Evaluation of Several Fungicides and Adjuvant Materials for Control of Brown Spot of Wild Rice

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ABSTRACT

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Several fungicides separately and mancozeb in combination with each of five different adjuvant materials were field-tested for effectiveness in reducing brown spot of wild rice (*Zizania aquatica*) caused by *Drechslera oryzae* (*Bipolaris oryzae*) and *D. sorokiniana* (*B. sorokiniana*). The fungicides were applied on wild rice plants at 14-day intervals from early flowering until 26 days before harvest. The following fungicides significantly ($P = 0.05$) controlled brown spot (114 L of spray per hectare): benomyl 50WP at 1.1 kg/ha; chlorothalonil 6F at 2.9 kg/ha; mancozeb at 2.3 kg/ha; fenapanil (RH-2161) 50WP at 0.6 kg/ha; and iprodione (RP 26019) 50 flowable at 6.4 kg/ha. Two or three applications of mancozeb with Pinolene (Nu-Film) at 0.6 ml/L or Acrylocoat at 1.2 ml/L resulted in significantly better control than the recommended four applications of mancozeb with Triton CS-7 at 1.2 ml/L.

Brown spot of wild rice (*Zizania aquatica* L.) has caused recurring, widespread, and severe losses in cultivated paddies (1). In 1976, it was demonstrated that four applications of mancozeb plus Triton CS-7 resulted in increased yields by controlling brown spot (3). This is the first report of significant control of brown spot in wild rice caused by *Drechslera oryzae* (Breda de Haan) Subramanian & Jain (*Bipolaris oryzae* (Breda de Haan) Shoemaker) and *D. sorokiniana* (Sacc.) Subramanian & Jain (*B. sorokiniana*) utilizing several different fungicides and adjuvant materials.

MATERIALS AND METHODS

Fungicides and adjuvants. The following materials were field-tested at recommended label rates for other grass species for effectiveness in controlling brown spot of wild rice. The fungicides were anilazine [4,6-dichloro-*N*-(2-chlorophenyl)-1,3,5-triazin-2-amine], 2.3 kg/ha; benomyl [methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate], 1.1 kg/ha; chlorothalonil (tetrachloroisophthalonitrile), 2.9 kg/ha; fenapanil (RH-2161: experimental fungicide, Rohm and Haas Company, Philadelphia, PA), 0.6 kg/ha; iprodione (RP-26019: experimental fungicide, Rhône-Poulenc, Fresno, CA), 6.4 kg/ha; and mancozeb (coordination product of zinc ion and manganese ethylene bisdithiocarbamate), 2.3 kg/ha. The adjuvants were Acrylocoat (experimental hard resin adjuvant, Rohm and Haas Company), 1.2 ml/L; Pinolene (Nu-Film 17: Di-1-*p*-methane, Miller Chemical Company, Benton Harbor, MI), 0.6 ml/L; Rhoplex B-95 (experimental hard resin adjuvant, Rohm and Haas Company), 1.2 ml/L; Triton AG-98 (alkyl aryl polyxethylene glycol), 1.2 ml/L; Triton B-1956 (modified phthalic glycerol alkyl resin), 0.6 ml/L; and Triton CS-7 (alkyl aryl polyethoxylate and sodium alkylsulfonated-alkylate), 1.2 ml/L.

Field trials. A randomized split block design with seven replicates was used. Plots consisted of squares measuring 3×3 m with 200 plants in 1978 and 1979. A standardized inner square of 1.5×1.5 m was hand harvested for data determination. Fungicides and adjuvants were applied with a sprayer pressurized by carbon dioxide and delivering 300 ml of materials at 25 psi per plot, equivalent to a rate of 331 L/ha. The initial application of the various chemical materials was made during the late boot and early flowering stages of plant development, approximately 72 days after emergence. The three additional applications were made at 10-day intervals. Controls were sprayed with water.

