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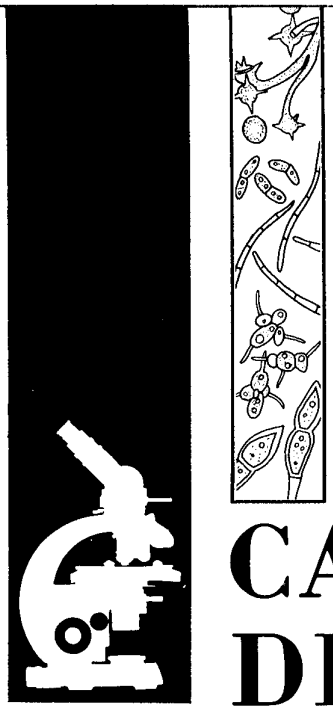
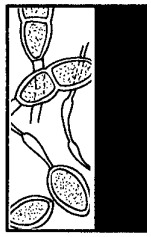


CANADIAN PLANT DISEASE SURVEY



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CANADIAN PLANT DISEASE SURVEY

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

CONTENTS

"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."

SURVEY OF FUNGICIDE SPRAYING PRACTICE FOR POTATO LATE BLIGHT IN PRINCE EDWARD ISLAND, 1972[1]

W.C. James,[2] C.S. Shih,[3] and L.C. Callbeck[4]

Abstract

All the seed potato acreage surveyed in P.E.I. was treated with one or more fungicide sprays to control late blight. Despite the fact that late blight was not prevalent in 1972, farmers applied an average of 5.4 sprays and used over 81 metric tons (approx 180 thousand lb) fungicide to protect 32,000 acres at an estimated total cost (fungicide and application) of about $0.5 million. Mancozeb was the fungicide most commonly used followed by maneb and metiram, the three accounting for 90% of the total. About half the farmers employed a routine spray schedule. Fewer sprays were applied to early cultivars and those possessing some resistance to blight than to late cultivars and those with no resistance. Almost three-quarters of the farmers used the same spray schedule for all the potato acreage on their farm and almost all used top killers. Four thousand acres were surveyed on 133 farms which grew a total of 15,000 acres of potatoes. The farms were selected in proportion to the potato acreage in each farm size group.

Introduction

Approximately 250,000 acres of potatoes (18) worth $100 million were grown in Canada in 1972. Forty thousand of these acres, including 32.4 thousand acres of seed potatoes, were grown in Prince Edward Island, where the warm humid climate usually favors the development of late blight disease caused by the fungus Phytophthora infestans (Mont.) de Bary. Losses due to blight may be substantial if no fungicides are used, and methods have been developed to measure these losses (8,9). Attempts have been made in many countries to develop cultivars resistant to P. infestans using either hypersensitive or vertical resistance (19) controlled by one or more r genes (1) or using field or horizontal resistance controlled by many genes (2,12). Since neither approach has yet led to success (16) fungicide spraying remains the only effective method of disease control available to farmers. Much research work has been done on the efficacy of new fungicides (5, 6, 7) and on the optimum frequency and timing for fungicide spray schedules (4). In conjunction with fungicide spraying, forecasting schemes are operated in many countries (10, 20, 21), the basis of which is the noting of critical weather periods conducive to the development of blight, followed by appropriately timed warnings to farmers for the spraying of their potato crops (3).

The number of sprays required depends on the progress and severity of the epidemic. In Prince Edward Island some crops are sprayed ten or more times but detailed information on the current spray programs operated by farmers is lacking. The object of this study was to collect information on current fungicide spraying practices for late blight control of seed potato producers in Prince Edward Island, who grow about 80% of the province's total potato acreage.

Methods

Farms were assigned to twelve size groups according to their 1971 seed potato acreage and a random sample of farms was selected within groups (see Fig. 1 for distribution) so that the numbers selected were approximately proportional to the acreage in each size group (Table 1).

A table of sampling numbers (Table 2) was used to select a field of potatoes at random. The seed potato fields on each selected farm were numbered and the field to be surveyed was chosen by referring to the table. For example, if there were six potato fields on the first farm visited, field no. 3 was selected and then 3 was deleted before the sampling table was used on another farm. A

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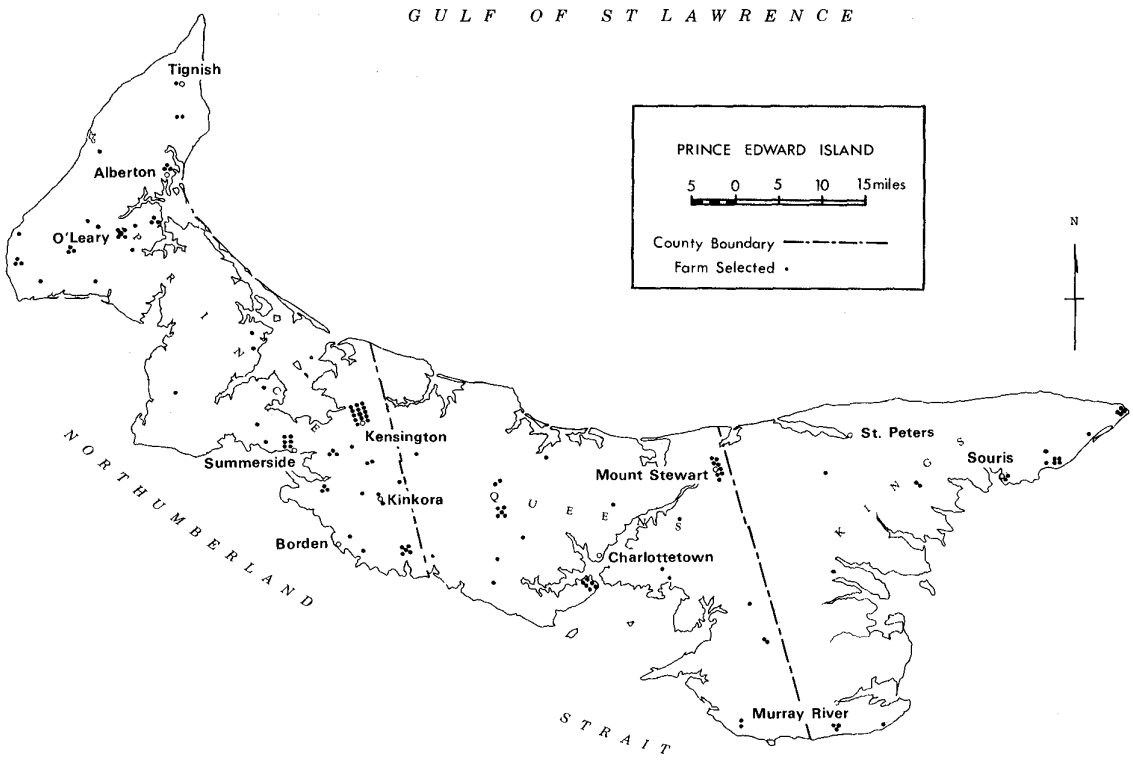

Figure 1. Approximate location of farms in the 1972 survey of fungicide spraying practice for potato late blight.

Table 1. Distribution by number and potato acreage of seed potato farms in Prince Edward Island, 1972

Size group	Seed potato acreage/farm	Farms surveyed			All seed potato farms*	
		No.	Acreage surveyed	Acreage grown	No.	Acreage
1	up to 10	24	162	181	441 (49)	2,419 (7)
2	11- 20	10	103	157	174 (19)	2,526 (8)
3	21- 30	10	118	248	74 (8)	1,879 (6)
4	31- 40	7	130	237	35 (4)	1,244 (4)
5	41- 50	7	322	319	26 (3)	1,194 (4)
6	51-100	19	672	1,491	73 (8)	5,337 (16)
7	101-200	33	1,515	4,549	55 (6)	7,697 (24)
8	201-300	15	764	3,642	19 (2)	4,590 (14)
9	301-400	4	225	1,423	4 <1	1,320 (4)
10	401-500	1	15	476	2 <1	861 (3)
11	501-600	1	20	558	3 <1	1,698 (5)
12	over 600	2	69	1,641	2 <1	1,641 (5)
Total		133	4,015	14,922	908 (100)	32,406 (100)

* Figures in parentheses are number or acreage as percentage of total.

reserve list of farms was also selected for each size group and these farms were used as alternatives if any of the selected farms could not be surveyed.

Table 2. Sampling numbers for selecting a random potato field

Number of potato fields/farm										
2	3	4	5	6	7	8	9	10	11	12
1	3	4	1	3	3	7	2	10	1	11
2	1	1	4	5	5	8	1	4	7	3
	2	2	3	4	4	5	5	6	5	12
		3	5	6	6	4	9	8	9	7
			2	2	7	2	6	2	8	2
				1	2	1	8	3	6	8
					1	3	7	5	4	1
						6	4	9	2	4
							3	1	11	9
								7	3	5
									10	10
										6

For each field selected the following information was requested by questionnaire from the grower: grower's name and address; acreage and cultivar grown in the field selected; date of planting; name and amount of fungicide applied (lb/acre, volume/acre); method and dates of application; estimated amount of blight on foliage (none to severe) at date of top killing; method and date of top killing; date of harvest; total potato acreage grown, by cultivar; and the uniformity of spray scheduling for all fields. The questionnaires were delivered to the growers in June and collected in the autumn by agricultural officers who used the visits to clarify any points in the questionnaire with the farmers. Before the questionnaires were processed, the distribution of acreage in 1972 was compiled, based on 1972 seed potato statistics. The percentage acreage of the size groups was used as weights to calculate provincial averages, e.g. amount of fungicide applied per acre. Some of the questionnaires were not fully completed and, therefore, tables may be based on different numbers of farms. The data were coded and tabulated by computer.

Results

All the fields surveyed were treated with fungicides and received from 1 to 12 spray applications, the provincial weighted average being 5.4 sprays. Table 3 shows that, in general, the more potatoes a farmer grew the more frequently he sprayed. Farms growing 100 acreas or less of seed potatoes applied an average of 4.4 fungicide sprays compared with 5.9 for those growing more than 100 acres. One-tenth of the crops sampled had received the first fungicide application by the end of June and approximately half of the crops had been sprayed by mid-July (Table 4). One-third of the blight susceptible, early maturing Irish Cobbler crops had been sprayed by the end of June, whereas only a very small percentage of Kennebec and Sebago and no Netted Gem crops had been sprayed during the same period.

Table 3. Number of fungicide sprays applied to control late blight in P.E.I., 1972

Size group	Potato acreage per farm	Average number of fungicide sprays
1	up to 10	4.0
2	11- 20	4.6
3	21- 30	4.3
4	31- 40	4.2
5	41- 50	4.8
6	51-100	4.9
7	101-200	5.5
8	201-300	6.1
9	301-400	7.0
10	401-500	8.0
11	501-600	5.0
12	over 600	8.0
1-12	Overall weighted mean	5.4

Table 4. Dates of first application of fungicides

Period	Percentage of crops receiving first fungicide spray
June 20 - June 24	5
June 25 - July 1	5
July 2 - July 8	5
July 9 - July 15	20
July 16 - July 22	32
July 23 - July 29	14
July 30 - Aug 5	14
Aug 6 - Aug 12	4
Aug 13 - Aug 19	<1
Aug 20 - Aug 26	<1

To characterize the timing of spray applications, spray schedules were classified into regular (routine) or irregular schedules. A schedule was arbitrarily defined as regular when the intervals between any two consecutive sprays were within 2 days of each other. The classification could only be applied to farmers who sprayed three times or more. Half of these farmers sprayed

regularly, usually on a 7-, 10- or 14-day basis, while the other half, who sprayed irregularly, had a mean interval of 8-19 days between sprays. One late blight warning was issued on August 4, 1972, but it did not stimulate farmers to spray. Late blight was not prevalent in 1972 and over 90% of the farmers interviewed had not observed late blight on the foliage and the remainder had seen only trace or slight infections.

Of the four main cultivars surveyed, Sebago received the least number of sprays (average of 4.2) followed by Irish Cobbler (4.5) and Kennebec (5.9), whereas Netted Gem received the most (6.7).

Ground sprayers were used almost exclusively. Only one farmer used aircraft spraying exclusively, while two farmers used both ground and aircraft sprayers.

Over three-quarters of the farmers treated their crops with the same chemical at the same rate and volume throughout the season. The remainder of the farmers changed the chemical during the season or applied a mixture of chemicals and/or used different volumes of water. Nine out of 10 farmers applied the same spray schedule to all the potato acreage on the farm.

Wettable powder formulations were used on nine-tenths of the acreage and liquid formulations (Table 6) on the remaining tenth. The most widely used fungicide was mancozeb, followed by maneb and metiram. These three fungicides accounted for approximately 90% of the fungicide usage, and the remaining 10% was captafol, nabam, or copper. Most farmers applied sprays at the medium volume (60 gals water/acre).

Table 5. Specifications of fungicide program for late blight of seed potatoes in P.E.I., 1972

Common name of fungicide	Percentage of acreage treated	Avg quantity of a.i.* applied (lb/acre)		Estimated total quantity of a.i. applied to total acreage	
		Each application	Season	('000 lb)	(metric tons)
Wettable powder					
Mancozeb	41	1.51	7.5	100	45
Maneb	25	1.25	5.4	44	20
Metiram	25	1.20	4.4	36	16
Copper	1				
Liquid					
Captafol	6				
Nabam	2				

* a.i. = active ingredient.

Estimates of quantities of active ingredient (a.i.) of the three fungicides most commonly used are given in Table 5 and are based on the data recorded for approximately 4,000 acres of potatoes in the 133 fields on separate farms. However, since 9 out of 10 farmers applied the same spray schedule to all their potato acreage, the data collected can be said to represent the total potato acreage (14,900 acres) on the farms surveyed (Table 1); this latter acreage is nearly half of the total seed potato acreage (32,406 acres, Table 1) grown in P.E.I. in 1972.

Top killers were used by 97% of the farmers, diquat and dinoseb being used on 70% and 30% of these farms, respectively. Some farmers mixed fungicides with the top killers to kill any late blight spores that may have been present. Table 6 shows that, on the average, the cultivars Irish Cobbler and Kennebec were top killed at approximately the same time; Sebago was the next to be top

Table 6. Number of crops of four cultivars top killed during weekly intervals, expressed as a percentage of the total number of crops for each cultivar

Period (week)	Percentage of crops top killed			
	Irish Cobbler	Kennebec	Sebago	Netted Gem
Aug 24 - Aug 30	14	16	2	
Aug 31 - Sept 6	29	27	17	14
Sept 7 - Sept 13	14	37	16	
Sept 14 - Sept 20	29	10	40	14
Sept 21 - Sept 27	14	7	21	29
Sept 28 - Oct 4		3	5	29
Oct 5 - Oct 10				14
Oct 11 - Oct 17				
Total number of fields	9	34	68	8

killed and was followed by Netted Gem. Consequently, the cultivars Irish Cobbler and Kennebec had to be protected by fungicide for a shorter period than Sebago, which needs protection for a shorter duration than Netted Gem.

