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REPORT TO THE ALMOND BOARD OF CALIFORNIA

Project Year 1995

91-ZG6

Project No. 91-ZG2- Relationship of irrigation and nitrogen fertilization on incidence of hull rot and brown rot.

Role of brown rot fungi in green fruit rot.

Bloom and foliage disease control.

Wound treatments to control Ceratocystis canker.

A. Relationship of Irrigation and Nitrogen Fertilization on Incidence of Hull Rot and Brown Rot

Objectives

1. Determine the relationship of various irrigation and nitrogen fertilization regimes on natural occurrence of hull rot.
2. Determine the effects of selected irrigation and nitrogen regimes on infection of fruit inoculated with *R. stolonifer* and *M. fructicola.*
3. Observe the effect of selected irrigation and fertilization practices on loosening of the hull.

Note: This was the last year of work on this portion of the project thus the following is a final report and includes data from all years.

Procedures

The irrigation experiments: The experiments were conducted on cultivar Nonpareil trees in a commercial orchard in Kern County. The experiment tested three amounts of total water per season (22, 28 and 34 inches water) each delivered to emphasize deficit irrigation (hence tree stress) at early, mid, and late season (Table 1). Ten treatments (22A, B and C, 28A, B, and C, and 34A, B, and C, and control) were replicated six times and arranged in a randomized complete block design. The A and B treatments employed periodic reductions to 50% of normal water whereas the C treatments were continuous reductions to 55, 70, or 85% of normal amounts of irrigation water. Plots were six rows wide, 12 trees long, and data were collected from the center eight cv Nonpareil trees. (The irrigation experiment was designed and conducted by Dr. Dave Goldhamer. All measurements of tree response to irrigation treatments and yield parameters were collected by him.)

The nitrogen experiments: Experiments were conducted in two commercial orchards, referred to here are Ceres and Salida, in Stanislaus County. The Ceres orchard was planted with Price, Nonpareil, and Carmel in a 1 row :1 row :1 row pattern, and the Salida orchard with alternating rows of Nonpareil and Carmel. Yields and leaf nitrogen contents of individual trees were taken in 1989 before nitrogen treatments were imposed. Trees having similar pre-treatment yields and leaf nitrogen contents were grouped to provide two adjacent trees in each of four replications of each nitrogen treatment arranged in a randomized complete block design. The two data trees were embedded in the center of plots which were three rows wide and four trees long. The nitrogen treatments were: 0, 125, 250, and 500 lbs nitrogen/acre. Nitrogen was applied each year as ammonium sulfate, 21 percent, one third the annual total placed in spring and the remaining two thirds in fall. The orchard was irrigated immediately following fertilizer placement. Leaf nitrogen data were obtained from Steve Weinbaum.

The hull rot experiments: In the irrigation trial, inoculation experiments were performed in the following irrigation treatments: normal (control), normal except 50 percent deficit during 1 June-15 July (treatment 34A),1-15 July (treatment 34B), 1 June-31 July (treatment 28B), and continuous 85 percent (treatment 34C) and 70 percent (treatment 28C) of normal all year. In each plot, twenty-five fruit with firmly attached hulls in early dehiscence and associated with healthy leaves were inoculated with 10^4 conidia/ml suspensions of the hull rot fungi *M. fructicola* and *R. stolonifer*. Inoculum was delivered into the open hull using a calibrated pump atomizer on 16, 21, and 21 July 1993, 1994, and 1995, respectively. Noninoculated healthy fruit at the same stage of dehiscence were used as controls. The condition (healthy or dead) of leaves associated with each test fruit were recorded on 3, 8, and 4 August 1993, 1994, and 1995. Trees were shaken for harvest on 11, 9, and 16 August 1993, 1994, and 1995, and natural incidence was assessed by counting all hull rot strikes (clusters of dead leaves) and estimating the inches dead wood in all trees in each plot on 13, 11, and 18 August, 1993, 1994, and 1995. On the same days that natural incidence of hull rot was evaluated, random samples of fruit were collected from beneath the data trees, returned to the laboratory and the number per 100 fruit having hull rot was counted and the pathogen(s) identified.

Similar inoculations were made in the nitrogen trial on 2, 10, and 3 August 1993, 1994, and 1995 in the Ceres orchard and on 9 August 1993 in the Salida orchard. Data from inoculation experiments were collected as described above on 18, 24, and 21 August 1993, 1994, and 1995 in Ceres and 9 August 1992 and 1993 in Salida. Trees were shaken for harvest on 19, 28, 29, and 24 August 1992, 1993, 1994, and 1995 in Ceres, and 18 and 22 August 1992 and 1993 in Salida. Natural infection was assessed on 21, 24, 31, and 25 August 1992, 1993, 1994, and 1995 in Ceres and on 21 and 24 August in 1992 and 1993 in Salida.

Rate of hull loosening and hull split: Fifty fruit that had not begun to dehisce (split) were tagged on one tree in each plot where inoculations occurred in the irrigation and nitrogen trials. The attachment of these fruit to their pedicels was examined weekly for four weeks beginning 13, 15, and 13 July 1993, 1994, and 1995 in the irrigation trial, and similarly monitored in the nitrogen trial on 15, 22, and 29 July in Ceres and 3 August 1993 in Salida. Abscission (hull loosening) was rated as 1=no abscission or dehiscence, 2=no abscission, slight dehiscence, 3= <25 percent abscission, 4=25-50 percent abscission, attachment still firm, 5= >50 percent abscission, attachment loose, and 6= hull yellowing, almost completely detached from pedicel. Hull split was defined as any fruit that fell into categories 2 through 6 of the hull abscission rating scale.

Hull moisture content was monitored by arbitrarily collecting 10 fruit from each plot on the day hull loosening observations were made. Hulls were removed from the collected fruit, weighed in the field, then transported to the laboratory, air dried at 65C for 72 h, dry weight recorded, and percent moisture content calculated.

Leaf nitrogen content was determined by analysis of 50 fully expanded, healthy leaves collected from fruitless spurs from each Nonpareil data tree in June of each year. Analyses were conducted in Steve Weinbaum's laboratory.

Brown rot (nitrogen trial only): On 4 March 1994, immediately before the grower treated the Ceres orchard with fungicide (Rovral 50W, 1.0 lb per acre), selected branches with open blossoms on one data Nonpareil tree in each plot were covered with plastic bags to prevent them from being treated with fungicide. After treatment, the bags were removed and the blossoms were misted with 10^4 conidia/ml suspensions of *M. laxa* or *M. fructicola*. The inoculated blossoms were again covered with plastic then paper bags for 48 hrs. Twenty-five flowers per replication were collected on 11 March and the number of infected and total number of stamens counted from which the percent infected stamens was calculated.

The Ceres orchard was treated with Rovral 50W fungicide, 1.0 lb per acre on 11 February 1995. The day before treatment (10 February) and 4 days later (15 February) several shoots bearing open flowers were collected from one data Nonpareil tree and one border Carmel tree. The shoots were returned to the laboratory where 25 open, healthy flowers with bright yellow anthers were removed from the shoots of each plot and placed face up on moist, sterile sand in plastic sweater boxes. Each flower was misted with a suspension of 10^4 condia per ml of *M. laxa*. Lids were placed on the sweater boxes and the inoculated flowers incubated at room temperature for 72 hours. Percent infected stamens was determined as described above.

