Response of *Rhizoctonia solani* and Binucleate *Rhizoctonia* to Five Fungicides and Control of Pocket Rot of Table Beets with Foliar Sprays

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ABSTRACT

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The response of 107 isolates of *Rhizoctonia solani* AG 2-1, 2-2, 4, and 5, and binucleate *Rhizoctonia* collected from roots, petioles, and leaf tissues of table beets, as well as directly from hymenia of *Thanatephorus cucumeris*, were tested in vitro for sensitivity against five fungicides (benomyl, iprodione, pencycuron, tolclofos-methyl, and fludioxonil [CGA-173506]) each at four different concentrations. The growth of the isolates was inhibited by fludioxonil and tolclofos-methyl at 1 μg a.i./ml and iprodione at 10 μg a.i./ml, but the isolates varied considerably in sensitivity to pencycuron and benomyl even at 100 μg a.i./ml. Benomyl, iprodione, tolclofos-methyl, and fludioxonil were evaluated for control of disease under field conditions. Table beets were inoculated with soil infested with three highly virulent isolates of *R. solani*. In 1991, one spray of each of these fungicides at a rate of 2.2 kg formulated product per hectare was applied before or after inoculation with *R. solani*. The experiment was repeated in 1992, except that a second spray was applied 2 wk after the first spray. In both years, all fungicide applications significantly ($P < 0.01$) reduced the number of infected roots. In 1991, fludioxonil applied before the inoculation of *R. solani* reduced the incidence of infected roots from 21.8 to 3.8% and was the most effective treatment. In 1992, one spray before inoculation or two sprays (one before inoculation and the second 2 wk later) of fludioxonil reduced the incidence of infected roots from 14.6 to 1.2 and 0.7%, respectively. Fungicide applications made before inoculation with *R. solani* were more effective than those made after inoculation (1 day later). In the field, fungicides should be applied before the first cultivation, at which time a considerable amount of *R. solani* infested soil is thrown on the beet plants.

Additional keywords: *Beta vulgaris*, chemical control, root rot

Rhizoctonia solani Kühn, the anamorph of *Thanatephorus cucumeris* (A.B. Frank) Donk, causes foliar infections on table beets resulting in the disease pocket rot, which has become increasingly important in the vegetable production area of central New York State. Symptoms of pocket rot generally become evident late in the growing season and initially appear as brown to black cankers on petioles and crown tissues. Infections also move downward into the upper tissues of table beet roots and may progress laterally. Infections may cause death of plants and open areas (pockets) in the planting rows (17–19). Root rot is another important disease of table beets in New York State that can be caused by *R. solani* (1). This disease reduces both the yield and quality of the fleshy table beet roots.

R. solani anastomosis group (AG)-2-2 has been identified as the principal causal agent of pocket rot and root rot on table beets in New York State (18). In 1990, the teleomorph *T. cucumeris* was observed under field conditions for the first time in New York State on the crown and lower part of the petioles of table beets (17,19). Pocket rot is always severe when long periods of wet conditions prevail, since table beet petioles and crowns retain moisture, providing favorable conditions for disease development. Another important factor in the development of pocket rot is the current cultivation practice in which large tractors at high speed throw large amounts of soil (which may be infested) onto petioles and crown tissues of table beets (19).

Control measures for pocket rot of table beets in central New York are currently lacking. Several fungicides such as benomyl, chloroneb, iprodione, and PCNB (quintozene), are effective in controlling *Rhizoctonia* diseases on several crop species. Seed, soil, and foliar applications of these fungicides have controlled *Rhizoctonia*-incited diseases on snap bean, lima bean, cowpea, celery, and other crops (14,20,25). At the present time, chemical control of pocket rot in New York State is not feasible, since none of these fungicides are registered for use on table beets. The objectives of this study were 1) to determine the in vitro sensitivity of 107 isolates of *R. solani* and binucleate *Rhizoctonia* obtained from naturally infected table beets to fungicides known to be effective against *Rhizoctonia*, and 2) to evaluate the efficacy of foliar sprays of these fungicides for control of pocket rot under field conditions.

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MATERIALS AND METHODS

Response of *Rhizoctonia* isolates to fungicides. One hundred and seven isolates of *Rhizoctonia* obtained from naturally infected root, petiole, and leaf tissues of table beets (98 isolates were multinucleate and identified as *R. solani*; nine isolates were binucleates) were tested against five fungicides. These isolates were previously characterized according to anastomosis groups, cultural features, and pathogenicity to foliar and root tissues of table beets (18).

