Effect of Triadimenol Seed Treatment and Triadimefon Foliar Treatment on Powdery Mildew Epidemics and Grain Yield of Winter Wheat Cultivars

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ABSTRACT

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The effect of triadimenol seed treatment and triadimefon foliar treatment on powdery mildew epidemics and grain yield was studied over a 3-year period on winter wheat cultivars with different susceptibilities. Area under the disease progress curve (AUDPC) was calculated from disease assessments taken from first node visible growth stage (Feekes growth stage 6) to completion of flowering or kernels watery ripe (growth stage 10.5.4 or 11.1). Analysis of variance of AUDPC indicated that the main effects of seed treatment, foliar treatment, and cultivar were significant all 3 years of the study. However, the main effects of seed treatment, foliar treatment, and cultivar on yield were significant in only 2, 1, and 3 years, respectively. The only significant interaction was cultivar by triadimefon foliar treatment. This indicated a differential response of cultivar to foliar treatment for yield in all 3 years. Foliar treatment reduced AUDPC for all cultivars, although the greater reductions were for the more susceptible cultivars. Triadimenol seed treatment resulted in lower AUDPC compared with carboxin-thiram treatment. The most susceptible cultivars were Becker and Hart; the least susceptible were Tyler and Scotty, with Adena, Cardinal, and Caldwell being intermediate. A single triadimefon foliar treatment applied at ligule of flag leaf just visible to boot stage (growth stage 9 to 10) provided substantially greater disease control and larger yield increases than triadimenol seed treatment.

Additional keywords: *Erysiphe graminis* f. sp. *tritici*, *Triticum aestivum*, yield loss assessment

Powdery mildew, caused by *Erysiphe graminis* DC. f. sp. *tritici* E. Marchal, is one of the most prevalent diseases of wheat (*Triticum aestivum* L.) in Ohio and other states in the midwest and eastern sections of the United States (4-7, 18,19,21,22). Over the last decade, the importance of this disease has increased due to changing production practices that incorporate higher seeding rates, earlier planting dates, and increased nitrogen fertilization (1,4,7,14). Powdery mildew has been controlled with resistant cultivars, but resistance is not available in some newer high-yielding cultivars. In years when environmental conditions favor the development of powdery mildew, chemical control has been economically feasible with systemic, ergosterol-biosynthesis-inhibiting fungicides (5,18,21,22,24).

Both the systemic, foliar-applied fungicide triadimefon (Bayleton, Mobay Chemical Corp., Kansas City, MO) and its closely related triazole derivative formulated for use as a seed treatment, triadimenol (Baytan, Gustafson Corp., Dallas, TX), have controlled powdery mildew and prevented yield losses on susceptible cultivars in tests in many states (5,6,21).

The economics of wheat production in the United States dictates that effective disease control be achieved with minimal cost. This limitation requires that fungicides be highly efficacious against a range of pathogens at low rates (24). A seed treatment that effectively controls powdery mildew until flowering of the wheat crop, or a foliar treatment that requires only one application, would provide economical options for grain producers.

The purpose of this study was to compare the effects of triadimenol seed treatment and a single foliar application of triadimefon, and combinations of both, on the development of powdery mildew epidemics and grain yield of wheat cultivars with varying levels of susceptibility to *E. g.* f. sp. *tritici*.

MATERIALS AND METHODS

Plots were established at the Ohio Agricultural Research and Development Center near Wooster, in fields that had been maintained under a corn-soybean-oat-wheat rotation. After plowing, plots were fertilized with 336 kg/ha of 6-24-24 (NPK) and then disked prior to planting. Plots were planted with 135 kg seed/ha using a seven-row drill with 17.8 cm between rows on 10 October 1984, 8 October 1985, and 10 October 1986. Plots were established in Ravenna silt loam in 1985, and in Wooster silt loam in 1984 and 1986. All plots were top-dressed with 100 kg/ha nitrogen as ammonium nitrate on 12 March 1985, 21 March 1986, and 18 March 1987. Throughout the rest of this paper, all experiments are identified by the year in which they were harvested. Plots were harvested with a plot combine on 23 July 1985, 15 July 1986, and 7 July 1987.

