Suppression of *Monilinia laxa* Spore Production by Fungicides Applied to Infected Apricot Twigs During Dormancy

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ABSTRACT

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Apricot twigs previously infected with *Monilinia laxa* were either dipped or sprayed with chemicals in winter, and the effect of the chemicals on spore production was measured. For both methods of application, prochloraz at 400 ppm reduced the production of sporodochia by more than 80%; this effect was similar to that achieved with benomyl at 250 ppm. Iprodione and procymidone at 500 ppm also suppressed the production of sporodochia, whereas CGA 64251, fenarimol, guazatine, imazalil, triadimefon, triforine, and a paraffinic oil were ineffective.

Monilinia laxa (Aderh. and Ruhl.) has been controlled on stone fruits by fungicides applied during dormancy to reduce the amount of primary inoculum on dead twigs. Ramsdell and Ogawa (5) found benomyl with or without the addition of oil to be more effective than sodium pentachlorophenate in suppressing the production of *M. laxa* sporodochia in almonds. Kable (2,3) reported benomyl to be the best of several fungicides in suppressing spore production of a closely related pathogen, *M. fructicola* (Wint.) Honey. Since these reports, new fungicides have been developed that control blossom blight and fruit rot of stone fruits caused by either *M. laxa* or *M. fructicola* (4,6,7). However, no data have been published on the effect of these fungicides on the overwintering phase of the fungi.

The chemicals were evaluated for their ability to suppress spore production by *M. laxa*, and the results are reported here.

MATERIALS AND METHODS

The chemicals and formulations used were benomyl (Benlate, 50% wettable powder [WP]); CGA 64251 (1-[2-(2,4-diclorophenyl)-4 ethyl-1,3 dioxolan-2-ylmethyl] 1H-1,2,4 triazole, 10% WP); fenarimol (Rubigan, 12% emulsified concentrate [EC]; guazatine (Panoctine, 38% EC); imazalil (75% WP); iprodione (Rovral, 50% WP); prochloraz (40% EC); procymidone (Sumisclex, 50% WP); triadimefon (Bayleton, 5% WP); triforine (Saprol, 19% EC). The oil used was paraffinic petroleum oil (B.P. Superior Winter Spray Oil, 84% w/v).

Experiments were conducted on 25-yr-old Trevatt apricot trees in a commercial orchard in the Barossa Valley, 70 km north of Adelaide, South Australia. Many twigs killed by *M. laxa* the previous season were present on all trees in the orchard.

In the first experiment, I collected dead, 1-yr-old twigs in early June (winter) when no sporodochia were evident. The twigs were randomized into bundles of 15 twigs, and each bundle was dipped into one of the treatments. A nonionic surfactant, Agral 60, was added at 150 ppm to all treatments. The bundles of twigs were drained after dipping and suspended in an apricot tree situated about 2 km from where the twigs were collected.

In late July, 2 mo after dipping, I measured the length of each twig and counted the number of sporodochia. For some treatments, 20 sporodochia were removed from each of several twigs and shaken in 10 ml of water containing a surfactant. The numbers of spores washed from the sporodochia were determined with a haemacytometer. Drops of the spore suspensions were placed onto potato-dextrose agar, and the percentage of germination was measured after 18 hr incubation at 21 C.

In the second experiment, I sprayed fungicides on dead twigs on trees in early June at the rates shown in Table 1. Each fungicide was applied to 20–30 twigs with a small hand sprayer.

In mid-August, 1 wk before bud burst, I removed the treated twigs from the trees, measured twig length, and counted the sporodochia per twig. Spores were washed from the twigs of each treatment by cutting the twigs into 5-cm lengths and vigorously shaking them for 30 sec in water containing Tween 20 surfactant at 250 ppm. The spore suspensions were filtered through tissue paper before spores were counted with a haemacytometer.

Spores obtained from trees treated with benomyl and from unsprayed trees were tested for sensitivity to benomyl by a method similar to that detailed by Yoder (10).

RESULTS

Ninety-four percent of the untreated twigs produced sporodochia. Removal from or attachment to the tree made no apparent difference in numbers of sporodochia formed on dead twigs. Because total twig length varied among treatments, the data were standardized to units of 30 cm, which was the average length.

Prochloraz at all rates (200–800 ppm) and iprodione and procymidone at 500 ppm were as effective as benomyl in suppressing the production of *M. laxa* sporodochia on infected twigs (Tables 1 and 2). Oil, CGA 64251, fenarimol, guazatine, imazalil, triadimefon, and triforine were ineffective at the rates tested in suppressing sporulation.

