Spread and Persistence of Benomyl-Resistant *Monilinia fructicola* in South Carolina Peach Orchards

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ABSTRACT

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The spread and persistence of benomyl-resistant *Monilinia fructicola* were studied in an experimental peach orchard, and results were compared with conditions in several commercial peach orchards in which resistance to benomyl had occurred. One fungus strain that was resistant to iprodione was also examined in the experimental orchard. Benomyl-resistant strains became established and spread in the experimental orchard, but the frequency of isolation of these strains relative to sensitive strains declined as the season progressed unless the trees were sprayed with benomyl. The iprodione-resistant strain spread slowly but was not detected by the end of the ripening period. Benomyl-resistant strains introduced in 1984 and 1986 were not detected in the orchard in 1987. In contrast, resistant strains that developed naturally in commercial orchards persisted for 2 yr or more when benomyl use was reduced or eliminated altogether. The elimination of benomyl-resistant strains of *M. fructicola* is probably not possible with management practices that are practicable in large commercial orchards in the southeastern United States.

Resistance in *Monilinia fructicola* (G. Wint.) Honey to the benzimidazole fungicides is well documented and was found in peach (*Prunus persica* (L.) Batsch) orchards in South Carolina in 1976. In 1982, widespread resistance was responsible for large losses of fruit to brown rot, caused by this fungus, and thereafter benomyl and thiophanate-methyl were withdrawn from the list of fungicides suggested for use in South Carolina to control this disease. From 1983 through 1985, benzimidazole fungicides were used sparingly in most South Carolina peach orchards.

Following the discovery of benzimidazole resistance in 1976, the efficacy of alternative fungicides and benzimidazoles mixed with companion fungicides was tested in field plots with resistant strains of *M. fructicola* collected from commercial orchards (Zehr, *unpublished data*). These experiments achieved only limited success, because the resistant fungal strains spread very slowly relative to sensitive strains in the experimental orchard and failed to overwinter in successive tests in the late 1970s and early 1980s.

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Some reports in the literature indicate that benomyl-resistant strains of *M. fructicola* and *M. laxa* are characterized by traits that may make them less competitive than sensitive strains. Resistant strains have been reported to cause less severe disease and to have a lower percentage of spore germination and longer incubation periods than sensitive strains (1,2,8,9). A benomyl-resistant strain exhibited greater sensitivity to captan than a benomyl-sensitive strain (3). Some benomyl-resistant strains of *Venturia inaequalis* were sensitive to *N*-phenylcarbamate, whereas benomyl-sensitive strains were not (5). Some resistant strains of *M. fructicola* (but not all) grow more slowly (4,10), produce fewer spores, and are less virulent than sensitive strains (4) and do not compete well with them in infected peach fruit (11).

To determine whether South Carolina strains of benomyl-resistant *M. fructicola* are competitive with sensitive strains, one resistant strain was introduced into a peach orchard in each of the years 1984, 1986, and 1987. The progress of dissemination was followed through the ripening season each year.

MATERIALS AND METHODS

Source of strains. Three strains of benzimidazole-resistant *M. fructicola* were collected from commercial peach orchards in South Carolina (courtesy of R. W. Miller). Each strain when isolated grew on potato-dextrose agar (PDA) amended with benomyl at 500 mg/L. The strains used in 1984 and 1986 were isolated from infected peach fruit, and that used in 1987 was isolated from an infected peach flower. All three were pathogenic when introduced into ripening peach fruit. Each strain was maintained on PDA prior to use in the field and was tested for sensitivity on benomyl-amended PDA before the experiment.

A strain that was resistant to iprodione at 15 mg/L was collected in 1979 from an experimental peach orchard in which procymidone (a similar chemical) had been tested for efficacy for four consecutive years. This strain was tested simultaneously with a benomyl-resistant strain in 1984, but not in 1986 or 1987.

Test orchard. Two experimental peach orchards, about 0.6 ha each, separated by a road 12.5 m wide, consisted of 14- to 18-year-old trees (cultivars Redskin, Redhaven, and Blake) with 6.1- × 6.1-m spacing. The orchards were at least 12 km from any known commercial orchard. Benomyl-resistant strains had been used in the orchards several years previously, but there was no evidence of persistence of these strains. Benzimidazole fungicides continued to be effective in suppressing brown rot, and late spring freezes had totally eliminated the fruit crop in 1982, 1983, and 1985. Herbicides were used to maintain bare ground under trees, and fescue sod separated the rows of trees. With this management practice, mummies on the ground decayed rapidly, and apothecia were rarely seen.

