HEAD SMUT OF PRAIRIE GRASS CONTROLLED BY TREATING SEED WITH ERGOSTEROL BIOSYNTHESIS INHIBITOR FUNGICIDES

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SUMMARY

Ergosterol biosynthesis inhibitor (EBI) fungicides were tested as seed treatments in glasshouse experiments for control of seedling infection of prairie grass (*Bromus willdenowii*) by the head smut fungus (*Ustilago bullata*). Fungicides were applied to seed heavily contaminated with *U. bullata* ustilospores. Some deleterious effects of fungicides on seedling emergence and growth were detected, but propiconazole (at 0.15 g/kg seed), triadimenol + fuberidazole (0.25 + 0.04 g/kg), triadimenol + imazalil (0.25 + 0.08 g/kg) and nuarimol (0.35 g/kg) gave excellent control of seedling infection, with little effect on seedling growth. Use of EBI fungicides for seed treatment of prairie grass is strongly recommended.

INTRODUCTION

Head smut (caused by *Ustilago bullata* Berk.) of prairie grass (*Bromus willdenowii* Kunth) can drastically reduce seed production from heavily infected stands (Luttrell and Craigmiles 1961; unpublished data). The disease is also potentially harmful to forage production, by reducing seedling establishment, plant tillering and survival (Falloon 1976; 1979a). Current seed quality regulations (Anon. 1985/86) specify that prairie grass seed crops will be rejected from certification if found, on field inspection, to contain head smut. For these reasons, control of this disease must be effective.

Seedling infection of prairie grass by *U. bullata* occurs from ustilospore contamination of seeds, and can be controlled with fungicide seed treatments such as thiram, carboxin or benomyl (Falloon 1980). However, there have been reports that control of head smut has been incomplete using these chemicals. Ergosterol biosynthesis inhibitor (EBI) systemic fungicides are a recently available alternative to established fungicides. This paper reports two glasshouse experiments which tested EBI fungicides from triazole, imidazole and pyrimidine classes (Siegel 1981) as prairie grass seed treatments for control of head smut.

TABLE 1: Fungicides tested as seed treatments for control of *U. bullata* seedling infection of prairie grass.

Common name	EBI class	Product name and formulation*
carboxin	—	Vitavax 75% WP
diclobutrazol	triazole	Vigil† 12.5% SC
nuarimol	pyrimidine	Trimidal 9.5% EC
prochloraz	imidazole	Sportak 45% EC
propiconazole	triazole	Tilt 25% EC
triadimefon	triazole	Bayleton 25% EC
triadimenol + fuberidazole	triazole	Baytan F17 15 + 2% WP
triadimenol + imazalil	triazole + imidazole	Baytan IM 15 + 5% WP

* WP = wettable powder, SC = suspension concentrate, EC = emulsifiable concentrate
† product withdrawn

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EXPERIMENTAL

Seed of *B. willdenowii* cv. Grasslands Matua was used in these experiments. Seed was either uninoculated or inoculated with *U. bullata* ustilospores of high germinability (94% on potato dextrose agar, 20 h, 25 °C), applied to seed at 9 g/kg. The fungicides used are listed in Table 1. Fungicides were applied with 0.5 ml water to 20 g lots of seed in 250 ml glass flasks.

Test of different fungicides

Seed treatments listed in Table 2 were applied to seed of 92% germination (N.Z. Official Seed Testing Station). Seeds were sown (September 1982) into seedling trays containing sand/peat potting mix, in rows (18 seeds/row), in a randomised block experiment (19 treatments in 12 replicates, each replicate consisting of two trays). Trays were placed in a glasshouse and 14 days later, seedlings in each row were counted, and heights of 25 seedlings from each treatment were measured. Ten days later, 20 seedlings from each treatment were planted into rows 4 m long in a field plot, in a randomised block arrangement of 19 treatments (rows) in five replicates. Five months after sowing, plants were assessed for *U. bullata* infection by inspecting all inflorescences on each plant.

