Further research should be conducted to determine if complex isolates would be selected against in natural and or agricultural systems. The isolates of anthracnose from Johnsongrass that infect sorghum and cause little damage might be manipulated as a useful biological control agent by possibly preemergent spraying of sorghum. There is a need for researchers who are studying the variability of C. graminicola to agree on a standard set of host-differential cultivars. The selected cultivars must exhibit low genotype × environment variance if they are to be adequate indicators of pathogen variability. Low host genotype × environment interaction appears in the study by Ali and Warren (1), in which plants at different growth stages produce the same reaction type in the field and greenhouse. Until there is some concordance among researchers it will not be possible to combine data to analyze population structures of this pathogen around the world.

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LITERATURE CITED


Comparison of Propiconazole and Mancozeb Applied Individually or Sequentially for Management of Fungal Brown Spot of Wild Rice

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ABSTRACT


Propiconazole and mancozeb applied at 0.24 and 1.12 kg a.i. ha⁻¹, respectively, to wild rice (Zizania palustris L.) plants inoculated with Bipolaris oryzae resulted in lower yields and higher disease severity ratings than fungicide-treated noninoculated controls. Inoculated plants receiving one application of propiconazole followed by two of mancozeb (at boot and heading) had higher yields than other inoculated plants. Between the two inoculated plants, the yield differences were not significant (P = 0.05) between those of noninoculated plants receiving four applications of mancozeb (at 7-day intervals, beginning at boot). Inoculated plants receiving one application of propiconazole plus two of mancozeb averaged 24% higher yields than inoculated plants receiving one application of propiconazole at either boot or heading. Propiconazole and mancozeb, individually or sequentially, resulted in significant (P = 0.05) increased yields in yield (20-120%) compared with the inoculated but noninoculated controls.

Additional keywords: C Cochliobolus miyabeanus

Wild rice (Zizania palustris L.) is grown commercially on 14,752 ha in Minnesota and California (13). Fungal brown spot, caused by Bipolaris oryzae (Breda de Haan) Schoen. (= Cochliobolus miyabeanus [Ito & Kurabayashi] ex Dastur), has resulted in widespread, recurrent, severe losses in cultivated fields of wild rice in Minnesota (1,9) but not in California. Yield reductions associated with epidemics of fungal brown spot have been quantified (10). The fungus (Dithane M-45) is currently the only registered fungicide for managing fungal brown spot in cultivated wild rice in Minnesota, where it has been applied at doses of 5 kg a.i. ha⁻¹. Although B. oryzae has not shown resistance to mancozeb in the field, resistant strains of the fungus have been selected in the laboratory (8).

Propiconazole is a systemic fungicide having ergosterol-biosynthesis inhibiting (EB1) properties similar to other related compounds (12). The fungicide is broad-spectrum and has shown efficacy against many representative species in the Ascomycetes, Deuteromycetes, and Basidiomycetes (4).

In 1985, 1986, and 1987, studies were done at the University of Minnesota North Central Experiment Station in Grand Rapids, MN, to determine the efficacy of propiconazole and mancozeb when used individually or sequentially at critical stages of plant development to control fungal brown spot on cultivated wild rice.
MATERIALS AND METHODS
Seed of the wild rice cultivar K-2, obtained from a commercial grower, was stored submerged in water at 2°C for 6 mo, then sown during the first week of May and June in 1984 and 1986. The experimental paddy was prepared by rototilling while incorporating 33.7 kg/ha of nitrogen, applied as urea. A second application of urea at 2.4 kg/ha was made during the boot stage of plant development. Seed was broadcast by hand in 1.5 × 2.1 m plots in a randomized complete block design with six replicates. Mean yield data were statistically analyzed (3). Plant density was adjusted to 23 plants per square meter. Most plants produced approximately three tillers. The plots were sprayed with the insecticide diazinon at 1.12 kg/ha 30 days after planting to control leafminers (Eriobius longatus (Loew)), then sprayed with malathion at 1.12 kg/ha at the early stage of grain filling (1.4) to control rice borer (Apamea apamifomis (Guenee)).

Inoculation. Isolates of B. oryzae were collected from lesions on cultivated wild rice plants in Minnesota, maintained on potato-dextrose agar slants (PDA) at 24°C and cycled through wild rice plants in the greenhouse to ensure pathogenicity. Cultures were reisolated from lesions on infested plants, single-spored, and subsequently maintained on PDA in the dark. A culture medium consisting of 3:1:4:16 (w:w:v) of cornmeal, rinsed perlite, and 3% PDA, respectively, was placed in aluminum foil-lined galvanized trays (30 × 30 × 10 cm), covered with two layers of aluminum foil and autoclaved for 1 hr at 121°C. After cooling for 4 hr, two PDA plates each containing 1- to 2-wk-old cultures of B. oryzae were diced into 1-cm squares and mixed into the medium. After 3 wk of incubation at 24°C, the inoculum was air-dried at 24°C, then stored in brown paper bags at 35°C until used. Approximately 1 L of bulk cornmeal-perlite inoculum, containing five to seven different isolates of B. oryzae, was mixed with 3 L of water immediately before inoculation. The resulting conidial suspension was sieved through a 300-μm screen and adjusted with water to a concentration of 1 × 10⁶ conidia per milliliter. Each plot was inoculated by means of a backpack sprayer (Hudson Stainless Steel Sprayer 67376, H.D. Hudson Mfg. Co., Chicago, IL) at 437 × 10⁶ m⁻² 30-40 cm above the plants. Inoculations were usually made by 2000 hrs on a day without rain and with expected night temperatures of 18–23°C.