The experimental fungicides Rizolex 75 WP (tolclofos-methyl), CGA-173506 50 WP (fludioxonil), and Monceren 50 WP (pencycuron), and the standard fungicides Benlate 50 WP (benomyl), and Rovral 50 WP (iprodione) were evaluated against eight isolates of *Rhizoctonia*: six of AG-2-2, one of AG-4, and one of AG-5. The fungicides were added to potato dextrose agar (PDA) at four concentrations: tolclofos-methyl and fludioxonil at 0, 0.1, 1, and 10 μg a.i./ml; benomyl, iprodione, and pencycuron at 0, 1, 10, and 100 μg a.i./ml. Mycelial disks (5-mm diameter) were transferred from the margin of 2-day old colonies to the center of PDA plates with or without the appropriate fungicide. Five plates were used for each isolate and for each fungicide concentration. The percentage inhibition of linear growth of the isolates was compared with the control (PDA without fungicide) after 48 hr of incubation at 28 C in the dark. The remainder of the isolates of *R. solani* and binucleate isolates were evaluated against each fungicide at one concentration. The data were subjected to ANOVA. The means of the effect of the fungicides were compared by least significant difference (LSD).

Control of pocket rot of table beets with foliar sprays of fungicides. Four fungicides (benomyl [Benlate], iprodione [Rovral], fludioxonil [CGA-173506], and tolclofos-methyl [Rizolex]) were evaluated under field conditions. In 1991,

Table 1. Inhibition of radial growth of eight isolates of *Rhizoctonia solani* by five fungicides

Fungicide concentration (μg/ml)	Inhibition of radial growth (%)[z] by isolate no. and anastomosis group							
	515 AG-4	550 AG-5	582 AG-2-2	589 AG-2-2	597 AG-2-2	619 AG-2-2	660 AG-2-2	665 AG-2-2
Tolclofos-methyl								
0.1	64.4 ± 1.3	60.6 ± 4.8	68.9 ± 2.3	65.6 ± 0.5	53.9 ± 2.6	66.1 ± 2.7	49.2 ± 3.8	62.7 ± 3.6
1.0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0
10.0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0
Fludioxonil								
0.1	81.4 ± 1.1	74.4 ± 1.1	67.8 ± 1.8	58.7 ± 2.2	91.1 ± 1.0	70.0 ± 2.9	57.1 ± 8.1	76.3 ± 4.6
1.0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0
10.0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0
Iprodione								
1.0	70.9 ± 3.0	67.4 ± 0.9	71.1 ± 2.6	54.4 ± 2.9	72.8 ± 0.7	62.8± 1.8	29.7 ± 3.5	53.5 ± 0.9
10.0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0
100.0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0	100.0 ± 0
Pencycuron								
1.0	3.1 ± 1.4	0 ± 0	89.5 ± 1.3	94.7 ± .8	96.4 ± 1.0	62.8 ± 1.2	94.3 ± 0.9	70.5 ± 3.8
10.0	17.3 ± 4.4	25.6 ± 2.6	89.7 ± 0.8	83.9 ± 7.9	95.0 ± 1.4	77.1 ± 2.3	93.7 ± 2.5	86.1 ± 2.1
100.0	22.4 ± 3.2	33.3 ± 1.2	73.6 ± 1.5	84.6 ± 0.8	79.6 ± 2.9	82.1 ± 2.3	80.0 ± 3.6	80.0 ± 5.8
Benomyl								
1.0	9.8 ± 4.3	68.5 ± 0.8	23.6 ± 1.6	6.9 ± 3.6	0 ± 0	0 ± 0	48.6 ± 2.4	0 ± 0
10.0	91.5 ± 0.8	90.7 ± 1.9	53.9 ± 3.1	42.6 ± 4.4	72.5 ± 1.8	55.4 ± 6.0	77.1 ± 2.0	57.6 ± 1.9
100.0	96.6 ± 0.5	94.4 ± 2.6	79.5 ± 3.4	75.4 ± 3.3	100.0 ± 0.0	77.1 ± 8.3	100.0 ± 0.0	87.8 ± 3.6

[z] Expressed relative to growth in the control (no fungicide) measured after 48 hr of growth at 28 C. Data are the means of five replicate dishes ± the standard error.

