Growth Rate of *Monilinia fructicola* Resistant and Sensitive to Benomyl on Potato-Dextrose Agar and on Peach Fruit

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ABSTRACT

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Mean radial growth of benomyl-sensitive *Monilinia fructicola* was faster than benomyl-resistant *M. fructicola* on peach fruit and on potato-dextrose agar. There was a greater difference in mean growth rate between benomyl-sensitive and benomyl-resistant isolates on peach fruit than on potato-dextrose agar. When the benomyl-sensitive isolates or benomyl-resistant isolates were compared separately, rankings of growth rate on potato-dextrose agar were not correlated with rankings of growth rate on fruit.

Benomyl has been used extensively in peach orchards in California since its registration in 1972. The fungicide was effective against brown rot blossom blight and preharvest and postharvest fruit rot incited by *Monilinia fructicola* (Wint.) Honey (4). Resistance of *M. fructicola* to benomyl in California peach orchards was first recorded in an orchard in 1977 (3). Since then, the incidence of resistant *M. fructicola* has become widespread. The resistance to benomyl in California peach orchards is at the level of 0.5–3 mg/L. Resistance of *M. fructicola* to benomyl in other areas of the United States has been reported to be at the level of 400 mg/L or more (1). *M. fructicola* resistant to benomyl at 20 mg/L or more has been reported in New South Wales, Australia (2).

Knowledge of the relative fitness of *M. fructicola* isolates resistant to benomyl will help in developing programs to control them effectively. One of the factors affecting fitness is the comparative pathogenicity of benomyl-resistant and benomyl-sensitive isolates. Jones and Ehret (1) in Michigan reported that two of three benomyl-resistant isolates of *M. fructicola* were as pathogenic as sensitive isolates. The third isolate grew slowly on potato-dextrose agar (PDA) and on peach fruit. Penrose et al (2) in Australia found that variation in growth rate on PDA within benomyl-sensitive and within benomyl-resistant isolates was about the same as between the two groups. Work in our laboratory indicated that a difference existed in growth rate between benomyl-sensitive and benomyl-resistant isolates of *M. fructicola*. The following is a report of this finding.

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MATERIALS AND METHODS

M. fructicola isolates were obtained from blighted peach blossoms or mummified peach fruits in the springs of 1979 and 1980 from the same peach orchard in Lockeford, San Joaquin County, CA. Pieces of diseased tissue were placed on PDA acidified with lactic acid (Difco APDA). Isolates obtained in 1979 were mass-transferred to test tube slants of Difco PDA and stored at 3 C until used. Isolates obtained in 1980 were single-spored from conidia and stored at 3 C on PDA slants. Resistance to benomyl was determined by transferring 4 mm disks of 3- to 7-day-old cultures of *M. fructicola* grown in petri dishes to PDA amended with benomyl at 1 mg/L. Isolates that grew on this media were considered resistant to benomyl.

Four-millimeter disks of 15 benomyl-sensitive and 17 benomyl-resistant isolates obtained in 1979 were transferred to three petri dishes each of PDA and

Table 1. Growth rate of benomyl-sensitive and benomyl-resistant *Monilinia fructicola* on Loadel peach fruit and on potato-dextrose agar (PDA)

Isolate	Radial growth (mm) and ranking				Reaction to benomyl
	Rank	Peach	Rank	PDA	
MF 15-79	1	22.0 a[y]	10	41.7 bcdefg[y]	S[z]
1-79	2	19.8 ab	4	43.7 abcd	S
8-79	3	19.5 ab	13	41.3 bcdefg	S
17-79	4	19.3 ab	20	40.7 defg	S
3-79	5	18.5 abc	6	42.7 bcde	S
6-79	6	16.8 abcd	18	41.0 cdefg	S
11-79	7	16.3 abcde	10	41.7 bcdefg	S
10-79	8	15.8 bcdef	13	41.3 bcdefg	S
25-79	8	15.8 bcdef	10	41.7 bcdefg	R
9-79	10	15.3 bcdef	8	42.0 bcdef	S
19-79	11	14.8 bcdef	31	35.7 jk	S
26-79	12	14.5 bcdef	13	41.3 bcdefg	R
29-79	13	14.3 bcdefg	5	43.3 bcd	R
4-79	14	13.8 bcdefg	1	46.7 a	S
18-79	15	13.5 bcdefg	3	44.3 abc	S
30-79	16	12.8 cdefg	32	33.0 k	R
31-79	16	12.8 cdefg	22	39.7 efghi	R
35-79	16	12.8 cdefg	28	37.0 hij	R
40-79	16	12.8 cdefg	2	44.7 ab	R
28-79	20	12.3 cdefgh	29	36.3 ij	R
2-79	21	12.0 defgh	26	38.7 fghij	S
7-79	21	12.0 defgh	6	42.7 bcde	S
32-79	23	11.5 defghi	22	39.7 efghi	R
39-79	24	11.3 defghi	22	39.7 efghi	R
33-79	25	10.3 efghi	22	39.7 efghi	R
36-79	26	10.0 efghi	8	42.0 bcdef	R
37-79	27	9.8 fghi	18	41.0 cdefg	R
12-79	28	8.0 ghi	21	40.3 defgh	S
34-79	28	8.0 ghi	13	41.3 bcdefg	R
23-79	30	6.3 hi	27	38.3 ghij	R
38-79	31	5.8 i	29	36.3 ij	R
24-79	32	5.5 i	13	41.3 bcdefg	R

