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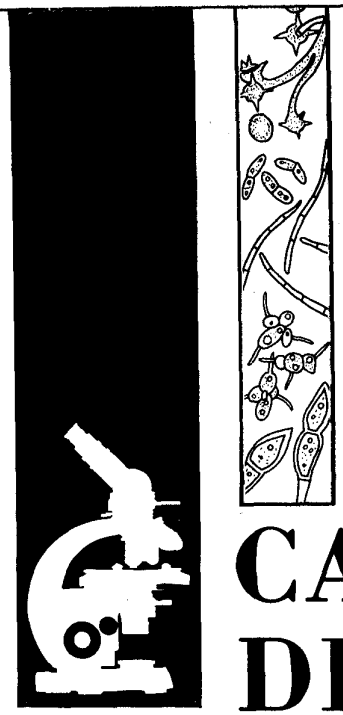

CANADIAN PLANT DISEASE SURVEY

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RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

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

THE POTENTIAL OF CORN AND WHEAT TO PERPETUATE WHEAT STREAK MOSAIC IN SOUTHWESTERN ONTARIO

L.F.Gates[1]

Abstract

Aceria tulipae (K) transmitted wheat streak mosaic virus from ripening kernels of corn (Zea mays) and wheat (Triticum aestivum) in the field until about 2 weeks before either crop was ready to harvest. Wheat infected in the fall was therefore a source of virus and vector under field conditions for infection of corn plants early in the following summer, and likewise infected corn was a source of infection for fall-sown wheat in September and October.

Introduction

Wheat streak mosaic has been recognized on winter wheat in southwestern Ontario since May 1964 (8), and on corn since August 1965 (6). The red striping of the corn pericarp known as kernel red streak is caused by the feeding of Aceria tulipae (K) on the kernels (4,7). Kernel red streak has been very widespread in southwestern Ontario since 1965, indicating that large populations of mites are present on kernels in most corn fields.

Since winter wheat is present in fields in southwestern Ontario from late September to late July, and corn from late May to October, the mite could transfer the virus in June and July from ripening kernels of wheat to corn and in October from kernels of corn to winter wheat. So far wheat streak mosaic virus has been found infrequently in this area, for reasons which are not known. A possible limitation on this cycle in the field is that at the time the mites leave each crop in large numbers they have been feeding on the pericarps of the ripening grains, which might not be good sources of virus for mite transmission.

Experiments were done to determine the potentialities of maturing wheat and corn as sources of viruliferous mites capable of infecting young plants of the alternate crop.

Methods

Movement of mites and virus from wheat to corn

To provide virus sources in a winter wheat crop, volunteer winter wheat (Triticum aestivum L.) plants that were infested with mites and showing symptoms of wheat streak mosaic were transplanted to eight sites in a winter wheat crop at the Harrow Research Station on November 9, 1967. At each site, plants in the two outer rows of a square yard plot (0.84 m^2) were replaced by infected plants. On May 1 and May 8 heavily infested wheat leaves from a greenhouse culture of healthy mites were placed on the infected plants in four of the eight plots. Mites were counted at intervals from May to July on the infected and nearby rows.

Movement of mites and virus from ripening wheat heads was detected by placing trap plants and vaseline-coated slides in or near the infected rows, and by testing wheat heads in the greenhouse for mites and virus. Further details are given in discussing the results of these tests.

Movement of mites and virus from corn to wheat

Sources of mites and virus in a corn crop were established by placing heads from the infected wheat rows in the whorls of 16 corn (Zea mays L. 'Pioneer 371') plants in the field on July 9. At this time the corn plants were 2 ft high. Similar corn plants received pieces of wheat leaf from a greenhouse culture with virus and mites. Some of the latter plants and some healthy ones were infested with healthy or with viruliferous mites on August 12 by placing pieces of healthy or infected wheat leaf with mites beneath the husks.

Ears were collected from these plants on several occasions in the fall and tested for the presence of mites and transmissible virus by pulling back the husks and laying the ears in trays of wheat seedlings. For weekly periods in the fall, vaseline-coated slides and trays of wheat seedlings were also set out as traps for mites between the corn rows at the height of the ears.

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Results

Development of mites on wheat

Some mites on the transplanted infected plants survived the winter, for mites were found on these plants from June 7 onwards (Table 1), but they were not found on plants in the general crop until July 8. There were many more mites throughout the season on the plants that received additional mites in May. The mites were found, as described by Kantack and Knutson (2), near the ligules of the upper leaves and eventually on the glumes and on the developing kernels, where large numbers were found in the kernel groove. In the plots reinfested in May the highest populations, averaging 33 mites per spikelet, were found on June 20. This would correspond to about 500 mites per wheat head, or about 200,000 per square meter. On plants in adjoining rows, which were somewhat later in maturing, peak populations of mites were found on July 2. In the general crop on July 8 there were 0.4 mites per kernel, or about 2500 per m^2. Mites could be found for 10 rows (about 6 ft) beside the infected rows, and for 4 ft along the rows containing the infected plants; similar spread was recorded by Orlob (5). Mite populations declined rapidly in the first 2 weeks of July, and many left the plants, for they were trapped in large numbers at this time on vaselined slides exposed for periods of about 5 days at the height of the ears (Table 1). The crop was harvested on July 30.

Table 1. Mites counted on winter wheat plants and caught on trap slides, 1968

Date	Site examined	No. of mites per site examined*: Plots with overwintered mites plus mites in May — Infested row	Adjacent row	2nd row away	Plots with overwintered mites only — Infested row	Adjacent row	2nd row away	Mites caught on vaselined slides (No./inch²/day)	Crop notes
May 24	Within 1 cm of ligule of 2nd leaf from top	19.3	2.6	1.4	0.0	0.0	n.c.**		Corn emerging
June 7	Within 1 cm of ligule of flag leaf	40.2	34.9	12.0	2.8	n.c.	n.c.		Wheat anthesis
June 20	Within 1 cm of ligule of flag leaf	0.2	0.2	0.2	0.0	0.0	0.0		Grain half size
June 7	Lower spikelet (glumes)	5.8	0.6	0.2	0.1	n.c.	n.c.		
June 20	Lower spikelet (glumes)	33.2	3.9	4.8	0.7	0.0	0.0		
June 28-July 3								3.7	
July 2	Lower spikelet (kernel)	21.7	13.1	15.5†	0.2	0.0	0.0		Grain milky inside
July 3-8								7.7	
July 8	Lower spikelet (kernel)	5.4	9.5	10.1††	0.8	0.2	0.5		Grain moist dough inside
July 8-10								12.4	
July 10-15								10.2	
July 18	Lower spikelet (kernel)	0.0	0.0	2.3	n.c.	n.c.	n.c.		(Most kernels (hard, mites on (immature grains
July 15-22								1.6	Wheat harvested July 30

* Mean of 5-10 counts on each of 4 plots.
** n.c. = no count made.
† On 2 July mites were also found on rows 3-10 (avg. 3.1 per kernel) and for 4 ft along row beyond the infected length; none were found in the general crop.
†† On 8 July mites were also found on rows 3-10 (avg. 6.8 per kernel) and in the general crop (0.4 per kernel).

Transmission of virus from wheat to corn

Very few visibly infected wheat plants were apparent apart from those in the original yard lengths, but many wheat heads from the four adjacent rows proved to be harboring infective mites when placed on corn seedlings in the greenhouse, and infective mites were also detected on plants in the 11th and 13th rows away from the infested rows on July 9 (Table 2, Test B).

Nearly all potted trap plants of corn and wheat placed in the field for 2-week periods

Table 2. Transmission of wheat streak mosaic from winter wheat to test plants of corn or wheat by field populations of mites

	TEST A				TEST B				
	Transmission of virus to equal numbers of corn and wheat plants in contact with or 18 inches from infected wheat plants				Transmission of virus to corn seedlings from heads* of wheat plants infested with overwintered mites plus mites added in May, and from heads of wheat from nearby rows				
	% of trap plants infected with virus								
	Rows with overwintered mites plus mites in May		Rows with overwintered mites only			No. of corn seedlings infected/no. tested			
Period of exposure of trap plants	Contact	18 inches	Contact	18 inches	Date	Infested wheat row	Adjacent wheat row	3rd row away	4th row away
May 24-June 10	80	89	5	0					
May 31-June 18	100	93	7	0					
June 10-28	70	50	8	12	June 11	9/12			
June 18-July 3	83	50	10	37	June 20	12/12	4/6		
June 28-July 10	80	100	33	25	July 2	12/12	4/6	2/3	
July 3-19	97	100	73	100	July 9	10/12		7/8	4/4†
July 10-19**	91	100	66	75					

* Wheat heads were tied to corn seedlings in this greenhouse test.
** Crop harvested July 30.
† Rows 9-17 were also tested on July 9, and heads from rows 11-13 contained infective mites.

in contact with or near plants that received mites in May became infected over the whole test period, May 24 - July 19 (Table 2, Test A). In the plots containing only mites that had developed from over-wintered populations, increasing proportions of test plants were infected from May 24 onwards when they were in contact with plants in the original yard lengths, and from June 10 onwards when they were in the centers of the plots with these plants. In early July, most trap plants in these plots also became infected.

Mites migrated from the wheat heads in large numbers in the 4th and 3rd weeks before harvest, and they could still transmit the virus to test plants in the 3rd week before harvest. Few mites remained on the wheat heads 2 weeks before harvest.

Transmission of virus from corn to wheat

The corn plants that received viruliferous mites in July or August did not show disease symptoms. Nevertheless, when ears were collected from these plants between September 13 and October 25 and placed on trays of wheat seedlings, mites were always detected and usually they transmitted the virus (Table 3). Mites and virus were obtained from a few of the ears collected on November 5, when the crop was harvested. Mites were not detected on vaselined slides in this period, but trap plants placed between the corn plants for periods of 7 to 11 days during October and early November became infested with mites, and a few plants became infected with the virus (Table 3). It is evident, therefore, that mites have the potential to transmit the virus from ripening corn kernels to wheat during October and early November, i.e. for several weeks after winter wheat usually germinates.

Discussion

This investigation has shown that wheat streak mosaic virus can readily be transmitted by mites from ripening wheat and corn kernels until about 2 weeks before harvest of either crop. This confirms the assumption that winter wheat and corn grown in close association can provide under field conditions sources of infection for each other, and thus can be complementary in the perpetuation of wheat streak mosaic virus and its vector A. tulipae.

In southwestern Ontario, wheat streak mosaic, although widespread, has infected so far only occasional plants of winter wheat and corn. In the autumns of 1966-68 wheat streak mosaic was seen in individual wheat plants every few paces in 16 of 42 fields examined, while in corn the disease was seen on occasional plants in 8 of 33 fields examined in late July and early August of those years. However, in this experiment the virus was recovered from wheat and corn plants that did not have symptoms, and infection may be more frequent than visual surveys suggest.

Del Rosario and Sill (1) found that A. tulipae from wheat adapted easily to several corn varieties, and readily transferred the virus from wheat to corn and back to wheat. Most virus isolates from wheat in southwestern Ontario were mechanically transmissible to the susceptible corn hybrid CH159 X CH3. The widespread occurrence of

Table 3. Transfer of mites and wheat streak mosaic from ears of corn to test seedlings of wheat

Source of infective or healthy mites used to infest corn in field	Ears placed on trays of wheat seedlings					Trays of wheat seedlings placed between corn rows			
	Sept. 13	Sept. 27	Oct. 11	Oct. 25	Nov. 5	Oct. 2-9	Oct. 9-18	Oct. 18-25	Oct. 25-Nov. 5
Winter wheat heads with mites and virus from field crop, July 9	0.7(+)†	1.0(+)	12.3(+)	0.3(+)	0.0(+)	0(+)	0(+)	0(+)	0(+)
Leaves with infective mites from culture, July 9	5.8(+)	5.8(+)	2.2(+)	0.0(+)	0.0(-)	0(-)	1(+)	0(+)	0(+)
Leaves with infective mites from culture, July 9, and healthy mites, Aug. 12	11.0(+)	8.8(+)	10.5(+)	0.8(+)	0.2(-)	0(+)	0(-)	0(+)	0(-)
Leaves with infective mites July 9 & Aug. 12	13.5(+)	4.5(+)	1.5(+)	0.5(+)	0.0(-)	0(+)	0(+)	1(+)	0(+)
Leaves with infective mites Aug. 12	17.4(+)	2.0(+)	0.0(+)	0.0(+)	0.2(-)	0(+)	0(+)	0(+)	0(-)
General crop	0.0(+)	0.0(+)	0.0(+)	0.2(+)	0.0(+)	0(+)	0(+)	0(+)	0(+)

† Figures represent avg no. of seedlings infected out of 50, and symbols in brackets indicate that mites were (+) or were not (-) detected on the test seedlings.

kernel red streak in recent seasons shows that mites reach a high proportion of corn plants, and should wheat streak mosaic become prevalent in a particular area it might well persist at a high level under present crop rotation practices.

