Prelayby Applications of Experimental Fungicides for Suppressing Rhizoctonia Root Rot in Sugar Beet

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ABSTRACT

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In a 3-yr study, prelayby applications of experimental fungicides Bay NTN 19701, triadimefon, triadimenol, and Bay HWG 1608 suppressed Rhizoctonia root rot in sugar beet; suppression was more pronounced in a susceptible than in a resistant cultivar. Generally, Bay NTN 19701 and Bay HWG 1608 at 28 and 14 g a.i./305 m of row provided the most supression. In-furrow applications and those made at the cotyledon or four- to six-leaf stage provided more suppression than those made at layby, when the foliage nearly covered the furrows. A split application of these fungicides at half-rates per application was as effective as the application at the cotyledon stage, indicating that most of the effectiveness was due to the early treatment. Soil population densities of *Rhizoctonia solani* at harvest were correlated with disease severity and negatively associated with recoverable sucrose from sugar beet.

Rhizoctonia root rot of sugar beet (*Beta vulgaris* L.) induced by *Rhizoctonia solani* Kühn causes appreciable losses in many sugar beet-producing areas of the world. The disease usually becomes evident in midsummer, when chemical control measures are impractical and ineffective.

Various fungicides have reduced root rot intensity in sugar beet (7,10–14), but the chemicals always were applied immediately before or after artificial inoculation of plants. Results of such tests, though important for determining efficacy of the chemicals against the pathogen, do not provide information on the timing of applications under natural conditions.

In Fort Collins, we have developed a system for field experiments with *R. solani* that closely simulates natural conditions encountered by growers. In an area of our previous year's breeding nursery, inoculated, rotted roots are disk-incorporated. Planting and harvest dates, as well as cultural practices employed, are similar to those of commercial sugar beet production. Thus, the objective of our study was to determine if early applications of promising experimental fungicides would provide season-long disease suppression under quasicommercial conditions. A preliminary report was published (8).

MATERIALS AND METHODS

Experimental design. In 1984, 1985, and 1986, randomized complete block designs were used with five replicates. Each year, two-row plots were 6 m long with 56 cm between rows. Cycloate at the recommended rate was applied preplant for weed control, and plots were planted on 19, 11, and 16 April each year, respectively. Seedlings were thinned to about 25 plants per 6-m row after 4–5 wk.

In 1984 and 1985, to ensure uniformity, dry, ground, barley-grain inoculum of *R. solani* (isolate R-9, AG-2; about 82 colony-forming units [cfu] per gram) (9) was broadcast at 56 kg/ha across the experimental site and incorporated 10 cm deep before planting. In 1986, to more

Table 1. Effects of three fungicides at three application times on the responses of resistant and susceptible sugar beets to infection by *Rhizoctonia solani* in the field in 1984[a]

Cultivar	Fungicide[b]	Application time[c]	Disease index[d]	Sucrose (%)	Roots (t/ha)
Mono-Hy RH83 (moderately resistant)	Bay NTN 19701	Early	2.2 fg	9.7 e	48.2 e
		Mid	2.8 ef	10.3 e	45.7 e
		Late	2.2 fg	10.9 e	50.2 e
	Triadimefon	Early	2.5 fg	9.6 e	47.7 e
		Mid	3.6 e	9.9 e	39.4 e
		Late	2.0 fg	10.9 e	48.6 e
	Triadimenol	Early	1.8 g	10.8 e	53.5 e
		Mid	2.2 fg	10.2 e	49.5 e
		Late	1.9 fg	10.5 e	51.5 e
	Untreated	···	2.2 fg	10.5 e	49.1 e
Mono-Hy A4 (susceptible)	Bay NTN 19701	Early	2.8 yz	10.0 xy	49.1 vwx
		Mid	2.7 z	10.0 xy	50.8 v
		Late	2.4 z	10.1 xy	50.0 vw
	Triadimefon	Early	4.2 x	9.5 xy	39.9 xy
		Mid	3.5 xy	9.3 yz	40.8 wxy
		Late	4.1 x	10.4 x	33.8 yz
	Triadimenol	Early	2.4 z	10.4 x	52.0 v
		Mid	3.5 xy	9.6 xy	43.5 vwx
		Late	2.3 z	10.6 x	50.0 vw
	Untreated	···	5.0 w	8.4 z	29.3 z