An overhead misting system consisting of Maxjet nozzles (0.15-mm diameter orifice) (Theayer Industries, Inc., Dunede, FL) was timer-activated for 12 hr after inoculation to provide intermittent moisture (12-3 min periods per hour) uniformly over the plots. An electric motor and piston pump provided up to 260.9 × 10⁻⁶ m³ to move the water from a large self-filling reservoir to the nozzles. Each nozzle delivered 1.9 L per cycle of water at 203 × 15 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. Mancozeb (Dithane M-45WP) and propiconazole (Tilt 3.6EC) were applied at 1.12 and 0.24 kg a.i./ha, respectively. The fungicides were applied with a sprayer pressurized by carbon dioxide and delivering 300 ml of material at 1.7 × 15 N m⁻² per plot, equivalent to a rate of 33 L/ha. The initial application of the chemicals was made during the boot and early flowering stages of plant development, approximately 72 days after the plants emerged from the water. Mancozeb and propiconazole applications were made at 10- and 14-day intervals, respectively (Table 1). Treatments were coded with descriptors to indicate the pattern of fungicide use. The first letter was a C (control) or an I (inoculated). M represented an application of mancozeb and P, an application of propiconazole; these letters were used to indicate which fungicide was used in what sequence (Table 1).

Disease assessment. Disease severity ratings were recorded periodically for each plot. Standard area diagrams (6) for Septoria leaf blight were used to determine the percentage of diseased leaf area. Disease ratings were recorded for the individual leaves, and the amount of disease was expressed as the percentage of leaf area covered by lesions on the flag leaf and the second and third leaves down from the flag leaf.

RESULTS AND DISCUSSION
Yields were significantly different among treatments that were artificially or naturally infected (Table 2). Average yields of all treatments during 1986 were greater than those during 1987; this may have been due to earlier sowing and plant emergence in 1986. Plants that were misted but not inoculated or treated with fungicides (C) resulted in average yield reductions of 18 and 22% because of natural infection during 1986 and 1987, respectively, when compared with plants receiving five applications of mancozeb (CMM). Average yield losses approaching 20% in commercial fields not treated with mancozeb are not unusual (10). All treatments that were not artificially inoculated with B. oryzae had significantly greater yields than inoculated treatments, with the exception of those given one application of propiconazole followed by two of mancozeb (IPM). The CMM and IPM treatment yields did not differ significantly from each other (Table 2), although the IPM treatment resulted in a greater amount of leaf infection because

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (kg/ha) 1986</th>
<th>Yield (kg/ha) 1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>625.5</td>
<td>1.0</td>
</tr>
<tr>
<td>CMM</td>
<td>559.9</td>
<td>1.0</td>
</tr>
<tr>
<td>IPM</td>
<td>470.9</td>
<td>1.0</td>
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<td>IP</td>
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<td>1.0</td>
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<td>351.0</td>
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<tr>
<td>IP</td>
<td>324.0</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>308.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1 C = control, M = mancozeb, P = propiconazole, I = inoculated (see Table 1).

2 Means of a column followed by the same letter are not significantly different at the P = 0.05 level according to Duncan's new multiple range test.

3 Percentage of the flag- second third leaf area infected at harvest.
pump provided up to 0.3 m3 of water from a reservoir to the nozzle(s) in a 1.9 L cycle of 1 N.m. The distance from the nozzle(s) was 6.95 m front and back. The nozzle(s) was adjusted to 1.1 and 0.2 l per cycle, respectively. The fungicide was delivered at 331 L/ha. The chemical was applied at 1.0 cm and 1.2 cm long. The plants emerged from the ground and were recorded for the percentage of the surface area that was C (inoculated). The surface area of the plant was calculated with the average yield of 22% because of the disease. The yield of the plants was recorded for the percentage of the plant that was inoculated and the fungicide treatments (Table 2). This may have been due to the systemic activity of the plant in the developing epidemic coupled with the promotant activity of mancozeb later in the season during grain elongation (11). inoculated plants receiving two applications of propiconazole (IP) had significantly lower yields than those receiving either one application of mancozeb followed by one of propiconazole (MP) or IPR treatments (Table 2). Even though there were no visible phytotoxic effects (leaf and stem damage, incomplete grain filling, and or grain size differences) (10), there may have been some effect(s) on the resulting IPR yields (7). Inoculated plants receiving a single application of propiconazole (IP) resulted in the lowest yields of any treatment except the inoculated control (1) (Table 2). This may have been due to sustained disease pressure resulting from both natural and artificial sources of inoculum.

In diseased plants, mancozeb followed by mancozeb should be considered the most effective use of propiconazole in fungal brown spot management. In the absence of artificial inoculation, the CPM treatment performed the best. Therefore, the use of propiconazole alone or in conjunction with mancozeb is effective in the management of fungal brown spot in cultivated wild rice. When mancozeb, either alone or in sequence with propiconazole, is applied to cultivated wild rice when trace amounts of disease (one to ten lesions per leaf) are first found, excellent yields and disease control can result.

Fungal mutants resistant to EBI fungicides can be induced readily and are frequently cross-resistant to other EBI fungicides (2,4). The development of resistance to EBI fungicides in the field appears to be unlikely because of reduced fitness and pathogenicity of laboratory-selected resistant fungi (5). More complete information is needed on the biochemical mechanisms for increased resistance as well as on the reduced fitness of these mutants (4). Because it has been demonstrated that B. oryzae can become tolerant of mancozeb in the laboratory (6), its continued use alone to manage fungal brown spot of wild rice may be unwise. An evaluation of the judicious use of propiconazole and mancozeb coupled with their long-term effects on field populations of B. oryzae is in progress.

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LITERATURE CITED