Discussion

Most of the planting was done during the latter part of May and continued until late June. The development and control of late blight is particularly influenced by weather and in 1972 the climate was not favorable for the late blight fungus because periods of high relative humidity (over 90%) were infrequent and short (7). The survey results suggest that spraying practices for late blight control may differ for big and small farms and for different cultivars; but it is important to note that the survey data per se can be used as evidence only to report and not to explain these differences. This does not preclude the interpretation of survey results using previously gained knowledge to advance plausible explanations for the reported differences found in practice. For example, there were probably two reasons why different cultivars received different numbers of fungicide sprays. Of the four varieties listed in Table 6, Sebago is the only cultivar with field resistance in the foliage or tuber. The other three cultivars are more susceptible than Sebago to the predominant Phytophthora infestans race 1, 4 (personal communication, W. A. Hodgson) and this may explain why they receive more sprays than Sebago. The number of sprays applied to the other three cultivars were related to the earliness of the variety because the earlier the variety the shorter the length of the blight protection period. Consequently, the late cultivar Netted Gem received more sprays than the earlier cultivars Irish Cobbler and Kennebec.

The practice of routine spraying, irrespective of the presence of blight or prevalence of weather conducive to the development of late blight, can be considered as an insurance against the disease but it certainly contributed to the substantial quantities of fungicide used. Despite the fact that late blight was not prevalent and that weather conditions conducive to the development of the disease occurred infrequently (7), over 80 tons of the active ingredient component of fungicides were applied to the seed potato acreage in P.E.I.

Costs

The cost of late blight control can vary considerably but mainly depends on whether the farmer does the spraying himself or uses the more expensive contract spraying. Almost all growers use their own sprayer but, because each operates under different conditions, it is difficult to obtain accurate cost estimates for spraying application (11). Estimates of application costs vary from $0.90 (personal communication, J. Lovering) to $1.32 per acre (17). Fungicide cost can also vary, depending on quantity purchased, etc., but $1.00 per lb (0.8 lb a.i.) can be used as a working average (11). Based on these cost estimates and on the data from Table 5, the cost per application per acre would vary from $2.40 to $2.82. Assuming 5.4 sprays per season the total cost per acre per season would be of the order of $13.00 to $15.25, with the cost of fungicide accounting for 1/2 to 2/3 of the total cost. In addition a very small percentage of the acreage was sprayed on contract by ground or aircraft, with costs per acre of approximately $2.00 and $1.75 respectively, not including the cost of the fungicide.

Based on the above estimates the total cost of the late blight control program for approximately 32,000 acres of seed potatoes in P.E.I. in 1972 was between $420,000 and $500,000.

Comparative studies

According to this survey the average number of sprays applied per acre was 5.4, which is similar to the figure of 5.1 reported by Scott (17) for New Brunswick in 1967 and 1968. Except for the findings reported in this paper, there is no detailed information available fungicide spraying practices in Canada but comparative data are available for Great Britain from three surveys (13, 14, 15) carried out in 1958, 1963, and 1968. Comparing the 1968 British survey data with the findings reported here, some similarities and differences were noted. Whereas all the crops were treated for blight in P.E.I., only 60% of the crops were treated by fungicide in Britain. In both countries mancozeb was the predominant fungicide and maneb ranked second. Tin fungicides were used in Britain to a considerable extent but none were used in P.E.I. In both countries the number of sprays applied varies for different cultivars and depends on the resistance of the cultivar to late blight. In Britain the cultivar King Edward received more sprays than the more resistant Majestic, and a similar situation was noted for the varieties Kennebec and Sebago in P.E.I. About half the farmers in P.E.I. sprayed on a routine basis compared with 75% in Britain, but the average number of sprays applied was much greater in P.E.I. (5.4) than in Britain (3.3). For comparative purposes the weighted mean number of sprays for the total British acreage would be 2.0 compared with 5.4 sprays for P.E.I. However, both the percentage of crops sprayed and the number of sprays applied per acre increased consistently in Britain during 1958-1963-1968 (13, 14, 15) and therefore, the 1968 figure of 2.0 may be an underestimate for 1972. In conclusion, it can be said that all aspects of the late blight program are more intensive in P.E.I. than in Britain. A series of surveys in

Canada, similar to those conducted in Britain would allow fungicide usage and practice to be monitored and provide a system for studying the effectiveness of implementing research knowledge to farming practice.

Acknowledgments

We gratefully acknowledge the assistance of Mr. S. I. Wong in preparing the data and figures. We also thank the participating farmers, who at some inconvenience to themselves, provided the information, which was kindly collected by personnel of Plant Protection Division, Production and Marketing Branch, Agriculture Canada.

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NONTRANSMISSIBLE, VIRUS-LIKE DISORDERS OF POME FRUITS IN ONTARIO

Wayne R. Allen[1]

Abstract

Apple trees with fluted or striped fruits and chlorotic leaf patterns, and a pear tree with sickle-shaped fruits, rough bark, and chlorotic leaf patterns were observed in Ontario. These conditions were not transmitted by grafting and, therefore, are not considered to be virus-induced.

Introduction

Orchard surveys in Ontario for disorders of pear and apple revealed three that in part or totally resemble known virus diseases. This paper provides descriptions of these disorders and reports the failure to transmit them by grafting.

Occurrence and symptoms

Fluted and misshapen apple fruits - An apple deformity (Fig. 1) very similar to "flute fruit" (3) has been described (1). It was observed in young apple trees of the varieties McIntosh, Golden Delicious, Red Delicious, Cox's Orange Pippin, Idared, Rome Beauty, Melba, Spy, Cortland, and Jonadell from 1965 to 1968 in the Collingwood and Milton areas of Ontario. The trees made good growth and had normal shape and good leaf and bark color. At the time of the investigation, no possible causes other than low temperature injury or virus infection could be suggested.

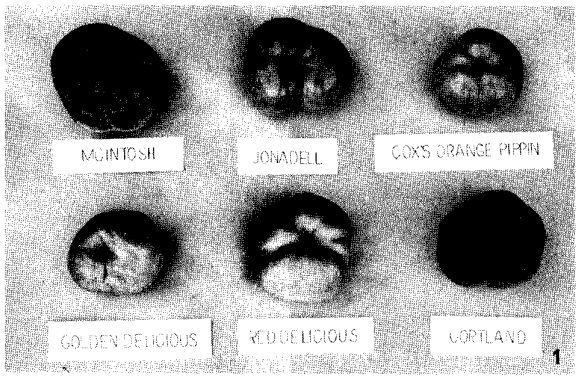
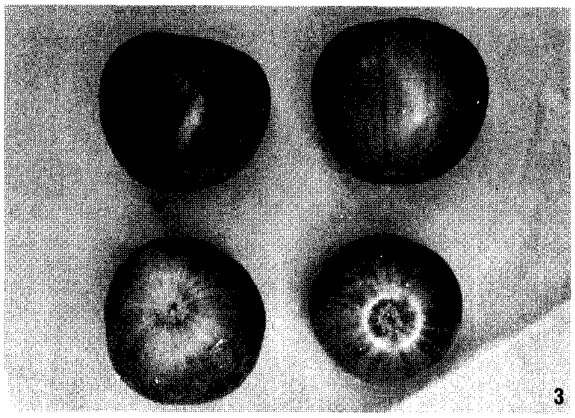


Figure 1. Apple fruits showing deep flutes or grooves and asymmetric development.

Fruit stripe and leaf pattern in apple - In 1966, a Northern Spy apple tree was found at Alymer, Ontario, with fruits that exhibited vertical green stripes (Fig. 3). Stripes were both continuous and broken; they varied in width and regularity, and were apparent in both green and mature fruits. In the latter, both the red and yellow background areas retained green stripes. Fruit size and shape were normal, but the color-break was so striking that fruits were unmarketable. Striped fruits were restricted to specific limbs.



Figures 2 and 3. Northern Spy apple. 2) Leaves with chlorotic patterns from tree with striped fruits; 3) Fruits exhibiting varying degrees of striping.

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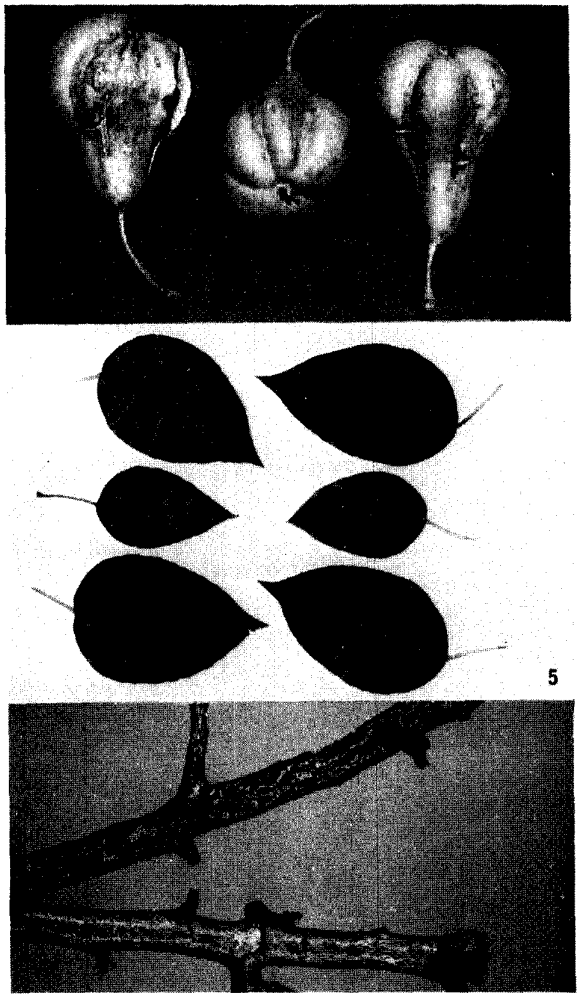
Leaf symptoms (Fig. 2) consisted of light green areas along the midrib and major veins; they strongly resembled those of the leaf pucker disease (4). In some cases, the chlorotic areas were confined to the veins, but in others the chlorotic areas coalesced and occupied the major part of the leaf surface. The development of chlorotic areas resulted in some leaf distortion. Chlorotic leaves were scattered throughout the tree. No texturing, scaling, or cracking of the bark was apparent.



Figures 4-6 Bosc pear. 4) Fruits with sickle shape and severe fluting and cracking; 5) Leaves with chlorotic patterns from trees with sickle shaped fruits, leaves at right are from a normal tree; 6) Rough bark on tree with sickle shaped fruits, branch at bottom is from a normal tree.

Sickle-shaped fruit, rough bark, and leaf pattern of pear - In 1968, an unfamiliar condition in a Bosc pear tree was observed in a Vineland, Ontario (Niagara Peninsula), orchard. Almost all fruits were sickle-shaped (Fig. 4) due to uneven tissue development in specific areas. Deep flutes extended from the blossom end to near the stem, and cracks often developed revealing corky, discolored tissue. Most affected fruits reached normal size.

Severe bark symptoms occurred on wood of all ages (Fig. 6) and resembled those reported for "rough bark" (2), though symptoms of the latter disease appeared less uniform.

Most leaves were chlorotic to some degree, but there was little or no leaf distortion. Chlorotic areas developed along the midrib and lateral veins, with larger areas coalescing to give the leaf a largely chlorotic appearance (Fig. 5).

Transmission

Fluted and misshapen apple fruits - Affected trees of Golden Delicious, Cox's Orange Pippin, Idared, Red Delicious, and McIntosh from the Collingwood or Milton orchards were transplanted in the spring of 1968 to the generally warmer region near Jordan, Ontario (Niagara Peninsula). Each tree was covered with an insect-proof cage. In the same year, buds from each variety were grafted to isolated, mature Red Delicious and Cortland trees growing in the Jordan area.

The fluted condition persisted on caged trees in 1968 and was again in evidence in the Collingwood area. However, from 1969 through 1971 no fluting or other abnormality was evident at either locality. At no time over a 4-year period did fruit fluting develop in either the Red Delicious or Cortland trees that had received buds from affected trees.

Fruit stripe and leaf pattern in apple - Fourty-three seedlings grown from seed of striped fruits of Northern Spy in 1967 failed to produce leaves with chlorotic symptoms in the ensuing 5 years. Twelve seedlings from the same fruits grafted in 1967 with buds from areas of the tree affected with leaf chlorosis also failed to develop leaf symptoms up to 1971. However, leaves on shoots from graft buds did express typical symptoms. A bearing Northern Spy tree in the original orchard failed to develop either fruit or leaf symptoms in the 6-year period following bud grafting from the affected tree. Several shoots from graft buds on this tree did, however, develop leaf symptoms but fruit did not develop.

Sickle-shaped fruit, rough bark, and leaf pattern of pear - In 1968, 9 and 10 buds, respectively, from the affected tree were grafted into two trees of same variety two rows distant from the donor tree. Only two buds on one tree failed to become established. No change in symptoms occurred on the affected tree and no symptoms developed on the grafted trees through 1972 except where graft buds were forced; these shoots developed the bark and leaf symptoms

but fruit was not produced.

Discussion

The large number of varieties simultaneously affected by the fluting condition of apple in the Collingwood orchard suggests causes other than virus. Further, the condition appeared to be most severe in low areas of the planting. The appearance of symptoms on transplanted trees only in the year of transplanting, and the failure to induce the condition in bearing trees of the same varieties after grafting, further indicates that viruses likely are not involved. Low temperature injury is the most probable cause of this disorder. Further, it seems possible that the injury is associated with the juvenile stage of growth or with size-controlling understocks or both.

The relatively uniform distribution of leaf symptoms associated with fruit stripe of Spy, and the more restricted distribution of striped fruit, initially suggested that the conditions might be due to separate causes. The failure to induce either condition in normal trees by grafting indicates that viruses are not involved. Whereas evidence of bud perpetuation was obtained for the leaf symptom, fruit were not formed on shoots from graft buds. However, the sectored nature of the fruit symptom suggests that it, as well as the leaf pattern, is caused by a genetical disorder.

The uniform distribution of leaf, fruit, and bark symptoms associated with the sickle-shaped fruit condition of pear suggests a single cause. The demonstration of bud perpetuation of bark and leaf symptoms from the same graft supports this view. The failure to induce fruiting on grafts, however, leaves doubt regarding bud perpetuation of the fruit condition. As with the stripe condition of apple, the definite and rather uniform sectoring in pear fruits is characteristic of genetical disorders.