[a] Means of five replicates; means within columns within each cultivar followed by the same letter are not significantly different at $P = 0.05$.
[b] Bay NTN 19701 was applied at 40 g a.i./305 m of row, whereas triadimefon and triadimenol were applied at 14 g a.i./305 m of row. Chemicals were applied once, in a 10-cm band down the row and into the beet crown.
[c] Early application was made at the cotyledon stage, mid application was made at the four- to six-leaf stage, and late application was made just before layby when the plants were nearly covering the furrows.
[d] Disease index based on a scale of 0–7, where 0 = healthy and 7 = dead.

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closely simulate growers' conditions, we relied on residual inoculum in the soil.

Two commercial hybrid sugar beet cultivars were included in each test: Mono-Hy A4, which is highly susceptible, and Mono-Hy RH83, which is moderately resistant to *R. solani*. Seeds were commercially treated with maneb to preclude damping-off. Irrigations were by overhead sprinklers in 1984 and 1985 and by furrow in 1986.

Fungicides and rates. In 1984, we tested protectant Bay NTN 19701 75WP at 40 g a.i., systemic triadimefon 50WP at 14 g a.i., and systemic triadimenol 25% dried flowable at 14 g a.i./305 m of row. Each chemical was applied in 10 L of water per 305 m of row. In 1985, triadimefon was replaced by systemic Bay HWG 1608 1.2EC at 10 g a.i./305 m of row, and the rate of Bay NTN 19701 was reduced to 28 g a.i. In 1986, only Bay NTN 19701 and Bay HWG 1608 were tested, at 28 and 14 g a.i./305 m of row, respectively.

Applications. Single applications were made either at the cotyledon stage (early), the four- to six-leaf stage (mid), or just before layby (late), when the plant canopy nearly covered the furrows and further field operations had to be discontinued. Additionally, in 1985 and 1986, early/late sequential applications were made with half-rates of the fungicides being used on each date. Also in 1986, fungicides were applied in the seed furrow just before planting. Chemicals were applied to beet crowns (and seed furrows in 1986) in a 10-cm band with a CO_2-powered bicycle sprayer (R & D Sprayers, Inc., Opelousas, LA); no. 8006 banding nozzles turned parallel to the row and a pressure of 148 kPa were used.

Data and statistical analyses. The average soil population density of *R. solani* was determined for the experimental sites before planting in 1985 and 1986 and postharvest on a treatment or plot basis with a soil-pellet sampler (4) and a *Rhizoctonia*-selective medium (5). At harvest in early October, taproots were dug and individually rated on a disease scale of 0–7, where 0 = healthy and 7 = dead. A weighted average (disease index [DI]) was calculated for each plot (9). Taproots 5 cm or more in diameter were considered harvestable and were washed and weighed for root yield. Standard laboratory procedures were used in 1985 and 1986 to determine percent sucrose (6) and percent thin juice purity (2). Recoverable sucrose was calculated from the yield/purity data.

Data were analyzed with and without those of untreated plots, because application times (dates) were not applicable for untreated plots. First, factorial analyses of variance (AOVs) were performed with each fungicide × application date as a treatment and with untreated controls as separate treatments. Second, data from untreated plots were excluded and factorial AOVs were performed on selected data to determine if first-order interactions were present. All percent data were transformed to arc sines for analyses, but actual percentages are given in tables. Either Duncan's multiple range (DMR) or least significant difference (LSD) tests were used for mean separations where applicable.