Wheat cultivars and their relative levels of susceptibility to *E. g.* f. sp. *tritici* in field trials during 1984 and 1985 (P. E. Lipps, *unpublished*) were: Hart (CI 17426), susceptible; Becker (PI 494524), susceptible; Adena (PI 481852), moderately susceptible; Caldwell (CI 17897), moderately susceptible; Cardinal (PI 502973), moderately resistant; Tyler (CI 17899), resistant; and Scotty (PI 469294), resistant. Not all cultivars were tested each year of the study.

Seed were treated with either triadimenol (Baytan 30F, 30% a.i.) at 98 ml/100 kg of seed or a carboxin (17% a.i.) and thiram (17% a.i.) combination (Vitavax 200, Gustafson Corp., Dallas, TX) at 260 ml/100 kg of seed. The carboxin-thiram treatment was chosen for comparison because it was the standard commercial treatment used in Ohio. The foliar treatment consisted of one application of triadimefon (Bayleton 50W, 50% a.i., in 1985 and Bayleton 1.8 EC, 22.5% a.i., in 1986 and 1987) at 140 g a.i./ha on 3 May 1985, 13 May 1986, and 10 May 1987. These dates corresponded to Feekes growth stages (GS) (13) GS-9, GS-10, and GS-10, respectively, on the cultivar Becker. Triadimefon was applied as a foliar spray in 187 L/ha of water with a CO_2-pressurized backpack sprayer with a constant boom pressure of 2.8 kg/cm^2.

Field plots were arranged in a strip-split plot design with four replicated blocks. Each block was divided in half lengthwise, with foliar treatment randomly applied to one of the halves. The block also was divided into sections widthwise, and the cultivars were randomly assigned to the sectors. Within a foliar treatment/cultivar combination, one experimental unit consisted of triadimenol seed treatment and the other consisted of

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carboxin-thiram seed treatment. Foliar fungicide treatment (triadimefon or no fungicide) and cultivar were strip plots, seed treatments (triadimenol or carboxin-thiram seed treatment) were subplots. Experimental units were one seven-row drill strip wide (125 cm) by 9, 11.4, and 19.5 m long in 1985, 1986, and 1987, respectively. All experimental units were adjacent to one another, but separated by a 22-cm space between outside rows for traffic. No effort was made to restrict interplot interference (2,11) from adjacent plots.

Disease evaluations were conducted at GS-6, GS-9, GS-10, GS-10.3, GS-10.5.1, and GS-10.5.4 in all 3 yr, and GS-11.1 in 1986 and 1987. Ten tillers were destructively collected at random from each experimental unit and ratings were conducted on all cultivars the same day. Although not all cultivars were at the same growth stage at each rating time, they varied no more than 2–3 days from the growth stage reported, except Caldwell, which was 3–4 days earlier than the other cultivars by flowering (GS-10.5.1). Powdery mildew severity was rated on a 0–10 scale where: 0 = 0 to trace percentage of leaf area covered by lesions, 1 = fourth leaf with trace to 50% of leaf area covered, 2 = third leaf with 1–5%, 3 = third leaf with 5–15%, 4 = third leaf with >15%, 5 = second leaf with 1–5%, 6 = second leaf with 5–15%, 7 = second leaf with >15%, 8 = flag or first leaf with 1–5%, 9 = flag or first leaf with 5–15%, and 10 = flag or first leaf with >15%. Several other rating scales, based on percentage of leaf area affected, were used in 1985 and 1986 with similar results as those reported here (Lipps and Madden, *unpublished*). The percentage of leaf area covered by powdery mildew lesions was determined using disease assessment keys developed by James (10). The mean rating of the 10 tillers was calculated to represent powdery mildew severity for each experimental unit. Leaf rust (*Puccinia recondita* Rob. ex Desm.) and Septoria blotch (*Leptosphaeria nodorum* Müller) were assessed at the same time as powdery mildew. Leaf rust was present on the flag leaves of Tyler in 1985 by GS-10.5.1, so data from this cultivar was dropped from the test. Septoria blotch was not present on the second or flag leaf by GS-11.1 in any year of the study.

