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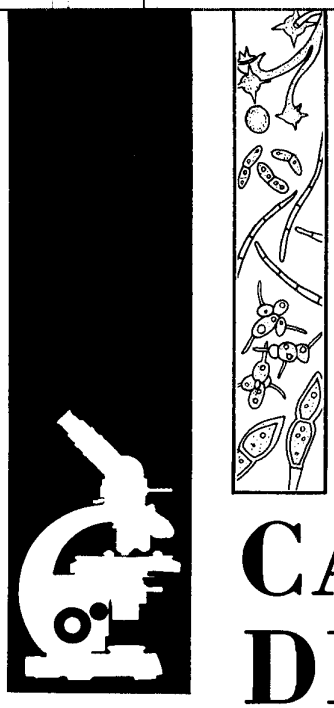
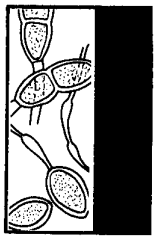


CANADIAN PLANT DISEASE SURVEY



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CANADIAN PLANT DISEASE SURVEY

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

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"The Canadian Plant Disease Survey is a periodical of information and record on the occurrence and severity of plant diseases in Canada. It will also accept other original information such as the development of methods of investigation and control, including the evaluation of new materials. Review papers and compilations of practical value to phytopathologists will be included from time to time."

A COMPARISON OF BENOMYL, THIOPHANATE-METHYL, AND CAPTAN FOR CONTROL OF STRAWBERRY FRUIT ROT[1]

C. O. Gourley

Abstract

Benomyl, thiophanate-methyl, and captan were tested in a 2-year trial to control gray mold fruit rot caused by Botrytis cinerea on the strawberry cultivars Cavalier and Redcoat. All treatments increased mean marketable yields and there was little difference among fungicides in the control of fruit rot. The maximum biological effectiveness of benomyl and thiophanate-methyl was attained with 1.68 kg/ha and 2.35 kg/ha, respectively, in 3 sprays.

Résumé

Au cours d'une expérience de deux ans, on a étudié le comportement du benomyl, du methyl-thiophanate et du captane contre la moisissure grise produite par Botrytis cinerea, sur des cultivars de fraises Cavalier et Redcoat. Tous les traitements ont augmenté les rendements commercialisables moyens et on n'a constaté que peu de différence d'efficacité entre ces fongicides. L'efficacité biologique maximale du benomyl et du méthyl-thiophanate a été obtenue aux doses de 1.68 kg/ha et 2.35 kg/ha respectivement, en trois pulvérisations.

The successful commercial production of strawberries necessitates a chemical control of gray mold fruit rot caused by Botrytis cinerea Pers. Infections occur mostly through the blossoms and latent infections often become established in the fruit (Jarvis 1962, Powelson 1960). Careful attention to methods and timing of fungicide spray applications improved the control of fruit rot (Bedard and Lechance 1970, Bennett 1972). Strawberry cultivars may differ in their reaction to fungicides and those chemicals that give good control of fruit rot may not always increase the yield of marketable fruit (Freeman 1966; Gourley 1963, 1968; Moore et al. 1965). Recently fungicides possessing systemic biological effectiveness have been evaluated as controls for strawberry fruit rot (Baltovski 1971; Bennett 1972; Borecka, Borecki and Millikan 1973; Branas 1971; Freeman and Pepin 1967, 1968; Garofalo 1971; Muller 1971; Tapio 1972).

The effects of benomyl, thiophanate-methyl, and captan were studied on Cavalier and Redcoat, two commercially important cultivars in eastern Canada. The results of a 2-year experiment of the efficacy and rate of application of these fungicides for the control of fruit rot are reported in this paper.

Materials and methods

The experimental design was a four-replicate, randomized-block split plot, with five fungicide treatments and a control as the main plots and two strawberry cultivars as the subplots. After harvest of the first fruiting year the plots were renovated by reducing the width of the matted rows from about 0.9 m to approximately 0.5 m with a rototiller.

The fungicide treatments were applied to the same plots in both years. The fungicides (active ingredient) and rate/2.25 kl of water per hectare and number of applications were as follows:

Fungicide	Proprietary product	Number of applications
Benomyl, 560.4 g	Benlate 50W	3
Thiophanate-methyl, 784.6 g	Cercobin-M 70W	3
Benomyl, 560.4 g	Benlate 50W	4
Thiophanate-methyl, 784.6 g	Cercobin-M 70W	4
Captan, 3362.5 g	Captan 50W	4
Control - unsprayed		

A blanket application of endosulfan (Thiodan 4 EC) at the rate 0.5 liter in 100 liter water was applied against insects at

[1]Contribution No.1511, Research Station, Agriculture Canada, Kentville, Nova Scotia.

early bloom and again 1 week later. The first fungicide sprays were applied in both years on 28 May at which time a few blossoms had opened. On plots receiving three and four applications, sprays were applied at 12- and 10-day intervals, respectively, in each of the 2 years.

There were seven pickings in 1972 and six in 1973, beginning on 28 June and 27 June, respectively. Yields were recorded by weight and converted to metric tons/ha on the basis that each fruiting bed covered an area of 5.57 m^2. All fruit, including rotten berries, were harvested from each cultivar in each plot. The weight of sound fruit was recorded as marketable yield and that of infected fruit as preharvest fruit rot.

The effect of fungicide treatment on fruit size was determined at each picking by weighing 25 sound fruit from each cultivar in each plot.

greatest yields occurred with three sprays of benomyl or thiophanate-methyl, but these yields were not significantly greater than those from plots which received four applications of these same fungicides. In England, Bennett (1972) concluded that benomyl at 1.68 kg a.i./ha/season in 3 or 4 applications gave satisfactory control of fruit rot in Cambridge Favourite strawberries. Here the maximum biological effectiveness of benomyl and thiophanate-methyl was reached with 3 sprays of the fungicides.

All fungicides significantly reduced the amount of fruit rot and there were no differences among fungicides (Table 2). In 1973 the amount of fruit rot was significantly greater than in 1972 only on unsprayed plots of Cavalier.

Table 1. Marketable yields in metric tons/ha

Fungicide and number of applications	Cavalier			Redcoat		
	1972	1973	Mean	1972	1973	Mean
Benomyl (3)	14.4	22.3	18.4* a	17.4	21.5	19.5 a
Thiophanate-methyl (3)	13.9	21.1	17.5 ab	16.5	22.3	19.4 a
Benomyl (4)	13.1	19.4	16.2 ab	16.5	20.1	18.4 a
Thiophanate-methyl (4)	13.9	20.3	17.1 ab	16.8	20.3	18.6 a
Captan (4)	12.2	18.1	15.2 b	15.0	19.5	17.3 a
Control	8.3	11.6	9.9 c	13.3	14.2	13.7 b
L.S.D. years (P .01)	5.5			4.4		
(P .05)	3.9			3.1		

* Figures followed by the same letter do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Results and discussion

All fungicide treatments significantly increased the mean marketable yields of Cavalier and Redcoat (Table 1). A significant difference between fungicide treatments occured only on Cavalier where plots that had received three applications of benomyl produced greater marketable yields than plots sprayed with captan. In 1973 yields of Cavalier were significantly greater than those in 1972 for all treatments, whereas yields of Redcoat were significantly greater in the second year than in the first year only for those treatments which received captan or three sprays of benomyl or thiophanate-methyl. For both cultivars the

Strawberry cultivars differ greatly in their susceptibility to fruit rot (Daubeny and Pepin 1973). In a trial conducted at Vineland Station, Ontario, for susceptibility to botrytis fruit rot, the cultivar Redcoat was rated 4 in a numerical range where 0 = resistant to 5 = very susceptible (C. L. Ricketson, unpublished data). In 1972 at Kentville, Redcoat had more Botrytis infection on blossoms and peduncles than any of the other 13 cultivars and selections examined (D. L. Craig, unpublished data). In this experiment the difference in yield between treated and non-treated plots may have been due partly to the loss of blossoms and peduncles prior to harvest.

Fungicides significantly increased the mean fruit size on Redcoat but not on Cavalier (Table 3). On Redcoat the mean weight of 25 fruit for three sprays of benomyl was significantly greater than that for four sprays of the same fungicide. Fruit size of both cultivars was significantly greater in the first than in the second crop year for all treatments which may have been the result of a heavier set of fruit the second year.

In England benomyl was phytotoxic to calyxes of Cambridge Favourite strawberries, and the amount of malformed fruit on Royal Sovereign was related to the dosage of fungicide applied per ha per season (Bennett 1969, 1972). In this experiment there was no visible evidence of phytotoxicity from any of the fungicides on either Cavalier or Redcoat. The maximum biological effectiveness of benomyl and thiophanate-methyl was attained with 1.68 kg and 2.35 kg, respectively, of fungicide was applied per ha per season. When a greater dosage of either fungicide was used yields were reduced and, although this effect was not significant, it was greatest in the second crop year for both cultivars.

Strains of B. cinerea have evolved which are tolerant of all benzimidazole compounds including benomyl and thiophanate-methyl (Norman 1973, Watson and Koons 1973). Also with these compounds there appears to be less decay of debris in plant rows (Norman 1973)

Table 2. Pre-harvest fruit rot in metric tons/ha

Fungicide and number of applications	Cavalier			Redcoat		
	1972	1973	Mean	1972	1973	Mean
Benomyl (3)	1.8	2.1	2.0* a	1.5	2.1	1.8 a
Thiophanate-methyl (3)	2.6	2.6	2.6 a	1.8	1.8	1.8 a
Benomyl (4)	2.5	3.0	2.8 a	1.4	2.0	1.7 a
Thiophanate-methyl (4)	2.8	3.0	2.9 a	1.6	2.2	1.9 a
Captan (4)	1.9	2.2	2.0 a	1.8	2.3	2.0 a
Control	3.2	5.5	4.4 b	2.7	3.7	3.2 b
L.S.D. years (P .01)	1.7			NS		
(P .05)	1.2			1.02		

* Figures followed by the same letter do not differ significantly at the 5% level (Duncan's Multiple Range Test).

Table 3. Weight in grams of 25 ripe strawberry fruit

Fungicide and number of applications	Cavalier			Redcoat		
	1972	1973	Mean	1972	1973	Mean
Benomyl (3)	214	194	204* a	255	212	233 a
Thiophanate-methyl (3)	214	204	209 a	242	214	228 ab
Benomyl (4)	221	196	208 a	239	210	224 b
Thiophanate-methyl (4)	227	195	211 a	243	217	230 ab
Captan (4)	208	191	199 a	245	215	230 ab
Control	212	202	207 a	231	196	214 c
L.S.D. years (P .01)	11			14		
(P .05)	8					

* Figures followed by the same letter do not differ significantly at the 5% level (Duncan's Multiple Range Test).

which creates a potential for massive production of inoculum. In this experiment there was a potential for greater inoculum production in the spring of the second crop year because it was observed that the debris and overwintered leaves carried an enormous residual infection of B. cinerea.

Foliage diseases were not observed on any of the fungicide treated plots and leaf scorch, caused by the fungus Diplocarpon earliana (Ell. & Ev.) Wolfe, was the only foliar disease that occurred on unsprayed plants.

Conditions were ideal for the development of gray mold fruit rot of strawberries when, coincidently in both years, rain fell on 11 days during the spray seasons, 28 May to 28 June, and on 6 days over the harvest periods, 27 June to 17 July.

Benomyl at 1.68 kg/ha and thiophanate-methyl at 2.35 kg/ha per season in 3 sprays beginning when the first blossom opened gave satisfactory control of fruit rot. Increasing the number of sprays or the amount of fungicide applied per ha per season did not enhance the control of fruit rot or increase yields of the strawberry cultivars Cavalier and Redcoat.

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ALTERNARIA BRASSICICOLA ON IMPORTED GARDEN CRUCIFER SEED, A POTENTIAL THREAT TO RAPESEED PRODUCTION IN WESTERN CANADA[1]

G. Allan Petrie[2]

Abstract

Alternaria brassicicola, a serious pathogen of crucifers which apparently does not occur normally in Canada's Prairie Provinces, was detected in 21 of 63 samples of garden crucifer seed obtained through commercial channels in Saskatoon, Saskatchewan. It was most common in samples of Brassica oleracea var. capitata, occurring in 50% of these. In each of four samples of 'Houston Evergreen' cabbage, 50% or more of the seeds carried the fungus. Following surface disinfestation of this seed, a considerable amount of infection remained. Commonly grown varieties of rape, turnip rape, and mustards were highly susceptible to A. brassicicola, both as seedlings and mature plants. Attention is drawn to the potential threat posed to Canada's rapeseed crop.

Résumé

Alternaria brassicicola pathogène dangereux des crucifères apparemment étranger aux provinces des Prairies a été décelé dans 21 des 63 échantillons de semence de crucifèrées maraîchères obtenues dans le commerce à Saskatoon. La fréquence la plus forte a été relevée chez Brassica oleracea var. capitata où elle a été décelée dans 50% des échantillons. Sur chacun des quatre échantillons du chou "Houston Evergreen", au moins 50% des semences étaient porteuses du champignon. L'infection est demeurée importante, même après un traitement superficiel des semences. Au stade de plantule, et à maturité, les variétés courantes de colza, de navette et de moutarde se sont montrées très sensibles à A. brassicicola. On souligne le danger éventuel de ce pathogène pour la culture de colza au Canada.

Species of Alternaria of significance in Canada as pathogens of cultivated Cruciferae are A. brassicae (Berk.) Sacc., A. raphani Groves & Skolko, and A. brassicicola (Schw.) Wiltshire (2). In western Canada the first two of these, alone or in combination, cause alternaria black spot on rape (Brassica napus L.), turnip rape (B. campestris L.) and cultivated mustards (B. hirta Moench and B. juncea (L.) Coss). Although the highly virulent A. brassicicola is relatively common in eastern Canada and British Columbia (2), it apparently occurs only sporadically in the three Prairie Provinces. It was found on cauliflower in Manitoba in 1934 (1) and cabbage in Alberta in 1944 (3), and Groves and Skolko in 1944 reported the isolation of Alternaria oleracea Milbr. (A. brassicicola) from seeds from Manitoba (5).