Plot design and inoculation. In 1984, a row of 18 Redhaven trees adjacent to a row of 18 Blake trees was chosen. The 18 Redhaven trees were divided into six blocks of three single-tree plots each. Captan 50W (240 g/100 L), benomyl (Benlate 50W, 60 g/100 L), and iprodione (Rovral 50W, 120 g/100 L) were assigned at random to plots within each block and sprayed by handgun on 2 and 11 July. On 7 July, six fruits per tree were wound-inoculated: two with a sensitive strain, two with a benomyl-resistant strain, and two with the iprodione-resistant strain described previously. After symptom development, inoculated fruit were assayed on potato-dextrose agar (PDA) amended with benomyl (10 μg/ml) or iprodione (15 μg/ml) or on unamended PDA to ascertain that the various strains had become established in the orchard. All 18 Blake trees were sprayed with triforine (Funginex 1.6 EC, 94 ml/100 L) on 19 and 27 July.

Sampling procedures. After symptom development in uninoculated fruits, 10 infected fruits per tree were assayed by the lip-balm tube procedure of Lalancette et al (6). Water agar amended with benomyl (10 μg/ml) or iprodione (15 μg/ml) was touched to spores on each infected fruit and incubated at room temperature (about 22–24 C). Spores were examined microscopically for germination after 3 days, since by this time fungicide-sensitive spores would have failed to germinate or produced abnormal germ tubes. A sample from each fruit on unamended medium was used for comparison. This sampling procedure was first performed on 12 July (5 days after inoculation) and repeated on 17, 20, 23, and 27 July and 1 August; 180 fruits were sampled on each date. All decaying fruits were removed from the trees and left on the ground after each sampling. The samplings on 12, 17, and 20 July were from the inoculated trees; those on 23 and 27 July and 1 August were from fruit on adjacent Blake trees, which ripened later in the season.

This procedure was also used in 1986 and 1987, except that the iprodione-resistant strain was not included, one fruit per tree was inoculated with a benomyl-resistant strain and one with a sensitive strain in 1986, two fruits per tree were inoculated with a resistant strain in 1987 (sensitive strains being already present), and benomyl was sprayed once on all inoculated trees to encourage the establishment of the resistant strain. In 1986, the spread of strains to Redskin trees was assayed instead of the spread to Blake. All Redskin fruits that developed brown rot were assayed for resistance to benomyl. Sampling intervals were determined by the amount of secondary spread that occurred during the dry weather of 1986.

Weather conditions. In 1984, frequent rainfall prevailed throughout July, and weather conditions favored rapid dissemination and infection. In contrast, July was dry in 1986 and 1987. Almost no secondary spread occurred in Redhaven fruit after the 11 July 1986 sampling, and no further samples were collected until brown rot appeared in the adjacent Redskin fruit early in August. In 1987, slightly more rainfall allowed two samplings (2 and 8 July) of secondary spread in Redhaven and two (21 and 28 July) in the adjacent Blake cultivar.

Assays of overwintering. Three methods were used in 1987 to determine whether benomyl-resistant strains introduced during previous years had survived and were being disseminated in the test orchard. First, two Andersen viable spore samplers (Andersen Samplers, Inc., Atlanta, GA) were placed in the orchard, one among inoculated trees and the other approximately 15 m downwind of the test site. Spores in the ambient air were collected on PDA acidified with HCl (pH 4.0) to control bacterial growth and amended with benomyl (5 μg/ml). Sampling began just prior to bloom (2 min of sampling per hour, 28 L of air per minute) and continued through bloom except during periods when temperatures were near freezing. Plates of media were changed daily, incubated, and examined after 5–6 days. Colonies resembling *Monilinia* sp. were transferred in pure culture and identified.

Second, moisture conditions during bloom favored blossom blight development, and infections became visible late in the flowering period. Infections that progressed into twigs were assayed by placing a twig in a capped test tube containing 0.5 ml distilled water. Sporulation on the lesion was visible after 1–2 days, and spores were transferred to PDA amended with benomyl (10 μg/ml) or to unamended PDA. Sensitivity was ascertained if no growth occurred on the amended medium within 4–5 days.

Third, as the fruits approached maturity they were sprayed twice with benomyl in the orchard. Fruits that became infected on the trees were assayed for benomyl sensitivity on PDA plus benomyl (10 μg/ml).

