

Triadimefon for Control of Powdery Mildew of Wheat

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ABSTRACT

Kingsland, G. C. 1982. Triadimefon for control of powdery mildew of wheat. *Plant Disease* 66: 139-141.

Triadimefon controlled powdery mildew (*Erysiphe graminis* f. sp. *tritici*) on two varieties of winter wheat (*Triticum aestivum*) during two growing seasons when applied as a foliar spray at one, two, or three rates on one, two, or three dates. Final disease intensity on the middle and lower culm leaves was substantially less following one application at the lowest rate, even when powdery mildew was established on the lower leaves at the time of application. The two uppermost leaves were also protected after receiving a single application of triadimefon at the lowest rate. Triadimefon suppressed the development of active lesions and inhibited sporulation. Yields from sprayed plots were always greater than those from unsprayed plots, but the differences were not statistically significant.

Powdery mildew of wheat (*Triticum aestivum* L.), caused by *Erysiphe graminis* DC ex Merat f. sp. *tritici* Marchal, occurs each year in South Carolina and is the most important disease of wheat in the state. Yields are not significantly reduced when the primary cycle begins during late March or early April because the disease is usually arrested by mid-April with the advent of warm, dry weather. Sometimes powdery mildew develops during late February or mid-March and continues into late April or later. Under these circumstances, yield reductions of economic importance may occur. In the spring of 1979, for example, wheat yields were reduced 25-35% in some fields following powdery mildew development during late February, March, and April (Kingsland, unpublished data).

Three cultivars of wheat recommended for South Carolina have good resistance to powdery mildew (9), but they do not represent a large percentage of the total wheat acreage in the state. Several cultivars that were resistant when first

introduced 4-6 yr ago now have only fair resistance.

Foliar fungicides are potentially valuable for the control of powdery mildew of wheat when serious disease development begins early in the season and persists past the time of 50% heading late in April. No fungicides are currently available in the United States to fill this need, although benomyl, ethirimol, and dinocap, and, more recently, biloxazol have been used experimentally (4,5). These compounds provide some control of powdery mildew, but they are not sufficiently effective to assure yield increases that would compensate for costs of application (4,5).

Triadimefon, synthesized in 1970 by W. Meiser at the Research Center of Bayer AG in Wuppertal, West Germany (7), has shown promise as a systemic fungicide for control of powdery mildew of cereals by seed or foliar application. Triadimefon provided control of powdery mildew of barley (*E. graminis* f. sp. *hordei*) when applied to soil at 0.04-0.4 mg a.i./250 ml of soil and when applied as a foliar spray at 1.5-15.0 mg a.i./L before inoculation (2). Powdery mildew was controlled and yields increased 29% over 4 yr when spring barley received a single application of triadimefon at 0.5 kg a.i./ha at the onset of infection (7). Yields were 28% greater in winter wheat in other spray trials over a 3-yr period because of more heads and increased kernel weights from the plants in the fungicide-treated plots (7). A second application of triadimefon resulted in an additional

yield increase of only 2 or 3%. Powdery mildew control in both spring barley and winter wheat was most effective when the fungicide was applied at the onset of infection.

Seed treatment with triadimefon protected wheat plants against *E. graminis* f. sp. *tritici* for 80 days in glasshouse research (10). Similar results were obtained with a single application as a foliar spray (11). Seed treatment with triadimefon gave almost complete control of powdery mildew of wheat and barley (1).

Eight reports were published in 1979 and six in 1980 (*Fungicide and Nematicide Tests*, vols. 34 and 35) about the control of powdery mildew of wheat by the foliar application of triadimefon. There is also evidence that triadimefon suppresses lesion development after infection and reduces sporulation by *E. graminis* f. sp. *tritici* (5,6).

The difficulties of achieving sufficient coverage and distribution of fungicides on wheat leaves and the costs of application preclude extensive use of protectant fungicides for control of powdery mildew of wheat. Systemic fungicides (3) such as triadimefon have the greatest potential for commercial control of powdery mildew of wheat. Their usefulness would be further enhanced if they also acted to suppress established infections and inhibit sporulation.