Natural incidence of brown rot was evaluated by counting all strikes in the data Nonpareil and the border Carmel trees on 26 May 1993 and 10 May 1994 in the Salida and Ceres orchards, respectively.

Analysis: Percent infected hulls, dead leaves, hull moisture content, split, and loosening were analyzed using factorial analysis with irrigation or nitrogen treatment as the main factors and fungal species and inoculation date as the subplot factors. Average number hull rot strikes per tree and percent infected fruit were analyzed by analysis of variance. Duncan's multiple range test or orthogonal contrasts were employed to determine the significance of F values where appropriate.

Results and discussion

Irrigation--Natural incidence of hull rot (hull rot strikes and inches dead wood) was greatest and similar in the normal and continuous constant 85% of normal (34C) treatments (Table 2). Generally, hull rot incidence declined with decreasing amounts of water applied, and hull rot was less in the periodic 50% reduction (B and C) treatments than in the continuous reduction (A) treatments. Reduction of water by 50% of normal during 1 June-15 July (34A) or 1-15 July (34B) decreased the incidence of hull rot by about half compared to that found in the normal or 34C treatments in all years. Even though the amount of water in the continuous 85% of normal treatment (34C) was similar to that in the periodic 50% of normal treatments (34 A and 34 B), hull rot was much less in the periodic 50% reduction treatments. The estimated inches of dead wood reflected similar patterns. There were no significant differences among treatments in percent infected hulls in any year. Apparently the ability of the pathogen to infect the hull was not affected by irrigation treatment but the processes leading to leaf and shoot death were. *R. stolonifer* was the only hull rot pathogen found in natural infections in all years.

Similar results occurred in inoculation experiments: more dead leaves were found associated with inoculated fruit in the normal and continuous 85% of normal treatments, and few differences were found among the other treatments (Table 3). Less hull rot occurred in periodic deficit treatments than in constant deficit irrigation treatments. Hull infection was not significantly affected by irrigation treatment. *M. fructicola* and *R. stolonifer* responded similarly to the irrigation treatments, and *M. fructicola* caused more leaf death and hull infection than *R. stolonifer*.

Hull loosening and split tended to proceed more rapidly in drier treatments (28B and 28C) and in one of the periodic deficit treatments (34A) (Table 4). The similarity between treatments 34C (continuous 85%) and 34B (50 % of normal for 2 wk) in hull loosening and split contrasts with the great difference between these treatments in amount of hull rot. The cause of the reduction in leaf death apparently was independent of the visible processes of abscission and dehiscence.

Hull moisture content decreased linearly with decreasing water and generally followed the same pattern as infection in inoculation tests (Table 4). The magnitude and pattern of hull moisture content does not, however, provide an explanation for the reduction of hull rot associated with treatment 34B.

Nitrogen --Natural incidence of hull rot increased with increasing amounts of applied nitrogen and often was more in the two higher (500 and 250 lbs) than in the two lower (125 and 0 lbs) nitrogen treatments (Tables 5 and 6). *M. fructicola* was the predominant hull rot pathogen in both orchards every year except 1992.

The response to nitrogen treatment was variable in the inoculation experiments (Table 7). Overall there was a trend toward more hull rot in the higher nitrogen treatments, but differences were not clear. In 1994, hull rot was lower in the two higher than in the two lower nitrogen treatments. This may be an artifact of the experiment. It was impossible to inoculate all treatments on the same date or at the same stage of fruit maturity because there were insufficient split fruit in the 250 and 500 treatments when fruit in the 0 and 125 treatments were ready for inoculation.

Although significant differences among hull loosening ratings and percent hull split data were found in only one of three years, the numerical trend was toward more rapid abscission in the lower levels of nitrogen treatments (Table 8). *M. fructicola* caused more leaf strikes and hull infection than *R. stolonifer* in inoculation tests.

Leaf nitrogen content increased with increasing amounts of applied nitrogen (Table 9). Leaf nitrogen levels were similar in the 250 and 500 lb per acre nitrogen treatments in 1992, 1993, and 1994 in the Ceres orchard. Data for 1995 were not available at this writing.

Brown rot: The percent infected stamens of flowers inoculated with *M. laxa* increased with increasing levels of applied nitrogen and was greater in the 250 and 500 than in the 0 and 125 lbs per acre applied nitrogen treatments (Table 10). This pattern was observed in 1993 in Salida, the only year in which brown rot was present in sufficient quantity to measure well.

Two objectives were not researched due to lack of time. These objectives were:

4. Examine the possibility that incipient infections by *M. fructicola* of young almond fruit may occur and later become hull rot lesions.
5. Investigate the role of insects in transmission of the pathogens.

B. Role of Brown Rot Fungi in Green Fruit Rot

Objectives

1. To demonstrate infection and rot of young green fruit by the brown rot pathogens and to determine susceptible stages of development.
2. To compare the effects of several wetness periods on the development of brown rot fungi in green fruit rot.

Bloom and fruit growth began two to three weeks earlier than expected thus even though we began work more than a week earlier than we had in 1994, fruit were much larger. Although we conducted the experiments as planned, the fruit already passed what apparently is the susceptible stage. Consequently, infection did not occur in these experiments and we have no data to report.

C. Bloom and Foliage Disease Control

Objective

1. Compare various fungicide programs for control of spring diseases.

Almond trees are usually treated with fungicides each year for control of brown rot (*M. laxa*), shot hole (*Wilsonomyces carpophilus*), and scab. Other diseases, including rust (*Tranzchelia discolor)* and leaf blight (*Seimatosporium lichenicola*) also are controlled with fungicides. Considerable information regarding efficacy of registered fungicides and appropriate timing is available for most of these diseases. Past research on fungicide control has concentrated on the control of a given disease without much regard to the effects of the treatment choices on other diseases. We arrive at program choices by combining knowledge from these isolated experiences.

When control emphasis shifts to one disease, other diseases may crop up as a result of inadvertent lesser control. Little attention has been paid to comparison of disease control programs which may include alternating chemicals, varying numbers of applications, and monitoring- or weather-driven decisions. Some knowledge of the relative effectiveness of various programs in use by growers or recommended by pest control advisors would be useful.

Procedures

Experiments were conducted in commercial orchards in Colusa, Merced, Tulare, and Kern Counties and at the University of California Kearney Field Station. We selected treatment programs following discussions with farm advisors and pest control advisors. In each case, the primary disease(s) of concern for each orchard was the focus of the program. Several options directed at the primary disease were selected, and other possible diseases also were taken into consideration. For instance, if brown rot was the primary concern, then several options for brown rot control were chosen and to these were added treatments that also would provide protection against shot hole, scab and/or rust. We included some choices that might improve upon common practices in a given area. We evaluated each trial for all diseases that appeared. Because most or all the program choices were designed to have efficacy, there often was little discrete statistical separation among programs. Nonetheless, some trends emerged as can be seen in each experience.

Details of treatment schedules, application, data collection, analysis, and interpretation may be found on the tables for each experiment.

Table 11. Efficacy of unregistered fungicides for control of almond brown rot, Kearney Agricultural Center, 1995.

Table 12. Comparison of fungicide sequences for control of brown rot of almond, Colusa County, 1995.

Table 13. Comparison of fungicide sequences for control of almond brown rot and shot home, Kern County, 1995.

Table 14. Efficacy of unregistered fungicides for control of almond scab, Tulare County, 1995.

