# Control of Stem Rust on Spring Wheat by Triadimefon and Fenapanil

J. B. ROWELL, Research Plant Pathologist, Cereal Rust Laboratory, AR, SEA, USDA, University of Minnesota, St. Paul 55108

**ABSTRACT**

Rowell, J. B. 1981. Control of stem rust on spring wheat by triadimefon and fenapanil. Plant Disease 65:235-236.

Two systemic fungicides, triadimefon and fenapanil, appear promising for control of stem rust epidemics on spring wheat in the north central United States. One spray of these fungicides, suitably timed to host and rust development, gave satisfactory control in moderate rust epidemics. Good control was obtained in most schedules of two sprays applied at a 7–20 day interval during the period from primary infection to early logarithmic increase of rust. Triadimefon was generally more effective than fenapanil at 280 g (a.i.)/ha.

The severe stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks. and E. Henn.) epidemics on spring wheat (*Triticum aestivum* L.) in 1953 and 1954 fostered the search for fungicides that, with one or two applications, would prevent similar devastating crop losses (7). Although formulations of inorganic nickel salts with zineb or maneb were effective (2,6), concern about the residue of nickel discouraged registration for use on wheat. In my preliminary trials, triadimefon (BAY MEB 6447) and fenapanil (RH 2161) controlled wheat stem rust. Test results of the relation of application time to the control of stem rust by these systemic fungicides on spring wheat in Minnesota are reported here.

## MATERIALS AND METHODS

The formulations of the fungicides tested were: triadimefon (BAY MEB 6447 50% WP, Mobay Chemical Corp., Kansas City, 64120), and fenapanil (24% EC, Rohm and Haas Co., Philadelphia, 19105). An experimental surfactant supplied by the manufacturer of fenapanil was added at 0.5% of the spray mixture in all treatments with fenapanil.

Cooperative investigations of Agricultural Research, Science and Education Administration, U.S. Department of Agriculture, and the University of Minnesota.

This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture and does not imply registration under FIFRA as amended.

Minnesota Agricultural Experiment Station Scientific Journal Series 11,259.

This article is in the public domain and not copyrightable. It may be freely reprinted with customary crediting of the source. The American Phytopathological Society, 1981.

The two fungicides were assayed on seedlings of wheat for systemic protectant and eradicant activity against *P. graminis* f. sp. *tritici*, by methods described previously (9).

For field tests, wheat line Purdue 5481C1, which is highly susceptible to stem rust and resistant to leaf rust, was planted at 101 kg/ha in a randomized complete block design with four replicates. Plots were 6.1 m long and consisted of four rows 30.6 cm apart in 1977 and seven rows 17.8 cm apart in 1978 and 1979.

In addition to the untreated control, each experiment had frequently treated and standard controls that were sprayed with zinc ion-maneb complex, a coordination product of zinc ion and manganous ethylenebis (dithiocarbamate), at 1.8 kg (a.i.)/ha. The frequently treated control was sprayed weekly or after 1.3 cm or more of rain during the rust season for nearly complete control of stem rust to determine the yield potential with little or no loss due to rust. The standard control was sprayed initially at a rust incidence of less than one uredium per tiller and again 7–10 days later to establish the degree of control attainable by available methods. Spray treatments were applied at a rate of 281 L/ha at a pressure of 21 kg/cm$^2$ by a mechanical sprayer with a 1.5-m boom and five hollow-cone spray nozzles on 30-cm centers.

Fungicides were applied at 280 g (a.i.)/ha. Spray applications of the two test fungicides were scheduled to coincide with rust development. The plots were inoculated with uredospores of race 15B on 2–4 successive days by methods previously described (10).

Plots were sprayed with each fungicide at one or two of three times: 1) when only

**Table 1.** Effective dose of triadimefon and fenapanil for 50% control of stem rust in assays of eradicant and protectant activity on Little Club wheat seedlings

| | ED 50 (μg/leaf)[a] | |
|---|---|---|
| **Fungicide** | **Eradicant** | **Protectant** |
| Triadimefon | 0.0036 | 0.018 |
| Fenapanil | 0.016 | 0.053 |

[a] Applied in a 10-μl drop 5 cm from leaf tip 48 hr after inoculation and 24 hr before inoculation for eradicant and protectant assays, respectively.