Table 2. Analysis of variance, least significant difference (LSD) and range of the linear growth inhibition of 107 isolates of *Rhizoctonia* by five fungicides[w]

	Growth inhibition (%)[x,y]			
	Mean	Range	df	Mean square[z]
Fungicide (a.i./ml)				
Iprodione (10 μg)	99.9 a	98–100		
Fludioxonil (1 μg)	99.5 a	86–100		
Tolclofos-methyl (1 μg)	99.4 a	75–100		
Pencycuron (100 μg)	74.3 b	0–100		
Benomyl (100 μg)	73.9 b	6–100		
Source of variation				
Fungicide			4	104,510.4*
Isolate			106	1,118.6*
Fungicide × isolate			424	1,556.0*
Error			2,140	27.0
Total			2,674	

[w] The *F* value to test the effect of fungicide on *Rhizoctonia* isolates was calculated using the mean square of the fungicide × isolate interaction.
[x] Values are the mean of five replicates. Means in each column followed by the same letter do not differ statistically ($P < 0.05$) according to the LSD test.
[y] The percentage of growth in the control after 48 hr of incubation at 28 C in the dark.
[z] * Indicates significance at $P \leq 0.001$.

one spray at a rate of 2.2 kg formulated product per hectare in 920 L of water was applied before or after artificial inoculation. Plants were inoculated with a soil-potato inoculum preparation of *Rhizoctonia* (2%, v/v) (12) by spreading 100 ml of inoculum per meter of row onto the petiole and crown tissues. The inoculated areas were immediately covered with field soil to simulate cultivation conditions, where soil is generally thrown on the lower plant parts. Overhead irrigation was applied shortly after inoculation and later as needed in order to create favorable conditions for disease development. This inoculation procedure was shown to be the best for development of pocket rot under field conditions (19). Three isolates of *R. solani* (nos. 513, 521, and 655) were used in the preparation of inoculum. These isolates were grown separately in the soil-potato medium, mixed together in equal volumes, and then diluted with pasteurized potting soil mixture at a rate of 2% (v/v). The experiment was repeated in 1992 with one modification; additional plots were established that received a second spray applied 2 wk after the first spray. Each plot consisted of 2 rows (5 m in length with 90-cm between rows) of 2-mo-old table beet cultivar Ruby Queen. The experimental designs were factorials with added control in four randomized complete blocks. Two rows of beets were left as a border between the treatments, and 2 m of row (break) was left among the blocks.

The percentage of plants that exhibited root and foliar infections and the severity of pocket rot development were determined 4 wk after inoculation. Disease severity was determined using a scale of 1 (no disease symptoms visible or healthy plants) to 9 (more than 75% of tissues affected) (18). Percentages of infected roots, foliar infections, and severity of pocket rot development data were subjected to ANOVA, and the LSD test was performed when significant differences among the means were found.

RESULTS

Response of isolates of *Rhizoctonia* to fungicides. The growth of all eight isolates was inhibited by tolclofos-methyl and fludioxonil at 1 μg a.i./ml (Table 1), and was greatly reduced at 0.1 μg a.i./ml. No growth was observed with iprodione at a concentration of 10 μg a.i./ml. The isolates differed in response to pencycuron and benomyl, and growth occurred even at a concentration of 100 μg a.i./ml (Table 1). For example, growth of *R. solani* isolates 515 and 550 (AG-4 and AG-5) was not affected at 1 μg a.i./ml of pencycuron and was not seriously reduced at 10 or 100 μg a.i./ml. Conversely, growth of several isolates of AG-2-2 was reduced by over 50% at 1 μg a.i./ml of pencycuron and by more than 80% at 10 or 100 μg a.i./ml. Isolates 515 and 550 were very sensitive to benomyl, with no growth occurring at 10 and 100 μg a.i./ml. All AG-2-2 isolates were unaffected by benomyl at 1 μg a.i./ml, and varied in percent inhibition at 10 μg a.i./ml (33–75%) and 100 μg a.i./ml (67–100%) (Table 1).