D. Wound Treatments To Control Ceratocystis Canker

Objectives

1. To test several wound dressing materials for prevention and control of Ceratocystis infections.
2 To evaluate several wound dressing materials for wound healing characteristics.
3. To determine the relationship of time between wounding and infection and infection and treatment on control of current season infections.
4. To test effectiveness of surgery and topical treatment on established cankers.

Procedures

Experiments were conducted on 20 year old cv Nonpareil or Mission almond trees at the Kearney Agricultural Center. Trees were wounded by removing a bark plug, about one half inch in diameter, with a cork borer. Spores of *Ceratocytis fimbriata* were collected in 0.5% water agar, the concentration adjusted to 10^5 per ml, and 0.1 ml placed onto the exposed cambial surface of the wound. Wounds were covered with tape immediately after wounding and inoculation. Tape was removed four days later.

Experiments were evaluated on 27 November 1995. Invasion of the tissue beyond the wound had not yet occurred, but the severity of gumming was rated on a scale of 0 to 5: 0= no gumming, wound margins dry, some callus may be forming, 1, 2, 3, and 4= up to 25, 50, 75, or 100% respectively of wound area with gum, and 5=gum present beyond would edge.

1. To test several wound dressing materials for prevention and control of Ceratocystis infections.
2 To evaluate several wound dressing materials for wound healing characteristics.

The following materials were tested for efficacy in preventing infection by *C. fimbriata* and effects on wound healing: Nectec, Stickum, Treeseal, Benlate 50, Benlate 50 + 2% Omni oil, Benlate 50 + Asana, Rovral 50, Rally 40, Spinout, and Kocide/hexsol/boiled linseed oil. Inoculated and noninoculated controls were included. Bark wounds were treated immediately and inoculated within 6 hours of treatment after materials dried. The wound healing experiment and fungicide screening experiments were conducted on cv Mission and Nonpareil trees, respectively. The wound healing experiment was begun on 21 September and the fungicide screening test on 11 October. Both experiments were evaluated on 27 November 1995. There were 5 replications of each treatment arranged in a randomized complete block design in both experiments.

3. To determine the relationship of time between wounding and infection and infection and treatment on control of current season infections.

The effect of time after inoculation when treatment occurred was tested by wounding and inoculating on the same day followed by treatment at 0, 7, 14, and 28 days later with Spinout, Nectec, or Benlate 50 + Omni oil. Inoculated and noninoculated controls were included.

4. To test effectiveness of surgery and topical treatment on established cankers.

The primary scaffolds of Nonpareil trees were inoculated with *C. fimbriata* 8 May 1995. The resulting cankers had extended 1 to 2 feet beyond the inoculation site by October 1995. On 10 October 1995, all gum balls were removed from the canker surface and Nectec, Spinout, and Stickum were swabbed over the surface on the infected area and 6 to 8 inches beyond the margin of active gumming. Cankers were observed on 27 November 1995 for presence of fresh gumming. There were six replications of each treatments arranged in a randomized complete block design.

Results

Noninoculated wounds treated with Stickum, Nectec, Treeseal or Benlate 50 + Asana exhibited no gumming and apparently were healing well (Table 20). Slight gumming was associated with wounds treated with Rovral 50 or Rally 40, slightly more gumming was present on wounds treated with Spinout or Benlate 50 + Omni Oil. The greatest amount of gumming was found on wounds treated with Benlate 50 or the Kocide/hexsol/linseed oil mixture. Gumming on the nontreated control was similar in severity to that of treatments with the greater amounts of gumming.

Inoculated wounds had generally more gumming than the noninoculated, treated wounds, and Nectec- and Stickum-treated wounds had almost no gumming (Table 20). All other treatments had greater gumming.

There was very little difference in the amount of gumming present among treatments in the experiment on time after inoculation when treated (Table 21). All wounds had moderate to severe gumming but cankers had not extended beyond the wound site.

These experiments will be observed for canker expansion during 1996. Final assessment of the treatments will be made then.

Topical treatment of existing cankers did not stop gumming from the cankers. Gumming usually is a sign of canker activity thus these treatments probably were ineffective.

Table 1. Schedules for regulated deficit irrigation treatments for almond 1993-1995, Kern County.

	Percent of normal irrigation									
Date	Black Control	Blue 34A	Blue bar 34B	Purple 34C	Green 28A	Red 28B	Rose 28C	Orn Bar 22A	Orn 22B	White 22C
Mar 1-15	100	100	100	85	100	100	70	100	100	55
Mar 16-31	100	100	100	85	100	100	70	100	100	55
Apr 1-15	100	100	100	85	100	100	70	100	100	55
Apr 16-30	100	100	100	85	100	100	70	50	50	55
May 1-15	100	100	100	85	50	100	70	50	50	55
May 15-31	100	100	100	85	50	100	70	50	50	55
June 1-15	100	50	100	85	50	50	70	50	50	55
June 16-30	100	50	100	85	50	50	70	50	50	55
July 1-15	100	50	50	85	50	50	70	0	50	55
July 16-31	100	100	100	85	50	50	70	50	50	55
Aug 1-15	100	100	100	85	50	100	70	50	100	55
Inches of water through harvest (Mar 1 - Aug 15)										
1993	27.8	22.6	25.9	23.8	18.0	20.7	19.3	11.7	16.1	15.3
1994	24.4	19.2	22.0	20.9	15.3	18.0	16.9	12.4	14.4	13.4
1995	33.3	27.1	30.9	29.8	19.0	24.2	23.3	15.2	19.0	18.3
Average	28.5	23.0	26.3	24.8	17.4	21.0	19.8	13.1	16.5	15.7
Total inches Mar 1 - Nov 15	39.3	34.1	34.1	33.4	28.3	27.8	27.5	22.5	21.8	21.6

Table 2. Effect of regulated deficit irrigation on natural incidence of hull rot of almond cv. Nonpareil, Kern County.

	Number leaf strikes/tree			Dead wood per tree (inches)			Hull infection (%)		
Treatment	1993	1994	1995	1993	1994	1995	1993	1994	1995
39 Control	23.8 a	18.4 a	23.01 ab	18.8 a	26.6 a	49.2 a	15.7	26.5	24.2
34 C	27.7 a	18.0 a	33.1 a	18.0 a	31.1 a	63.3 a	15.5	35.0	24.3
34 B	11.7 bc	6.2 b	13.5 bcd	6.3 bc	8.1 bc	17.0 b	12.5	24.2	14.5
34 A	12.0 bc	6.7 b	7.3 cde	3.9 bc	2.6 cd	10.2 bc	13.0	22.7	24.5
28 C	16.1 bc	7.1 b	15.5 bc	11.0 ab	8.5 bc	17.2 b	12.3	27.5	22.3
28 B	9.4.cd	4.7 bc	5.4 ef	4.4 bc	2.2 cd	2.2 cd	12.8	26.9	18.3
28 A	9.4 cd	5.5 bc	6.3 def	5.2 bc	6.1 cd	5.4 bc	15.7	25.5	14.7
22 C	8.7 cd	6.0 bc	10.6 cde	3.5 bc	3.8 cd	10.7 bc	13.3	20.4	11.7
22 B	6.2 de	4.1 bc	3.1 f	1.2 c	5.3 cd	2.5 cd	15.5	21.3	17.8
22 A	3.3 e	2.4 c	0.9 g	2.1 c	1.4 d	0.1 d	17.0	19.5	20.2
Contrasts:									
Continuous vs. periodic (C vs. A, B)	.000	.000	.000	.029	.000	.000	NS	NS	NS

Table 3. Effect of regulated deficit irrigation on infection of almond cv. Nonpareil fruit inoculated with the hull rot pathogens *Monilinia fructicola* and *Rhizopus stolonifer*, Kern County.

