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

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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 qrowth 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-3E-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	Uniroya1	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%	chlorani1
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 activatedpolyethylenethiuramdisulfide
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 1.070	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	TI)-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*	I*	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, 084, 1085, 1090, 1099, 1144
Lodgepole pine alone	7	103, 951, 971, 973, 013, 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

	Emergence (%)			Damping-off (%)		
Treatment	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; Dolyram + 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.

2. Carlson, L.W., and J. Belcher. 1969. Seed-treatment fungicides for control of conifer damping-off: Laboratory and greenhouse tests, 1967-68. Can. Plant Dis. Surv. 49:38-42.