Area under the disease progress curve (AUDPC) was calculated for each experimental unit using the ratings at each assessment time (8,16). Analysis of variance (ANOVA) was used to determine the effect of cultivar, foliar and seed fungicide treatment, and their interactions, on disease severity, AUDPC, and yield for each year. Disease severity over time within each year was analyzed as a repeated measure of ANOVA (17). When a main effect or interaction was significant, Fisher's least significant difference (LSD) was determined to compare means. The BMDP (3) statistical package was used for data analysis.

RESULTS

Repeated measures ANOVA (17) indicated significant ($P < 0.05$) effects of foliar and seed treatment, cultivar, time, and the interaction of time with all the other experimental factors on disease severity. Therefore, an interaction LSD ($P = 0.05$) was calculated to compare treatment means at any time in each of the years (Figs. 1–3). Least significant difference values for 1985, 1986, and 1987

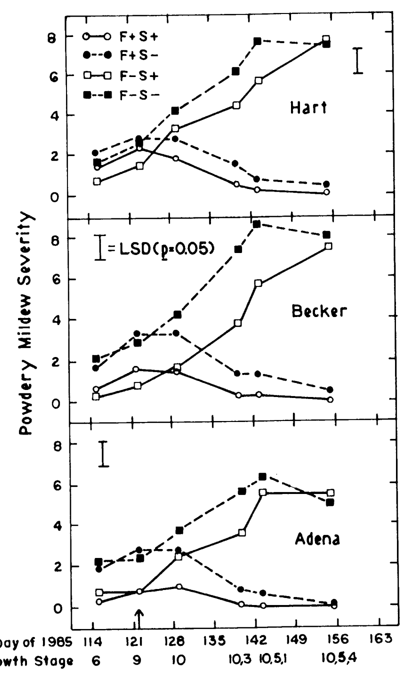

Fig. 1. Powdery mildew disease progress curves for Hart, Becker, and Adena wheat from first node visible (Feekes GS-6) through the end of flowering (GS-10.5.4) in 1985 based on a 0–10 disease severity scale. Treatment codes are: F+S+ = triadimefon foliar treatment plus triadimenol seed treatment, F+S− = triadimefon foliar treatment plus carboxin-thiram seed treatment, F−S+ = no foliar treatment plus triadimenol seed treatment, F−S− = no foliar treatment plus carboxin-thiram seed treatment. Triadimefon foliar treatment (140 g a.i./ha) applied at GS-9 (3 May 1985) is marked by the arrow. Triadimenol (30% a.i., 98 ml/100 kg seed) or carboxin-thiram (17% + 17% a.i., 260 ml/100 kg seed) applied as seed treatments.

