ALMOND BOARD REPORT 1990

Project Number: 90-ZG1
Leaders: Beth L. Teviotdale
Themis J. Michailides

I. EFFECT OF IRRIGATION CUT-OFF DATE ON INCIDENCE OF HULL ROT CAUSED BY *RHIZOPUS STOLONIFER*

Hull rot develops in late summer and causes death of fruiting wood and small branches. It is most severe on vigorous, heavily-cropped Nonpareil trees. The disease results from infection of the hull by any of these fungi: *Monilinia fructicola*, *M. laxa* (the brown rot fungi), *Rhizopus stolonifer*, or *R. arrhizus* (bread mold fungi). *M. fructicola* and *R. stolonifer* are the most frequent incitants of hull rot. Hulls are susceptible to infection as soon as they begin to split. The fungi enter through the natural opening, invade the inner hull surface and apparently produce a toxin that is transported into the spur or twig causing death of those tissues.

Because chemical control of the disease is not available and most likely will not be an acceptable option, manipulation of cultural practices may prove to be the best chance for management of this disease. The incidence of hull rot may be reduced by reducing the interval between hull split and harvest (early harvest). Other cultural practices also may aid in reducing hull rot.

In 1989, differences in incidence of hull rot were observed among treatments in Dr. Dave Goldhamer's trial in which he is investigating the effect of irrigation cut-off date on almond tree performance (Almond Board Project 89-11). Here, rot was considerably more severe in trees having the three latest irrigation cut-off dates than in those deprived of water earlier. Our project is designed to examine more closely the relationship of irrigation cut-off date and incidence of hull rot with the hope of finding cultural practices consistent with productive tree culture that also will ameliorate damage caused by hull rot.

General procedure - The experimental orchard was located in Kern County and planted with cultivars Nonpareil and Carmel. The orchard is divided into six replications of eight treatments in a randomized complete block design. Each replication of cultivar Nonpareil included eight trees, four trees in two adjacent rows. Our experiments were conducted on any of the four center trees of these eight. Three of the six replications received a post-harvest irrigation in 1989, three did not: our experiments were restricted to cultivar Nonpareil trees in the three replications receiving the 1989 post-harvest irrigation. All trees received identical and standard irrigation until the experiment began. Then, each treatment was an irrigation cut-off date, meaning that the trees in the treatment were not irrigated after the cut-off date, until the post-harvest irrigation in early fall. The irrigation cut-off dates were 26 June, 3, 10, 17, 25 July, 1, 8, and 15 August. These treatments were numbered 1 (26 June) through 8 (15 August) and correspond to 50, 43, 36, 29, 22, 15, 8, and 1 days before harvest, respectively. (For further description of the irrigation experimental design and procedure, please refer to the report by Dr. Dave Goldhamer.) The trees were harvested on 16 August.

The pathogen used was an isolate of *R. stolonifer* obtained from almond. Inoculum was prepared by collecting spores in sterile deionized water containing

a wetting agent (Tween 20). Spore concentration was adjusted to 10/4 spores/ml and approximately 0.1 ml inoculum was delivered to each test fruit using a syringe fitted with a 22 g needle. Fruit collected in the field were placed in plastic bags, the bags sealed, and stored on ice until use in the laboratory.

Data were analyzed by analysis of variance, Duncan's multiple range test and regression where appropriate.

Inoculation of fruit on the tree - Fruit were inoculated at early (13 July), mid (19 July), and full (25 July and 2 August) hull split. Twenty fruit located in the lower periphery of the southern half of one tree in each replication were inoculated on each date. Fruit with split hulls were difficult to find on the first two inoculation dates and/or the earliest three cut-off treatment dates all summer. Thus, most fruit in treatments 1 through 6 inoculated on the first date did not have fully split hulls. Inoculum on these fruits was placed onto the suture. Otherwise, fruit with open sutures and with the suture facing upward (to help retain the inoculum) were selected for inoculation. Fruit in the earliest three irrigation cut-off treatments were not inoculated on 26 July and 2 August because split hulls were too difficult to find. All fruit were collected on 13 August and returned to the laboratory for evaluation. Each fruit was examined with a stereo microscope for evidence of *R. stolonifer*. The highest percentages of infection were found in fruit inoculated on 19 July and there were no significant differences in percent infection among treatments 5 through 8 and no correlation between percent hull split or percent hull moisture and irrigation cut-off date (Table 1). Also, at that inoculation date there were no significant differences in percent hull split among treatments 5 through 8 (Table 2). On all dates, percent infection was highly correlated with irrigation cut-off date.

Incidence of natural infection - Clusters of withered or dry leaves on shoots was regarded as the symptom of hull rot. All such withered shoots on each of the four data trees were counted on 17 August, the day after harvest. We were unable to make a pre-harvest count of withered shoots because there were so many leaves showing desiccation that we could not reliably distinguish the wilted clusters. We collected samples of fruit from the harvested crop on the ground beneath each tree, and evaluated 100 fruit per replication for presence of *R. stolonifer* and *Aspergillus niger* in the laboratory as described above. The greatest numbers of wilted shoots and percentages of fruit infected with *R. stolonifer* were found in trees from treatments 7 and 8, and the number of wilted shoots and percent infected fruit increased with increasing numbers of irrigations (Table 3).