Diclobutrazol (at 0.15 g/kg) and triadimefon (0.25 g/kg and greater) adversely affected seedling emergence (Table 2). Several of the seed treatments gave seedlings that were smaller than untreated seed ($P < 0.05$). Greatest stunting of seedlings occurred with diclobutrazol and carboxin (2 g/kg) treated seed (Table 2).

TABLE 2: Effects of seed treatments on emergence (from 18 seeds sown per treatment, 12 replicates) and height (25 per treatment) of 14 day old prairie grass seedlings.

Seed treatment Fungicide	Rate (g/kg seed)	*U. bullata* inoculation	Mean number emerged seedlings[a]	Mean seedling height (mm)
nil	–	–	15.5	111†
nil	–	+	15.3	94*
carboxin	0.15	+	16.4	81†
	2.00	+	16.3	70†
diclobutrazol	0.15	+	13.8*	31*†
nuarimol	0.05	+	16.5	104
	0.15	+	15.6	110†
	0.25	+	15.6	90*
	0.35	+	15.3	100
prochloraz	0.05	+	16.3	117†
	0.15	+	16.4	109†
	0.25	+	16.0	110†
	0.35	+	15.3	108†
propiconazole	0.15	+	16.0	94*
triadimefon	0.05	+	15.8	89*
	0.15	+	14.8	88*
	0.25	+	14.1*	93*
	0.35	+	13.5*	91*
triadimenol +	0.15 +	+	15.3	81*†
fuberidazole	0.02	+		

*Means different from nil treatment ($P < 0.05$)
†Means different from *U. bullata* inoculated treatment ($P < 0.05$)
[a]Statistical analysis on arcsine square root transformed data.

No smutted plants developed from uninoculated seed, but all plants from untreated, inoculated seed produced smutted inflorescences. All of the fungicides tested as seed treatments reduced infection in the resulting plants (Fig. 1), although only propiconazole (0.15 g/kg) completely prevented infection. Similar control of seedling

