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Control of common root rot and loose smut and the phytotoxicity of seed treatment fungicides on Gateway barley

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Several fungicides, such as nuarimol, etaconazole, and fenapanil, applied as seed dressings to barley (*Hordeum vulgare*) cv. Gateway 63, significantly reduced the symptoms of common root rot [*Cochliobolus sativus* and *Fusarium spp.*] on the subcrown internode at four locations in western Canada. However there was no significant increase in grain yield from treatments that reduced symptoms of root rot, and at the higher of several rates of application of chemical, grain yields were significantly reduced at two of three locations. Percent emergence of Gateway 63 barley seed treated with etaconazole, triadimenol, nuarimol, and fenapanil was similar to that of treated Bonanza, Galt, Betzes, and Klondike. Reduced grain yield, seedling emergence, and seedling growth indicated that most fungicides were phytotoxic to Gateway 63 at some of the rates used. Loose smut [*Ustilago nuda*] was reduced significantly by most of the experimental seed dressings and, of these, etaconazole, trivax, and triadimenol were the most effective.

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Plusieurs fongicides comme le nuarimol, l'étaconazole, et le fénapanil, utilisés pour l'enrobage des semences de l'orge Gateway 63, ont permis de réduire de façon appréciable les symptômes de la pourriture commune des racines (*Cochliobolus sativus* et *Fusarium* spp.) sur les entre-noeuds subcoronaux, en quatre sites différents de l'ouest du Canada. Il n'y a eu aucune augmentation appréciable du rendement en grains après les traitements réduisant les symptômes de la pourriture commune, et une baisse notable de ces rendements a été observée dans 2 sites sur 3 après l'application de la plus forte d'une série de plusieurs doses de produit chimique. Le pourcentage de levée des semences d'orge Gateway 63 traitées à l'étaconazole, au triadiménol, au nuarimol, et au fénapanil a été semblable à celui des variétés Bonanza, Galt, Betzes, et Klondike. La baisse des rendements en grains, du pourcentage de levée des semis et du taux de croissance des plantules indiquent que la plupart des fongicides sont phytotoxiques pour l'orge Gateway 63 à certaines des doses employées. Cependant la plupart de ceux-ci ont diminué le charbon nu [*Ustilago nuda*] d'une manière significative, l'étaconazole, le trivax, et le triadimenol étant les plus efficaces.

Chemical control of plant diseases, especially by chemicals that act in a systemic manner, is of considerable interest to the grain industry. Smuts and seedling blights can be effectively controlled by a variety of fungicides currently available to the grower. Common root rot of wheat and barley, as caused by *Cochliobolus sativus* (Ito and Kurib) Drechs, ex Dastur (imperfect state *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. = *Helminthosporium sativum* P.K. and B.) and some *Fusarium* spp., is considered a nonspectacular disease, with annual yield losses of about 6% to 10% for wheat and barley, respectively (Ledingham et al. 1973, Piening et al. 1976). A small measure of root rot control may be obtained by selecting cultivars, such as Bonanza or Conquest, which have some resistance to common root rot when compared with Galt or Gateway 63. There is, however, no satisfactory method to effectively control this disease at present and identifying suitable chemicals that can be applied to the seed would represent a major achievement.

This report compares the emergence, growth, yield, and suppressive effects on root rot and loose smut of 13 fungicides applied to the seed of Gateway 63 barley. The possible phytotoxic effects of these chemicals on barley yields is discussed.