Nault and Styer (3) reported that in Ohio high populations of Aceria tulipae were found on wheat in early summer and on corn in early fall, and that large numbers of this mite were trapped as these crops matured. They considered that the movement of mites and virus from wheat to corn in early summer and from corn to wheat in the fall could pose a threat to these crops in the Corn Belt.

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SEED-TREATMENT FUNGICIDES FOR CONTROL OF CONIFER DAMPING-OFF: LABORATORY AND GREENHOUSE TESTS, 1968-1969

L. W. Carlson[1] *and J. Belcher*

Abstract

One-hundred forty-eight seed treatment chemicals were tested in laboratory bioassays, 128 in laboratory germination tests, and 69 in greenhouse damping-off control tests. Preemergence damping-off was effectively controlled by 17 chemicals for jack pine (Pinus banksiana), by 8 for lodgepole pine (Pinus contorta var. latifolia), and by 8 for white spruce (Picea glauca). Effective control of postemergence damping-off was attained with 5 chemicals for jack pine, 8 for lodgepole pine, and 4 for white spruce. No fungicide tested was effective in controlling postemergence damping-off of all three conifer species. However, one experimental fungicide, 26-67, was more effective than captan or thiram in controlling postemergence damping-off of jack pine and lodgepole pine.

Introduction

Previously 69 seed treatment chemicals were tested for their inhibitory activity against isolates of Pythium sp., Rhizoctonia sp., and Fusarium sp.; 61 were tested in laboratory germination tests on jack pine (Pinus banksiana Lamb.), lodgepole pine (P. contorta Dougl. var latifolia Engelm.), and white spruce (Picea glauca (Moench) Voss); and 25 were tested in greenhouse damping-off control tests (1,2). Of these chemicals tested, only 13 were chosen for field evaluation, including the two standard conifer seed treatments, captan and thiram. It is necessary to evaluate new experimental fungicides as they become available because their development depends on their broad usage. Also the chances of finding a more efficient chemical are greater with inclusion of more fungicides in the screening trials. Reported here are the laboratory and greenhouse tests for 148 more experimental seed treatment chemicals.

Materials and methods

General procedures for laboratory bioassay and germination tests, and greenhouse damping-off control tests were described in an earlier report (1). The following is a brief description of these methods with modifications that were made for this study.

Laboratory bioassay--One hundred forty-eight seed-treatment chemicals (Table 1) were tested for inhibition of mycelium growth of isolates of Rhizoctonia, Fusarium, and Pythium known to cause conifer seedling damping-off. Sterile 10 mm filter paper discs infiltrated with the chemicals were placed on potato dextrose agar along with a 5 mm disc of actively growing mycelium. The amount of inhibition was recorded after 3 days for Rhizoctonia and Pythium, and after 5 days for Fusarium.

Laboratory germination tests--Seeds of jack pine, lodgepole pine, and white spruce were pelleted with seed-treatment chemicals at a rate of 0.33 g chemical per gram of seed. Dow Latex 512R was used as a binder. Treated seeds were placed on moistened filter paper and incubated at 100% relative humidity in a light and temperature controlled germinator. Germination was recorded after 14 days. The same seed sources were used throughout the study and each test was repeated at least once.

Greenhouse damping-off control tests--Seeds of the three above-mentioned conifer species were pelleted in the same manner as in the laboratory germination tests and were germinated in soil naturally infested with the damping-off organisms. The experimental plots containing 100 seeds per 5 inch plastic pot were arranged in a randomized block design with five replications for each treatment. Damping-off was recorded weekly from the beginning of emergence until 2 months after seeding.

Results and discussion

Laboratory bioassay--Data on the lowest concentration of those seed-treatment chemicals tested that inhibited growth of Rhizoctonia, Fusarium, and Pythium are shown in Table 2. Fifty-six of the 148 chemicals tested demonstrated a high level of activity (inhibitory at concentrations equal to or less than 631 g/ml) against all three fungi. Seven others were effective in inhibiting Rhizoctonia and Pythium only, and seven were active against Pythium alone. High activity

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Table 1. Source and identity of seed treatment chemicals

Treatment number	Source*	Product and formulation	Chemical name or active ingredient
100	Dupont	Benlate	benomyl
101	Chemagro	Bay 33172 5%	2-(furyl) benzimidazole
102	Chemagro	Bay 33172 50%	2-(furyl) benzimidazole
103	Dupont	Demosan 10-D	1,4-dichloro-2,5-dimethoxybenzene (chloroneb)
104	Chemagro	Bay 33172 3%, HCB 20%	2-(furyl) benzimidazole + hexachlorobenzene
105	Chemagro	Bay 33172 10% HCB 20%	2-(furyl) benzimidazole + hexachlorobenzene
106	Green Cross	Siapa mixture of 4 chemicals	identity not available
107	Green Cross	Pennsalt T.D. 5056 50%	identity not available
108	Morton	EP 346 1%	identity not available
925-933	Green Cross	Numbered compounds	identity not available
934	Green Cross	Hercules 3944X 50%	5-chloro-4-phenyl-3H-1, 2-dithol-3 one, 30% + captan, 40% + HCB, 20%
938-947	Chipman	Numbered compounds	identity not available
951-959	Morton	Numbered compounds	identity not available
962	Niagara	Cufram Z 80%	Zn, Mn, and Cu co-ordinated with a mixed metal ethylene oxtadithiocarbamate
965-973	Metasol	Numbered compounds	identity not available
974	Co-op	Single purpose fungicide	identity not available
976	Niagara	Polyram dual purpose	identity not available + zinc activated polyethylene-thiuram disulfide
978	Olin	Terrachlor	quintozene, 75%
979-980	Olin	Terrachlor mixtures	5-ethoxy-3 trichloromethyl-1, 2, 4-thiadiazole + quintozene
987	Chipman	Gammasan	gamma BHC (from lindane), 75% + captan, 10%
988	Chipman	Numbered compounds	identity not available
991	Niagara	Thiralin	thiram, 10% + lindane, 75%
992	Uniroyal	F-849	10% 2-amino-4-methyl-5-carboxanilido thiazole
994	Niagara	Polyram + lindane	zinc activated polyethylene-thiuram disulfide + lindane
995-996	Chipman	Numbered compounds	identity not available
997	Olin	Terracoat	5-ethoxy-3-trichloromethyl-1, 2, 4-thiadiazole, 1% + quintozene, 2%
1001	Uniroyal	F-427	2, 3-dihydro-5-orthophenyl-carboxanilide-6-methyl-1, 4-oxathiin
1002	Green Cross	Res Q	captan, 20% + HCB, 20% + maneb, 15%
1005-1012	Green Cross	Numbered compounds	identity not available
1013	Uniroyal	G696; 75%	2, 4-dimethyl-5-carboxanilido thiazole
1019	Buckman	Busan 72	2-(thiocyanomethylthio) benzothiazole
1021-1040	Green Cross	Numbered compounds	identity not available
1045	Green Cross	Captan 90%	captan
1046	Green Cross	PCNB 75%	quintozene
1047	Green Cross	HCB 40%	HCB
1049	Green Cross	Glyodex	glyodin 37%, dodine 22%
1051	Green Cross	Sulfur 95%	sulfur
1052	Rohm and Haas	Karathane 25%	dinocap
1053	Green Cross	Copper oxychloride 100%	copper oxychloride
1055	Green Cross	Spergon 100%	chloranil
1057-1078	Morton	Numbered compounds	identity not available
1083-1093	Chipman	Numbered compounds	identity not available
1096-1098	Rohm and Haas	Numbered compounds	identity not available
1099	Chipman	Numbered compounds	identity not available
1106-1108	Green Cross	Numbered compounds	identity not available
1110	Green Cross	Tillex DB	ethoxyethyl mercury hydroxide
1111	Green Cross	Tillex DB + lindane	ethoxyethyl mercury hydroxide + lindane
1112	Green Cross	Pennsalt numbered compound	identity not available

Table 1 (Continued)

Treatment number	Source	Product and formulation	Chemical name or active ingredient
1113	Green Cross	Boots RD 19693	identity not available
1114-1116	Buckman	Busan compounds	identity not available
1122	Niagara	Polyram 53.5%	zinc activated polyethylene thiuram disulfide
1132	Chipman	Dyfonate + a fungicide	identity not available
1133	Hopkins	W-O-M-DB compound	identity not available
1144	Niagara	Numbered compound	identity not available
1146	Vanderbilt	Vancide 51	sodium dimethyldithiocarbamate, 27.6% + sodium derivative of 2-benzothiazol-ethiol, 24%
1147	Hoechst	Numbered compound	identity not available

* Chemicals were supplied by: Dupont of Canada Ltd., Montreal, Que.; Chemagro Corp., Kansas City, Mo.; Sherwin-Williams Co. of Canada Ltd., Montreal, Que.; Morton Chemical Co., Woodstock, Ill.; Chipman Chemical Ltd., N. Hamilton, Ont.; Niagara Brand Chemicals, Burlington, Ont.; Merck and Co. Inc., Hawthorne, N.J.; Interprovincial Co-operatives Ltd., Winnipeg, Man.; Olin Research Centre, New Haven, Conn.; Uniroyal Chemicals Ltd., Elmira, Ont.; Buckman Laboratories Inc., Memphis, Tenn.; Rohm and Haas Co., Philadelphia, Pa.; Hopkins Agricultural Chemical Co., Madison, Wisc.; American Hoechst Corp., North Hollywood, Calif.