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EFFECTS OF PREPLANT AND POSTPLANT NEMATICIDES ON POPULATIONS OF NEMATODES IN THE SOIL AND ON GROWTH OF FRUIT TREES IN THE NIAGARA PENINSULA

C.F. Marks and T.R. Davidson[1]

Abstract

Preplant, tree-row, fumigation of Vineland fine sandy loam provided good control of the root-lesion nematode, Pratylenchus penetrans, in the soil around peach trees for at least 2 years. The same treatments controlled the pin nematode, Paratylenchus sp., for only 1 year. Vorlex at 112 l/ha appeared to be the most effective preplant treatment and should be practical in orchards where other crops are not being interplanted. Though postplant applications of Nemagon reduced numbers of root-lesion nematodes around established peach trees, they did not result in any promotion of growth, indicating that this treatment might not be practical in the Niagara Peninsula.

Introduction

The root-lesion nematode, Pratylenchus penetrans Cobb 1917, is one of the important organisms associated with peach replant problems (1, 7, 8, 9) and with decline of peach trees in established orchards. Also it is a primary parasite of apple (12) and has damaged tree fruit crops on lighter soils in New York State (11).

The pin nematode, Paratylenchus curvitatus v.d. Linde 1938, is believed to be responsible for most of the decline of apple orchards in the Hudson Valley (10). Though pin nematodes, Paratylenchus spp., are quite prevalent in the orchard soils of the Niagara peninsula it has not been determined if these nematodes are of economic importance. Mountain and Boyce (8) suggested that pin nematodes may affect mainly the longevity and productivity of peach trees.

Preplant nematicides control the root-lesion nematode, Pratylenchus penetrans Cobb 1917, and promote growth of peach trees in Fox sandy loam (8). Such treatments also reduce replant problems of apple and cherry on lighter soils and trees in treated soil have a faster growth rate than those in non-treated soil (4). Preplant soil fumigation did not promote growth of peach seedlings in Vineland fine sandy loam in the greenhouse (8), but did promote the growth of nursery stock of apple, cherry, pear and plum in the field (2).

The postplant nematicide, Nemagon (1,2-dibromo-3-chloropropane) improved the growth and/or yield of peaches and apples in established orchards (10,13). However growth was promoted in only 31% of trials with postplant applications of Nemagon in established orchards of peach, prune or walnut in California (3).

This report outlines the effects of preplant and postplant nematicides on the numbers of root-lesion and pin nematodes in Vineland fine sandy loam and subsequently on growth of orchard trees.

Materials and methods

Preplant treatments

Experiment 1 (Table 1) with peaches was conducted in a former peach orchard (trees removed 2 months before treatment) that averaged 700 root-lesion and 500 pin nematodes/0.45 kg soil prior to treatment. Vorlex (1,3-dichloropropene and related C_3 hydrocarbons 80%; methylisothiocyanate, 20%) was applied at 34, 112 and 220 l/ha in the tree row. The fumigant was injected 15-20 cm deep in bands 2.4 m wide with a spring tooth fumigation rig in November 1968. The soil was sealed immediately and left undisturbed until spring. The check plots were treated similarly but no chemical was applied. Each plot consisted of four peach (Prunus persica (L.) Batsch cv. Babygold 7) trees. The treatments were replicated at least twice and arranged at random in the orchard. Planting holes were drilled in the middle of the treated bands and the trees were planted in April 1969.

Experiment 2 (Table 1) with apples was also conducted in a former peach orchard from which trees had been removed 2 months before the treatment. The population densities prior to treatment were about 1750 root-lesion and 1140 pin nematodes/0.45 kg soil.

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Table 1. Effects of pre-plant nematicides on numbers of root-lesion and pin nematodes in the soil and on the growth of fruit trees

Expt. no. and crop	Treatment and rate (l/ha)*	No. of nematodes/0.45 kg soil at end of 2 seasons of growth		Increase in trunk x-section area (cm^2)			% Larger than check trees after two seasons
		Root-lesion	Pin	1st season	2nd season	Total	
1 Peach	Check	2130†	1900				
	Vorlex, 34	650	4770				14
	Vorlex, 112	25	2070				47
	Vorlex, 220	300	1550				32
2 Apple	Check	130a§	80a	3.33a	3.67 b	7.00 b	
	Telone, 72	20b	40a	3.77a	4.60ab	8.37ab	20
	Vorlex, 34	30b	70a	4.03a	5.40a	9.43ab	35
	Vorlex, 112	2b	40a	3.73a	5.90a	9.60a	38
	Vorlex, 220	2b	3a	3.53a	4.67ab	8.20ab	17

* Tree row application; multiply by 2.5 to obtain the actual broadcast rate.

† Data not analyzed because of varying number of replications for the treatments.

§ Means followed by the same letter are not significantly different at P = 0.05 (Duncan's Multiple Range Test).

In November 1970, Telone (1,3-dichloropropene and related chlorinated C. hydrocarbons) at 72 l/ha and Vorlex at 34, 112, and 220 l/ha were applied as described for experiment 1. Each plot contained four apple (Malus pumila Mill. cv. Scotia) trees planted in April 1971. Treatments were replicated three times and arranged in a randomized block design.

Postplant treatments

Experiment 1 (Table 2) was conducted with 10-year-old sweet cherry trees (Prunus avium L. cv. Heidelfingen). Prior to treatment there were 1000 root-lesion and 100 pin nematodes/0.45 kg soil. On May 20, 1968, the orchard was shallow disked and Nemagon 130 EC (1,2-dibromo-3-chloropropane, 1.3 kg ai/l) was applied at 33.7 l ai/ha with a spring tooth fumigation rig. The nematicide was injected 13-15 cm deep in bands 2.4 m wide, as close to the trunks as possible on the row sides of the trees. The soil surface was sealed, straw mulch was spread under the trees, and the soil was then left undisturbed. Ten, single-tree replicates per treatment were randomized throughout the orchard.

Experiment 2 (Table 2) was established in a 2-year-old peach orchard containing five rows of cultivar Babygold and three rows of cultivar Sunhaven. The population densities prior to treatment were 1500 root-lesion and 1300 pin nematodes/0.45 kg soil. On June 4, 1968, Nemagon 130 EC was applied at 33.7 and 22.5 l ai/ha to freshly disked soil, as in experiment 1. However, the application of the lower rate of Nemagon was repeated in early June of 1969. In 1968 the check plots were treated similarly to the nematicide plots but chemical was not applied. In 1969 only the plots that received the chemical (22.5 l ai/ha treatment) were shanked but all plots were disked and sealed. The treatments were applied across the rows and replicated six times in a randomized block design.

Experiment 3 (Table 2) was established in a 3-year-old peach orchard, cultivar Royalvee, having population densities of 400 root-lesion and 1200 pin nematodes/0.45 kg soil. On June 22, 1970, Nemagon 130 EC was applied at 33.7 l ai/ha, as described for experiment 1, and Nemagon 25% G (1,2-dibromo-3-chloropropane, 25% ai) was applied at 73 kg ai/ha. The granular formulation was applied with a hand-operated cyclone seeder to a similar area to that treated with Nemagon 130 EC and incorporated to a depth of 13-15 cm by disking. Corresponding checks were used for each type of application and all plots were sealed by rolling. Seven replications of each treatment, four trees per replicate, were arranged in a randomized block design.

All experimental sites were situated on Vineland fine sandy loam. Soil samples for

Table 2. Effects of a postplant, fumigant-type nematicide on numbers of root-lesion and pin nematodes in soil around established fruit trees

Expt. no. and crop†	Treatment and rate (l ai/ha)††	Number§ of nematodes/0.45 kg soil							
		Root lesion				Pin			
		Growing seasons after treatment				Growing seasons after treatment			
		1	2	3	4	1	2	3	4
1 Sweet cherry	Check	560	830	2030	3380	290	1400	320	1320
	Nemagon 130 EC (33.7)	180**	160**	330**	580**	20*	30*	70*	300*
2 Peach	Check	1170a	2450a	1750a		800a	4040a	2420a	
	Nemagon 130 EC (22.5)¶	510 b	970 b	920a		180 b	490 c	1200a	
	Nemagon 130 EC (33.7)	410 b	870 b	2000a		190 b	1370 b	5040a	
3 Peach	Check - shanked & rolled	820a	650a			3060a	4950ab		
	Nemagon 130 EC (33.7) injected & rolled	15 b	110 b			0 c	570 c		
	Check - disked & rolled	690a	310ab			3090a	6170a		
	Nemagon 10G (73) disked & rolled	360ab	190 b			300 b	2300 b		

† Expt. 1, 10-year-old trees; Expts. 2 and 3, 4-year-old trees.

†† Tree row application; multiply by 1.25 to obtain the actual broadcast rate.

§ Expt. 1, means followed by ** are significantly different at P = 0.01, * at P = 0.05. Expts. 2 and 3, means followed by the same letter are not significantly different at P = 0.05 (Duncan's Multiple Range Test).

¶ Nemagon was injected at 22.5 l ai/ha in June 1968 and repeated in June 1969.

nematode counts were taken from the drip-line areas at time of treatment and thereafter annually in November. Nematodes were extracted from the soil by the modified Baermann pan technique (13) and nematode counts were transformed to log (x + 200) before statistical analyses. Tree measurements were taken either at planting time, or when the postplant nematicides were applied. Subsequent measurements were made in December of each year, except for experiment 1 (Table 1) where the trees were measured only after the second growing season.

In all experiments the cultural practices, except for nematicide treatments, were those of the cooperators. In preplant experiment 2 (Table 1) and in postplant experiments 2 and 3 (Table 2) the conventional cultural practice of clean cultivation until July 1 followed by a mowed weed cover for the remainder of the growing season was used. In preplant experiment 1 (Table 1) the between-row areas were interplanted with potatoes in 1969 and 1970; weed cover was allowed to grow around the trees.

Results

Preplant treatments

In experiment 1 (Table 1), Vorlex at 112 l/ha seemed to be the best treatment in terms of nematode control and growth response of peach trees.

In experiment 2 (Table 1), the number of nematodes in the area planted to apples declined considerably, irrespective of treatment, during the two years following planting. At the end of the second growing season there were fewer root-lesion nematodes in the treated plots than in the check plots (Table 1). With pin nematodes, however, there were no significant differences between treatments after two seasons. None of the chemical treatments promoted tree growth in the first growing season and Vorlex at 112 l/ha was the only treatment to give a significant increase relative to the check in the second season.

Postplant treatments

In experiment 1 (Table 2), Nemagon at 33.7 l ai/ha controlled root-lesion and pin nematodes in the soil around 10-year-old sweet cherry trees for four years.

Experiments 2 and 3 (Table 2) showed that 33.7 l ai/ha (experiments 2 and 3) controlled both root-lesion and pin nematodes around peach trees for two growing seasons. Two applications of Nemagon at 22.5 l ai/ha did not result in any significant improvement in nematode control over a single application of 33.7 l ai/ha. Nemagon 25 G at 73 kg ai/ha did not reduce numbers of root-lesion nematodes below those of the corresponding check but it did reduce the numbers of pin nematodes.

The injection of Nemagon 12-15 cm deep with a spring tooth fumigator apparently did not cause any damage to feeder roots nor did it affect tree growth. None of the postplant nematicide treatments resulted in promotion of tree growth so data are not presented.

Discussion

Preplant, tree-row, fumigation of Vineland fine sandy loam can provide good control of root-lesion nematodes in the soil for at least two years but seems to control pin nematodes for only one growing season (Table 1, experiment 2). Mountain and Boyce (8) have reported that pin nematodes increase rapidly in fumigated soils in peach orchards during the second growing season.

Both apple and peach showed improved growth on Vineland fine sandy loam treated with preplant nematicides. The present data show that, in terms of nematode control and growth response, a tree-row application of Vorlex at 112 l/ha, should be effective. Furthermore, since the numbers of P. penetrans increase very slowly in fumigated soil in peach orchards (8) and since the rate of increase can be reduced further by good weed control practices and the use of proper cover crops (5,6), tree-row fumigation should be as effective as broadcast fumigation for growers who are not interplanting with other crops.

Postplant applications of Nemagon can provide nematode control up to four years after treatment in sweet cherry (Table 2, experiment 1). However it appears that the normal cultural practice of using a weed cover crop in peach orchards may shorten the period to two years (Table 2, experiment 2) in orchards with very high densities of weeds. It is also possible that peach is a more suitable host than sweet cherry.

In agreement with other studies (8,3) postplant applications of Nemagon failed to enhance tree growth. Perhaps a yield response would occur with bearing trees treated with a postplant nematicide. However, it appears that postplant applications of Nemagon on tree fruit crops generally are not practical on the Vineland fine sandy loam soils in the Niagara Peninsula. The use of a postplant nematicide may be more beneficial on Fox sandy loams, such as those in the tree fruit growing areas of Essex and Norfolk counties. Because of the smaller amount of available water in these coarser soils, the trees would be subjected to greater moisture stress and would be less tolerant of nematode damage than trees on the Vineland fine sandy loam (14).

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DISTRIBUTION OF PARATYLENCHUS PROJECTUS IN CENTRAL AND NORTHERN ALBERTA

G.R. Webster[2] *and E.J. Hawn*[3]

Abstract

A survey was conducted during the summers of 1970 and 1971 to determine the distribution of Paratylenchus projectus in the central and the Peace River areas of Alberta. A total of 91 locations were sampled. Counts in the Peace River were low with only 25% of the samples showing greater than 1000 and only 4% with more than 10,000 per kilogram of soil. In contrast, an area in central Alberta had 56% of the counts greater than 1,000 and 20% greater than 10,000 per kilogram of soil. Counts were not related to soil parameters or cropping history.

Introduction

The reason for conducting the nematode survey is discussed in detail in a previous paper (4). In brief the senior author has been studying an alfalfa disorder called "alfalfa sickness" for a number of years. Particular interest in nematodes of the genus Paratylenchus Micoletzky was stimulated by the late W.R. Orchard, Nematologist, Canada Department of Agriculture, Saanichton, British Columbia. From 1962 to 1969 he examined alfalfa roots and their rhizosphere soil and consistently found appreciably higher counts of Paratylenchus in soils collected from areas of poor growth in the field as compared to adjacent areas of good growth. The relationship indicated that the nematode was at least partially responsible for the disorder. He recommended that a survey be conducted to determine the magnitude of the infestation in central and northern Alberta. The results of this survey, which was conducted during the summers of 1970 and 1971, are presented herein.

Materials and methods

Several District Agriculturists within the central and the Peace River areas of Alberta were asked to provide, for each of their respective districts, a list of 10 farmers who were currently growing alfalfa. Fields selected at random from these lists together with a number of experimental plots gave a total of 91 locations from widely distributed areas. During sampling, the vigor of growth was described as good, medium, or poor and such areas were sampled separately. In addition, the cropping history of each field was recorded.

In most cases sampling was done by two techniques. One involved removing three plants from a given area together with the soil adhering to the roots. The excess soil was trimmed away leaving approximately 1000 g (field moist basis) of rhizosphere soil. The other technique consisted of compositing 15 to 20 soil cores taken at random throughout the sampling area by inserting an auger to a depth of 20 cm close to the crowns of the plants.