RESULTS

1984 Test. Under a moderately intense Rhizoctonia root rot epiphytotic, the moderately resistant cultivar Mono-Hy RH83 had less disease and greater root yield than the susceptible cultivar Mono-Hy A4. Because of a highly significant cultivar × fungicide interaction in most overall AOVs, AOVs were performed on data from each cultivar separately.

Compared with the untreated controls, fungicide treatments significantly decreased the DI 16–54%, increased root yield 36–73%, and increased percent sucrose 12–26% in the susceptible cultivar but had no beneficial effects in the resistant cultivar (Table 1). Only percent sucrose for the mid application and root yield for the late application of triadimefon were not significantly different from the untreated susceptible control. Across application times in the susceptible cultivar, mean DIs and root yields (t/ha) for Bay NTN 19701 (2.6 and 49.3) and triadimenol (2.7 and 47.0) were lower and greater, respectively, than the means for triadimefon (3.9 and 38.1) but were not significantly different from each other. Generally, time of application had little effect on disease suppression, although there was a slight trend toward lower DIs and higher root yields in the early and late applications of Bay NTN 19701 and triadimenol in both cultivars compared with mid treatments.

1985 Test. The root rot epiphytotic was severe in 1985, with mean DIs for the untreated susceptible and resistant cultivars of 6.0 and 4.8, respectively (Table 2). The resistant cultivar outperformed the susceptible cultivar for all parameters (Tables 2 and 3).

When the experiment was analyzed as 2 × 13 factorial, differences in DIs among treatments were highly significant; however, there was a significant cultivar × treatment interaction. Consequently,

Table 2. Effects of prelayby applications of fungicides in 1985 on severity of Rhizoctonia root rot in resistant and susceptible sugar beets and soil population densities of *Rhizoctonia solani* at harvest (means of five replicates)

Cultivar	Fungicide[a]	Application time[b]	Disease index[c]	*R. solani*[d] (cfu/g)
Mono-Hy RH83 (moderately resistant)	Bay NTN 19701	Early	3.5 fgh	2.7
		Mid	4.1 ef	4.5
		Late	4.2 ef	2.0
		Early/late	2.9 ghi	2.9
	Triadimenol	Early	4.0 ef	2.5
		Mid	3.5 fgh	1.3
		Late	4.8 e	2.5
		Early/late	3.3 fgh	1.8
	Bay HWG 1608	Early	2.5 hi	1.5
		Mid	2.9 ghi	1.5
		Late	3.9 efg	1.8
		Early/late	2.2 i	1.5
	Untreated	...	4.8 e	3.8
Mono-Hy A4 (susceptible)	Bay NTN 19701	Early	4.4 xyz	1.8
		Mid	3.9 z	1.8
		Late	5.5 wx	2.5
		Early/late	4.7 xyz	4.0
	Triadimenol	Early	5.3 wxy	2.9
		Mid	4.8 xyz	3.3
		Late	5.4 wx	1.5
		Early/late	4.9 xyz	2.5
	Bay HWG 1608	Early	4.0 z	2.5
		Mid	4.8 xyz	2.9
		Late	4.2 yz	0.7
		Early/late	3.9 z	1.1
	Untreated	...	6.0 w	4.0

[a] Bay NTN 19701 was applied at 28 g a.i./305 m of row, whereas triadimenol and Bay HWG 1608 were applied at 14 g a.i./305 m of row. Additionally, each chemical was applied sequentially early and late, with half the rates being applied each time. Chemicals were banded down the row and into the beet crown.

[b] Early application was made at the cotyledon stage, mid application was made at the four- to six-leaf stage, and late application was made just before layby when the plants were nearly covering the furrows.

[c] Disease index based on a scale of 0–7, where 0 = healthy and 7 = dead. Means within cultivars followed by the same letter are not significantly different at $P = 0.05$.

[d] Population densities of *R. solani* are in colony-forming units per gram of soil. Before planting, the population density of the pathogen across the experimental site was 0.7 cfu/g of soil.