The remainder of the isolates were evaluated for their responses to tolclofos-methyl and fludioxonil at 1 μg a.i./ml, to iprodione at 10 μg a.i./ml and to pencycuron and benomyl at 100 μg a.i./ml. There were highly significant differences in the percentage of growth inhibition of isolates among the five fungicides (Table 2). The fungicide-isolate interaction was also highly significant ($P <$

0.001), suggesting that the isolates responded differently to the various fungicides. Linear growth of the 107 isolates was almost completely inhibited by tolclofos-methyl and fludioxonil at a concentration of 1 μg a.i./ml and by iprodione at 10 μg a.i./ml. The percentage of growth inhibition by these fungicides was very high (>99%) (Table 2). The overall growth inhibition of the isolates by benomyl and pencycuron was also high (>70%) and was significantly different from that of tolclofos-methyl, fludioxonil, and iprodione (Table 2).

Growth inhibition by AGs of *R. solani* and binucleate *Rhizoctonia* differed significantly according to the fungicide used (Table 3). Tolclofos-methyl, iprodione, and fludioxonil were able to inhibit completely all the AGs of *R. solani* and binucleate *Rhizoctonia*. AG-2-1 and AG-2-2 isolates were less inhibited by benomyl. Isolates of *R. solani* in AG-4 and AG-5, as well as the binucleate *Rhizoctonia* isolates, were less sensitive to pencycuron (Table 3).

Control of pocket rot of table beets with foliar sprays. In both 1991 and 1992, all fungicide applications significantly reduced the incidence and severity of pocket rot. There were highly significant differences ($P < 0.01$) among the fungicide treatments compared with the uninoculated control in percentage of *R. solani* infected roots and severity of pocket rot development (Tables 4 and 5). In both years, significant differences in the incidence and severity of disease were also detected between the times of application of the fungicide (either before or after inoculation with *R. solani*) (Table 4).

In 1991, the percentage of infected roots averaged 21.8% and severity of pocket rot symptoms averaged 5.3 in the control. One application of fludioxonil applied before inoculation was the most effective treatment since it reduced pocket rot incidence to 3.8% and the disease severity rating to 3.3. Tolclofos-methyl, iprodione, and benomyl sprays applied before inoculation with *R. solani* were also effective in controlling pocket rot (Table 6). Although the incidence of foliar infections by *R. solani* was reduced by some of the fungicide treatments, the incidence of foliar infections was relatively high (Table 6). However, most of the lesions incited by *R. solani* on fungicide-treated plants were relatively small and remained restricted.

In 1992, the percentage of infected roots was reduced from 14.6 to 0.7% with two applications of fludioxonil (one before and one after inoculation with *R. solani*) (Table 6). One spray of fludioxonil before inoculation was also effective. One or two sprays of tolclofos-methyl and iprodione also reduced the percentage of infected roots significantly, especially when the first spray was applied before inoculation. The severity of pocket rot symptoms in the nonsprayed control averaged 4.3. This was reduced to 2.0 with two sprays of fludioxonil (one before and one after inoculation with *R. solani*). One or two sprays of tolclofos-methyl and iprodione before inoculation with the pathogen were also effective. The incidence of foliar infections was reduced by the fungicides, and there were differences among the various treatments. The percentage of foliar infections in the nonsprayed control was 9.9, and this was reduced to 2.4 and 2.6% with two sprays (one before and one 2 wk later) of iprodione and fludioxonil, respectively. In general, it was observed that sprays applied before inoculation with *R. solani* in both years were more effective for control of *R. solani* than those made after inoculation (Table 6).

DISCUSSION

Isolates of *R. solani* and binucleate *Rhizoctonia* obtained from naturally infected table beets in New York exhibited variable sensitivity to fungicides in vitro. The experimental fungicides tolclofos-methyl and fludioxonil were very effective at low concentrations in

Table 3. Least significant difference (LSD) analysis of the percentage of radial growth inhibition of anastomosis groups of isolates of *Rhizoctonia solani* and binucleate *Rhizoctonia* by five fungicides[y]

		Fungicide[z]				
Rhizoctonia group	No. of isolates	Tolclofos-methyl	Benomyl	Iprodione	Pencycuron	Fludioxonil
AG-2-1	2	100.0 a	80.6 b	100.0 a	98.3 a	100.0 a
AG-2-2	86	99.5 a	68.9 c	100.0 a	86.4 b	99.6 a
AG-4	6	98.0 b	95.6 a	100.0 a	20.8 d	99.3 a
AG-5	4	100.0 a	96.0 a	99.6 b	43.4 c	98.9 a
Binucleate	9	100.0 a	100.0 a	100.0 a	13.4 d	99.2 a

