Reduction of Monilinia laxa Inoculum Potential in Almond Orchards Resulting from Dormant Benomyl Sprays

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ABSTRACT

A presporodochial spray of proprietary benomyl 50W reduced numbers and size of sporodochia of *Monilinia laxa* to a greater extent than did 37% sodium pentachlorophenate (SPCP) but conidial release per unit size and percent germination were about equal. Mycelium was alive in the host tissue following benomyl treatment, but thin sections from these twigs showed fewer mycelial strands than in the untreated twigs where masses of mycelium were evident. Addition of oil to the benomyl spray enhanced sporodochial inhibition by providing longer residual action although the initial deposit was less. Oil increased penetration of benomyl into the bark and provided additional activity against the fungus. In shake cultures, the degradation product, methyl-2-benzimidazolecarbamate (MBC), but not benomyl, was concluded to be the chemical which inhibited mycelial growth and caused lysis of *M. laxa* mycelium.

Benomyl and oil applied before sporodochial development controlled blossom blight equally as well as 37% SPCP in large-scale field trials using both high volume and concentrate spray applications. Applications of benomyl and oil made after sporodochial development provided less disease control than 37% SPCP, but more than 79% SPCP.

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Additional key words: sporodochial inhibition, brown rot.

Adequate control of blossom and twig blight of almond and apricot, caused by *Monilinia laxa* (Aderh. & Ruhl.) Honey, using eradicant fungicides, was first achieved by Wilson (15) with the knowledge that apothecial stage of *M. laxa* in California orchards is nonexistent (3). Wilson successfully directed control efforts toward reduction of the primary inoculum source; i.e., sporodochia on apricots, by spraying in the dormant season with arsenite compounds. Because of phytotoxicity of arsenites to almond trees, Wilson (16) tried sodium pentachlorophenate (SPCP) and found that it destroyed sporodochia of *M. laxa* on almond trees. Good control was achieved through eradicative action without injury. Ogawa et al. (8) demonstrated that SPCP dormant sprays on almond inhibited sporodochial production and reduced conidial release and germination of conidia on sporodochia developed. With the advent of improved formulations of SPCP, greater control of blossom blight was achieved by almond growers. Because monocalcium arsenite is no longer registered for use and since SPCP is phytotoxic when applied after bud break and could be hazardous to the applicator, a replacement dormant fungicide for almonds and other stone fruits is needed. Ramsdell & Manji (10) demonstrated in 1969 that early dormant benomyl sprays applied to 'Drake' almond trees markedly reduced the development of sporodochia by *M. laxa*. The addition of commercial dormant oil sprays to benomyl also reduced both sporodochial development and blossom blight in 'Jordanolo' almond (11). Kable (6) found that benomyl, arsenic and mercury compounds effectively suppressed sporulation of *Monilinia fructicola* on peduncles and mummified peach fruits.

The effect of dormant benomyl or benomyl plus oil sprays upon reduction of primary inoculum of *M. laxa* and reduction of blossom and twig blight were studied during a 3-year period. Results are presented here.

MATERIALS AND METHODS.—*Field plot descriptions.*—To study the effects of a benomyl dormant spray upon sporodochial development, Benlate 50W [a wettable powder containing 50% benomyl 1-(butylcarbamoyl)-2-benzimidazole carbamic acid] at 1.19 g/liter (1 lb/100 gal) of water was applied to mature Drake almond trees (*Prunus amygdalus* Batsch) to the drip stage with a handgun on 30 November 1968 at Davis, California. The test trees exhibited a high level of *M. laxa* blossom and twig blight from the previous season, and sporodochia were not present at the time of spraying. A standard treatment of sodium pentachlorophenate (SPCP), 37% formulation at 9.52 g/liter (8 lb/100 gal) of water, was included. The effects of these treatments upon reduction of inoculum potential were evaluated at blossom time.

