present with G. fructicola on the spots characteristic of blotch infections. G. fructicola was isolated from almost all of the blotch spots on fresh leaves but only occasionally was D. obscurans present, When D. obscurans appeared on moist chamber leaves without G. fructicola, it was generally on a necrotic area around the margin of the leaf, D. obscurans was more prevalent on dead petioles, damaged runners, and dead runner plants than on leaves of living plants, Insufficient observations of this type made it impossible to postulate whether D. obscurans was actually parasitic on the leaf areas from which it was isolated. The presence of D, obscurans with G, fructicola on a blotch spot and on damaged runners and runner plants suggests that D. obscurans is less parasitic than G. fructicola, It would appear that G. fructicola is the primary pathogen causing the blotch spot with D. obscurans occasionally entering the spot as a secondary organism. This does not agree with the findings and views of Fall (3) who described symptoms for D, obscurans infections which resemble those symptoms noted in this survey for blotch caused by G. fructicola, She considered G. fructicola the less parasitic of the two and described no symptoms for G. fructicola infections. Fall (3) noted that a Gnomonia sp, was isolated from lesions thought to be caused by D. obscurans and questioned whether Gnomonia was causing the lesion or was secondary to some other fungus such as D. obscurans,

D. obscurans was isolated only after the middle of July. The data in Table 2 show that the highest severity rating for blight occurred around the 1st of August, Even at this time the proportion of infected leaves was low, D. obscurans was most prevalent on Sparkle (Table 1).

From this survey, Diplocarpon earliana, the scorch organism, does not generally appear to be of great importance as a strawberry leaf pathogen in Nova Scotia, When first noted in the field survey the scorch, infections were blotchy and resembled a small G, fructicola blotch area without a dead center. This blotchy area was later determined to be the result of a number of infections of D, earliana in a small area. Because the organism was difficult to isolate it is suspected that it was not identified as early as the primary symptoms were actually present. Plants infected with D. earliana were inspected periodically to follow the symptom sequence, Symptoms began as small red spots which could be mistaken for early infections caused by other organisms. The red color of the spots disappeared with age and finally changed to a dark purple-black, Where spots coalesced the leaf tissue between the points of infection dried out and turned brown, Occasionally entire leaves were

killed, Black acervuli formed in the center of the dark purple-black spots and these fruiting structures could barely be distinguished with the naked eye, Fall (3) noted the presence of both a blotch and a spot type symptom. The blotch type which began as a red spot was the only type noted in this survey. The results in Table 1 show that D. earliana infection was found mainly on the leaves of Robinson Beauty, Catskill and Sparkle. A trace was found on Cavalier and Redcoat,

D. earliana was isolated from leaves collected from fruiting beds in Digby and Colchester Counties. In agar plates a Septoria sp. often appeared along with D. earliana, The fungus Septoria aciculosa Ell. & Ev. was reported from Nova Scotia as the cause of a leaf spot on strawberry by C. O. Gourley (5). The species of Septoria encountered in this survey was not determined and may have been a secondary organism. In Kings Co. scorch symptoms appeared on both Grenadier and Guardsman varieties but no isolations were made to verify this diagnosis, These fields were plowed before further samples could be taken, Early in September scorch was found in fields of first year Sparkle nursery stock in Kings Co., not in the general survey, and leaves were collected and placed in moist chambers. Within a few days abundant acervuli were present on the purple-black spots and D. earliana spores could easily be identified, Thus, Lunenburg Co, was the only area in the survey where D. earliana was not found, possibly because later observations were not made,

An organism formerly unreported on strawberry leaves in Nova Scotia and suspected to be a species of Gloeosporium (henceforth referred to as Gloeosporium) was frequently isolated from lesions on strawberry foliage, Generally it was relatively unimportant as a pathogen compared to M. fragariae and G. fructicola, The spots from which Gloeosporium was isolated were reddish to purple in color with no definite margins and varying in size from 2 to 5 mm in diameter. Occasionally leaves showing areas of reddening along the main veins and in the adjacent tissues yielded cultures of Gloeosporiurn. On Premier the center of the spots became a much darker purple than with other varieties. These spots never became necrotic suggesting a higher type of parasitism than with M, fragariae and G, fructicola, Except for Colchester Co, this organism was found in each area surveyed, It was most prevalent in the Chester Basin area of Lunenburg Co,

Gloeosporium was isolated, at least in trace amounts, from all varieties except Senator Dunlap, Early Dawn, Grenadier and Guardsman, The data in Table 1 indicate that it was most prevalent on Seedling #K53-1-77, Premier and Sparkle. The number of Gloeosporium infections increased as the season advanced, These results were based only on comparative visual symptoms since the fungus was not actually isolated in culture until early August, In Lunenburg Co., Gloeosporium appeared to be almost universally present on all varieties, especially on fruiting beds and was more prevalent on alder plantings.

Gloeosporium was present in association with other organisms causing leaf spots. In the Chester Basin area it was isolated from tan colored spots associated with M. fragariae from a typical scorch spot from which D. earliana was also isolated and from a typical blotch spot of G. fructicola. This indicates that this species of Gloeosporium besides being the cause of primary infections on strawberry foliage may also act in a secondary capacity,

The results of the survey show that Mycosphaerella fragariae leaf spot is at present the only economically important disease on strawberry foliage in this province. Infections caused by Gnomonia fructicola, Dendrophoma obscurans, Diplocarpon earliana and Gloeosporium species, although present in most fields surveyed, are not considered to be important foliage pathogens in Nova Scotia,

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Appendix 1

'Strawberrv Production in Nova Scotia[1]

Year	Production (Quarts)	Price per quart	Value
1939	943,000	$ .10	$ 94,000
1955))average 1959)	1, 061,400	.25	267, 800
1960	2, 295, 000	.20	459,000
1961	2,300,000	.245	563, 500
1962[2]	1, 800, 000	.28	404,000

[1] Crop and Seasonal Price Summaries, Canada Department of Agriculture Vol, 14, Part 1, 1960-61, with amendment,

'Figures obtained from Nova Scotia Departrnent of Agriculture and Marketing,

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