[y] Isolates of *Rhizoctonia* were evaluated on potato dextrose agar amended with a fungicide as follows: tolclofos-methyl and fludioxonil at 1 μg a.i./ml, iprodione at 10 μg a.i./ml, and pencycuron and benomyl at 100 μg a.i./ml. The radial growth inhibition was measured after 48 hr of incubation at 28 C in the dark. Data are the means of five replicate dishes per isolate.

[z] Means in each column followed by the same letter do not differ statistically ($P < 0.05$) according to the LSD test.

Table 4. Statistical analysis of the data on incidence and severity of pocket rot of table beets incited by *Rhizoctonia solani* under field conditions as influenced by fungicide applications[u]

		Means[v] (LSD)		
Source of variation	df	Infected roots[w] (%)	Disease severity[x]	Foliar infections[y] (%)
1991				
Replications	3	51.5	1.4	9.0
Control vs. fungicides	1	545.6***	3.6***	0.1 ns
Fungicides	3	29.7 ns	1.8**	25.8 ns
Application (before/after)[z]	1	148.8**	3.1***	29.3 ns
Fungicide × application	3	9.1 ns	0.2 ns	49.1 ns
Residual	24	20.9	0.4	22.2
Total	35	41.9	0.8	23.3
1992				
Replications	3	16.4	1.0	45.5
Control vs. treatments	1	429.8***	8.3***	195.8***
Fungicides	3	55.6***	3.4***	30.7*
Application	1	96.5***	5.6***	75.5**
Sprays	1	25.0*	2.6*	77.7**
Fungicides × application	3	1.8 ns	0.3 ns	11.6 ns
Fungicide × sprays	3	0.4 ns	0.3 ns	2.6 ns
Applications × sprays	1	4.6 ns	0.8 ns	2.4 ns
Fungicide × application × sprays	3	1.1 ns	0.7 ns	14.5 ns
Residual	48	8.8	0.7	12.3
Total	67	18.0	1.0	18.7

[u] All fungicides were applied at a rate of 2.2 kg of formulated product per hectare in 920 L of water.

[v] ***, **, and * refer to statistical significance at $P \leq 0.01$, $P \leq 0.05$, and $P \leq 0.10$, respectively; ns refers to no significant difference.

[w] Mean percentage of fleshy roots infected with *R. solani* recorded 4 wk after inoculation.

[x] Disease severity ratings recorded on a scale from 1 (healthy plants) to 9 (>75% of tissue affected).

[y] Mean percentage of plants with infection on aboveground tissues (petioles and leaves).

[z] In 1991, one fungicide application was made either one day before (B) or one day after (A) inoculation with three different isolates of *R. solani*. In 1992, a second fungicide application was applied two weeks after the first spray.

Table 5. Statistical analysis of incidence and severity of pocket rot of table beets as influenced by applications of five fungicides[v]

Fungicide	*n*	Means[w] (LSD) Infected roots[x] (%)	Disease severity[y]	Foliar infections[z] (%)
1991				
Control (uninoculated)	4	21.8 a	5.3 a	16.7 a
Tolclofos-methyl	8	9.9 b	4.3 bc	15.7 a
Fludioxonil	8	6.6 b	3.6 c	14.7 a
Benomyl	8	9.9 b	4.8 ab	18.9 a
Iprodione	8	11.1 b	4.4 b	17.0 a
1992				
Control (uninoculated)	8	14.6 a	4.3 a	13.1 a
Tolclofos-methyl	16	3.4 c	2.6 b	6.3 bc
Fludioxonil	16	2.4 c	2.4 b	4.2 c
Benomyl	16	6.6 b	3.4 a	7.5 b
Iprodione	16	3.3 c	2.6 b	5.5 bc

[v] All fungicides were applied at a rate of 2.2 kg of formulated product per hectare in 920 L of water.
[w] Means in each column followed by the same letter do not differ significantly ($P = 0.05$) according to the LSD test.
[x] Mean percentage of fleshy roots infected with *Rhizoctonia solani* recorded 4 wk after inoculation.
[y] Disease severity ratings recorded on a scale from 1 (healthy plants) to 9 (>75% of tissue affected).
[z] Mean percentage of plants with infection on aboveground tissues (petioles and leaves).