To determine the effects of dormant presporodochial benomyl, and benomyl plus oil, sprays upon inoculum potential reduction and disease control, a large-scale plot was established in a severely diseased mature Jordanolo almond orchard at Winton, California (San Joaquin Valley). No sporodochia were evident on the day of treatment, 18 December 1969. Treatments were applied with an air blast sprayer at 1,892.5 liters/0.41 hectare (500 gal

spray/acre). Treatments were as follows: grams (lb) and liters (gal) refer to amounts of Benlate 50W and Volck Supreme Oil used/hectare (acre). SPCP 37% 44.8 kg/hectare (40 lb/acre), Benlate 50W 5.6 kg/hectare (5.0 lb/acre) + Volck Supreme Oil 70.2 liters/hectare (7.5 gal/acre), Benlate 50W 2.8 kg/hectare (2.5 lb/acre) + Volck Supreme Oil 70.2 liters/hectare (7.5 gal/acre), and Benlate 50W 5.6 kg/hectare (5.0 lb/acre). Volck Supreme Oil (Chevron Chemical Co., Richmond, Calif.) is a heavy, paraffinic oil with a viscosity of 145 Seconds Saybolt Universal. It is more persistent on crop surfaces than the usual dormant or summer-type spray oils. Treatments were replicated three times in a completely randomized plot design (4). This plot was designed to minimize reinfection of the trees evaluated from sources outside the plot area (17). Sporodochial development counts were made at full bloom. Three trees from the center of each block (replication) were evaluated for shoot strikes on 26 March 1970. Residue analyses for fungicide on or in twigs were made after treatment.

The relative effectiveness of a postsporodochial dormant benomyl plus oil spray was tested in a large-scale field plot at Durham, California (Sacramento Valley). Mature Drake almond trees exhibiting evidence of blossom and twig blight from the previous season were selected. Sporodochial development was well advanced by the treatment date of 9 December 1970. A randomized complete block design (4) with three replications of six trees each was used. The following sprays were applied as a full volume 1,892.5 liters/0.41 hectare (500 gal water/acre) spray using an air blast sprayer (rates are expressed as /hectare (acre). SPCP 37% 44.8 kg/hectare (40 lb/acre), Benlate 50W 2.8 kg/hectare (2.5 lb/acre) + Volck Supreme Oil 46.8 liters/hectare (5.0 gal/acre), and SPCP 79% 21.0 kg/hectare (18.75 lb/acre). All plots except the untreated control received a pink bud cover spray of captan 50W at the rate of 11.2 kg/hectare (10 lb/acre) applied in 473.1 liters/0.41 hectare (125 gal water/acre) with a semiconcentrate air blast sprayer. Sporodochial development on twigs from the benomyl plus oil sprayed trees vs. untreated trees was counted at full bloom. Conidia were released from treated sporodochia 4 days after spraying and were tested for percent germination and germ tube growth. Disease control evaluations were made later by counting shoot strikes.

Laboratory investigations - residue analyses of benomyl and benomyl + oil dormant-treated blighted twigs and blossoms.—Samples of blighted twigs at the Winton plot were collected from all benomyl treatments and untreated controls at 4, 33, and 82 days after spraying to determine the levels of the fungitoxic benomyl degradation compound, methyl-2-benzimidazolecarbamate (MBC) on or in the sprayed twigs. The purpose of determining residue curves on the twigs was for comparison of penetration and longevity of fungitoxic residues as affected by oil added to Benlate 50W. Residue analysis was performed on all samples according to the method of White & Kilgore (14). Where oil was applied with benomyl, two-dimensional thin-layer chromatography was used to separate the oil from MBC. Internal twig residue of MBC was determined by re-extracting the same twig samples which were surface-extracted with benzene for the external residue determination. Samples were chopped into small pieces and ground with dry ice for 3 min in a Hobart food chopper, and placed in a beaker with a 4:1 ratio (v/w) of benzene and sonicated for 7 min with a Branson Model J-32A Sonifier. The previously mentioned residue determination method was then used.

Liquid shake culture studies to compare the inhibition of M. laxa mycelial growth by benomyl and MBC.—Conidia of *M. laxa* were obtained by growing fungus cultures on oatmeal agar for 7-9 days under continuous fluorescent light. A conidial suspension of 10^6 spores/ml was added to flasks, each containing 147 ml of Dion's liquid medium altered to give high buffering capacity (KH_2PO_4, 20 g; K_2HPO_4, 10 g; NaCl, 0.5 g; $MgSO_4 \cdot 7\ H_2O$, 10 mg; $ZnSO_4$, 10 mg; $FeSO_4 \cdot 7\ H_2O$, 10 mg; dextrose, 30 g; l-asparagine, 5 g; and thiamine, 100 μg/liter of glass-distilled water). The medium was autoclaved for only 10 min to avoid destruction of thiamine. The pH of the medium was 6.7 throughout the experiment. After 24 hr at 25 C, when the culture was in the log stage of mycelial growth, analytical grade benomyl or MBC in ethyl acetate was added to give final concentrations of 0.05, 0.1, and 1.0 μg/ml of nutrient medium. Equal amounts of ethyl acetate were added to all flasks. Ten-ml samples were aseptically pipetted from the flasks over a 48-hr period. The fungus mat was washed with water on dried and tared Whatman GF/C 2.4-cm filters. Dry weight determinations of the fungus tissues were used as a comparative index of growth rates. To determine the rate of benomyl conversion to MBC in the medium, a flask containing 1.0 μg analytical grade benomyl/ml of medium plus fungus separate from those prepared for the growth study was used. Samples taken at various times were analyzed for benomyl and MBC levels. Only the nutrient medium fraction was analyzed. Thin-layer methods previously described (9) were used to determine the rate of breakdown of benomyl to MBC.