In the laboratory, approximately 300 g (field moist) of composite soil or of soil washed from the roots were placed in 6 liters of water. A representative sample was dried at 105.C so the counts could be expressed on an oven dry weight basis. The soil suspension was allowed to settle for about 30 seconds and the supernatant passed through a 60-mesh Endecott sieve. The material on the sieve was rinsed and the entire supernatant passed through 100, 200, 325, and 400-mesh sieves and screenings from the latter two were placed in Baermann funnels for roughly 16 h (1). In 1971 a rapid centrifugal flotation technique (2) was used. The supernatant was prepared in the same manner, then placed in 50 ml conical centrifuge tubes, spun for 5 minutes at approximately 400 x g, liquid decanted, about 40 ml sugar solution added to the residue, slurried, centrifuged for 1 minute and the supernatant immediately poured onto a 400-mesh sieve and the sugar solution washed through with water. The nematodes remaining on the sieve were rinsed off into small beakers to be relaxed and counted. Counts of Paratylenchus projectus Jenkins were based on morphological characteristics (3). The presence of parasitic nematodes other than P. projectus was recorded also.

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Chemical analyses of the soils were conducted by the Alberta Soil and Feed Testing Laboratory. Available nitrogen was estimated as nitrate-nitrogen extracted with 0.02 N $CuSO_4$ solution, extractable phosphorus was extracted with 0.03 N NH_4F - 0.03 N H_2SO_4, exchangeable potassium was extracted with 1 N NH_4OAC, manganese and aluminum were extracted with 0.01 M $CaCl_2$, and pH was determined in a 1:1 soil-water mixture.

Results and discussion

Counts of Paratylenchus projectus varied widely from field to field covering a range from undetectable numbers to approximately 40,000 per kilogram of rhizosphere soil for alfalfa and approximately 80,000 for alsike and red clover. There was a tendency, based on a limited number of observations, for the rhizosphere soil from clover plants to have higher counts than rhizosphere soil from alfalfa growing in close proximity.

The two methods of sampling (composite and rhizosphere) produced similar count distribution patterns (Table 1) indicating that they were equally good. The composite method has the advantage that only one sample is required to represent an area whereas for the rhizosphere technique, soil from at least three plants must be analyzed to obtain a representative count.

Table 1. Comparison of Paratylenchus projectus counts obtained by the composite and rhizosphere methods expressed as a percentage of the samples analyzed by each method

Count range	Soil composite[1]	Soil rhizosphere[2]
0	17.4	14.2
1 - 500	35.8	38.4
500 - 1,000	12.1	5.3
1,000 - 2,000	13.2	8.9
2,000 - 4,000	7.4	8.9
4,000 - 6,000	3.1	8.3
6,000 - 8,000	2.1	1.8
8,000 - 10,000	0.5	3.0
10,000 - 15,000	5.2	5.3
15,000 - 20,000	1.6	1.8
20,000 - +	1.6	4.1

[1] 190 soil composite samples (15 to 20 cores 3.0 x 20 cm).

[2] 169 soil rhizosphere samples (average of 3 plants).

There were several points of interest in the distribution of P. projectus in central Alberta (agricultural reporting areas 4A, 4B, 5, and 6) and the Peace River (reporting area 7) (Figure 1). The Peace River area (north of TWP 66) generally had low counts with only 25% of the samples showing more than 1,000 and only 4% with counts greater than 10,000 per kilogram of soil. In contrast, a belt in central Alberta an area extending from about 75 miles S.W. of Edmonton to approximately 75 miles north, and including counts in the vicinity of the city, had 56% of the total count greater than 1,000 and 20% greater than 10,000 per kilogram of soil. Soils in this sampled area, with the exception of the Chernozemic soils south of the city, are predominately Luvisolic and Dark Gray Luvisolic and it is in this area of relatively high counts where alfalfa sickness is most prevalent.

Nematode counts by the composite method were correlated with various soil parameters to determine whether there was a significant relationship. The correlation coefficients between counts and the following soil parameters were as follows: nitrate nitrogen - 0.26; extractable manganese - 0.02; extractable aluminum - 0.10; and pH - 0.02. All these coefficients were nonsignificant indicating the counts were not related to the soil parameters. Furthermore, the counts did not appear to be related to cropping history.

The average count (composite method) for the areas designated as vigorous growth was 500 nematodes per kilogram of soil, for areas of medium vigor 2600 and for areas of poor vigor 4900. This is the same relationship that Orchard found from analyses made prior to the survey during the period 1962 to 1969. However, these values do not provide proof that the nematode is responsible for the difference in plant vigor. Detailed studies are underway to determine the effect of adding known populations of the nematode in pure culture and in combination with other organisms on the vigor of alfalfa.

Other genera identified in the soils were Aphelenchus Bastian, Aphelenchoides Fischer, Tylenchorhynchus Cobb, Dorylaimus Dujardin, Tetylenchus Filipjev, Xiphinema Cobb, and Ditylenchus Filipjev. These contain species that are suspect or have been shown to be plant parasites. The numbers observed in survey samples were, however, too small to warrant their being considered as significant in the epidemiology of alfalfa sickness.

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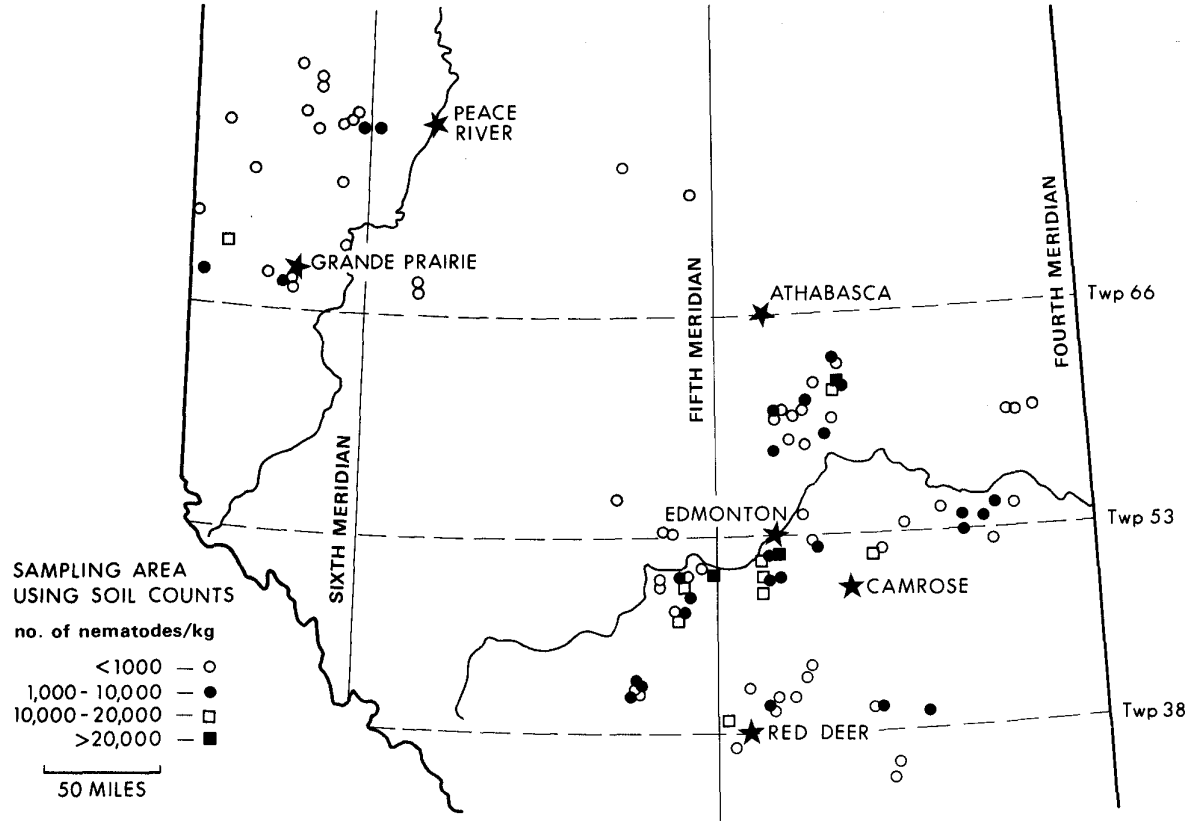

Figure 1. Distribution of *Paratylenchus projectus* in central and northern Alberta; numbers of nematodes per kilogram of soil (composite sample).

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COOPERATIVE SEED TREATMENT TRIALS - 1973

J.T. Mills[2]

Abstract

Twenty-one seed treatment chemicals were tested for their efficacy in controlling bunt of wheat (Tilletia caries and T. foetida), covered smut of oats (Ustilago kolleri), and covered smut of barley (U. hordei) and for their effects on the emergence of flax. Heavy bunt infection permitted a good evaluation of seed treatments and showed that bunt may be readily controlled by chemical seed treatments applied as dusts, wettable powders, or liquids. Effectiveness of treatments on oats and barley was difficult to assess because of low smut infections. None of the treatments gave a significant increase in flax emergence.

Introduction

In 1973, 21 seed treatment chemicals were tested for their efficacy in controlling common bunt of wheat [Tilletia foetida (Wallr.) Liro and T. caries (DC.) Tul.], covered smut of oats (Ustilago kolleri Wille), and covered smut of barley [U. hordei (Pers.) Lagerh.] and for their effects on the emergence of flax under Manitoba conditions.

Materials and methods

Table 1 lists the chemical composition, where available, and the product name and source of the materials used. Panogen 15B was included as a comparison standard.

Seeds of CT 931 wheat (Triticum aestivum L.), 'Random' oats (Avena sativa L.), and 'Herta' barley (Hordeum distichon L.) were used in the smut tests. 'Redwood' flax (Linum usitatissimum L.) was used for emergence tests.

Prior to chemical treatment the cereals were inoculated with the appropriate dry smut spores at the rate of 1 g per 200 g of wheat, oats, or barley seed. The chemical dosages used were those suggested by the manufacturer (Table 2). Each sample was hand-shaken in a glass jar to cover the seed uniformly with the chemical.

After 3 days or more, 200 seeds were removed from each jar and placed in a paper envelope. Envelopes that contained seed of the same treatment were stored in polyethylene bags at 15 C for up to 4 weeks before seeding.

Tests were carried out at Brandon and duplicated at Morden, Manitoba. There were four replicates at each location. Each replicate consisted of 200 seeds planted in a row 12 ft long; all rows were planted 9 inches apart; plots were arranged in a randomized block design. Emergence of flax was recorded 3-4 weeks after seeding.

Wheat, oats, barley, and flax were sown at Brandon on 11 April, 8 May, and 15 May and at Morden on 13 April, 10 May, and 14 May, respectively.

The number of smutted heads in each row was recorded after the crop had headed and was expressed as a percentage of the number of heads in the untreated rows. The results are given as means of four replicates, at each planting site. The "LSD-05" was determined from the means of the treatments at each station.

Results and discussion

Smut infection of untreated seed varied from 39% to 51% for wheat, from 5% to 8% for oats, and from 1% to 3% for barley.

Bunt infection was very high and no treatment gave complete control at either station. Products that gave less than 1% infection at both stations were: for dusts TF 3219; for wettable powders BAS 3293F, BAS 3304F, and NF 48 (1 oz rate); and for solutions Me 112a, Panogen 15B and RHC 364. The effectiveness of the treatments on oats and barley was difficult to assess because of the low smut infections on these crops. Sn 513 was ineffective against all smut diseases.

Emergence of untreated flax checks varied from 63% to 77% (Table 2). None of the treatments gave a significant increase in flax emergence, but the highest dosages of Me 112a and RHC 364 significantly reduced emergence at both stations.

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Acknowledgments

The writer thanks members of the staff of the Morden and Brandon Research Stations for their co-operation and assistance.

Table 1. Seed treatment materials used in the cooperative tests

Treatment no.	Source*	Product name	Chemical name
1		Untreated check	
2	BASF	BAS 3293-F	2,5-dimethyl-3-furylanilide (50%) + maneb (32%)
3	BASF	BAS 3304-F	N-cyclo-hexyl-2,5-dimethyl-furane-3-carbonic acid amide (50%) + maneb (32%)
4	Chipman	TF 3222	identity not available
5	Chipman	TF 3219	identity not available
6	Chipman	TF 3235	identity not available
7	Ciba-Geigy	NF 48	methyl 4-(2-aminophenyl)-3-thioallophanate (80%)
8	Ciba-Geigy	A 4759 A	identity not available
9	Ciba-Geigy	A 4743 A	identity not available
10	Dow	Dowco 263	identity not available
11	DuPont	Benlate T	benomyl [methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate] (30%) + thiram (30%)
12	Fisons	NC 5936	2,3,5-trichloromuconononitrile (5%)
13	Hoechst	Hoe 6053 + maneb	2-methyl-5,6 dihydro-4-H-pyran-3-carboxylic anhydride (75%) + maneb (50%)
14	Interprovincial	Busan 30 IP	2-(thiocyanomethylthio) benzothiazole (30%)
15	Interprovincial	Busan 30	2-(thiocyanomethylthio) benzothiazole (30%)
16	Merck	Me 112a	identity not available
17	Niagara	Polyram liquid	zinc activated polyethylene thiuram disulfide (22.5%)
18	Nor-Am	Panogen 15B	methylmercuric dicyandiamide (3.7 oz/gal)
19	Nor-Am	Sn 513	9-aza-1,17-diguanidinoheptadecane triacetate (30%)
20	Rohm & Haas	RHC 364	identity not available
21	Uniroyal	Uni 2001	identity not available
22	Uniroyal	Uni 2036	identity not available
23		Untreated check	

* BASF Canada Ltd., Montréal, Québec; Chipman Chemicals Ltd., Hamilton, Ontario; Ciba-Geigy Canada Ltd., Montréal, Québec; Dow Chemical of Canada Ltd., Sarnia, Ontario; E.I. DuPont de Nemours & Co., Inc., Wilmington, Delaware; Fisons (Canada) Ltd., Don Mills, Ontario; Hoechst Chemicals Canada Ltd., Montréal, Québec; Interprovincial Cooperatives Ltd., Winnipeg, Manitoba; Merck & Co., Inc., Rahway, New Jersey; Niagara Chemicals, Burlington, Ontario; Nor-Am Agricultural Products Inc., Woodstock, Illinois; Rohm & Haas Co. of Canada Ltd., West Hill, Ontario; Uniroyal Chemical Division, Elmira, Ontario.