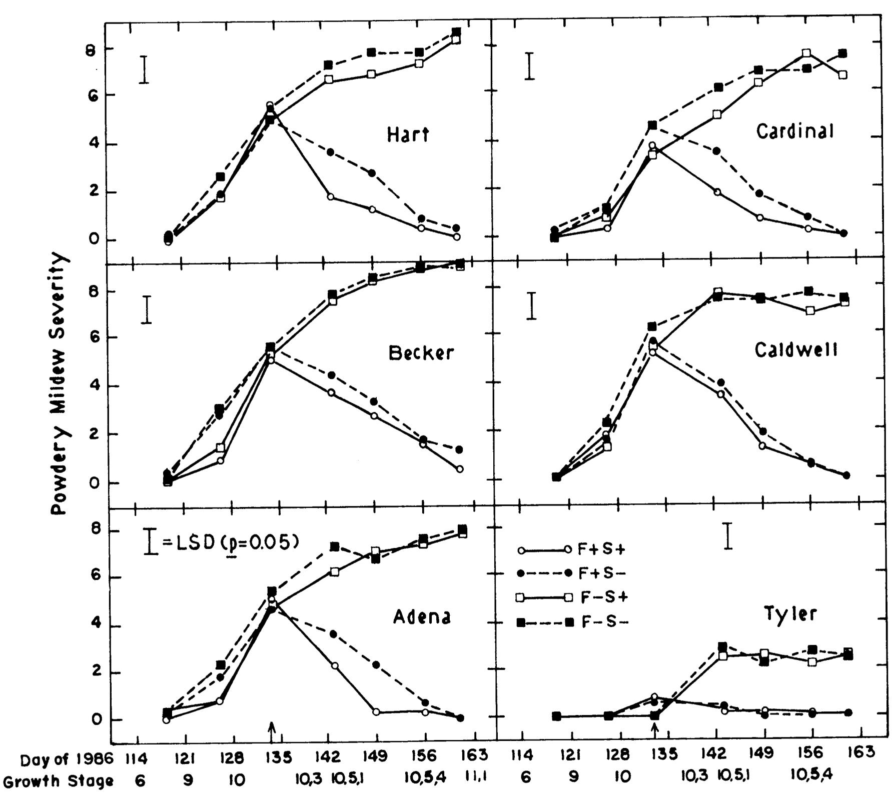

Fig. 2. Powdery mildew disease progress curves for Hart, Becker, Adena, Cardinal, Caldwell, and Tyler wheat from first node visible (Feekes GS-6) through watery ripe kernel development (GS-11.1) in 1986 based on a 0–10 disease severity scale. Treatment codes are: F+S+ = triadimefon foliar treatment plus triadimenol seed treatment, F+S− = triadimefon foliar treatment plus carboxin-thiram seed treatment, F−S+ = no foliar treatment plus triadimenol seed treatment, F−S− = no foliar treatment plus carboxin-thiram seed treatment. Triadimefon foliar treatment (140 g a.i./ha) applied at GS-10 (13 May 1986) is marked by arrow. Triadimenol (30% a.i., 98 ml/100 kg seed) or carboxin-thiram (17% + 17% a.i., 260 ml/100 kg seed) applied as seed treatments.

were 1.1, 1.0, and 1.4, respectively. At most assessment times, the foliar fungicide treated plots had significantly lower disease than those with no foliar treatment. The difference between plots planted with seed treated with triadimenol and those treated with carboxin-thiram was significant less often, especially in 1986 and 1987.

Powdery mildew was first detected on the leaves below the F4 leaf on plants in plots planted with carboxin-thiram treated seed on day 106 in 1985 and 1986 and on day 112 in 1987 (16 April and 22 April, respectively). In 1985, the cool, humid weather that persisted through April, May, and June (monthly mean 11, 15, and 16 C, respectively) favored powdery mildew development. Plots planted with triadimenol-treated seed had somewhat lower disease severities than those planted with carboxin-thiram treated seed from GS-6 through GS-10.5.1 (Fig. 1). However, only the cultivar Becker had significantly lower disease severity ratings at each of these growth stages. Powdery mildew severity ratings increased as wheat growth advanced from GS-6 to GS-9, then leveled by GS-10, and decreased to near 0 by GS-10.5.4 in plots treated with triadimefon at GS-9. Powdery mildew continued to increase in plots not treated with triadimefon until GS-10.5.1 in plots planted with carboxin-thiram treated seed and until GS-10.5.4 in plots planted with triadimenol treated seed.

Similar results occurred in 1986 and 1987, but with minor differences. In 1986, the weather conditions throughout May were cool (mean daily temperature 16 C) and humid, but by the first week in June high temperatures (6 of 7 days with maximum temperatures above 25 C) restricted further spread of *E. g.* f. sp. *tritici*. In 1987, weather conditions in May were limiting to disease development due to above normal temperatures (mean daily temperature 17 C, long term mean 14.5 C) and low precipitation (monthly mean 5.9 cm, long term mean 9.8 cm). Disease progress curves for cultivars tested in 1986 exhibited an early and rapid increase in the severity of powdery mildew up to GS-10.5.1 (Fig. 2). In 1987, the rate of disease increase was slow until GS-9 to GS-10, then severity ratings increased rapidly until GS-10.5.4 (Fig. 3). The warm, dry conditions that prevailed in 1987 did not permit powdery mildew severity to reach the high level observed in 1986 by GS-10.5.4 (Figs. 2 and 3).

Plots of Hart, Becker, Adena, Cardinal, and Caldwell planted with triadimenol-treated seed in 1987 had somewhat lower disease severities than plots planted with carboxin-thiram treated seed at GS-9 through GS-10.5.4 (Figs. 2 and 3). However, these differences were only significant for the cultivar Becker at GS-9 in 1986. Triadimefon foliar treatment had a greater effect on powdery mildew development than triadimenol seed treatment in both years. As in 1985, the severity ratings declined after triadimefon treatment at GS-10 in 1986. The disease severity ratings did not decline in 1987 because the level of powdery mildew was low at the time of triadimefon application and the disease increase did not occur until after this date in plots not treated with triadimefon.

