if seed treatments were to achieve complete eradication of *T. indica* on infected seed samples, they would not by themselves provide control of the disease, since teliospores may survive for 4 yr in the soil.

With the possible exception of mercurial compounds, none of the available fungicides are capable of killing teliospores of *T. indica* when applied to infected seed. This means that there is currently no chemical seed treatment that can guarantee that wheat seed is not carrying viable teliospores of *T. indica*.

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LITERATURE CITED

1. Agarwal, V. K., Verma, H. S., and Khetarpal, R. K. 1977. Occurrence of partial bunt on *Triticale*. FAO Plant Prot. Bull. 25:210-211.
2. Anonymous. 1955. Report of the Division of Mycology and Plant Pathology. Pages 87-99 in: Sci. Rep. Agric. Res. Inst. New Delhi 1953-1954.
3. Aujla, S. S., Grewal, A. S., and Sharma, I. 1981. Karnal bunt and other diseases of wheat and their control. Prog. Farming (Nov.):18-20.
4. Chona, B. L., Munjal, R. L., and Adlakha, K. L. 1961. A method for screening wheat plants for resistance to *Neovossia indica*. Indian Phytopathol. 14:99-101.
5. Fuentes, S., Torres, E., and Garcia, C. 1983. Chemical seed treatment for partial bunt of wheat. (Abstr.) Phytopathology 73:122.
6. Hoffmann, J. A., and Waldher, J. T. 1981. Chemical seed treatments for controlling seedborne and soilborne common bunt of wheat. Plant Dis. 65:256-259.
7. International Seed Testing Association. 1976. International rules for seed testing. Seed Sci. Technol. 4:3-177.
8. Mitra, M. 1931. A new bunt on wheat in India. Ann. Appl. Biol. 18:178-179.
9. Mitra, M. 1935. Stinking smut (bunt) of wheat with special reference to *Tilletia indica* Mitra. Indian J. Agric. Sci. 5:1-24.
10. Mitra, M. 1937. Studies on the stinking smut or bunt of wheat in India. Indian J. Agric. Sci. 7:459-478.
11. Mundkur, B. B. 1940. A second contribution towards a knowledge of Indian Ustilaginales. Trans. Br. Mycol. Soc. 24:312-336.
12. Mundkur, B. B. 1943. Karnal bunt, an air-borne disease. Curr. Sci. 12:230-231.
13. Rai, R. C., and Singh, A. 1979. Effect of chemical seed treatment on seed-borne teliospores of Karnal bunt of wheat. Seed Res. 7:186-189.
14. Singh, D. V., Srivastava, K. D., and Joshi, L. M. 1979. Prevent losses from Karnal bunt. Indian Farming (Feb.):7-8.
15. Smilanick, J. L., Hoffmann, J. A., Secrest, L. R., and Wiese, K. 1988. Evaluation of chemical and physical treatments to prevent germination of *Tilletia indica* teliospores. Plant Dis. 72:46-51.

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Comparison of Propiconazole Rates for Control of Fungal Brown Spot of Wild Rice

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ABSTRACT

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Wild rice (*Zizania palustris* 'K-2') was inoculated with conidial suspensions of *Bipolaris oryzae*. Propiconazole was applied at 124, 186, and 247 g a.i./ha at boot and heading and 247 and 308 g a.i./ha at boot only. Plants treated with 124 g a.i./ha twice or 308 g a.i./ha once did not have significant ($P = 0.05$) yield increases or decreased disease severity when compared with the nontreated control. Plants treated with either 186 or 247 g a.i./ha at boot and heading had average significant yield increases of 54 and 87%, respectively. Only one application of propiconazole at 247 g a.i./ha resulted in a significant yield increase of 61% above the control. With the exception of the treatments at 124 and 308 g a.i./ha (phytotoxic), propiconazole reduced leaf infection by 80, 89, and 80% on the flag, F-1, and F-2 topmost leaves, respectively, when compared with the control.

Wild rice (*Zizania palustris* L.) is grown commercially on 11,129 ha in Minnesota and California (11). Fungal brown spot (FBS) of wild rice caused by *Bipolaris oryzae* (Breda de Haan) Shoem. (=*Cochliobolus miyabeanus* (Ito & Kuribayashi) Drechs. ex Dastur) is destructive in cultivated paddies in Minnesota (1,5) but not in California. Yield reductions associated with FBS have been quantified (6,7). Significant disease control can be achieved by the use of mancozeb (6), chlorothalonil, and/or iprodione (7,8). It has been demonstrated that *B. oryzae* can become tolerant to high concentrations of mancozeb in the laboratory (4). However, mancozeb is currently the only registered fungicide for FBS control on cultivated wild rice in Minnesota.

