Chemical Suppression of Gloeotinia temulenta Apothecia in Field Plots of Lolium perenne

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ABSTRACT

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Formation of apothecia of *Gloeotinia temulenta* (cause of blind seed disease) was suppressed by 1-4(4-chlorophenoxy)-3,3-dimethyl-1-(1*H*-1,2,4-triazol-1-yl)-2-butanone (triadimefon); α-(2-chlorophenyl)-α-(4-fluorophenyl)-5-pyrimidinemethanol (nuarimol); and α-(2-chlorophenyl)-α-(4-chlorophenyl)-5-pyrimidinemethanol (fenarimol) each at less than 0.4 mg active ingredient (a.i.)/92 cm^2 applied once over cold-conditioned, infected seeds of *Lolium perenne* (pseudosclerotia) at the soil surface in plastic pots. In field plots of *L. perenne* 'Linn', triadimefon, and fenarimol both gave complete control at 1.12 kg/ha after one application as a soil-surface drench. Triadimefon and nuarimol applied once in a spray or in a granular formulation gave poor to incomplete control. Apparently, the leaf canopy in the field interfered because these chemicals gave excellent control in concurrent pot tests at field rates. Apothecium formation was prevented by sodium azide at 12 and 16 mg/92 cm^2 soil surface in greenhouse pot tests; 8 mg gave nearly complete control. In field plots, sodium azide applied 29 April, at 11.2 kg/ha exerted complete control that lasted through the anthesis period 1-15 June. When applied 11 May, sodium azide gave 75% control at 11.21 kg, 99% control at 16.8 kg, and complete control at 22.4 kg/ha. Incomplete control resulted from applications on 14 April. Sodium azide provides the first case of control of blind seed disease by a chemical applied with conventional equipment in field plots. Control was achieved by suppression of apothecia.

Additional key words: Bayleton, BAY MEB 6447, perennial ryegrass, chemical control, fungicidal control.

Blind seed disease which is caused by *Gloeotinia temulenta* (Prill. & Del.) Wilson, Noble, and Gray, has been controlled in Oregon seed crops of perennial ryegrass, *Lolium perenne* L., and tall fescue, *Festuca arundinacea* Schreb., since 1948 and 1949, respectively, by burning straw and stubble in fields after the seed harvest (1, 2, 6). This near-perfect control may be lost if Oregon legislation eliminates most field burning after 1978. Control of blind seed depends on treatments that will kill the pathogen in infected seeds (pseudosclerotia) at the soil surface and/or development of control by chemicals. Studies on disease control by heat treatments applied with various mobile field sanitizers are in progress (6). Many chemicals suppressed apothecium formation in small pot tests (3, 4, 5), but did not perform satisfactorily in field tests. Therefore, the search for active chemicals was continued in field plots by testing the most promising chemicals for suppression of ascosporic inoculum of *G. temulenta.*

MATERIALS AND METHODS

Seeds of *L. perenne,* many of which were infected with *G. temulenta,* were placed on the surface of a sandy loam (pH 5.8) soil, 8.5 cm deep, in 10-cm-square plastic pots with four bottom drainage holes (about 500 seeds/pot). The soil and seed were moistened and, after germination of healthy seed, the pots were frozen to kill the seedlings. The pots were held outdoors over winter or indoors at 5 C in a constant-temperature chamber for 30 to 90 days to condition the pseudosclerotia for apothecium production.

Just before chemical treatment, the pots were brought into a greenhouse (20-30 C) to force apothecium development. The soil was moistened and pressed firmly to provide a flat surface area of 92 cm^2 and to prevent the chemical solutions from running down the inner walls of the pot. The chemicals were applied once in either a suspension or solution. Sufficient water was used to allow for soil absorption and to provide a uniform distribution layer of chemical on the soil surface. All dosages are expressed as actual chemical.

The pots were kept in plastic saucers constantly supplied with water to keep the soil surface continuously moist. Mature apothecia with attached seeds were removed from three pots treated with each chemical dosage and counted periodically after chemical application.

