PEAR FIREBLIGHT CONTROL TESTS

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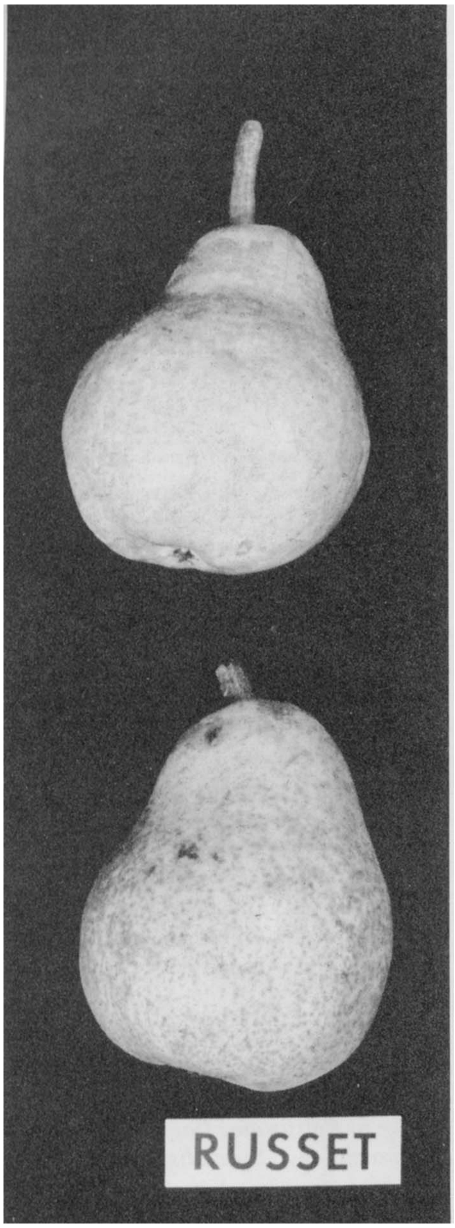
Copper compounds were the only currently registered bactericides that controlled streptomycin-resistant strains of fireblight bacteria in Bartlett pear trees, but they induced considerable amounts of fruit russet. An anti-transpirant material reduced the amount of russet caused by the copper materials when applied alternately, or in conjunction with copper sprays. A new organic bactericide, MBR 10995, provided excellent control of fireblight in a limited trial but is not currently registered. Biological control of fireblight with application of bacteria antagonistic to **Erwinia amylovora** was somewhat effective. The efficacy of bactericides can also be determined by their effect on epiphytic populations of **E. amylovora** in blossoms.



Fruit with no russetted lenticels (top) compared with fruit having 50% russetted lenticels, below.

TABLE 1. EFFECT OF COPPER AND ANTIBIOTIC SPRAYS ON FIREBLIGHT INFECTIONS AND FRUIT RUSSETTING OF BARTLETT PEAR, GRIDLEY ORCHARD, 1973
(Applied with concentrate sprayer at the rate of 100 gal per acre)

Treatment (Eight applications)	Amount material per acre per application	No. blight infections per tree May 25*	Percent lenticels russetted July 19*
Kocide (copper)	½ lb	0.86abc	49.7d
Kocide	2 lbs (1st & 2nd applic then ½ lb)	0.42a	53.2e
Kocide	1 lb	0.72ab	47.2cd
Kocide	2 lbs	0.36a	56.2e
COCS (copper)	1 lb	0.62ab	45.5c
COCS	1 lb (First 6 applic.)	0.54ab	41.7b
COCS	2 lbs	0.52ab	45.7c
Citcop (copper)	1 gal	1.26bc	48.2cd
Citcop	2 gal	1.61cd	55.3e
Streptomycin 17%	10 oz	0.70ab	33.7a
Terramycin 17%	10 oz	0.68ab	32.7a
Control	....	2.24d	34.3a

* Values followed by different letters are significantly different

THE EFFICACY of chemical sprays in controlling streptomycin-resistant strains of *Erwinia amylovora* in 'Bartlett' pear trees was studied in two commercial orchards in the Sacramento Valley during the 1973 season. One orchard consisted of 15-year-old trees near Gridley and the other, near Hamilton City, consisted of 7 to 12-year old trees. Most of the experimental trees were planted in hedgerows. Fireblight bacteria resistant to streptomycin were present in both orchards.

Periods of warm temperatures combined with rainfall and high humidity favor the development of fireblight while low temperatures, rain and high humidity are conducive to fruit russet. Weather conditions favoring blight and russet occurred in both orchards. At Gridley, the first bloom occurred March 14 and full bloom, March 26. First blight infections were found April 25. At Hamilton City, the first bloom was March 15 and full bloom, March 26. First blight infections were found April 17.