The decline in disease severity ratings after triadimefon treatment was due to a decrease in visible lesions on leaf surfaces. Powdery mildew lesions began to turn from cotton white to a light tan color within several days after treatment. By 1 wk following treatment, some lesions appeared brown and diffuse. As time advanced, these lesions became more diffuse and were difficult to detect visually. Such lesions were not included in disease assessment percentages and they accounted for the decrease in severity ratings over time.

Analysis of variance for AUDPC indicated statistically significant ($P = 0.05$) main effects of cultivar, foliar treatment, and seed treatment in all 3 yr of the study and the interaction of cultivar and foliar treatment in 1986 and 1987 (Table 1). Examination of the AUDPC values for cultivar main effects indicated that a listing of cultivars in order of decreasing susceptibility to *E. g.* f. sp. *tritici* would be: Becker, Caldwell, Hart, Adena, Cardinal, and Tyler in 1986 and Becker, Hart, Adena, Caldwell, Cardinal, and Scotty in 1987. Main effect of foliar treatment indicated that triadimefon reduced the AUDPC by an overall 71, 60, and 85% in 1985, 1986, and 1987, respectively, compared with nontreated controls. Additionally, the seed treatment main effects indicated that triadimenol reduced the AUDPC by an overall 38, 13, and 29% in 1985, 1986, and 1987, respectively, compared with the respective carboxin-thiram seed treatments. The significant interaction indicated that the difference in AUDPC between the foliar treatment and control was not the same for each cultivar. Comparison of means revealed that the foliar fungicide treatment always had lower AUDPC compared with no treatment (Table 1), but the relative benefit of the treatment varied with the relative susceptibility of the cultivar. For example, AUDPC for the very susceptible Becker was reduced by 3.08 (5.28–2.19) in