Table 2. Effects of seed-treatment chemicals on smuts in wheat, oats and barley and emergence of flax

Treatment no.	Product name	Formulation*	Dosage (oz/bu)	% Smutted heads***						% Emergence	
				Wheat		Oats		Barley		Flax	
				B**	M**	B**	M**	B**	M**	B**	M**
1	Untreated check			51.1	40.0	7.8	6.2	2.6	1.6	63.0	73.8
2	BAS 3293-F	WP+	3.95	0.3	0.3	0.0	0.0	0.0	0.0	56.8	75.8
3	BAS 3304-F	WP+	3.95	0.0	0.2	0.0	0.0	0.0	0.0	59.8	73.3
4	TF 3222	D	1.50	0.9	1.2						
			2.00			0.0	0.0	0.0	0.0	51.0	81.8
5	TF 3219	D	1.50	0.4	0.7						
6	TF 3235	D	2.00			0.0	0.0	0.0	0.0	63.8	75.8
7	NF 48	WP	0.50	1.3	2.6						
			1.00	0.0	0.1						
8	A 4759 A	D	0.75			0.1	0.3				
			0.79					0.0	0.1		
			1.00							49.0	72.5
9	A 4743 A	D	0.75			0.3	0.1				
			0.79					0.0	0.0		
			1.00							62.5	77.8
10	Dowco 263	D	0.30	20.8	15.6						
			0.60	19.6	16.4						
			1.70			0.1	0.0				
			3.40			0.0	0.0				
			2.40					0.0	0.0		
			4.80					0.0	0.0		
			2.80							64.8	76.5
			5.60							56.8	70.5
11	Benlate T	WP	0.60	0.6	3.1						
			0.75	0.4	2.7						
			0.80			0.0	0.0	0.0	0.0		
			1.00			0.0	0.0	0.0	0.0		
			1.50							61.5	74.8
			2.00							49.5	78.8
12	NC 5936	D	2.88	34.0	30.2	0.3	0.0	0.0	0.0		
			5.76	35.1	29.3	0.0	0.0	0.0	0.0	57.8	56.0
			11.52							53.0	67.0
13	Hoechst 6053 + maneb	D	1.50	0.1	1.4	0.0	0.0	0.0	0.0	54.8	65.8
			2.00	0.2	1.3	0.0	0.0	0.0	0.0	70.5	75.3
14	Busan 30 IP	SN	0.75	6.4	3.3	0.0	0.0	0.0	0.0	60.3	74.5
15	Busan 30	SN	0.75	9.1	5.9	0.0	0.0	0.0	0.0	55.8	68.0
			1.00	5.6	2.2	0.0	0.0	0.0	0.0	53.3	70.3
16	Me 112a	SN	2.00	0.7	0.0	0.0	0.0	0.0	0.0	63.3	58.5
			4.00	0.1	0.0	0.0	0.0	0.0	0.0	42.3	47.0
17	Polyram	SL	2.00	0.8	4.2	0.9	2.7	0.0	0.1	69.0	74.8
			3.00	0.0	2.2	0.4	1.3	0.0	0.0	56.3	73.3
18	Panogen 15B	SN	0.75	0.5	0.2	0.0	0.0	0.0	0.0		
			1.50							66.0	82.0
19	SN 513	SN	1.33	5.8	5.7	3.2	5.1	2.0	0.5	63.5	74.3
			1.67	7.2	6.7	3.6	6.7	0.6	0.4	57.8	76.0
20	RHC 364	SN	1.60	0.4	0.0	0.0	1.5	0.0	0.0		
			3.20	0.1	0.1	0.1	0.1	0.0	0.1	61.8	75.8
			6.40							42.8	62.8
21	Uni 2001	SL	1.50	2.2	5.4	0.0	0.0	0.0	0.0		
			3.00							62.3	74.8

Table 2. (Cont'd)

Treatment no.	Product name	Formulation*	Dosage (oz/bu)	% Smutted heads*** Wheat B**	Wheat M**	Oats B**	Oats M**	Barley B**	Barley M**	% Emergence Flax B**	Flax M**
22	Uni 2036	D	0.75	4.0	6.6						
			1.50			0.0	0.0	0.0	0.0		
			3.00							63.0	79.0
23	Untreated check			40.1	38.9	5.3	5.2	2.5	1.1	66.3	77.0
LSD (0.05)										15.9	10.9

* Formulation code: D = dust, SN = solution, SL = slurry, WP = wettable powder, WP+ = wettable powder but applied as a slurry.

** B = Brandon, M = Morden.

*** $= \frac{\text{number of smutted heads}}{\text{number of heads in control}} \times 100.$

ADDITIONAL FUNGI AND A GALL DISEASE OF DWARF MISTLETOE SWELLINGS IN WESTERN HEMLOCK

A. Funk and J.A. Baranyay[1]

Résumé

Les Champignons qui habitent les chancres sur les renflements causés par le Faux-gui (Arceuthobium tsugense (Rosendahl) G.-N. Jones) sur la Pruche de l'Ouest (Tsuga heterophylla (Raf.) Sarg.) furent d'abord étudiés par Baranyay (1966) dans une zone restreinte près de Vancouver, C.B. Durant les années 1969-1971, les auteurs conduisirent un relevé de l'aire totale de répartition des Faux-guis de la Pruche sur la Pruche de l'Ouest en Colombie Britannique, ce qui permit d'identifier sept autres espèces de Champignons et une Galle affectant les renflements. Le Champignon le plus important du groupe, Nectria fuckeliana Booth var. macrospora (Wr.) Booth, fut déja signalé par Funk et al. (1973).

Figure 1. *Botryosphaeria tsugae* on hemlock dwarf mistletoe swelling. X 2

Fungi associated with cankers of dwarf mistletoe (Arceuthobium tsugense (Rosendahl) G. N. Jones) swellings on western hemlock (Tsuga heterophylla (Raf.) Sarg.) were first studied in a restricted area around Vancouver, B.C. by Baranyay (1966). A survey of the whole range of hemlock dwarf mistletoe on western hemlock in British Columbia during the years 1969-1971 has identified seven more species of fungi and a gall disease affecting the swellings; the most important of these, Nectria fuckeliana Booth var. macrospora (Wr.) Booth, has been reported elsewhere (Funk et al. 1973).

1. Xenomeris abietis Barr. Can. J. Botany 46:842, 1968. Rare in south coastal area.
2. Phomopsis lokoyae Hahn. Mycologia 25:372, 1933. Perfect state: Diaporthe lokoyae Funk. Can. J. Botany 46:601, 1968. Rare in south coastal area.
3. Botryosphaeria tsugae Funk, Can. J. Botany 42:770, 1964. Conidial state: Macrophoma. Common in the Cowichan Valley, south Vancouver Island.
4. Discocainia treleasei (Sacc.) J. Reid & Funk. Mycologia 58:432, 1966. Common in N. Vancouver Island, rare in south coastal area.
5. Coccomyces heterophyllae Funk. Can. J. Botany 45:2263, 1967. Rare on Vancouver Island.
6. Ascoconidium tsugae Funk. Can. J. Botany 44:219, 1966. Occasional throughout range.
7. Hemlock Gall Disease. Forest Chron. 26: 308, 1950. Rare in North Vancouver Island.

Dwarf mistletoe swellings are susceptible to invasion by a wide variety of parasites and facultative parasites, some of which may kill the branch and thus, indirectly prevent spread of the mistletoe. These fungi are of particular interest because they exert some natural control. With the 11 fungi reported by Baranyay (1966), this report brings to 18 the number of fungi and diseases found associated with hemlock dwarf mistletoe in British Columbia.

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PHOMOPSIS ELAEAGNI ON RUSSIAN OLIVE (ELAEAGNUS ANGUSTIFOLIA) IN CANADA[1]

Ruth Horner Arnold[2] and A.E. Straby[3]

Abstract

The occurrence and distribution of Phomopsis elaeagni, the causal fungus of a canker and dieback of Russian olive (Elaeagnus angustifolia), is reported for the first time in Canada. In Canada it has been found only in nurseries on seedlings imported from Europe, and not in ornamental plantings as in the United States where it causes a serious disease. A description of the fungus and symptoms of the disease are given.

This fungus species was described by Carter and Sacamano (1967) as Fusicoccum elaeagni, the causal agent of a severe canker and dieback of Russian olive (Elaeagnus angustifolia L.) in Missouri. In a subsequent note, Carter and Dodd (1969) reported the discovery and distribution of this disease in Illinois. In Canada, a canker and dieback of Russian olive seedlings imported from Europe in 1968 was detected by inspectors of the Plant Protection Division, Agriculture Canada, and was found to be associated consistently with F. elaeagni. This disease was found again in 1969, 1970, and 1973 during surveys of commercial nurseries carried out by the Plant Protection Division. Dr. Carter confirmed the identification of the fungus and sent us part of the type collection of F. elaeagni (ILLS 34453) for study, along with cultures made from it. Single conidial cultures made from conidia that formed in this type culture were grown on 2% potato dextrose agar (PDA). Typical Phomopsis pycnidial stromata that contained both the alpha-conidia previously described by Carter and Sacamano, and beta-conidia, along with conidia intermediate in shape and size between these two types were formed in these cultures within 17 days at room temperatures that fluctuated between 24 and 30 C, or within 3 weeks when room temperatures fluctuated between 20 and 24 C. Accordingly, this species was redescribed as Phomopsis elaeagni (Carter and Sacamano) R. H. Arnold and Carter (Mycologia 1974, in press). A report of a Phomopsis dieback of Russian olive in Ohio by White and Ellett (1972) proved to involve the same fungus when cultures obtained from these authors were grown and examined.

In Canada the disease has not been reported from ornamental plantings of Russian olive. All confirmed reports of the occurrence of P. elaeagni (Table 1) have been on imported seedlings in nurseries, where the disease was often associated with mechanical injury. These specimens have been deposited in the National Mycological Herbarium. In the nurseries the disease occurred only on seedlings imported from Europe and not on nursery stock grown from seed or on stock propagated within the nursery from trees originally grown from seed. In one case the fungus was found on seedlings at the time of their inspection on import from Europe; in some shipments seedlings that appeared disease-free at the time of importation were found to be infected the following year (Table 1). This is quite a different situation from that in the United States where P. elaeagni was found to cause a severe disease of Russian olive, both in nurseries and in ornamental plantings (Carter and Sacamano 1967; Carter and Dodd 1969).

Symptoms

P. elaeagni causes cankers that are elongated and red-brown in color. Pycinidial stromata form quickly in diseased bark and are usually abundant by the time the disease is detected (Figs. 1, 2, 4). Cankers usually girdle affected branches or main stems of seedlings, causing rapid wilting and death of the affected parts. In the U.S. similar symptoms have been reported on mature trees as well as on seedlings by Carter & Sacamano (1967), Carter & Dodd (1969), and White & Ellett (1972). In Illinois Carter and Dodd (1969) reported the wilting and death of current season's twigs and branches having basal cankers, and the formation of large cankers on structural branches and trunks of trees up to 4 inches diam at ground level. Inoculation experiments in June in Illinois (Carter and Sacamano 1967) resulted in the development of visible cankers within 14 days and formation of pycnidial stromata within 30 days on branches up to 1 inch diam of large trees; cankers and stromata appeared within 7 days on small trees inoculated in July; girdling, wilting, and death of branches up to 0.5 inch diam occurred during the growing season in which they were inoculated, and cankers extended up to 5 inches beyond the inoculated area, with brown staining of sapwood beneath the diseased bark. White and Ellett (1972) also reported rapid development

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Table 1. Collections of *Phomopsis elaeagni* on imported seedlings of Russian olive (*Elaeagnus angustifolia*) in Canadian nurseries*, 1968-73

DAOM no.	Date collected	Location	No. of seedlings affected/examined	Comments
124924	30 Oct. '68	Aylmer, Que.	10/35	NA†
130290	13 Feb. '69	Richmond, B.C.	250/250	Intercepted on arrival from Holland
130666	26 June '70	Richmond, B.C.	2/10	Remainder of shipment examined 13-2-69
130289	25 June '69	Ottawa, Ont.	2/20	NA; 150 seedlings in shipment
130667	25 June '70	Ottawa, Ont.	50/50	Remainder of shipment examined 25-6-69; considerable mechanical injury
130852	17 July '70	Aldergrove, B.C.	20/20	Remainder of a shipment of 200 seedlings imported in 1969 from Europe
130895	19 Aug. '70	Ottawa, Ont.	2/4	NA
144555	14 June '73	Arnprior, Ont.	4/25	NA; only older trees affected by cankers and dieback of branches, 100 trees in planting
144556	20 June '73	Schomberg, Ont.	1/200	NA; seedlings imported in 1969 or 1970

* Note: during June and July 1970, an intensive inspection for this disease was carried out by inspectors of the Plant Protection Division in both commercial nurseries and ornamental plantings. In addition to the above positive cases, places inspected and found negative were Trenton, Ont., Pt. Burwell, Ont., St. Thomas, Ont., Petrolia, Ont., Kentville, N.S., Regina, Sask., and London, Ont.; the majority of these plantings had been propagated in Canada from seed or were not recent imports. DAOM numbers refer to collections deposited in the National Mycological Herbarium, Ottawa.

† NA: information not available on country of origin or date of entry.

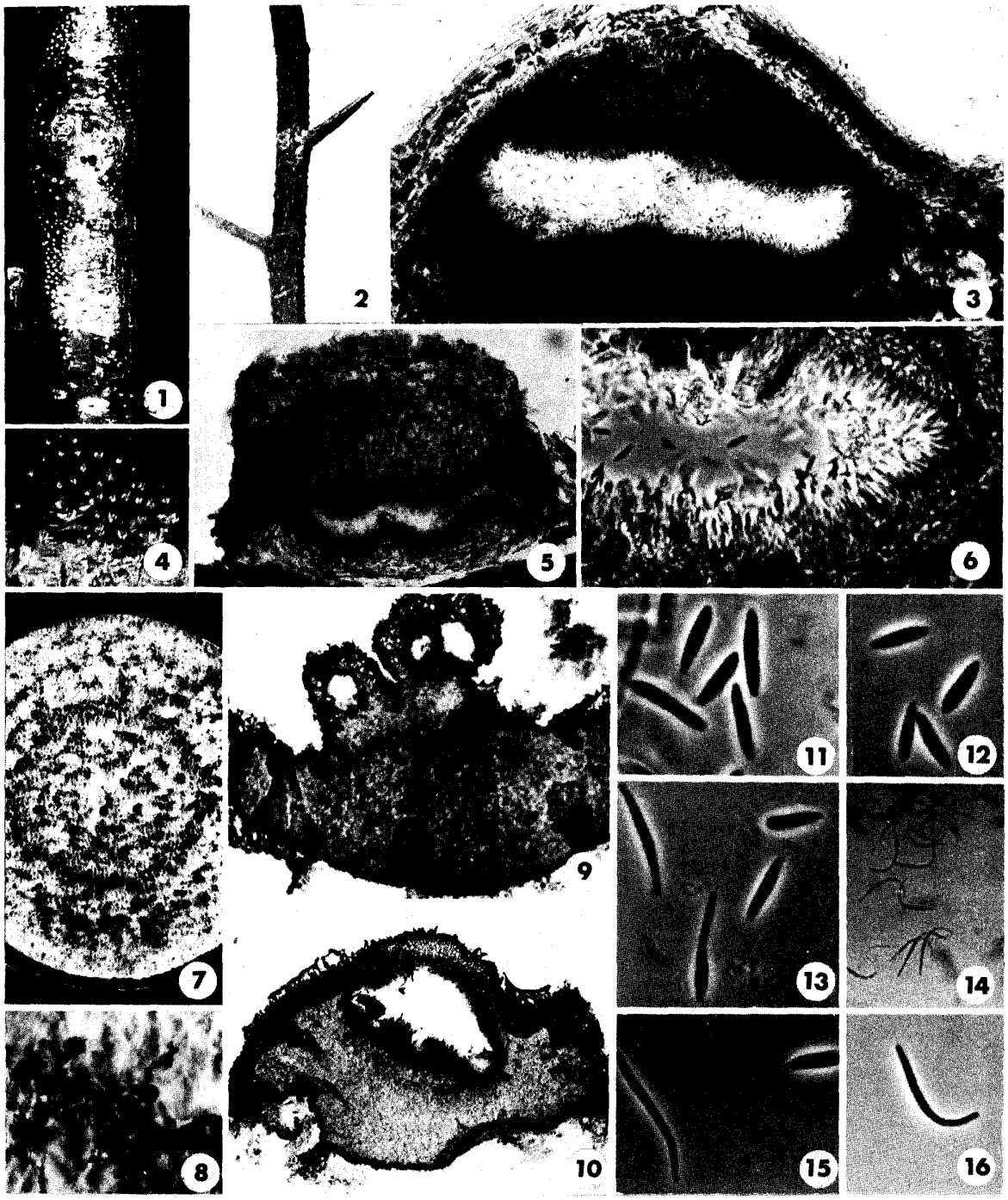
of symptoms (cankers, wilt, and dieback), and formation of pycnidia in the diseased bark of inoculated potted seedlings and twigs up to 1.2 cm diam of established trees.