Field plots were located in a 5-yr-old planting of *Lolium perenne* 'Linn' with plants in rows spaced 30.48

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cm apart. In addition to naturally occurring pseudosclerotia that fell to the ground, infected seed of *L. perenne* were broadcast at about 112 kg/ha over the plot area during October 1974 and 1975. Straw was raked off and additional plant material removed from the plot area with a flail chopper.

Triadimefon (= Bayleton or BAY MEB 6447) and nuarimol (EL-228) both were applied in sprays and in granular formulations. Sodium azide was applied only in a 15% granular formulation (Smite, PPG Industries, Pittsburgh, PA 15222). All chemicals were applied only once to individual plots randomized in four replications.

The sprays were discharged at 2.81 kg/cm^2 through a three-nozzle boom, with the end nozzles directed to cover the 0.76-m swath. Fungicides were measured to quantities required for either 3.78 or 7.56 liters (1 or 2 gal) of spray formulation based on a base volume of 189 liters of spray/0.405 ha (50 gal/acre). Variations in dosages in subplots were obtained by changes in ground speed, which changed the spray volumes to give desired dosages of either 1, 1.5, and 2× or 1, 2, and 3× the base rate and a maximum volume of 567 liters of spray/ha. Granular formulations were applied with a 0.609-m-wide spreader with openings set and ground speed predetermined for delivery of desired dosages. In contrast during 1975, a few chemicals were applied in large quantities of water as a drench to field plots.

The plot area was irrigated as needed to favor apothecium production just before and during anthesis of the Linn perennial ryegrass 1-15 June. Control of apothecium formation was monitored throughout the anthesis period by counting and removing apothecia with attached seeds in 0.185-m^2 areas in the center of each plot for a total area of 0.67 m^2. The plots were irrigated again at the end of June to maintain favorable conditions for apothecium production in order that apothecium prevention coincident with anthesis of late-maturing grasses could be reliably monitored.

TABLE 1. Suppression of apothecium formation in *Gloeotinia temulenta* by chemicals applied over infected seeds of *Lolium perenne* at the soil surface in field plots

Chemical	Rate at soil surface (mg/92 cm^2)	Apothecia and attached seeds removed per three pots following application of the chemical after: 5 wk (no.)	6 wk (no.)	7 wk (no.)	8 wk (no.)
Triadimefon	0.1	0/0	0/0	0/0	9/6
	0.2	0/0	0/0	0/0	0/0
Fenarimol	0.2	2/2	6/4	9/6	11/10
	0.4	0/0	0/0	0/0	0/0
Sodium azide	4.0	11/8	46/43	57/47	26/21
	8.0	1/1	5/4	14/11	2/2
	12.0	0/0	0/0	5/5	2/2
	16.0	0/0	0/0	0/0	1/1
None		68/47	108/84	76/61	35/28

RESULTS

Pot tests in the greenhouse.—In many tests, triadimefon has prevented apothecium formation of *G. temulenta* for up to 8 wk at dosages of 0.1 to 0.2 mg/92 cm^2 soil surface when applied over cold-conditioned, infected seeds of *L. perenne* (5) (Table 1).

Nuarimol and fenarimol (EL-222) at 0.4 mg/92 cm^2 were highly active in suppressing formation of apothecia of *G. temulenta*. These chemicals provided control comparable to the strong activity reported for the related pyrimidine, triarimol (5). Results of one test with fenarimol are shown in Table 1.

Sodium azide prevented apothecium formation at 12-16 mg/92 cm^2 but was unsatisfactory at 2 and 4 mg/92 cm^2. Treatment with 8 mg gave a high degree of control. Sodium azide at 12 mg exerted complete control at 6 wk after treatment, but a few apothecia appeared at 7 and 8 wk (Table 1).