A recently completed 5-year seed health study, in which platings were made of over 1,000 seed samples of rape and turnip rape produced in Alberta, Saskatchewan and Manitoba, failed to yield a single colony of A. brassicicola (unpublished data). In conjunction with this study, enquiries were made of the Plant Products Division of Agriculture Canada regarding the availability of seed of cabbage and closely related plants produced in this country. It was learned that, with few exceptions, all such seed sold in Canada is imported from Holland, Britain or California. One sample of pedigreed 'Houston Evergreen' cabbage seed produced in British Columbia was obtained. This sample was heavily contaminated with A. brassicicola. In the spring of 1973, 'Houston Evergreen' cabbage seed was observed for the first time in two stores in Saskatoon. This prompted an investigation of the extent to which the serious pathogen, A. brassicicola, was entering the rape-growing area on crucifer seed from other parts of Canada and from abroad.

Methods

Seed samples of garden crucifers were obtained from various local commercial suppliers and a minimum of 100 seeds per sample plated without pretreatment on V8 juice agar containing 40 ppm rose bengal and 100 ppm streptomycin sulfate. Plates were examined 7 to 10 days after being seeded. Fresh subsamples from heavily contaminated

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samples were surface disinfested by immersion in 10% Javex (0.6% available chlorine) for 20 min and plated as before to determine the level of internal infection.

The characteristic sooty black colonies, typical conidia (5) and high virulence on emerged seedlings enabled relatively certain identification of A. brassicicola on the original plates. Transfers were made to tubes of V8 juice agar and, later, pathogenicity tests on seedlings of eight crucifer species (Table 5) were conducted using a method similar to that of Davis (4). A disease severity index (%) was calculated as previously described (7). Other seedlings were similarly inoculated with representative isolates of A. raphani and A. brassicae for comparison of virulence. Plants with 3 to 5 leaves were sprayed with suspensions of conidia of A. brassicicola and incubated under plastic bags in a growth room held at 21 C during the 18-h light period and 15.5 C during the 6-h dark period. Those inoculated were Brassica campestris L. cv. Span, B. juncea cv. Ekla, B. hirta, B. napus cv. Zephyr, B. oleracea var. capitata cv. Early Golden Acre, B. oleracea var. acephala DC., Raphanus sativus cv. Scarlet Globe and Crambe abyssinica Hochst. ex R. E. Fries. Final notes were taken on the extent of infection 10 to 14 days after inoculation.

Table 1. Garden crucifer seed samples plated for detection of *Alternaria brassicicola*

Species and variety	Common name	No. samples plated
Brassica caulorapa Pasq.	Kohlrabi	3
B. oleracea L. var. *acephala* DC.	Kale	1
B. oleracea var. *botrytis* L.	Cauliflower	6
B. oleracea var. *capitata* L.	Cabbage	30
B. oleracea var. *gemmifera* Zenker	Brussels sprouts	5
B. oleracea var. *italica* Plenck	Broccoli	2
B. napobrassica (L.) Mill	Rutabaga	3
B. rapa L.	Turnip	1
B. pekinensis Rupr.	Chinese cabbage	3
Cheiranthus cheiri L.	Wallflower	2
Iberis umbellata L.	Candytuft	1
Matthiola incana R. Br.	Stocks	1
Raphanus sativus L.	Radish	5
Total samples		63

Results

Brassica oleracea samples comprised almost 75% of the 63 crucifer seed lots plated. Thirty of the samples were cabbage cultivars (Table 1). In 50% of the latter and 29% of the remaining B. oleracea samples, Alternaria brassicicola was detected (Table 2). The only other species from which the pathogen was isolated were Brassica caulorapa Pasq. and Cheiranthus cheiri L. In the former, 1 of 3 samples had 1%, and in the latter, 1 of 2 samples had less than 1% of the seeds affected. The number of B. oleracea samples in each of 7 infestation severity categories may be seen in Table 3. In all 4 samples of "Houston Evergreen" cabbage 50% or more of the untreated seeds carried the pathogen. In some of these samples, considerable amounts of infection remained following treatment with Javex (Table 4).

Alternaria raphani occurred in a sample of brussels sprouts and in the only sample of Matthiola incana R. Br. The infestation levels were 8% and 2%, respectively. A. brassicae was isolated from two cabbage samples. In both, 1% of the seeds carried the pathogen.

Alternaria brassicicola isolates from Brassica oleracea seed were highly virulent to seedlings of 7 of the 8 crucifers tested, including currently grown rape and turnip rape varieties and three common weeds (Table 5). Its virulence exceeded that of A. brassicae, the most prevalent pathogenic Alternaria found on Brassica species in western Canada. Following spray inoculation with conidia of A. brassicicola numerous small leaf spots developed on all the crucifers tested with the exception of radish and Zephyr rape which were somewhat more lightly infected.

Discussion

The effects of fungicidal treatment of A. brassicicola contaminated seed did not form a part of this study. However, Richardson (8) reported that, following treatment of Brassica seed, a considerable amount of A. brassicicola still could be detected.

McDonald (6) has pointed out that temperature optima reported in the European literature for growth, spore germination, and disease development for A. brassicicola were higher than those for A. brassicae and that moisture and temperature requirements of the former for infection appeared to be more exacting. This is a possible explanation for the absence of A. brassicicola from the Canadian prairies. However, it has by no means been demonstrated experimentally that the fungus is unable to survive, or indeed, to develop to epidemic proportions, in this area. Therefore, at the present time, we are confronted with an apparent yearly importation of a potentially serious pathogen into the Prairie Provinces, an area from which it is virtually absent and in which there are large acreages of a highly vulnerable crop.

Acknowledgments

The technical assistance of Mrs. Marjorie M. Richardson is gratefully acknowledged.

Table 2. Samples of garden crucifer seed contaminated with pathogenic *Alternaria* species*

Crucifer and no. samples plated	Samples having					
	A. brassicicola		*A. raphani*		*A. brassicae*	
	No.	%	No.	%	No.	%
Brassica oleracea var. *capitata* (30)	15	50	0	0	2	7
Remaining samples of *B. oleracea* (14)	4	29	1	7	0	0
Total *B. oleracea* (44)	19	43	1	2	2	5
Other *Brassica* spp. (10)	1	10	0	0	0	0
Other genera (9)	1	11	1	11	0	0
All samples (63)	21	33	2	3	2	3

* Seed plated without pretreatment.

Table 3. Categorization of *Brassica oleracea* seed samples by the prevalence of *Alternaria brassicicola* infestation

Crucifer and no. samples plated	Categories (% of seeds per sample infested)						
	0	<1	1-4.9	5-9.9	10-19.9	20-49.9	50-100
Brassica oleracea var. *capitata* (30)	15	1	3	3	4	0	4
Remaining *B. oleracea* samples (14)	10	1	2	0	1	0	0
Total *B. oleracea* samples (44)	25	2	5	3	5	0	4

* Seed plated without pretreatment.

Table 4. Effect of surface disinfestation of 4 samples of "Houston Evergreen" cabbage seed heavily contaminated with *Alternaria brassicicola*

Sample no.	% of seeds per sample having the pathogen	
	Untreated seed	Surface disinfested*
12	>50.0	17.0
43	57.0	6.7
54	50.0	3.3
94	>50.0	16.0
Average	>50.0	10.8

* A 10% solution of Javex (0.6% available chlorine) was used for 20 min.

Table 5. Relative susceptibility of the seedlings of 8 crucifers to infection by *Alternaria brassicicola*, *A. raphani* and *A. brassicae*

Crucifer species	Disease severity index (%)		
	Alternaria species		
	A. brassicicola *	*A. raphani* **	*A. brassicae* **
Brassica campestris cv. Span	99	91	85
Brassica napus cv. Zephyr	94	95	73
B. juncea cv. Ekla	91	78	76
B. oleracea var. *capitata* cv. Early Copenhagen Market	100	100	95
Camelina sativa	6	12	1
Descurainia sophia	95	91	76
Sisymbrium loeselii	99	98	90
Thlaspi arvense	97	100	57

* The data for 6 isolates were averaged.

** Data for one representative isolate.

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DISEASES OF RAPESEED IN CENTRAL AND NORTHERN ALBERTA IN 1972

B. Berkenkamp[1] and K. Degenhardt[2]

Abstract

Rapeseed (Brassica campestris) crops in central and northern Alberta were surveyed for diseases by sampling 91 fields from July 4 to July 31, 1972. About 50 fields in the same area were examined in August and September. The early survey showed disease intensities of: white rust, 2.5% leaf area affected; staghead, 0.5% heads affected; alternaria black spot, 1.5% leaf area affected; and root rot, 11.9% roots and crowns affected. White rust and alternaria black spot increased in severity, and staghead and root rot decreased in severity in comparison with a 1971 survey. Ringspot, black spot on pods and stem rot appeared in August and September. Results indicate that the crop should be examined at intervals during the season to give a progressive measure of disease effects.

Résumé

On a étudié l'état de contamination des cultures de navette (Brassica campestris) dans le centre et le nord de l'Alberta en échantillonnant 91 champs, du 4 au 31 juillet 1972. On a en outre examiné environ 50 champs dans la même région en août et en septembre. La première enquête a permis de recueillir les taux d'infestation suivants: rouille blanche, 2.5% de la zone foliaire; albugine (bois de cerf), 0.5% des inflorescences; tache noire, 1.5% de la zone foliaire; pourridié, 11.9% des racines et des collets. Par comparaison avec une enquête effectuée en 1971, les infestations de rouille blanche et de tache noire étaient plus graves et celles d'albugine et de pourridié l'étaient moins importantes. La tache annulaire et la tache noire ainsi que la pourriture sclérotique se sont manifestées en août et en septembre. D'après ces résultats, il serait souhaitable d'inspecter cette culture régulièrement pendant la saison pour déterminer l'effet progressif de la maladie.

Rape acreage in Alberta decreased from 2.3 million acres in 1971 to 1.3 million acres in 1972. In both years, surveys were carried out to determine the distribution and intensity of diseases affecting the crop in central and northern Alberta. In this area almost all the rape grown is turnip rape, Brassica campestris L.; only rarely in summer rape, B. napus L., encountered.

Materials and methods

The survey in 1972 used similar methods to those reported in 1971 (2). Ninety-one fields were sampled from July 4 to July 31, by pulling 10 plants two paces apart, beginning 10 paces from the edge of each field. For each plant the percentage area of leaves, stems, and pods affected by diseases was estimated. In the case of staghead, the percentage of flowering shoots affected was recorded. Root rot was recorded as the percentage of plants showing symptoms.

About 50 additional fields were examined later in the season to determine the progress of diseases detected earlier and the incidence of later appearing ones.

Results and discussion

The intensity and distribution of rapeseed diseases in Census Divisions (C.D.) 8 to 15 are shown in Table 1. Limited production in C.D. 9 and C.D. 14 precluded sampling.

The 1972 survey showed an increase in the disease index of rust caused by Albugo cruciferarum S. F. Gray on leaves from 0.3 to 2.5 over 1971 (2), whereas the index for the staghead phase of white rust decreased from 1.2 to 0.5. This change could be due to the fact that a greater number of the fields sampled in 1971 were at a more advanced stage of growth. As the plants mature, the leaves drop off but the flowering head is exposed to white rust infection from which staghead develops.

The index for black spot on leaves caused by Alternaria brassicae (Berk.) Sacc. and A. raphani (Groves and Skolko) was similarly affected by the earlier sampling in 1972, with an increase from 0.2% to 1.5% of the leaf area affected. The high percentage of root rot (Rhizoctonia sp. and Fusarium spp.) in C.D. 12 in 1971, may be partly accounted

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Table 1. Distribution and intensity of rape diseases in central and northern Alberta in 1972

Census Division	Fields assessed		Disease index (avg)			
	No.	Date	White rust	Staghead	Black spot	Root rot
8	14	July 14	1.8	1.3	1.1	11.4
10	19	July 11	3.5	0.1	1.4	5.0
11	5	July 13	3.6	2.0	1.0	6.0
12	7	July 10	5.6	0.0	2.3	0.0
13	17	July 17	1.2	0.7	1.4	19.4
15	28	July 19	1.9	0.1	1.7	16.4
Average		July 15	2.5	0.5	1.5	11.9

for by the late date of sampling, August 12, as July 10, 1972, samples from the same area showed essentially no root rot.

Staghead and black spot occurred in all 50 fields observed in August and September. Staghead was more severe in thinner stands, whereas black spot was generally more severe in denser stands (3). In the late 1972 survey, 26 fields could be classed as slightly, 20 moderately, and 4 severely infected with alternaria black spot.

In a plot study of alternaria black spot made in 1972, yield losses caused by the disease on the Brassica campestris L. var. Span were 11% for slight, 14% for moderate, and 58% for severe infection. On B. napus L. var. Zephyr, of which only one field was encountered in the survey, the corresponding losses were 5%, 17% and 39% respectively (3).

Alternaria black spot was more severe in 1972 than in 1971, probably encouraged by favorable weather and increased inoculum (2). The summer of 1972 was wetter than average with slightly higher than normal temperatures (1). Increased inoculum probably contributed to the increase in black spot, since in Saskatchewan the disease has doubled annually from 1970 to 1972. (G. A. Petrie, personal communication.)

Ringspot caused by Mycosphaerella brassicicola (Fr.) Lindau was found in only a few fields late in the season, during ripening. Stem rot caused by Sclerotinia sclerotiorum (Lib.) de Bary was observed in several fields during September, with up to 20% infected plants.

In Alberta the leaf diseases of rapeseed appear early in the growing season and increase in severity until the leaves become senescent and drop. The flower and pod diseases appear later in the season and increase in severity as the plants mature. This variation in severity of diseases with date of sampling is evident in comparing the 1972 survey and the early and late 1972 surveys.

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FUNGI ASSOCIATED WITH HYPERTROPHIES CAUSED BY INFECTION OF CRUCIFERAE BY ALBUGO CRUCIFERARUM[1]

G. Allan Petrie[2] and T. C. Vanterpool[3]

Abstract

Over 20 species of fungi, including several pathogens of crucifers, have been found in association with hypertrophies of the inflorescence (stagheads) and stem and pod blisters produced on turnip rape (Brassica campestris), wild mustard (B. kaber) and false flax (Camelina microcarpa) by the white rust fungus, Albugo cruciferarum. The most prevalent associates of Albugo were Peronospora parasitica, Alternaria alternata, Fusarium roseum 'Acuminatum' and 'Equiseti', Alternaria raphani, A. brassicae and Cladosporium sp. Most of these were recovered on agar media following surface disinfestation of the hypertrophied tissue. Very few Albugo infected tissues failed to yield some secondary invaders, and five occasionally were isolated from a single staghead. The possible significance of these associations is discussed.