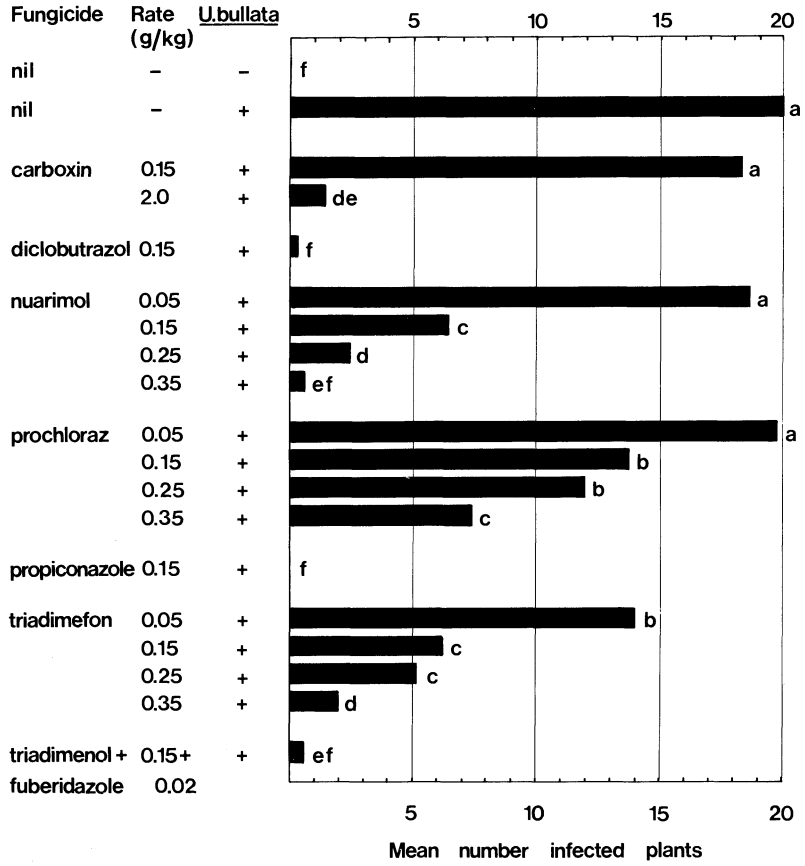

Fig. 1: Mean numbers of *U. bullata* infected prairie grass plants (5 replicates, 20 plants each) grown from either uninoculated seed, or *U. bullata* inoculated seed treated with different fungicides. Plants were assessed for infection 5 months after sowing. Means accompanied by the same letter are not significantly different ($P < 0.01$, arcsine square root transformed data).

infection was obtained with diclobutrazol (0.15 g/kg), nuarimol (0.35 g/kg) and triadimenol + fuberidazole (0.15 + 0.02 g/kg) ($P < 0.01$). Carboxin at 0.15 g/kg had little effect on seedling infection, but at 2 g/kg reduced infection to a level equivalent to that for the more effective EBI treatments.

The phytotoxic effects of fungicides at the seedling stage were not apparent at the time of assessment for *U. bullata* infection for all treatments except diclobutrazol. Plants grown from diclobutrazol treated seed were about 1/3 the size of untreated plants, with prostrate stems and dark green leaves.

Test of triadimenol-based fungicide mixtures

The fungicide mixtures triadimenol + fuberidazole and triadimenol + imazalil were each applied to seed (germination 98%, N.Z. Official Seed Testing Station) at 5 rates (Table 3). Seeds were then sown (September 1985) into seedling trays containing potting mix, in rows (18 seeds per row) in a randomised block experiment (22 treatments in 10 replicates, each replicate consisting of two trays). Trays were placed in a glasshouse, and 14 days later, all seedlings were counted and heights measured. All seedlings from uninoculated untreated seeds, and all *U. bullata* inoculated treatments,

TABLE 3: Effects of triadimenol + fuberidazole or triadimenol + imazalil seed treatments on emergence and height of 14 day old prairie grass seedlings grown from either uninoculated or *U. bullata* inoculated seeds (18 seeds per treatment, 10 replicates).

Fungicide and rate (g/kg seed)	Uninoculated seed: Mean number emerged seedlings[a]	Uninoculated seed: Mean seedling height (mm)	Inoculated seed: Mean number emerged seedlings[a]	Inoculated seed: Mean seedling height (mm)
nil	10.2	108	7.7	85
triadimenol + fuberidazole				
0.05 + 0.01	11.9	119*	8.0	107*
0.15 + 0.02	10.3	112	10.2*	107*
0.25 + 0.03	11.5	108	9.7*	106*
0.50 + 0.07	11.9	108	8.6	100*
1.00 + 0.13	6.6*	89*	8.4	96*
triadimenol + imazalil				
0.05 + 0.02	11.8	121*	10.4*	110*
0.15 + 0.05	11.1	111	10.2*	113*
0.25 + 0.08	7.9*	98*	8.7	98*
0.50 + 0.17	7.8*	98*	5.9	85
1.00 + 0.33	7.0*	54*	5.7*	75

*Means in each column different from nil treatment ($P < 0.05$)
[a]Statistical analysis on arcsine square root transformed data