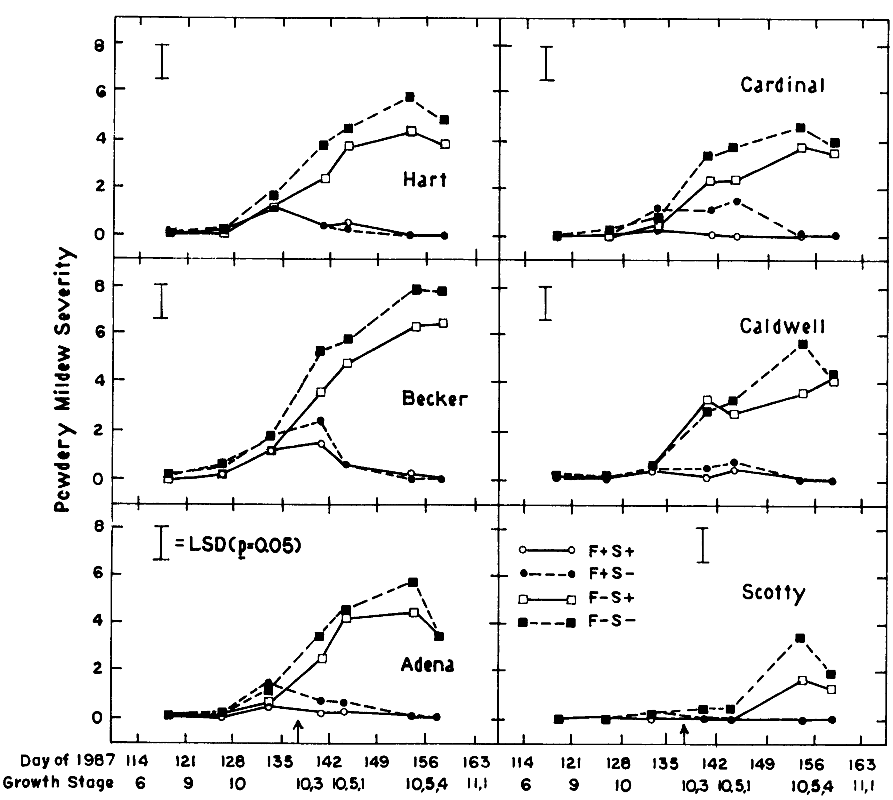

Fig. 3. Powdery mildew disease progress curves for Hart, Becker, Adena, Cardinal, Caldwell, and Scotty wheat from first node visible (Feekes GS-6) through watery ripe kernel development (GS-11.1) in 1987 based on a 0–10 disease severity scale. Treatment codes are: F+S+ = triadimefon foliar treatment plus triadimenol seed treatment, F+S− = triadimefon foliar treatment plus carboxin-thiram seed treatment, F−S+ = no foliar treatment plus triadimenol seed treatment, F−S− = no foliar treatment plus carboxin-thiram seed treatment. Triademefon foliar treatment (140 g a.i./ha) applied at GS-10 (10 May 1987) is marked by arrow. Triadimenol (30% a.i., 98 ml/100 kg seed) or carboxin-thiram (17% + 17% a.i., 260 ml/100 kg seed) applied as seed treatments.

1986; for the less susceptible Tyler, AUDPC was only reduced by 1.12 in the same year (Table 1). The ranking of the cultivars within a year was virtually the same for the foliar fungicide treatments and the controls.

Triadimefon foliar treatment and triadimenol seed treatment had varying effects on grain yield of the cultivars tested in each year of the study. ANOVA for yield indicated a significant ($P < 0.05$) main effect for cultivar in 1985, 1986, and 1987; foliar treatment in 1986 only; and seed treatment in 1986 and 1987 (Table 2). However, there was a significant ($P < 0.05$) interaction for cultivar and triadimefon foliar treatment all 3 years, the only interaction that was significant in any of the test years. Seed treatment with triadimenol had no effect on yield in 1985, but in 1986 and 1987 it increased yield by 406 (11%) and 147 (3%) kg/ha, respectively (Table 2). Of the three cultivars tested in 1985, only Becker had significantly higher yield when treated with triadimefon based on the interaction means. However, all cultivars treated with triadimefon had significantly higher yields than untreated plots in 1986 and 1987, based on a comparison of interaction means. The significant interaction occurred because cultivars varied in the difference in yield between foliar fungicide treated and untreated plots. For example, yield for Becker in 1986 was increased by 908 kg/ha when treated with the foliar fungicide, but yield of Caldwell was only increased by 306 kg/ha in the same year. Cultivars listed in order of decreasing yield response (%) to triadimefon foliar treatment were: Becker (15.1%), Adena (6.6%), and Hart (6.5%) in 1985; Hart (27.2%), Becker (23.5%), Adena (22.7%), Tyler (16.5%), Caldwell (13.4%), and Cardinal (8.0%) in 1986; and Adena (12.8%), Becker (12.1%), Hart (10.2%), Caldwell (8.2%), Cardinal (6.2%), and Scotty (4.3%) in 1987. In general, the more susceptible cultivars (Table 1) had the greatest difference in yield between foliar treated and untreated plots.

Table 1. Effect of cultivar, triadimefon foliar treatment, and triadimenol seed treatment on area under the powdery mildew disease progress curve (AUDPC) for 1985, 1986, and 1987

		AUDPC[a]		
Effect		**1985**	**1986**	**1987**
Main effects				
Cultivar				
Hart		3.00	3.73	1.42
Becker		2.93	4.30	2.09
Adena		2.40	3.50	1.35
Cardinal		...	3.02	1.15
Caldwell		...	3.86	1.17
Tyler		...	0.78	...
Scotty		...	...	0.29
	LSD ($P = 0.05$)	0.29[b]	0.40	0.39
Foliar treatment				
None		4.31	4.56	2.16
Triadimefon		1.25	1.84	0.33
	LSD ($P = 0.05$)	1.16	1.07	1.21
Seed treatment				
Carboxin-thiram		3.43	3.43	1.45
Triadimenol		2.13	2.97	1.04
	LSD ($P = 0.05$)	0.25	0.14	0.22
Interaction effects				
Cultivar × foliar treatment				
Hart	Triadimefon	1.43	2.19	0.35
	None	4.58	5.28	2.49
Becker	Triadimefon	1.34	2.76	0.71
	None	4.53	5.84	3.47
Adena	Triadimefon	0.98	1.95	0.34
	None	3.83	5.06	2.35
Cardinal	Triadimefon	...	1.66	0.34
	None	...	4.37	1.95
Caldwell	Triadimefon	...	2.26	0.23
	None	...	5.46	2.11
Tyler	Triadimefon	...	0.22	...
	None	...	1.34	...
Scotty	Triadimefon	...	...	0.01
	None	...	...	0.57
	LSD ($P = 0.05$)	NS[c]	0.39	0.40