Sampling in commercial orchards. To determine whether trends of resistance observed in the experimental orchard were consistent with those in commercial orchards, five orchards where resistance had occurred in the past were sampled in 1988. Four orchards were in Edgefield County (an area of intensive peach cultivation) and one was in Anderson County, where peaches are few. Except in one Edgefield orchard (where benomyl had been used in 1987 and as a blossom spray in 1988), benzimidazole fungicides had not been used in 1987 or 1988. Blossom blight caused by *M. fructicola* was extensive in the orchard where benomyl had been used during bloom, and 67 blighted flowers were assayed after isolation on acidified PDA by transfer PDA amended with benomyl (0, 10, 50, 300, or 1,000 mg/L) in petri dishes. Determinations of resistance or sensitivity were made after the fungus on unamended medium had grown enough to cover the agar surface.

In the other four orchards, infected ripening peach fruits were collected from the ground or from the trees and assayed in the same manner. The number assayed per orchard ranged from 94 to 139.

Statistical methods. Least squares analyses of variance for a split-plot-in-time context were conducted to evaluate the effects of captan, benomyl, and iprodione on the frequency with which peach fruit were infected with sensitive, benomyl-resistant, and iprodione-resistant strains of *M. fructicola* in the 1984 experiment. Because meaningful interaction of fungicide and sampling date was evident for both sensitive and benomyl-resistant strains, contrasts with a single degree of freedom were used to compare fungicide means for each sampling date and to evaluate response changes over time for each fungicide. Similar analyses were not done in 1986 or 1987, because the entire population of rotted fruits was sampled on each date.

RESULTS

Persistence of introduced fungicide-resistant strains. The benomyl-resistant

Table 1. Frequency of isolation of benomyl-resistant and benomyl-sensitive strains of *Monilinia fructicola* from infected peach fruit after introduction of strains into a peach orchard

		Frequency of isolation (%)	
Date	Cultivar[a]	Resistant strains	Sensitive strains
1984[b]			
12 July	Redhaven	29.8	70.2
17 July	Redhaven	9.4	90.6
20 July	Redhaven	5.4	94.6
23 July	Blake	16.3	83.7
27 July	Blake	7.6	92.4
1 August	Blake	1.1	98.9
1986[c]			
11 July	Redhaven	22.9	77.1
4 August	Redskin	5.5	94.5
14 August	Redskin	3.9	96.1
1987[d]			
2 July	Redhaven	25.3	74.7
8 July	Redhaven	17.3	82.7
21 July	Blake	10.6	89.4
28 July	Blake	14.8	85.2

[a] Redhaven fruit were inoculated, and infected fruit were subsequently assayed to determine the spread of infection in Redhaven and to adjacent trees of a second cultivar (Blake in 1984 and 1987 and Redskin in 1986).

[b] Two fruits per tree were inoculated with a sensitive strain and two with a resistant strain on 7 July 1984. The percentages are based on 53–180 fruits sampled on each date.

[c] One fruit per tree was inoculated with a sensitive strain and one with a resistant strain on 20 June 1986. The percentages are based on 140–311 fruits sampled on each date.

[d] Two fruits per tree were inoculated with a resistant strain on 26 June 1987. Sensitive strains were already present. The percentages are based on 61–150 fruits sampled on each date.

strains became established and spread in the orchard each year (1984, 1986, and 1987) (Table 1). The fraction of decaying fruits infected with a resistant strain at the first sampling ranged from 22.9% (1986) to 29.8% (1984). These percentages may not reflect the relative rates of spread of resistant and sensitive strains, because sources of inoculum for sensitive strains other than those introduced probably existed in the orchard each year.

Following the first sampling and during dissemination in inoculated Redhaven trees and to adjoining cultivars, there was a consistent tendency for the frequency of isolation of the resistant strain to decline relative to that of the sensitive strains. In 1984 and 1986, the percentage of fruit infected with a resistant strain at the end of the sampling period was only 1.1 and 3.9%, respectively. In 1987, however, the isolation frequency of the resistant strain was higher at the end of the sampling period (14.8%) and also was higher at other sampling times than had been observed in the preceding two years.