Résumé

On a relevé la présence de plus de 20 espèces de champignons, y compris plusieurs pathogènes des crucifères, associées à des hypertrophies de l'inflorescence (bois de cerf) et à des boursouflures des tiges et des gousses de navette (Brassica campestris), de moutarde sauvage (B. kaber) et de caméline à petits fruits (Camelina microcarpa) produites par le champignon de la rouille blanche, Albugo cruciferarum. Avec Albugo, les isolats les plus fréquemment associés étaient Peronospora parasitica, Alternaria alternata, Fusarium roseum 'Acuminatum' et "Equiseti', Alternaria raphani, A. brassicae et Cladosporium sp. On a recouvré la plupart des pathogènes sur un milieu d'agar après désinfestation superficielle du tissu hypertrophié. Très peu des tissus infestés d'Albugo ont produit de parasites secondaires et on est quelquefois parvenu à en isoler cinq dans un même "bois de cerf'. Les auteurs analysent l'importance éventuelle de ces associations.

Galls which form on plants in response to fungal infection appear to provide sites particularly favorable to the development of secondary microorganisms. For example, Koch (5) reported the isolation of a dozen fungal species from the tissues of black knots produced on Prunus spp. by Dibotryon morbosum (Schw.) Theiss. & Syd. A few of these secondary invaders, notably Trichothecium roseum (Pers.) Lk., were active parasites of the stroma of D. morbosum, and appeared to check the development of the latter. Byler et al. (1, 2) also demonstrated that secondary fungi and insects were responsible for mortality of galls of pines caused by the rust Peridermium harknessii Moore.

Rust pustules may also serve as points of entry for other fungi. The infection of onion by Botrytis sp. via the sori of Puccinia asparagi DC. provides an early example of this (16). Invariably a rust pustule was found in the center of each Botrytis lesion and no infection by the latter occurred other than through sori of the rust. When invasion took place before the sori opened, the aecia failed to mature. A number of observers have reported infection of flax by various pathogens by way of pustules of Melampsora lini (Ehrenb.) Lév. Secondary invaders included species of Fusarium (4, 6, 9, 10), Alternaria linicola Groves & Skolko (11, 12), Polyspora lini Laff. (11), and Septoria linicola (Speg.) Garass. (11). In certain years at least, fusarium stem canker of flax was invariably associated with rust infection (6), and Alternaria linicola stem lesions originated either in rust telia or leaf scars (12).

Observations over the last 15 years or more in western Canada have indicated that hypertrophies of the inflorescence (stagheads) of turnip rape (Brassica campestris L.) caused by Albugo cruciferarum S. F. Gray are ideal sites for copious spore production by various fungi. The association of Peronospora parasitica (Pers. ex Fr.) Fr.

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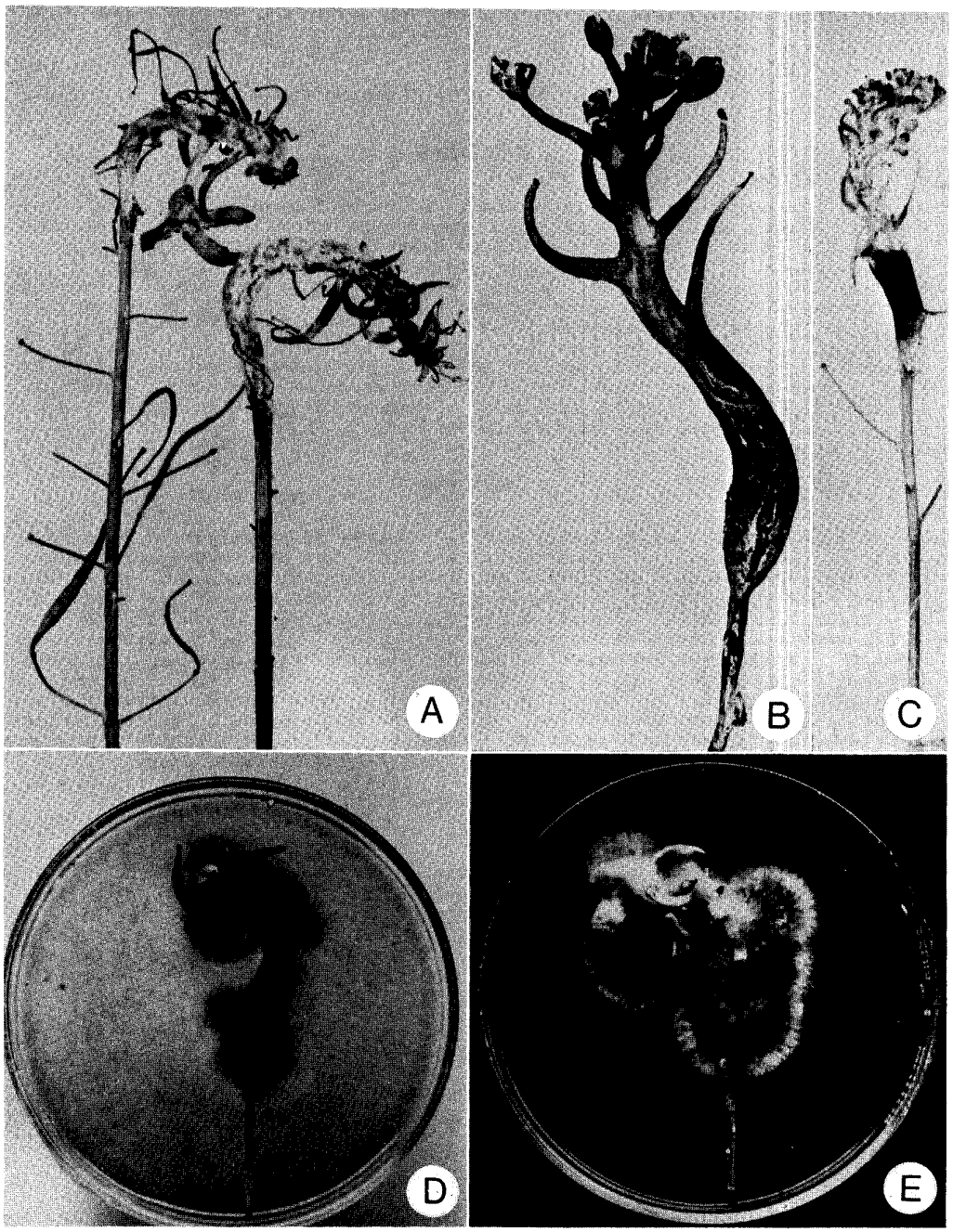

Figure 1. Fungi associated with *Albugo* hypertrophies (stagheads) on *Brassica campestris*. A) Downy mildew (*Peronospora parasitica*). B) *Alternaria brassicae*. C) *Peronospora* and *Alternaria* sp. developing on the same hypertrophy. D, E) *Alternaria* spp. growing from stagheads plated on nutrient medium.

with Albugo (Fig. 1 A, C) was perhaps the first commented upon (13). The appearance of black mold, mostly Alternaria alternata (Fries) Keissler, on stagheads (Fig. 1 B, C) is frequently striking following late summer or autumn rains (14), both in standing crops and those in swath. Less common associates of Albugo which we have reported previously are Fusarium spp., Alternaria raphani Groves & Skolko, A. brassicae (Berk.) Sacc. (7), and Mycosphaerella brassicicola (Duby) Lind. (8). Notes made by the junior author show that Fusarium spp. and Alternaria raphani had been found on hypertrophies collected at Meadow Lake, Saskatchewan, as early as 1959.

It was thought likely that other fungi commonly associated with stagheads went undetected during these observations. The fungi colonizing Albugo stem and pod blisters had also received scant attention. In addition, we had no indication of the effect that some or all of these associated species might have on A. cruciferarum. Therefore, in an attempt to obtain data relating to some of these considerations, the studies to be described were conducted over three growing seasons (1970-72).

Materials and methods

Stagheads and stem and pod blisters caused by Albugo, clipped from disease survey material collected in Saskatchewan largely in August of 1970, 1971, and 1972, were surface sterilized 2 min in 10% Javex (0.6% available chlorine) and plated on V8 juice agar containing 40 ppm rose bengal and 100 ppm streptomycin sulfate. Plating was done as soon as possible following collection. Plates were examined microscopically at 10 days and a record made of all microorganisms present. Many colonies were subcultured on V8 juice agar for further study.

Results

Prior to plating, a majority of the stagheads and stem and pod blisters bore no obvious indications that they harbored other fungi. Adjacent host tissue also usually appeared healthy. Nevertheless, there were few hypertrophies from which secondary organisms failed to grow. Initially, upon incubation profuse development of the mycelium and spores of secondary organisms occurred on the staghead or blister with no growth being evident on attached host tissue (Fig 1 D, E). On some stems, blisters were surrounded by prominent lesions (Fig. 2 A, B, C). It was evident from the symptoms and plating results that Alternaria had gained entry through the broken surfaces of the blisters and had initiated rather severe infections.

In all, 457 stagheads and 1841 stem and pod blisters were plated. All specimens came from Brassica campestris, with the exception of several pod blisters and stagheads from a collection of B. kaber (DC.) Wheeler from Eston, Saskatchewan, and a few stem blisters from plants of Camelina microcarpa Andrz. from near Pike Lake, Saskatchewan. The fungi most commonly isolated from the Brassica spp. are listed in Table 1. On B. campestris a greater variety of fungi occurred in stagheads than in blisters and usually each species was found in a higher percentage of stagheads than of blisters. On an average, approximately three fungi were found in a

Table 1. Fungi most commonly isolated from *Albugo* hypertrophies on *Brassica* spp.

	Stagheads infected		Stem and pod blisters infected	
Fungi isolated	No.	%	No.	%
Alternaria alternata	378	82.7	1,631	88.6
A. brassicae	66	14.4	633	34.3
A. raphani	153	33.4	278	15.1
Fusarium roseum	318	69.6	425	23.0
Cladosporium sp.	133	29.1	150	8.1
Stemphylium sp.	60	13.1	27	1.5
Epicoccum sp.	42	9.2	38	2.1
Gonatobotrys sp.	32	7.0	34	1.8
Rhizopus sp.*	28	6.1	5	0.3
Botrytis cinerea	14	3.1	1	0.1
Total no. pieces plated	457		1,841	

* And related genera.

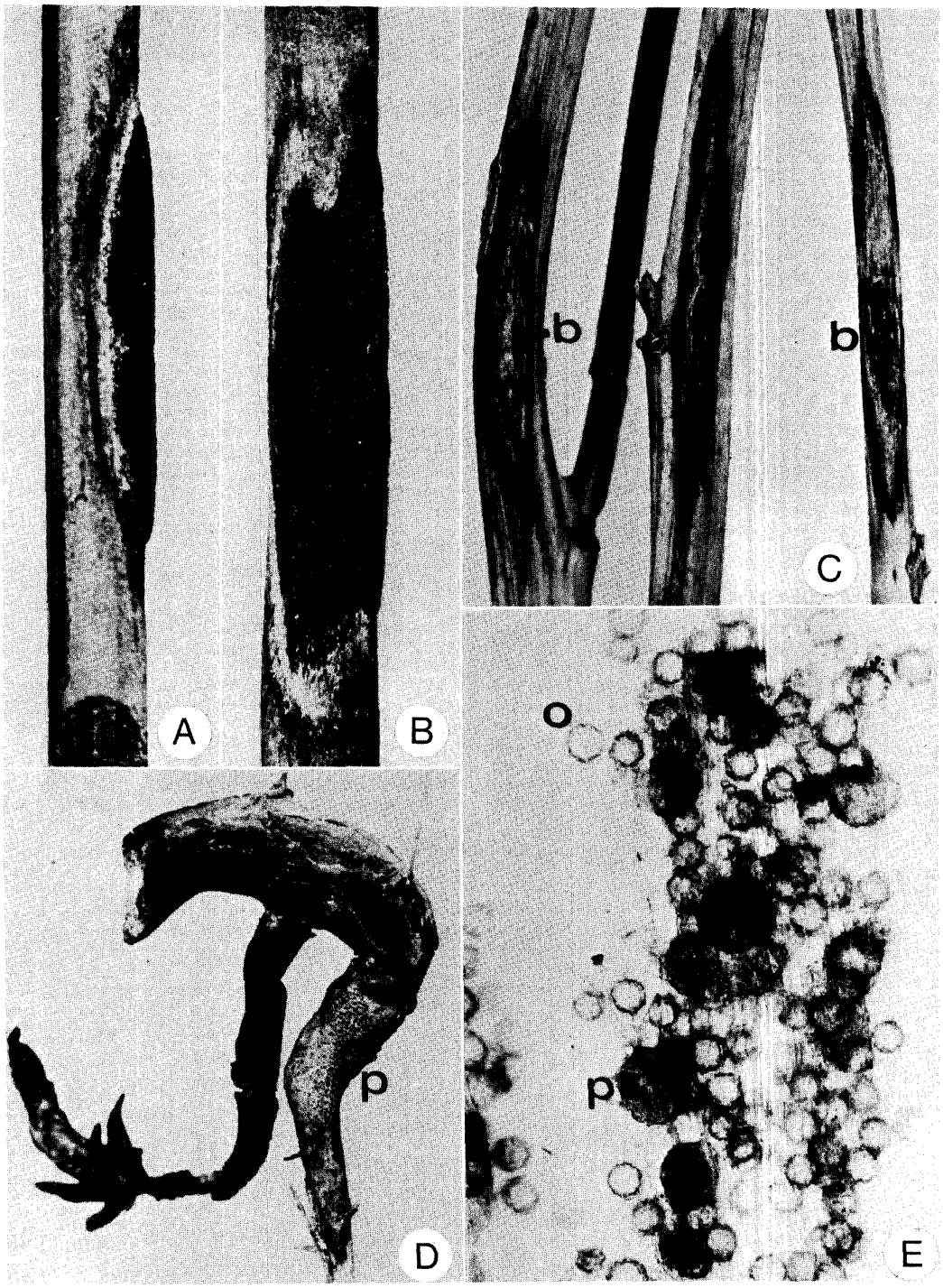

Figure 2. Fungi associated with *Albugo* hypertrophies. A, B, C) *Alternaria brassicae* developing on and around stem blisters (b). D) Pycnidia (p) of *Phoma* sp. on a staghead. E) Pycnidia (p) and oospores (o) in a scraping prepared from the staghead in D.

staghead and two in a blister. In a few individual fields, the average was closer to five fungi per staghead.