Inoculation of plants. Wild rice plants, cultivar K_2, were inoculated with five different single-conidial isolates of both *D. oryzae* and *D. sorokiniana* from field-infected leaves. The fungi were maintained on potato-dextrose agar slants at 5 C and increased on potato-dextrose agar in petri dishes at 24 C under 12 hr of near ultraviolet light to induce abundant sporulation at 7 days. Conidial suspensions were used to inoculate sterilized, premoistened mixtures of oats, barley, and wheat seeds (5:5:1) in stainless steel trays ($16 \times 57 \times 70$ cm). The trays were incubated under 12 hr of near ultraviolet light and 12 hr of darkness at 24 C for 30 days. Aqueous inoculum suspensions were obtained by flooding mixtures in trays. Inocula containing 1×10^6 conidia were sprayed on plants until runoff. Plants were artificially inoculated 24 hr after each of the four applications of chemicals was made. Secondary infection from applied and presumably naturally occurring *Drechslera* spp. inocula did occur. Successful inoculations were confirmed by reisolations of the brown spot pathogens in unsprayed controls.

Plant evaluation. All plots were hand harvested 26 days after the last fungicide application. The grain from each plot was dried at 55 C for 72 hr and weighed (grams). An average disease index on a scale of 1–5 (1 = no leaf lesions, 2 = 25%, 3 = 50%, 4 = 75%, and 5 = 100% of leaf area covered with lesions) was determined at mid-flowering, early grain formation, and maturity for each test plot.

Mean yield data in all tests were compared using Duncan's multiple range test at the 5% level of significance.

RESULTS

All chemicals tested except iprodione resulted in increased yields by reducing brown spot of wild rice when applied at least twice (Table 1). Control plots had a disease index rating of 2.8 (46% of leaf area covered) averaged over the growing season. Yields increased in all fungicide-treated plots with additional applications, except those treated with the systemic compounds benomyl and fenapanil, in which phytotoxicity was characterized by a progressive and generalized, yellowish chlorosis after the third and fourth spray. However, plots sprayed only twice with either benomyl or fenapanil produced the highest significant ($P = 0.05$) yields recorded, with season average disease index of 0.8 and 1.4, respectively, for 1979 and 1980. This was true even though the plants were inoculated an additional two times with both *D. oryzae* and *D. sorokiniana* without a fungicide treatment preceding inoculation. The reisolation and identification of 260 fungal isolates from the control plots after the third spray yielded primarily *Dreschslera* spp. (60% of the isolates), *Colletotrichum* sp.

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Table 1. Control of brown spot of wild rice by several different fungicides applied up to four times during the crop season

	Seed weight (kg/ha)[y]				Increase over control (%)			
	Number of applications				Number of applications			
Treatment	1	2	3	4	1	2	3	4
Benomyl	494 b[z]	863 a	743 a	523 c	2 b	88 a	69 a	31 c
Chlorothalonil	505 b	628 b	629 a	707 a	4 b	37 c	57 b	76 b
Anilazine	486 b	541 bc	569 bc	580 c	1 b	18 d	29 d	46 c
Mancozeb	493 b	523 bc	763 a	772 a	2 b	14 d	73 a	94 a
Fenapanil	493 b	789 a	636 ab	523 c	2 b	72 b	45 c	31 c
Iprodione	597 a	597 bc	588 bc	688 ab	23 a	30 c	34 a	73 b
Control	485 bc	458 c	440 c	398 d				

[y] Mean seed weights of 14 pooled samples from two experiments, each having seven replicates per treatment.
[z] Means in each column followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range test.

Table 2. Comparison of various adjuvant materials in combination with mancozeb for brown spot control of wild rice

	Seed weight (kg/ha)[y]				Increase over mancozeb + Trition CS-7 (%)			
	Number of applications				Number of applications			
Treatments	1	2	3	4	1	2	3	4
Mancozeb alone	473 a[z]	467 bc	676 d	712 c	...	...	...	...
Mancozeb plus								
Triton CS-7	493 a	523 b	763 bc	772 c	...	...	...	...
Acrylocoat	533 ab	620 a	860 a	899 b	8 a	18 a	18 a	16 b
Pinolene	540 ab	575 a	909 a	1,066 a	10 a	10 b	19 a	38 a
Triton AG-98	501 a	571 a	672 d	611 de	2 b	9 b	...	...
Triton B-1956	511 a	552 ab	803 ab	849 c	4 b	6 c	5 b	10 c

[y] Mean seed weights of 14 pooled samples from two experiments, each having seven replicates per treatment.
[z] Means in each column followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range test.