Table 6. Effect of foliar sprays of fungicides on incidence and severity of pocket rot of table beets incited by *Rhizoctonia solani* under field conditions

Fungicide[u]	Application time[v]	Infected roots[w] (%)	Disease severity[x] (1-9)	Foliar infections[y] (%)
1991				
None (control)	...	21.8 a[z]	5.3 a	16.7 a-c
Iprodione	A	14.0 b	4.5 a-d	20.8 ab
Tolclofos-methyl	A	12.1 b	4.8 a-c	17.4 a-c
Benomyl	A	10.6 b	5.0 ab	16.7 a-c
Fludioxonil	A	9.4 bc	4.0 c-e	15.3 a-c
Benomyl	B	9.3 bc	4.5 a-d	21.1 a
Iprodione	B	8.1 bc	4.3 b-d	13.2 c
Tolclofos-methyl	B	7.7 bc	3.8 ed	14.0 bc
Fludioxonil	B	3.8 c	3.3 e	14.1 bc
1992				
None (control)	...	14.6 a	4.3 a	9.9 ab
Benomyl	A	8.7 b	4.0 ab	13.1 a
Benomyl	A+2 wk	7.7 bc	3.8 a-c	8.0 b-d
Benomyl	B	5.8 b-d	3.5 a-d	8.5 a-c
Tolclofos-methyl	A	5.7 b-d	3.0 b-e	8.1 bc
Iprodione	A	4.9 b-e	3.5 a-d	7.6 b-e
Fludioxonil	A	4.8 b-f	3.0 b-e	7.6 b-e
Benomyl	B+2 wk	4.3 c-f	2.5 de	3.8 c-f
Tolclofos-methyl	A+2 wk	3.3 d-f	2.5 de	4.2 c-f
Iprodione	A+2 wk	3.3 d-f	2.5 de	6.9 b-f
Fludioxonil	A+2 wk	2.8 d-f	2.3 e	3.7 c-f
Tolclofos-methyl	B	2.6 d-f	2.8 c-e	6.1 b-f
Iprodione	B	2.5 d-f	2.3 e	5.3 b-f
Iprodione	B+2 wk	2.5 d-f	2.3 e	2.4 f
Tolclofos-methyl	B+2 wk	1.9 d-f	2.3 e	6.9 b-f
Fludioxonil	B	1.3 ef	2.3 e	3.0 d-f
Fludioxonil	B+2 wk	0.7 f	2.0 e	2.6 ef

[u] All fungicides were applied at a rate of 2.2 kg of formulated product per hectare in 920 L of water.
[v] In 1991, one fungicide application was made either 1 day before (B) or one day after (A) inoculation with three different isolates of *R. solani*. In 1992, a second fungicide application was applied 2 wk after the first spray.
[w] Mean percentage of fleshy roots infected with *R. solani* recorded 4 wk after inoculation.
[x] Disease severity ratings recorded using a scale from 1 (healthy plants) to 9 (>75% of tissue affected).
[y] Mean percentage of plants with infection on aboveground tissues (petioles and leaves).
[z] Values are the means of four replicates. Means in each column followed by the same letter do not differ significantly ($P = 0.05$) according to the least significant difference test.

inhibiting radial growth of the isolates. Tolclofos-methyl is an aromatic hydrocarbon fungicide compound (organic phosphate) that is used as a contact material, with a curative and protective activity, especially against some soilborne fungi (16). Tolclofos-methyl at 0.1 and 1 μg a.i./ml has also been reported to inhibit radial growth of *R. solani* isolates from peanuts (3). However, isolates of *Sclerotium rolfsii* were not affected by tolclofos-methyl except at much higher rates (100 and 1,000 μg a.i./ml) (3,8). Tolclofos-methyl was reported to be more effective than PCNB in reducing incidence of *Rhizoctonia* on peanuts (3). Tolclofos-methyl in combination with other fungicides has been used for soil disinfestation, seed treatment, and foliar sprays. Tolclofos-methyl in combination with iprodione gave adequate control of *Rhizoctonia* and *Botrytis* on lettuce (24). Treatments of bean seeds with tolclofos-methyl, applied either as a dust treatment or by infusion in acetone solution, reduced preemergence mortality and hypocotyl rot caused by *R. solani* (21).