Evaluation of oil as an aid in the penetration of ^{14}C-MBC into the bark of almond twigs killed by M. laxa.—Methyl-2-^{14}C-benzimidazolecarbamate (^{14}C-MBC), specific activity 2.7 mc/mmole (ICN Co., Inc., Irvine, California) was used in this study. The labeled MBC powder was diluted 10:1 with Benlate 50W on an active ingredient basis (1.8 mg ^{14}C-MBC + 34.2 mg Benlate 50W). The ^{14}C-MBC powder was mixed with Benlate 50W to increase the wettability of the labeled material, which by itself does not wet or suspend well. A water suspension equivalent to 113.4 g (4 oz) active ingredient/378.5 liters (100 gal) of water was made. To one-half of the mixture, Volck Supreme Oil was added to make the spray mixture 1.5% (v/v). The concentration of both mixtures was ca. 1.2×10^6 dpm/ml. Twigs blighted by *M. laxa* were sprayed to the drip stage with both mixtures

TABLE 1. Reduction in numbers of *Monilinia laxa* sporodochia on 'Drake' almond twigs at full bloom stage as a result of presporodochial dormant sprays, U.C., Davis, California

Treatment[a]	Avg. no. of sporodochia/twig[b,d]	Avg. size rating of sporodochia[c,d]
Benlate 50W - 1.19 g/liter (1 lb/100 gal)	0.1 a	0.3 a
Sodium pentachlorophenate SPCP 37% - 9.52 g/liter (8 lb/100 gal)	2.6 b	1.3 b
Check (untreated)	4.1 b	1.7 c

[a] Spray applied by handgun on 30 November 1968, at the rate of 18.93 liters (5 gal) H_2O/tree prior to the formation of sporodochia.
[b] Fifteen 15-cm-long blighted twigs were evaluated/replication. The numbers shown represent an average of three replications.
[c] Sporodochia size rating: (diameter) 1 = 0.5 - 1.0 mm; 2 = 1.0 - 1.5 mm; 3 = 1.5 - 2.0 mm; 4 = 2.0 mm +.
[d] Duncan's multiple range test was used (P = .05) (2). Treatments followed by the same letter do not differ significantly.

TABLE 2. Conidial release[a] from *Monilinia laxa* sporodochia on 'Drake' almond twigs and conidial germination at full bloom stage as affected by dormant sprays, U.C., Davis, California

Treatment	No. of conidia/sporodochium collected/mm² on a glass cover slip at 40.2 km/hr (25 mph)[c,d]	% conidial germination on H_2O agar at 72 hr[c,d]
Presporodochial[b]		
Benlate 50W-1.19 g/liter (1 lb/100 gal)	2.7 a	42.7 a
Sodium pentachlorophenate 37%-9.52 gm/liter (8 lb/100 gal)	8.2 a	45.3 a
Check (untreated)	56.9 b	78.7 b

[a] A cyclone-type spore collector was used in this experiment (8). Wind velocity determined with an Alnor thermal anemometer.
[b] Spray applied by handgun on 11/30/68 at the rate of 18.93 liters (5 gal) H_2O/tree prior to the formation of sporodochia.
[c] The figures in the columns are an average of three replications.
[d] Duncan's multiple range test was used (P = .05) (2). Treatments followed by the same letter do not differ significantly.

during the winter, using a DeVilbiss No. 15 hand atomizer. The sprayed twigs were collected after 14 days in the field. Longitudinal free-hand sections were prepared for radioautography according to the methods of Crafts & Yamaguchi (1).