In 1985, 1986, and 1987, the efficacy of propiconazole at various rates in controlling FBS was studied at the University of Minnesota North Central Experiment Station in Grand Rapids. Propiconazole, a systemic fungicide having ergosterol-biosynthesis inhibiting properties (2), has demonstrated efficacy against many representative species in the Ascomycetes, Deuteromycetes, and Basidiomycetes (10). This is the first report of the effects of propiconazole at various rates on yield and control of FBS on cultivated wild rice.

MATERIALS AND METHODS

Wild rice seed, cultivar K-2, obtained from a commercial grower was stored in water at 2 C for 6 mo and then sown during the first week of May in 1985, 1986, and 1987. Experimental paddies were fertilized with 33.7 kg N/ha applied as urea and incorporated using a Rototiller. The seed was sown by hand-broadcasting at 11.25 kg/ha in 1.5 × 2.1 m plots. A second fertilization urea at 3.4 kg N/ha was made during the boot stage of plant development. Plots were sprayed with diazinon at 1.12 kg/ha 30 days after planting to control leaf miner (*Eribolus longulus* Loew) and with malathion at 1.12 kg/ha at early milk stage of grain development to control riceworm (*Apamea apamiformis* Guenee) (9).

Experimental design. A randomized complete block design with six replicates was used. Plant density in each plot was adjusted to 23 plants/m². Most plants produced approximately three tillers. Grain was hand-harvested from a 1.2 × 1.8 m area when the plants were at the 50% darkened grain (ripe) stage of plant development.

Inoculation. Isolates of *B. oryzae* were collected from lesions on cultivated wild rice plants in Minnesota, maintained on Difco potato-dextrose agar (PDA) slants at 24 C, and cycled through wild rice plants in the greenhouse to ensure pathogenicity. Cultures were reisolated from lesions on the infected plants and were single-spored. They were then maintained on PDA at 4 C in the dark. A grain culture medium consisting of oat, wheat, and rye (1:1:1) seed was placed in galvanized trays (30 × 20 × 10 cm) lined with aluminum foil and soaked for 12 hr in distilled water. After decanting the water, the trays were covered with aluminum foil and autoclaved at 121 C for 2 hr. Mycelial plugs from several isolates of *B. oryzae* were added and the medium was incubated at 24 C for 3 wk

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Table 1. The effect of various rates of propiconazole on the yield and disease severity of wild rice cultivar K-2 infected with fungal brown spot caused by *Bipolaris oryzae* in 1985, 1986, and 1987

Fungicide rate (g a.i./ha)	Growth stage at application	Yield (kg/ha)[y]			Percent disease severity			Average percent disease severity
		1985	1986	1987	1985	1986	1987	
124	Boot and heading	319 a	320 a	339 a	2/6/40[z]	3/8/30	4/5/30	3/6/33
186	Boot and heading	315 a	503 b	454 b	2/5/20	1/4/17	1/4/19	1/3/18
247	Boot and heading	508 c	617 c	690 c	1/3/5	1/2/4	1/4/4	1/3/4
247	Boot	407 b	493 b	491 b	2/2/15	1/3/15	1/3/15	1/3/15
308	Boot	332 a	344 a	304 a	1/2/10	1/2/10	1/2/18	1/2/13
Control		359 a	299 a	324 a	5/50/50	8/20/80	5/20/60	6/30/63

[y] Means in each column followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range test.
[z] Flag/F-1/F-2 leaves (from top down).

and then spread to dry in the laboratory (24 C).

One liter of bulked grain culture inoculum containing five isolates of *B. oryzae* was mixed with 3 L of water immediately before inoculation. The resulting condial suspension was sieved through a 300-μm (U.S. Standard Sieve Series No. 50, W. S. Tyler Co., Mintor, OH) screen and adjusted with water to a concentration of 1×10^6 condia/ml. Each disease-free plot was inoculated using a backpack sprayer (Hudson Stainless Steel Suprema 67376, H.D. Hudson Mfg. Co., Chicago, IL) at 4.2×10^5 N/m^2 at a height of 30–40 cm above the plants. Inoculations were usually made by 2000 hr on a day free of precipitation and with expected night temperatures of 18–23 C. An overhead misting system consisting of Maxijet nozzles (0.15-cm-diameter orifice) (Thayer Industries, Inc., P.O. Box 1849, Dundee, FL) was timer-activated for 12 hr after inoculation to provide intermittent moisture (on 12 3-min periods per hr) uniformly over the plots for 3 days. An electric motor and piston pump provided 3.4×10^6 N/m^2 to move the water from a large reservoir to the nozzles. Each nozzle delivered 1.9 L/cycle at 2.1×10^5 N/m^2. The distance between the nozzles was 6.95 m diagonally and 8.23 m front and back. The height of the nozzles was adjusted with plant growth.

Fungicide application. Propiconazole (Tilt, 3.6EC, Ciba-Geigy Corp., Greensboro, NC) was applied at 124, 186, 247, and 308 g a.i./ha. The fungicide was applied with a CO_2-pressurized sprayer that delivered 300 ml of material at 1.7×15 N/m per plot (331 L/ha). The chemical was applied either once at boot or again 14 days later at the heading stage of plant development. The control was sprayed with water only.