Different types and concentrations of copper sprays were compared with streptomycin and Terramycin sprays in the Gridley orchard (table 1), and two copper sprays were compared with streptomycin in the Hamilton City orchard (table 4). These sprays were applied in replicated plots with a concentrate sprayer at the rate of 100 gallons per acre. The bactericides were applied in the Gridley orchard at approximately five-day intervals, from March 16 through April 18, with a total of eight applications throughout the bloom period. The Hamilton City orchard received a total of six applications, the first on March 18 and the last on April 16. Both orchards were in the full bloom stage on March 26.

MBR 10995

Additional applications were made in another part of the Gridley orchard to test a new organic bactericide, MBR 10995, and a combination of three *Pseudomonas* spp. and one *Erwinia* sp. antagonistic to *E. amylovora* (table 3). An antitranspirant spray, Mobileaf, was also applied in an attempt to reduce fruit russet. Treatments were applied with a hand sprayer at the rate of two gallons per tree on the same dates that the concentrate sprays were applied.

The first blight infections became apparent April 17 and new infections continued to appear for about three weeks. The average number of infections that developed on each of 20 trees per treatment (tables 1 and 4) was determined from final counts made May 25.

All of the blight control materials used in the concentrate sprays in the Gridley orchard gave significant reductions in the number of blight infections (table 1). There were no significant differences between the number of infections that occurred on trees sprayed with either fixed coppers (Kocide or COCS) or antibiotics (streptomycin or Terramycin), but the higher concentrations of fixed coppers (2 lbs per acre) tended to give better control than the lower ones (1 lb per acre). The liquid copper formulation (Citcop)

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gave the poorest control of blight and caused considerable leaf burn at either 1 or 2 gallons per acre.

Hand-sprayed plots

In the hand-sprayed plots in the Gridley orchard, the new organic bactericide, MBR 10995, gave better control of blight than Kocide at 1 lb per 100 gallons and did not increase fruit russet (table 3). The applications of bacteria antagonistic to *E. amylovora* bacteria also gave significant reductions in the numbers of fireblight infections with little or no effect on fruit russetting. This was encouraging and further tests of such biological control sprays should be more fully investigated.

Copper residues were determined by collecting samples of mature leaves from current season's growth on April 26 from each of 12 trees treated with a copper bactericide and from each of 12 control trees in the Gridley orchard. The leaves were analyzed for copper residues to indicate spray coverage. The amount of copper in the residues includes that translocated from the soil (approximately 9 to 15 ppm), as well as copper from spray deposition (table 2). Control trees showed some copper deposit as a result of drift from adjoining plots. Leaves sprayed with Kocide had a significantly greater copper residue than those sprayed with equivalent amounts of COCS or Citcop. Based on the amount of copper residue, the poorest coverage was obtained with Citcop.

TABLE 2. COVERAGE OF CONCENTRATE COPPER SPRAYS AS INDICATED BY COPPER RESIDUE ON BARTLETT PEAR LEAVES, GRIDLEY ORCHARD, 1973
(Eight applications from March 16 through April 18)

Material	Amount of material per acre per application	Amount of metallic copper per acre per application	Copper residues on leaves collected April 26*
		(pounds)	(ppm)
COCS	1 lb	½	184b
COCS	2 lbs	1	280c
Citcop	1 gal	½	172b
Citcop	2 gal	1	176b
Kocide	½ lb	¼	177b
Kocide	1 lb	½	273c
Kocide	2 lbs	1	428d
Control	....	..	34a

* Values followed by different letters are significantly different at the 0.05 level.

The amount of fruit russet that developed with each treatment was determined near harvest by making four evaluations on each of 15 trees per treatment. Each evaluation was based on the estimated average percent russetted lenticels, in comparison with standards, on pears located in an area from 4 to 7 ft above the ground and from the tips of the branches to 3 ft within the tree. Bartlett pears with less than 20% of their lenticels russetted are considered desirable for fresh fruit consumption, while those with 40% or more of their lenticels russetted are normally unsuitable for the market. Russet does not affect the sales of pears used for canning. In the Gridley orchard, the concentrate sprays of coppe- (table 1) caused significant increase in the amounts of fruit russet while the fruits from the streptomycin- or Terramycin-sprayed trees had about the same amount of russet as the controls. The higher concentrations of Kocide and Citcop caused more russet than those of COCS.

Antitranspirant spray

Some of the russet caused by the Kocide sprays was prevented by the inclusion of the antitranspirant sprays (Mobileaf), but there was considerably less russet on the fruit from the control trees as well as the trees sprayed with MBR 10995 or bacteria (table 3). Mobileaf was more effective when applied alternately between applications of Kocide than when it was mixed and applied with the Kocide copper spray.