**Table 2.** Timing of experimental operations in days after planting and the stages of crop and rust development in three field tests of triadimefon and fenapanil for control of wheat stem rust in Minnesota.

| | 1977 | | | 1978 | | | 1979 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Operation** | **Time[a]** | **Host[b] stage** | **Rust[c] (%)** | **Time[a]** | **Host[b] stage** | **Rust[c] (%)** | **Time[a]** | **Host[b] stage** | **Rust[c] (%)** |
| Planting | April 9 | | | May 3 | | | April 26 | | |
| Inoculations | 43–45 | 10 | 0 | 43–44 | 7 | 0 | 54–57 | 8 | 0 |
| Spray time[d] | | | | | | | | | |
| 1 | 44 | 10 | 0 | 49 | 9 | Tr | 63 | 11 | 0 |
| 2 | 55 | 17 | Tr[e] | 57 | 13 | 0.1 | 70 | 16 | Tr |
| 3 | 65 | 21 | 1 | 64,68 | 19 | 2 | 77 | 18 | 5 |
| Disease notes | 79 | 27 | 75 | 84 | 27 | 100 | 90 | 27 | 80 |
| Harvest | 99 | 31 | | 100 | 31 | | 110 | 31 | |

[a] In days after planting.
[b] Romig scale (1) for assessment of wheat growth stages: 10 = boot stage, 27 = early dough.
[c] Severity in untreated control plots.
[d] In relation to rust development: 1 = only primary infection present, 2 = initial secondary infection, 3 = early period of logarithmic increase in rust infection.
[e] Trace amounts of rust less than 0.1% in severity.

**Table 3.** Relation of timing of sprays to the effectiveness of triadimefon and fenapanil for control of stem rust on Purdue 5481C1 wheat in Minnesota

| Treatment | | 1977 | | 1978 | | 1979 | |
|---|---|---|---|---|---|---|---|
| Material | Spray time[a] | Severity (%)[b] | Yield (kg/ha) | Severity (%) | Yield (kg/ha) | Severity (%) | Yield (kg/ha) |
| Treated control[c] | | T a | 2,926 a | 5 ab | 895 b | 8 a | 2,169 ab |
| Standard control[d] | 2,3 | 15 bc | 2,125 bcd | 78 e | 605 cd | 15 a | 1.934 abcde |
| Triadimefon | 2,3 | 6 b | 2,408 b | 13 bc | 1,009 a | 11 a | 2,314 a |
| | 1,3 | 13 b | 2,401 b | 2 a | 895 b | 15 ab | 2,030 abcd |
| | 1,2 | 13 b | 2,388 b | 50 d | 794 b | 8 a | 2,072 abc |
| | 3 | 19 bc | 2,051 cd | 21 c | 807 b | 40 d | 1,670 efg |
| | 2 | 33 c | 2,388 b | 86 e | 575 cde | 21 abc | 1,894 bcdef |
| | 1 | 54 d | 2,112 bcd | 83 e | 646 c | 31 bcd | 1,592 fgh |
| Fenapanil | 2,3 | 13 b | 2,226 bcd | 85 e | 626 c | 20 abc | 1,640 efg |
| | 1,3 | | | 46 d | 847 b | 31 bcd | 1,718 defg |
| | 1,2 | | | 91 ef | 619 c | 16 ab | 1,764 cdefg |
| | 3 | | | 81 e | 599 cd | 34 cd | 1,478 gh |
| | 2 | | | 97 fg | 451 fg | 48 d | 1,628 efg |
| | 1 | | | 99 fg | 457 fg | 48 d | 1,502 gh |
| Untreated | | 75 e | 1,924 d | 100 g | 397 g | 80 e | 1,296 h |

[a] In relation to rust development: 1 = only primary infection present, 2 = initial secondary infection, 3 = early period of logarithmic increase in rust infection.
[b] Within columns, values followed by the same letter are not significantly different at $P = 0.05$, according to Duncan's multiple range test.
[c] Treated controls sprayed with zinc ion-maneb complex weekly or after 1.3 cm or more of rain during the rust season.
[d] Initially sprayed with zinc ion-maneb complex at a rust incidence less than one uredium per tiller and again 7–10 days later.

primary infection was present, 2) in the initial stage of secondary infection, and 3) during the logarithmic increase of rust infection. The timing intervals were 10 or 11 days in the slowly developing epidemic of 1977 and 7 or 8 days in the rapidly developing epidemics of 1978 and 1979. The fungicides were applied as a single spray treatment at each time and were applied in two sprays in all possible combinations of the three times.

Only one treatment was made of fenapanil in 1977. In 1978, rains after the third time of application (1.04 cm on day 64, 1.75 cm on day 66, and 0.30 cm on day 67) were judged highly adverse to fungicidal performance; these treatments were therefore sprayed again on day 68. No treatments were repeated in 1979 when 1.12 cm of rain fell on day 63 after the first spray and 3.56 cm fell on day 78 after the third spray.

Terminal stem rust severities were estimated at the early dough stage of crop development and were converted to arc sines for analysis. The center 0.9 × 4.9 m of all plots was harvested with a mechanical plot-combine for yield determinations.