Table 3. Yield and thin-juice purity of two sugar beet cultivars treated with fungicides for control of Rhizoctonia root rot in the field in 1985 (means of five replicates)

Cultivar	Fungicide[a]	Application time[b]	Roots (t/ha)	Sucrose (%)	Purity (%)	Recoverable sucrose (t/ha)
Mono-Hy RH83						
(moderately resistant)	Bay NTN 19701	Early	38.5	11.2	88.2	3.3
		Mid	32.8	11.0	88.2	2.8
		Late	36.6	11.8	87.4	3.2
		Early/late	38.5	11.1	87.7	3.2
	Triadimenol	Early	36.7	10.7	87.3	2.9
		Mid	41.6	10.3	85.6	3.0
		Late	32.5	11.0	86.7	2.7
		Early/late	38.3	11.0	86.5	3.1
	Bay HWG 1608	Early	41.8	11.3	88.4	3.6
		Mid	43.6	12.6	89.3	4.2
		Late	35.1	11.7	89.1	3.2
		Early/late	42.1	12.6	89.8	4.2
	Untreated	...	28.6	9.7	83.8	2.0
Mono-Hy A4						
(susceptible)	Bay NTN 19701	Early	31.4	11.3	89.1	2.7
		Mid	34.2	11.0	87.0	2.8
		Late	16.2	10.7	86.6	1.3
		Early/late	26.9	11.2	87.6	2.2
	Triadimenol	Early	22.3	9.8	83.2	1.6
		Mid	30.2	9.6	85.5	2.0
		Late	24.7	10.3	86.6	1.9
		Early/late	23.9	9.7	86.7	1.8
	Bay HWG 1608	Early	32.5	10.6	87.6	2.6
		Mid	25.3	10.3	86.8	1.9
		Late	28.7	11.0	88.1	2.4
		Early/late	30.8	11.6	86.9	2.6
	Untreated	...	16.0	8.9	82.9	0.9
LSD ($P = 0.05$)			10.2	1.3	2.7	1.1

[a] Bay NTN 19701 was applied at 28 g a.i./305 m of row, whereas triadimenol and Bay HWG 1608 were applied at 14 g a.i./305 m of row. Additionally, each chemical was applied sequentially early and late, with half the rates being applied each time. Chemicals were banded down the row and into the beet crown.

[b] Early application was made at the cotyledon stage, mid application was made at the four- to six-leaf stage, and late application was made just before layby when the plants were nearly covering the furrows.

Table 4. Mean separations on fungicide means across cultivars and application times when untreated controls were excluded in factorial analyses (1985 test)[a]

Fungicide[b]	Disease index[c]	Roots (t/ha)	Sucrose (%)	Purity (%)	Recoverable sucrose (t/ha)
Triadimenol	4.5 x	31.4 x	10.3 y	86.0 y	2.4 y
Bay NTN 19701	4.2 x	31.9 x	11.2 x	87.8 x	2.7 xy
Bay HWG 1608	3.6 y	35.0 x	11.5 x	88.2 x	3.1 x

[a] Means of 40 measurements. Means within columns followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range tests.

[b] Bay NTN 19701 was applied at 28 g a.i./305 m of row, whereas triadimenol and Bay HWG 1608 were applied at 14 g a.i./305 m of row. Additionally, each chemical was applied sequentially early and late, with half the rates being applied each time. Chemicals were banded down the row and into the beet crown.

[c] Disease index based on a scale of 0–7, where 0 = healthy and 7 = dead.

Table 5. Mean separations on application-time means across cultivars and fungicides when untreated controls were excluded in factorial analyses (1985 test)[a]

Application time[b]	Disease index[c]	Roots (t/ha)	Sucrose (%)	Purity (%)	Recoverable sucrose (t/ha)
Early	3.95 yz	33.9 ns	10.8 ns	87.3 ns	2.8 ns
Mid	4.00 y	34.6 ns	10.8 ns	87.2 ns	2.8 ns
Late	4.67 x	29.1 ns	11.1 ns	87.4 ns	2.5 ns
Early/late	3.62 z	33.4 ns	11.2 ns	87.5 ns	2.9 ns

[a] Means of 30 measurements. Means within columns followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range tests; ns = not significant.