	Leaf strikes (%)			Hull infection (%)		
Treatment	1993	1994	1995	1993	1994	1995
Irrigation						
39 Control	46.0 a	43.9 a	49.8 a	70.0	68.2	81.6
34 C	46.4 a	41.8 a	53.1 a	67.7	63.8	77.8
34 B	—	28.3 bc	35.1 b	—	63.3	74.7
34 A	31.5 b	28.8 bc	35.6 b	75.3	63.3	75.2
28 C	31.8 b	33.7 ab	40.9 ab	66.3	64.8	74.7
28 B	31.8 b	22.2 c	36.7 b	59.8	56.9	78.3
Pathogen						
Monilinia	72.9 a	51.6 a	73.7 a	92.8 a	85.1 a	89.3 a
Rhizopus	35.4 b	44.9 b	42.1 b	77.7 b	70.5 b	51.7 b
Control	4.2 c	2.3 c	9.7 c	33.0 c	34.5 c	25.8 c
Significance of *F*, *P*=						
Irrigation (I)	.042	.001	.008	NS	NS	NS
Pathogen (P)	.000	.000	.000	.000	.000	.000
I x P	NS	.006	NS	NS	NS	NS
Contrasts, *P* =						
Continuous vs. periodic (C vs. A, B)	.025	.000	.001	—	—	NS

Table 4. Effect of regulated deficit irrigation on loosening, split, and moisture content of cv Nonpareil almond hulls, Kern County.

	Loosening			Split			Hull moisture (%)		
	1993	1994	1995	1993	1994	1995	1993	1994	1995
Irrigation									
39 Control	3.6 d	3.0 bc	2.1 bc	83.1 b	60.4 b	43.4 bc	75.2 a	71.2 a	79.5 a
34 C	3.9 bc	2.9 c	1.8 c	89.7 a	62.7 b	37.0 c	75.4 a	72.8 a	79.9 a
34 B	—	2.9 c	2.2 bc	—	60.1 b	44.2 bc	—	68.1 ab	77.0 bc
34 A	4.3 a	3.5 a	3.1 a	87.3 ab	72.8 a	67.0 a	70.1 b	64.5 b	77.6 bc
28 C	4.1 ab	3.2 ab	2.4 ab	90.2 a	73.2 a	52.1 ab	70.0 b	67.4 ab	78.3 ab
28 B	3.7 cd	3.4 a	2.7 ab	76.9 b	70.1 b	56.8 ab	66.8 c	65.2 b	76.3 c
Date									
1st	1.6 a	1.1 a	1.0 a	53.4 a	7.3 a	0.5 a	76.4 a	80.2 a	—
2nd	3.4 b	2.1 b	1.4 b	92.7 b	66.4 b	31.2 b	78.0 a	77.4 a	78.1 ab
3rd	4.7 c	4.2 c	3.1 c	97.7 c	94.1 c	77.3 c	77.8 a	73.2 b	79.2 a
4th	5.9 d	5.3 d	4.1 d	97.9 c	98.6 d	91.4 d	53.8 b	42.1 c	77.0 b
Significance of *F*, *P* =									
Irrigation	.000	.001	.005	.000	.017	.010	.000	.015	.001
Date	.000	.000	.000	.000	.000	.000	.000	.000	.003
Irrigation x date	.000	.003	.001	.189	.013	.008	.001	.005	NS
Contrasts, *P* =									
Continuous vs. periodic (C vs. A, B)	.050	.031	.003	.074	NS	.016	.152	.004	.000

Table 5. Natural incidence of hull rot in almond trees cv. Nonpareil fertilized with four levels of nitrogen, Ceres orchard, Stanislaus County.

	Number leaf strikes/tree				Hull infection (%)			
	1992	1993	1994	1995	1992	1993	1994	1995
Nitrogen, lbs/acre								
500	22.8	39.5	34.5	23.2	12.6	28.5	35.0	12.9
250	22.0	33.5	32.7	15.5	11.0	30.2	32.3	10.6
125	19.2	24.5	21.5	11.2	9.6	26.0	25.1	9.1
0	17.0	17.2	14.0	9.2	8.5	17.0	21.5	6.6
Contrasts								
Linear	.044	.012	.007	.000	.016	.074	.010	.030
500 & 25 vs. 125 & 0	.067	.001	.001	.020	NS	.012	.001	.043
Pathogen								
Monilinia					8.9	49.7	51.7	17.8
Rhizopus					12.0	1.1	5.1	1.8
Contrasts, *P* =					NS	.000	.000	.000

Table 6. Natural incidence of hull rot in almond trees cv Nonpareil fertilized with four levels of nitrogen, Salida orchard, Stanislaus County.

	Number leaf strikes/tree		Hull infection (%)	
	1992	1993	1992	1993
Nitrogen, lbs/acre				
500	37.5	59.2	18.7	32.0
250	36.0	47.1	18.0	28.5
125	24.5	22.5	12.2	27.6
0	35.3	27.4	18.0	22.0
Contrasts				
Linear	.066	.001	.196	.024
500 & 250 vs. 125 & 0	NS	.001	NS	.001
Pathogen				
Monilinia			8.7	52.7
Rhizopus			24.7	2.3
Contrasts, P =			.000	.000

Table 7. Effect of four levels of applied nitrogen on hull rot of cv Nonpareil almond fruit inoculated with the hull rot pathogens *Monilinia fructicola* and *Rhizopus stolonifer*, Stanislaus County.

	Leaf strikes, %				Hull infection, %			
Nitrogen	Salida	Ceres			Salida	Ceres		
lbs/acre	1993	1993	1994	1995	1993	1993	1994	1995
Nitrogen, lbs/acre								
500	49.0	56.8	30.7	55.7	74.7	76.5	58.5	48.6
250	51.0	58.0	38.5	46.3	65.2	69.1	65.5	50.7
125	39.1	47.5	54.0	39.7	60.7	71.1	70.5	42.1
0	38.5	50.8	49.5	43.3	60.3	65.9	74.5	47.7
Pathogen								
Monilinia	84.6 a	83.1 a	48.1 a	55.6 a	96.5 a	98.2 a	83.5 a	62.4 a
Rhizopus	33.0 b	57.2 b	38.2 b	62.7 a	54.2 b	69.2 b	51.0 b	58.8 a
Control	15.7 c	19.5 c	13.9 c	20.4 b	45.1 c	44.6 c	36.2 c	20.5 b
Nitrogen (N)	.004	.097	.009	.063	.025	.005	.323	NS
Pathogen (P)	.000	.000	.019	.000	.000	.000	.000	.000
N x P	.076	NS	.389	NS	NS	NS	NS	NS
Linear contrast, P =	.003	NS	.002	.017	.000	.028	NS	NS

Table 8. Effect of four levels of nitrogen fertilization on loosening, split, and moisture content of cv Nonpareil almond hulls, Stainislaus County.