Table 2. The lowest concentration of seed treatment chemical that inhibited the growth of three damping-off fungi on potato-dextrose agar

Treatment number	Product and formulation	Lowest inhibitory concentration (µg/ml)		
		Rhizoctonia	Fusarium	Pythium
100	Dupont 1991 50%	631	158	158
102	Bay 33172 50% WP	631	631	N
104	Bay 33172 3% + HCB 20%	10,000	40	N
105	Bay 33172 10% + HCB 20%	2512	2512	N
106	Siapa granular soil treatment	158	10,000	2512
107	TD-5056	40	40	158
108	EP-346 1%	N*	N	N
925	SWF 510	631	2512	158
926	SWF 520	631	631	631
927	SWF 530	631	2512	631
928	SWF 540	631	631	631
929	SWF 550	2512	158	158
930	SWF 560	631	158	158
931	SWF 570	631	40	158
932	SWF 580	631	158	40
933	SWF 610	2512	158	158
934	3944X 50%	395*	99*	335*
938	TF-10-67	631	631	158
939	TF-11-67	2512	40	10,000
940	TF-12-67	40	40	40
941	TF-13-67	40	40	40
942	TF-14-67	40	40	158
943	TF-15-67	40	40	N
945	TF-17-67	158	158	158
946	TF-18-67	10,000	10,000	N
947	TF-19-67	N	N	10,000
951	EP-342 50%	40	2512	10,000
952	EP-346 33%	N	N	10,000
953	EP-351 33%	631	40	631
954	EP-352 33%	10,000	631	40
955	EP-363 33%	N	2512	158
959	EP-371B 50%	631	158	40
962	Cufram Z 80%	2512	N	158
965	FV-XI-128A	631	40	40
966	FV-XI-129A	40	158	N

Table 2 (Continued)

Treatment number	Product and formulation	Lowest inhibitory concentration (µg/ml)		
		Rhizoctonia	Fusarium	Pythium
967	FV-XI-122A	40	158	158
968	FV-XI-127A	2512	631	2512
969	FV-XI-146A	631	158	2512
970	FV-XI-126A	631	40	40
971	FV-XI-123A	631	631	N
972	FV-XI-124A	631	158	40
973	FV-XI-131A	2512	158	631
974	Co-op. single purpose	N	395*	1335*
976	Polyram dual-purpose	10,000	158	N
978	Terrachlor	631	631	N
979	Terrachlor Super X EC 2-D-5-1	631	158	2512
980	Terrachlor 2 + 1	631	158	2512
987	Gammasan	2512	158	40
988	26-67	40	10,000	N
991	Thiralin	40	158	631
992	F 849 75%	158	2512	158
994	Polyram + Lindasan	631	158	N
995	TF-56-67	631	158	N
996	TF-72A-67	40	40	N
997	Terracoat	40	N	158
1001	F 427	40	10,000	N
1002	Res. Q	40	40	158
1005	SWF 790	40	631	158
1006	SWF 800	40	N	N
1007	SWF 810	40	N	158
1008	SWF 820	40	158	2512
1009	SWF 830	40	631	N
1010	SWF 840	40	631	631
1011	SWF 850	40	2512	N
1012	SWF 860	40	2512	N
1013	G 696 75%	40	N	N
1019	Busan 72	158	158	40
1021	SWF 880	40	N	10,000
1022	SWF 890	40	N	N
1023	SWF 900	2512	10,000	N
1024	SWF 910	40	10,000	N
1025	SWF 920	631	2512	N
1026	SWF 930	631	2512	N
1027	SWF 940	631	2512	10,000
1028	SWF 950	631	2512	N
1029	SWF 960	158	158	158
1030	SWF 970	631	631	N
1031	SWF 980	631	158	10,000
1032	SWF 990	158	40	2512
1033	SWF 1000	631	631	631
1034	SWF 1010	40	631	2512
1035	SWF 1020	40	40	631
1036	SWF 1030	158	158	2512
1037	SWF 1040	40	158	158
1038	SWF 1050	40	158	2512
1039	SWF 1060	158	631	10,000
1040	SWF 1070	2512	N	10,000
1045	Captan 90%	40	40	40
1046	PCNB 75%	40	40	N
1047	HCB 40%	40	158	N
1049	Glyodex 66%	2512	631	N
1051	Sulfur 95%	158	N	631
1052	Karathane 25%	158	2512	N
1053	COC	N	N	N
1055	Spergon 100%	2512	158	40
1057	EP-279B	2512	631	40
1058	EP-411	40	40	40
1059	EP-411A	158	40	40

Table 2 (Continued)

Treatment number	Product and formulation	Lowest inhibitory concentration (µg/ml)		
		Rhizoctonia	Fusarium	Pythium
1060	EP-347	2512	158	10,000
1061	EP-405A	2512	158	N
1062	EP-406A 25%	40	631	158
1063	EP-407A 25%	40	40	40
1064	EP-430 25%	158	158	158
1065	EP-431 25%	40	158	40
1066	EP-432 25%	N	N	2512
1067	EP-433 25%	N	N	631
1068	EP-342A 25%	158	2512	631
1069	EP-339A 25%	631	158	631
1071	S-91	N	158	2512
1072	EP-279C	10,000	2512	2512
1073	EP-371A	631	158	631
1074	EP-371D	631	158	631
1075	EP-402	158	158	40
1076	EP-408	158	40	40
1077	EP-409	158	158	40
1078	EP-410	158	158	40
1083	19-68	10,000	N	2512
1084	22-68	631	N	N
1085	23-68	631	N	2512
1086	24-68	10,000	N	2512
1087	26-68	2512	10,000	158
1088	27-68	10,000	10,000	40
1089	28-68	10,000	10,000	631
1090	29-68	10,000	158	40
1091	30-68	631	631	40
1092	32-68	2512	2512	40
1093	33-68	N	631	631
1096	RH-058, 90% EC	158	158	40
1097	RH-893 90%	40	40	40
1098	RH-575 50%	40	40	40
1099	TF 34-68	40	40	40
1106	SWF 1080	158	631	158
1107	SWF 1090	158	158	40
1108	SWF 2000	158	158	40
1110	Tillex Drillbox	2512	10,000	2512
1111	Tillex Lindane Drillbox	2512	10,000	2512
1112	TD-8538 40%	N	N	N
1113	Boots RD, 19693 10%	631	158	2512
1114	Busan 70	2512	158	631
1115	Busan Dust	158	158	40
1116	Busan Liquid	158	158	40
1122	Polyram 53.5%	631	631	10,000
1132	42-68 (Dyfonate + a Fungicide)	2512	158	2512
1133	W.O.M. D.B.	631	158	158
1136	Busan 11 M-1	N	158	N
1144	ETM BE1-24, 76%	158	40	40
1146	Vancide Liquid	158	40	40
1147	Hoc. 2966	631	631	631
Check	Captan 50WP	158	200	158

* Average of two trials.
** N = no inhibition at highest concentration tested.

against Rhizoctonia was demonstrated by 18 chemicals, against Fusarium by 11 chemicals, against Pythium and Fusarium only by 10 chemicals, and against Rhizoctonia and Fusarium by 24 chemicals. Fifteen of the chemicals tested showed little or no inhibitory activity. Of the 63 chemicals that showed high activity against Rhizoctonia and Pythium (the major damping-off fungi in local tree nurseries), 30 were more effective than the standard captan seed treatment.

Laboratory germination tests--Fifty-eight of the 128 chemicals tested did not inhibit germination of one or more of the test species (Table 3), and 15 of them had no inhibitory effect on germination of any of the test species (Table 4). In the present tests captan (90%) was not phytotoxic to any of the test species, whereas in previous tests captan (50%) was phytotoxic to all species tested. Others of the 15 chemicals having no phytotoxic effect on conifer germination, but still demonstrating a high

Table 3. Germination in seed germinator of conifer seed pelleted with chemicals (amount of chemical = 1/3 weight of seed)

Treatment no. and product	Germination (%)		
	Jack pine	Lodgepole pine	White spruce
100 Dupont 1991, 50%	0*	3*	0*
101 Bay 33172, 5%	85	54*	62
102 Bay 33172, 50%	74	41*	38*
103 Demosan 100	83*	76	58*
106 Siapa granular mix	87	74	76
107 TD-5056 50%	86	45*	15*
108 EP 346 1%	91	71	78
925 SWF 510	89	40*	62
926 SWF 520	89	49*	70
927 SWF 530	91	30*	77
928 SWF 540	84	31*	72
929 SWF 550	81*	38*	75
930 SWF 560	77*	34*	75
931 SWF 570	84	37*	71
932 SWF 580	86	23*	68
933 SWF 610	87	50*	32*
934 3944X 50%	50*	45*	35*
938 TF-10-67	20*	38*	3*
939 TF-11-67	19*	47*	2*
940 TF 12-67	7*	22*	0*
941 TF 13-67	48*	17*	0*
942 TF 14-67	10*	1*	0*
943 TF 15-67	47*	21*	8*
945 TF 17-67	60*	40*	28*
951 EP-342 50%	41*	69	-†
953 EP-351	0*	0*	0*
954 EP-352	5*	1*	5*
955 EP-363	48*	47*	0*
959 EP-371B	0*	0*	0*
962 Cufram Z 80%	36*	11*	8*
965 FV-XI 128A	88	65	61
966 FV-XI 129A	83*	68	72
967 FV-XI 122A	82*	48*	10*
968 FV-XI 127A	88	68	59
969 FV-XI 146A	29*	16*	18*
970 FV-XI 126A	87	70	68
971 FV-XI 123A	71*	72	43*
972 FV-XI 124A	86	60*	46*
973 FV-XI 131A	50*	69	48*
974 Co-op single purpose	9*	22*	50*
978 Terrachlor	4*	10*	0*
979 Terrachlor super X-EC	1*	0*	0*
980 Terrachlor 2 + 1	0*	0*	0*
987 Gammasan	93	84	75
988 26-67	89	76	38*
991 Thiralin	93	86	66
992 F849 75%	78*	67	70
994 Polyram + Lindasan	82*	63*	82
995 TF 56-67	87	73	12*
996 TF 72A-67	70*	60*	32*
997 Terracoat	1*	3*	0*
1002 Res. Q	90	77	56
1005 SWF 790	92	74	51

Table 3 (Continued)

Treatment no. and product	Germination (%)		
	Jack pine	Lodgepole pine	White spruce
1006 SWF 800	66*	47*	37*
1007 SWF 810	85	73	2*
1008 SWF 820	40*	19*	6*
1009 SWF 830	41*	52*	51
1010 SWF 840	85	47*	60
1011 SWF 850	51*	32*	36*
1012 SWF 860	58*	44*	31*
1013 G696 75%	76*	69	28*
1019 Busan 72	0*	0*	0*
1021 SWF 830	17*	24*	9*
1022 SWF 890	81*	43*	44*
1023 SWF 900	65*	6*	2*
1024 SWF 910	48*	14*	28*
1025 SWF 920	20*	22*	9*
1026 SWF 930	70*	25*	68
1027 SWF 940	70*	37*	40*
1028 SWF 950	2*	18*	2*
1029 SWF 960	43*	20*	17*
1030 SWF 970	30*	24*	73
1031 SWF 980	63*	9*	2*
1032 SWF 990	83*	57*	41*
1033 SWF 1000	63*	3*	6*
1034 SWF 1010	65*	21*	28*
1035 SWF 1020	58*	14*	9*
1036 SWF 1030	84	66	74
1037 SWF 1040	86	77	69
1038 SWF 1050	52*	21*	0*
1039 SWF 1060	78*	70	38*
1045 Captan 90%	87	79	84
1046 PCNB 75%	72*	57*	63*
1047 HCB 40%	72*	26*	3*
1051 Sulfur 95%	56*	72	83
1052 Karathane 25%	51*	64*	75
1055 Spergon 100%	66*	60*	74
1057 EP 279 B	0*	0*	0*
1058 EP 411	0*	0*	0*
1059 EP 411A	0*	0*	0*
1062 EP 406A 25%	37*	16*	5*
1063 EP 407A	38*	9*	9*
1064 EP 430	11*	22*	27*
1065 EP 431	2*	3*	0*
1067 EP 433	74*	31*	41*
1068 EP 342A	39*	38*	3*
1069 EP 339A	0*	0*	0*
1073 EP 371A	0*	0*	0*
1074 EP 371D	0*	0*	0*
1075 EP 402	10*	2*	0*
1076 EP 408	5*	3*	9*
1077 EP 409	83*	59*	17*
1078 EP 410	82*	65	18*
1084 22-68	88	57*	41*
1085 23-68	87	51*	49*
1087 26-68	61*	28*	3*
1088 27-68	77*	44*	11*
1089 28-68	76*	18*	10*
1090 29-68	86	39*	17*
1091 30-68	28*	7*	41*
1092 32-68	89	72	55
1093 33-68	85	46*	54
1096 RH-058 90%	0*	0*	0*
1097 RH-893 90%	0*	0*	0*

Table 3 (Continued)

Treatment no. and product	Germination (%)		
	Jack pine	Lodgepole pine	White spruce
1098 RH-575 50%	9*	5*	20*
1099 TF 34-68	92	63*	34*
1106 SWF 1080	88	62*	67
1107 SWF 1090	92	66	72
1108 SWF 2000	90	68	71
1113 Boots RD 19693 10%	49*	4*	20*
1114 Busan 70	8*	0*	0*
1115 Busan Dust.	26*	45*	45*
1116 Busan Liquid	0*	0*	0*
1122 Polyram 53.5%	87	74	45*
1133 W.O.M. D.B.	89	68	13*
1144 ETM BEI 24 76%	88	8*	33*
1146 Vancide 51	7*	6*	2*
1147 Hoechst 2966	95	0*	12*
Control	95	76	69

* Statistically significant from the untreated control at the 5% level.
† - = not tested.

