Evaluation of Bitertanol and Thiabendazole Seed Treatment and PCNB Soil Treatment for Control of Dwarf Bunt of Wheat

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ABSTRACT

Hoffmann, J. A., and Sisson, D. V. 1987. Evaluation of bitertanol and thiabendazole seed treatment and PCNB soil treatment for control of dwarf bunt of wheat. Plant Disease 71: 839-841.

Bitertanol and thiabendazole seed treatment (1.5 g a.i./kg) and PCNB soil treatment (2.67 kg a.i./ha) were compared for control of dwarf bunt in Nugaines and Wanser winter wheat seeded on four dates. PCNB applied to the soil surface in late fall was the most effective treatment and reduced dwarf bunt incidence 88–96% in both cultivars seeded on all four dates. Seed treatment with bitertanol was about twice as effectve as thiabendazole and reduced dwarf bunt to less than 5% in both cultivars seeded on 27 September and 11 October. Thiabendazole seed treatment provided control only in wheat seeded on 11 October. Both seed treatments reduced wheat yields. Dwarf bunt reduced yields by about 0.83% for each percentage of disease incidence.

Dwarf bunt caused by *Tilletia controversa* Kühn has been a persistent disease problem of winter wheat (*Triticum aestivum* L.) in localized areas of the western United States. Recently, the disease also has reappeared in Michigan (D. W. Fulbright, *personal communication*). Distribution records and observations in the United States and other countries (6,14,16) indicate that the disease is restricted to areas where wheat is grown under a persistent snow cover. Presumably, snow cover provides suitable conditions of moisture and temperature at the soil surface for teliospore germination and subsequent infection of the wheat plant (6,13).

Wheat cultivars resistant to dwarf bunt are currently available in the western United States; however, because the disease does not occur regularly, susceptible cultivars are sometimes grown in areas of known dwarf bunt infestation. Consequently, dwarf bunt continues to occur in amounts sufficient to contaminate wheat assembled for export at Pacific Northwest (PNW) ports (3,11). This contamination has in effect excluded PNW wheat from sale to the People's Republic of China (PRC) because of their quarantine against the dwarf bunt fungus (17).

Because dwarf bunt infection occurs during a protracted period after seedling emergence (13), the traditional seed-treatment fungicides that control common bunt fungi (*T. caries* (DC) Tul. and *T. foetida* (Wallr.) Liro) do not control dwarf bunt. Some of these materials (e.g., polychlorobenzenes) are effective against dwarf bunt, however, when applied to the soil surface before the infection period (12). The development of fungicides with systemic activity offered renewed hope for control of dwarf bunt by seed treatment. Numerous systemic materials have been tested as seed treatments (4,5,7), but only thiabendazole has consistently reduced dwarf bunt incidence sufficiently to be recommended as a control measure in the United States. Unfortunately, reliable control with thiabendazole is achieved only when wheat is seeded late (October) or when fall growth is retarded by cool temperatures (4,6,7). Moreover, because dwarf-bunt-resistant cultivars are available, growers are reluctant to bear the added cost of thiabendazole seed treatment.

Recently, Trägner-Born and Kaspers (16) reported control of dwarf bunt in Germany by seed treatment with bitertanol (Sibutol). The objective of our study was to compare the efficacy of bitertanol and thiabendazole as seed treatments with that of PCNB applied to the soil surface at several seeding dates.

MATERIALS AND METHODS

The fungicide formulations used were thiabendazole, 30% (Mertect LSP); bitertanol, 50% (BAY KWG-0599); and PCNB, 24% (Terraclor 2EC). Thiabendazole and bitertanol were applied to 500-g units of seed of the dwarf-bunt-susceptible winter wheat cultivars Nugaines and Wanser at the rate of 1.5 g a.i./kg on 27 August 1984. The procedure used was the same as described previously (9), except a 2-L Erlenmeyer flask was used to accommodate the larger quantity of seed. PCNB was applied to the soil surface with a bicycle-wheel sprayer with a four-nozzle boom at the rate of 2.67 kg a.i./ha (1.5 g a.i. in 0.6 L of water per plot) after inoculation on 20 November 1984.

The experiment was conducted near Logan, UT, at a site known to be conducive to high dwarf bunt incidence. Plots of each cultivar and fungicide treatment were seeded at biweekly intervals on 30 August, 13 September, 27 September, and 11 October 1984. Each plot consisted of four 3-m rows spaced 46 cm apart. Seeds were planted shallow (1–2 cm) in open furrows at a rate of 7 g/3-m row with a four-row belt seeder.

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Contribution of the USDA, ARS, in cooperation with the Utah Agricultural Experiment Station. Journal Series Paper No. 3290 of the Utah Agricultural Experiment Station.

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Accepted for publication 20 February 1987.