	Loosening			Split (%)			Hull moisture (%)		
	Salida	Ceres		Salida	Ceres		Salida	Ceres	
	1993	1994	1995	1993	1994	1995	1993	1994	1995
Nitrogen, lbs/acre									
500	2.5	3.7	3.2	46.4	72.5	65.5	73.1	71.5	68.4
250	3.7	3.7	3.1	70.3	72.9	65.0	68.1	72.9	71.4
125	3.9	4.0	3.1	71.7	78.9	63.7	69.8	70.4	72.8
0	3.9	4.2	3.7	71.6	79.8	71.7	64.7	69.2	64.2
Week 1	0.2 d	1.6 d	1.3 d	17.2 d	30.6 c	34.0 c	78.9 a	--	80.2 a
Week 2	0.6 c	3.1 c	2.5 c	53.2 c	76.3 b	58.9 b	76.8 a	78.8 a	80.8 a
Week 3	4.1 b	5.1 b	4.3 b	90.1 b	97.3 a	83.5 a	79.3 a	72.6 a	79.1 a
Week 4	5.1 a	5.8 a	5.2 a	98.8 a	99.9 a	89.5 a	41.3 b	61.6 b	36.6 b
Nitrogen (N)	.003	NS	.101	.021	NS	.116	.176	NS	.214
Date (D)	.000	.000	.000	.000	.000	.000	.000	.000	.000
N x D	NS	NS	.312	.001	NS	NS	.078	NS	NS
Linear (N)	.001	.265	.088	.006	.287	.090	NS	NS	NS

Table 9. Leaf nitrogen content of almond trees cv Nonpareil fertilized with four levels of nitrogen, Stanislaus County.

	Ceres orchard				Salida orchard	
	1992	1993	1994	1995[z]	1992	1993
Nitrogen, lbs/acre						
500	2.48	2.74	2.76	NA	2.36	2.68
250	2.44	2.68	2.74	NA	2.24	2.52
125	2.30	2.51	2.63	NA	2.21	2.46
0	2.24	2.36	2.51	NA	2.12	2.28
P =	.003	.001	.010		.009	.024
Linear contrast, *P* =	.001	.000	.005		.001	.004

[z] Not available.

Table 10. Natural incidence of brown rot and infection of flowers inoculated with *Monilinia laxa* from almond trees fertilized with four levels of nitrogen, Stanislaus County.

	Natural infection, srikes/tree			Inoculation, infected stamens (%)[x]				
	1993		1994	1994[y]	1995[z]			
	26 May		10 May	4 Mar	10 Feb		15 Feb	
	Carmel	Nonpareil	Carmel	Nonpareil	Carmel	Nonpareil	Carmel	Nonpareil
Nitrogen, lbs/acre								
500	60.8	13.0	4.7	15.1	9.5	5.3	68.4	14.2
250	61.2	9.0	4.0	14.6	9.2	7.2	68.9	10.6
125	24.7	5.5	3.5	8.2	5.2	3.7	51.9	5.4
0	19.0	4.2	2.5	7.5	4.8	3.0	36.3	3.2
P =	.003	.003	.05	.076	.040	.096	.004	.020
Linear contrast, *P* =	.001	.000	.153	.019	.012	.032	.001	.009

Table 11. Efficacy of unregistered fungicides for control of almond brown rot, Kearney Agricultural Center, 1995.

	Rate of product oz/acre or pt/100 gal		# Strikes/tree[y]		
Material[x]	Fungicide	Adjuvant	*Monilinia laxa*	*Monilinia fructicola*	*Monilinia laxa & fructicola*
Elite	6.00 oz	–	0.5 bc[z]	2.5 c	3.0 c
Elite	8.00 oz	–	0.0 c	3.7 bc	3.7 c
Rovral 4F	0.25 pt	–	0.2 c	3.0 c	3.2 c
Rovral 4F + Omni oil	0.25 pt	1.0%	0.5 bc	4.7 bc	5.2 c
Rovral 4F + Dynamic	0.25 pt	6.0 oz	0.0 c	5.5 bc	5.5 c
CGA 219417 (75WP)	5.30 oz	–	0.7 bc	3.5 bc	4.2 c
Rubigan IE + Latron B-1956	12.00 oz	4.0 oz	3.0 bc	9.2 bc	12.2 bc
Rubigan IE + Latron B-1956	18.00 oz	4.0 oz	1.5 bc	9.5 bc	11.0 bc
ICI A5504 (80 WDG)	4.00 oz	–	4.0 bc	7.5 bc	11.7 bc
ICI A5504 (80 WDG)	5.00 oz	–	2.7 bc	12.0 bc	14.7 bc
Rally 40 W + Latron B-1956	6.00 oz	0.06%	1.0 bc	11.0 bc	12.0 bc
Bravo 720	1.00 pt	–	5.5 b	14.5 b	20.0 b
Control			20.7 a	58.2 a	79.0 a

x Materials applied to run-off with a hand-gun sprayer operated at 280 psi, approximately 2.5 gallons solution per tree. Applied at 10% (15 Feb) and 100% (21 Feb) bloom.

y Trees inoculated at full bloom with *M. laxa*; *M. fructicola* infections from natural inoculum. All strikes on each tree counted 21 April 1995.

z Four single-tree replications arranged in a randomized complete block design. Means followed by the same letter do not differ significantly according to Duncan's multiple range test, P = 0.05.

Comments: These are 4th leaf trees adjacent to a nectarine block that has *M. fructicola* brown rot, which we believe to be the source of inoculum for this fungus. *M. laxa* was introduced in 1995 by spraying a spore suspension on all trees with a hand-gun sprayer during full bloom. The weather was rainy, overcast or foggy throughout bloom. The *M. laxa* and *M. fructicola* infections were identified by the appearance of the strikes and culture of representative samples. *M. laxa* produced typical spur or shoot death whereas *M. fructicola* was associated with death of small clusters of leaves and flowers.

The fungicides tested were unregistered materials, and Rovral 4F was used as the standard. All materials were considerably better than the nontreated control, and separation among materials was not definite. Generally, Elite, Rovral, and CGA 219417 treatments tended to have the least brown rot. The addition of Omni oil or Dynamic to Rovral did not improve control over that achieved with Rovral alone.

Table 12. Comparison of fungicide sequences for control of brown rot of almond, Colusa County, 1995.

Treatment[x]						Disease evaluation[y]
		Full		Weeks after petal fall		
Dormant	Pink bud	bloom	Petal fall	2	5	
1 Feb	10 Feb	20 Feb	3 Mar	16 Mar	5 Apr	Strikes/tree
	TOP	ROV	MX		MX	6.0 f[z]
	TOP	ROV		MX	MX	7.4 def
	TOP	ROV	MX			6.0 ef
	TOP	ROV			ZIR	9.0 cdef
	TOP		MX	MX		33.6 bc
	TOP		MX		MX	17.0 bcd
CU	TOP		MX		MX	25.0 bc
	B+MX		MX		MX	18.6 bcd
		ROV	MX		MX	22.6 bc
	R+O		R+O			11.0 bcdef
	R		R			16.6 bcdef
	TOP		MX			16.4 bcdef
	TOP		ZIR			17.4 bcdef
Control						61.8 a

[x] Materials applied to run-off with a hand-gun sprayer, operated at 300 psi, approximately 4 gallons solution per tree.

Fungicides	Rate of product/acre (lbs) or 100 gal (qts, pts)
B = Benlate SP	1.5 lb
CU = Kocide 101	8.0 lb
MX = Manex 37F	1.6 qts
O = Gavicide	1% v/v
R = Rovral 4F	0.25 pts
TOP = Topsin M	1.5 lb
ZIR = Ziram 76	12.0 lb

[y] All strikes on each tree counted 20 April 1995.