Histological studies of benomyl-treated and nontreated twigs blighted by M. laxa.—The effect of benomyl on sporodochial inhibition in treated almond twigs was studied as follows: free-hand sections of twigs from treated and nontreated trees were killed and fixed in formalin-acetic acid-alcohol (FAA) solution and dehydrated with alcohol (5). Tissue sections were embedded in Spurr's epoxy resin (13). A Porter-Blum Model MT-2 ultramicrotome equipped with a diamond knife was used to cut 1-μ-thick sections for light microscope examination. The sections were stained with Magdala red and light green according to Rawlins' method (12). Phase contrast light microscopy was used to locate the fungal mycelium within the dead host tissue.

RESULTS AND DISCUSSION.—*Effects of benomyl and SPCP dormant treatments upon primary inoculum production.*—At full bloom at the U.C. Davis plot, the presporodochial dormant benomyl spray reduced by 41-fold the number of sporodochia which developed on previous years' blighted twigs (Table 1). The diameters of these sporodochia were only 18% as large as those from untreated twigs. The standard SPCP treatment reduced sporodochial numbers on twigs 36% and reduced size 24%.

By the use of a cyclone spore collector apparatus (7), conidia were released from sporodochia 1 mm in diam, which formed subsequent to the presporodochial benomyl and SPCP sprays. Numbers of conidia released were reduced 95% and 86% (Table 2), respectively, by the benomyl and SPCP standard treatments compared to control twigs. Percent germination of these conidia on water agar after 72 hr was reduced 46% and 42%, respectively, by these treatments. Isolations from the inner bark and xylem tissue of twigs exhibiting sporodochial inhibition yielded *M. laxa* mycelium from both of these areas. Therefore, neither benomyl nor SPCP act as an eradicant as is the case with monocalcium arsenite, which actually kills the fungal mycelium in the twig (15).

The effects of commercial scale, air blast sprayer application of presporodochial benomyl and benomyl + oil sprays upon sporodochial development and disease levels.—The sporodochial development on previous years' blighted blossoms and peduncles was evaluated at full bloom about 2 months after air blast sprayer application at the Winton plot (Table 3). The standard SPCP 37% treatment and the 5.6 kg (5.0 lb) Benlate 50W + oil rate both reduced sporodochial numbers on blighted blossoms and peduncles 95%

and 83%, respectively. The 5.6 kg (5.0 lb) Benlate 50W rate without oil gave reductions of 50% on blossoms and 100% on peduncles. Disease control data (Table 3) correlate well with inoculum reduction. The dormant treatments listed above were the only chemicals applied to these trees. The standard SPCP treatment reduced disease incidence 73%, the 5.6 kg (5.0 lb) Benlate 50W + oil rate 69%, the 2.8 kg (2.5 lb) Benlate 50W + oil rate 67%, whereas the 5.6 kg (5.0 lb) Benlate 50W rate without oil gave only a 44% reduction in disease level. The addition of Volck Supreme Oil to the benomyl spray enhanced both sporodochial inhibition and disease reduction.

Effects of benomyl plus dormant oil sprays applied after sporodochium formation.—Average pretreatment sporodochium counts (0.6, 0.2, and 2.0 sporodochia per previous season's blighted blossoms, peduncle, and twig, respectively) indicate that sporodochial production was well underway at the time of the benomyl + oil dormant application. Sporodochial counts made at full bloom on the

TABLE 3. Reduction of sporodochial production by *Monilinia laxa* and blossom blight in 'Jordanolo' almond resulting from air blast sprayer application presporodochial dormant sprays, Winton, California

Treatment[a]	Amount /hectare	Amount (acre)	Avg no. of sporodochia Blighted blossom[b,d]	Avg no. of sporodochia Peduncle[b,d]	Avg no. of shoot strikes/1,200 shoots counted[c,d]	Percent disease reduction
Sodium penta-chlorophenate 37%	44.8 kg	(40.0 lb)	0.2 a	0.1 a	83.0 a	73
Benlate 50W + Supreme Oil	5.6 kg 70.2 liters	(5.0 lb) (7.5 gal)	0.2 a	0.1 a	95.0 a	69
Benlate 50W + Supreme Oil	2.8 kg 70.2 liters	(2.5 lb) (7.5 gal)	1.4 b	0.0 a	100.7 a	67
Benlate 50W	5.6 kg	(5.0 lb)	1.9 b	0.0 a	169.7 b	44
Control			3.8 c	0.6 b	305.0 b	

[a] Air blast sprayer application was made on 18 December 1969. Approximately 1892.5 liters (500 gal) H_2O/tree was applied prior to formation of sporodochia.
[b] Evaluation of sporodochial reduction made at full bloom. Nine twigs evaluated/replication. Three replications/treatment.
[c] Disease evaluation was made on 26 March 1970. One hundred shoot strikes per quadrant per tree were counted. Treatments were replicated three times with three trees per replication.
[d] Duncan's multiple range test ($P = .05$)(2). Treatments followed by the same letter do not differ significantly.