[b] Early application was made at the cotyledon stage, mid application was made at the four- to six-leaf stage, and late application was made just before layby when the plants were nearly covering the furrows.

[c] Disease index based on a scale of 0–7, where 0 = healthy and 7 = dead.

separate AOVs were performed on data from each cultivar. In these AOVs, differences among treatments were highly significant, and mean separations are presented in Table 2. The overall trend in both cultivars was for greater disease suppression with early, mid, and early/late sequential treatments than with late applications.

Because there were no significant interactions for any yield parameters, overall AOVs were used and LSDs are provided to compare each mean with its respective untreated control (Table 3). Again, early, mid, and early/late treatments generally provided greater increases in root yield, percent sucrose, percent thin-juice purity, and recoverable sucrose than late applications, but the data were quite variable.

In 2 × 3 × 4 factorial analyses excluding untreated control data, fungicides were compared across cultivars and application times, and application times were compared across fungicides and cultivars (Tables 4 and 5, respectively). Mean separations showed that Bay HWG 1608 was superior to the other chemicals in DI and surpassed triadimenol in percent sucrose, percent purity, and recoverable sugar (Table 4). In the last three parameters, Bay HWG 1608 was not significantly different from Bay NTN

19701, and there were no significant differences among fungicides in root yield. Differences among application times were not significant in any yield measurement (Table 5).

The mean population density of *R. solani* across the experimental site before planting was 0.7 cfu/g of soil. After harvest, the population density in the treatment plots ranged from 0.7 to 4.5 cfu/g of soil (Table 2). Correlation analysis indicated a low ($r = 0.44$) but significant relationship between population density and DI within application time within fungicide. There was no significant correlation between population density and fungicide DI ($r = 0.94$); however, this test had only one degree of freedom. Mean population densities of the pathogen in colony-forming units per gram of soil for fungicides across cultivars and application times were 2.8 for Bay NTN 19701, 2.4 for triadimenol, 1.7 for Bay HWG 1608, and 3.9 for untreated plots.

1986 Test. The root rot epiphytotic in 1986 was extremely mild, with mean DIs across treatments of only 1.2 and 1.7 for the resistant Mono-Hy RH83 and susceptible Mono-Hy A4 cultivars, respectively. Mean yield of the resistant cultivar (49.7 t/ha) was significantly less than that of the susceptible cultivar (51.1 t/ha); however, the former produced more recoverable sucrose (7.1 t/ha) than the latter (6.9 t/ha).

When the experiment was analyzed as a 2 × 11 factorial, differences across cultivars in DIs, root yield, and recoverable sucrose among treatments were highly significant (Table 6). There were no significant cultivar × treatment interactions and no significant differences in percent sucrose or percent purity. A DMR test indicated that DIs in plots treated with Bay NTN 19701 applied at the early (cotyledon) and late (layby) stages and Bay HWG 1608 applied late (layby) were not different from those in the untreated control. In yield parameters, no treatment was better than the control, although some treatments tended to increase root yield and recoverable sucrose, particularly those applied in-furrow or at an early sugar beet growth stage.

In 2 × 2 × 5 factorial analyses without untreated control data, differences among application times were significant for DI, root yield, and recoverable sucrose and differences between fungicides were significant for DI; however, treatment × fungicide interactions also were significant in the AOVs of DI and recoverable sucrose data. There were no significant cultivar × treatment or cultivar × fungicide interactions, and treatment differences in percent sucrose and percent purity also were nonsignificant.

Because of the interactions, only certain trends can be mentioned regarding DI and yield data (Table 7). Generally, plots treated with Bay HWG 1608 tended to have lower DIs and higher recoverable sucrose than those treated with Bay NTN 19701, and early applications of fungicides tended to be more effective than late applications.