[z] Five single-tree replications of each treatment arranged in a randomized complete block design. Means followed by the same letter do not differ significantly according to Duncan's multiple range test, $P = 0.05$.

Comments: The treatment schedules were chosen as possible options for control of brown rot, shothole, scab, and rust. Of these diseases, only brown rot was observed in the test trees. Treatment schedules included two, three, or four applications during the season. Manex was the most commonly selected fungicide for the last application (5 weeks after petal fall) in anticipation of rust against which it may have some efficacy as well as against scab and shothole.

All schedules were significantly better than the nontreated control. The timings that most affected brown rot control should have been those made during bloom. Significant separation of treatment schedules was minimal, but there was a trend toward better brown rot control where applications of very efficacious fungicides (Topsin M, Rovral 4F, or Benlate 50W) were made at pink bud and full bloom. Control lessened somewhat (not significantly) where Rovral 4F (with or without Omni oil) was applied at pink bud and petal fall. Most treatments that included only one application of a very efficacious fungicide during bloom were least effective and control among these was variable. The addition of a dormant treatment of copper did not improve control nor did the addition of Omni oil to Rovral 4F.

Table 13. Comparison of fungicide sequences for control of almond brown rot and shot hole, Kern County, 1995.

Treatment[x]				Disease evaluation[y]	
Pink bud	Full bloom	Petal fall	2 Wks after petal fall	Brown rot	Shothole
6 Feb	12 Feb	20 Feb	8 Mar	# Strikes per tree	% Infected nuts
R	B+C	C		4.0 b[z]	4.0
R	C	C		7.0 b	1.3
R+O	C	C		4.0 b	0.7
R+O		C	C	6.8 b	1.0
	C	C	C	7.3 b	0.7
R+O	C			4.3 b	1.3
R+O		C		4.3 b	1.7
R+O			C	6.3 b	0.7
C				8.2 b	1.0
	C			8.8 b	2.3
		C		7.5 b	5.7
			C	8.8 b	0.3
Control				13.8 a	0.0 NS

x Materials applied to run-off with a hand-gun sprayer operated at 280 psi, approximately 4 gallons solution per tree.

Fungicide	Rate of product
B = Benlate SP	1.5 lb/acre
C = Captan 50	9.0 lb/acre
O = Omni oil	1% v/v
R = Rovral 4F	0.25 pts/100 gal

y All brown rot strikes in each tree counted, and 50 nuts selected arbitrarily, per tree inspected for shot hole lesions 3 May 1995.

z Six single-tree replications of each treatment arranged in a randomized complete block design. Means followed by the same letter do not differ significantly according to Duncan's multiple range test, $P = 0.05$.

Comments: Shot hole was the principle disease for which the treatments were designed hence the frequent use of Captan. A treatment to evaluate the shot hole monitoring system was planned but not executed. Unfortunately, shot hole was observed late and only at very low incidence (occasional fruit lesions). Brown rot, too, was not severe but was present in sufficient quantity to warrant counts. All treatments were significantly better than the control and there were no differences among schedules.

Table 14. Efficacy of unregistered fungicides for control of almond scab, Tulare County, 1995.

	Rate of product	Disease evaluation[x]		
	lbs or oz/acre	Diseased leaves, %		Defoliation, %
Material[w]	pts/100 gal	10 July	24 August	25 September
Benlate SP + Captan 50	1.5 lb + 9.0 lb	11.2 c	18.8 d	43.0 c
Benlate SP + Captan 50 (5W)[y]	1.5 lb + 9.0 lb	12.4 c[z]	16.4 d	30.7 d
Bravo 720	1.0 pt	29.6 c	37.2 c	56.2 b
ICI A5504	4.0 oz	22.0 c	42.0 c	53.8 b
ICI A5504	5.0 oz	19.6 c	40.8 c	58.7 b
Elite	6.0 oz	49.6 b	61.2 b	70.2 a
Elite	8.0 oz	53.2 ab	68.8 b	70.9 a
Rally 40W*	6.0 oz	69.2 a	76.0 ab	76.0 a
Rally 40W* (5W)[y]	6.0 oz	60.8 ab	68.8 b	76.0 a
CGA 219417	5.3 oz	71.2 a	70.4 b	74.3 a
Control	--	70.8 a	87.6 a	76.0 a

* Plus 0.06% Latron B-1956

w Materials applied to run-off with a hand-gun sprayer operated at 280 psi, approximately 4 gallons solution per tree. Treatments made at full bloom (13 February) and two weeks after petal fall (13 March).

x Fifty leaves selected arbitrarily on the day of evaluation from the outer and lower periphery of each tree. Trees shaken 20 Sep and percent defoliation estimated 25 Sep 1995.

y Second application made at five weeks after petal fall, 4 April 1995.

z Five replications of each treatment arranged in a randomized complete block design. Means followed by the same letter do not differ significantly according to Duncan's multiple range test, *P*=0.05.

Comments: On the earliest disease evaluation date, 10 July, treatments could be separated into two general groups: 1) Benlate + Captan, Bravo, and ICI A5504 which gave better control than 2) Elite, Rally, and CGA 219417. By the second reading, 24 August, the group 1 fungicides had further separated in that the Benlate + Captan treatments were superior to the Bravo and ICI A5504 treatments. The group 2 fungicides became more like each other and the control and were again inferior to the other materials. As measured by percent defoliation, the Benlate + Captan treatments provided the best control and of these, the second application timing at 5 weeks after petal fall was better than the 2 week after petal fall timing. Bravo and ICI A5504 continued to occupy the mid-level protection site, and Elite, Rally, and CGA 219417 were similar to the control.

Table 15. Comparison of fungicide sequences for control of almond scab, Kern County, 1995.

Treatment[x]				Disease evaluation[y]
Pink bud	Full bloom	Petal fall	2 Wks after petal fall	
6 Feb	12 Feb	20 Feb	8 Mar	Diseased leaves, %
R	B+C	C		4.3 c[z]
	C	C	C	7.3 bc
R	C	C		17.7 ab
R+O	C	C		20.3 ab
R+O		C	C	14.0 ab
R+O	C			18.7 ab
R+O		C		11.3 ab
R+O			C	12.7 ab
C				29.7 a
	C			23.3 a
		C		18.7 ab
			C	17.0 ab
Control				18.6 ab

x Materials applied to run-off with a hand-gun sprayer operated at 280 psi, approximately 4 gallons solution per tree.

Fungicide	Rate of product
B = Benlate SP	1.5 lb/acre
C = Captan 50	9.0 lb/acre
O = Omni oil	1% v/v
R = Rovral 4F	0.25 pts/100 gal

y Fifty leaves per replication evaluated for presence of scab lesions 27 July 1995.

z Six single-tree replications of each treatment arranged in a randomized complete block design. Means followed by the same letter do not differ significantly according to Duncan's multiple range test, $P = 0.05$.

Comments: Statistical separation of treatment was minimal, but some trends were apparent. The only treatment which included a Benlate + Captan application provided the best control, even though the Benlate Captan was applied early (full bloom). Nearly equivalent control was found with three applications of Captan. Although not statistically different, control tended to improve with later applications. This agrees with results in other trials.