The most prevalent species in stagheads were Alternaria alternata, Fusarium roseum Lk. emend. Snyder & Hansen ('Acuminatum' and 'Equiseti'), A. raphani, A. brassicae, Cladosporium sp., Stemphylium sp., Epicoccum sp., Gonatobotrys sp., Rhizopus and related genera, and Botrytis cinerea Pers. All of these with the exception of A. alternata and A. brassicae were much less common on blisters (Table 1) but still were among the 10 most prevalent species. A. brassicae was recovered considerably more often from blisters than from stagheads, the reverse of what was found for A. raphani. This difference may result from the prevalence of moister conditions below the plant canopy where blisters occur, than at its top, where stagheads usually are found. Evidence from seed plating studies (15) has indicated that in drier years A. raphani is more common than A. brassicae.

The overall results were generally quite consistent from year to year. Comparing in each case the 2 years in which the greatest numbers of plating were made, Fusarium roseum was found in 69.4% and 65.5% of the stagheads and 22.0% and 25.9% of the blisters. The corresponding percentages for A. alternata were 90.4 and 79.5 for stagheads and 91.4 and 85.3 for blisters. When data from the different fields were compared, considerable variation was noted in the percentages of hypertrophies from which any given species was isolated. For example, in 1972, percentages of stem blisters harboring A. raphani ranged from 1.5% to 66.7%, with an average for all fields of 13%. For Fusarium roseum the range was 0 to 84.3%, with an average of 25.9%. A. alternata was much more uniformly distributed, occurring in over 80% of the stem blisters in all fields but two.

In addition to the 10 species listed in Table 1, at least as many more were found relatively less frequently. These included Acremoniella sp., Alternaria of the linicola type, Arthrinium sp., Chaetomium sp., Curvularia sp., Gliocladium roseum (Lk.) Bainier, Plenodomus lingam (Tode ex Fr.) Höhn., Pleospora herbarum (Fr.) Rabh. and miscellaneous pycnidial fungi, principally Phoma herbarum Westend. Mycosphaerella brassicicola was observed on a few stem blisters before they were plated but could never be cultured from the material due to the presence of more aggressive species. Of those fungi which could not be identified to genus, the most common was a white, rapidly-growing non-sporulating form.

The Brassica kaber specimens yielded Alternaria alternata, Cladosporium sp., A. raphani and the white, non-sporulating fungus. Fusarium and Stemphylium occurred sporadically. Several cultures of A. alternata, A. brassicae and Fusarium roseum and a few of Epicoccum sp. and Cladosporium sp. were obtained from the Camelina stem blisters.

A few unreported observations made by the junior author prior to 1970 may also be noted. In 1968, Erysiphe polygoni DC. ex Mérat was found in association with Albugo at Saskatoon. Also in that year, Fusarium roseum 'Avenaceum' was isolated from hypertrophies. In 1960, three isolates of Phoma were obtained from stagheads collected at Brooksby, Saskatchewan, and in 1962 an unusual species of Phoma moderately pathogenic to rape seedlings was isolated from material received from Fort Vermilion, Alberta (Fig. 2D, E).

Discussion

The plating method used here for the determination of the fungal associates of Albugo was undeniably imperfect, in that some important species could not be recovered. The bacterial flora was not studied. However, if observations made in the field and verified by microscopic examinations are combined with the plating data, it is felt that a reasonably complete picture may be obtained of the fungi to be found most frequently in hypertrophies. These would appear to be Peronospora parasitica, Alternaria alternata, Fusarium roseum, A. raphani, A. brassicae and Cladosporium sp. The association of the first of these with Albugo is so intimate that the two fungi have long been considered to constitute a single disease complex.

The advantages afforded secondary invaders of Albugo hypertrophies for spore production and dissemination are quite apparent. Other advantages may also accrue. Stem blisters are obviously an important avenue for invasion of the plant by pathogenic Alternaria species (Fig. 2) and other fungi including Fusarium, and, occasionally, Plenodomus lingam. Much work remains to be done on the mutual interactions of Albugo and associated microorganisms. Inhibitory substances have been leached from stagheads (unpublished data) but the effects of these on other fungi are unknown. Some of the Alternaria species considered here are known to produce toxins (3) and these could conceivably have an adverse effect on survival of Albugo. Work is continuing in an attempt to clarify some of these points.

Acknowledgments

The authors express their appreciation to Mrs. Jean Key and Mrs. Marjorie Richardson for technical assistance.

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OCCURRENCE OF SQUASH MOSAIC VIRUS IN MUSKMELON SEEDS AVAILABLE IN ONTARIO IN 1973

W. G. Kemp[1], J. Wiebe[2], and P. A. Troup[1]

Abstract

Squash mosaic virus was detected in seed of 3 of 29 muskmelon cultivars commercially available to Ontario growers in 1973. A count of infected plants from 53 seed samples indicated that seed transmission of the virus in infected cultivars reached a maximum of 6.3% in Early Delicious 51, 3.1% in Iroquois, and 1.9% in Saticoy.

Résumé

On a décelé le virus de la mosaïque de la courge dans les semences de 3 des 29 cultivars de melon brodé disponibles aux producteurs de l'Ontario en 1973. D'après une numération des plantes infestées provenant de 53 échantillons, la transmission du virus de la semence aux cultivars infestés atteignait un maximum de 6.3% chez Early delicious, 51.3% chez Iroquois, et 1.9% chez Saticoy.

Most muskmelon (Cucumis melo L.) seed distributed in Ontario is imported and originates from a limited number of seedsmen in the U. S. A. Squash mosaic virus (SMV) sometimes persists in the seed of some cultivars (3). Infected seed imported into Ontario has served as a primary source of SMV inoculum for subsequent infection of muskmelon crops (2). In early 1973, samples of commercial seed of muskmelon cultivars offered for sale in the province were tested for seedborne SMV to uncover potential problem cultivars in advance of spring planting.

Methods and results

Two methods were used to detect SMV in or on the seed. The first used 72 seeds selected at random from each of 53 samples representing 29 cultivars and obtained from 7 seedhouses. Individual seeds were sown in steamed soil in 1-inch-square peat pots, placed in sterile plastic trays and isolated in a small greenhouse compartment. The number of infected seedlingss in each of the 53 samples was recorded after the first true leaves had fully expanded (3 to 4 weeks). The second method was a direct seed test on each of the samples. Five lots of 20 seeds were selected at random from each sample. Each seed lot was ground separately in 0.5 ml of 0.25% Na_2SO_3 in a sterilized mortar. The paste from each lot was then applied to leaves of Vigna sinensis Savi (cowpea, cv. Black-eye), Nicotiana glutinosa L., Citrullis vulgaris Schrad. (watermelon, cv. Market Midget), Cucurbita pepo L. (pumpkin, cv. Small Sugar), and sometimes Cucumis sativus L. and Chenopodium quinoa Willd. These plants reportedly are useful in detecting and differentiating SMV from other cucurbit viruses (1). Final symptoms assessments were made 4 weeks after inoculation. The results of this seed assay test suggests that no more than 5% of the seed lot was infected with SMV.

As results from the two detection methods were in complete agreement, the data from these tests are combined in Table 1. In this survey the number of muskmelon cultivars in which SMV was detected in the seed or the seedlings was low. Only 3 of the 29 cultivars - Early Delicious 51, Iroquois, and Saticoy - contained the virus. Moreover, only 3 of the 7 seedhouses were distributing infected seed. Two infected cultivars were identified from source C, whereas one infected cultivar was identified from each of sources B and F.

The number of infected seedlings did not exceed 7% of the total emergence of any of the 53 seed samples. From sources B and C, 2.0% and 6.3% respectively, of the Early Delicious seedlings showed visible mosaic symptoms. Seedlings of Saticoy with typical SMV symptoms from source C represented 1.9% of the total stand. The virus was found in 3.1% of the Iroquois seedlings from source F.

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Table 1. Occurrence of seed-borne squash mosaic virus in 29 cultivars of muskmelon from seven seed distributors

Cultivar	Seed distributor						
	A	B	C	D	E	F	G
Ananas							-*
Banana					-		
Burpee Hybrid						-	-
Chlarentais Hybrid					-		
Chlarentais Improved						-	
Canada Gem Hybrid						-	
Classic Hybrid	-	-					
Early Delicious 51		2.0%**	6.3%	-		-	-
Farnorth					-		
Gold Star			-				
Golden Crispy					-		
Honey Rock				-	-	-	-
Hales Best Jumbo				-			
Harper Hybrid			-		-	-	
Hearts of Gold		-					
Harvest Queen		-	-	-			
Iroquois			-	-		3.1%	-
Minnesota Midget					-		
Milwaukee Market				-			
Mainerock	-						
New Yorker				-			
Orange Ananas							-
Perfection						-	
Pride of Wisconsin				-			
Samson Hybrid						-	
Sugar Salmon						-	
Sungold Casaba				-			
Supermarket	-	-	-	-			
Saticoy Fl	-	-	1.9%	-		-	

* - = SMV not detected in cultivar.

** % = percentage of emerged seedlings with visible SMV symptoms in a sample

Only about 10% of the cultivars tested were infected with SMV. However, the three cultivars in which SMV was found are commercially important in Ontario. Hence, should high vector populations coincide with infected cultivars in the field, commercial losses might well occur.

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MEASURING EARLY BLIGHT, ITS PROGRESS AND INFLUENCE ON FRUIT LOSSES IN NINE TOMATO CULTIVARS[1]

P. K. Basu

Abstract

In field tests conducted for 3 years, the severity of early blight [Alternaria porri f. sp. solani] in nine tomato cultivars was reliably measured by counting the leaves having 75% to 100% necrotic area. The small lesioned areas on the remaining leaves rarely exceeded 6% of the total foliage surface of a plant exposed to either natural infection or artifical inoculation. Disease progress curves based on both leaf and fruit infection indicated that, on average, 60% defoliation would be necessary to obtain 10% infected fruits in all cultivars tested except Mini-Rose. Fruits of Mini-Rose were free from early blight lesions. Under conditions of moderate natural infection, the total number of fruits of marketable size was not significantly reduced but the loss due to visibly infected fruits ranged from 0% to 13%. Under conditions of severe disease created by artificial inoculation, yield reductions of 10% to 34% occurred in some cultivars in addition to a 13% to 37% loss in quality due to blemished fruit.

Résumé

Au cours de 3 ans d'essais de plein champ, on a déterminé avec précision la virulence de la brûlure alternarienne (Alternaria porri f. sp. solani) sur neuf cultivars de tomates, en comptant les feuilles dont les zones nécrosées dépassaient 75%. Les plages légèrement atteintes du reste des feuilles dépassaient rarement 6% de la surface totale du feuillage des plants exposés soit à l'infestation naturelle soit à l'inoculation artificielle. D'après les courbes de progression de l'infection, calculées d'après les infestations des feuilles et du fruit, il faut en moyenne une défoliation de 60% pour que 10% des fruits de tous les cultivars analysés, à l'exception de Mini-rose, soient infestés. Les fruits de Mini-rose étaient exemptés de lésions de la brûlure alternarienne. En conditions d'infestation naturelle modérée, la quantité de fruits commercialisable n'a pas subi de baisse significative cependant, les pertes provenant de fruits visiblement infestés variaient de 0 à 13%. En conditions de forte infestation provoquées par inoculation artificielle, on a observé des baisses de rendement de 10 à 34% chez certains cultivars en plus de pertes de qualité de 13 à 37% dues à l'altération des fruits.

Tomato early blight incited by Alternaria porri f. sp. solani has caused serious losses (7, 16). Although this disease can be controlled by fungicides (5, 6, 7, 13), highly resistant tomato cultivars are still being sought (1). In the process of evaluation of fungicides and disease resistance, attempts have been made to determine blight severity by visually estimating damaged leaf area or by counting dead leaves, or both (6), by counting leaf spots (5), and by measuring the size of leaf spots (1). The effect of the disease on fruit yield, however, has remained uncertain for several reasons as discussed by Horsfall and Heuberger, although they reported a linear relationship between the numbers of killed leaves and infected fruits up to a limit of 65% defoliation (6, 7).

The present work was initiated to assess the severity of early blight and its effects on yield in several tomato cultivars of commercial type.

Materials and methods

A pathogenic isolate of Alternaria porri (Ellis) Cif. f. sp. solani (Ell. & Mart.) Neerg. and the following tomato (Lycopersicon esculentum Mill.) cultivars and lines were used in field plot experiments during 1969-71: Geneva John Baer was tested for 3 years; Fireball VR, New Yorker, Mini-Rose, Trent, Ottawa 78, Heinz 1350, Campbell 19, and Jet Star were tested for 2 years. For each cultivar a randomized block design with four replications and three treatments

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corresponding to low, moderate, and severe disease levels was used. In early June, 5- to 6-week-old tomato seedlings were transplanted to the field in rows 4.5 ft apart with 3 ft spacing between plants in a row. Three adjacent rows constituted a plot for each treatment. Plots were separated by untreated buffer rows. The number of plants per row was 22 for John Baer in 1969 and 12 for all cultivars in 1970-71. After the first or second fruit trusses had formed, the plants were staked and pruned to develop only two main branches. Plants in treatment 1 (T1, low disease level) were protected by weekly sprays of maneb which is recommended for the control of early blight in Ontario (13) and is not known to affect tomato yield. Plants in treatment 2 (T2, moderate disease level) received no application of maneb and were exposed to natural infection (2, 7, 14). Plants in treatment 3 (T3, severe disease level) were spray-inoculated once in late July with a heavy suspension of conidia of the pathogen in water (4 x 10. conidia/ml) and received no fungicide sprays.

Tomato yield and disease data were recorded only from the center rows of each plot, discarding one plant at each end of the row. All fruits of marketable size (diam. 2 inches or more) were picked weekly as they ripened. Green fruits were harvested at the end of the growing season (last week of September). Fruits from each plot were sorted into infected and healthy groups and counted. The number of infected fruits at each harvest was expressed as a percentage of the total number of fruits produced during the season. The severity of the disease on tomato foliage was recorded every 2-3 weeks by counting the killed leaves on each plant and by estimating the area of necrotic spots on one branch from each of 4 (1969) or 2 (1970) pre-determined, labelled plants, usually every 5th one, in a row. The area of the leaves and of the necrotic spots was estimated by comparing them with tomato leaflet diagrams prepared by standard methods (8). The average amount of necrotic area at each date of recording was expressed as a percentage of the total leaf area produced by a labelled plant during the season (i.e. potential leaf area). A record of necrotic areas on the top 10 leaves of one branch of each of these plants was maintained separately. A leaf with 75% or more damage was considered killed; the area of such a leaf was estimated from the average area of a random sample of 100 previously tagged leaves, from the lower half of the plants.