[a] AUDPC calculated for treatments from disease assessments taken at growth stages 6, 9, 10, 10.3, 10.5.1, and 10.5.4 in 1985, plus 11.1 in 1986 and 1987; area was then divided by the time span of the disease assessments to standardize values. AUDPC could range from 0 to 10.

[b] Statistical differences based on Fisher's least significant difference test at $P = 0.05$.

[c] Significant main effect for foliar treatment and lack of interaction indicates that foliar treatment reduces AUDPC for all cultivars.

DISCUSSION

Results of these tests indicate that triadimefon foliar treatment and triadimenol seed treatment reduced the level of powdery mildew on the cultivars tested. However, triadimefon foliar treatment was much more effective in reducing powdery mildew severity and increasing yield than the triadimenol seed treatment in each year of the test. The reduction in disease severity was evident from the calculated AUDPC for the treatments (Table 1). Examination of the disease progress curves also showed that triadimenol seed treatment reduced the level of disease at some assessment dates, but the effect was not always statistically different. Although triadimenol seed treatment reduced the level of disease each year, yield increases occurred in only 2 of the 3 years tested, as indicated by the main effect of seed treatment on yield (Table 2). Frank and Ayers (6) also reported that triadimenol seed treatment effectively reduced the level of powdery mildew and contributed to a yield increase in 2 of 3 years tested on the single cultivar Hart. Their results indicated that the lack of a yield response was due to low disease severities early in the season. Royse et al (19) indicated that powdery mildew infection of the lower leaves at an early stage had a much greater effect on yield than originally suspected. Yield increases from triadimenol seed treatment appear to be dependent on early season (prior to GS-9) control of *E. g.* f. sp. *tritici* because the proportion of active ingredient in tissues decreases with increasing shoot growth (23). However, in our results, there was relatively high early season disease severity in 1985 (Fig. 1), yet this was the only year that triadimenol seed treatment did not significantly increase yield. Perhaps the higher variability among plot yields in 1985, as compared with 1986 and 1987, masked the yield response to triadimenol, as detected by a greater standard error of a difference that year (94 kg/ha for 1985, 27 kg/ha in 1986 and 1987).

Although differences were detected in disease severities among treatments, interplot interference probably played a major role in limiting the yield response of cultivars to some fungicide treatments tested (2,6,11). The effect of interplot interference was greatest for seed treatment comparisons because of the field plot design used. Because seed treatments were subplots and no border plots were planted, these treatments were adjacent to one another. Inoculum from heavily infected plants in the control plots would have had an effect on those in the triadimenol-treated plots. The ultimate influence would be higher than normal levels of disease and lower yield response in treated plots, thus leading to apparent loss of efficacy (11). In commercial-sized fields, both triadimenol seed treatment and triadimefon foliar treatment would be expected to control powdery mildew and increase yield to a greater extent than observed in these tests.

Triadimefon foliar treatment was highly effective in reducing the severity or preventing the increase of powdery mildew and, thus, increasing yield. The significant interaction between cultivar and triadimefon application for AUDPC and yield (Tables 1 and 2) indicated that cultivars respond differently to treatment with triadimefon. This was expected because the cultivars tested differed in susceptibility to *E. g.* f. sp. *tritici*. Yield response to triadimefon was generally greater for those cultivars that sustained higher levels of disease, as determined by AUDPC, in untreated plots. The exception to this was the cultivar Tyler in 1986. This cultivar had little disease in previous years and was presumed to be highly resistant (Lipps, *unpublished*). However, in this year, disease developed on leaves up to the third leaf and the cultivar sustained a 16% yield loss. Apparently, a race virulent on Tyler became prevalent in plots during this study.