TABLE 4. Evaluation of blossom and twig blight (*Monilinia laxa*) control by air blast sprayer applied dormant sprays to Drake almond after sporodochial formation, Durham, California

Material	Time of application[a]	Amount per hectare	Amount per (acre)	Total no. of shoot strikes/4,500 shoots counted for each treatment[b]	Percent disease reduction
Sodium penta-chlorophenate 37%	dormant	44.8 kg	(40.0 lb)	204 a	59
Captan 50W	pink bud	11.2 kg	(10.0 lb)		
Benlate 50W + Supreme Oil	dormant	2.8 kg 46.8 liters	(2.5 lb) (5.0 gal)	250 b	50
Captan 50W	pink bud	11.2 kg	(10.0 lb)		
Sodium penta-chlorophenate 79%	dormant	21.0 kg	(18.75 lb)	347 c	30
Captan 50W	pink bud	11.2 kg	(10.0 lb)		
Control				498 c	

[a] Dormant treatments were applied with an air blast sprayer at 1892.5 liters/0.41 hectares (500 gal H_2O/acre on 9 December 1970. Pink bud treatments were applied with an air blast sprayer at 473.1 liters/0.41 hectares (125 gal H_2O/acre on 17 February 1971.
[b] Disease control evaluation was done on 13 April 1971. 750 shoots/tree were counted; two trees/replication were evaluated; three replications total. Duncan's multiple range test ($P = .05$) (2). Treatments followed by the same letter do not differ significantly.