Materials and methods

Tests were conducted on the Agriculture Canada Research Stations at Lacombe, Saskatoon, Beaverlodge, and Lethbridge in 1980. Seed of barley cv. Gateway 63 with about 4% loose smut was obtained from a farmer in the Lacombe area. Fungicides were thoroughly mixed with 1 kg of seed in glass jars. Seed was sown at 55 kg/ha in 4-row plots, 6 m long with 23 cm between rows, replicated four times in a randomized block design at all locations except Saskatoon where six replicates were planted. At Beaverlodge, seed was planted in six rows, 4 m long. Emergence at Saskatoon was recorded 31 days after sowing in 2 m of one of the center rows of each plot. At Lacombe emergence of five barley cultivars was compared 25 days after sowing four replicates of 100 seeds each. Root rot was determined a few days prior to harvest by rating the amount of lesioning of the subcrown internodes of 50 plants pulled from the two border rows of each plot, except at Saskatoon where root rot was recorded immediately after harvest. Determination of percent disease was similar to the method used by Ledingham et al. (1973). The numbers of smutted heads were counted in the two center rows

Table 1. Fungicides used as barley seed dressings

Product	Active ingredient*	Manufacturer
GCA-64251 SD (Vanguard)	etaconazole (2.5%)	Ciba-Geigy
CGA-64251 SCO (Vanguard)	etaconazole (2.5%)	Ciba-Geigy
Baytan 150FS	triadimenol (15%)	Chemagro
RH-2161	fenapanil (284 g/L)	Rohm and Haas
BAS-389-05	furmecyclox (500 g/L)	B.A.S.F.
DPX-14	carbendazim (15%), maneb (60%)	DuPont
DPX-1015	carbendazim (10%), thiram (15%)	DuPont
EI-228	nuarimol (Trimidal)	Elanco
H719-7510	trivax (75%)	Uniroyal
UBI-2186	trivax (6.9%), lindane (20%)	Uniroyal
UBI-2238	trivax (7.8%)	Uniroyal

*Etaconazole, 1-[2(2,4-dichlorophenyl)-4-ethyl-1, 3-dioxolan-2-ylmethyl]-1H-1,2,4-triazole; fenapanil (Sisthane, RH2161), α-butyl-α-phenyl-1H-imidazole-1-propanenitrile; furmecyclox, N-cyclohexyl-N-methoxy-2,5-dimethyl-3-furan carboxamide; carbendazim, methyl-2-benzimidazole carbamoyl phosphate; trivax, 3-carboxanilido-2,4,5-trimethylfuran.

of each plot. At Lethbridge yield was obtained by harvesting 5 m from the two center rows of each plot; at Saskatoon, four rows from each plot were harvested; and at Beaverlodge the four center rows of 6-row plots were harvested. At Lacombe plots were not harvested because of hail damage.

Phytotoxic effects of the seed-borne chemicals, as reflected by the leaf development of seedlings from treated seed stored 5 weeks prior to testing, was compared with growth of barley from nontreated seed. Ten seeds were planted in soil in 10-cm plastic pots replicated five times, and the growth of the seedlings was compared 14 days following sowing.

The fungicides and their sources are listed and described in Table 1.

Results and discussion

The summarized disease data are presented in Table 2. The amount of common root rot of barley from nontreated seed was quite variable at the four locations and was lowest at Beaverlodge. The incidence of root rot was very high at Lacombe; partly this was due to an abnormally large amount of take-all (*Gaeumannomyces graminis* (Sacc.) Arx & Olivier), especially in one replicate.

At all locations common root rot was significantly reduced only by treating seed with nuarimol, triadimenol, and fenapanil. Almost all the chemicals, however, reduced root rot significantly at Beaverlodge and Lethbridge, where there was considerably less root rot in all treatments than at the other two locations. None of the treatments resulted in the significantly higher yields obtained in tests in previous years (Piening et al. 1979).

Loose smut was significantly reduced by most of the experimental seed dressings, and of these etaconazole, trivax, and triadimenol were the most effective (Table 2). The amount of loose smut from the nontreated seed varied at the different locations, being lower at Saskatoon and Beaverlodge than at Lacombe and Lethbridge.