Fludioxonil is a new class of nonsystemic fungicides related to the natural antibiotic pyrrolnitrin. It has a broad spectrum of activity at low rates of application and is used as a seed treatment and foliar spray (6,13). Fludioxonil is active not only against Basidiomycetes but also against Ascomycetes and Deuteromycetes (13) and effective against pathogens with resistance to currently used chemicals (such as benzimidazoles, dicarboximides, and guanidines). This fungicide may be a suitable component of a strategy to overcome fungicide resistance in plant pathogens of many crops (6).

Isolates of *Rhizoctonia* from table beets were very sensitive to iprodione at a relatively low concentration (10 mg a.i./ml). Similar results were found by Martin et al (15), who reported that isolates of *R. solani*, *Rhizoctonia*-like fungi and *R. zeae*, from different sources, were extremely sensitive to iprodione. Iprodione is an organic fungicide (dicarboximide compound) used as a foliage-contact material essentially for protective activity (22). This fungicide has also been reported to strongly inhibit 10 different anastomosis groups of *R. solani* at very low concentrations (11). Foliar blight caused by basidiospore inoculum of AG-2-2 isolates of *R. solani* was effectively controlled by sprays of iprodione in Japan (26). Iprodione is also used for effective control of bottom rot of lettuce (20) and sheath blight of rice caused by *R. solani* (9).

The sensitivity of *Rhizoctonia* isolates from table beets to pencycuron and benomyl at 100 μg a.i./ml was variable. Large number of the isolates showed less than 50% inhibition by these fungicides. Pencycuron, a phenylurea compound, is

used as a protective contact fungicide to control diseases caused by *R. solani* (30). Isolates of *R. solani* causing damping-off of radishes were found to be highly resistant to pencycuron, and they were not inhibited even at 1,000 μg a.i./ml, but they were sensitive to benomyl at 50 μg a.i./ml (5). A number of the AG-4 and AG-5 isolates of *R. solani* as well as the binucleate isolates obtained from table beets in this study were also highly resistant to pencycuron. This fungicide has been reported to be ineffective against isolates of AG-2-1, AG-4, AG-5, AG-7, and AG-8 but very effective against AG-2-2, AG-3, AG-6, and AG-9 isolates (11). However, in this study the sensitivity of AG-2-2 isolates from table beets to pencycuron was variable and in some cases very low. Mycelial growth of AG-4 isolates of *R. solani* from chrysanthemum was reported to be significantly reduced by pencycuron (29). Pencycuron has been found to be very effective in controlling sheath blight of rice caused by AG-1 isolates of *R. solani* as well as diseases caused by AG-2-2 isolates on sugar beets and other crops. This chemical inhibits germination of the sclerotia of *R. solani* (30). In the United States, pencycuron has significantly reduced *Rhizoctonia* root and crown rot on sugar beets caused by AG-2-2 (27).

Benomyl is a benzimidazole systemic foliar fungicide with a broad spectrum of activity against a large number of important fungal pathogens (4). The variable sensitivity of *R. solani* and binucleate *Rhizoctonia* from table beets to benomyl contrasts with results reported by researchers who have reported *Rhizoctonia* isolates to be highly sensitive to benomyl at 100 μg a.i./ml (2,5,15). Resistance to benomyl has been documented in several fungal pathogens including *Botrytis cinerea* (2), *Venturia inaequalis* (28), and *Sphaerotheca fuliginea* (23). *R. solani* and binucleate *Rhizoctonia*-like fungi have also been reported to vary in their sensitivity to the fungicide PCNB (15). Foliar sprays of benomyl have also been effective in controlling diseases incited by *Rhizoctonia* such as sheath blight on rice (10) and web blight on beans (7).

We demonstrated that one or two foliar sprays of each of the fungicides tested were effective in reducing the incidence and severity of pocket rot under field conditions. Fungicide applications made before inoculation with *R. solani* were found to be more effective than those applied after inoculation. These results suggest that fungicides should be applied before or at cultivation time, when infested soil is thrown up on petioles and crown tissues of table beets, to effectively control pocket rot under commercial field conditions (25). However, the number of sprays required, the minimum effective dosage of fungicidal concentrations, and other factors need to be studied further.

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