[y] Means followed by the same letter are not significantly different at $P = 0.05$ (Duncan's multiple range test).

[z] S = sensitive, R = resistant. The mean radial growth (mm) of sensitive and resistant isolates was 15.8 and 11.0 on peach fruit and 41.6 and 39.8 on PDA, respectively.

incubated at 20 C. These same isolates were inoculated on Loadel peach fruit. The fruit was injured with a sharp point of a 2-mm-diameter glass rod, and a 4-mm disk of inoculum was placed mycelium-side down over the injury. The fruit was placed on a wire mesh platform, 12 fruits to each plastic box with 250 ml of water in the bottom of the box, and incubated in a walk-in incubator at 20 ± 1 C. Four fruits were inoculated with each isolate. Growth rate of the fungi on PDA and lesion development on fruit were recorded 72 hr after inoculation. Thirteen single-spore isolates obtained in 1980, seven sensitive to benomyl and six resistant, were inoculated on Loadel peach fruit as described above, and the rate of lesion development determined 72 hr after inoculation.

RESULTS AND DISCUSSION

The mean growth rate of benomyl-sensitive isolates of *M. fructicola* obtained from the field in 1979, as a group, was significantly ($P = 0.05$) greater on PDA (41.6 mm) and on peach fruit (15.8 mm) than was the average growth rate of benomyl-resistant isolates on PDA (39.8 mm) and on peach fruit (11.0 mm) obtained from the same field at the same time. On PDA, the growth rate of the sensitive isolates was 4.6% faster than that of the benomyl-resistant group of isolates. On peach fruit, lesions of the sensitive isolates grew 43.9% faster than did lesions of the benomyl-resistant groups of isolates. When the benomyl-sensitive isolates were considered individually, there was no correlation between ranking of growth of an isolate on PDA and the ranking of its growth on peach fruit. Similar results were obtained when growth of the benomyl-resistant isolates on PDA and on fruit were compared (Table 1).

The single-spored, benomyl-sensitive and benomyl-resistant isolates obtained from the orchard in 1980 behaved similarly: Mean growth of benomyl-sensitive isolates was 16.4% faster than that of benomyl-resistant isolates on peach fruit (Table 2).

The results of this study indicate that in the absence of benomyl, benomyl-resistant isolates of *M. fructicola* as a group grew more slowly on peach fruit and on PDA than did benomyl-sensitive isolates (Table 1). In the summer when peaches are ripening, secondary infection cycles can occur, with inoculum from earlier maturing fruit infecting later maturing fruit in the same tree, or inoculum from fruit on earlier maturing cultivars infecting fruit on later maturing cultivars. Assuming equal production of conidia per unit area, equal ability to infect, and equality of other factors, faster growing isolates should eventually be present in a greater proportion. Further studies are needed to determine whether this scenario is occurring.

Table 2. Growth on peach fruit of single-spore subcultures of benomyl-sensitive and benomyl-resistant *Monilinia fructicola*

Isolate no.[x]	Radial growth (mm)	Reaction to benomyl
25o-9	23.2 a[y]	S[z]
19b5-4	22.6 ab	S
5bl-1	22.4 ab	S
9o6s-4	21.5 abc	S
24o4-14	21.4 abc	S
8o8-18	20.9 bcd	R
15b5-15	20.8 bcd	S
12w2s-17	20.0 cde	R
16b8-1	19.3 def	S
11w6-17	18.1 efg	R
6y3-11	17.9 fg	R
10y7-2	17.5 fg	R
20w6-15	16.9 g	R

[x] Cultures obtained from blighted peach blossoms in 1980.

[y] Means followed by the same letter are not significantly different at $P = 0.05$ (Duncan's multiple range test).

[z] S = sensitive, R = resistant. The mean radial growth (mm) of the benomyl-sensitive and benomyl-resistant isolates as a group was 21.6 and 18.6, respectively.

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