Influence of fungicide sprays. The influence of fungicides used after resistant strains were introduced was studied in 1984 (Tables 2 and 3). After the introduction of the sensitive, benomyl-resistant, and iprodione-resistant strains, the trees were sprayed twice with captan, benomyl, or iprodione. Following sprays of captan, the isolation frequency of the benomyl-resistant strain declined relative to that of the sensitive strains, and the iprodione-resistant strain spread only slightly in the sprayed trees. Sprays of iprodione increased the frequency of the iprodione-resistant strain only slightly and did not affect the benomyl-resistant strain. In contrast, sprays of benomyl greatly increased the frequency of the benomyl-resistant strain, to the point that infections with this strain predominated in the population after two sprays.

Table 2. Frequency of isolation of strains of *Monilinia fructicola* sensitive or resistant to benomyl or iprodione as influenced by fungicides sprayed on peach foliage and fruit

		Frequency of isolation (%)[b]		
Fungicide applied[a]	**Date of isolation**	**Fungicide-sensitive strains**	**Benomyl-resistant strain**	**Iprodione-resistant strain**
Benomyl	12 July	62.8 ± 7.6	26.5 ± 7.3	10.7 ± 4.1
	17 July	53.5 ± 8.3	39.7 ± 7.0	6.9 ± 4.0
	20 July	37.6 ± 7.3	55.5 ± 7.0	7.0 ± 4.0
Captan	12 July	61.2 ± 7.3	28.7 ± 7.0	10.1 ± 3.9
	17 July	81.6 ± 7.3	8.3 ± 7.0	10.0 ± 3.9
	20 July	88.4 ± 7.4	4.9 ± 7.1	6.7 ± 4.0
Iprodione	12 July	74.2 ± 7.3	20.7 ± 7.0	5.1 ± 4.0
	17 July	76.7 ± 7.2	5.0 ± 6.9	18.3 ± 3.9
	20 July	82.0 ± 7.6	6.2 ± 7.2	11.7 ± 4.1

[a]Sprays of benomyl, captan, and iprodione were applied at commercial rates on 2 and 11 July 1984.
[b]Data shown are mean percentages plus or minus standard error, based on assays of 60 infected peach fruits per treatment on each sampling date.

Table 3. Summary of analysis of variance for sensitive, benomyl-resistant, and iprodione-resistant strains of *Monilinia fructicola* as affected by three fungicides across three sampling dates

		Sensitive strains		Benomyl-resistant strain		Iprodione-resistant strain	
Source	**df**	**Mean square**	***P***	**Mean square**	***P***	**Mean square**	***P***
Rep	5	14,927	0.049	7,632	0.120	4,087	0.053
Fungicide (*F*)	2	38,827	0.006	45,951	0.003	598	0.343
Error *a*	10	4,467		4,186		501	
Date (*D*)	2	948	0.740	2,563	0.420	594	0.531
F × *D*	4	10,390	0.023	11,530	0.010	1,218	0.283
Error *b*	30	3,116		2,869		919	
Contrasts[a]							
12 July							
B vs C & I	1	874	0.600	120	0.839	346	0.544
C vs I	1	4,963	0.217	1,875	0.425	737	0.378
17 July							
B vs C & I	1	25,716	0.007	42,427	0.001	2,081	0.143
C vs I	1	734	0.631	333	0.736	2,057	0.145
20 July							
B vs C & I	1	86,689	0.001	94,912	0.001	186	0.656
C vs I	1	1,139	0.550	51	0.895	708	0.387
B							
Date linear	1	17,926	0.023	23,559	0.007	384	0.523
Date lack-of-fit[b]	1	409	0.720	65	0.881	147	0.692
C							
Date linear	1	21,563	0.013	16,426	0.023	349	0.542
Date lack-of-fit	1	1,825	0.450	2,788	0.332	102	0.742
I							
Date linear	1	1,734	0.462	5,861	0.163	1,220	0.258
Date lack-of-fit	1	83	0.872	2,804	0.331	3,850	0.050

[a]B = benomyl; C = captan; I = iprodione.
[b]Deviation from linearity.

The spread of the iprodione-resistant strain was monitored in adjacent Blake peach trees, which ripen 2–3 wk later than Redhaven, and which had been sprayed with triforine. The frequency of isolation in this block of trees was 4.4% on 23 and 27 July but 0% on 1 August.

Overwintering of resistant *M. fructicola*. Many fungi germinated and grew on benomyl-amended PDA from samples taken in the viable spore trap on 18–19 March 1987, at early flowering, and throughout the flowering period. Fungal colonies that grew on the agar medium were checked by dissecting microscope, but no *M. fructicola* was isolated during this period from mycelium or spores transferred to fresh agar medium.