Table 4. Seed treatment chemicals not inhibiting conifer seed germination under laboratory conditions

Conifer	Number of chemicals	Treatment number
Jack pine, lodgepole pine, and white spruce	15	106, 108, 965, 970, 987, 991, 1002, 1005, 1036, 1037, 1045, 1092, 1107, 1108
Jack pine and lodgepole pine	5	988, 995, 1007, 1122, 1133,
Jack pine and white spruce	10	101, 925, 926, 927, 928, 931, 932, 1010, 1093, 1106
Lodgepole pine and white spruce	3	966, 992, 1051
Jack Pine, alone	9	102, 107, 933, 972, 1084, 1085, 1090, 1099, 1144
Lodgepole pine alone	7	103, 951, 971, 973, 1013, 1039, 1078
White spruce, alone	9	929, 930, 994, 1009, 1026, 1030, 1046, 1052, 1055
Total	58	
Jack pine, total	39	101, 102, 106, 107, 108, 925, 926, 927, 928, 931, 932, 933, 965, 968, 970, 972, 987, 988, 991, 995, 1002, 1005, 1007, 1010, 1036, 1037, 1045, 1084, 1085, 1090, 1092, 1093, 1099, 1106, 1107, 1108, 1122, 1133, 1144
Lodgepole pine, total	30	103, 106, 108, 951, 965, 966, 968, 970, 971, 973, 987, 988, 991, 992, 995, 1002, 1005, 1007, 1013, 1036, 1037, 1039, 1045, 1051, 1078, 1092, 1107, 1108, 1122, 1133

Table 4 (Continued)

Conifer	Number of chemicals	Treatment number
White spruce, total	37	101, 106, 108, 925, 926, 927, 928, 929, 930, 931, 932, 965, 966, 968, 970, 987, 991, 992, 994, 1002, 1005, 1009, 1010, 1026, 1030, 1036, 1037, 1045, 1046, 1051, 1052, 1055, 1092, 1093, 1106, 1107, 1108

level of activity against all three fungi, were FV-XI-128A, FV-XI-126A, Thiralin, Res. Q, SWF 790, SWF 1040, SWF 1090, and SWF 2000.

Greenhouse damping-off control tests--Preemergence damping-off was significantly reduced by 17 chemicals for jack pine, 8 for lodgepole pine, and 8 for white spruce (Table 5). Postemergence damping-off losses were significantly less with 5 chemicals for jack pine, 8 for lodgepole pine, and 4 for white spruce.

Table 5. Effects of seed treatments on preemergence and postemergence damping-off of conifer seedlings in the greenhouse

Treatment	Emergence (%)			Damping-off (%)		
	Jack pine	Lodgepole pine	White spruce	Jack pine	Lodgepole pine	White spruce
101	74	53	54	63	72	20*
102	60	-†	-	75	-	-
103	88*	69*	54	13*	68	43
106	57	56	33	35	16*	59
107	59	-	-	70	-	-
108	67	41	35	35	60	66
925	68	-	54	40	-	22*
926	70	63*	67*	40	25*	42
927	70	-	57	38	-	43
928	73	-	65*	29	-	39
929	66	-	68*	47	-	46
930	86*	-	69*	9*	-	32
931	84*	-	41	27	-	69
932	81	-	63*	25	-	42
933	80	51	-	43	41	-
934	77	-	-	40	-	-
965	85*	66*	-	20	64	-
966	45	41	-	50	65	-
967	69	64*	-	31	12*	-
968	80	45	-	22	81	-
970	68	59	64*	32	68	22*
971	73	19	-	37	93	-
972	75	58	-	47	16*	-
973	62	35	-	25	39*	-
987	78	49	56	22	94	56
988	81	53	-	6*	11*	-
991	91*	58	53	28	100	66
992	85*	47	58	33	92	39
993	84*	45	-	65	89	-
994	85*	53	76*	25	10*	60
995	87*	50	-	32	61	-
1002	75	48	-	22	42	-
1005	88*	46	-	17*	49	-
1007	66	43	-	18	78	-
1009	-	51	43	-	63	36

Table 5 (Continued)

Treatment	Emergence (%)			Damping-off (%)		
	Jack pine	Lodgepole pine	White spruce	Jack pine	Lodgepole pine	White spruce
1010	82*	53	-	7*	69	-
1026	67	-	34	60	-	61
1027	77	-	-	20	-	-
1030	-	-	37	-	-	48
1032	-	46	-	-	78	-
1036	-	61*	-	-	62	-
1037	70	55	38	51	80	75
1039	-	45	-	-	50	-
1045	65	48	49	27	47	55
1046	44	50	-	85	91	-
1047	66	-	-	21	-	-
1051	-	47	37	-	63	53
1052	-	46	50	-	67	65
1055	-	42	53	-	63	64
1067	67	-	-	19	-	-
1077	70	52	-	41	89	-
1078	72	51	-	29	76	-
1084	76	38	-	23	22*	-
1085	73	39	-	23	18*	-
1088	68	-	-	24	-	-
1089	56	-	-	27	-	-
1090	80	-	-	87	-	-
1092	83*	52	-	46	57	-
1093	85*	-	-	89	-	-
1099	83*	48	-	89	95	-
1106	85*	-	58	53	-	57
1107	83*	54	45	61	74	70
1108	81	53	58	41	50	35
1122	84*	62*	-	34	56	-
1133	74	39	-	57	81	-
1144	47	-	-	95	-	-
Captan	72	68*	54	31	58	56
Thiram	74	74*	67*	21	44	24*
Untreated control	63	46	43	24	67	34

* Significantly different from the untreated control at the 5% level.
† - = not tested.

Many of the chemicals selected in the laboratory germination test for greenhouse tests were used despite minor phytotoxic effects; 20 of 58 were slightly phytotoxic for jack pine, 17 of 45 for lodgepole pine, and 1 of 28 for white spruce. Significant reduction of preemergence damping-off was observed with 5 of the 20 for jack pine (nos. 103,930,992,993, and 994); and with 2 of the 17 for lodgepole pine (nos. 926 and 967); but not with the only one for white spruce. Postemergence damping-off losses were significantly less with 2 of the 20 chemicals for jack pine (nos. 103 and 930), and with 5 of the 17 for lodgepole pine (nos. 967, 972, 994, 1084, and 1085).

The most effective chemicals for control of preemergence damping-off were Thiralin for jack pine, Demosan for lodgepole pine and Polyram + Lindasan for white spruce. Others of high activity were Demosan, TF-56-67, and SWF 790 for jack pine; FV-XI-128A and the two standards (captan and thiram) for lodgepole pine; and SWF 520, SWF 550, SWF 560 and thiram for white spruce. Postemergence damping-off was best controlled with 26-67 for jack pine; Polyram + Lindasan for lodgepole pine; and Bay 33172 (5%) for white spruce. Chemicals SWF 560 and SWF 840 were fairly effective on jack pine; FV-XI-122A and 26-67 on lodgepole pine; and SWF 510 and FV-XI-126A on white spruce. Effective control of both pre- and postemergence damping-off was obtained with Demosan, SWF 560, SWF 790, and SWF 840 for jack pine; SWF 520 and FV-XI-122A for lodgepole pine; and FV-XI-126A and thiram for white spruce. All the above-mentioned test chemicals performed better than the captan standard. However, the thiram standard performed well in preemergence tests on lodgepole pine and in pre- and postemergence tests on white spruce.

Seed treatment chemicals for the control of pre- and postemergence damping-off are now available for extensive field testing. The program to date (1,2) has resulted in the

selection of approximately 33 test chemicals for further field testing. Experiments to date indicate that there are non-phytotoxic chemicals that control damping-off better than captan or thiram, but they can only be used on specific tree species. It is not likely that the two standards, captan and thiram, will be replaced until the testing is completed. However, from data presented here and in previous reports (1,2) it appears that thiram is a more effective chemical than captan and should be used more extensively.

Literature cited

1. Belcher, J., and L.W. Carlson. 1968. Seed-treatment fungicides for control of conifer damping-off: Laboratory and greenhouse tests, 1967. Can. Plant Dis. Surv. 48:47-52.

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EFFECTS OF SEED TREATMENT ON THE VIABILITY OF TOUGH AND DAMP CEREAL AND FLAX SEED[1]

H.A.H. Wallace and J.T. Mills

Abstract

Wheat, barley, oat, and flax seed with high natural moisture contents, and untreated or treated with fungicidal or dual-purpose seed treatment chemicals were sealed in jars and stored in an unheated room (-3.5C to 23.5C). Germination tests were made on filter paper immediately after treatment, and on both filter paper and in soil after storage for 42-47 days and 192-264 days. Germination of tough and damp grain was higher in soil, especially cold soil (9.0C and 15.5C), than on filter paper. It is recommended that germination tests on all such grain be made in soil just prior to seeding because of possible dormancy or deterioration by fungi. Deterioration of tough and damp grain by fungi is usually retarded or prevented in the winter months by cold weather. Therefore seed from the crop of the previous fall can be sown providing results from germination tests made in soil are satisfactory. Tough and damp seed of flax generally responded to seed treatments, but cereals did not. Although tough and damp seed more than 1 year old tends to be infected by storage molds, germination of untreated seed was not reduced at 192-264 days if the original moisture content of the cereals was below 19.0% and of flax below 14%. It is recommended that cereal seed containing more than 19.0% moisture not be sown, because germination will be reduced by storage molds against which seed treatments are usually ineffective. However, there are indications that compounds that contain maneb can reduce storage molds.

Introduction

It has been estimated that 72% of the grain harvested in Alberta, Saskatchewan, and Manitoba in 1968 was tough or damp (3). Although the entire area is rarely so generally affected, excessive rainfall occurs in small areas nearly every year. Each year, therefore, the question is asked, "Can damp grain be used for seed?" Information on the effect of chemical seed dressings on such grain is needed. Koehler and Bever (6) found that volatile mercury compounds reduced germination as the dosage, contact time, or moisture content of the grain increased. Campbell (2) showed that wheat, barley, and oats with moisture contents of 16% or more could not be stored for 2 years without deterioration, and his results indicated that treatment of such seed with fungicides did not improve storage qualities. Machacek et al. (8) found that seed containing 18.5% moisture molded when stored for 14 weeks at room temperature and the percentage germination declined to a low level irrespective of whether mercurial, insecticidal, or dual-purpose treatments were used. Because artificially moistened seed was used in these tests the workers did not encounter the prolonged dormancy phenomenon which often occurs in naturally damp grain.

The present study on effects of seed treatment materials on naturally damp grain was undertaken because formulations have changed in recent years; non-mercurials and drill box treatments that require no storage are now commonly used.

Materials and methods

Seed of wheat (Triticum aestivum L.), barley (Hordeum vulgare L.), oats (Avena sativa L.), and flax (Linum usitatissimum L.) grading either tough or damp and produced in 1968 within 50 miles of Winnipeg, Manitoba, was used. Moisture determinations were made on each sample according to AACC Method 44-18 (1).

Grains are graded tough when seed contains the following moisture levels: wheat 14.6-17.0%, barley 14.9-17.0%, oats 14.1-17.0%, flax 10.6-13.5%. Wheat, barley, and oat seed is graded damp when the moisture content exceeds 17.0%, and flax seed is graded damp at levels exceeding 13.5%.

[1] Contribution No. 430, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba.

Sixteen seed treatment dressings were used. The manufacturers of these compounds* and the active ingredients, where known, are as follows:

Chipman Chemicals Ltd.: Agrox DB (1.79% phenyl mercuric acetate + 0.25% ethyl mercuric chloride [1.25% Hg equivalent]); Mergamma DB (1.79% phenyl mercuric acetate + 0.25% ethyl mercuric chloride + 18.75% gamma BHC from lindane [1.25% Hg equivalent]); Agrox NM (37.5% maneb + 10.0% hexachlorobenzene); and Mergamma NM (37.5% maneb + 18.75% .gamma BHC from lindane).