Table 16. Comparison of fungicide sequences for control of almond scab, Merced County, 1995.

Treatment[x]						Disease evaluation[y]			
				Weeks after petal fall					
Dormant	Pink bud	Full bloom	Petal fall	2	5	Diseased leaves, %			Defoliation
29 Jan	9 Feb	16 Feb	24 Feb	14 Mar	4 Apr	5 June	10 July	11 Aug	3 Oct
	R+O	B+MX	MX	B+C	MX	1.3 e[z]	28.3 d	33.0 d	31.7 a
	R+O	B+MX		MX		6.7 cde	70.7 ab	62.2 ab	64.2 cd
	R+O	B+MX			MX	7.0 cde	41.3 cd	38.3 cd	42.5 b
LLS	R+O			B+C		3.7 cde	35.0 d	57.3 abc	46.7 bc
LLS	R+O				B+C	9.0 cde	32.7 d	46.0 bc	30.8 a
	R+O			B+C		12.3 bcd	70.0 ab	68.3 a	71.7 d
	R+O				B+C	14.3 bc	44.0 cd	59.3 ab	60.8 bcd
	R+O	R+O		B+C		11.0 bcd	68.0 ab	63.0 ab	70.0 d
	R+O	R+O		R+O		23.0 ab	76.7 a	63.0 ab	72.5 d
		B+C				4.7 de	58.0 bc	69.3 a	75.0 d
Control						37.0 a	76.7 a	46.7 bc	71.7d

x Materials applied to run-off with a hand-gun sprayer operated at 280 psi, approximately 3 gallons solution per tree.

Fungicides	Rate of product/acre (lbs) or 100 gal (qts, pts)
B = Benlate SP	1.5 lb
C = Captan 50	9.0 lb
LLS = Liquid lime sulfur	5.3 gal
MX = Manex 37F	1.6 qts
O = Omni oil	1% v/v
R = Rovral 4F	0.25 pts

y Fifty leaves selected arbitrarily from the outer and lower periphery of each tree on the day of evaluation. Leaves with one or more lesions scored as diseased. Trees shaken 2 Oct and percent defoliation evaluated on 3 Oct 1995.

z Six single-tree replications arranged in a randomized complete block design. Means followed by the same letter do not differ significantly according to Duncan's multiple range test, P=0.05.

Comments: Treatments were designed for general disease control including brown rot, scab and rust. The choices included a 'cadillac' program of five applications during the season and several two- or three-spray choices. All spring programs began with Rovral plus Omni oil for brown rot control. We chose a full bloom timing for the second brown rot application as that should provide better brown rot control than a petal fall treatment. Treatments at two and five weeks after petal fall were aimed primarily at scab control. Manex was chosen in some treatments as a possible control of rust. The orchard was treated with an airblast sprayer on 15 July by the grower with 6.0 lbs per acre of microthiol sulfur.

Based upon percent diseased leaves, differences among many programs were not distinct, but some trends were present. Season-long control of scab, as measured by percent infected leaves in the August reading, was best where five applications were made. Of these five, four used scab-active fungicides (Benlate, Manex or Captan) and two treatments used Benlate, the most efficacious scab fungicide available. Control nearly comparable to the five applications was achieved with two applications of scab-active fungicides (Benlate + Manex at full bloom and Manex again at five weeks after petal fall. Generally, control was better where two spring treatments of scab-active fungicides were used and where the last application was made at five rather than at two weeks after petal fall. While still true in August, the statistical separation was less distinct in August. Three applications of Rovral + Omni oil did not differ from the control at any observation.

The dormant liquid lime sulfur application improved scab control where only one of two spring treatments included scab-active materials (Benlate + Captan), and was evident in the July reading.

Percent defoliation followed the general pattern found for percent diseased leaves except that some differences were clearer in the defoliation data. The least defoliation occurred in the five application treatment and where dormant liquid lime sulfur was followed by Rovral + Omni oil at pink bud and Benlate + Captan at 5 weeks after petal fall. The liquid lime sulfur and the Benlate + Captan are to be credited with this control as the Rovral + Omni oil is ineffective against scab. Nearly as effective were the dormant liquid lime sulfur-Rovral + Omni oil at pink bud- Benlate + Captan at 2 weeks after petal fall and the Rovral + Omni oil at pink bud-Benlate + Manex at full bloom-Manex at 5 weeks after petal fall treatments. All other treatments did not differ from the control. Dormant liquid lime sulfur significantly improved control when added to the Rovral + Omni oil at pink bud-Benlate + Captan at 2 or 5 weeks after petal fall programs.

Brown rot was not observed in this orchard.

Table 17. Efficacy of dormant treatments in control of almond scab, Merced County, 1995.

Treatment[x]				Disease evaluation[y]			
		Weeks after petal fall					
Dormant	Pink bud	2	5	Diseased leaves, %			Defoliation, %
29 Jan	9 Feb	14 Mar	4 Apr	5 June	10 July	11 Aug	3 Oct
LLS	B+C	B+C		1.0	34.0	47.7	40.8
	B+C	B+C		5.0	37.3	57.7	53.3
LLS	B+C		B+C	5.3	34.0	58.7	35.8
	B+C		B+C	10.3	29.0	45.3	32.5
LLS	R+O	B+C		3.7	35.0	57.3	46.7
	R+O	B+C		12.2	70.0	68.3	71.7
LLS	R+O		B+C	9.0	32.7	46.0	30.8
	R+O		B+C	14.3	44.0	59.3	60.8
Control				37.0	76.7	46.7	71.7
Mean separation (contrasts)[z]							
Dormant vs. no dormant				.005	.091	NS	.077
1 vs. 2 B+C				NS	.001	NS	NS
2 weeks vs. 5 weeks				.027	.001	NS	NS
Treatment vs. control				.000	.000	NS	.001
Interactions							
Dormant x 1 or 2 B+C				NS	.000	NS	.000
Dormant x 2 or 5 weeks				NS	.004	NS	.029

[x] Materials applied to run-off with a hand-gun sprayer operated at 280 psi, approximately 4 gallons solution per tree.

Fungicides	Rate of product/acre (lbs) or 100 gal (qts, pts)
B = Benlate SP	1.5 lb
C = Captan 50	9.0 lb
LLS = Liquid lime sulfur	5.3 gal (16 gal/acre)
O = Omni oil	1% v/v
R = Rovral 4F	0.25 pts

[y] Fifty leaves selected arbitrarily from the outer and lower periphery of each tree on the day of evaluation. Leaves with one or more lesions scored as diseased. Trees shaken 2 Oct and percent defoliation evaluated on 3 Oct 1995.

[z] Six single-tree replications arranged in a randomized complete block design. Means separated by contrasts, P=0.05.

Comments: Based upon percent diseased leaves, dormant application of liquid lime sulfur caused significant improvement in control of scab as of the June evaluation. In July, control still was better with the dormant treatment, but at a less rigorous significance level (.091), but by August control was not significantly improved over that in treatments without dormant applications.

Disease levels were low in the first (June 1) evaluation thus these data do not well represent the potential of these treatments. Similarly, by August infection had progressed such that no differences among treatments were observed. The following discussion focuses on the July data which may offer some insight into the usefulness of the treatments.

The effectiveness of dormant applications of liquid lime sulfur appeared to depend upon the efficacy of the spring treatment program. The dormant treatment improved control where the spring program was minimal, that is, only one effective scab treatment (Benlate + Captan). Dormant treatment did not improve control where two applications of Benlate + Captan were made.