Following rainy periods on 23–24 March and again on 27 and 30 March, blossom blight developed in the test orchard. Assays of 410 infected flowers in late April and early May showed that all were infected with benomyl-sensitive strains.

In late June, maturing fruit naturally infected with indigenous strains of the fungus were assayed for resistance following two preharvest sprays with benomyl. Of the 43 infected fruits assayed, none was infected with a resistant strain of *M. fructicola*. Thus, the benomyl-resistant strains introduced during previous years were not detected in 1987.

Resistance in commercial orchards. Resistant strains persisted in each of the commercial orchards, in contrast to the experimental orchard. Following benomyl application during bloom, only 14.9% of infected flowers in orchard 1 in Edgefield County harbored strains sensitive to benomyl at 10 mg/L (Table 4). Resistance was less frequent in the Edgefield County orchards where benomyl had not been used (38.7–65.7% were sensitive to benomyl at 10 mg/L), but some strains grew well with benomyl at 1,000 mg/L (Table 4). More than 90% of the strains tested from the Anderson County orchard were sensitive to benomyl at 10 mg/L in 1988. Approximately 20% of the trees in this orchard received one spray of benomyl plus triforine in 1989 but no benzimidazole fungicide in 1990. Assays of 168 infected flowers and fruit on PDA plus benomyl (10 mg/L) in 1990 detected 13 (7.7%) that were resistant to benomyl, most at concentrations less than 50 μg/ml.

DISCUSSION

The three benomyl-resistant strains introduced into the experimental orchard in 1984–1987 declined in frequency over time relative to benomyl-sensitive strains already present or introduced there. The resistant strain introduced in 1987 seemed to be more competitive with sensitive strains than those introduced in 1984 and 1986. Fitness is difficult to determine from these experiments, because external sources of benomyl-sensitive strains are an unknown variable that might have the influenced the inoculum level of sensitive strains relative to that of the resistant strains. However, reduced fitness is suspected from the lack of large amounts of inoculum from sources outside or in the orchard, the failure to detect overwintered resistant strains, and the failure of a benomyl spray in 1986 and 1987 to arrest the decline in the frequency of isolating benomyl-resistant strains.

Benzimidazole-resistant strains that were introduced into the experimental orchard in the late 1970s and again in 1984 and 1986 failed to persist, as shown in the failure to detect them in 1987. In contrast, resistant strains overwintered and persisted for at least 2 yr in commercial orchards where benomyl had not been used or was used very little. The failure to persist in the experimental orchard might indicate that the resistant strains studied do not compete well or that orchard management practices used there help to suppress resistance. The orchard is isolated from other stone fruit orchards and wild *Prunus*, weed control beneath the trees is managed carefully with herbicides year-round, blighted twigs and cankers are removed during winter pruning, and prunings are chopped into a fine mulch. With these management practices, blossom blight does not often develop, and inoculum often must be introduced to initiate epidemics of brown rot.

Landgraf and Zehr (7) found that apothecia develop from mummies partially or completely buried in soil or in plant debris. In South Carolina, mummies and rotting peach fruit on bare, undisturbed soil usually decay completely before the bloom period begins, and therefore apothecia are seldom seen to develop from them. The careful orchard floor management and pruning practices used in this orchard probably explain the failure of the resistant strains to persist from one year to another, and probably most sources of inoculum of sensitive strains are removed as well. Management practices such as these may not be feasible for controlling brown rot in large commercial orchards, but they might deserve more emphasis for operators of small stone fruit orchards who wish to reduce fungicide use and avoid resistance to fungicides.

Table 4. Sensitivity to benomyl among strains of *Monilinia fructicola* isolated from South Carolina peach orchards

Benomyl concentration (mg/L)[a]	Frequency of isolation of sensitive strains (%)[b]				
	Edgefield 1	Edgefield 2	Edgefield 3	Edgefield 4	Anderson
10	14.9	38.7	65.7	51.0	90.7
50	50.7	47.5	71.6	55.3	92.8
300	86.5	69.4	92.5	60.6	94.9
1,000	100	93.5	100	76.6	100

[a] Strains were assayed on potato-dextrose agar amended with benomyl in various concentrations.
[b] Percentages of sensitive strains in isolations from infected flowers (Edgefield 1) or fruits (remaining orchards in Edgefield and Anderson counties, South Carolina). The numbers of flowers or fruits assayed per orchard were 67, 137, 134, 94, and 139, respectively.