Streptomycin failed to provide significant control of fireblight in the Hamilton City orchard (table 4) and laboratory tests confirmed the presence of streptomycin-resistant strains of fireblight bacteria in this orchard. Kocide gave significantly better control of fireblight than either Citcop or streptomycin, but also caused more fruit russet. Citcop at one gallon per acre caused leaf burn in the Hamilton City orchard, as it did in the Gridley orchard. It is interesting that the streptomycin sprays, as well as the copper sprays, caused an increase in the amount of russet in this orchard.

The effect of bactericides on the epiphytic population of *E. amylovora* in healthy blossoms was also investigated since this population should correlate with the actual disease incidence in an orchard. The efficacy of bactericides has usually been determined on the basis of disease control. However, the disease incidence in test plots was frequently too low to make reliable comparisons and additional years of testing were required. Recent research, however, has indicated that the pathogen is commonly present in healthy blossoms without necessarily leading to disease development. With the development of techniques to monitor the presence and changing populations of *E. amylovora*, it is now possible to test the efficacy of bactericides against *E. amylovora* without having to depend on disease development. For example, if a chemical reduces the population of *E. amylovora*, one may assume *a priori*, that the incidence of disease will be reduced. Therefore, a study was undertaken to determine if a relationship existed between the epiphytic population of bacteria in healthy blossoms, the type and rate of chemical applications, and the subsequent disease incidence in test plots.

Individual healthy blossoms were collected from the plots treated with bacteri-

TABLE 3. EFFECT OF NEW FIREBLIGHT CONTROL SPRAYS ON FIREBLIGHT INFECTIONS AND FRUIT RUSSETTING OF BARTLETT PEARS, GRIDLEY ORCHARD, 1973
(Sprays applied with a single-nozzle gun at the rate of 2 gal per tree)

Treatment (Eight applications)	Concentration	No. blight infections per tree May 25*	Percent lenticels russetted July 13*
MBR 10995 (organic bactericide)	150 ppm	0.40a	7.3a
	300 ppm	0.40a	7.2a
	600 ppm	0.40a	7.4a
Kocide (copper)	1 lb per 100 gal	1.90b	20.2c
Antitranspirant (Mobileaf) plus	3 gal per 100 gal		
Kocide	1 lb per 100 gal	1.65b	13.3b
Antitranspirant (Mobileaf) alternated with	3 gal per 100 gal		
Kocide	1 lb per 100 gal	0.85ab	8.5a
Antagonistic bacteria mixture		1.00ab	8.1a
Control	....	3.00c	7.1a

* Value followed by different letters are significantly different at the 0.05 level.

TABLE 4. EFFECT OF COPPER AND STREPTOMYCIN SPRAYS ON FIREBLIGHT INFECTIONS AND FRUIT RUSSETTING OF BARTLETT PEAR, HAMILTON CITY ORCHARD, 1973
(Applied with concentrate sprayer at the rate of 100 gal per acre)

Treatment (Six applications)	Amount material per acre per application	No. blight infections per tree May 25*	Percent lenticels russetted July 19*
Kocide (copper)	1 lb	0.16 a	42.5 d
Citcop (copper)	1 gal	1.09 b	22.5 c
Streptomycin 17%	10 oz	2.01 c	18.0 b
Control	.....	2.35 c	13.2 a

* Values followed by different letters are significantly different at the 0.05 level.

cides, washed, and a portion of the wash water was spread on plates of a selective growth medium. The number of *E. amylovora* colonies on the plates was counted, and the number of bacterial cells per flower was calculated.

There was good correlation between the percentage of healthy blossoms infested with *E. amylovora*, the type and rate of chemical applied, and subsequent disease incidence (table 5). For example, 52% of the blossoms from the untreated plots were infested with fireblight bacteria and 3.2 strikes per tree were observed while only 15 to 16% of the blossoms from the MBR 10995 plots were infested and only .4 strikes per tree occurred. The average number of bacteria per blossom was also a good indication of the efficacy of a particular chemical (table 5). Flowers from the untreated block contained an average of 760,000 bacteria per blossom, but only 23,000 cells per blossom were detected in the flowers from the block treated with MBR 10995 (1 lb per acre). The per cent of blossoms contaminated with fireblight bacteria and the actual population of bacteria per blossom were good indicators of the efficacy of a chemical application.