Control was better where trees were treated at two than at five weeks after petal fall in the June evaluation but the reverse was true by July. Greater differences between the two and five week treatments occurred where no dormant applications were made.

Defoliation patterns reflected the disease levels observed in July. Dormant liquid lime sulfur improved control where the spring programs were weak (only one application of Benlate + Captan). Dormant liquid lime sulfur followed by Rovral + Omni oil at pink bud and Benlate + Captan at 5 weeks after petal fall was equivalent to two applications of Benlate + Captan during the season. Treatment at 5 weeks after petal fall was generally better than treatment at 2 weeks after petal fall.

It is important to limit use of Benlate to once per season because the scab fungus may develop resistance to this fungicide. The substantial improvement in control offered by dormant liquid lime sulfur should allow effective use of otherwise lesser spring programs thereby reducing the risk of resistance encountered in depending upon multiple treatments with Benlate.

The incubation period of the scab fungus has been studied on peach fruit but not on almond fruit or leaves. If the incubation period is similar on the two hosts, then one to two months after infection is required for symptoms to show. The later rains in 1995 perhaps fostered later infections which were controlled better by the later 5 week after petal fall treatment. Treatments later than the five weeks after petal fall timing also may have been beneficial this year.

Table 18. Comparison of fungicide sequences for control of almond rust, Merced County, 1995.

Treatment[x]						Disease evaluation[y]	
				Weeks after petal fall			
Dormant	Pink bud	Full bloom	Petal fall	2	5	Diseased leaves, %	
29 Jan	9 Feb	16 Feb	24 Feb	14 Mar	4 Apr	11 Aug	13 Sep
	R+O	B+MX	MX	B+C	MX	2.0 b[z]	34.0 de
	R+O	B+MX		MX		2.0 b	47.0 bcd
	R+O	B+MX			MX	1.3 b	26.0 e
LLS	R+O			B+C		2.3 b	41.7 cde
LLS	R+O				B+C	1.0 b	36.0 de
	R+O			B+C		13.0 a	42.7 cde
	R+O				B+C	3.4 ab	49.3 bcd
	R+O	R+O		B+C		5.7 ab	51.0 bcd
	R+O	R+O		R+O		3.0 b	62.3 abc
		B+C				6.0 ab	67.7 ab
Control						6.3 ab	76.0 a

x Materials applied to run-off with a hand-gun sprayer operated at 280 psi, approximately 3 gallons solution per tree.

Fungicides	Rate of product/acre (lbs) or 100 gal (qts, pts)
B = Benlate SP	1.5 lb
C = Captan 50	9.0 lb
LLS - Liquid lime sulfur	5.3 gal
MX = Manex 37F	1.6 qts
O = Omni oil	1% v/v
R = Rovral 4F	0.25 pts

y Fifty leaves selected arbitrarily from the outer and lower periphery of each tree on the day of evaluation. Leaves with one or more lesions scored as diseased. Trees shaken 2 Oct and percent defoliation evaluated on 3 Oct 1995.

z Six single-tree replications arranged in a randomized complete block design. Means followed by the same letter do not differ significantly according to Duncan's multiple range test, $P = 0.05$.

Comments: These data were collected from the same trees as were the scab data reported in Table 6. Rust appeared late in summer and was present sporadically at the August reading. Treatments did not differ greatly in the August reading. By September, rust was more prevalent, and all programs that included either Manex or Benlate + Captan at 2 or 5 weeks after petal fall had significantly lower percent rusted leaves than did the control. Three applications of Rovral + Omni oil or one application of Benlate + Captan (at full bloom) did not differ from the control. There was a tendency towards better control where Manex was applied at full bloom and 5 weeks after petal fall.

Table 19. Efficacy of dormant treatments for control of almond rust, Merced County, 1995.

Treatment[x]				Disease evaluation[y]	
		Weeks after petal fall			
Dormant	Pink bud	2	5	Diseased leaves, %	
29 Jun	9 Feb	14 Mar	4 Apr	11 Aug	13 Sep
LLS	B+C	B+C		5.0	37.7
	B+C	B+C		3.0	43.3
LLS	B+C		B+C	3.3	49.3
	B+C		B+C	7.3	33.7
LLS	R+O	B+C		2.3	41.7
	R+O	B+C		13.0	42.7
LLS	R+O		B+C	1.0	36.0
	R+O		B+C	3.7	49.3
Control				6.3	76.0
Mean separation (contrasts), $P = 0.05^z$					
Dormant vs. no dormant				NS	NS
1 vs. 2 B+C				NS	NS
2 vs. 5 weeks				NS	NS
Treatment vs. control				NS	.000

[x] Materials applied to run-off with a hand-gun sprayer, operated at 280 psi, approximately 4 gallons solution per tree.

Fungicides	Rate of product/acre (lbs) or 100 gal (qts, pts)
B = Benlate SP	1.5 lb
C = Captan 50	9.0 lb
LLS = Liquid lime sulfur	5.3 gal
O = Omni oil	1% v/v
R = Rovral 4F	0.25 pts

[y] Fifty leaves selected arbitrarily from the outer and lower periphery of each tree on the day of evaluation. Leaves with one or more lesions scored as diseased. Trees shaken 2 Oct and percent defoliation evaluated on 3 Oct 1995.

[z] Six single-tree replications arranged in a randomized complete block design.

Comments: These data were collected from the same trees as were the scab data reported in Table 8. Dormant application of liquid lime sulfur did not improve control of rust, but all treatments were significantly better than the nontreated control in the September reading.

Table 20. Effect of various materials on healing and infection of almond bark wounds, 1995.

Material	Severity of gumming at wound[x]	
	Healing[y]	Infection[z]
Stickum	0.0	0.0
Nectec	0.0	0.6
Treeseal	0.0	3.2
Benlate 50 + Asana	0.0	3.6
Rovral 50	1.2	4.2
Rally 40	1.6	4.2
Spinout	2.4	3.6
Benlate 50 + Omni oil	2.4	4.2
Benlate 50	3.0	4.2
Kocide/hexsol/linseed oil	3.0	4.2
Controls		
Inoculated, nontreated	---	4.4
Noninoculated, nontreated	2.2	0.6

[x] Rating scale: 0 = no gumming to 5 = gum present beyond wound

[y] Bark wounds treated, not inoculated.

[z] Bark wounds treated and inoculated.

Table 21. Effect of time after inoculation on infection by Cerateceptis of almond bark wounds treated with fungicides, 1995.

Days after inoculation when treated[y]	Material	Severity of gumming at wound[z]
0	Nectec	3.0
	Benlate 50 + Omni oil	3.0
	Spinout	4.5
	Inoculated control	4.2
	Noninoculated control	4.0
7	Nectec	4.0
	Benlate 50 + Omni oil	3.2
	Spinout	4.3
	Inoculated control	4.2
	Noninoculated control	4.0
14	Nectec	4.2
	Benlate 50 + Omni oil	4.2
4.2	Spinout	4.2
	Inoculated control	4.2
	Noninoculated control	3.8
28	Nectec	4.0
	Benlate 50 + Omni oil	4.5
	Spinout	4.2
	Inoculated control	4.2
	Noninoculated control	2.7

[y] Day 0 = 15 Sep 95

[z] Evaluated 27 Nov 95; rating scale: 0 = no gumming, to 5 = gum present beyound wound