Tests in field plots, 1975.—Chemicals were applied as a heavy drench in water at the huge volume of 1 liter/0.37 m^2 during May 1975. Triadimefon gave unsatisfactory control of apothecia at 0.224 kg/ha, about 79% control at 0.448 kg/ha, and complete control at 1.121, 1.56, and 2.24 kg/ha. Fenarimol was unsatisfactory at 0.224 kg/ha, but gave 72% control at 0.448 kg, 98% control at 1.121 kg, and complete control at 1.56 and 2.24 kg/ha. In the same tests benomyl [methyl 1-(butylcarbamoyl)-2-benzimidazole-carbamate] produced about 40% control at 1.12 kg/ha, 97% at 2.24, 99% control at 3.36 kg, and complete control at 4.48 kg. Cadmium chloride exerted complete control at 1.12, 2.24, 3.36, and 4.48 kg/ha.

Tests in field plots, 1976.—After one application to field plots on 14 April, 29 April, or 11 May, triadimefon in a 5% granular formulation at 0.616, 1.23, 1.57, and 2.02 kg (a.i.)/ha reduced the number of apothecia formed, but control was unsatisfactory. Triadimefon applied in a spray at 0.5 kg also reduced the number of apothecia, but did not result in satisfactory control. Applied 14 April or 29 April in a spray, triadimefon at 1.68 or 2.24 kg/ha provided nearly complete control. The same dosages applied 11 May were much less effective and unsatisfactory for field control.

Nuarimol applied 14 April in a 0.2% granular formulation at 0.55, 1.17, 1.57, and 2.13 kg (a.i.)/ha provided no apparent control. Nuarimol applied 11 May gave more than 80% control at 0.55 and 1.17 kg and more than 90% control at 1.57 and 2.14 kg. Nuarimol applied 14 April in a spray at 1.12 and 1.68 kg/ha gave about 80% control and more than 90% control at 2.24 kg. Nuarimol applied 29 April as a spray was unsatisfactory for field control. The chemical applied 11 May in a spray provided no apparent control at 1.12 and 1.68 kg and only about 89% control at 2.24 kg/ha.

Sodium azide applied 14 April provided about 73% control at 11.2 kg, 85% at 16.8 kg, and 89% control at 22.4 kg/ha (Table 2) that persisted through 15 June. Complete control was obtained with 11.2, 16.8, and 22.4 kg/ha applied 29 April. Sodium azide applied 11 May gave about 75% control at 11.21 kg, 99% control at 16.8 kg, and complete control at 22.4 kg. This control persisted through the anthesis period 1-15 June. However, the fungus was not killed in all seeds, as shown by the presence of a few apothecia in treated plots on 1 July (Table 2).

Tests in pots using 1976 field-plot dosages.—The effectiveness of chemicals was studied in the absence of a leaf canopy. The chemicals were applied over cold-conditioned pseudosclerotia on 92 cm^2 of bare soil surface in plastic pots at some of the same dosages that were studied in field plots. Wherever possible, the chemicals were applied to separate pots on different dates to compare with field applications. The treated pots were either left outdoors after treatment until 13 May, or immediately brought into the greenhouse for continued apothecium development.

Triadimefon prevented apothecium formation when applied as a 5% granular formulation at 0.62, 1.23, 1.57, and 2.01 kg (a.i.)/ha in the treated pots left outdoors until 13 May. It also prevented apothecium formation in the pots at 0.616, 1.23, and 1.57 kg/ha when the chemical was applied 14 April, and the pots were brought immediately into the greenhouse (Table 3). Triadimefon, in an aqueous spray by several methods, gave complete control at 0.56, 1.12, 1.68, and 2.24 kg/ha when applied 21 April and pots left outdoors until 13 May; applied on 14 April (1.12 kg/ha only) and pots brought into the greenhouse the same day; and applied on 29 April and treated pots left outside, put into saucers with water 6 May, and moved indoors on 13 May.

Similarly, nuarimol prevented apothecium formation when applied 14 April as a 0.2% granular formulation at 0.548, 1.177, and 1.57 (a.i.)/ha when treated pots were left outdoors and moved into the greenhouse on 13 May. Complete control was also obtained by 1.569 kg/ha applied on 14 April and moved into the greenhouse on the same day. Nuarimol also gave complete control in sprays applied in several ways at 1.12, 1.68, and 2.24 kg/ha (Table 3).