The causal fungus (Figs. 3-16)

Pycnidial stromata formed in the dead bark of infected stems and branches and became erumpent, subspherical, with closely adhering bark, less than 1 mm diam, usually 800-900 µm diam, 500 um high, very numerous, one to several pycnidial locules within a stroma, usually one or two, locules lined with a layer of small, angular, dark cells from which the conidiophores arise. Conidiophores (phialides) 6-16 x 1-2 µm, cylindrical, tapered toward tip, simple or occasionally branched once near the base, sometimes with a single septum. Alpha conidia (5.0-)5.5-11.0 x (1-)1.5-2.0(-2.5) µm, narrow ellipsoid to fusiform, sometimes tapered more at one end, straight or slightly curved, hyaline, unicellular, sometimes biguttulate especially when young. Beta conidia 15-20 x 0.75-1.0(-1.5) µm, filiform, blunt at one end, tapered toward the other, curved, or hamate at the tapered end, hyaline.

Usually we found only alpha conidia in pycnidial stromata on the host. However, stromata found on the roots of one sample contained abundant beta conidia, and on PDA both alpha- and beta conidia with many intermediate forms were usually found in stromata formed in culture.

The fungus grew rapidly on 2% PDA; the rate of mycelial growth and the rate of development and the number of pycnidial stromata increased with increase in temperature at the three temperatures tested (15 C, room temperature fluctuating between 20 and 24 C, room temperature fluctuating between 24 and 30 C). At 24-30 C, colonies resulting from single germinated conidia averaged 45 mm radial growth in 4-7 days, and mature pycnidia extruding conidial tendrils were abundant when cultures were 17 days old. The aerial mat of cultures was predominantly white at 1 week, felty, appressed, with the surface rather furfuraceous in appearance, indistinctly zonate, with some gray-brown or olive-brown color appearing on the central part of the mat and in splotches beyond that area, the mat gradually becoming more felty-matted and predominantly dark gray or tan-gray. Pycnidial stromata developed in culture were black on the surface, similar to those on the host but larger, with pycnidial locules lined by hymenium as on the host, or with black columnar stromatal projections on a basal stroma with one locule in each projection. Conidiophores (phialides) and alpha- and beta conidia were similar to those on the host but alpha conidia (5.5-7.5 x 1.5-



Figures 1-16. *Phomopsis elaeagni*. Figs. 1-6, 11, 12. Fungus on the host: 1) Portion of canker on 4-year-old branch, with pycnidial stromata in diseased bark, X 1.5; 2) Portion of canker on 1-year-old branch, with pycnidial stromata, X 1.5; 3,5) Sections through pycnidial stromata, X 150); 4) Surface view of pycnidial stromata, X 4; 6) Portion of section through pycnidial stroma to show hymenium lining locule, X 600; 11,12) Alpha conidia, phase, X 1200. Figs. 7-10. Fungus in culture: 7) Culture on 2% PDA, 4 weeks, room temperature (20-24 C), X 2/3; 8) Portion of surface of culture to show pycnidial stromata with conidial tendrils, X 4; 9,10) Vertical sections through pycnidial stromata, 8 weeks, 2% PDA, room temperature (20-24 C), X 50. Figs. 13-16. Conidia formed in culture: 13) Alpha conidia and conidia intermediate between alpha- and beta conidia, phase X 1200; 14) Beta conidia, bright field, X 600; 15) One alpha conidium and one beta conidium, phase X 1200; 16) Beta conidia, phase X 1200.

2.0 µm) usually were consistently smaller than on those on the host.

White and Ellett (1972) found that pycnidia containing both alpha- and beta conidia were produced in 1 week in cultures grown at 28 C under continuous light. The size range of alpha conidia reported by White and Ellett agreed with that of our isolates, but their measurements of beta conidia (17-26 x 1-2 µm, majority 20-21 µm long) were larger than ours. However we have had an opportunity to study White and Ellett's cultures and there is no doubt that we are dealing with the same species.

Discussion

The ascigerous state of P. elaeagni should be a Diaporthe. To date no Diaporthe has been found on Elaeagnus in North America by contemporary investigators. The fact that Russian olive seedlings recently imported from Europe were found to have the disease caused by P. elaeagni with the fungus fruiting on them, and that seedlings propagated in nurseries from trees grown from seed were disease free in Canada, suggests that this species may be the conidial state of the European Diaporthe elaeagni Rehm. However, no data on the conidial state of that species has been found, and no recent collection of D. elaeagni has been made in Europe from which we might obtain information about the conidial state by cultural methods.

Diaporthe elaeagni Rehm was listed in the USDA Index of Plant Diseases (1960) on dead branches of Elaeagnus commutata in New York State, but we have not been able to find the source of that report. However, in the USDA files (M.L. Farr, personal communication), there is a report of D. elaeagni on dead branches of Elaeagnus longipes, published by Fairman (1910) as D. elaeagni Rehm var. Americana n. var. No information about the conidial state was included with this description. However, the Fairman specimen (Mycotheca Fairmani 2520) has been borrowed from Cornell University (CUP) and found to match the type specimen of Diaporthe elaeagni Rehm from the Wehmeyer herbarium (in DAOM 120601). In the Fairman specimen, there is an associated conidial state that appears to be the same as Phomopsis elaeagni. It is still necessary to obtain viable material of the ascigerous state to prove the genetic connection by cultural methods.

The severity of the symptoms described and the high percentage of infection in artificial inoculations of seedlings and trees in the United States (Carter and Sacamano 1967; Carter and Dodd 1969; White and Ellett 1972 in Missouri, Illinois, and Ohio) indicate that P. elaeagni is a serious threat to young nursery-grown Russian olive trees as well as to older trees in ornamental plantings, even though in Canada it has yet been found only on imported seedlings in nurseries. It is possible that temperature may be a limiting factor, but, as recommended by Carter and Dodd (1969), nurserymen and arborists should use extreme care to reduce mechanical injury and to avoid leaving wounds unprotected when pruning and taking cuttings, to eliminate this avenue of infection for the fungus. Seedlings used in ornamental plantings should be screened carefully, since the use of diseased nursery grown stock in such plantings will greatly increase the potential spread of the fungus.

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The authors appreciate the interest of Dr. J.C. Carter, Illinois Natural History Survey, who supplied type material of Fusicoccum elaeagni on the host and in culture, and of Dr. C. Wayne Ellett, The Ohio State University, who sent cultures of the Phomopsis isolated from diseased Elaeagnus in Ohio. The following inspectors of the Plant Protection Division participated in the survey for this disease in Canada: J. Bell, V. Bemberg, D. Bertoia, P. Froese, G.E.B. Fuller, B. Gill, E.A. Hayward, H. Herdy, R.M. Hlatky, S. J. Jager, R.D. Kirkham, G. McBay, R. Scott, B. Wellman, and B. Wiebe. The technical assistance of Mrs. P.M. LeClair and Mr. E.G. Kokko is gratefully acknowledged.

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DISEASES OF THREE SPECIALTY LEGUME CROPS IN SASKATCHEWAN IN 1972: FIELD PEA, LENTIL, AND FABABEAN

D.L. McKenzie and R.A.A. Morrall[1]

Abstract

A total of 20 fields of field pea (Pisum sativum var. arvense), lentil (Lens culinaris), and fababean (Vicia faba) were assessed quantitatively in late summer for leaf, stem, and root diseases. The most prevalent disease was ascochyta blight (Ascochyta pinodes) of field peas. Powdery mildew, sclerotinia stem rot, and root and foot rots incited by Fusarium spp. and Rhizoctonia sp. were also commonly found.

Introduction

A survey of the diseases of three legume crops, field pea (Pisum sativum var. arvense (L.) Poir.), lentil (Lens culinaris Medik.) and fababean (Vicia faba L.) was undertaken in 1972 as part of a continuing project in this laboratory on diseases of specialty crops in Sasktachewan. Previous surveys (2) had provided preliminary qualitative data on field pea and lentil and had suggested that an effort to gather quantitative data was warranted. In addition, fababean, grown for the first time in 1972 as a field crop in Saskatchewan, was included in the survey. Field pea has been grown in Saskatchewan for many years, while lentil is a relatively new crop (2). Actual acreages of field pea and lentil grown in previous years in the Province have been published elsewhere (2); in 1972 the acreages of the three crops were: lentil (13,000 acres), field pea (5,000 acres), fababean (500 acres). All of these figures represent increases over 1971.

The three crops were grown mainly in localized parts of the Province. Field pea was concentrated in the Bellevue area (60 miles N.E. of Saskatoon) and in the Nipawin area (150 miles N.E. of Saskatoon). Lentil was mainly in the Eston-Coleville area (150 miles S.W. of Saskatoon). Most of the fababean fields were in the Outlook irrigation district (60 miles S. of Saskatoon), but at least two fields were on dryland, one near Bellevue and the other near Perdue (40 miles W. of Saskatoon). These areas dictated the locations of the fields surveyed.

Methods

General

The survey was conducted in the period August 16 - September 3, 1972, and involved a total of 20 fields. The methods of sampling the crops and assessing diseases involved considerable improvisation, mainly due to a lack of pertinent information in the literature, such as appropriate field keys. Each field was sampled in four locations, usually near the corners, but about 50-100 ft into the crop. Sampling was done in a manner which ensured that for root and stem diseases it was possible to derive values for either the number of diseased plants per square meter or the percentage of diseased plants. At the same time it ensured that for foliar diseases the percentage of leaf area diseased could be determined. Thus, for root and stem disease assessment, either known areas of the crops were delimited with quadrats and the numbers of diseased plants in the quadrats counted, or a fixed number of plants in a row or cluster were pulled and rated for disease, or a combination of the two methods was used. Foliage, or whole plants, were collected from each sample area and taken to the laboratory for leaf disease assessment. Isolations from diseased tissue were always made when the identity of the casual agent was unknown. Tissue pieces were surface sterilized in 10% Javex (5.0% NaOCl) for 1 min and plated on potato dextrose agar (PDA). The disease assessments of each sample area or quadrat were averaged to give field means and then these were used to calculate the means for all the fields of the crop that were sampled.

Field pea

Root and stem diseases were assessed by placing 1 m^2 quadrats on the ground and counting the number of diseased plants in the quadrat. Foliage and pods were collected from the upper green portions of plants in the quadrats and taken to the laboratory. Leaves from the lower parts of the stems were invariably dead at the time of sampling and consequently were not included in the sampled foliage. The percentages of leaf area affected by ascochyta blight and by powdery mildew were determined with a disease assessment key for stemphylium leaf spot of red clover (1). Field pea leaflets were removed from the leaves and arranged in

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triplets, so that they could be compared roughly with the diagrams in the key. Twenty-five triplets of leaflets were rated from each quadrat sample. In addition, 25 pods were rated for the same two diseases by approximation using an assessment key for bacterial blight of bean pods (1).

Lentil

Groups of 50 plants were collected at random at each sample area and taken to the laboratory, where all disease assessments were made. Root infections were classified on the basis of the area covered by lesions on the main root; a rating of slight was given if less than 50% was affected, and a rating of severe if 50% or more was affected. All diseased root material was retained and isolations made on PDA to determine the causal organisms. Leaf diseases were not assessed because very few leaves had lesions; however, isolations were made from a few infected leaves.

Fababean

In most fields, a 1 m^2 quadrat was used to delimit a group of plants in each sample area, and the total number and the number with foot rot were recorded. In one field where the crop was planted in very wide rows, 50 plants from part of a row were scored in each sample area. In addition, foliage was collected from some of the assessed plants, normally from all the leaves still living from 5 plants in each sample area. The bean pods from the same plants were also collected and taken to the laboratory. Diseases of the leaf and pod samples respectively were assessed using the same keys as for field pea.

Table 1. Diseases of field pea

Disease	Fields of occurrence		% area lesioned		No. of plants affected per m^2	
	No.	%	Range	Mean	Range	Mean
Ascochyta blight						
leaf	9	100	0.4- 6.7	4.65	n.a.*	
pod	9	100	0.1- 6.6	1.57		
Powdery mildew						
leaf	1	11.1	0 -13.2	1.46	n.a.	
pod	1	11.1	0 - 2.7	0.30		
Fusarium root rot	3	33.3	n.a.		0-0.8	0.2
Sclerotinia stem rot	2	22.2	n.a.		0-0.3	0.07

* n.a. = not applicable.

Results

Field pea

Table 1 shows that only 4 diseases were found in the nine fields surveyed. Ascochyta blight (Ascochyta pinodes L. K. Jones) was the predominant disease, with lesions covering means of 4.65% and 1.57% of the leaves and pods respectively. Most plants, and in fact, most of the leaves and pods were infected in all fields. Powdery mildew (Erysiphe polygoni D. C. ex Mérat) was noticeably absent in all but one of the fields examined. In that field infection was quite heavy in two of the sample areas but absent in the other two. Root and stem diseases (Fusarium spp. and Sclerotinia sclerotiorum (Lib.) de Bary) occurred in almost insignificant amounts.