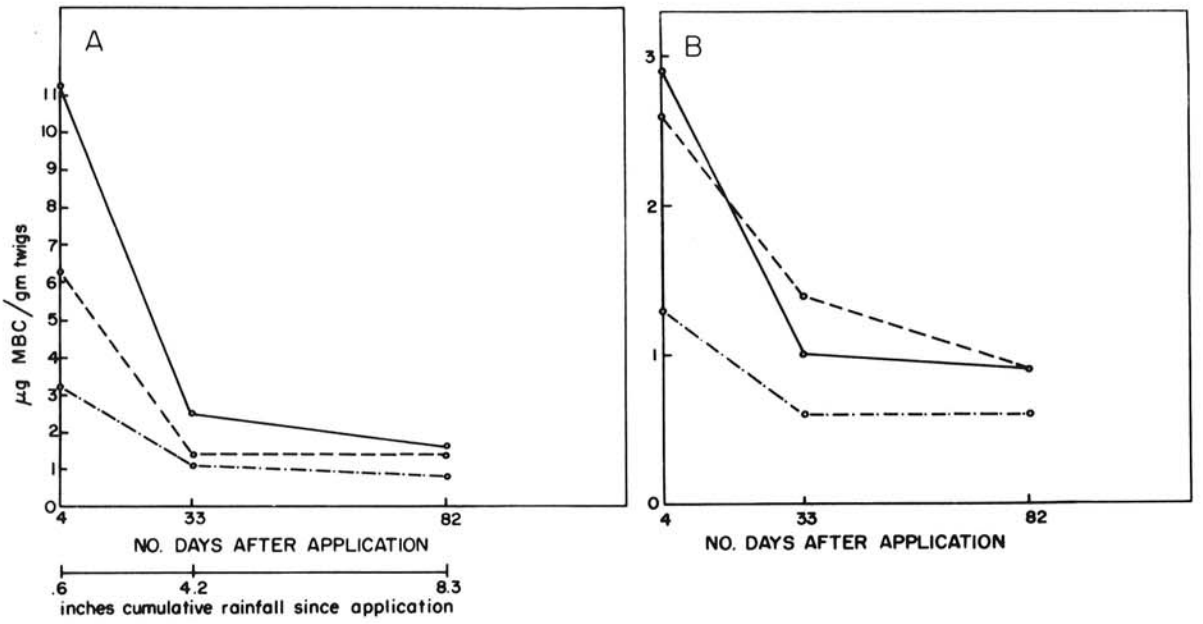

Fig. 1. A) External methyl-2-benzimidazolecarbamate (MBC) residue on previous years' *Monilinia laxa* blighted almond twigs, resulting from a full volume dormant air blast sprayer application on 18 December 1969 at Winton, Calif. Materials applied [hectare (acre)] were: Benlate 50W 5.6 kg (5.0 lb) = ————; Benlate 50W 5.6 kg (5.0 lb) + 28.39 liters (7.5 gal) Volck Supreme Oil = – – – – –; Benlate 50W 2.8 kg (2.5 lb) + 28.39 liters (7.5 gal) Volck Supreme Oil = –·–·–·–. **B)** Internal MBC residue in the bark and wood tissue from the same twigs as shown in Fig. 1-A. Same treatments as in Fig. 1-A.

control vs. treated host parts revealed counts of 0.9 vs. 0.8, 0.3 vs. 0.4, and 5.6 vs. 4.7 sporodochia on blossom, peduncle and twig, respectively, indicating that the dormant treatment did not stop further development. Conidia released from sporodochia which received the benomyl + oil treatment 4 days earlier did not differ significantly in percent germination or germ tube length after 24 hr on water agar compared with conidia released from untreated sporodochia. Percent germination and germ tube length for treatment vs. control were 80% and 60 μ vs. 82% and 60 μ, respectively.

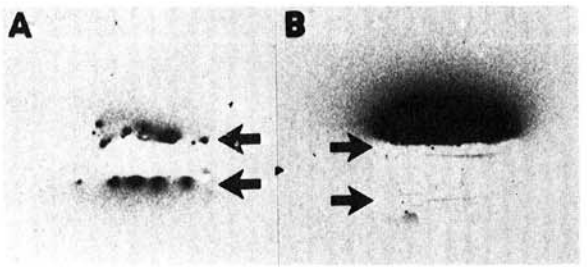

Fig. 2. A) Radioautogram showing penetration of ^{14}C-MBC into the bark of previous years' *Monilinia laxa*-blighted almond twigs (arrows). The twigs were dormant sprayed with a water suspension containing 1.8 mg ^{14}C-MBC + 34.2 mg Benlate 50W + Volck Supreme Oil (1.5% v/v), which is equivalent to 113.4 g (4 oz) active ingredient fungicide/378.5 liters (100 gal) water. **B)** Radioautogram showing that ^{14}C-MBC did not penetrate far into the bark (arrows) when the above mixture without oil was sprayed on twigs.

Disease control data shown in Table 4 demonstrate that a postsporodochial benomyl + oil spray resulted in only 50% disease reduction. The disease reduction given by this treatment is intermediate between that given by the two formulations of SPCP, the standard commercial dormant fungicide presently used.

Levels of MBC residue on and in twigs as affected by the addition of oil to a Benlate 50W spray mixture.—External MBC levels where oil was used with benomyl were initially about 45% less than where benomyl was used along at the same rate/378.5 liters (100 gal) water (Fig. 1-A). After 33 days and 106.7 mm (4.2 inches) of rain, larger residues of MBC were still present on the 453.6 g (1 lb) Benlate 50W treated twigs compared to the plus oil treatment. After 82 days and 210.8 mm (8.3 inches) of rain, the 453.6 g (1 lb) Benlate 50W plus oil treatment had an MBC residue level similar to that which resulted from the 453.6 g (1 lb) Benlate 50W spray. Although the internal MBC residue (Fig. 1-B) levels 4 days after treatment were slightly less where oil was used, after 33 days the MBC level was ca. 25% greater where oil was used with Benlate 50W at the 453.6 g (1 lb) rate. Also, at 33 days the 226.8 g (0.5 lb) + oil rate resulted in ca. half as much MBC as did the 453.6 g (1 lb) benomyl 50W rate without oil. After 82 days the MBC level from the 226.8 g (0.5 lb) benomyl 50W + oil rate was only 25% less than the amount of MBC from the 453.6 g (1 lb) benomyl 50W rate with or

without oil. These data indicate that benomyl and/or MBC in the oil phase was carried into the bark tissue of dead almond twigs. Radioautograms (Fig. 2) made from equal rates of ^{14}C-MBC with and without oil (1.5 % v/v in water) sprayed on twigs during the winter indicate that more ^{14}C-MBC resulted in the bark area where the oil was used (Fig. 2-A). Apparently, the presence of oil in the spray mixture caused greater amounts of run-off of the fungicide, resulting in initially lower external residues. Even so, a higher internal residue of MBC resulted in the bark of the twigs, which is the site of sporodochium production by *M. laxa.*