Table 1. Effects of thiabendazole and bitertanol seed treatment and PCNB soil treatment on dwarf bunt incidence and yield of Nugaines and Wanser wheat seeded on four dates at Logan, UT

	Seeding date											
	30 August			13 September			27 September			11 October		
Cultivar and treatment[a]	Spikes[b] (no.)	Dwarf bunt[b] (%)	Yield[c] (g)	Spikes (no.)	Dwarf bunt (%)	Yield (g)	Spikes (no.)	Dwarf bunt (%)	Yield (g)	Spikes (no.)	Dwarf bunt (%)	Yield (g)
Nugaines												
Untreated check	113[d]	84	134	106	88	91	84	80	82	58	28	121
Thiabendazole	77	69	172	81	59	136	61	30	125	54	0	136
Bitertanol	94	31	290	70	17	280	67	4	209	63	0	154
PCNB	77	3	379	62	3	366	58	3	211	68	1	193
Wanser												
Untreated check	110	85	127	119	99	69	100	97	42	60	52	94
Thiabendazole	120	74	210	126	84	154	65	28	146	42	2	118
Bitertanol	93	42	319	79	28	204	47	4	171	59	0	136
PCNB	68	7	387	80	12	304	62	5	189	59	2	170

[a] Thiabendazole and bitertanol were applied to seed at the rate of 1.5 g a.i./kg; PCNB was applied to the soil surface after seedling emergence at the rate of 2.67 kg a.i./ha.
[b] Number of spikes and percent dwarf bunt were determined from the middle 1 m of the first row of each four-row plot.
[c] Yield represents the weight of clean grain harvested from the two center rows of each four-row plot.
[d] Each value is the mean of four replicates. LSD ($P = 0.05$) for differences among chemical treatments of the same cultivar and date combination = 29 for number of spikes, 12 for percent bunt and 58 for yield.

Table 2. Combined analysis of variance for number of spikes, percent dwarf bunt, and yield of Nugaines and Wanser wheat treated with three fungicides and seeded on four dates at Logan, UT

		Mean squares		
Sources of variation	df	Spikes (no.)	Dwarf bunt (%)	Grain yield
Seeding date (D)	3	9,700.89**[a]	10,715.72**	87,661.09**
Plots/date	12	358.67	104.85	2,979.27
Cultivar (C)	1	1,116.28	1,464.76**	7,185.01*
Treatment (T)	3	4,482.05**	31,429.51**	199,233.05**
D × C	3	1,079.26	155.95	3,925.88
D × T	9	1,201.74**	2,154.82**	14,258.92**
C × T	3	861.68	81.53	3,122.42
D × C × T	9	448.80	125.52	973.72
Error	84	438.30	76.37	1,683.20

[a] * = Significant at $P = 0.05$ and ** = significant at $P = 0.01$.

The cultivars and fungicide treatments were randomized in a complete block design with four replicates within each planting date.

Supplemental inoculum was applied to the naturally infested soil by spraying a water suspension of *T. controversa* teliospores (1 g/3-m row) in the seeded furrows of all plots on 20 November 1984. The teliospores used as inoculum were collected from dwarf-bunted spikes of different wheat cultivars grown at an adjacent site the previous summer.

Dwarf bunt incidence was determined by recording the number of healthy and bunted spikes in the middle 1 m of the first row of each plot in August 1985. Yield data were obtained by hand-harvesting and machine-threshing all spikes from the center two rows of each plot. Bunt sori were removed from the seed before weighing by threshing the seed from each plot a second time with a belt thresher. The nursery was not fertilized and was kept free of weeds by hand. The nursery was dusted with furnace ash in March 1985 to hasten snow melt and reduce damage from snow mold.

RESULTS AND DISCUSSION

Soil moisture and temperature during the fall were conducive to prompt seed germination and seedling emergence. Growth stages of plants seeded on 30 August, 13 September, 27 September, and 11 October, recorded on 20 November when fall growth had essentially ceased, were four leaves with three to six tillers, three leaves with one to three tillers, three leaves with zero or one tiller, and one leaf with no tillers (just emerging), respectively. Snow covered the nursery from 24 November 1984 to 30 March 1985. The temperature at the soil surface under the snow during this period ranged from 0 to −2 C. Throughout most of the winter the soil surface temperature was 0 C and the soil was unfrozen. The growth stages of plants after snow melt (April) were essentially the same as in late November, indicating that little or no growth had occurred during winter. Snow mold, caused by *Fusarium nivali* (Fr.) Ces. and, to a lesser extent, by *Typhula idahoensis* Remsberg, killed leaves and reduced stands up to 20% in plots seeded on 30 August and 13 September but was not apparent in the two later plantings.