MATERIALS AND METHODS

Six-row field plots of Coker 68-15 wheat measuring 1.82 × 3.04 m (5.5 m²) with 30 cm between rows were established in five replicates on a Cecil sandy clay soil at the Simpson Experiment Station, Clemson University, Clemson, SC, during early November in 1977 and 1978. The plots received 6-12-12 fertilizer at the equivalent of 672 kg/ha and limestone at 1,680 kg/ha before 10 g of seeds per row were planted with a Planet Jr. single-row planter. Ammonium nitrate (33.5% N) at the equivalent of 168 kg/ha was applied to the plots on 20 March. Plots of McNair

Technical Contribution 1856 of the South Carolina Agricultural Experiment Station, Clemson University. This research was supported in part by a grant from Mobay Chemical Corporation.

Accepted for publication 28 April 1981.

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0191-2917/82/02013903/\$03.00/0

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1003 were set out in a farm field in Calhoun County during the spring of 1979. Nitrogen was applied to this field 5 wk later than the date specified in the crop recommendations for central South Carolina.

Triadimefon was applied to the Coker 68-15 wheat at 140 and 281 g a.i./ha on two dates in 1978. It was applied to Coker 68-15 and McNair 1003 at one, two, or three dates at 280, 560, and 840 g a.i./ha in 1979. A hand-pump sprayer (Model N124S, B and G Sprayers, Plumsteadville, PA 18949) was used to apply the fungicides at 35 psi using 375 L of water per hectare. The initial fungicide application to Coker 68-15 coincided with the first observed occurrence of powdery mildew on 6 April 1978, when the plants were in stage seven of development on the Feekes scale (8). Powdery mildew intensity was rated visually by estimating the percentage of leaf area with mildew lesions and assigning values between 0 and 100, with 0 = no mildew and 100 = powdery mildew

lesions on 90% or more of the leaf or leaves being rated.

In 1979, powdery mildew intensity was determined on six randomly sampled, 34-cm row segments per replicate of Coker 68-15 on 13 March (stage five in plant development) and on culm leaves two and three (counting up from the lowest) of seven rows in three replicates on 26 March (stage six). The first spray was applied to these plots on 27 March 1979. Fungicides were applied to McNair 1003 for the first time on 10 April 1979 (stage seven) when powdery mildew intensity was 77 and 27% on culm leaves three and four, respectively.

Disease was also rated on culm leaves one, two, and three of Coker 68-15 wheat on 27 April (stage 10.3) and on leaves four and five on 19 May 1978 (stage 11.1). In 1979, ratings were made on culm leaves two and three of Coker 68-15 on 18 April (stage nine) and on culm leaves five and six on 1 May (stage 10.5). Ratings were made on leaf five of McNair 1003 on 18 April 1979 (stage nine) and on leaves four

and six on 1 May (stage 10.5).

Average infection-response ratings for lesions were also made on whole plots of Coker 68-15 on 27 April 1978 and on 18 April 1979, using a scale of 0 to 10 with 0 = no lesion development and 10 = mature, necrotic mildew lesions with local chlorosis and abundant sporulation. Intensity ratings were recorded on every row of plants to which triadimefon had been applied plus the nearest adjacent border rows in the check plots in 1978.

Six random leaves from three replicates of the Coker 68-15 plots that had received one application of triadimefon at 140 and 281 g/ha in 1978 and an equal number of leaves from unsprayed plots were observed for sporulation in the laboratory and rated on a 0 to 10 scale (0 = no sporulation; 10 = profuse sporulation over the entire lesion). These leaves were also rated for infection response and for intensity (percentage of leaf area infected).

The middle four rows of the plots were harvested with a two-row plot harvester. The grain was threshed in a Vogel plot thresher and allowed to air-dry before recleaning and weighing. Yields from individual plots were converted to kilograms per hectare, and these figures were analyzed for variance.

Table 1. Powdery mildew intensity, infection response, sporulation ratings, and yield of Coker 68-15 wheat receiving one or two applications of triadimefon at one or two rates

| Treatment rate (g a.i./ha) | Applications (no.) | Intensity (%) ^a | | Infection Response ^b | | Sporulation ^c | | Yield (kg/ha) |
|----------------------------|--------------------|----------------------------|-------------------|---------------------------------|------------|--------------------------|------------|---------------|
| | | Leaves one, two, three | Leaves four, five | Leaves one, two, three | Leaf three | Leaf three | Leaf three | |
| 140 | 1 | 9 | 0 | 4 | 2 | 1 | 3,091 | |
| | 2 | 7 | 0 | 1 | ... | ... | ... | |
| 281 | 1 | 5 | 0 | 2 | 3 | 1 | 3,293 | |
| | 2 | 3 | 0 | 1 | ... | ... | ... | |
| Control | 0 | 55 | 20 | 10 | 7 | 6 | 2,957 | |
| Yield ($F=1.30$) | | | | | | | | NS |

^aPercentage of leaf area with mildew lesions. Leaves one, two, and three were rated 27 April 1978; leaves four and five were rated 9 May 1978.

