

Fungicide Control of Molds That Attack Caprifigs

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ABSTRACT

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Fusarium moniliforme, *Rhizopus stolonifer*, *Alternaria* sp., and a yeast were the most common fungi isolated from the mamme and profichi crops of caprifigs. A combination of benomyl and potassium sorbate was the most effective treatment in suppressing development of these molds. Addition of DCNA or chlorothalonil or both did not significantly alter the numbers of molds isolated. Benomyl was essential to control *Fusarium*, while either potassium sorbate or DCNA controlled *Rhizopus*. Incidence of *Cladosporium* and *Penicillium* ranged from 0 to 3 or 4%. Benomyl treatment significantly increased the incidence of *Alternaria* and DCNA increased yeasts when either fungicide was applied alone but not when combined with each other or with other fungicides.

Caprifigs are used as a source of pollen to pollinate the Smyrna-type figs of the cultivar Calimyrna. Pollination is accomplished by the fig wasp, *Blastophaga psenes* L. (3,5), which carries the pollen as it emerges from the profichi (spring) crop. Early in the history of the fig industry in California, it was shown that fig wasps contaminated with *Fusarium moniliforme* Sheld. var. *fici* Caldis emerging from the mamme (winter) caprifig crop also contaminated the profichi crop and subsequently the edible Smyrna fig, resulting in the disease described as endosepsis by Caldis (1,2). Before chemical control measures were developed, endosepsis accounted for 30–50% losses of the Calimyrna crop (10). Endosepsis was controlled by treating the

mamme caprifig crop with a mercury fungicide to prevent the contamination of the profichi crop (6,7). In 1972, Gerdtz (4) developed an alternative control method using benomyl.

Recently, Obenauf (8) showed that caprifigs treated with benomyl had reduced *Fusarium* levels but contained an abundance of other molds. We undertook this study to identify molds in the caprifigs and to develop control measures for them.

MATERIALS AND METHODS

In the pollination of the Smyrna-type fig, pollen from the profichi figs is transferred by the fig wasp, which can be contaminated with mold fungi. To prevent mold contamination of the profichi crop by the fig wasp emerging from the mamme crop, the mamme crop is harvested and treated with fungicides.

The mamme and profichi caprifigs we used were harvested from a commercial caprifig orchard, and initial sampling indicated that they contained a complex of mold organisms. Before being treated with fungicides, mamme figs were cut in half with a sterile knife; the incision extended from the neck of the fig alongside the eye to the neck on the opposite side. With the profichi crop, care was taken to cut into the fresh pulp

only and not into the floral parts of the fig. Figs were separated into two halves, which were still connected to the stem. For the preliminary test with the mamme crop, 83–85 figs were dipped in fungicide suspensions for 5 min; for the profichi crop, four replications of 25 fruit were dipped for 20 min. Control fruits were dipped in water. Mixtures were agitated every 5 min. The fruit were dried on a wire screen at room temperature, placed in a

Table 1. Incidence of *Fusarium* and other fungi in mamme caprifigs treated with fungicides^a

Treatment ^b	<i>Fusarium</i> (%)	Other fungi ^c (%)
Control	29.4	70.6
Benomyl	9.5	67.9
Benomyl plus potassium sorbate	7.1	9.4
Benomyl plus DCNA	7.1	67.9
Benomyl plus chlorothalonil	0.0	72.9
Benomyl plus captan	2.4	84.7
Benomyl plus fixed copper	8.1	91.9
Benomyl plus CGA-64251	17.6	63.3
Potassium sorbate	18.1	22.9
DCNA	72.6	25.0
Chlorothalonil	4.7	62.4
Captan	14.1	83.5
Fixed copper	27.1	72.9
CGA-64251	97.6	2.4

^a Percentage of 83–85 figs that were infected. Figs were split, dipped for 5 min in fungicide suspension, and stored for 5 days.

^b Concentrations of fungicides used, regardless of combination, were as follows (in $\mu\text{g a.i./L}$): benomyl, 595; potassium sorbate, 21,825; DCNA, 893; chlorothalonil, 22,773; captan, 1,508; fixed copper, 48,148; and CGA-64251, 397.

^c Other fungi detected were primarily *Rhizopus*, plus *Alternaria*, *Cladosporium*, and *Penicillium*.