Du Pont of Canada Ltd.: Ceresan M (7.7% ethyl mercury-p-toluene sulfonanilide [3.20% Hg equivalent]).

Green Cross Products: Res-Q (20.0% hexachlorobenzene + 20.0% captan + 15.0% maneb) and Res-Q Dual Purpose (16.0% hexachlorobenzene + 16.0% captan + 12.0% maneb + 30.0% gamma BHC from lindane).

Niagara Brand Chemicals: Polyram (53.5% zinc activated polyethylene thiuram disulphide); Polyram + aldrin (26.7% Polyram + 25.0% aldrin); and Polyram + lindane (26.7% Polyram + 25.0% lindane).

Nor-Am Agricultural Products Ltd.: Panogen PX (0.9% methyl mercuric dicyandiamide [0.60% Hg equivalent]); Panogen 15B (3.7 oz/gal methyl mercuric dicyandiamide [2.5 oz/gal Hg equivalent]); Pandrinox PX (0.72% methyl mercuric dicyandiamide + 20.0% heptachlor [0.48% Hg equivalent]); Pentadrin A (1.6 lb/gal quintozene + 2.6 lb/gal aldrin); and Pentadrin PX (13.2% quintozene + 20.0% heptachlor).

Uniroyal Ltd.: Vitavax (75% 5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide).

For each treatment 200 g of seed and an appropriate quantity of fungicide were placed in a sealed 1-liter glass jar and shaken thoroughly; the fungicide:grain ratio used was that recommended for field application (Table 1). The tightly sealed jars were stored in a room where the temperature during the storage period (December 16, 1968 to September 6, 1969) ranged from -3.5C to +23.5C. Samples of both treated and untreated grain were taken at time of treatment and 21, 42, and 192-264 days after treatment. Effects of treatment material and storage time on the microflora and percentage germination of the seed and on plant development were determined.

Table 1. Formulation and dosage of seed treatment materials

Treatment	Form*	Dosage (g/kg)			
		Wheat	Barley	Oats	Flax
Agrox DB	Du	2.10	2.60	3.70	4.40
Mergamma DB	Du	2.10	2.60	3.70	4.40
Agrox NM	Du	2.10	2.60	3.70	4.40
Mergamma NM	Du	2.10	2.60	3.70	4.40
Ceresan M	WP	0.52	0.65	0.92	1.10
Res-Q	Du	1.05	2.60	3.70	4.40
Res-Q Dual Purpose	Du	1.30	2.60	3.70	4.40
Polyram	Du	1.05	1.30	1.85	2.22
Polyram + aldrin	Du	2.10	2.60	3.70	4.40
Polyram + lindane	Du	2.10	2.60	3.70	4.40
Panogen PX	Du	2.10	2.60	3.70	4.40
Panogen 15B	Sn	0.80	0.98	1.20	1.70
Pandrinox PX	WP	2.60	3.25	4.60	5.55
Pentadrin A	Sn	2.10	2.60	3.70	4.40
Pentadrin PX	Du	2.60	3.25	4.60	5.55
Vitavax	WP	2.10	2.60	3.70	4.40

* Formulation code: Du = dust, Sn = solution, WP = wettable powder.

*Sources: Chipman Chemicals Ltd., Hamilton, Ontario; Du Pont of Canada Ltd., Toronto, Ontario; Green Cross Products, CIBA Co. Ltd., Montreal, Quebec; Niagara Brand Chemicals, Burlington, Ontario; Nor-Am Agricultural Products Ltd., Woodstock, Illinois; Uniroyal Ltd., Elmira, Ontario.

To determine the microflora on the seed, a No. 3 Whatman filter paper disc (9 cm) in a petri dish was moistened with 5 ml distilled water, and 25 seeds were placed on it in a circular pattern near the periphery. The plates were exposed to daylight at room temperature (ca. 23C) for 7 days, after which

the microflora of each seed was examined microscopically.

Evidence for phytotoxicity was obtained by sowing seeds 4 cm deep in a mixture of soil, sand, and peat (3:1:1) (7). Phytotoxic effects were shown by abnormalities of the seedling root and plumule. To determine the effect of temperature on germination and phytotoxicity, seeds were planted in moist soil in pots and kept at 9.0C, 15.5C and 27.0C with 16 hr/day fluorescent light. Replicates consisting of two pots each containing 25 seeds were sown 2 weeks apart and the seedlings were examined for phytotoxic symptoms upon emergence (7-21 days after sowing).

Results and discussion

Untreated seed

Germination of seed on filter paper immediately before storage varied from 17% in flax to 86% in one oat sample (Table 2); germination percentages tended to be slightly higher after 42 days storage. For samples stored for 192-264 days, the germination percentages of all the wheat samples and two of the three flax samples were considerably higher than for earlier tests, but for oat sample no. 4, both barley samples, and flax sample no. 10, germination percentages were much lower. No storage fungi were found on the seed plated on filter paper immediately before storage, suggesting that the low initial germination was due to dormancy. High moisture content of the seeds together with long storage periods favor development of storage fungi, which may have contributed to the depressed germination in some of the samples stored for prolonged periods.

Percentage germination of untreated seed in soil was always higher than on filter paper, and it was higher in cold soil (9C and 15.5C) than in warm soil (27C), suggesting that seeding in cold soil reduced dormancy.

Treated seed

Most fungicides had little effect on percentage germination of cereals on filter paper (Table 3) or in soil. However, Agrox NM increased germination of wheat, and most treatments increased the percentage germination of flax. Vitavax decreased germination of all four crops.

Addition of an insecticide to the fungicide, as in the dual purpose seed dressings, sometimes increased and sometimes decreased germination. However, lindane, unlike heptachlor or aldrin, produced phytotoxic effects in roots and plumules of seedlings on filter paper, but not in soil, after 42-47 days post-treatment storage. After 200 days post-treatment storage, lindane-treated wheat samples No. 1 and No. 2 showed a marked reduction in germination in soil in some instances, but no symptoms of

Table 2. Percentage germination* and microflora of untreated seed after different intervals in sealed storage

Type of test	Days stored	WHEAT Sample no. 1	WHEAT Sample no. 2	WHEAT Sample no. 3	OATS Sample no. 4	OATS Sample no. 5	BARLEY Sample no. 6	BARLEY Sample no. 7	FLAX Sample no. 8	FLAX Sample no. 9	FLAX Sample no. 10
Moisture content (%)	0	19.6	19.9	17.3	19.2	16.4	19.6	19.6	11.7	11.6	14.2
Grade (moisture)**	0	D	D	D	D	T	D	D	T	T	D
Filter paper test											
Germination	0	18	22	80	86	83	15	60	71	17	48
%	42	30	22	94	84	90	18	75	83	7	65
	192-264	62	59	98	45	79	5	0	86	43	25
Aspergillus spp.	0	0	0	0	0	0	0	0	0	0	0
%	42	0	0	0	0	0	0	0	0	0	0
	192-264	88	76	82	48	0	100	100	0	8	68
Penicillium spp.	0	0	1	0	0	0	0	0	0	0	1
%	42	0	0	0	0	0	0	0	0	0	9
	192-264	28	20	0	20	4	40	8	0	0	76
Soil test											
Germination % at:											
9.0C	47	78	91	97		92		97			29
15.5C	47	71	77	97		94		91			49
27.0C	47	52	43	90	98	90	31	78	67	44	37

* Mean percentage of four replicates of 25 seeds.
** Grade (moisture): D = damp, T = tough.

Table 3. Percentage germination* on filter paper of untreated seed and treated seed immediately after treatment

Treatment	WHEAT Sample no. 1	2	3	OATS Sample no. 4	5	BARLEY Sample no. 6	7	FLAX Sample no. 8	9	10
Check (untreated)	18	22	80	86	83	15	60	71	17	48
Mercurials										
Panogen 15B	20	22	80	87	90	19	62	85	20	75
Panogen PX	26	14	86	93	85	19	49	85	19	70
Agrox DB	31	19	93		86		41			84
Ceresan M	16	9	85	93	90	18	50	90	40	69
Non-mercurials										
Agrox NM	53	41	92		87		56			77
Res-Q	24	21	89	43	80	11	58	86	22	59
Polyram	22	20	87	91	94	18	55	81	15	77
Vitavax	6	2	42	81	77	4	27	52	11	17
Dual purpose with heptachlor										
Pandrinox PX	14	9	84	92	89	12	54	84	25	79
Pentadrin PX	22	9	84	90	85	23	59	83	4	55
Dual purpose with aldrin										
Pentadrin A	21	28	96	89	83	14	62	62	6	47
Polyram + aldrin	13	25	87	84	94	17	50	73	13	63
Dual purpose with lindane										
Mergamma DB	27+†	11+	46+		74+		27+			91
Mergamma NM	53+	32+	95+		86+		35+			74
Res-Q Dual	31+	26+	84+	59+	79+	10+	46+	87	24	52
Polyram + lindane	18+	27+	79+	89+	89+	10+	42+			78

* Mean percentage of four replicates of 25 seeds.
† + indicates phytotoxicity as shown by short clubbed roots and short swollen shoots.

phytotoxicity were evident. Flax seedlings did not show phytotoxic symptoms from any of the formulations.

Because frequency of occurrence of the storage molds Penicillium spp. and Aspergillus spp. on seed lots No. 3 (wheat), Nos. 4 and 5 (oats), and Nos. 8 and 9 (flax) was low, data for these samples have been omitted from Table 4. The lots excluded are those for each crop with the lowest moisture contents. Lots graded tough, therefore, are of less importance in the occurrence of storage molds; cereal samples with over 19% moisture and flax with 14% moisture were heavily infested by storage molds. Wheat sample No. 3, which was intermediate in moisture content between the tough and the other damp cereal samples, carried a heavy infestation of Aspergillus spp. but, unlike the other damp samples, germination of this seed was unaffected, probably because of delayed infection. The results from the tough and damp cereal samples suggest that tough grain and perhaps even damp cereal grain with moisture contents below 19% could be safely maintained until the following summer under the cold winter conditions prevailing in Western Canada.

After 200 days post-treatment storage none of the chemicals had completely prevented infestation by storage molds of all the seed lots tested (Table 4). Aspergillus spp. and Penicillium spp. developed on all lots of untreated seed, indicating that inoculum was present at the start of the experiment. Agrox NM and Res-Q were the most effective in preventing fungus infestation; mercurials and Polyram were the least effective. Insecticides often altered the effectiveness of the fungicide in dual-purpose compounds. For example, control of Aspergillus and Penicillium was sometimes increased or decreased when an insecticide was added to the fungicide. Generally, fungus infestation of treated or untreated grain tended to reduce germination.

It is known (5) that in dormant grain representatives of all stages of dormancy are usually found; hence germination tests show uneven responses with time. We found that uneven germination was most evident with seed on moist filter paper, apparently due to "water sensitivity" (4), and least evident with seed sown at cold soil temperatures.

Table 4. Occurrence* of Aspergillus spp. and Penicillium spp. on wheat, barley and flax seed plated on filter paper 192-264 days after treatment

Treatment	Wheat				Barley				Flax	
	Sample no. 1		Sample no. 2		Sample no. 6		Sample no. 7		Sample no. 10	
	Asp.†	Pen.†	Asp.	Pen.	Asp.	Pen.	Asp.	Pen.	Asp.	Pen.
Check (untreated)	88	28	76	20	40	0	100	8	68	76
Mercurials										
Panogen 15B	0	28	96	32	0	0	0	0	4	40
Panogen PX	92	20	0	0	0	0	0	12	0	60
Pandrinox PX	0	0	24	0	0	0	0	0	0	100
Agrox DB	0	100	64	60			0	76	0	96
Mergamma DB	0	80	80	8			0	8	20	84
Non-mercurials										
Agrox NM	0	0	12	0			4	0	0	0
Mergamma NM	16	0	44	0			0	0	20	4
Res-Q	0	0	8	4			0	0	0	0
Res-Q Dual	4	0	4	0			0	0	0	0
Polyram	8	12	20	16	0	0	76	28	4	80
Polyram + aldrin	32	12	32	36	12	4	96	32	0	20
Polyram + lindane	0	0	68	16	4	0	28	0	52	24
Vitavax	0	0	0	0	4	0	80	0	16	0
Pentadrin PX	12	4	0	0	0	44	68	44	4	40
Pentadrin A	12	4	4	0	0	0	0	20	80	12

* Percentages are based on one replicate of 25 seeds; three other replicates of 25 seeds were examined for agreement.