Table 1. Percentage* of necrotic area on leaves of naturally infected and spray-inoculated John Baer tomatoes at four dates in 1969

Treatment and leaves assessed	Dates of recording disease			
	Aug 12	Aug 26	Sept 9	Sept 22
Naturally infected				
1. killed leaves	21.75	40.11	58.97	67.25
2. all remaining leaves	6.10	2.74	2.52	5.97
3. top 10 leaves	1.46	0.43	0.85	1.71
4. total (1 + 2)	27.85	42.85	61.49	73.22
Spray-inoculated				
1. killed leaves	64.32	76.99	100.00	
2. all remaining leaves	0.85	3.33		
3. top 10 leaves	0.48	1.51		
4. total (1 + 2)	65.17	80.32	100.00	

* Percentage based on the total foliage area produced by a plant during the season (i.e. potential leaf area); each entry represents an average of 16 plants.

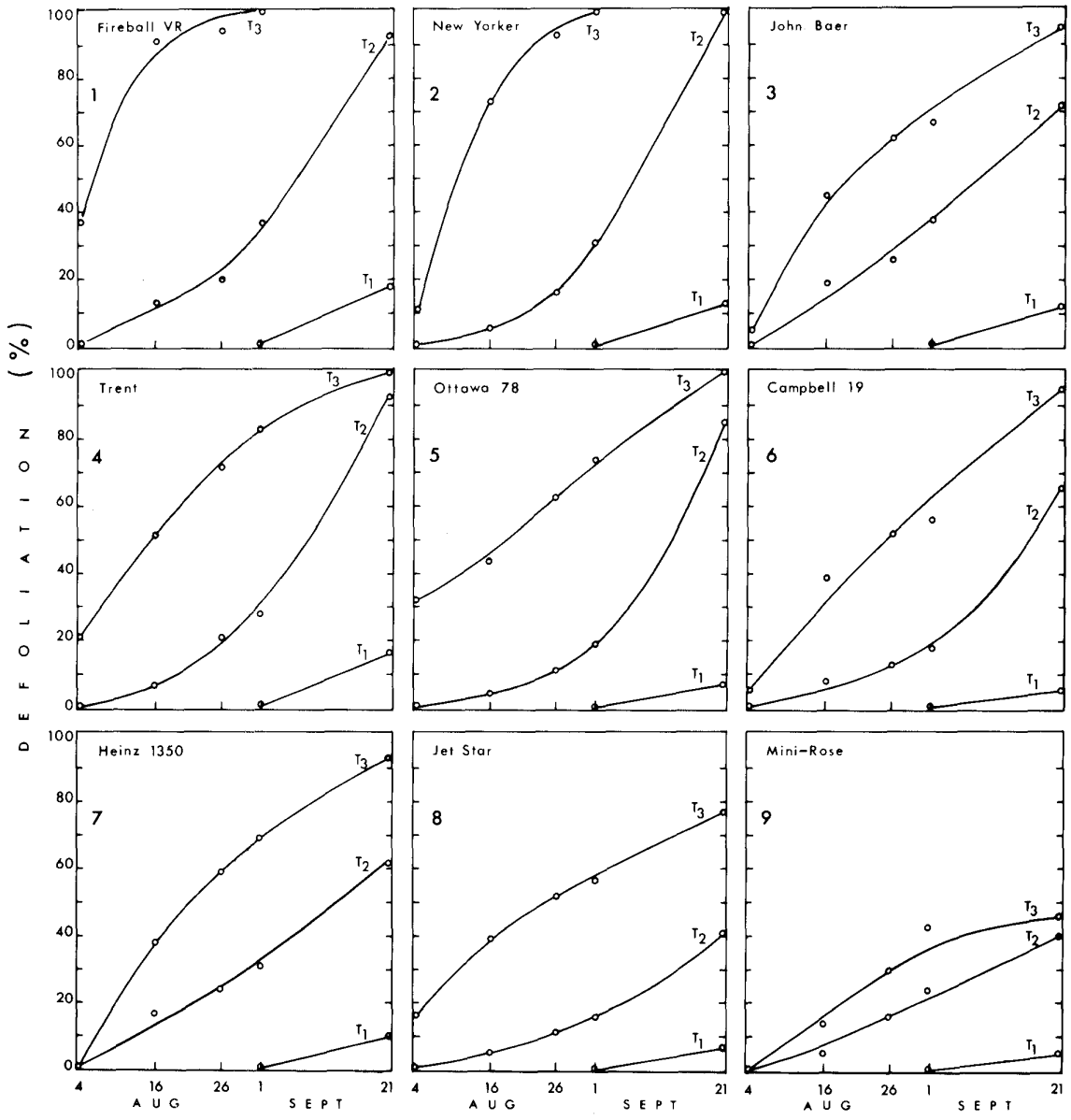
Results

Measurement of foliage blight

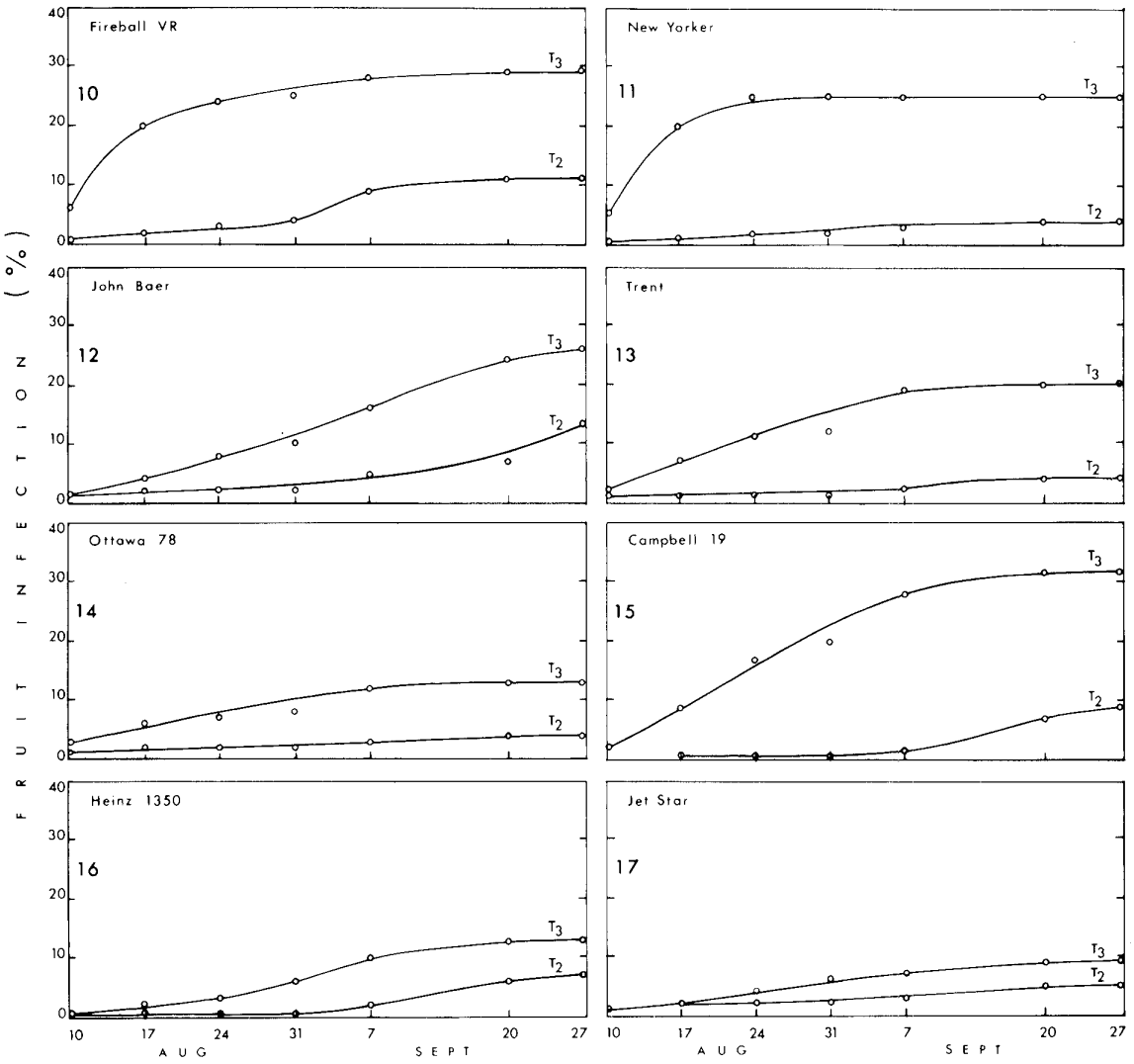
The percentage of necrotic area, based on potential leaf area, produced on naturally infected and spray-inoculated John Baer tomatoes during 1969 is shown in Table 1. The killed leaves, which averaged 90 cm^2 in size, accounted for the major portion of damage on a plant. The total necrotic area on the remaining leaves rarely exceeded 6%, and on the top 10 leaves it was less than 2% at all times during the season. It should be noted that a gradual increase in disease was reflected both by the percentage of killed leaves and by the total damage, but not by the area of small necrotic spots on the living leaves alone (Table 1). Consequently, the percent defoliation, based on the number of killed leaves, was sufficiently accurate to express the magnitude of the disease. Similar conclusions were arrived at from the 1970 results. In 1971 the progress of disease on the foliage was determined only by the percentage of killed leaves (% defoliation).

Disease progress on foliage and fruits

Foliage - Disease progress curves based on percent defoliation of nine tomato cultivars in the three treatments are presented in Figures 1-9. On spray-inoculated (T3) plants of most cultivars, early blight progressed rapidly; Fireball VR and New Yorker were completely defoliated by September 1, 1971. At that time natural infection (T2) had resulted in less than 40% defoliation in Fireball VR, New Yorker, John Baer, Trent, and Ottawa 78. Three weeks later, these cultivars suffered 70% to 100% defoliation, Campbell 19 and Heinz 1350 about 60%, and Jet Star and Mini-Rose less than 40% defoliation. In fungicide protected (T1) plants very few blight lesions were found and, in these plants, defoliation due to natural senescence ranged from 5% to 20% in the nine cultivars tested.



Figures 1 to 9. Progress of defoliation caused by early blight in nine tomato cultivars in 1971 under conditions of fungicide protection (T_1), natural infection (T_2), and artificial inoculation (T_3).



Figures 10 to 17. Progress of early blight infection on fruits of eight tomato cultivars in 1971 under conditions of natural infection (T_2) and artificial inoculation (T_3).

Fruit - Fungicide-protected (T1) plants of all cultivars showed less than 1% fruit infection. The cultivar Mini-Rose had no infected fruits even when plants were spray-inoculated (T3). Disease progress curves based on the percentage of infected fruits under conditions of natural (T2) and artificial (T3) infection for 8 of the 9 cultivars are shown (Figs. 10-17). Inoculated (T3) Jet Star, Heinz 1350, and Ottawa 78 showed lower levels of fruit infection than the other five cultivars. The rapid rise and subsequent flattening of the T3 curves of Fireball VR and New Yorker were due to their early maturity. The percentage of naturally infected (T2) fruits increased gradually in most cultivars. Overall, fruit infection rarely exceeded 30% in the spray-inoculated and 13% in the naturally infected plants.

Relationship between foliage and fruit infection

The data on the percentage of defoliation and fruit infection from the progress curves of eight cultivars were plotted to determine if a relationship between foliage and fruit infection could be established, irrespective of the conditions of infection (treatments) and of the relative susceptibility of the cultivars. The composite curve (Fig. 18) showed that more than 60% defoliation would be needed to produce 10% infected fruits; however, large variations existed especially in the higher ranges of infection.

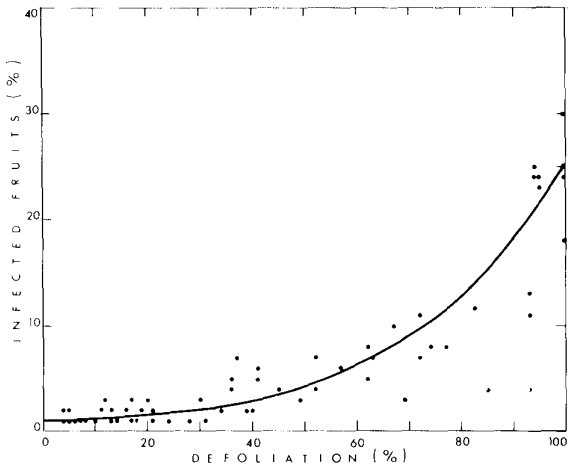


Figure 18. Composite curve showing approximate relationship between defoliation (%) and infected fruits (%) of eight tomato cultivars, irrespective of the conditions of early blight infection.

Losses due to yield reduction and fruit infection

Tomato losses may be of two kinds, quantitative and qualitative. In this study, it is assumed that a visibly infected fruit is unsalable in markets for fresh vegetables, although it could be used by processing firms depending upon the amount of fruit rot caused by the disease. These two aspects of loss are considered here.

Under conditions of natural infection, the mean yields (average number of both healthy and infected fruits from four groups of 10 plants) of nine cultivars were not significantly less than the yield of fungicide protected plants (Table 2, cols. 1-3). Artificial inoculation caused statistically significant yield reductions in five cultivars (Table 2, cols. 1, 4 and 5). The overall loss due to reduction in yield ranged from 0% in Mini-Rose to 10-34% in other cultivars.

Losses from infection of fruits were significant in three of nine naturally infected cultivars (Table 2, col. 9), and in all artificially inoculated ones (Table 2, col. 11). The average percentage of infected fruits of the cultivars tested during 1969-71 is presented in Table 3. Fruit infection ranged from 13% to 36.9% on artificially inoculated plants and 3.9% to 12.7% on naturally infected plants of most cultivars except Mini-Rose which had no fruit infection. Very few (0.5-3.5%) fruits of the plants protected by fungicide showed symptoms of early blight.