Lentil

The amount of root infection by Fusarium spp. was extremely high (Table 2). However, with all types of root rot, the effect of even the severe lesions on the above-ground parts of the plants did not appear to be very great. This, of course, is a subjective impression, but it is likely that the root lesions were initiated at a late stage of plant development. Table 2 also indicates that Sclerotinia and Botrytis infections on stems were at quite a low level; they appeared to be less frequent than in a previous survey (2), although it must be recognized that the earlier survey was mainly qualitative and was done in fields in different locations from those in the 1972 survey. Representative isolates from the Botrytis infections were identified as B. cinerea Pers. Some stem lesions, which resembled those incited by Sclerotinia, yielded Alternaria spp. and Fusarium spp. on isolation. However, pathogenicity tests were not conducted on the isolates. Similarly, a few punctiform leaf lesions yielded Alternaria spp. on isolation, but proof of pathogenicity was not established.

Table 2. Diseases of lentil

Disease	Fields of occurrence		% of plants infected	
	No.	%	Range	Mean
Fusarium root rot				
slight	6	100	15.5-69.0	49.08
severe	6	100	1.0-35.0	21.33
Rhizoctonia root rot				
slight	2	33.3	0 - 4.5	0.83
severe	2	33.3	0 - 2.5	0.50
Rhizoctonia - Fusarium root rot				
slight	2	33.3	0 - 0.5	0.17
severe	2	33.3	0 - 0.5	0.17
"*Alternaria* stem rot"	6	100	2.5-12.0	6.50
Sclerotinia stem rot	1	16.7	0 - 3.0	0.50
Botrytis stem rot	1	16.7	0 -10.0	1.67
"*Fusarium* stem rot"	2	33.3	0 - 2.5	0.75

Table 3. Diseases of fababean

Disease	Fields of occurrence		% area lesioned		% of plants infected	
	No.	%	Range	Mean	Range	Mean
Leaf spot	5	100	2.2-11.8	4.58	n.a.*	
Pod spot	5	100	0.4-22.2	6.46	n.a.	
Powdery mildew of leaf	1	20	0 - 0.3	0.06	n.a.	
Rhizoctonia sp. foot rot	3	60	n.a.		0-4.1	1.16
Fusarium spp. foot rot	1	20	n.a.		0-0.5	0.10

* n.a. = not applicable.

Fababean

Table 3 indicates that the principal pathological conditions recorded on fababean were leaf and pod spotting. Spotting of both organs was of two types: large irregular necrotic areas with indefinite edges and smaller oval lesions with light brown centers and dark brown definite margins. Alternaria spp. were frequently, but not consistently, isolated from both types of lesions, but pathogenicity tests were not made on the isolates. While the cause of these two leaf spots is obscure, it seems likely that at least some of the former type was tissue necrosis associated with senescence. Powdery mildew[2] was recorded in only one field, and then in only one of the four sample areas. However, in another field it was observed outside of the sample areas, in moderate amounts in a strip of plants which had not been inoculated with Rhizobium at seeding. Elsewhere in the field the disease was practically nonexistent, suggesting a marked effect of nitrogen nutrition on disease severity.

[2] The pathogen was initially identified as Erysiphe polygoni. Subsequent work suggested that it may have been another species, but no specimens were retained

Discussion

While the acreages of field pea, lentil, and fababean in Saskatchewan were small in 1972, there are indications that all three crops may become more important in future. Systematic breeding programs on all three crops are in progress at the Crop Development Centre, University of Saskatchewan, and possible new uses are also being studied. Thus, pathological studies, including disease surveys, are important and should be continued and expanded. The results reported here, as well as those of previous work on two of the crops (2), have demonstrated only one disease, ascochyta blight of field pea, to be occurring at serious levels. This disease is already receiving attention in the breeding program at the Crop Development Centre. However, the surveys have pointed to a number of other pathological problems which could become more serious and which require further study.

Field pea has been grown in Saskatchewan for many years (2), during which time the varieties have changed and the relative frequencies of the three species of Ascochyta known to cause blight of peas have probably also changed (3). However, levels of inoculum of all pea pathogens have probably stabilized in the traditional pea growing areas. Thus, the major factor affecting disease severity is probably weather conditions during the growing season. On the other hand, inoculum of pathogens of lentil and fababean will almost certainly increase over the next few years if the crops continue to be grown and the acreages expanded. Diseases so far not recognized in Saskatchewan will probably appear and it remains to be seen whether serious losses will occur. Even now, further work is necessary to identify the cause of some of the pathological conditions found in 1972, such as leaf spot of fababean and stem rot of lentil. Also, the exact role of Fusarium spp. and Rhizoctonia sp. in root necrosis of lentil, and the effects of necrosis, if any, on yield need to be clarified. The relationship of weather to the severity of certain diseases under Saskatchewan conditions may require study; 1972 was considered to be a relatively dry year in most parts of the Province, and this probably affected all foliage diseases, and diseases such as botrytis and sclerotinia stem rots. Another problem which may require study is the host range of some of the pathogens of these legumes, since rotation is often important in disease control.

A major shortcoming in the surveys of specialty crops so far conducted from this laboratory is that they have been done only at the end of the growing season. Thus, not only have seedling, and perhaps some other kinds of diseases, been completely overlooked, but also no picture has been developed of the progression of diseases with time. It is intended to remedy these deficiencies in future surveys.

Acknowledgments

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RHIZOPHYDIUM GRAMINIS (CHYTRIDIALES): MORPHOLOGY, HOST RANGE, AND TEMPERATURE EFFECT

D.J.S. Barr[1]

Abstract

Rhizophydium graminis, an obligate parasite of root cells was found in soil from most winter wheat growing areas of Ontario. In laboratory tests an isolate from wheat grew abundantly on barley (Hordeum vulgare), Agropyron repens, Bromus japonicus, Digitaria sanguinalis, Elymus canadensis, Lolium perenne, and Zea mays but poorly or not at all on oats (Avena sativa), 13 other species of Gramineae and 9 commercial plants in other families. R. graminis was also found in Ontario on six nongraminaceous hosts. Two isolates from Plantago major failed to infect wheat. The morphology of R. graminis is discussed and a non-sexual origin of the resting spores is suggested. The fungus grew between 5 and 21 C with optimum about 15-19 C.

Introduction

The chytridiaceous fungus Rhizophydium graminis was first reported by Ledingham (3) on roots of wheat and Panicum from Ontario and Massachusetts. More recently, MacFarlane (4) found this fungus on cereals, grasses, Chenopodium, Stellaria, and tobacco in England. In Ontario, R. graminis was one of four zoosporic fungi commonly found associated with wheat spindle streak mosaic virus (1). The possibility of it being a vector of WSSM virus prompted further investigation on morphology, distribution in Ontario, host range, and temperature effect.

Methods

Rhizophydium graminis Ledingham was found on the roots of winter wheat seedlings grown in soil from various fields at 15-18 C for 3 to 4 weeks. To increase the number of fruiting bodies and to make roots easier to examine microscopically, the roots of seedlings removed from the soil were rinsed in tap water, the young plants potted in sand and watered with half-strength Hoagland's solution. The fruiting bodies were usually abundant after a further 2 to 3 weeks at 15-18 C. Previous failure to find the fungus on roots of plants grown in sand (1) can be attributed to temperature which occasionally exceeded 20.C.

The fungus was transmitted to other seedlings by growing seedlings around an infected wheat plant in sand in a 4-inch pot for 2-3 weeks. The test seedlings were then repotted in sand. The fungus has been maintained on wheat in this manner for over 4 years. Host range and temperature experiments were done with an isolate from a mixture of soils collected from wheat fields near Brantford, Ontario.

Observations and results

Morphology

Rhizophydium graminis occurs on root hairs and epidermal cells of wheat, barley, and certain grasses and weeds. It is recognized by spherical sporangia on the surface of root cells (Fig. 1), or by the cup-shaped walls of empty sporangia following zoospore release (Fig. 2). The host cell is penetrated by a fine germ tube which grows into a sparingly branched rhizoid (Fig. 2) while the external zoospore cyst enlarges and becomes a sporangium. The empty sporangia and rhizoids clearly distinguish the fungus from the protozoa or from Pythium sporangia which are at times superficially similar to the globular, external sporangia of R. graminis.

Sporangia of all isolates that I have examined from Ontario were typically spherical, 6-36 um diam and occasionally ovate. Larger sporangia, reported up to 100 um diam (3), were not seen on either freshly collected plants or on plants grown in sand. At maturity sporangia release zoospores by a sudden bursting of a thin apical portion of the sporangium wall. The zoospores, which swim away immediately, vary from spherical, 2-2.5 µm diam to elliptical, 2X3-1.5X4 µm and have one lipid body, 0.5-1.5 µm diam, and one posterior flagellum. The flagellum lengths of five isolates differed as follows: 10-12, 12.5-14, 13-15, 14-15.5, and 15-16 µm. The measurements include the very fine and difficult-to-see whiplash end 1.5 µm in length.

Resting spores are 10-18 µm diam and have a hyaline or very pale brown outer wall 0.5-

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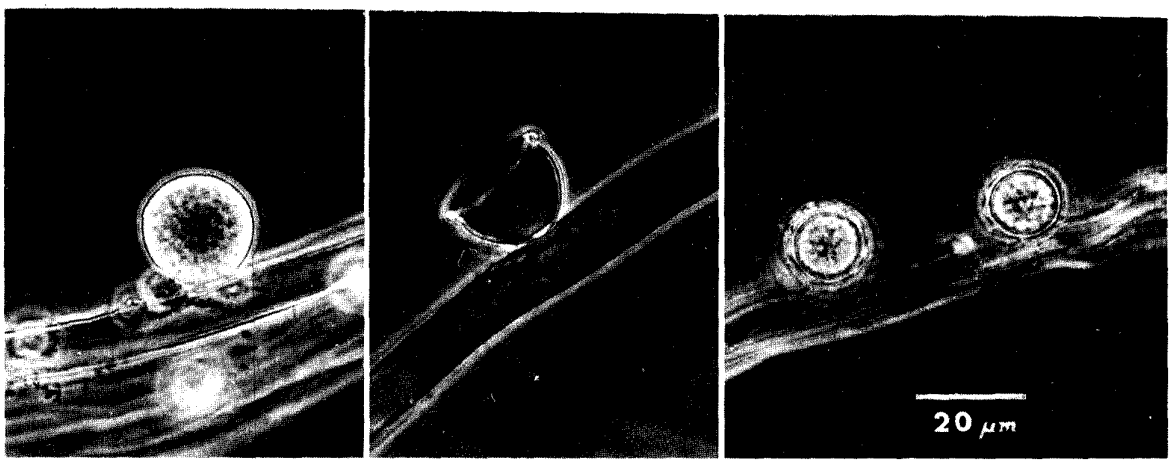

Figures 1-3. *Rhizophydium graminis* on root hairs of wheat. 1) Mature sporangium; 2) Empty sporangium following discharge of zoospores, note the rhizoids inside the root hair; 3) Two thick-walled resting spores. All figures at the magnification shown in Fig. 3.

1.0 µm thick and a hyaline inner wall 0.5 µm. The outer wall is at first smooth but becomes roughened when mature (Fig. 3). I have not been able to confirm earlier observations (3) that resting spores result after fusion of rhizoids. Although root hairs usually are infected by many large and small thalli with interlacing rhizoids, I believe resting spores are asexual because often a solitary resting spore was seen without any sign of fusion to an adjacent cyst or rhizoid.

Temperature effect on growth

The maximum temperature measured among the roots in sand culture was 20-21 C;the estimated optimum growth, based on the abundance of sporangia, was between 15 and 19 C. The fungus also grew at 5 C which was the lowest temperature tested. Resting spores occurred at 5 to 21 C and were exceedingly abundant at 20-21 C.

Survival

The fungus has survived 9 years, the longest period tested, in air-dried soil stored in a greenhouse in which the temperature varied from about 15 to 30 C.

Distribution

In 1971 R. graminis was recovered from 15 out of 19 soil samples collected in wheat fields in southern Ontario, including the following counties: Elgin, Haldimand, Huron, Kent, and Lincoln. It has been recovered from soil at the Central Experimental Farm, Ottawa, and at Amherst Island in Lake Ontario. It is therefore probably present in all wheat growing areas of Ontario. In addition, it was found in muck soil in which vegetable crops had been grown for many years from the Bradford Marsh, Simcoe County.

Host range

Plants were recorded as susceptible, lightly infected or resistant to an isolate of R. graminis from wheat.

Susceptible - Susceptible species were infected at least as severely as cv. Kent winter wheat; mature sporangia were abundant on epidermal cells and root hairs and the fungus was able to subsist on the test plant after removal of the infected wheat plant from the pot. Susceptible plants included winter wheat (Triticum aestivum L. cv. Kent), durum wheat (T. durum Desf. cv. Ramsey), barley (Hordeum vulgare L. cv. Vantage), field corn (Zea mays L. cv. Dekalb), sweet corn (Zea mays var. rugosa Bonsf.), perennial rye grass (Lolium perenne L.), Agropyron repens (L.) Beauv., Bromus japonicus Thumb., Digitaria sanguinalis (L.) Scop., and Elymus canadensis L.

Light infection - Lightly infected plants had a few mature sporangia on roots and possibly only succumbed to R. graminis because of the favorable test conditions. The fungus either did not survive or was barely detectable on the test plants when the infected wheat plant was removed from the pot. Species included in this category were cabbage (Brassica oleracea var. capitata L. cv. Golden Acre), cress (Lepidium sativum L.), rice (Oryza sativa L. cv. Blue Bonnet), lettuce (Lactuca sativa L. cv. Grand Rapids), Agropyron trachycaulum (Link) Malte., Avena byzantina K. Koch, A. sterilis L., Bromus inermis Leyss., Festuca rubra L., Holcus lanatus L., and Hordeum bulbosum.

Resistant - Plants were considered resistant if encysted zoospores failed to develop into mature sporangia. It is interesting to note that within the genus Avena, wild oats (A. fatua and A. barbata) and the cultivated varieties Stormont and Garry were completely resistant, whereas on cv. Clintland 60 a few aborted sporangia were seen with their germ tubes walled-off by host plug material. In contrast, the wild

grasses A. byzantina and A. sterilis were lightly infected. Resistant plants included oats (Avena sativa L. cv. Stormont, Garry, and Clintland 60), beet (Beta vulgaris L.), green bean (Phaseolus vulgaris L. cv. Harvester), parsley (Petroselinum crispum (Mill.) Mansf. cv. Moss Curl), Avena barbata Brot., Avena fatua L., Dactylis glomerata L., and Poa pratensis L.