† Asp. = Aspergillus, Pen. = Penicillium

Conclusions

Germination of tough and damp grain was higher in soil, especially cold soil, than on filter paper. It is recommended that germination tests on all such grain be made in soil just prior to seeding because of possible dormancy or deterioration by fungi. Deterioration of tough and damp grain by fungi is usually retarded or prevented in the winter months by cold weather. Therefore seed from the crop of the previous fall can be sown providing results from germination tests made in soil are satisfactory. Treatment of such seed, with the exception of flax, does not affect germination. Tough and damp seed more than 1 year old tends to be infected by storage molds, although in this study germination of untreated seed was not reduced after 192-264 days when the original moisture content of the cereals was below 19.0% and of flax below 14%. It is recommended that damp cereal seed containing over 19.0% moisture not be sown because germination will be reduced by storage molds against which seed treatments are usually ineffective. However, there are indications that compounds that contain maneb can reduce storage molds.

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EVALUATION OF CHEMICALS IN TIMED-RELEASE PELLETS FOR CONTROL OF COMMON ROOT ROT OF WHEAT

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Abstract

In test plots at Regina, Saskatchewan, timed release pellets consisting of a nucleus of pearl barley coated with molasses and limestone, significantly reduced root rot of wheat caused by Cochliobolus sativus when compared with pearl barley alone. However, similar treatment at Morden, Manitoba, did not significantly reduce root rot. Differences in rainfall following sowing and in the microflora of the soil at the two locations may have contributed to the differing results. The addition of fungicides, chitin, or soybean meal to the pellets did not give additional control.

Introduction

Attempts to control common root rot of cereals caused by soil-borne Cochliobolus sativus (Ito & Kurib.) Drechsl. ex Dastur by seed treatment have generally not been effective (5,9). Fungicides may be effective in laboratory tests, but under field conditions they are probably not present in the region of the sub-crown internode 3-10 weeks after sowing. Timed-release pellets have been developed (8) that are broken down by soil moisture, thereby releasing chemicals incorporated within the pellets. In the present work such pellets were used to release fungicides for direct action on C. sativus and to release other substances known to stimulate antagonists of the pathogen. The fungicides used are at least partly effective against the pathogen in the field (10) and in the laboratory (7, and Mills, unpublished data); soybean meal and sugar beet molasses (1) are known to promote germination of C. sativus, and chitin (3) promotes growth of Streptomyces spp., known to be antagonistic to the pathogen.

Materials and methods

The manufacturers[4] of the 10 fungicides used in this study and the active ingredient and formulation of each, where known, are as follows: Green Cross, SWF 910; Hoechst, 2874, 2981, 2988, 2989; Murphy, MC 25 monosulphate (bis-[8-guanidinooctyl]amine sulphate), MC 25 sesquisulphate (bis-[8-guanidinooctyl]sesquisulphate); Nor-Am, Panogen PX (0.9% methyl mercuric dicyandiamide); Rohm & Haas, Dithane M45 (zinc coordinated maneb); and Uniroyal, Vitavax (5,6-dihydro-2-methyl-1, 4-oxathiin-3-carboxanilide).

The pellets all had a nucleus of pearl barley. The coating process consisted of coating 1150 g of pearl barley with a mixture of 337 g ground limestone, 40 g flour, 75 ml sugar beet molasses, 450 ml water, and 63 g fungicide formulation, or chitin (Sigma Chemical Co., St. Louis), or soybean meal (Canada Packers, Feed Division, Winnipeg). The resulting pellets were coated with a latex formulation, the thickness of which determined the time of release, i.e. after approximately 30, 50, and 70 days. Pearl barley was coated with the substances by using Wurster air suspension equipment (11). Substances were used without special preparation except that the limestone was ground commercially to pass a 200 mesh screen; the chitin was ball milled for 22 hr; and the soybean meal was ball milled for 3 hr. Forty-two grams of pellets consisting of equal amounts of each of the 30, 50, and 70 day lots of a particular treatment were used in each 12 ft row. However, in each row of treatment no. 15 (Table 1), 7 g of the mixture of 30-, 50-, and 70-day release pellets from each of treatment nos. 2 and 14 were applied. Forty-two grams of instant release pellets, those without latex coats, were applied to each row of treatment no. 16. In addition to being used at the standard rate, Panogen PX (treatment 4) was also used at the lower rate of 16 g of formulation to 1150 g of pearl barley.

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[4] Green Cross Products, Montreal, Quebec; American Hoechst Corp., North Hollywood, California; Murphy Chemical Co., Wheathampstead, Herts, England; Nor-Am Agricultural Products Ltd., Woodstock, Illinois; Rohm and Haas Co. of Canada Ltd., West Hill, Ontario; Uniroyal (1966) Ltd., Elmira, Ontario

Wheat (Triticum aestivum L. 'Cypress') seed from the 1968 crop was sown in single row plots 12 ft long and 1 ft apart. Each plot was replicated six times at each location. Plots were sown at Morden, Man., on May 16 and at Regina, Sask., on May 27, 1969. Two hundred seeds were sown 2 inches deep in each row with a twin cone seeder (6), and the pellets were simultaneously placed about 1 inch above the seed. Double guard rows of 'Cypress' wheat were sown at the end of each block of replicates. The plants were pulled while in the late milk-early dough stages (71-73 days after seeding) and 100 plants in each row were rated for root rot on a 0-5 scale (4). The disease rating percentage for each treatment was determined by the following formula:

$$\text{Disease rating \%} = \frac{\text{Avg of numerical ratings of individual plants} \times 100}{5}$$

The results from all replicates were subjected to an analysis of variance. Pellets were collected from soil adjacent to the subcrown internodes from all rows, plated with adherent soil on moistened filter paper, and examined for fungi after 15 days.

Results and discussion

Root rot disease ratings at Regina ranged from 20.6% to 14.3%, depending on treatment; 12 treatments and the molasses control (treatment 2) gave significant control ($P < 0.05$) (Table 1), but there were no differences among the 12 treatments and the molasses control.

Root rot disease ratings at Morden ranged from 21.2% to 17.9%, but none of the treatments had statistically significant effects.

Pellets that did not contain fungicides (treatments 2, 14, 15, and 16) taken from the Regina plots generally possessed a different microflora than pellets with fungicides (Table 1). For example, Doratomyces purpureofuscus (Fr.) Morton & Smith was found on pellets of treatment nos. 2 and 15 only; Chaetomium perlucidum Sergej on those of nos. 2 and 16 only; Dactylella asthenopaga Dreschler on those of 2, 14, and 16; and a non-sporulating green shiny mycelium on those of nos. 2, 14, 15, and 16. Penicillium crustosum Thom was found in abundance on Panogen pellets (treatments 3 and 4) and was visible in the adjacent soil. Absidia lichtheimii (Lucet and Constantin) Lendner, Gliocladium c.f. solani (Hartig) Petch, Fusarium solani (Mart.) Sacc. and a species of Melanospora were commonly present on pellets both with and without fungicides. Cochliobolus sativus was observed only on root fragments in treatment no. 2. Stachybotrys atra Corda was observed in treatment nos. 2 and 8 (Hoechst 2981); nematodes were found on pellets of nos. 6 (SWF 910) and 7 (Hoechst 2874) only.

Table 1. Composition of pellets and results of field trials at Regina and Morden for control of soil-borne root rot

Treatment no.	Constituents†	% root rot (means of 6 replicates) Regina	Morden
1	Control (pearl barley)	20.6	19.1
2	Control (pearl barley + molasses + limestone)	16.6	20.2
3	Panogen PX	16.5	19.7
4	Panogen PX	16.9	20.0
5	Dithane M45	14.4	21.2
6	SWF 910	15.1	19.5
7	Hoechst 2874	16.6	20.5
8	Hoechst 2981	14.3	19.0
9	Vitavax	18.8	18.4
10	Hoechst 2988	16.9	20.6
11	Hoechst 2989	16.1	20.5
12	MC25 monosulphate	16.3	17.9
13	MC25 sesquisulphate	15.6	19.1
14	Chitin	15.9	20.4
15	Mixture of treatments 2 and 14	16.4	21.0
16	Soybean meal††	19.3	18.3
LSD (0.05)		3.3	NS

† Treatments 3 to 16 consisted of pearl barley coated with a mixture of the named ingredient, molasses, and limestone.
†† Instant release only.
NS = not significant.

Pellets taken from Morden soil often possessed Stachybotrys atra, Gonatobotrys simplex Corda, Fusarium solani, Alcaligenes faecalis Castellani & Chalmers, and a Bacillus belonging to the B. subtilis group. Occasionally Cochliobolus sativus was seen sporulating on root fragments. Penicillium crustosum Thom and P. patulum Bain. were associated with Panogen PX (treatments 3 and 4), and Gliocladium c.f. solani (Hartig) Petch and G. roseum Bain. with other fungicides (treatments 6,8,9,10,11,12). Cladosporium cladosporioides (Fresen.) De Vries was found only on pellets without

fungicides (treatments 1,14,15). Melanospora sp. was present on pellets of treatments 1 and 3 only, and nematodes were observed on those of 2 and 9. Absidia lichtheimii, although occurring on pellets both with and without fungicide, was at much lower levels than at Regina. Dactylella asthenopaga was observed once on a pellet of treatment no. 14, and the nonsporulating green shiny mycelium once on a pellet of no. 16; Chaetomium and Doratomyces were not observed. Streptomyces sp. was seen on pellets of treatments 2,4,11, and 14 at Morden but was not observed at Regina.

The materials in the pellets are released by moisture. Total rainfall during the periods between seeding and harvesting at Morden and Regina was 6.80 inches and 5.29 inches respectively. The rainfall during the 40 day period immediately after seeding, during which the 30-day pellets were scheduled to break down, was almost identical at the two locations (Table 2). The rainfall

Table 2. Rainfall (in inches) at Regina and Morden during the interval between sowing and the day before harvest

	Days after sowing		
Location	0-40	41-60	61-harvest
Regina	2.65	1.33	1.31
Morden	2.70	3.35	0.75

41-60 days after sowing, which would help degrade the 50-day release pellets, was much heavier at Morden than at Regina, and the reverse was true for the period beyond 60 days after seeding which would affect the breakdown of the 70-day release pellets. It is suggested that most infection resulted at Morden during the period of low rainfall as there probably was inadequate release of the 70-day pellets. Further, there may have been some leaching of chemicals from the 70-day pellets during the period of heavy rainfall 41-60 days from sowing. Rainfall was more evenly distributed during the 50- and 70-day pellet release periods at Regina, thus resulting in the better control.

There was adequate infection in the controls (treatment 1) at both locations (Table 1). Some root rot control was obtained at Regina, but not at Morden, and was effected with pellets that contained molasses both with and without fungicides. The control mechanism is not apparent, but it may involve stimulation by the molasses of germination of C. sativus spores and subsequent lysis of mycelium (2) or stimulation of antagonists, or both. The microflora on the pellets and on the adherent soil from Regina and Morden differed, and possibly there were more antagonistic microorganisms in the Regina soil.