Discussion

The measurement of early blight on tomato foliage by counting the number of leaves killed (75% or more damage) was less time consuming and more objective than by estimating the area of the lesions with the aid of standard area diagrams (8, 11). Results (Table 1) indicate that in order to obtain typical disease progress curves (12, 15), the percentage of killed leaves alone could be used satisfactorily. It would appear that the small amount of necrotic area (leaf spots) on the remaining green leaves can be disregarded as far as yield loss is concerned. Tomato plants tolerated more than 60% defoliation from natural infection without showing significant reduction in yield (cf. Figs. 1-9 and Table 2). Although Khan & Sagar (9, 10) reported that all leaves contribute to fruit production, it is interesting to note that in de-leafing experiments (3,4), the loss of up to 32 leaves per plant caused no yield loss in tomato. Based on our results, it appears that yield reductions of 10-34% may occur only from early epiphytotics, comparable to those created by deliberate inoculation. Therefore, when the disease is not in epiphytotic proportions, the loss would be only from the number of visibly infected

Table 2. Effects of early blight on yield and fruit infection of 9 field-grown tomato cultivars under conditions of fungicide protection (control), natural infection, and artificial inoculation with *A. porri* f. sp. *solani* in 1971

Tomato cultivar	Mean yield[a] and percent reduction[b] of fruits						Average number and percentage of infected fruits						
	Control	Natural infection		Artificial inoculation			Control		Natural infection		Artificial inoculation		
	Yield	Yield	% reduction	Yield	% reduction	S.E.[c]	No.	%	No.	%	No.	%	S.E.
Campbell 19	357.8	313.7	12.32	268.5*[d]	24.95	24.30	1.0	<1	27.0*	8.6	84.8**	31.58	3.30
Fireball VR	324.0	291.0	10.18	258.3	20.27	15.46	3.0	<1	31.8**	10.92	76.8**	29.73	3.75
H 1350	352.8	289.5	17.94	239.8*	32.02	26.44	0.8	<1	15.8	5.45	31.8*	13.26	7.53
Jet Star	365.3	317.5	13.08	327.0	10.48	21.94	3.0	<1	17.3	5.44	30.3*	9.26	5.40
John Baer	381.3	395.8	- 3.80	342.3	10.22	15.32	1.5	<1	50.8*	12.83	88.3**	25.79	9.74
New Yorker	367.5	323.0	12.10	241.5**	34.28	13.98	0.5	<1	12.5	3.86	61.0**	25.25	6.55
Ottawa 78	322.8	273.3	15.33	230.5*	28.93	19.74	2.5	<1	9.5	3.47	31.0**	13.44	2.64
Trent	391.0	330.5	15.47	283.8*	27.41	16.91	1.3	<1	13.3	4.03	56.5**	19.90	6.80
Mini-Rose[e]	621.7	622.0	0.00	693.0	0.00		0.0		0.0	0.00	0.0	0.00	

[a] Mean number of fruits from 4 replications, each containing 10 tomato plants.

[b] Based on yield of control plants (col. 1).

[c] Standard error of the grand mean as obtained from analysis of variance with actual number of fruits.

[d] Level of significance, * at 5% and ** at 1%, by L.S.D. values from the mean of control (fungicide protected) plants.

[e] Mini-Rose produced large numbers of small fruits (avg diameter 1") with no loss due to early blight.

Table 3. Percentage* of infected fruits of nine tomato cultivars under conditions of fungicide protection, natural infection, and artificial inoculation with *A. porri* f. sp. *solani*

Tomato cultivar	Fungicide protection	Natural infection	Artificial inoculation
Campbell 19	1.6	12.7	31.2
Fireball VR	1.0	8.1	34.4
Heinz 1350	2.3	6.2	18.9
Jet Star	1.4	6.8	13.1
John Baer	2.4	12.2	36.9
Mini-Rose	0.0	0.0	0.0
New Yorker	1.1	6.4	20.9
Ottawa 78	1.3	7.2	13.0
Trent	2.1	3.9	21.3

* Based on the average of 3 years for John Baer (1969-71) and 2 years (1970-71) for the remaining tomato cultivars.

fruits. This loss, however, may not be considered too serious to the tomato processing industries except for the possible increase in mold count.

An attempt was made to correlate percent defoliation and fruit infection, as was done by Horsfall and Heuberger (6), in order to estimate the amount of fruit infection from defoliation data. The composite curve (Fig. 18) for the cultivars tested shows only an approximate relationship between defoliation and fruit infection. It indicates that the amount of infected fruits can be expected to be less than 10% unless defoliation exceeds 60% and that the upper limit of fruit infection would be near 30% even in severe disease outbreaks.

It may be concluded that a reliable estimate of loss can be made directly from the percentage of infected fruits and that the percent defoliation bears only an approximate relationship to fruit infection. The measurement of necrotic areas on leaves that are not killed seems unnecessary in relation to estimation of loss.

Acknowledgments

The author wishes to thank C.S. Shih, Statistical Research Service, Agriculture Canada, Ottawa, for helpful suggestions, and S.I. Wong for technical assistance.

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CONTROL OF STORAGE DISEASES OF CARROTS WITH POSTHARVEST FUNGICIDE TREATMENTS[1]

C. L. Lockhart[2] and R. W. Delbridge[3]

Abstract

Postharvest treatment of washed carrots with benomyl or thiabendazole type fungicides gave significantly better control of storage decay than did Dowicide A. Gray mold and crater rots were the dominant types of decay.

Résumé

Le traitement d'après-récolte des carottes lavées, avec des fongicides de type benomyl ou thiabendazole a donné des résultats significativement meilleurs qu'avec le Dowicide A contre la pourriture d'entrepôt. La moisissure grise et les pourritures en cratère étaient les principaux types de pourriture.

Previously it was shown that decay of carrots stored for 15 or 16 weeks was significantly reduced by washing, grading, and treating them with fungicides prior to storage (2). One of the fungicides, Dowicide A, was adopted for commercial use but has not been consistently effective in controlling rots of carrots for long storage periods, and it became evident that better control measures were needed. Recently, Derbyshire and Crisp (1) found that benomyl postharvest dips were effective in controlling decay of carrots stored for 7 months. One year's test with thiabendazole (2) indicated that it was effective.

This paper presents further tests on postharvest fungicide treatments for the control of decay of carrots stored in a commercial jacketed cold storage.

Materials and methods

In 1972 and 1973 carrots (Daucus carota L. var. sativa D.C. cv. Nantes) machine harvested in late September were washed, spray rinsed and graded as previously described (2), except that excess soil was washed off prior to the entry of the carrots into the washer, and a final rinse of clean well water replaced the pond water used previously. The prestorage fungicide treatments and rate of formulation/100 gal of water were as follows:

1. Washed control - carrots from conveyer following grading.
2. Dowicide A (97% sodium orthophenyl phenate, Dow Chemicals of Canada Ltd., Sarnia, Ontario), 0.5 lb.
3. Benlate 50 W (50% benomyl, DuPont of Canada Ltd., Montreal, Quebec), 0.5 and 1.0 lb.
4. Benlate T-20 (30% benomyl and 30% thiram, E. I. DuPont de Nemours and Company (Inc.) Wilmington, Delaware, U. S. A.), 0.5 lb.
5. MPXP-37 (experimental liquid formula of thiabendazole of unknown concentration in hypophosphate. Merck Chemical Division, Merck and Co., Inc., Rahway, New Jersey U. S. A.), 10 fl oz.
6. Mertect 460 (60% thiabendazole, Merck Sharp and Dohme Canada Ltd., Kirkland, Quebec), 0.56 and 1.12 lb in 1972.
7. Mertect Flowable (41.8% thiabendazole, Merck Sharp and Dohme International, Division of Merck and Co. Inc., Rahway, New Jersey, U. S. A.), 6 and 12 fl oz in 1973.

The fungicides were applied to the carrots on the conveyor belt following final water rinse. Dowicide A was drenched onto the carrots while the other fungicide treatments were sprayed on at 200 p.s.i. Each treatment was applied to four 18-bushel bulk bins of carrots. The carrots were held for 17 weeks (1972-73) and 14 weeks (1973-74) in a jacketed cold storage at 0 C and 97-100% R.H. and then graded into healthy or rots and weighed.

The rots were identified visually and the causal organisms verified by isolations onto potato dextrose agar from a 10-lb sample of rotted carrots from each treatment.

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For statistical analyses data on rots were transformed to angles.

Results and discussion

No field rots were found in 1972 or 1973 when the carrots were graded. This was attributed to growing carrots in fields known to be free of Botrytis problems, and to favorable weather during the growing season. Growers had experienced severe losses from Botrytis cinerea Pers. when carrots were grown in fields previously vacated by pea and bean growers because of gray mold rot problems. Better growing practices and changing the final prestorage rinse from pond water to well water may have accounted for most of the decrease in decay of the washed and graded control to 2% or less (Table 1) compared to losses of 6.1% to 10.3% reported previously (2).

There was significantly less storage decay in carrots that had received postharvest treatment with benomyl and the thiabendazole type fungicides than in those treated with Dowicide A or that were washed and graded only (Table 1). In 1972-73 Benlate 50W gave better control at 1.0 lb/100 gal than at 0.5 lb/100 gal but in 1973-74 there was no significant difference in % decay between the two rates. Control with Benlate T20 was not significantly different from that with Benlate 50W. The various formulations of thiabendazole were equally effective and control was comparable to that obtained with the two benomyl compounds.

Table 1. Percentage rots in carrots stored at 0 C and 97-100% relative humidity for 14-17 weeks

Postharvest treatment	Rate per 100 Imp gal	% decay 1972-73	% decay 1973-74
Washed and graded		2.1 a*	1.8 b
Dowicide A	0.5 lb	1.3 ab	3.2 a
Benlate 50W	1.0 lb	0.1 d	0.3 c
Benlate 50W	0.5 lb	0.8 b	0.4 c
Benlate T20	0.5 lb	**	0.6 c
Mertect 460	1.12 lb	0.4 cd	
Mertect 460	0.56 lb	0.3 cd	
MPXP-37	10 fl oz	0.3 cd	0.3 c
Mertect Flowable	12 fl oz		0.6 c
Mertect Flowable	6 fl oz		0.4 c

* Letters indicate treatments which do not differ significantly in Duncan's Multiple Range groupings at the 5% level.

** Blank spaces indicate no evaluation.

Table 2. Types of rots and loss in pounds of carrots stored at 0 C and 97-100% relative humidity for 14-17 weeks (avg of 4 replicates each averaging 800 lb)

Postharvest treatment	Rate per 100 Imp gal	1972-73 *Botrytis*	1972-73 Crater	1972-73 Total	1973-74 *Botrytis*	1973-74 Crater	1973-74 Others***	1973-74 Total
Washed and graded		9.9	5.6	16.5 a*	9.4	3.8	1.3	14.5 b
Dowicide A	0.5 lb	8.5	1.9	10.4 ab	20.6	3.1	1.8	25.5 a
Benlate 50W	1.0 lb	0.45	0.45	0.9 d	0.4	1.2	0.7	2.3 c
Benlate 50W	0.5 lb	2.3	4.3	6.6 b	0.5	0.5	2.2	3.2 c
Benlate T20	0.5 lb	**			0.8	1.7	1.5	4.0 c
Mertect 460	1.12 lb	1.3	0.1	1.4 cd				
Mertect 460	0.56 lb	2.5	1.1	3.8 cd				
MPXP-37	10 fl oz	0.9	0.9	1.8 cd	0.5	1.1	0.5	2.1 c
Mertect Flowable	12 fl oz				1.0	2.1	2.1	5.2 c
Mertect Flowable	6 fl oz				0.3	0.9	1.5	2.7 c

* Letters indicate treatments which do not differ significantly in Duncan's Multiple Range groupings at the 5% level.

** Blank spaces indicate no evaluation.

*** Indicates rots caused by *Alternaria* spp., *Fusarium* spp., *Penicillium* spp. and bacteria.

Gray mold (B. cinerea) rot was the most prominent type of decay of stored carrots followed by crater rot (Rhizoctonia), and miscellaneous rots caused by Alternaria spp., Fusarium spp., Penicillium spp. and bacteria (Table 2).

The results obtained in this study confirm those of Derbyshire and Crisp (1) and of Wells and Merworth (3) that benomyl is an effective postharvest fungicide treatment for control of decay on stored carrots. Thiabendazole in various formulations is also effective.

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CHLOROTIC LEAFSPOT AND STIPPLE SPOT, NEWLY DESCRIBED DISEASES OF BUCKWHEAT IN MANITOBA[1]

R. C. Zimmer[2]

Abstract

Large, mostly circular chlorotic lesions were observed on the upper leaves of buckwheat (Fagopyrum esculentum) plants in plots at the Morden Research Station and in commercial fields in 1972 and 1973. They were present on plants by the beginning of flowering. Another lesion type, a tan stipple-like necrotic spotting, was observed also in several commercial plantings in 1973. Isolates of Alternaria alternata and Bipolaris sorokiniana were obtained from diseased foliage as well as from seed. The Alternaria isolates were not pathogenic but the Bipolaris isolates from both seed and foliage caused a tan stipple-like necrotic spotting on inoculated buckwheat leaves. The chlorotic leafspot symptoms were not observed in any of the inoculation tests.

Résumé

On a constaté en 1972 et 1973 de grandes lésions chlorotiques, généralement circulaires, sur les feuilles supérieures de plants de sarrasin (Fagopyrum esculentum) à la Station de recherches de Morden et dans des cultures commerciales. Ces lésions étaient apparues dès le début de la floraison. On a aussi observé, en 1973, dans plusieurs plantations commerciales, un autre genre de lésion en forme de tachetures nécrotiques brunes pointilliées. On a obtenu des isolats d'Alternaria alternata et de Bipolaris sorokiniana sur feuillage et des semences atteintes. Les isolats d'Alternaria n'étaient pas pathogènes mais ceux de Bipolaris inoculées sur sarrasin ont produit des taches nécrotiques brunes pointilliées sur les feuilles. On n'a observé aucun symptôme de taches chlorotiques dans les essais d'inoculation.