^b0 = no lesion development; 10 = mature, necrotic mildew lesions with local chlorosis and abundant sporulation. Leaves one, two, and three were rated 27 April 1978; leaf three was rated in the laboratory.

^c0 = no sporulation, 10 = profuse sporulation over entire lesion. Rated 27 April 1978 in the laboratory.

^d... = not tested.

RESULTS

In 1978, the intensity of powdery mildew was lower on culm leaves one, two, and three in all fungicide-treated plots than on the leaves of plants in the unsprayed check plots (Table 1). Rates of triadimefon and numbers of applications did not affect disease intensity. Powdery mildew did not develop on leaves four and five of the plants sprayed with triadimefon; about 20% of the leaf area was infected in the control plots. Triadimefon also inhibited lesion development, as shown by lower infection-response ratings in sprayed plots than on plants in the unsprayed plots (Table 1). Ratings of individual leaves indicated that triadimefon suppressed development of established mildew lesions and inhibited sporulation on mature lesions (Table 1). Yields from triadimefon-sprayed plots were higher than those from unsprayed control plots, but the differences were not statistically significant.

When disease intensity in plots sprayed once with triadimefon at 140 and 281 g/ha was compared with intensity on the nearest adjacent rows in the check plots, both rates were very effective even under the conditions of high inoculum provided by the border rows. The average rating for all rows in all of the sprayed plots was six, compared with an average of 30 for the border rows in the adjacent plots (Fig. 1). Mean ratings between rates of application and ratings of any of the individual rows were about the same.

In 1979, triadimefon at three rates

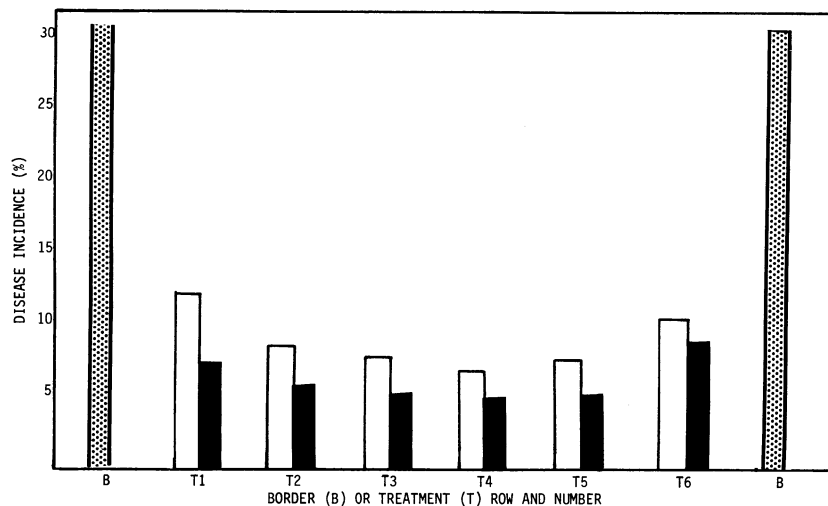


Fig. 1. Average intensity of powdery mildew on six rows of Coker 68-15 wheat from plots sprayed once with triadimefon at 140 (open bars) or 281 g a.i./ha (solid bars) compared with border rows of adjacent check plots (dotted bars).

Table 2. Powdery mildew intensity and infection response ratings and yield of two varieties of winter wheat receiving one, two, or three applications of triadimefon at three rates