A DMR test of the various application times means across cultivars and chemicals indicated that root yields from all early applications and the sequential application were significantly greater than those from plots sprayed at layby

Table 6. Mean separations on treatment means across cultivars in a 1986 test of two fungicides when data were analyzed as a 2 × 11 factorial experiment (means of 10 observations)[a]

Fungicide[b]	Application stage[c]	Disease index[d]	Roots (t/ha)	Recoverable sucrose (t/ha)
Bay NTN 19701	In-furrow	1.3 xyz	53.3 y	7.5 y
	Early	1.6 w	53.5 y	7.4 y
	Mid	1.2 xyz	49.7 yz	7.1 y
	Late	1.7 w	48.6 yz	6.8 yz
	Early/late	1.9 w	50.3 yz	6.8 yz
Bay HWG 1608	In-furrow	1.3 xyz	51.6 y	7.2 y
	Early	0.8 z	49.7 yz	7.0 yz
	Mid	0.8 z	50.7 yz	7.3 y
	Late	2.1 w	43.9 z	5.9 z
	Early/late	0.9 yz	53.2 y	7.5 y
Untreated	···	2.2 w	49.7 yz	6.7 yz

[a] Means within columns followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range tests.
[b] Bay NTN 19701 and Bay HWG 1608 applied at 28 and 14 g a.i./305 m of row, respectively. Additionally, each was applied sequentially at the early (cotyledon) and late (layby) stages, with half the rates being applied each time.
[c] Early application was made at the cotyledon stage, mid application was made at the four- to six-leaf stage, and late application was made just before layby when the plants were nearly covering the furrows.
[d] Disease index based on a scale of 0–7, where 0 = healthy and 7 = dead.

Table 7. Effects of fungicides on root rot severity and yield of roots and recoverable sucrose of resistant and susceptible sugar beet cultivars and soil population densities of *Rhizoctonia solani* after harvest in 1986 (means of five replicates)[a]

Cultivar	Fungicide treatment[b]	Disease index[c]	Roots (t/ha)	Recoverable sucrose (t/ha)	*R. solani*[d] (cfu/g)
Mono-Hy RH83 (moderately resistant)	A1	1.3	52.3	7.5	0.7
	A2	1.1	53.4	7.6	0.4
	A3	1.1	49.7	7.2	0.5
	A4	1.5	47.7	6.8	0.3
	A5	1.7	49.0	6.8	0.6
	B1	0.9	50.9	7.3	0.4
	B2	0.7	49.9	6.7	0.3
	B3	0.7	49.8	7.4	0.3
	B4	1.4	43.6	6.2	0.3
	B5	0.8	53.1	7.6	0.3
	Untreated	1.6	50.1	6.9	0.9
Mono-Hy A4 (susceptible)	A1	1.4	54.3	7.5	0.4
	A2	2.0	53.6	7.2	0.4
	A3	1.3	49.8	6.9	0.4
	A4	1.8	49.4	6.8	0.7
	A5	2.2	51.7	6.8	0.7
	B1	1.8	52.3	7.1	0.3
	B2	1.0	52.5	7.2	0.4
	B3	0.9	51.7	7.2	0.2
	B4	2.8	44.2	5.7	0.4
	B5	1.0	53.4	7.4	0.5
	Untreated	2.8	49.3	6.5	1.0

[a] There were no significant differences among means within any column at $P = 0.05$.
[b] A = Bay NTN 19701 and B = Bay HWG 1608; applications were made in-furrow preplant, 1; at the cotyledon stage (early), 2; at the four- to six-leaf stage, 3 (mid); at layby, 4 (late); and sequentially at the early and late stages, 5. Bay NTN was applied at 28 and Bay HWG at 14 g a.i./305 m of row, except half rates were used for each application of the sequential treatment.
[c] Disease index based on a scale of 0–7, where 0 = healthy and 7 = dead.
[d] Population densities of *R. solani* are in colony forming units per gram of soil; densities determined with a soil-pellet sampler (4) and a *Rhizoctonia*-selective medium. The population density of the pathogen across the experimental site before planting or the in-furrow applications of fungicides was 0.6 cfu/g of soil.

but were not different from each other. Yield means of 20 measurements for each application time were 52.5 (in-furrow), 51.6 (cotyledon), 50.3 (four- to six-leaf), 51.8 (sequential), and 46.2 t/ha (layby).