Table 1. Spore production by *Monilinia laxa* on infected Trevatt apricot twigs sprayed with fungicides during dormancy

Fungicide (concentration)	Number of sporodochia per 30 cm of twig[a]	Transformed data log (x+1)[b]	Number of conidia per sporodochium (× 10⁴)	Number of conidia per 30 cm of twig (× 10⁴)	Reduction in number of conidia (%)
Prochloraz (400 ppm)	0.6	0.098 a	46.8	28	87
Benomyl (250 ppm)	1.3	0.25 ab	6.5	8.5	96
Iprodione (500 ppm)	3.1	0.41 bc	10	31	85
Procymidone (500 ppm)	4.0	0.56 c	30	120	43
Imazalil (250 ppm)	15.3	0.95 d	14	214	...[c]
Triadimefon (50 ppm)	15.8	1.02 d	21	332	...
Fenarimol (40 ppm)	20.1	1.12 d	10	201	5
Nil	11.8	0.94 d	18	212	...

[a] Average from 20 to 30 twigs per treatment.
[b] Treatments with no letter in common are significantly different ($P = 0.05$, $F[7,194] = 15.2^{***}$).
[c] ... = Not tested.

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Table 2. Spore production by *Monilinia laxa* on infected Trevatt apricot twigs dipped in fungicides

Fungicide (concentration)[a]	Number of sporodochia per 30 cm of twig[b]	Number of conidia per sporodochium ($\times 10^4$)	Germination of conidia (%)[c]
Oil (12,600 ppm)[d]	15.0	12.6	89
Triforine (250 ppm)	16.0	...[e]	...
Guazatine (500 ppm)	12.0	18.6	95
Fenarimol (40 ppm)	8.4	8.2	93
Fenarimol (40 ppm) + oil[d]	12.4	...	...
Fenarimol (80 ppm)	14.0	...	...
Triadimefon (50 ppm)	13.0	2.8	95
Triadimefon (100 ppm)	17.0	...	...
CGA 64251 (50 ppm)	11.0	...	...
CGA 64251 (100 ppm)	7.0	...	...
Prochloraz (200 ppm)	2.7	1.6	89
Prochloraz (200 ppm) + oil[d]	0.6	...	...
Prochloraz (400 ppm)	1.8	...	...
Prochloraz (800 ppm)	2.5	1.6	64
Benomyl (250 ppm)	4.5	0.1	...
Benomyl (250 ppm) + oil[d]	1.4	...	...
Nil	10.4	11.6	92

[a] The surfactant Agral 60 was added at 150 ppm to all treatments except those with oil.
[b] Average from 15 twigs per treatment.
[c] From 500 conidia per treatment.
[d] B.P. Superior Winter Spray Oil, 84% w/v paraffinic petroleum oil.
[e] ... = Not tested.

Most fungicides had similar effects on spore production whether applied by dipping or spraying. The addition of oil to benomyl, fenarimol, or prochloraz did not markedly affect their ability to suppress sporulation on dipped twigs.

At least 10×10^4 conidia were produced on most sporodochia; the exceptions were those on twigs treated with benomyl and those dipped in fenarimol at 40 ppm, triadimefon at 50 ppm, or prochloraz. The unusually high number of conidia produced on twigs sprayed with prochloraz is difficult to explain. The viability of conidia from fungicide-treated twigs and untreated twigs was usually greater than 90%. Conidia from unsprayed trees and from those sprayed with benomyl both produced distorted germ tubes when germinated on potato-dextrose agar containing benomyl.

DISCUSSION

Prochloraz, iprodione, and procymidone suppressed *M. laxa* spore production and thus warrant further testing. The suppression was similar to that obtained with benomyl, the chemical used commercially in Australia as a dormant eradicant spray for stone fruits.

Strains of *M. laxa* resistant to benomyl were not found in these experiments, nor have they been detected elsewhere (1,8,10). However, resistant strains may develop after frequent use of benomyl, as has occurred with *M. fructicola* (1,4,9).

Fungicides with modes of action different from benomyl and that could be used as alternatives in suppressing *M. laxa* spore production would be useful additions to the range of fungicides presently available for use on stone fruits. Prochloraz and possibly the dicarboximide fungicides may be suitable for this purpose.

Rates of prochloraz less than 200 ppm may be effective in suppressing the production of *M. laxa* sporodochia and may also control brown rot fungi on other tree fruits.

The dicarboximides, iprodione and procymidone, were applied at 500 ppm, a rate higher than that normally used on stone fruits. These fungicides should be tested further to determine the most cost-effective rate for use as dormant sprays.

Although CGA 64251, fenarimol, triadimefon, and triforine have controlled *M. fructicola* blossom blight when applied after infection (7), none of these chemicals suppressed sporulation of *M. laxa* when used at double the recommended rate of application. Kable (3) also found triforine ineffective in suppressing sporulation of *M. fructicola.*

Dipping infected twigs in a fungicide suspension was a convenient method of screening chemicals and determining rates suitable for suppressing spore production of *M. laxa*. A similar technique has been used for *M. fructicola* on peaches (2,3).

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