| Treatment rate (g a.i./ha) | Appli- cations (no.) | Coker 68-15 | | | Yield (kg/ha) | McNair 1003 | | | |
|-------------------------------|----------------------------|-------------------------------|------------------------|-------------------------------|------------------|----------------------------|--------------|-------------|------------------|
| | | Intensity (%) ^a | | Infect. resp. ^b | | Intensity (%) ^c | | | |
| | | Leaves two, three | Leaves five, six | Leaves two, three | | Leaf four | Leaf five | Leaf six | Yield (kg/ha) |
| 280 | 1 | 10 | 0 | 4 | 3,024 | 43 | 14 | 0 | 2,016 |
| | 2 | 10 | 0 | 5 | 3,427 | 39 | 17 | 0 | 2,083 |
| | 3 | 8 | 0 | 4 | 3,091 | ... ^d | ... | ... | ... |
| 560 | 1 | 12 | 0 | 5 | 2,990 | 34 | 14 | 0 | 2,150 |
| | 2 | 9 | 0 | 5 | 3,091 | 33 | 16 | 0 | 2,083 |
| 840 | 1 | 9 | 0 | 4 | 2,990 | 30 | 17 | 0 | 2,150 |
| | 2 | ... | ... | ... | ... | 31 | 15 | 0 | 2,285 |
| Control | 0 | 43 | 25 | 10 | 2,755 | 63 | 31 | 31 | 1,814 |
| LSD 0.05 | | | | | NS | | 11 | | NS |
| 0.01 | | | | | | | 15 | | |

^a Percentage of leaf area with mildew lesions. Leaves two and three were rated 18 April 1979; leaves five and six were rated 1 May 1979.

^b 0 = no lesion development; 10 = mature, necrotic mildew lesions with local chlorosis and abundant sporulation. Rated 18 April 1979.

^c Leaves four and six were rated 1 May 1979; leaf five was rated 18 April 1979.

^d ... = not tested.

applied one, two, or three times provided good control of powdery mildew on both Coker 68-15 and McNair 1003 wheat under epidemic conditions. The average intensity of powdery mildew in the field was less than one on 13 March. The first application to the Coker 68-15 was on 27 March, when the disease intensity on culm leaves two and three in the plots was 10. An average of 56% of the leaves in each row rated had at least one powdery mildew lesion on this date. Intensity on these leaves did not exceed 12 during the 3 wk following the first application of triadimefon. Powdery mildew continued to develop on the checks during this period, resulting in an intensity rating of 43% (Table 2). Triadimefon provided complete control on leaves five and six throughout the season. Conversely, an average of 25% of the leaf area of leaves five and six was diseased in the control plots. Infection-response ratings of 18 April on culm leaves two and three (sprayed on 10 April) indicated that lesion development was suppressed at all three rates (Table 2).

Powdery mildew was well established (an average intensity of 77 and 27 on culm leaves three and four, respectively) in the commercial field of McNair 1003 at the time of the initial fungicide application on 10 April. Disease intensity increased to an average of 32% by 1 May on leaf four of the plants in plots receiving one or two applications of triadimefon, compared with 63% on the plants in the check plots. All rates of triadimefon controlled powdery mildew on leaf number five (rated an average of 15 on 18 April) and provided control on leaf six (the topmost

leaf, rated on 1 May). Leaf six in the control plots was rated 31 on this date. Rates and numbers of applications provided equivalent control.

Yields from the sprayed plots of both varieties were always higher than the yields from control plots, but the differences were not statistically significant.

DISCUSSION

Triadimefon has significant potential for controlling powdery mildew of wheat and other small grains. Cost of application may be a limiting factor during some years. Another important concern of fungicide use in integrated pest management schemes is the reduction of chemical contamination of the environment. The control of powdery mildew of wheat by triadimefon with a single application at low rates is an important consideration in the economics of application and minimization of chemical contamination of the environment.

Triadimefon is effective in controlling powdery mildew on the uppermost two leaves of the wheat plant. This is an important aspect of control, because these leaves are essential to assure maximum development and maturation of the grain.

The large number of conidia produced by each infection cycle of *E. graminis* is an important epidemiologic characteristic of this pathogen. Triadimefon suppresses the development of active lesions and inhibits sporulation of *E. graminis* f. sp. *tritici* when applied after infection. This characteristic may be of importance in

control by interfering with the successful completion of the life cycle.

Control of four rust diseases of small grains, including leaf rust of wheat caused by *Puccinia recondita* Rob. ex Desm., has been reported for triadimefon (12). This characteristic constitutes an important attribute for this fungicide, because leaf rust of wheat is also a potential problem for wheat production in South Carolina.

The initial application of triadimefon at the onset of disease is important for the control of powdery mildew of wheat. The timing of the initial application will be most important when the disease begins to develop during late February or early March in South Carolina. Protection of the uppermost two leaves throughout the season is another important aspect of the control program. The success of a fungicide regime for control of powdery mildew on wheat will thus be determined by early recognition of the disease and prompt application of the most effective fungicides available.

ACKNOWLEDGMENT

Appreciation is expressed to Curtis Powell for technical assistance.

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