The iprodione-resistant strain used in the 1984 test appeared not to be a vigorous strain in the orchard. The use of iprodione as a spray slightly increased the relative frequency of its isolation (Table 2), but the effect was much less than when benomyl was used with the benomyl-resistant strain. The iprodione-resistant strain spread slowly to the adjacent Blake orchard but was not detected at all on the last sampling date. This strain appeared not to be a threat for the establishment of resistance to iprodione or for increased crop loss when iprodione was used.

Assays from fruits in commercial orchards indicated that benomyl-resistant strains of *M. fructicola* may persist for long periods after benomyl use has been discontinued, when customary cultural practices are utilized. All of the benomyl-resistant strains studied in 1984–1987 originated from orchards where brown rot control failed after 5–10 yr of regular benomyl use. Benzimidazole fungicides cannot be used successfully on a regular basis in such orchards. The persistence of resistant strains in commercial orchards might be favored by the kinds of maintenance practices used there, but selection pressures over time might have resulted in the emergence of resistant strains that are ecologically fit. Perhaps the time period of this study was too short to allow the resistant strains studied to become adapted to the environment of the test orchards. Detailed studies of the overwintering of *M. fructicola* might help to explain the contrasting results from commercial orchards versus the experimental plots, and regular, exclusive use of benzimidazoles might result in the persistence of resistance in the test orchard also.

In South Carolina and some other states, peaches are grown in localities of concentrated production, and ripening of the various cultivars extends over a 2-mo period. Any renewed use of benzimidazole fungicides that may favor an increased frequency of resistant strains in a given orchard may affect other orchards and cultivars nearby, especially those ripening later in the season. For these reasons, benzimidazoles should be used sparingly and only when urgently needed. Careful, well-informed management may permit the effective use of benzimidazole fungicides in some localities where resistance has occurred in the past, but assays for resistance should be done prior to orchard use.

LITERATURE CITED

1. Cañez, V. M., Jr., and Ogawa, J. M. 1982. Reduced fitness of benomyl-resistant *Monilinia laxa*. (Abstr.) Phytopathology 72:980.
2. Cañez, V. M., Jr., and Ogawa, J. M. 1985. Parasitic fitness of benomyl-resistant and benomyl-sensitive *Monilinia laxa*. (Abstr.) Phytopathology 75:1329.
3. Dijkhuizen, J. P., Ogawa, J. M., and Manji, B. T. 1983. Activity of captan and prochloraz on benomyl-sensitive and benomyl-resistant isolates of *Monilinia fructicola*. Plant Dis. 67:407-409.
4. Jones, A. L., and Ehret, G. R. 1976. Isolation and characterization of benomyl-tolerant strains of *Monilinia fructicola*. Plant Dis. Rep. 60:765-769.
5. Jones, A. L., Shabi, E., and Ehret, G. R. 1987. Genetics of negatively correlated cross-resistance to a *N*-phenylcarbamate in benomyl-resistant *Venturia inaequalis*. Can. J. Plant Pathol. 9:195-290.
6. Lalancette, N., Jr., Russo, J. M., and Hickey, K. D. 1984. A simple device for sampling spores to monitor fungicide resistance in the field. Phytopathology 74:1423-1425.
7. Landgraf, F. A., and Zehr, E. I. 1982. Inoculum sources for *Monilinia fructicola* in South Carolina peach orchards. Phytopathology 72:185-190.
8. Ogawa, J. M., Manji, B. T., Bostock, R. M., Cañez, V. M., and Bose, E. A. 1984. Detection and characterization of benomyl-resistant *Monilinia laxa* on apricots. Plant Dis. 68:29-31.
9. Skylakakis, G. 1983. Theory and strategy of chemical control. Annu. Rev. Phytopathol. 21:117-135.
10. Sonoda, R. M., and Ogawa, J. M. 1982. Growth rate of *Monilinia fructicola* resistant and sensitive to benomyl on potato-dextrose agar and on peach fruit. Plant Dis. 66:1155-1156.
11. Sonoda, R. M., Ogawa, J. M., and Sholberg, P. L. 1982. Competition between conidial isolates of benomyl resistant and benomyl sensitive *Monilinia fructicola* on peach fruit. (Abstr.) Phytopathology 72:988.