Sodium azide in a 15% granular formulation at 16.8 and 22.42 kg (a.i.)/ha gave only partial control of apothecia when it was applied on 14 April and the treated pots were left outdoors until 13 May. Results were comparable to those from the field plots (Tables 2 and 3). Sodium azide gave nearly complete control at 16.8 kg and complete control at 22.4 kg/ha when applied 14 April to pots that were moved immediately to saucers with water in the greenhouse on the day of treatment. Possibly the activation of the chemical was better in the pot tests than in the field tests.

DISCUSSION

Chemical control of blind seed by suppression of apothecium formation has awaited the discovery of chemicals that would function following application with conventional equipment or the development of new equipment that would improve application of chemicals already known to be active. Many chemicals will prevent apothecium formation in small tests in pots in the greenhouse (some at very low rates), such as triarimol, fenarimol, nuarimol, benomyl, and triadimefon. Some of the chemicals have suppressed nearly all apothecia in field plots after application as suspensions with abundant water. The water apparently provided adequate distribution and contact of the chemicals with infected seeds at or near the soil surface. Two of the most active chemicals known, triadimefon and nuarimol, applied in sprays or in granular formulations, suppressed only some of the apothecia in field plots. This incomplete suppression from dosages much higher than effective in pot tests suggests that active but water-insoluble

TABLE 2. Suppression of *Gloeotinia temulenta* apothecia by application of sodium azide in field plots of *Lolium perenne* 'Linn'

Date applied	Rate (kg/ha)	Apothecia/infected seeds in 0.67 m^2 27 May to 1 June (no.)	Apothecia present in 0.67 m^2 30 June to 1 July (no.)
14 April	0	2,108/1,492	
	11.21	557/351	
	16.8	304/190	
	22.4	229/135	
29 April	0	2,064/1,440	26
	11.21	0/0	102
	16.8	0/0	14
	22.4	0/0	24
11 May	0	2,032/1,720	86
	11.21	508/380	51
	16.8	12/12	84
	22.4	0/0	79

TABLE 3. Suppression of *Gloeotinia temulenta* apothecia by chemicals applied to soil in pots during 1976

Formulation and kind of chemical	Rate (kg/ha)	No. apothecia/attached seeds in three pots 8 June — Treatment dates: 14 April[a]	21 April[a]	14 April[b]	29 April[c]
None (ck)	0	321/214	321/214	233/154	269/152
Granular formulations:					
Sodium azide	16.8	185/101		4/2	
	22.4	123/68		0/0	
Triadimefon	0.62	0/0		0/0	
	1.23	0/0		0/0	
	1.57	0/0		0/0	
Nuarimol	0.55	0/0			
	1.17	0/0			
	1.57	0/0		0/0	
Sprays:					
Triadimefon	0.56		0/0		0/0
	1.12		0/0	0/0	0/0
Nuarimol	1.12		0/0	0/0	0/0
	1.68		0/0		0/0

[a]Pots left outdoors, and moved to greenhouse 13 May.
[b]Pots moved to greenhouse day of treatment, 14 April.
[c]Pots left outside in saucers 6 May, moved inside 13 May.

fungicides applied in sprays or granular formulations in the field plots will not be distributed well enough by conventional application equipment to contact infected seeds at the soil surface.

Sodium azide is the only chemical that has provided a level of control in field plots comparable to that obtained in small pot tests. The success of sodium azide may be due to better contact with infected seeds as a result of its solubility in water that aids its distribution over most of the soil surface area and/or by its production of hydrazoic acid vapor that permeates the space under the leaf canopy. However, for reliable control with sodium azide, time of application should be studied in relation to soil surface moisture, temperature of soil and air, and the stage of pathogen development.

Control of blind seed disease should be coordinated with control of ergot (*Claviceps purpurea*) a disease that affects all grasses that are susceptible to blind seed. Most chemicals that are active against *C. purpurea* will suppress *G. temulenta* apothecia at much lower dosages. Sodium azide is an exception because it will control ascocarps of *C. purpurea* at about half the dosage required to suppress apothecia of *G. temulenta* (7, 8). If sodium azide is registered for control of these pathogens of grass seed crops, cost may be the most important factor in deciding the dosage level to be used.

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