In addition to the host range tests recorded above, R. graminis has been found on a number of occasions on plants other than wheat. In a sample of muck (organic) soil from the Bradford Marsh, R. graminis grew abundantly on barnyard grass (Echinochloa crus-galli (L.), Beauv.), purslane (Portulaca oleracea L.), and common groundsel (Senecio vulgaris L.), which grew from seed inadvertently collected with the soil. The fungus grew on wheat grown in this soil but not on cabbage, carrot (Daucus carota L.), celery (Apium graveolens L.), lettuce, onion (Allium cepa L.), parsley, tomato (Lycopersicum esculentum Mill.), or Oenothera biennis L.

On two occasions in 1973 R. graminis was found on plantain (Plantago major L.) from Vineland and Port Colborne. On each occasion attempts to transmit the fungus to wheat were unsuccessful.

R. graminis was found on five other occasions in 1973 on the following grasses and weeds collected in Ontario: Agropyron repens, redroot pigweed (Amaranthus retroflexus L.), shepherd's purse (Capsella bursa-pastoris (L.) Medic.), wild strawberry (Fragaria virginiana Duchesne) and Polygonum aviculare L.

These findings suggest there are host specific strains of R. graminis because the isolate from wheat severely infected only graminaceous plants whereas the fungus occurred naturally on non-graminaceous weeds from several locations. Moreover, two isolates from Plantago major failed to infect wheat under favorable test conditions in the laboratory.

A search of the literature shows that apart from the rather scarce reportings of R. graminis (1, 3, 4), a species of Rhizophydium has been found parasitic on Erica gracilis in Switzerland (5), and in Germany R. patellarium was reported parasitic on cortical cells of cabbage (2). However, most species of Rhizophydium occur on algae in aquatic habitats or have been isolated on pine pollen or other baits from soil. Several have been grown in pure culture on chemically defined media but all attempts by the author to grow R. graminis on algae, pine pollen, or in pure culture have, so far, failed.

Acknowledgments

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NEMATODE NUMBERS UNDER CULTIVARS OF FORAGE LEGUMES AND GRASSES

J.L. Townshend and J.W. Potter[1]

Abstract

Cultivars of timothy supported moderate to high numbers of Paratylenchus projectus, Pratylenchus neglectus and Helicotylenchus digonicus whereas orchardgrass supported only the latter two nematodes well. Red, sweet, and white clovers and alfalfa supported moderate numbers of H. digonicus and birdsfoot trefoil high numbers of P. projectus.

Résumé

Des variétés de Phleum pratense supportèrent des populations variables de Paratylenchus projectus, Pratylenchus neglectus et Helicotylenchus digonicus tandis que Dactylis glomerata supportèrent seulement que les deux dernières espèces de nematode. Trifolium pratense, T. repens, Melilotus alba et Medicago sativa supportèrent des populations modérés de H. digonicus et de Lotus corniculatus, de grande populations de P. projectus.

Eight genera of plant parasitic nematodes were found associated with forages in Ontario (Potter & Townshend, 1973; Townshend, Willis, Potter & Santerre, 1973). Four of these predominated: Pratylenchus Filipjev; Paratylenchus Micoletzky; Helicotylenchus Steiner; and Meloidogyne Goeldi. Almost without exception all Ontario forage fields were infested with one or more of these four genera. Subsequently the authors had the opportunity to sample pure stands of forage legumes and grasses in test plots managed by the Department of Crop Science, University of Guelph, at Elora, Ontario. The results from these samples are presented.

The forage species were growing on London or Guelph loam soil types and were sampled in June and November, 1971. Ten cores were taken to a depth of 20 cm with a 2.5 cm soil sampler close to the crowns of the plants. Cores from each plot were thoroughly mixed and nematodes extracted from 50 g subsamples in Baermann pans (Townshend 1963) for 1 week, counted, and recorded as the number per 0.45 kg of soil.

Three species of nematodes, Pratylenchus neglectus (Rensch) Chitwood & Oteifa, Paratylenchus projectus Jenkins, and Helicotylenchus digonicus Perry were found. Alfalfa (Medicago sativa L.) supported large numbers of H. digonicus and much smaller numbers of P. neglectus and P. projectus (Table 1). White clover (Trifolium repens L.), red clover (Trifolium pratense L.), and sweetclover (Melilotus alba Desr.) supported large numbers of H. digonicus and small numbers of P. neglectus. Paratylenchus projectus developed large numbers only under white clover. Sainfoin (Onobrychis viciaefolia Scop.) supported small numbers of P. projectus and H. digonicus. Cultivars of birdsfoot trefoil (Lotus corniculatus L.) supported very large numbers of P. projectus, small numbers of H. digonicus, and none of P. neglectus.

Bromegrass (Bromus inermis Leyss.) supported large numbers of P. neglectus and a few of H. digonicus (Table 1). Cultivars of orchardgrass (Dactylis glomerata L.) supported large numbers of both P. neglectus and H. digonicus. The four cultivars of timothy (Phleum pratense L.) listed in Table 1 supported all three nematodes well, particularly P. projectus and H. digonicus. The other 24 cultivars of timothy sampled but not listed supported similar numbers of these nematodes.

This pattern of nematode multiplication may explain, in part, the success of the bromegrass-alfalfa mixture now recommended in Ontario. Mixtures of birdsfoot trefoil, red clover, or sainfoin with bromegrass may offer promise for nematode control and deserve study. Perhaps a mixture of bromegrass, birdsfoot trefoil, and red clover would be even more suitable. Red clover could develop initially with bromegrass until the slower growing birdsfoot trefoil developed to take over as the red clover died out. The effect of timothy in forage mixtures needs further study because of the number of nematode species that multiply under this grass.

An assessment in microplots of crop loss caused by each nematode species on each forage species is essential before an intensive program is initiated to search for nematode resistance in forage species. Other assessments are required as well, such as the

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effect of combinations of forage species on the population development of individual nematode species and conversely the effect of individual forage species on populations of combinations of nematode species.

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Table 1. Number of nematodes associated with cultivars of forage legumes and grasses

	Nematodes/0.45 kg soil					
	Lesion		Pin		Spiral	
	June	Nov.	June	Nov.	June	Nov.
Legumes						
Alfalfa						
Saranac	150	100	20	0	3,130	1,730
Vernal	130	180	50	20	2,460	1,000
White clover						
Merit*	200		9,040		5,150	
Red Clover						
Canadian common double-cut*	30		60		4,680	
Sweetclover						
Goldtop*	160		20		2,330	
Sainfoin						
Melfort	0	0	0	70	10	0
Birdsfoot trefoil						
Empire	0	0	3,880	7,000	0	50
Leo	0	0	2,480	12,800	0	20
Maitland	0	0	6,560	11,500	0	0
Grasses						
Brome						
Saratoga†		1,900		0		100
Orchard						
Kay*	1,800		20		3,900	
Rideau	930		60		3,000	
OSG-5	4,320		50		2,850	
OSG-7	1,800		60		3,070	
Timothy						
Champ	600	9,400	1,000	5,000	6,400	10,800
Eskimo	200	5,000	400	11,600	5,500	6,200
S-352	400	11,600	5,000	9,000	7,200	7,800
Topaz	300	1,800	2,000	4,600	2,900	12,600

* Crop ploughed down.

† Crop not sampled in June.

SOME OBSERVATIONS ON THE SURVIVAL AND DEVELOPMENT OF HELICOTYLENCHUS DIGONICUS UNDER ALFALFA

J.L. Townshend and J.W. Potter[1]

Abstract

In the laboratory Helicotylenchus digonicus became quiescent at 2 C and survived in soil at -3 C. In the field H. digonicus overwintered in equal numbers in alfalfa plots with and without snow cover. During the growing season the number of H. digonicus increased and declined normally where alfalfa had survived with snow cover but neither increased nor declined where alfalfa had winter-killed without snow cover.

Résumé

En laboratoire Helicotylenchus digonicus est devenu inactif à 2 C et survivèrent dans le sol à -3 C. Sur le terrain H. digonicus hivernèrent en nombre égal dans des parcelles de Medicago sativa recouvertes ou non de neige. Aucours de l'été le nombre de H. digonicus s'accrût et déclina normalement ou le Medicago sativa, recouvert de neige, avait survécu; mais ou la Medicago sativa était mort, n'ayant pas été recouvert de neige, le nombre de nématode ne s'accrût pas ni déclina.

The spiral nematode, Helicotylenchus digonicus Perry, is one of four dominant plant parasitic nematodes associated with forage in Ontario (Townshend et al. 1973). Field and greenhouse studies showed that alfalfa, clover, and timothy were hosts of the spiral nematode (Townshend 1972, Townshend and Potter 1973). This ectoparasitic nematode is able to survive our winters though its host likely provides little or no protection. Some laboratory and field observations on the survival and development of H. digonicus under alfalfa are reported.

Methods

In the laboratory, quiescence and freezing tolerance of H. digonicus were examined. Quiescence was studied by plunging vials containing a water suspension (2 ml) of nematodes into cold water baths at 2, 4, 6, and 8 C for 20, 40, 60, and 180 minutes. Active and inactive nematodes were counted in chilled dishes. The nematodes in this test originated from infested soil stored at 1 C, and were extracted in Baermann pans (Townshend, 1963) at room temperature to obtain nematode suspensions. Freezing tolerance was studied by placing vials of the infested soil in a freezer at -3 C for 2, 4, and 8 days. Each vial contained 400 nematodes in 17 g of soil at 18.5% moisture. Upon thawing, nematodes were extracted for 1 week in Baermann pans and counted. All treatments were replicated 10 times.

In the field, the survival and development of H. digonicus in a London loam were examined in alfalfa management plots maintained by the University of Guelph at Elora, Ontario. Subplots with and without snow cover during the preceding winter were sampled monthly from May to November in 1971. In 1972 a second set of subplots on a new location were sampled every 5 weeks from May to October. A minimum of 9 cores (2.5 x 20 cm) were taken from each subplot at each sampling. Nematodes were extracted from 50-g subsamples and counted as before. Soil temperatures were recorded through each winter.

Results and discussion

In the laboratory, larval and adult nematodes became quiescent within 20 min at 2 C. At higher temperatures, the nematodes remained active but their movements were sluggish and there was a greater tendency for the nematodes to coil. Quiescent nematodes became fully active within 30 min at room temperature. After 8 days in frozen soil at -3 C, the numbers of larvae and adults recovered were not significantly less than those from unfrozen soil.

In the field, the alfalfa plants were killed in those subplots that had no snow cover the preceding winter. In May of each

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year the number of spiral nematodes (larvae and adults) in those subplots in which the alfalfa had been killed, was not significantly lower than in those subplots in which the alfalfa had survived (Fig. 1). Furthermore by August or September the number of nematodes had neither declined nor increased significantly in the subplots in which the alfalfa had been winterkilled. However, in the subplots in which alfalfa had survived the number of nematodes had increased significantly during the same period (Fig. 1).

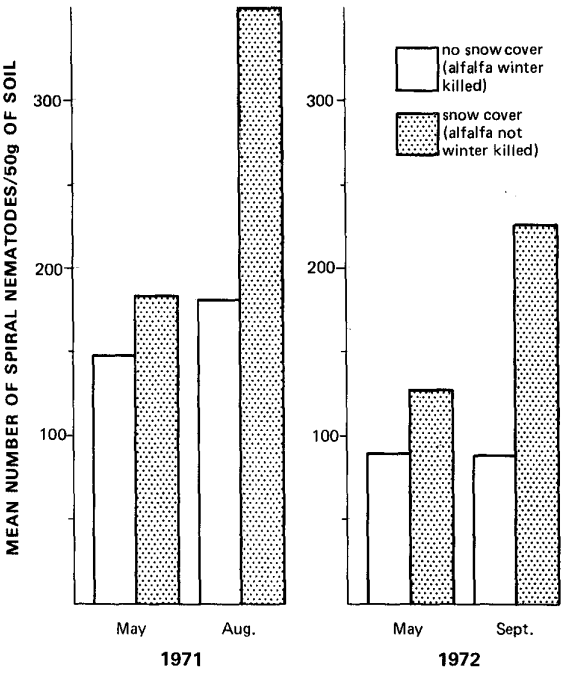

Figure 1. Survival, in May each year, and peak population development (August 1971 and September 1972) of the spiral nematode in alfalfa plots with and without snow cover. LSD 5% (August 1971) 95; LSD 5% (September 1972) 58.

The spiral nematodes multiplied at different rates in the summers of 1971 and 1972 in subplots with no winterkill. In 1971, the spiral nematode population peaked in August and November and declined from May to June and from August to September (Fig. 2). In 1972, the number of spiral nematodes continued to increase from May through September before declining in October (Fig. 2). The summer of 1972 was cool relative to that in 1971 but in both summers irrigation was used to maintain suitable moisture levels. Hence the difference in the rate of nematode multiplication in the two summers appears to be mostly the result of temperature.

Helicotylenchus digonicus has the capacity to survive winter and summer soil conditions. In early winter as soil temperatures decline, our laboratory studies suggest that the nematode becomes sluggish and then becomes quiescent before the soil freezes. In this environment many nematodes survive the mid- and late-winter soil temperatures, which average 0 C under snow cover and -4 C with no snow cover. On the basis of Sayre's (1964) study this nematode is "freezing tolerant". During the summer, without a host, the spiral nematode does not decline in numbers, supporting other experimental findings regarding the longevity of spiral nematodes in fallow soil (Golden 1956 and Ferris 1960). Perhaps spiral nematodes are immobilized in the fine-textured London loam and thus are better able to survive (Townshend and Webber 1971) in the absence of a host than if they were active in a coarse-textured soil.

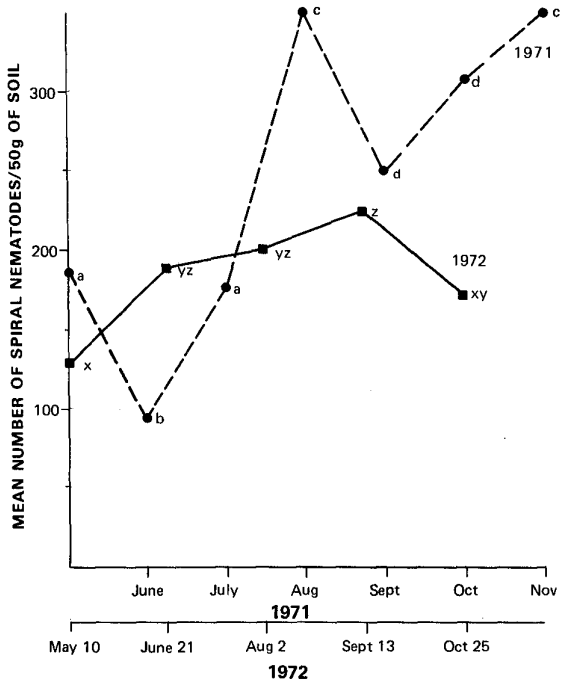

Figure 2. Population development of the spiral nematode in alfalfa plots having 60% or more plant survival in 1971 and 1972. The letter beside each coordinate indicates its significance in a Duncan's Multiple Range test.

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AUTHOR INDEX TO VOLUME 53