At Saskatoon and Lethbridge but not at Beaverlodge, significant reductions in yield occurred with some of the treatments, especially carbendazim plus thiram, nuarimol (5% at 0.3 g ai/kg seed), and etaconazole (Table 2). Dewey and Albrechtsen (1977) showed that the yield of barley cv. Gem was reduced more than that of cv. Piroline when grown from seed treated with carboxin, benomyl, and thiabendazole. Their results suggest that barley cultivars may differ in their response to chemical seed treatments. Forster et al. (1980) noticed that the growth of roots, shoots, and coleoptile of Brevia barley grown from seed treated with triadimenol (0.25 g/kg) was inhibited. The inhibition of growth diminished with time, and the flag leaves of such plants at maturity had a greater surface area and also weighed more than leaves from untreated plants; furthermore the yields of the treated and untreated barley were similar. Gateway 63, the barley used in this test, is a relatively fast-maturing cultivar developed for the northern portions of the prairies. It is considered to be more susceptible to common root rot than most of the other commercial varieties grown in western Canada. At Lacombe the emergence of Gateway and four other cultivars from seed treated with etaconazole, triadimenol, nuarimol, and fenapanil was reduced significantly (Table 3).

Phytotoxicity was also expressed by inhibition of seedling growth (Table 4) compared to the control. The carbendazim plus thiram treatment had the most depressing effect on germination, and after 5 weeks of storage seeds failed to germinate. In part

Table 2. The effect of fungicides applied to the seed on the incidence of common root rot and loose smut and on yield of Gateway 63 barley at four locations

	Rate	Common root rot at harvest (%)				Loose smut†				Yield‡		
Treatment	(g ai/kg seed)	Saskatoon	Lacombe	Beaverlodge	Lethbridge	Saskatoon	Lacombe	Beaverlodge	Lethbridge	Saskatoon	Beaverlodge	Lethbridge
Check		62	84	29	28	1.7	10.0	6.5	12.8	2006	1027	866
CGA 64251SD	0.05 g ai	38**	82	20*	18**	0.5*	0.5**	0.3**	0.3**	1891	1028	750*
CGA 64251SD	0.075 g ai	26**	77	4**	16**	0 **	0.3**	0 *	0 **	1768	1032	782
CGA 64251SCO	0.05 g ai	24**	82	6**	18**	0.5*	0.3**	0.3**	0 **	1753	1003	662**
CGA 64251SCO	0.075 g ai	22**	64*	2**	17**	0.3*	0.3*	0 **	0 **	1761	1010	656**
Baytan	0.156 g ai	41**	74	5**	17**	0 **	0 **	0 **	0 **	2042	1119	806
Baytan	0.626 g ai	45**	68	2**	21**	0 **	0.3**	0 **	0 **	1971	1027	747*
RH 21161	1.2 g ai	29**	62*	5**	20**	0.2*	1.5**	0.5**	0.5**	1916	1115	699*
BAS 389-05	1.5 g ai	49*	64*	1**	29	0 **	0.8**	0.3**	0.5**	1906	1042	670**
DPX 14	3.8 g ai	64	80	6**	22*	1.3	2.5**	4.0*	5.5*	1924	1072	811
DPX 1015	22,5 g ai	58	89	1**	35	0.2*	0.3**	0.5**	0 **	1453**	1031	400**
EL 228 5%	0.3 g ai	27**	60*	6**	19**	0 **	0.5**	0 **	0 **	1546**	999	570**
EL 228 5%	0.15 g ai	34**	69	2**	16**	1.2	3.0**	0.8**	1.3**	2034	1092	767
EL 228 10%	0.3 g ai	33**	75	2**	19**	1.3	5.0*	1.5**	2.3**	1896	1065	814
EL 228 10%	0.15 g ai	35**	75	6**	11**	2.8	4.5*	4.0*	4.0*	1874	1027	783
EL 228-70WP	0.30 g ai	30**	64*	4**	19**	1.2	4.3*	0.8**	1.0**	1946	1079	811
EL 228 70WP	0.15 g ai	40**	63*	2**	14**	2.2	5.0*	2.0**	2.3**	1846	1071	773
H 719 75W	1.56 g ai	66	84	18*	23*	0 **	0 **	0.3**	0 **	1848	1047	774
UBI 2186	0.138 g ai	54	83	13*	19**	0 **	0.5**	0 **	1.0**	1946	1100	810
UBI 2238	0.156 g ai	68	80	9**	24*	0 **	0 **	0 **	0 **	2060	1061	826
DPX 14 + EL 228-70%	3.8 g ai 0.3 g ai	28**	79	1**	21**	0 **	0.8**	0 **	0 **	1835	994	729*
DPX 14 + Baytan	3.8 g ai 0.156 g ai	57	72	5**	16**	0.7	4.5*	1.3**	3.5*	1859	1063	803
DPX 14 + Baytan + EL 228 70WP	1.9 g ai 0.156 g ai 0.15 g ai	22**	73	4**	19**	0.2*	0.8**	0 *	0 **	1750*	1040	725*