Russian investigators (3) have observed considerable yield reduction in buckwheat caused by botrytis rot (Botrytis cinerea Pers.), downy mildew (Peronospora fagopyri Elen.), fusarium wilt (Fusarium sp.), and blight (Phytophthora parasitica Dost.). Other less destructive diseases of buckwheat have been reported (1,2,3,4). This is apparently the first reference to a chlorotic leafspot, and to a tan stipple-like necrotic spotting caused by Bipolaris sorokiniana (Sacc. in Sorok.) Shoem., perf. stat. Cochliobolus sativus (Ito. & Kurib.) Drechsler. ex Dastur.

Observations and results

In August 1972 chlorotic lesions were observed on leaves of 6- to 8-week-old buckwheat (Fagopyrum esculentum Mill.) plants, which were beginning to flower or were in full flower in field plots at the Agriculture Canada Research Station, Morden, Manitoba. Similar symptoms were observed in several commercial buckwheat fields in Manitoba. Approximately 50% of the leaves on the upper half of the plants were affected. The lesions were randomly located on the leaf blade and were mostly circular, ranging in diameter from 12-26 mm with an average of 20 mm. They were categorized into three types: type 1 - spreading, uniformly chlorotic (Fig. 1); type 2 - spreading, with concentric chlorotic bands alternating with normal dark-green tissue (Fig. 2): type 3 - small restricted lesions (Fig. 1) with borders more sharply defined than in the spreading type. Necrosis occurred in the more advanced lesions and in the older chlorotic rings of Type 2 lesions.

Investigations into the etiology of the chlorotic leafspot disease did not suggest that the disease was caused by a bacterium. To test for virus infection, healthy buckwheat and cucumber plants in the first true leaf were inoculated by rubbing with juice expressed from diseased leaves. Also, aphids were allowed to feed on diseased leaves for 48 hours before being transferred to healthy buckwheat and cucumber plants. None of the test plants developed symptoms of the disease.

Since many phytopathogenic fungi are seedborne, remnant seed, from the lots used to plant the plots at the Research Station, was examined for internal fungi. One hundred seeds of each of the cultivars, Tokyo and Tempest were surface-sterilized for 1 minute in a 1:1 mixture of 2% Javex and 70% ethanol

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and plated on potato dextrose agar. Alternaria alternata (Fr.) Keissler, syn. Alternaria tenuis, was isolated from 38% of the Tokyo seed and from 41% of the Tempest seed. Another fungus, Bipolaris sorokiniana, was isolated from 6% of the Tokyo seed and from 2% of the Tempest seed.

During the 1973 growing season buckwheat plots at the Morden Station, the Portage la Prairie Sub-station, and 18 commercial buckwheat fields were observed for disease. In the plots as well as in many of the commercial fields the chlorotic leaf lesion (Type 1) was observed again. Another lesion type, a tan stipple-like necrotic spotting, was also observed (Fig. 3).

Of 61 isolations made from diseased foliage in 1973, 59 resembled A. alternata and two were B. sorokiniana. The Alternaria isolates were obtained from the lesion types illustrated in Figures 1 and 2. The Bipolaris isolates were obtained from the tan stipple-like lesions illustrated in Figure 3.

Pathogenicity tests were carried out with isolates from seed as well as with foliage isolates. In these tests the Alternaria isolates were not pathogenic. The Bipolaris isolates caused a tan stipple-like necrotic spotting similar to that observed in the field (Fig. 3). A re-isolate of B. sorokiniana resembled the original inoculum and caused a similar tan stipple-like spotting.

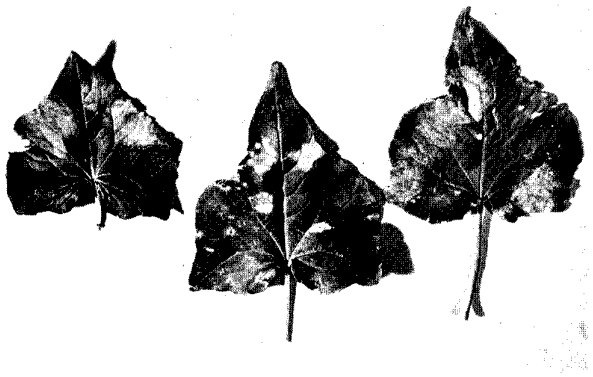

Figure 1. Center leaf illustrates restricted lesions (type 3); the two outside leaves illustrate the spreading, continuous chlorotic lesions (type 1).

No evidence of the chlorotic type leafspot was observed during these pathogenicity tests.

From observations made during the past 2 years these diseases do not appear to be of economic importance. The fungi studied were identified at the Biosystematics Research Institute, Agriculture Canada, Ottawa, Ont., and representative isolates have been deposited in the mycological herbarium as DAOM 145824, Alternaria alternata; and DAOM 145801, Cochliobolus sativus.

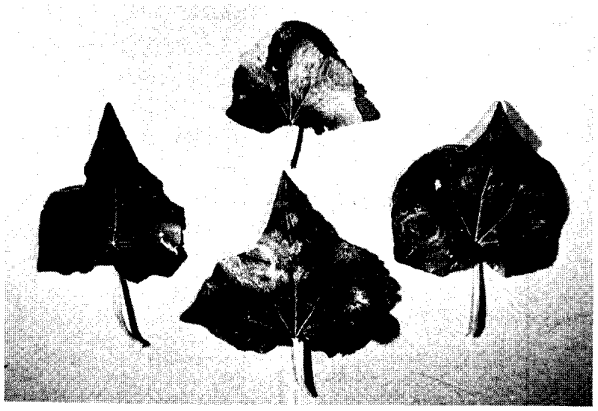

Figure 2. Spreading type lesions with concentric chlorotic bands alternating with normal dark-green tissue (type 2).

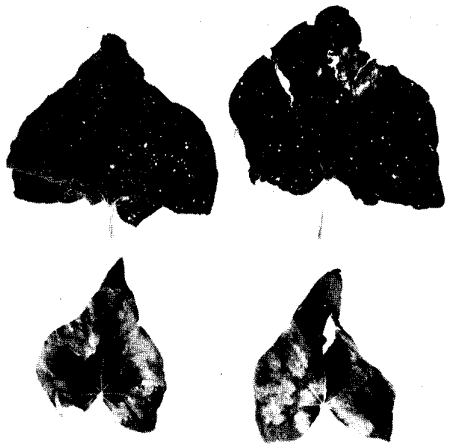

Figure 3. Stipple spot predominates on the upper leaves. Chlorotic leafspot is present on the lower leaves and one lesion is present on the upper right leaf. These leaves were collected from a commercial field August 21, 1973.

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SURVEY FOR VERTICILLIUM WILT OF TOBACCO IN QUEBEC, 1972

J. W. Sheppard and M. A. Viswanathan[1]

Abstract

Verticillium wilt of tobacco was found to occur naturally in Quebec. The pathogen in this case was not the highly virulent species Verticillium dahliae, but the less virulent V. nigrescens. Four commonly grown tobacco cultivars in Quebec were found to be susceptible to V. dahliae while only two were susceptible to V. nigrescens. Studies with 45 cultures of Verticillium from a wide range of hosts and geographical locations have indicated that some specilization occurs within the cultures in respect to host preference. Cultures from solanaceous hosts were more pathogenic on tobacco than cultures from non-solanaceous hosts.

Résumé

On a observé l'apparition spontanée de la flétrissure verticillienne du tabac au Québec. Le pathogène observé n'étaient pas le très virulent Verticillium dahliae mais une espèce moins virulente V. nigrescens. Quatre cultivars couramment cultivés au Québec étaient susceptibles à V. dahliae, mais deux seulement à V. nigrescens. Des études effectuées sur 45 cultures de Verticillium provenant d'hôtes et de secteurs géographiques très variés portent à croire qu'une certaine spécialisation se produit dans les cultures quant à la préférence pour l'hôte. Les cultures prélevées sur solanacées étaient plus pathogènes pour le tabac que celles provenant d'autres hôtes.

Verticillium wilt has become a limiting factor in tobacco production in New Zealand, where the disease is attributed chiefly to Verticillium dahliae Kleb. In 1971, 6.5% of the total tobacco acreage of New Zealand was affected and one fifth of this area has been put out of production (Wright 1972). Verticillium wilt of tobacco has been known to occur elsewhere, including the U.S.A., but has generally been regarded as being unimportant (Lucas 1965). The disease in New Zealand is believed to have originated on tobacco planted in soil where potatoes and tomatoes had been grown. Similar climatic conditions exist in Quebec, where the major tobacco growing region is also an important potato growing area. Verticillium wilt caused by V. albo-atrum Reinke & Berth. is increasing rapidly in the potato crop and environmental conditions are suitable for development of the disease on tobacco in Quebec (Wright and Sackston 1973).

Verticillium wilt of tobacco is characterized by bright orange "tiger-stripe" discoloration of diseased leaves. External symptoms are not apparent until about the time of flowering. One of the first symptoms is wilting of the lower leaves, followed by the orange discoloration of the interveinal areas, which, as the disease progresses, turns brown leaving an orange border between living and dead tissue. Eventually all the leaves may become infected, often before they can be harvested (Thompson and McLeod 1959).

In 1972 a survey of the tobacco producing area of Quebec, primarily L'Assomption and Joliette counties, was undertaken to determine the presence of the disease in this province. With the advice and co-operation of Marcel Dupré of the Agriculture Canada Research Station at L'Assomption, Quebec, major tobacco growers in the province were located.

The ability of several strains of Verticillium dahliae and V. albo-atrum from various hosts and geographical locations in Quebec and elsewhere to attack and cause disease in tobacco was also investigated. In addition four commonly grown tobacco cultivars were tested for resistance to the disease.

Materials and methods

Thirty tobacco fields were visited twice during the 1972 growing season. The first circuit began early in August just before flowering. The second circuit of the tobacco survey began August 19 and the survey was terminated by September 9. Leaf samples from over fifty plants exhibiting Verticillium-like symptoms were collected. Midribs were removed and surface sterilized using a 50%

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sodium hypochlorite solution, and plated on V-8 juice agar. After 7-10 days incubation at 25 C the plates were examined for signs of Verticillium growing from the tissues.

Cultures of Verticillium used for inoculation of test plants were grown for 14 days on potato dextrose agar at 25 C. The cultures were then comminuted in a Waring Blendor for 3 minutes and the inoculum concentration adjusted to 30 x 10^6 propagules per ml using a haemocytometer.

Test plants were inoculated by the root dip technique. Forty-day-old seedlings were removed from the seedbed and all soil was removed from the roots by gentle washing. The seedlings were then placed for 5 min in a beaker containing the inoculum suspension before transplanting into randomized rows in field plots. The plants were observed routinely and isolations made from all plant showing symptoms of the disease.

The four commonly grown cultivars of Nicotiana tabacum L. used in the course of this investigation included the flue cured cultivars Delhi 34 and Hicks Broadleaf, and the cigar cultivars Ottawa 705 and RH 211.

The severity of the disease on each plant was estimated 90 days after inoculation and was recorded as the percentage of leaves showing symptoms of the disease.

Results

Survey

In 1972 the only positive identification of Verticillium on tobacco in Quebec was from one plant of cigar tobacco (Nicotiana tabacum L. cv. Ottawa 705) collected August 10 at the Agriculture Canada Research Station, L'Assomption, from a field where clover had been grown previously. The lower leaves of this plant exhibited the characteristic orange tiger-stripe discoloration and were badly wilted. The plant was in flower at the time. The disease was not identified in samples from any other place in the province, although verticillium-like symptoms were observed at six other locations in L'Assomption, Joliette, and Rouville counties.

The isolate of Verticillium collected from L'Assomption was identified as V. nigrescens Pethybr. Although this species of Verticillium has been reported on other crops in the same area (Devaux and Sackston 1966), this is the first report of V. nigrescens causing wilt of tobacco in Canada or elsewhere. The pathogenicity of this isolate of Verticillium was verified by inoculation of healthy tobacco seedlings of the cigar tobacco cultivar RH 211.

In 1973 the disease was found again in an adjacent plot at the L'Assomption Research Station, also on cigar tobacco cultivar Ottawa 705 (3 plants) and on the cigar tobacco cultivar Comstock Pomeroy (1 plant).

Pathogenicity of Verticillium cultures to tobacco

Symptoms of verticillium wilt occurred on plants of the flue-cured tobacco cultivar Hick Broadleaf inoculated with 25 of 45 Verticillium cultures tested (Table 1). However the typical tiger-stripe symptoms described by Thompson and McLeod (1959) did not develop in most cases. Early symptoms of the disease were characterized by chlorosis of the interveinal areas and wilting of the lower leaves. As the disease progressed the tissue became necrotic followed by a rapid drying out of the leaf. Pure cultures of Verticillium were isolated from all plants showing symptoms of the disease but not from the symptomless ones, nor from the controls.

Susceptibility of four commonly grown tobacco cultivars to V. dahliae and V. nigrescens

All plants of the four cultivars inoculated with V. dahliae (isolate VIFT, Wright and Sackston 1973) produced severe symptoms of the disease by the time of flowering. In decreasing order of resistance these were Ottawa 705, RH 211, Delhi 34, and Hicks Broadleaf. Cigar tobacco cultivars appeared more susceptible to attack by V. nigrescens. In descending order of resistance these were Hicks Broadleaf, Delhi 34, Ottawa 705, and RH 211.

Discussion and conclusions

Verticillium wilt of tobacco was found to occur naturally in Quebec in 1972 and again in 1973. The fungus in this case was not the highly pathogenic species V. dahliae but the less virulent V. nigrescens. Symptoms on infected plants were not always the characteristic tiger-stripe discoloration of the interveinal areas of infected leaves, as described by Thompson and McLeod (1959), but often were merely severe chlorosis and/or necrosis accompanied by wilting of the lower leaves and puckering of the lamina. This is the first report of the disease in Canada and also the first report of V. nigrescens as a pathogen of tobacco.

V. nigrescens is, in general, a relatively weak pathogen and isolates vary in their pathogenicity to tobacco and other hosts. This variability has been observed by other workers (Aubé 1963, Devaux 1964).

Studies on the pathogenicity of various cultures of V. albo-atrum and V. dahliae have shown that the tobacco cultivar Hicks Broadleaf is susceptible to both V. dahliae and V. albo-atrum. Of the two species V. dahliae is far more virulent on tobacco. There appears to be some host specificity among strains; however, strains from both related and nonrelated hosts were capable of attacking tobacco and causing the disease.