Dwarf bunt incidence (Table 1) was uniformly high (≥80%) in the untreated control plots of both cultivars seeded on or before 27 September but was significantly ($P < 0.01$, Table 2) lower (≥52%) in those seeded on 11 October. A reduction in dwarf bunt incidence in late-seeded (as well as very early-seeded) wheat was demonstrated also in a previous study (8).

With the exception of the thiabendazole treatment of Wanser seeded on August 30, all three fungicide treatments significantly ($P = 0.05$) reduced dwarf bunt incidence in all planting dates of both cultivars (Table 1). PCNB applied to the soil surface after seedling emergence was the most effective treatment, reducing disease incidence to ≤3% in Nugaines and to ≤12% in Wanser. More important, the effectiveness of the PCNB soil treatment was independent of seeding date. The effectiveness of this material and certain other contact and systemic fungicides against dwarf bunt, when applied to the soil surface before infection, has been demonstrated in previous studies (2,5,12). Probably because of economic and environmental considerations, however, this practice has not been adopted commercially for dwarf bunt control in the United States.

Of the two seed treatments tested, bitertanol was about twice as effective as thiabendazole and provided satisfactory control (e.g., <5% incidence) in wheat planted on 27 September and 11 October. In contrast, thiabendazole seed treatment provided satisfactory control only in the latest seeding (11 October). Neither seed treatment provided adequate control in wheat seeded on 30 August or 13 September (Table 1). The reduced effectiveness of thiabendazole seed treatment with early seeding has been reported previously (4,7) and is presumed to result from dilution of the fungicide with greater plant growth before the infection period.

A comparison of the number of spikes in plots having high dwarf bunt incidence

Table 3. Adjusted yield, regression coefficient, and percent yield reduction for each percent increase in dwarf bunt incidence in wheat seeded on four dates at Logan, UT

Seeding date	Adjusted[a] yield	Regression[b] coefficient	Percent yield loss for each percent dwarf bunt
30 August	393	−3.22	0.81
13 September	358	−3.01	0.84
27 September	206	−1.63	0.79
11 October	173	−1.50	0.87
Mean	282	−2.34	0.83

[a] Expected yield (g/plot) with 0% dwarf bunt.
[b] Regression coefficient of yield on percent dwarf bunt.

(e.g., untreated control plots) with those having low incidence (e.g., PCNB-treated plots) confirmed previous observations (8,14) that dwarf bunt infection increases tillering of wheat. For example, in the 30 August seeding of untreated Nugaines (Table 1), dwarf bunt incidence was 84% and the number of spikes (healthy and bunted) was 113; in the corresponding PCNB-treated plot, bunt incidence was 3% and the number of spikes was 77. A similar significant ($P = 0.05$) positive correlation ($r = 0.94$) between dwarf bunt incidence and number of spikes was shown in the three earliest seeding dates of both cultivars (Table 1).

The data (Table 1) from the 11 October seeding show that, in the absence of bunt infection, seed treatment with either bitertanol or thiabendazole, significantly ($P = 0.05$) reduced grain yields compared with PCNB soil treatment and that thiabendazole was significantly ($P = 0.05$) more detrimental to yield than was bitertanol. Adverse effects on seedling emergence, stands, and/or yield of winter wheat has been noted with thiabendazole and certain other systemic materials used as seed treatments in previous studies (1,10). The data (Table 1) show also that yields were decreased by late seeding. It is generally accepted that late planting of winter wheat almost always results in lower yields.

To determine the effect of dwarf bunt incidence on yield, the regression coefficient of yield on percent dwarf bunt was calculated for each planting date using the data from the untreated controls (high bunt incidence) and the PCNB soil treatments of both cultivars. The data from the seed treatments were not used in the regression calculations because (as indicated above) both had an effect on yield independent of bunt incidence (Table 3). The regression coefficient (slope) divided by the expected yield when percent bunt is zero (intercept) provided an estimate of yield loss for each percent increase in dwarf bunt incidence. The average yield loss for each percent of dwarf bunt incidence was 0.83%. This agrees closely with the yield reduction percentage, 0.77%, reported by Slinkard and Elliot (15) for common bunt.

The results of this study indicate that, at comparable rates of active ingredient, bitertanol is more effective as a seed treatment for control of dwarf bunt and has less detrimental effects on wheat yield than the previously recommended material, thiabendazole. It should be noted, however, that whereas thiabendazole is registered for use as a seed treatment on wheat, bitertanol is not.

Even with the most judicious use of effective chemical treatments and resistant wheat cultivars, low levels of dwarf bunt will occur where inoculum potential is high and when weather is conducive to disease development. Mathre and Johnston (11), using a procedure similar to that used by the PRC, detected dwarf bunt contamination in grain at infection levels of two bunted spikes per hectare. Therefore, it is unlikely that northwestern U.S. grain producers and exporters can meet a zero tolerance for *T. controversa.*

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