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STEM EYESPOT ON INTRODUCED FESTUCA SPP. IN ALBERTA AND BRITISH COLUMBIA[1]

J.Drew Smith[2] and C.R.Elliott[3]

Abstract

A 1969 survey indicated that the stem eyespot of creeping red fescue, Festuca rubra L. subsp. rubra caused by Phleospora idahoensis Sprague was widespread and locally severe on seed crops in the Beaverlodge district of northern Alberta. In the adjoining seed growing area around Dawson Creek and Fort St. John in British Columbia, where crop concentration is lower, there was less disease. Disease severity may be related to cropping intensity which is higher in the more humid cleared parkland than on the open prairie. The disease may cause considerable losses. This is indicated by a decline in seed yields averaging 29% from moderately to severely infected stems in three crops. The disease was found on all cultivars of creeping red rescue (F. rubra subsp. rubra), Chewings fescue (F. rubra subsp. commutata Gaud.), tall fescue (F. arundinacea Schreb.), and meadow fescue (F. pratensis Huds.) at Beaverlodge. It was present on 'Olds' and 'Boreal' cultivars of creeping red fescue at Olds, Alberta. The 'Olds' cultivar may be one of the sources of infection or susceptibility, for most commercial creeping red fescue seed crops of the north because most are derived from this strain. However, the disease may have spread to the introduced fescues from the native ones on which the pathogen appears endemic. The possibilities of controlling the disease are discussed.

Introduction

A stem eyespot of creeping red fescue (Festuca rubra L. subsp. rubra) due to Phleospora idahoensis Sprague (4) was found causing damage to seed crops of this grass in northern Alberta in 1967 and 1968 (3). In late July 1969, a disease survey was made in the main red fescue seed growing area, which extends west and north from Grande Prairie in Alberta and over the border into British Columbia. Some crops were surveyed between Dawson Creek and Fort St. John in the latter province. Plots of Festuca spp. and cultivars were examined at Research Stations at Beaverlodge and Lacombe, at Olds Agricultural College in Alberta, and at Prince George Experimental Farm in British Columbia. The survey was part of a more extensive study of the distribution of the disease on introduced and native Festuca spp. in Western Canada and northwestern U.S.A.

Results

Disease incidence

An estimate was made of the percentage of infected culms in each crop on samples plucked at random on one or more transects. The acreage of the field was also estimated (Table 1).

Thirty-two of the 47 Alberta crops had more than 50% of stems infected; whereas only one of 13 crops in British Columbia reached this level. Both common and the 'Boreal' (1) cultivars of red fescue were infected. Infection percentage could not be closely correlated with age of the crop. Some crops in their first year of seed production showed as high incidence as those which had "run out" or those which had been rejuvenated (1). Crops on open prairie in the Codesa, Belloy, and Wahnam localities, 30 miles north of Grande Prairie, showed a much lower incidence than those in the Beaverlodge, Valhalla, and Hythe triangle in cleared parkland and bush. At Prince George Experimental Farm, B.C., there were no symptoms on 10 cultivars of creeping red fescue and Chewings fescue, F. rubra L. subsp. commutata Gaud. No disease was found on stands of red fescue at seven locations on embankments and cuttings on Highways 16 and 93 south from Prince George to Banff. The disease was absent from a plot of 'Olds' cultivar at Lacombe Research Station, but a light infection was found in the 'Olds' and 'Boreal' cultivars at Olds Agricultural College and on the regrowth from two broken 'Olds' crops in the Olds area in

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Table 1. Incidence of infected culms in crops of creeping red fescue surveyed in northern Alberta and northern British Columbia in 1969

Alberta			British Columbia		
Infection (%)	Number of crops	Total acreage	Infection (%)	Number of crops	Total acreage
0	4	320	0	11	857
0-0.5	4	122	0-0.5	1	4
0.6-25	6	440	0.6-25	0	0
26-50	1	50	26-50	1	40
51-90	10	840	51-90	0	0
91-100	22	905	91-100	0	0

Alberta. Disease ratings were made on plots of cultivars of four Festuca spp. at Beaverlodge Research Station on 22 July 1969 (Table 2).

The disease was found on all Festuca species. The identity of the fungus was confirmed on 'Manade' tall fescue by isolating the fungus (3). Slight infections were found on 12 parent clones of the 'Boreal' cultivar of red fescue grown in isolation. The disease was also found on spaced plants of F. altaica Trin. collected adjacent to Mile 240 of the Mackenzie Highway just south of the 60th parallel in north Alberta. Stem lesions very similar to those on creeping red fescue were present on timothy (Phleum pratense L.), bromegrass (Bromus inermis Leyss.) and on Agropyron sp. growing as impurities in heavily infected crops of red fescue in the Beaverlodge district. We have been unable to confirm that these spots were cuased by P. idahoensis, but a fungus with similar cultural characters was isolated from bromegrass and timothy. Like most isolates made from creeping red fescue these did not sporulate in culture (3).

Table 2. Disease ratings for stem spot on cultivars of four Festuca spp. at Beaverlodge Research Station, 22 July 1969

Species and cultivar	Country† of origin	Average rating* 1966 seeding	Average rating* 1967 seeding
F. rubra rubra			
Olds	Canada	1.6	1.0
Boreal	Canada	1.8	1.3
Reptans	Sweden	2.3	1.4
Ruby	Neth.		0.8
Steinacher	Germany		1.4
Taborska	Czech.		1.5
Roznovska	Czech.		1.3
Levocska	Czech.		0.2
F. rubra commutata			
Golfrood A	Neth.		0.5
Golfrood B	Neth.		0.3
F. arundinaceae			
Manade	France	2.1	0.7
Fawn	U.S.A.		0.6
Alta	U.S.A.		0.4
F. pratensis			
Bergamo	Neth.		0.5
Mommersteeg Hay	Neth.		0.1
Trader	Canada		0.3
Mewa	Poland		0.4
Ola	Poland		0.4
Dina	Poland		0.1
Sequana	France	0.6	0.4
Barenza	Neth.	0.2	0.4
Mimer	Sweden	0.1	0.2
Dufa A	Neth.	0.5	0.3
Sceempter	Neth.	0.3	0.3
R.v.P.	Belgium	0.3	0.1
AS-9	Sweden	0.3	0.8
S-53	G.B.	0.2	1.0
Dufa B	Neth.	0.5	0.0
Roznovska	Czech.		0.1
Levocska	Czech.		0.1
SK-6	Poland		0.3

* 10 plants were rated per plot on a 0 to 4 scale, where 0 is no disease and 4 very severe disease.

† Neth. = The Netherlands; Czech. = Czechoslovakia; G.B. = Great Britain.

Effect of the disease on seed yield of creeping red fescue

Samples of red fescue stems were collected at random from three crops in the Beaverlodge area during the survey and separated into categories according to severity of the disease (Table 3). The following 4-point scale was used:

0 - No spots on stem, sheath, or inflorescence.

1 - Rare spots on stem, sheath, none on inflorescence.

2 - Few spots on stem, sheath, rare on inflorescence.

3 - Many spots on stem, sheath, and inflorescence, or moderate spotting of stem and sheath and culm girdled.

Table 3. Effect of P. idahoensis infection on seed yield of samples of creeping red fescue from three heavily infected crops

Sample	Seed yield in grams per culm in infection categories: 0	1	2	3	% decline in yield*
1		0.65 (53)**	0.55 (95)	0.48 (77)	12.7
2			0.88 (38)	0.63 (62)	28.4
3			0.63 (55)	0.34 (142)	46.0

* $\frac{\text{Category 2 - Category 3}}{\text{Category 2}} \times 100$

** Figures in brackets indicate number of culms in each infection category.

Yield declined as disease severity increased in all crops. It was not possible to find crops showing all categories of infection at the time of the survey.

Discussion

The 1969 survey indicated that the disease was widespread and locally severe on crops of red fescue in the Beaverlodge, Valhalla and Hythe triangle in northern Alberta but less severe in the Dawson Creek and Fort St. John areas in British Columbia, where the concentration of this crop was lower. The severity of the disease appeared to be higher in the more humid cleared bush and parkland than on the open prairie. Creeping red fescue, however, is more commonly grown in the parkland areas, and cropping density and frequency may have been the cardinal epidemiological factor rather than the higher humidity.

When the disease is severe a considerable decline in seed production may be expected (Table 3). We were unable to compare yields of uninfected stems with diseased ones but the yields from the first sample suggest that the seed yield in infected crops would decline as the disease became more severe. There was a tendency for severely infected crops to ripen prematurely and shatter; this would add to crop losses.

Unploughed remnants of crops of the 'Olds' cultivar were found to be infected in the Olds district. This cultivar may have been one source of infection or susceptibility for the northern seed growing district since most of the acreage grown today originates from this introduction (1). There were no fields of this cultivar in the Olds locality for more extensive examination. Recent studies (unpublished) have shown that the fungus is present on native Festuca spp. in Western Canada and northwestern U.S.A. This finding supports the suggestion that the native species may have been the original source of inoculum for introduced fescues (3).

All species of Festuca appeared to be susceptible to the disease but the cultivars of F. pratensis appeared less susceptible generally than those of other species. Since the plots which were rated were isolated from large concentrations of other heavily infected Festuca spp. and were of small size, the ratings probably do not give a true assessment of varietal resistance. Further studies of varietal resistance under field conditions are therefore indicated.

The only method of disease control which seems applicable to this disease at present is the removal of infected crop debris by burning or flaming of stubbles, as practised in the grass seed growing areas in Oregon, Washington, and Idaho (2). Both common red fescue and 'Boreal', which are commonly grown, are susceptible and to replace these with resistant varieties is a long term process. There is little information on the effects of burning crop debris on the physiology and seed yield of creeping red fescue, so adequate controlled experimentation is required before large scale field burning is attempted.

Acknowledgment

We are indebted to Mr. Maurice Hiltz, Beaverlodge Research Station, for technical assistance on survey and for information on the sequence of cropping of red fescue in particular fields in the Beaverlodge district.

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ASSESSMENT OF YIELD LOSSES FROM BARLEY YELLOW DWARF IN OATS[1]

J.W. Martens and W.C. McDonald[2]

Yellow dwarf or red leaf of oats (Avena sativa L.) is caused by the aphid-transmitted barley yellow dwarf virus (BYDV) that also infects wheat, barley, and some grasses. The disease is common in Manitoba (2,3) but, with one exception (1), yield losses from the disease have not been estimated. One reason for this has been the lack of a method of estimating losses based on experimental data obtained under natural conditions in the field. In 1969 a severe epidemic of yellow dwarf in the Winnipeg area provided an opportunity to obtain data on the comparative yields of symptomless, apparently healthy plants, and of naturally infected plants showing symptoms of the disease; from these data a disease loss formula was developed.

Methods

Heavy, natural infections of BYDV appeared in stands of the oat cultivars Kelsey and Eagle planted for other purposes near Winnipeg. The oats were planted June 5th and symptoms of virus infection were evident by July 10th. Twenty-five stakes were placed at random in a 1-acre stand of each cultivar on August 5th, when the plants were in the soft dough stage of growth. The area around each stake constituted one replicate. In each plot, 10 main tillers each of healthy (no apparent symptoms), lightly infected (slight streaking on flag leaf), and moderately infected (definite reddening of flag leaf) plants were tagged. Severely infected, stunted plants were not considered because they produce no seed. The tagged panicles were harvested on Sept. 12th and threshed carefully. Germination tests were done in greenhouse soil beds with 50 seeds per replicate of each cultivar. All data presented are the means of 25 replicates.

Results and discussion

BYDV infection reduced yields from plants of both cultivars that had moderate infections and also from plants of 'Eagle' with light infections (Table 1). In 'Kelsey' the reduction appeared to be attributable mainly to reduced seed set, whereas in 'Eagle' seed set and weight were both reduced. Seed germination of both cultivars was also significantly affected by virus infection. Kelsey, which is grown on about 10% of the oat acreage in Manitoba, appears to have some tolerance to yellow dwarf.