Correlation analyses on a plot basis ($n = 110$) indicated a low but highly significant relationship between population density of *R. solani* and DI ($r = 0.40$) and a significant negative association between population density and recoverable sucrose ($r = -0.20$) at harvest. Mean population densities are given in Table 7; the population density of *R. solani* across the experimental site before the in-furrow fungicide applications was 0.6 cfu/g of soil.

DISCUSSION

In 3 yr of field tests, applications of Bay NTN 19701, triadimefon, triadimenol, and Bay HWG 1608 fungicides were effective in suppressing Rhizoctonia root rot of sugar beet. Recently, Fernandez (3) reported similar results but provided no yield data.

Generally, greatest disease suppression was realized with protectant Bay NTN 19701 and systemic HWG 1608, and the latter often resulted in lower DIs than the former, particularly under a severe epiphytotic as occurred in 1985 (Tables 2 and 4). Lower DIs, however, were not always associated with significant increases in yield (Tables 4 and 7). Thus, yield data are important in determining the efficacy of a fungicide.

With some exceptions, earlier applications tended to be more suppressive to root rot than late (layby) applications. This may indicate that the fungicides were effective against resting structures of *R. solani* (sclerotia, monilioid cells) in the soil or plant debris, that the fungus infected sugar beet earlier than previously suspected, or that the fungicides had a long residual effect in soil and/or root (in the case of systemics).

In 1984 and 1985, when additional inoculum was broadcast-incorporated over the experimental site before planting, our epiphytotics were severe compared with 1986. This preplant infestation plus high residual nitrogen in our field resulted in extremely low root yields, sucrose percentages, and recoverable sucrose the first 2 yr. When we relied on residual inoculum from our 1985 breeding nursery, our 1986 epiphytotic was mild but our yields were high. Reduced root rot intensity in our 1986 test cannot be explained by environmental factors unfavorable for disease development, because the epiphytotic in our adjacent 1986 inoculated nursery was more severe than those in 1984 or 1985 (*unpublished*). Apparently, in our soils with low organic matter (<2%), survival of *R. solani* over winter was not as great as that reported by others and reviewed by Baker and Martinson (1). Thus, in soils low in organic matter, crop rotations of 3–5 yr are effective in managing this disease. Unfortunately, many growers have shortened rotations considerably.

In years of moderate to severe epiphytotics, root rot suppression with chemicals was greater in the susceptible than in the resistant cultivar (Tables 1–3). Chemical treatments generally raised the yields and decreased disease severity in the susceptible cultivar to the level of the untreated resistant cultivar, indicating the importance of genetic resistance in reducing losses caused by Rhizoctonia root rot. Currently, only a few cultivars with moderate resistance are available for commercial sugar beet production.

Root diseases induced by soilborne pathogens present growers with the difficulty of not knowing when to apply fungicides. Our study demonstrated that single, prelayby applications of suitable chemicals gave season-long protection. Such applications could be made in conjunction with other cultivation operations, and thus, application costs would be minimized. Although costs of the chemicals used in our tests have not been established, a sugar beet yield increase of 4–5 t/ha should more than offset product cost.

Generally, fungicide applications reduced population densities of *R. solani* compared with untreated plots (Tables 2 and 7). The long-term effect of such reductions across years is not known, but reductions in inoculum potential may be an important disease management strategy, especially in shortened rotations.

Control of devastating Rhizoctinia root rot diseases in sugar beet and most other crops has been an evasive goal. Registration of the fungicides used in our study, or similar chemicals, would provide growers with important weapons against *R. solani* until higher levels of genetic resistance are achieved.

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