Yield and disease severity assessment. Each plot was hand-harvested. The plants were counted and the grain was threshed, dried at 90 C, dehulled, and weighed. Treatment means were compared by Duncan's new multiple range test. The percentage of diseased leaf area was recorded four times during the growing season for each plot with the aid of standard area diagrams (3) for Septoria leaf blotch (key no. 1.6.1). Disease ratings recorded for the flag, F-1, and F-2 topmost leaves were expressed as the percent of leaf area covered by lesions.

RESULTS AND DISCUSSION

Each year, propiconazole at 124 g a.i./ha had no significant ($P = 0.05$) effect on yield (Table 1). Also, the severity of FBS on the flag, F-1, and F-2 topmost leaves was greater than in other fungicide treatments.

In 1986 and 1987, propiconazole application of 186 g a.i./ha at both boot and heading stages of development resulted in increased yields ($P = 0.05$) of 68 and 40%, respectively, when compared with the control (Table 1). In 1985, a combination of poor seed germination (20%), requiring selected transplanting, and storm and bird damage may have contributed to yields that were generally lower in the fungicide treatments at 186 and 247 g a.i./ha.

When applied at 247 g a.i./ha during the 3 yr, propiconazole significantly increased yields (Table 1). Plants treated at both boot and heading produced significantly higher yields than other treatments. Yield increases of 42, 106, and 113% over the control occurred in 1985, 1986, and 1987, respectively. The average FBS over the 3-yr period on the flag, F-1, and F-2 topmost leaves were 1, 3, and 4%, respectively, when compared with an average 6, 30, and 63% for the control (Table 1). Plants receiving a single propiconazole application of 247 g a.i./ha during boot produced an average yield significantly greater than the control (average of 59%) in 1986 and 1987. Disease severity ratings on the flag, F-1, and F-2 topmost leaves averaged 1, 3, and 15%, respectively, for the 3-yr period (Table 1).

A single application of propiconazole at 308 g a.i./ha at boot did not significantly affect yield (Table 1). Phytotoxicity characterized by tissue death at the site of fungicide application occurred 5 days after application at the 124 g a.i./ha rate. However, the fungicide did inhibit pathogen development, as shown by lower FBS, when compared with both the control and the rates of 186 and 247 (at boot only) g a.i./ha over the 3-yr period (Table 1).

In summary, consistent significant control of FBS on cultivated wild rice throughout the season under controlled epidemic conditions was achieved by the application of propiconazole at 247 g a.i./ha at boot alone and/or at both boot and heading.

LITERATURE CITED

1. Bean, G. A., and Schwartz, R. 1961. A severe epidemic of Helminthosporium brown spot on cultivated wild rice in northern Minnesota. Plant Dis. Rep. 45:901.
2. Berg, D. 1986. Biochemical mode of action of fungicides: Ergosterol biosynthesis. Pages 25-52 in: Fungicide Chemistry—Advances and Practical Applications. M. B. Green and D. A. Spilker, eds. American Chemical Society, Washington, DC.
3. James, W. C. 1971. An illustrated series of assessment keys for plant diseases, their preparation and useage. Can. Plant Dis. Surv. 51:39-51.
4. Kardin, M. K., and Percich, J. A. 1983. Adaptation of mancozeb by *Bipolaris oryzae* and *B. sorokiniana*, the causal organisms of brown spot of wild rice. Plant Dis. 67:477-480.
5. Kernkamp, M. F., Kroll, R., and Woodruff, W. 1976. Diseases of cultivated rice in Minnesota. Plant Dis. Rep. 60:771-775.
6. Kohls, C. L. 1985. Epidemiology, yield reductions and field surveys of fungal brown spot of cultivated wild rice. Ph.D. thesis, University of Minnesota, St. Paul, MN. 154 pp.
7. Kohls, C. L., Percich, J. A., and Huot, C. M. 1987. Wild rice yield losses associated with growth-stage-specific fungal brown spot epidemics. Plant Dis. 71:419-422.
8. Percich, J. A., and Nickelson, L. J. 1982. Evaluation of several fungicides and adjuvant materials for control of brown spot of wild rice. Plant Dis. 66:1001-1003.
9. Peterson, A. G., Noetzel, D. M., Sargent, J. E., Hanson, P. E., Johnson, C. B., and Semawinata, A. T. 1981. Insects of wild rice in Minnesota. Pages 157-198 in: Minn. Agric. Exp. Stn. Misc. Rep.
10. Siegel, M. R. 1981. Sterol-inhibiting fungicides: Effects on sterol biosynthesis and sites of action. Plant Dis. 65:986-989.
11. Winchell, E. H., and Dahl, R. P. 1984. Wild rice production, prices, and marketing. Minn. Agric. Exp. Stn., Misc. Publ. 29-1984. 35 pp.