Greater differences were detected in yield response and AUDPC for triadimefon foliar treatment than for triadimenol seed treatment. We believe interplot interference played a less important role in the results of triadimefon foliar treatment because disease level steadily declined after application. This decline was the result of the eradicant action of this fungicide. Lesions changed from a bright white to a tan color within a few days and colonies became more diffuse with time, presumably due to the lack of conidial production. The reduction in the amount of inoculum produced on infected tissues subsequent to fungicide application and the residual-systemic action of triadimefon eliminated any new infections resulting from inoculum originating within plots or from adjacent plots. This disease-control activity persisted to the last disease assessment dates (GS-10.5.4 or GS-11.0) (Figs. 1–3).

In agreement with other studies (6,8), AUDPC was found to be an acceptable measure of overall disease severity and a discriminator for the effects of fungicide treatment on disease progression. Disease severity at any single time was a less consistent measure of treatment differences because the differences varied considerably during the epidemics. The effect of seed treatment, also, was far less obvious when severity ratings at individual growth stages were compared than when AUDPC for treatment were compared. Because disease severity was not a direct estimate of the proportion of leaf area infected, but included information on the leaf position of powdery mildew on the tillers, rates of disease increase were not calculated. Additionally, Fry (8) found that rate of disease increase was less useful than AUDPC in comparing potato cultivars and fungicide rates for the control of potato late blight.

Table 2. Effect of cultivar, triadimefon foliar treatment, and triadimenol seed treatment on grain yield of wheat in 1985, 1986, and 1987

Effect		Yield (kg/ha)[a]		
		1985	1986	1987
Main effects				
Cultivar				
Hart		5,114	3,100	4,289
Becker		5,925	3,403	5,024
Adena		4,696	2,584	4,438
Cardinal		...	3,667	5,170
Caldwell		...	3,457	4,420
Tyler		...	3,862	...
Scotty		...	...	4,941
	LSD ($P = 0.05$)	497[b]	200	182
Foliar treatment				
Triadimefon		5,518	3,680	4,933
None		4,972	3,011	4,493
	LSD ($P = 0.05$)	NS	226	NS
Seed treatment				
Triadimenol		5,433	3,671	4,787
None		5,057	3,265	4,640
	LSD ($P = 0.05$)	NS	141	131
Interaction effects				
Cultivar × foliar treatment				
Hart	Triadimefon	5,289	3,588	4,520
	None	4,940	2,613	4,059
Becker	Triadimefon	6,409	3,857	5,346
	None	5,441	2,949	4,701
Adena	Triadimefon	4,856	2,915	4,741
	None	4,536	2,253	4,136
Cardinal	Triadimefon	...	3,820	5,336
	None	...	3,514	5,004
Caldwell	Triadimefon	...	3,706	4,610
	None	...	3,208	4,230
Tyler	Triadimefon	...	4,197	...
	None	...	3,505	...
Scotty	Triadimefon	...	...	5,050
	None	...	...	4,832
	LSD ($P = 0.05$)	397	187	188

[a]Yield based on grain weight at 13.5% moisture.
[b]Statistical differences based on Fisher's least significant difference test at $P = 0.05$.

Because both triadimenol seed treatment and triadimefon foliar treatment have potential for control of powdery mildew, their use will only be restricted by economics. Results of these tests and others (5,7,21) indicate that triadimenol seed treatment would give best economic return when used on highly susceptible cultivars, or in regions where powdery mildew is consistently prevalent prior to flag leaf emergence (GS-9). In addition, triadimenol seed treatment has activity against Septoria leaf blotch (6,21) and seedborne smuts (*Ustilago tritici* (Pers.) Rostr., *Tilletia caries* (DC.)Tul.) (9,12,15). Triadimefon foliar treatment would provide greatest economic return using a single application on susceptible cultivars in regions where powdery mildew epidemics are erratic and applications are based on disease scouting. This foliar application may also provide protection against the cereal rusts (5,18,20). When used in combination, triadimenol seed treatment may reduce the need for a foliar application of triadimefon, except on highly susceptible cultivars, in seasons conducive to powdery mildew epidemics or on cultivars susceptible to other foliar diseases, such as leaf rust, where later season protection is required.

ACKNOWLEDGMENTS

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