†No. of smutted heads in 2 centre rows (4 centre rows at Beaverlodge
‡Yield from plots of 4 rows, 5 m long at Saskatoon; 4 rows, 4 m long at Beaverlodge;
Yield from 4 rows, 4 m long
Yield from 2 rows, 5 m long. No yield from Lacombe because of hail early in August
*and ** denote values that differ from those of the control at the 5 and 1% levels of significance, respectively, using Duncan's test.

Table 3. Seedling emergence, expressed as percent of control, of chemically treated seeds of five barley cultivars at Lacombe

Chemical	Rate (g ai/kg seed)	Percent emergence					
		Bonanza	Galt	Betzes	Klondike	Gateway	Avg
CGA-64251SD (etaconazole)	0.075	53**	74*	72*	72*	77*	70
Baytan (triadimenol)	0.626	93*	87*	83*	81*	86*	86
El-228-5% (nuarimol)	0.30	55**	62**	59**	54**	62**	58
RH-2161 (fenapanil)	1.20	62**	59**	62**	63**	65*	62
Control (untreated)		100	100	100	100	100	100

* and ** denote values that differ from those of control at the 5 and 1% level of significance, respectively, using Duncan's test.

the failure to emerge might have been due to the use of a very high concentration of total chemical (9 g carbendazim, 13.5 g thiram). Phytotoxicity usually increases as dosage increases. The most marked reduction in emergence and seedling growth occurred when the rate of 5% nuarimol was doubled from 0.15 to 0.3 g ai/kg seed. Doubling the 10% nuarimol formulation had essentially no effect on emergence or seedling growth, whereas doubling the 70 WP formulation of nuarimol only slightly decreased emergence and seedling growth. Increasing the concentration of triadimenol from 0.156 g ai to 0.626 g ai/kg seed did not affect emergence, and the germination rate following these treatments was not significantly less than that of the control. Seedling growth, however, was markedly inhibited by triadimenol at the higher concentration and only slightly inhibited at the lower concentration. Increasing the concentration of 2.5% etaconazole from 0.05 to 0.075 g ai/kg seed reduced emergence and seedling growth. Increasing the concentration of the other formulation of etaconazole (SCO) had a lesser effect on emergence and no effect on seedling growth. Fenapanil used at one concentration

Table 4. Effect of seed treatments on the germination and on seedling growth of Gateway 63 barley at Lacombe

Treatment	Rage (g ai/kg seed)	Emergence†	Seedling top growth in soil§
Check		79	***
CGA 64251SD	0.05 g ai	65	***
CGA 64251SD	0.075 g ai	56**	**
CGA 64251SCO	0.050 g ai	58**	**
CGA 64251SCO	0.075 g ai	54**	**
Baytan	0.156 g ai	68	**
Baytan	0.626 g ai	70	*
RH 2161	1.2 g ai	52**	***
BAS 389 01F	1.5 g ai	62*	**
DPX 14	3.8 g ai	84	**
DPX 1015	22.5 g ai	25**	0
EL 228 5%	0.3 g ai	44**	*
El 228 5%	0.15 g ai	73	***
El 228 10%	0.3 g ai	74	**
El 228 10%	0.15 g ai	72	**
EL 228 70WP	0.30 g ai	68	**
EL 228 70WP	0.15 g ai	71	***
H 719 75W	1.56 g ai	79	**
UBI 2186	0.138 g ai	78	**
UBI 2238	0.156 g ai	84	**
DPX 14 +	3.8 g ai		
EL 228 70WP	0.3 g ai	58**	*
DPX 14 +	3.8 g ai		
Baytan	0.156 g ai	79	***
DPX 14 +	1.9 g ai		
Baytan +	0.156 g ai		
EL 228 70WP	0.15 g ai	63**	**

* and ** denote values that differ from those of the control at the 5 and 1% levels of significance respectively, using Duncan's test.