(24%), *Fusarium* spp. (12%), *Cercospora* sp. (3%), and *Septoria* spp. (1%). However, isolates from benomyl-treated plants contained no *Colletotrichum* or *Cercospora* species.

Based on yield, anilazine and iprodione did not provide any disease control. Plants having four applications of iprodione had a disease index of 1.4 and yielded significantly more than did anilazine ($P = 0.05$).

Chlorothalonil and mancozeb at one, two, three, and four applications resulted in similar but significant brown spot control. Disease index ratings when averaged over the growing season were 1.6 and 1.7 for chlorothalonil and mancozeb, respectively. These fungicides resulted in greater increased yields at both three and four applications, except for benomyl at three applications, than any of the compounds tested.

Five different adjuvant materials, each in combination with mancozeb at one, two, three, and four applications, were compared (Table 2). The combination of mancozeb and Triton CS-7 at two and three applications resulted in significant yield increases compared with mancozeb alone. Two applications of mancozeb and Triton AG-98 did not increase yields significantly more than did the fungicide in combination with Triton CS-7. However, when mancozeb was applied with either Acrylocoat or Pinolene, significant yield increases resulted at two, three, and four applications compared with the fungicide and Triton CS-7. Even though Acrylocoat and Pinolene did not differ from each other at one, two, or three applications, yields were significantly different from each other after four applications, resulting in increases of 16 and 38%, respectively, over mancozeb plus Triton CS-7. Mancozeb with either Triton CS-7 or Triton B-1956 did not result in yields significantly different from each other regardless of the number of applications.

DISCUSSION

Field testing of six different chemicals in 1978 and 1979 indicated that when each was applied at least twice, significant increase in yields and reduction of brown spot of wild rice resulted.

The systemic compounds benomyl and fenapanil after just two applications resulted in the highest recorded yields. However, benomyl was phytotoxic, and fenapanil has been withdrawn from the market by the manufacturer. Benomyl may have increased yields by effectively controlling natural infection by *Colletotrichum* and *Cercospora* species. In Manitoba, anthracnose of wild rice, incited by an unidentified *Colletotrichum* sp., can affect at least 5% of the total leaf area and was found in 75% of the natural stands surveyed (D. A. R. McQueen, *unpublished data*). Investigations into the incidence and severity of anthracnose in cultivated wild rice paddies are in progress.

Anilazine and iprodione gave good yields with two applications. With increasing numbers of applications, however, they did not further increase yields, except iprodione at four applications. Both compounds are at least twice as expensive as mancozeb.

Mancozeb and chlorothalonil, regardless of the number of applications, did not differ significantly in their ability to control brown spot. However, increasing applications tended to increase yields. Chlorothalonil at the rate used is not as cost-effective as mancozeb. Therefore, because of economic and possible fungicide residue problems, mancozeb continues to be the fungicide of choice for controlling brown spot of wild rice.

Each adjuvant tested with mancozeb at two, three, and four applications resulted in significantly higher yields than mancozeb alone. Mancozeb plus Triton B-1956, regardless of number of applications, did not improve yields significantly compared with the mancozeb plus Triton CS-7.

Two, three, and four applications of mancozeb with either Acrylocoat or Pinolene resulted in significantly higher yields than the fungicide plus Triton CS-7. Good brown spot control with three or four applications of either adjuvant in combination with mancozeb appears to be possible. Both Acrylocoat and Pinolene, even at four applications, would cost no more than Triton CS-7.

Continuous exposure of *Drechslera* spp. to either mancozeb and chlorothalonil can result in fungal tolerance (2). Therefore, control of brown spot of wild rice may in the future necessitate the rotational use of two or more fungicides. Investigation of utilizing mancozeb and chlorothalonil at reduced rates and numbers of applications in combination with Acrylocoat or Pinolene is in progress.

LITERATURE CITED

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