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TABLE 5. EFFECT OF EITHER SAPROPHYTIC BACTERIA OR CHEMICALS ON THE EPIPHYTIC POPULATIONS OF **ERWINIA AMYLOVORA** IN BLOSSOMS AND DISEASE INCIDENCE IN BARTLETT PEAR TREES

Treatment	Amount applied per acre	No. of bacteria/ blossom x 10^5**	Percent of blossoms infested with **E. amylovora****	No. of infections per tree**
Check	. .	7.6 a	52a	3.2a
Citcop	1 gal	6.6 ab	51a	1.7bc
Citcop	2 gal	5.9 ab	48ab	2.2ab
Streptomycin	10 oz	5.7 ab	37ab	0.8cd
Saprophytic bacteria	50 gal*	4.6 abc	45ab	1.0bcd
Terramycin	10 oz	3.6 bc	40ab	0.8cd
Kocide	0.5 lb	2.5 cd	32ab	1.0bcd
Kocide	2 lb	1.2 d	28bc	0.4d
MBR 10995	0.25 lb	0.62d	16c	0.4d
MBR 10995	1 lb	0.23d	15c	0.4d

* 10^6 bacteria per ml.
** Values followed by different letters are significantly different at 0.05 level.

SUBFLOOR MONITORING OF SHADY GROVE LIQUID MANURE HOLDING POND

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This report of the subfloor monitoring of the Shady Grove Dairy liquid manure holding pond near Chino offers further proof that such ponds are self-sealing and allow little or no seepage.

TABLE 1. CHEMICAL ANALYSES OF SOIL SOLUTIONS FROM SUBFLOOR MONITORING OF SHADY GROVE LIQUID MANURE HOLDING POND

Depth	EC*	TDS**	NO_3-N†	NO_3‡
ft.	mmhos	ppm	ppm	ppm
0–1	1.40	896	15.0	66
1–2	1.00	640	15.0	66
2–3	1.00	640	10.0	44
3–4	0.91	583	8.0	35
4–5	0.67	439	7.8	34
5–6	1.40	896	32.0	141
6–7	0.72	461	9.5	42
7–8	1.50	960	38.0	167
8–9	1.30	831	24.0	106
9–10	0.69	442	6.2	27

* EC = electrical conductivity.
** TDS = total dissolved salts.
†NO_3-N = nitrate nitrogen.
‡ NO_3 = nitrate.

TABLE 2. CHANGES IN EC, TDS, NO_3-N, AND pH AT 2-FT DEPTH BELOW MANURE POND CERAMIC CUP EXTRACTS

Date	EC	TDS	NO_3-N	pH
	mmhos	ppm	ppm	
6/11/72 (clean water, 2 ft deep in pond)	.75	480	16	8.2
6/14/72 (brown water, 2 ft deep in pond)	.74	473	15	9.3
6/16/72	1.10	704	19	8.4
6/20/72	1.50	960	17	8.2
6/27/72	1.90	1216	15	8.5
7/4/72	3.20	2048	102	7.8
7/13/72	2.60	1664	67	8.1
7/18/72	2.00	1280	8	8.3
7/25/72	2.10	1344	1	8.1
8/2/72	2.20	1408	1	7.4
8/9/72	**	**	**	**

** No solution extract.

SUBFLOOR MONITORING of the Shady Grove Dairy liquid manure holding pond, located about three miles east of Chino, California, was begun in June 1972 with the installation of duplicate tensiometer cups at 2, 4, 6, 8, and 9 ft below the pond floor (see sketch). The retention pond is 216 ft long, 121 ft wide, 10 ft deep, and has a storage capacity of 4.3 acre ft (see cover photos). Dual nylon spaghetti tubes lead from each cup to a mercury manometer station on the pond levee. This procedure permits the taking of soil extracts as well as measuring the vertical hydraulic gradient (pressure over depth). To insure uniform hydraulic factors, wetting of the cups, and initial infiltration, a 5-ft-square by 12-inch-deep infiltrometer was installed above the tensiometer cups and later removed before clean water was added to a depth of 2 ft in the pond.

Core samples of soil (53mm in diameter and 60mm in length) were taken from beneath the pond floor in one foot increments. These samples showed greater stratification than had been anticipated, with loamy sand present down to 2 ft, fine sand between 2 and 6 ft, silt between 6 and 8 ft, fine sand again between 8 and 9 ft, and coarse sand and gravel between 9 and 10 ft.

Extracts for subsequent analysis were collected weekly from ceramic cups for the first six weeks after the pond was filled with manure water. Chemical analyses of soil solution extracts from beneath the pond were shown in table 1. Manometers were also read and recorded daily during the first six weeks. Thereafter, manometer readings were made two or three times weekly, and soil extracts were collected every other week. Changes in electrical conductivity, total dissolved salts, nitrate nitrogen, and pH at the five ceramic cup depths are shown in tables 2, 3, 4, 5, and 6.

Hydraulic gradient is the driving force which causes movement of moisture between two specified points (2-ft to 8-ft probes). When hydraulic gradient reaches zero, indicated by Φ/L (the difference of gradients/distance), there is no water movement. This is considered a sealed condition. Data plotted from the 2-ft to 8-ft probes shown in the graph