†Emergence in the field at Saskatoon only recorded as number of plants in 2 m of one of the centre rows of each plot.

§0 = no growth; + = growth inhibited markedly; ++ = growth inhibited slightly; +++ = no inhibition.

reduced emergence significantly but did not affect seedling growth.

Decreased yields were not generally consistent with decreased emergence or reduced seedling growth at Saskatoon or Beaverlodge, but they were at Lethbridge. It is possible that environmental conditions at Saskatoon allowed for sufficient tillering that even though emergence was reduced, yields were not generally significantly lower. The significant yield reduction caused by the carbendazim plus thiram treatment at Saskatoon and Lethbridge was not evident at Beaverlodge. Also plants grown from carbendazim plus thiram treated seed were shorter than those from untreated seed at all locations except Beaverlodge.

We have not been able to identify a fungicide that will consistently reduce root rot and also significantly increase yields. Although several of the products tested, nuarimol, triadimenol, and fenapanil, did significantly reduce root rot lesions on the subcrown internode, their phytotoxic properties may have negated any yield increase expected from reduced root rot. The reduction of common root rot of cereals from seed treated with systemic fungicides has been documented by Richardson (1972) for barley and by Chinn (1978) for wheat, but in no case was an effect on yield noted. Data presented here indicate that the products were more phytotoxic at the higher rate than at the lower rate of application. This fact suggests that mixtures of the more promising fungicides at a low rate of application might reduce phytotoxicity. However the data indicate that the lowest rates used in this study are still too high.

The variable results from the different locations also suggest that environmental factors such as temperature, soil moisture or soil microflora influence the fungicidal and phytotoxic nature of these products. Further research into factors influencing the phytotoxicity of these fungicides and possibly reducing the amounts of chemicals in mixtures may ultimately offer a reliable method of chemical control of common root rot of cereals.

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Chinn, S.F. 1978. Influence of seed treatment with imazalil on common root rot and the size of the subcrown internode of wheat. Phytopathology 68:1662-1666.

Dewey, W.B., and **R.S. Albrechtsen.** 1977. Effect of seed treatment with three systemic fungicides on yields and stands of wheat and barley. Plant Dis. Rep. 6:1057-1060.

Forster, H., H. Buchenaur, and **F. Grossmann.** 1980. Side effects of the systemic fungicides triadimefon and triadimenol on barley plants. 1. Influence on growth and yield Z. Pflanzenkr. Pflanzenschutz 87:473-492.

Ledingham, R.J., T.G. Atkinson, J.S. Horricks, J.T. Mills, L.J. Piening, and **R.D. Tinline.** 1973. Wheat losses due to common root rot in the Prairie Provinces of Canada, 1969-71. Can. Plant Dis. Surv. 53:113-122.

Piening, L.J., T.G. Atkinson, J.S. Horricks, R.J. Ledingham, J.T. Mills, and **R.D. Tinline.** 1976. Barley losses due to common root rot in the Prairie Provinces of Canada, 1970-72. Can. Plant Dis. Surv. 56:41-45.

Piening, L.J., L. Duczek, T. Atkinson, and **J.G.N. Davidson.** 1979. The effect of seed treatment on common root rot and smuts of barley. Pages 468-471 *in* Pestic. Res. Rep. Expert. Comm. Pestic. Use Agric., Minist. Supply Serv. Canada, Ottawa, Ont.

Richardson, L.T. 1972. Effectiveness of systemic fungicide seed dressings as protectants of barley seedlings against *Cochliobolus sativus*. Can. J. Plant Sci. 52: 849-953.