These data could be used to estimate yield losses from BYDV in field surveys of oats by multiplying the percentage of lightly, moderately, and severely infected plants in each field by the average percentage yield reduction for each class (Table 1), e.g. light - 27.5%; moderate - 66%; severe - 100%, or for practical purposes 30, 65, and 100%, respectively. The loss in bu/acre for an area in which the average yield is known would be the difference between the potential average yield without disease and the average yield. The potential yield would be calculated by dividing the

Table 1. Effect of barley yellow dwarf on yield, seed set, seed weight, and germination in two oat cultivars

Cultivar and disease class	Yield (g/plot)	Seed set (no./tiller)	Seed weight (mg/seed)	Germination (%/plot)
Kelsey				
healthy	12.1	48.0	25.3	96.3
light	10.7 (12)†	42.1* (12)	25.3 (0)	96.3
moderate	4.5* (63)	19.5* (59)	23.2 (8)	89.6*
Eagle				
healthy	16.3	65.3	24.9	91.3
light	9.2* (43)	43.1* (44)	21.4 (14)	84.8*
moderate	5.0* (69)	25.2* (61)	20.0 (20)	79.3*

* Significantly different from the healthy (P = 0.01).
† Figures in brackets indicate % reduction from the healthy.

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average yield by 100 minus the average % loss in all fields. The accuracy of such a figure would depend on whether the number of fields surveyed was large enough to reflect the distribution of varieties differing in susceptibility, on the variable incidence of disease, and on the occurrence of late and early sown crops.

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LOSSES FROM STORAGE ROT OF McINTOSH APPLES IN NOVA SCOTIA, 1962-68[1]

C.L.Lockhart, C.A.Eaves, and F.R.Forsyth

Abstract

Rot of 'McIntosh' apples in storage at 32 F (0 C) was assessed for each of the years 1962 to 1968. The average loss from rot during the 7-year period was 4.8%. Gloeosporium album was the most common cause of rot, followed by Penicillium spp., Botrytis cinerea, and Gloeosporium malicorticis.

Introduction

The annual average production of 'McIntosh' apples in the Annapolis Valley of Nova Scotia from 1962 to 1968 was 550,000 bushels. Other than a report (1) of pockets of rot occurring in a 7,000-bushel controlled atmosphere storage in 1963, there have been no published reports of losses by rot of stored 'McIntosh' apples during this period. Rot losses have been reported on other varieties. Four lots of 'Golden Russett' apples averaged 4.7% loss due to rot in January 1964 (2), and in December 1964 a 10% loss of 'Rome Beauty' apples from rot in a cold storage was reported (3).

This paper is a report of the losses caused by rot of 'McIntosh' apples in cold storage in each of the years, 1962 to 1968.

Methods

Each year, beginning in 1962, samples of apples were harvested from the same five trees in each of 12 different orchards in various parts of the Annapolis Valley. They were arranged on a wooden tray in a single layer and placed in cold storage. Samples usually consisted of 100 apples per tree for a total of 500 apples per orchard per year. After six months at 32 F (0 C), the apples were examined and the number showing rot recorded. The cause of each rot was identified from fungus sporulation on the apple or by isolation on potato dextrose agar.

Results and discussion

Rots caused by Penicillium spp., were observed on apples after 4 to 6 weeks in storage. Rots caused by Gloeosporium spp. and Botrytis cinerea Pers. usually started to develop after 3 months. Generally after 6 months the cause of the rots could be identified by the fungus fruiting structures which developed on the decayed area of the apple.

During the 7-year period, the average total loss from rot in 'McIntosh' apples was 4.8%. The largest number of rots were caused by Gloeosporium album Osterw., followed by Penicillium spp., B. cinerea, and Gloeosporium malicorticis Cordley (Table 1). Rots due to Gloeosporium spp. and B. cinerea were more prevalent in 1962, 1963, and 1964 than in the other storage seasons (Table 2).

Except for 1967, there was a positive correlation between the apple rots caused by G. album and the total rainfall for the 3 months prior to harvest (Tables 2 and 3). Above average rainfall in 1962, 1963, and 1964 favored field infections of 'McIntosh' apples with G. album. In those years, several periods of wet weather lasting for 4 or 5 days occurred during July, August, and September. Total rainfall for July, August, and September of 1967 was above average but few rots were caused by G. album. The wet periods in 1967 occurred in July and early August, when fungicide cover sprays would still be effective in preventing field infections. Ross and Lockhart (4) have shown that two late cover sprays of captan give complete control of G. album storage rot. The data in this paper suggest that these sprays would be economical for G. album in years of high rainfall in August and September. Growers who usually have an above average incidence of this disease and who have yields of 500 bushels per acre or more should seriously consider adopting this practice.

Since 4.8% of stored 'McIntosh' apples may be lost from rots, the annual loss of revenue to growers of this variety in the Annapolis Valley could be $39,600, based on an average price of $1.50 per bushel. The actual loss of revenue may be less than estimated since 70% of these apples are usually sold by the end of January. However 30% of the crop is now held until June in controlled atmosphere storage, so loss of revenue due to rots should be close to the estimate. Storage costs have not been considered.

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Table 1. Average percentage rot in McIntosh apples after storage for 6 months at 32F (0C), 1962-1968

Grower	% rot caused by					
	Gloeosporium album	Gloeosporium malicorticis	Botrytis cinerea	Penicillium spp.	Others*	Total rot
A	1.8	0.3	1.2	1.5	0.0	4.8
B	1.3	0.1	0.8	1.2	0.2	3.6
C	3.5	0.6	0.7	0.9	0.3	6.0
D	2.2	0.2	1.7	1.3	0.1	5.5
E	1.6	0.5	1.2	1.6	0.2	5.1
F	1.5	0.9	0.7	1.2	0.0	4.3
G	2.2	1.1	2.9	0.6	0.3	7.1
H	1.7	0.3	0.8	0.9	0.0	3.7
I	1.1	0.1	0.2	0.7	0.1	2.2
J	2.6	0.5	0.2	1.2	0.0	4.5
K	1.6	0.5	1.1	1.3	0.3	4.8
L	3.1	0.9	1.1	1.1	0.1	6.3
Avg	2.0	0.5	1.0	1.1	0.2	4.8

* Includes Alternaria sp., Sphaeropsis malorum, Sclerotinia sp., and Gloeosporium sp. (perennans?).

Table 2. Average percentage rot in individual years

Years	% rot caused by					
	Gloeosporium album	Gloeosporium malicorticis	Botrytis cinerea	Penicillium spp.	Others*	Total
1962	3.9	0.9	1.3	1.2	0.1	7.4
1963	2.8	0.7	1.3	0.4	0.1	5.3
1964	2.4	0.7	3.4	1.0	0.1	7.6
1965	1.6	0.4	0.3	1.7	0.4	4.4
1966	1.9	0.2	0.3	1.7	0.4	4.5
1967	0.6	0.1	0.4	0.3	0.1	1.5
1968	0.5	0.1	0.3	1.7	0.2	2.8
Avg	2.0	0.5	1.0	1.1	0.2	4.8

* Includes Alternaria sp., Sphaeropsis malorum, Sclerotinia sp., and Gloeosporium sp. (perennans?).

Table 3. Total rainfall* in inches for 3 months prior to harvest

Month	1962	1963	1964	1965	1966	1967	1968	50-year average
July	3.14	2.27	2.70	1.62	2.08	4.26	0.82	2.71
August	6.38	7.18	5.22	2.63	1.33	3.18	1.36	3.56
September	6.37	3.68	3.62	0.56	3.23	3.79	2.74	2.74
Total	17.89	13.13	11.54	4.81	6.64	11.23	4.92	9.01

* Rainfall recorded at CDA Research Station, Kentville, N.S.

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LEAF SPOT OF HIGHBUSH BLUEBERRY CAUSED BY GODRONIA CASSANDRAE F. VACCINII[1]

C.L. Lockhart

Abstract

A leaf spot found in 1968 and 1969 on highbush blueberry (Vaccinium spp.) was apparently caused by Godronia cassandrae f. vaccinii. Pycnidia of the imperfect state Fusicoccum putrefaciens formed in affected leaf tissues held in a moist chamber or on agar media. The cultivar Bluecrop was more susceptible than the cultivars Berkeley or Coville. There appeared to be a positive correlation between the severity of leaf spot infection and the susceptibility of the cultivars to canker caused by G. cassandrae.

Introduction

In August 1968 a leaf spot was found on the highbush blueberry (Vaccinium spp.) cultivar Bluecrop growing at the Research Station, Canada Department of Agriculture, Kentville, Nova Scotia. In 1969 it was also detected on the cultivars Berkeley and Coville. The fungus Godronia cassandrae Pk. f. vaccinii Groves (1), which caused a stem canker of highbush blueberry, was subsequently isolated from the leaf spot. There are apparently no published reports of a leaf spot on highbush blueberry caused by G. cassandrae or its imperfect state Fusicoccum putrefaciens Shear (1).

This paper is a report of the occurrence and symptoms of the leaf spot on highbush blueberry apparently caused by G. cassandrae.

Symptoms and occurrence

Spots varying from one to several per leaf were observed on highbush blueberry foliage from July to September. They were circular, 1.5 to 10 mm in diameter, with well defined margins (Figure 1). The color ranged from light to dark brown, with the border of the lesions being darker than the center. Each spot appeared on both the upper and under surfaces of a leaf, and in advanced stages the spots often coalesced. Fungus fruiting structures were not apparent on the leaf spots in the field. Leaf spots were more abundant on 'Bluecrop' than on 'Berkeley' or 'Coville' and they usually occurred on the foliage of the lower branches of blueberry plants infected with canker caused by G. cassandrae.

No leaf spot was found in a commercial field of 'Burlington', 'Coville' and 'Jersey' adjoining the Research Station. This field had received a dormant spray of phenyl mercury acetate (2) in the spring of 1969 for the control of Godronia canker.

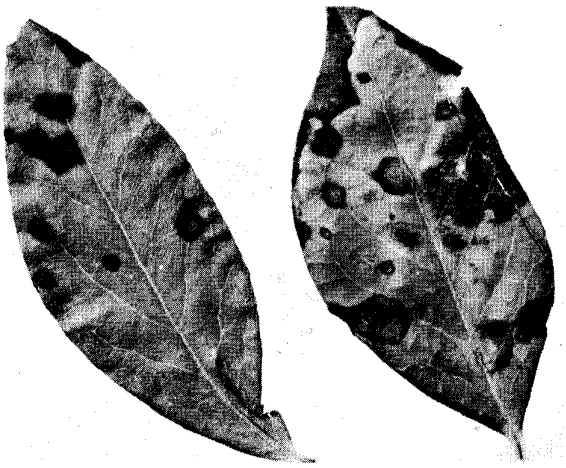

Figure 1. Highbush blueberry leaves infected with the fungus *Godronia cassandrae* f. *vaccinii*.

Isolation of the fungus

In a moist chamber a dark stroma-like structure formed under the surface of spots on leaves collected in 1968. Sections of leaf spots sterilized in 2% chlorine for two minutes and placed on potato dextrose agar (PDA) produced F. putrefaciens.

Diseased leaves were also collected in July and August 1969 and placed in a moist chamber. From the July collections, pycnidia of F. putrefaciens developed only on five spots of one leaf, but pycnidia were more numerous on spots of leaves collected in August. The fruiting structures were similar to those described by Groves for F. putrefaciens (1). Almost all isolations on PDA yielded F. putrefaciens. Samples of the leaf spot are deposited in herbarium of the Plant Pathology Section, Research Station, Kentville, under number KP 2635.

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[1] Contribution No. 1375, Research Station, Canada Department of Agriculture, Kentville, Nova Scotia.

Conclusions

The fungus F. putrefaciens, the imperfect state of G. cassandrae f. vaccinii was commonly isolated from a previously unknown leaf spot of highbush blueberry. Leaf spot infections are probably caused by inoculum from the Godronia cankers that occur on the wood of the blueberry. The leaf spot was found only on cankered bushes, and cultivars more susceptible to canker were also more susceptible to leaf spot.

The dormant mercury spray recommended for the control of canker (2) will probably give control of the leaf spot. The leaf spot was not found on the canker susceptible cultivar 'Jersey' which had received a dormant mercury spray.

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