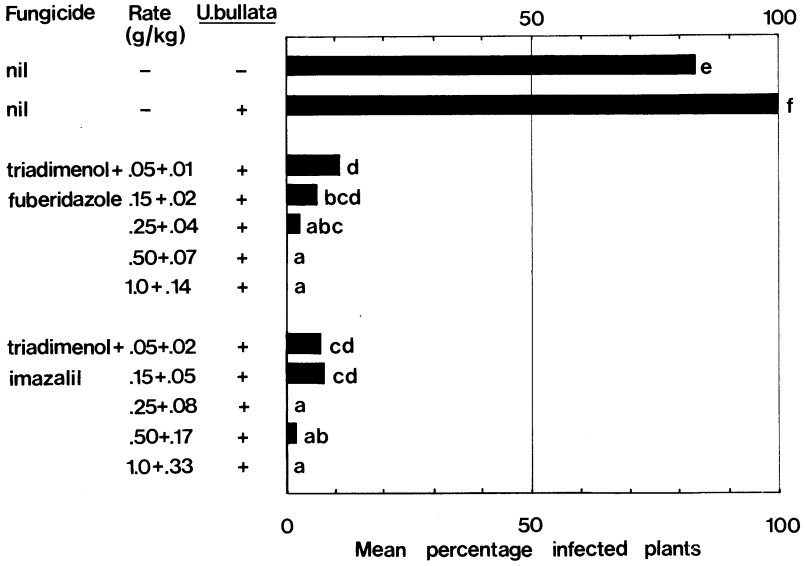

Fig. 2: Mean percentage of *U. bullata* infected prairie grass plants grown from either uninoculated seed, or *U. bullata* inoculated seed treated with different rates of triadimenol + fuberidazole or triadimenol + imazalil. Plants were assessed for infection 4 months after sowing. Means accompanied by the same letter are not significantly different ($P < 0.01$, arcsine square root transformed data).

were then planted singly into pots in glasshouses, and when all plants had produced inflorescences (4 months after sowing) they were assessed for *U. bullata* infection.

Seedling emergence in this experiment was low (52% of viable seeds sown). As the seed line used was only 9 months old, low emergence may have been due to seed dormancy (Jensen and Pierpoint 1961). Similar results have been recorded in other experiments with prairie grass (unpublished data).

The fungicide mixtures increased height of seedlings when applied at low rates to uninoculated seed (Table 3). At high rates (triadimenol + fuberidazole 1.00 + 0.14 g/kg; triadimenol + imazalil 0.25 + 0.08 g/kg and greater), both mixtures reduced seedling emergence and height of seedlings. Inoculation of seed with *U. bullata* ustilospores reduced both seedling emergence and height ($P < 0.05$). These effects were overcome by both fungicide mixtures.

Uninoculated and *U. bullata* inoculated seed both produced a high proportion of *U. bullata* infected plants (Fig. 2) indicating that the seed line used was naturally contaminated with ustilospores. The fungicide mixtures reduced infection to low levels, even when applied at the lowest rates tested. Infection was almost completely prevented by seed treatments with both mixtures at 0.25 g triadimenol per kg seed or greater.

DISCUSSION

These experiments have demonstrated that head smut of prairie grass can be controlled with EBI fungicides. Several of these chemicals, including two triadimenol-based products used widely for cereal seed treatment, controiled *U. bullata* seedling infection when applied to seed inoculated with ustilospores at a rate far greater than that likely to occur in natural infestations. These fungicides are active at rates about 1/10 to 1/20 of those of other chemicals (carboxin or benomyl). Use of suitable EBI seed treatments is therefore strongly recommended for prevention of *U. bullata* seedling infection of prairie grass.

It is well recognised that EBI fungicides can retard plant growth, although these chemicals can also enhance growth of plants under moisture, temperature or ozone stress (Fletcher 1985). Our results indicate that some EBI fungicides are more harmful to prairie grass seedlings than others, and care should be taken when applying this group of chemicals to seed. Nevertheless, good control of *U. bullata* seedling infection can be achieved with some of these chemicals (nuarimol, propiconazole or mixtures based on triadimenol) at rates not injurious to seedlings.

U. bullata can infect vegetative tillers of healthy field-grown prairie grass plants (Falloon 1979b). Effective seed treatments will give healthy stands, but infection from outside inoculum sources is still possible. Shoot infection therefore poses considerable problems for prairie grass seed producers who must maintain smut-free crops. Systemic EBI fungicides have shown promise for control of shoot infection in glasshouse trials (unpublished data). This group of chemicals may therefore adequately control head smut of prairie grass, a goal as yet not fully attained.

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