Liquid shake culture growth comparison of the inhibitory effect of benomyl vs. MBC upon M. laxa mycelium.—Benomyl at the rate of 0.05 μg/ml of nutrient medium added to a 24-hr-old mycelial culture did not cause inhibition of growth until 24 hr later (Fig. 3-A); higher benomyl rates of 0.1 and 1.0 μg/ml inhibited growth by 50% and 70%, respectively. MBC at all three rates inhibited mycelial growth at 8 hr after addition (Fig. 3-B). After 24 hr these levels of toxicant caused growth inhibitions of 50%, 66%, and 75%, respectively, with greater inhibition evident after 48 hr. The decrease in growth rates after 24 hr caused by the two highest rates of benomyl and all three rates of MBC was due to lysis of the mycelium, which was very evident microscopically. Analysis of the nutrient medium to which benomyl was added at 1.0 μg/ml showed no benomyl present even for the zero time sample. Benomyl was converted to MBC rapidly in the aqueous medium as was reported previously (9). The 0.05 μg benomyl/ml of nutrient medium level caused very little inhibition of mycelial growth compared with the same level of MBC. This is probably due to some loss of MBC during conversion (*unpublished data*). The 0.1 and 1.0 μg/ml levels of benomyl and MBC exhibited similar inhibition of mycelial growth throughout the experiment.

Histological examination of sporodochial production in dead twigs.—The photomicrograph in Fig. 4-A shows normal development of the fungus in the almond twig. The mycelium ramifies throughout the dead xylem and bark tissues and erupts through the bark as a sporodochium. Figure 4-B shows a photomicrograph of a longitudinal section through a twig which received a presporodochial dormant spray a few months previous to sampling. Isolations from this twig piece onto potato-dextrose agar (PDA) produced *M. laxa* colonies. Note the presence of mycelium in the dead xylem. Although an early dormant benomyl spray prior to sporodochial formation with or without oil does not result in true eradicant action against *M. laxa* blossom and twig blight, the result is inhibition of primary inoculum production and more effective disease control. It is critical that the treatment be applied prior to appearance of sporodochia in the fall or early winter. If sporodochia are present at the time of application, normal and infective conidia will be dispersed at blossom time and infection will result. The primary