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Table 2. Incidence of *Fusarium* and other fungi in profichi caprifigs treated with fungicides^x

Treatment ^y	Fungi ^z				
	<i>Fusarium</i>	<i>Rhizopus</i>	<i>Alternaria</i>	Yeasts	Others
Control	61 ab	65 a	11 bcde	18 cd	4 ab
Benomyl	13 de	55 a	26 a	29 cd	3 ab
Benomyl plus potassium sorbate	7 e	11 cde	15 abcde	18 cd	0 b
Benomyl plus potassium sorbate plus DCNA	18 de	0 e	13 abcde	15 d	3 ab
Benomyl plus potassium sorbate plus DCNA plus chlorothalonil	11 e	2 e	7 e	17 d	1 b
Benomyl plus potassium sorbate plus chlorothalonil	15 e	0 e	9 de	30 bcd	2 b
Benomyl plus DCNA	17 de	5 cde	23 abc	65 a	11 ab
Benomyl plus DCNA plus chlorothalonil	14 de	2 e	22 abcd	41 abcd	0 b
Benomyl plus chlorothalonil	11 e	26 bc	10 cde	27 abc	16 a
Potassium sorbate	58 ab	20 cd	11 bcde	17 d	0 b
Potassium sorbate plus DCNA	58 ab	2 e	15 abcde	40 abcd	10 ab
Potassium sorbate plus DCNA plus chlorothalonil	41 bc	0 e	8 e	18 cd	1 b
Potassium sorbate plus chlorothalonil	32 cd	5 cde	8 e	20 cd	1 b
DCNA	72 a	1 e	24 ab	61 ab	7 ab
DCNA plus chlorothalonil	32 cd	3 de	19 abcde	26 cd	13 ab
Chlorothalonil	44 bc	43 ab	20 abcde	41 abcd	7 ab

^x Percentages of 100 fruit that were split, dipped for 20 min in fungicide suspension, and stored for 5 days.

^y Concentrations of fungicides used, regardless of combination, were as follows (in $\mu\text{g a.i./L}$): benomyl, 595; potassium sorbate, 21,825; DCNA, 893; and chlorothalonil, 1,702.

^z Values within a column followed by a common letter do not differ significantly ($P = 0.05$), according to Duncan's multiple range test.

plastic bag, and held at room temperature for later examination.

Fungicides tested were benomyl, DCNA (2,6-dichloro-4-nitroaniline), potassium sorbate (potassium salt of 2,4-hexadienoic acid), chlorothalonil, captan, fixed copper (copper hydroxide with 56% metallic copper), and CGA-64251 (1-((2-[2,4-Dichlorophenyl]-4-ethyl-1,3-dioxolan-2-yl)methyl)-1H-1,2,4-triazole; Ciba-Geigy Corp., Greensboro, NC 27409).

Five days after treatment, the floral parts were scooped from each fruit, placed in a petri dish, and covered with warm acidified potato-dextrose agar. Plates were held at room temperature until mold growth was sufficient (about 5 days). Sample isolates were pure-cultured for identification.

RESULTS AND DISCUSSION

F. moniliforme and *Rhizopus stolonifer* (Fr.) Lind. were the most prevalent fungi

in the mamme crop of untreated caprifigs harvested; other fungi present included *Alternaria*, some yeasts, and to a lesser extent, *Cladosporium* and *Penicillium* (Table 1).

Benomyl alone effectively controlled *Fusarium* in mamme figs; combinations with other fungicides appeared to be of no benefit except with chlorothalonil at 22,773 $\mu\text{g/ml}$ (Table 1). Chlorothalonil at 1,702 $\mu\text{g/ml}$, a rate used on other crops, did not control *Fusarium* (Table 2). Thus, chlorothalonil at high rates (22,773 $\mu\text{g/ml}$), or possibly captan and potassium sorbate, could be an alternative for benomyl alone, but DCNA could not (Table 1). Potassium sorbate and DCNA (9) together or alone appeared promising for the control of *Rhizopus* (Table 2).

In the test with profichi figs, benomyl alone controlled *Fusarium* but in combination with potassium sorbate gave excellent control of both *Fusarium* and *Rhizopus* (Table 2). Similar results

were obtained when benomyl plus potassium sorbate was combined with DCNA or chlorothalonil. The mixture of benomyl, potassium sorbate, DCNA, and chlorothalonil did not appear to provide any additional control of these molds. One avenue not explored here would be to use higher dosages of potassium sorbate and/or chlorothalonil as combinations for controlling *Alternaria* and yeasts.

Our results indicate that adding potassium sorbate to the benomyl suspension would be beneficial in reducing molds in the mamme crop, because potassium sorbate is considered to be in the category "generally regarded as safe" by the U.S. Environmental Protection Agency. If *Rhizopus* becomes a major concern, the addition of DCNA should be considered.

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