Table 1. Pathogenicity of *Verticillium* cultures on Hicks Broadleaf tobacco

Culture	Species*	Source of original culture	Original host	Pathogenicity† on tobacco
V1	V. a.	La Moline		+
V3	V. a.	La Moline	Sunflower	+
V4	V. a.	La Moline	Eggplant	+
V5	V. a.	Mac. College, Que.	Sunflower	-
V7	V. a.	Ontario	Strawberry	-
V8	V. a.	Ontario	Dahlia	+
V9	V. a.	Ontario	Eggplant	+
V10	V. a.	Ontario	Shiro plum	-
V12	V. a.	Ontario	Maple	+
V13	V. a.	Ontario	Raspberry	+
V14	V. a.	Ontario	Rose	-
V15	V. a.	Ontario	Tomato	-
V16	V. a.	P. E. I.	Potato	+
V17	V. a.	California	Tomato	-
V27	V. d.	Ontario	Tomato	-
V29	V. d.	Ontario	Strawberry	-
V30	V. d.	Ontario	Tomato	++
V51	V. a.	Versaille	Melon	-
V53	V. a.	St. Germain, Que.	Potato	++
V55	V. a.	L' Assomption, Que.	Potato	++
V57	V. d.	Mac. College, Que.	Potato	+
V60	V. a.	Fredericton, N.B.	Potato	-
V63	V. d.	Summerland, B.C.	Squash	-
V65	V. d.	Summerland, B.C.	Nightshade	-
V67	V. d.	Summerland, B.C.	Sweet pepper	-
V69	V. d.	Summerland, B.C.	*Sisymbrium altissimum*	++
V70	V. d.	Summerland, B.C.	Cantaloupe	-
V72	V. d.	Summerland, B.C.	Lamb's quarters	-
V73	V. d.	Summerland, B.C.	*Capsella bursa-pastoris*	-
V74	V. d.	Summerland, B.C.	Tomato	++
V78	V. d.	Summerland, B.C.	*Amaranthus graecizans*	+
V79	V. d.	Summerland, B.C.	Hop	-
V81	V. d.	Summerland, B.C.	Strawberry	-
V84	V. a.	Dade Co., Florida	*Crotalaria spectabilis*	-
V85	V. a.	Dade Co., Florida	*Solanum nigrum*	++
V87	V. a.	Dade Co., Florida	Okra	++
V89	V. a.	Dade Co., Florida	Southern pea	+
V91	V. a.	Dade Co., Florida	Cuban squash	+
V93	V. d.	Ste. Dorthée, Que.	Eggplant	++
V94	V. d.	Ste. Clotilde, Que.	Eggplant	-
V96	V. a.	St. Augustin, Que.	Potato	++
V97	V. a.	Deschambault, Que.	Potato	++
V98	V. a.	Ste. Clotilde, Que.	Potato	++
V75	V. d.	Summerland, B.C.	*Lactuca scariola*	++
VIFT**	V. d.	Mac. College, Que.	Tobacco	++

* V. a. = *Verticillium albo-atrum*, V. d. = *Verticillium dahliae*.

† + = Mild symptoms, ++ = severe symptoms.

** Wright and Sackston 1973.

The majority of tested cultures found to be pathogenic to tobacco were from solanaceous hosts, primarily tomato and potato, both of which are closely related to tobacco.

Of the four tobacco cultivars used in the course of this investigation all were susceptible to V. dahliae, while only Ottawa 705 and RH 211 appeared to be susceptible to the less virulent species V. nigrescens.

Verticillium wilt cannot at this time be considered a threat to tobacco production in Quebec. The occurrence of V. nigrescens as a weak pathogen on tobacco should be taken as a warning to be on the alert for more serious developments in the future. The disease in New Zealand was first reported in 1944, and it was not until 1959, 15 years later, that it became a serious problem (Thompson and McLeod 1959). Efforts should be made to

develop suitable resistant cultivars which can be made available to growers. Growers should be made aware of the problem and be advised to practice the best possible field sanitation, to ensure adequate sterilization of seedbed soil, and to use only crops resistant to verticillium wilt in rotation with tobacco.

Acknowledgments

We wish to thank Dr. W. E. Sackston, the initiator of this survey, which was made possible by a grant from the Quebec Agricultural Research Council for which we are very grateful.

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MONITORING FIELD BEANS IN ONTARIO FOR BACTERIAL BLIGHT AND ROOT ROT BY AERIAL PHOTOGRAPHY - 1972[1]

V. R. Wallen and D. Galway

Abstract

In 1972, 65 field bean (Phaseolus vulgaris) fields (1,519 acres) in the vicinity of Hensall, Ontario, were aerially photographed, using infrared film, to determine the incidence of bacterial blight and root rot. Fifty-one fields were affected by blight, with the percentage of plants infected ranging from less than 1% in most fields to 6.5%. The overall infection level, 0.668%, is the lowest recorded since the initiation of this work in 1968. Root rot was detected in 61 of the 65 fields, with 27% of the plants affected, representing over 413 acres of the crop in the area. Root rot is now more important in Ontario than bacterial blight and appears to be more severe in fields where herbicides have been used extensively.

Résumé

En 1972, on a effectué des photographies aériennes dans l'infra-rouge pour déterminer l'incidence de la brûlure bactérienne et du pourridié dans 65 champs (1,519 acres) de haricots (Phaseolus vulgaris) de la région de Hensall (Ont.). Cinquante-et-un champs étaient atteints de brûlure bactérienne, le pourcentage de plants infestés variant de moins de 1%, dans la plupart des champs, jusqu'à 6.5%. Le taux moyen d'infestation, 0.668%, est le plus faible enregistré depuis la mise en marche de ces relevés en 1968. La pourridié était présent dans 61 des 65 champs et 27% des plantes étaient atteintes, ce qui représentait plus de 413 acres cultivés de cette région. Le pourridié est aujourd'hui plus dangereux que la brûlure bactérienne en Ontario; il semble être plus virulent dans les champs où on a fait un vaste usage d'herbicides.

Aerial photographic surveys in 1968 and 1970 revealed that under a selected flight path at Hensall, Ontario, 5.22% and 6.56%, respectively, of the field bean (Phaseolus vulgaris) crops were affected by bacterial blight (1,2). This particular flight path was chosen because it contains a number of select seed plots as well as foundation and commercial bean fields. The select seed plots are disease-free or are discarded if they contain bacterial blight. Seed from these plots is used to produce, initially, pedigreed seed and, through year to year multiplication, commercial bean crops. The Hensall flight path, therefore, is important in showing the effects of the select seed program as a blight control measure, and in measuring the overall incidence of blight in the bean crop.

In 1972, in addition to the determination of blight, an attempt was made to ascertain the incidence of root rot in the crop, as it was apparent that this problem was more prevalent than in previous years.

Methods

Sixty-five bean fields representing 1,519 acres were aerially photographed in the vicinity of Hensall, Ontario. This represents a total of 30.4 line miles of aircraft flying. The flying altitude was 6,900 feet above sea level to produce a photographic scale of 1:6,000 (datum plane: 900 feet). For maximum photographic interpretation, a Zeiss camera with a 12 inch focal length and Aerochrome infrared 2443 film, 9 x 9 inch format, developed as a positive, were used throughout the study. Although flights were scheduled for August 10 and 20, flights were delayed until August 20 and September 9 due to adverse weather conditions. However, interpretations were made only from the August 20 photographs because the crop had matured by the time of the second flight and the photographs could not be interpreted.

During the period August 1 to August 23 extensive ground truth studies were carried out. Each of the 65 fields was examined twice during this period. Within each field an area of from 1 to 3 acres, depending on field size, was examined thoroughly for symptoms of blight. Infected leaf samples were collected and forwarded to the Ottawa laboratory for determination of the causal organisms, Xanthomonas phaseoli (E.F.Sm.)

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Table 1. Severity of bacterial blight and root rot in field beans in the Hensall, Ontario, area 1972

Field number	Total acreage	Bacterial blight		Root rot	
		Acreage infected	Percent infection	Acreage infected	Percent infection
1	47.433	0.1349	0.2844	0.6207	1.3085
2	15.7028	0.1706	1.0865	3.5359	22.5176
2A	19.4571	0.0232	0.1194	7.3135	37.5878
3	15.9411	0.0410	0.2575	1.4146	8.8739
4	39.8965	0.1651	0.4138	16.4805	41.3081
5	15.6778	0.0643	0.4100	6.4156	40.9216
6	35.6807	0.0164	0.0461	21.5409	60.3713
7	7.4992	0.1825	2.4331	1.4048	18.7327
8	66.8204	0.0312	0.0467	32.4909	48.6242
9	12.8704	0.0668	0.5194	2.6335	20.4617
10	18.1008	0.5539	3.0601	2.7823	15.3711
11	11.1184	0.716	6.4396	0.5986	5.3839
12	9.882	0.6469	6.5465	2.5599	25.9047
13	17.1956	0.4636	2.6962	3.2482	18.8897
14	10.0459	0.1519	1.5119	2.4871	24.7574
15	75.7727	0.0169	0.0223	17.9899	23.7419
16	20.7248	0.0153	0.074	13.2116	63.7478
17	68.9842	0.0512	0.743	11.7878	17.0877
18	5.6543	0.0091	0.1608		
19	19.4262	0.0613	0.3158	2.9871	15.3766
20	9.0092	0.0780	0.8664	5.201	57.7299
21	39.5451	0.0977	0.2471	18.2076	46.0426
22	25.3387			10.9407	43.1778
23	54.1598	0.5689	1.0504	27.1611	50.1499
24	13.0135	0.0192	0.1475	1.0403	7.9940
25	36.7393	0.0274	0.0747	13.1623	35.8262
26	13.2205	0.2821	2.1338	2.9949	22.6535
27	48.9666	0.0168	0.0343	25.2076	51.4792
27A	40.689	0.9120	2.2316	15.4549	37.9830
28	21.4758	0.0323	0.1505	7.2479	33.7492
28A	7.1388	0.0767	1.0741	2.8094	39.3540
29	33.4232	0.1379	0.4127	3.7190	11.3424
30	67.5289	1.6338	2.4194	0.1714	0.2538
31	22.9904	0.1064	0.4629	2.8582	12.4322
32	38.8088	0.0755	0.1945	0.1759	0.4533
33	13.8518	0.0627	0.4528	0.3463	3.2689
34	1.3658				
35	9.3242			0.0033	0.0354
36	24.1668	0.0148	0.0612	0.1237	0.5119
37	3.0563	0.1122	3.6715	0.1888	6.1774
38	2.5566			0.1218	4.7614
39	2.8988	0.0467	1.6124	0.1446	4.9883
40	2.7750			0.3777	13.6108
41	11.6208	0.1158	0.9964	1.3513	11.6283
42	8.4342	0.0125	0.1481	2.6172	31.0308
43	15.0423	0.4668	3.1036		
43A	4.4658	0.0814	1.8218		
44	18.6231	0.0174	0.0577	1.8693	10.0375
45	40.0171			2.5676	6.4163
46	10.6074			0.7727	7.2845
47	57.1723	0.0091	0.0159	2.0446	3.5762
48	10.1839			2.231	21.9071
49	46.665	0.0400	0.0858	30.6345	65.6477
50	50.1094	0.0086	0.0215	19.537	48.7093
51	48.6915	1.447	3.0182	31.2646	64.2096
52	39.4608			13.3208	33.7570
53	21.6339	0.0119	0.0552	1.7040	7.8765
54	9.5163	0.0268	0.2383	4.0381	42.4335
55	1.8515			0.0583	3.1488
56	1.9066			0.2412	12.6508
57	17.217	0.0159	0.0928	1.989	11.5525
58	9.9191			4.1443	41.7810
58A	7.3185			1.6755	22.8440
59	9.8883	0.0093	0.0938	3.0598	30.9436
60	14.0836			0.7933	6.6328
Total acreage	1519.8715	10.1457		413.4004	
Overall percent infection			0.668		27.1997

Dows. and Xanthomonas phaseoli var. fuscans Burkh. (Starr. & Burkh.). Patterns of root rot were noted in affected fields but root samples were not taken.

Disease interpretations were made from 9 x 9 inch color prints and ground truth notes. The field infection levels were determined using the drum scanner method (3).

Results and discussion

Fifty-one of the sixty-five fields were infected with blight to some extent (Table 1). Although most fields had less than 1% of the crop area affected, infection levels ranged up to 6%. The overall infection was low, 0.668% involving 10 acres of a total of 1,519 acres photographed and interpreted. This level of infection is the lowest since aerial photography of the crop was initiated in 1968. Future surveys will determine if the low level of blight in 1972 was the result of the select bean program, initiated in 1967. August conditions for an epiphytotic of blight in 1972 were similar to those in 1968, when 5.22% of the crop was infected, as mean daily temperatures in both years were the same and the relative humidities varied between 78% and 80%. The fact that 48 of the 65 fields contained less than 1% infection, indicates a low level of seed infection.

By ground truth survey, 41 fields were found to be infected with blight, 10 less than by photographic interpretation. Of the 10 affected fields missed in the ground survey, nine showed less than 0.5% infection. The difference between the ground and aerial survey results can be accounted for in part because it was not possible to cover more than 20% of the larger fields by ground survey whereas the entire area of each field was photographed and interpreted. Pathogenic cultures of X. phaseoli (common blight) or of X. phaseoli var. fuscans (fuscous blight) were isolated from leaves from 32 of 41 fields sampled. Isolates of X. phaseoli were isolated more frequently than X. phaseoli var. fuscans (Table 2). This trend has persisted since 1970, although the initial epiphytotics of bacterial blight in 1961 and 1962 were caused primarily by X. phaseoli var. fuscans (4).

Table 2. Frequency of occurrence of *X. phaseoli* and *X. phaseoli* var. *fuscans* in bean fields, 1970-72

Year	Number of fields affected by		
	X. phaseoli	*X. phaseoli* var. *fuscans*	Both pathogens
1970*	30	21	4
1971*	36	6	
1972**	29	12	9

* Data from fields in Chatham and Hensall areas; a total of 84 and 69 fields were examined in 1970 and 1971, respectively.

** Data from Hensall area; a total of 65 fields were examined.

Root rot was present in 61 of the 65 fields under the flight path and more than 27% of the plants were infected, representing over 413 acres of the crop in the area. No information is available on the incidence of root rot in previous years or on the effect of root rot on yield. Root rot appears more severe in fields where herbicides have been used extensively over a number of years and there is apparently some confusion in distinguishing between herbicide injury and root rot.

Literature cited

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