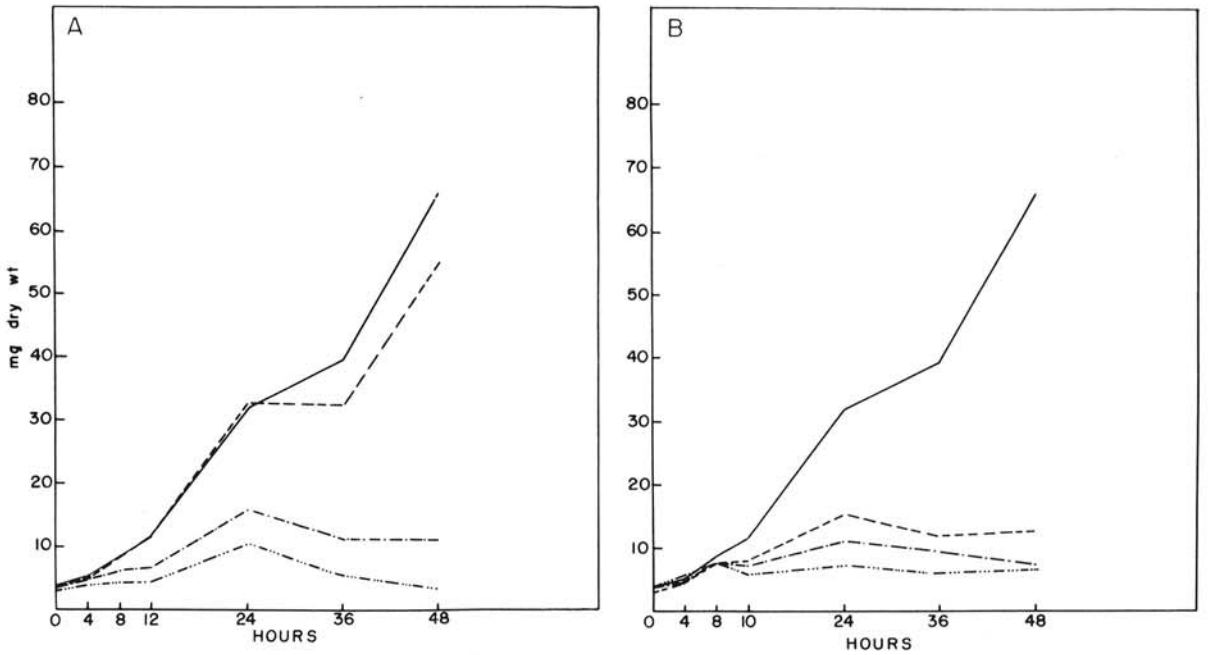

Fig. 3. A) Growth of 24-hr-old *Monilinia laxa* mycelium for an additional 48 hr in liquid shake culture as affected by the addition of technical benomyl at the following rates (all rates are expressed as μg benomyl/ml nutrient medium); 0.05 μg = – – – – –; 0.1 μg = –•–•–•–; 1.0 μg = –•••–•••–; control = ———. **B)** Growth of 24-hr-old *M. laxa* mycelium for an additional 48 hr in liquid shake culture as affected by the addition of technical MBC at the following rates (all rates are expressed as μg MBC/ml nutrient medium): 0.05 μg = – – – – –; 0.1 μg = –•–•–•–; 1.0 μg = –•••–•••–; control = ———.

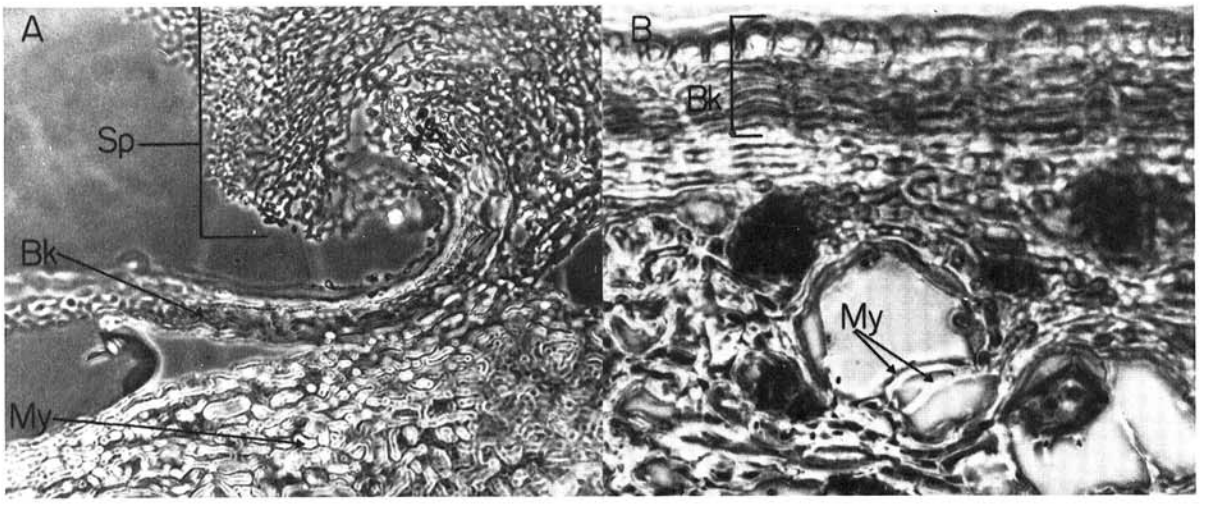

Fig. 4. A) Longitudinal thin section through a blighted almond twig showing a normal sporodochium (Sp) of *Monilinia laxa* protruding through the bark (Bk) of the twig (×65). **B)** Longitudinal section through an almond twig exhibiting sporodochial inhibition as a result of a presporodochial dormant benomyl spray. Note mycelial strands (My) in the woody tissue. There was no mycelium in the bark (Bk) area of twigs exhibiting inhibition of sporodochial development (×250).

degradation compound of benomyl, MBC, is the apparent fungitoxic chemical which inhibits *M. laxa* sporodochial formation in twigs of almond. The addition of oil to benomyl increased the effectiveness of MBC by aiding its penetration into the bark of blighted twigs, the site of sporodochial production by *M. laxa*. The fact that benomyl and oil are compatible allows simultaneous application of combinations of insecticides, miticides, fungicide, and oil by orchardists.

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