## RESULTS AND DISCUSSION

Seedling assays of triadimefon and fenapanil for systemic protectant and eradicant activity (Table 1) indicated that these fungicides were highly effective against stem rust at doses similar to the best compounds evaluated in previous tests (8). Triadimefon was three to four times more effective than fenapanil. The three to five times greater eradicant activity than protectant activity of these fungicides indicated that they would be most effective when applied during the period of logarithmic increase of a rust epidemic.

The three field seasons encompassed the range of conditions for wheat and stem rust development in Minnesota (Table 2). The 1977 crop season was unusually warm and early, wheat matured rapidly, and the rust epidemic was late and moderately severe; 1978 was very wet and warm, wheat matured normally, and the rust epidemic was extremely severe; and 1979 was moderately wet and cool, wheat matured slowly, and the rust epidemic was intermediate between those of 1977 and 1978.

Stem rust was controlled excellently in the frequently treated control in 1977 (Table 3) but less effectively under the wet conditions in 1978 (rain totals were 20.1 cm in June and 17.8 cm in July) and 1979 (rain totals were 14.1 cm in June and 7.6 cm in July). Scab and ergot were extremely severe and moderately severe on Purdue 5481C1 wheat in 1978 and 1979, respectively, and greatly depressed yields. No control of these diseases was evident, however, in any of the treatments, and the differences in yield mainly resulted from control of stem rust. Treatment with two sprays of zinc ion-maneb complex in the standard control gave good control of the stem rust epidemics in 1977 and 1979 but only slight control in the severe 1978 epidemic.

All two-spray treatments of triadimefon and fenapanil controlled rust as well as or better than the standard control. The nonsignificant differences in yield between the two spray treatments, except for triadimefon sprayed at times 2 and 3 and fenapanil sprayed at times 1 and 3 in 1978, suggests that considerable latitude in timing exists for scheduling two sprays of these fungicides. Although rust was generally more severe than on the standard control at the early dough stage, the single spray treatments of triadimefon did not differ significantly from the standard control in yield except for the better yield for spray 3 in 1978 and the poorer yield for spray 1 in 1979. Single spray treatments of fenapanil were not significantly better in yield than the untreated control except the third spray treatment in 1978 and the second spray treatment in 1979. These results suggest that fenapanil is more adversely affected than triadimefon by washing rains. Generally the treatments with triadimefon had less rust and greater yields than the corresponding treatments with fenapanil, but these differences were not always significant.

These results indicated that triadimefon and fenapanil have potential for control of wheat stem rust epidemics on spring wheat in the north central United States. Coupled with a suitable system of monitoring and forecasting disease development, satisfactory control could often be achieved with a single application. At present, however, there is little need for such a control measure. Use of resistant spring wheat cultivars has prevented stem rust epidemics in this area for 25 years (4). Furthermore, the annual race survey (3,5) has not detected any race with the requisite virulence to cause epidemics on the hard red spring and durum cultivars currently in use. Thus, manufacturers of these fungicides have little incentive to proceed with the registration process for use of these materials for the control of wheat stem rust.

## LITERATURE CITED


1. Calpouzos, L., Roelfs, A. P., Madson, M. E., Marten, F. B., Welsh, J. R., and Wilcoxson, R. D. 1976. A new model to measure yield losses caused by stem rust in spring wheat. Minn. Agric. Exp. Stn. Tech. Bull. 307. 23 pp.
2. Forsyth, F. R., and Peterson, B. 1960. Control of leaf and stem rust of wheat by zineb and inorganic nickel salts. Plant Dis. Rep. 44:208-211.
3. Green, G. J. 1979. Stem rust of wheat, barley and rye in Canada in 1978. Can. Plant Dis. Surv. 59:43-47.
4. Roelfs, A. P. 1978. Estimated losses caused by rust in small grain cereals in the United States—1918-76. U.S. Dept. Agric. Misc. Publ. 1363. 85 pp.
5. Roelfs, A. P., Casper, D. H., and Long, D. L. 1979. Races of *Puccinia graminis* f. sp. *tritici* in the U.S.A. during 1978. Plant Dis. Rep. 63:701-704.
6. Rowell, J. B. 1964. Factors affecting field performance of nickel salt plus dithiocarbamate fungicide mixtures for the control of wheat rusts. Phytopathology 54:999-1008.
7. Rowell, J. B. 1968. Chemical control of the cereal rusts. Annu. Rev. Phytopathol. 6:243-262.
8. Rowell, J. B. 1972. Fungicidal management of pathogen populations. J. Environ. Qual. 1:216-220.
9. Rowell, J. B. 1976. Control of leaf rust on spring wheat by seed treatment with 4-N-butyl-1,2,4-triazole. Phytopathology 66:1129-1134.
10. Rowell, J. B., and McVey, D. V. 1979. A method for field evaluation of wheats for low receptivity to infection by *Puccinia graminis* f. sp. *tritici*. Phytopathology 69:405-409.