The fungus *Aspergillus niger* was observed on many fruit showing lesions on the hull. On 17 August, we collected 100 fruit from wilted shoots and found *R. stolonifer* and *A. niger* associated with 33 and 48 percent of them, respectively. Nineteen percent had no discernible fungal infections. The role, if any, played by *A. niger* in hull rot is not known.

Infection of detached fruit - The differences in incidence of hull rot observed among irrigation cut-off dates may reflect variation in moisture content of the hulls. This hypothesis was tested in two ways. In the first, we collected 15 fruit from each replication of each treatment on 16, 25 July and 1

August. Five fruit were used to determine percent hull moisture: half of each hull was removed, the five halves combined and fresh weight measured, followed by 24 hr drying in a forced air oven at 105°F, then dry weight measured and percent hull moisture content calculated. The remaining ten fruit were inoculated in the same manner as were those in the field, placed in closed ziplock bags and incubated at room temperature, 68-72°F, for five days. Growth of *R. stolonifer* on the fruit was rated on a scale of 1 to 4: 1 = no growth, 2 = growth present but not visible to the unaided eye, 3 = growth visible, and 4 = growth profuse. Amount of fungal growth increased with increasing numbers of irrigations and with increasing hull moisture content in fruit collected on 25 July (Table 4). Correlation among these factors - amount of fungal growth, irrigation cut-off date and percent hull moisture - was not found for fruit collected on 16 July and 1 August.

In the second test, percent hull moisture content was varied by drying fruit for 0, 2, 4, 6, 8, 16, 24, 36, 48, and 72 hr at 105°F. 100 fruit, collected from Nonpareil trees grown at the Kearney Agricultural Center, Parlier, California, having turgid, green, healthy split hulls were divided into ten groups of ten each, one group dried for each period. Dry weight of the fruit and of the hull only was measured and percent hull moisture calculated. In this way a range of hull moisture percentages from 72.9 (fresh) to less than 1 (48 and 72 hr drying periods) was established. The drying periods were set such that all fruit were inoculated, as described above, at the same time. Inoculated fruit were placed in ziplock bags, the bags closed, and incubated for five days at room temperature. *R. stolonifer* grew on 93.7 to 100 percent of fruit having percent hull moisture contents ranging from 72.9 to 19.2 (Table 5). There were 20% infected fruit at 8.1% moisture and no growth on hulls containing less than 20% moisture. The appearance of fungal growth on hulls at 19.2 and 8.1% most closely resembled that found on hulls in nature.

Survey of mycoflora - Five fruit from each of the four data trees (twenty fruit per replication) were collected on 21 June, 23 July, and 1 August. Fruit from each replication were combined and washed in 200 ml sterile deionized water on a rotary shaker for 30 minutes. Two ten-fold dilutions were made of the wash water and 0.1 ml of each placed onto each of three acidified potato dextrose agar culture plates. The seeded plates were incubated at room temperature for seven days then colonies counted and identified. The greatest number and variety of fungi and yeast were found on fruit taken from trees that received the most irrigations the previous season (Fig. 1). The most common fungi were species of *Penicillium, Cladosporium* and *Aspergillus*. *Rhizopus* was infrequently detected. The most intriguing aspect of this survey is that effects of the previous season's irrigation cut-off treatments were reflected in the mycoflora population on fruit surfaces some nine months later and before irrigation cut-off treatments had been initiated in the current season.

II. ETIOLOGY OF *CERATOCYSTIS* LIMB CANKER ("DRY CANKER")

A death of almond branches associated with small cankers was found to be caused by *Ceratocystis fimbriata*. Pruning wounds were susceptible to infection at least from November through February (1988-1989) and August through January (1989-1990). Inconspicuous wounds were susceptible throughout the year in an experiment conducted in 1988-1989. Thus, wounds made during pruning, the pruning

wounds themselves and wounds incurred when pruned branches are pulled from the tree are potential sites for infection. Experiments in 1989-1990 examined the effects of wound age, depth and severity on infection by the pathogen. Ascospores and endoconidia of the fungus survived on bark surface from November to 30 January and caused infection of wounds.

All experiments were conducted at the Kearney Agricultural Center, Parlier, California.

Infection of pruning wounds - Tertiary scaffolds of cultivar Nonpareil almond trees were pruned each month using a chain saw from September through January. Each month, branches were pruned 0, 2, 7, and 14 days before inoculation and there were six replications of each treatment in a randomized complete block design. All wounds were inoculated on the same day by placing 0.25 ml suspension of 10^4 endoconidia/ml onto the exposed bark, cambium and outer wood of one-fourth the circumference of each pruning cut. Noninoculated control cuts were included for each treatment. In August, canker length was measured and tissue samples taken for recovery of the fungus. Cankers were found at pruning wounds in each month tested; canker length was affected by the age of the wound but not time of year when inoculated (Table 6).

Infection of inconspicuous bark wounds - The relative importance of wound age, depth, and severity was tested using cultivar Mission almond trees by puncturing the bark of tertiary scaffolds using a small lancet needle. Zero, 2, 4, 6, and 8 wounds were made of full-depth (to the cambium), half-depth (did not reach the cambium), or superficial scratch punctures of the bark surface. The wounds were inoculated immediately with 0.25 ml suspension of 10^4 endoconidia/ml. In a separate experiment, eight each full- and half-depth punctures were made then inoculated as above at 0, 4, 8, 24, 48, and 96 hr after wounding. Noninoculated controls were included for each treatment. There were six replications of each treatment arranged in a two-way factorial with split plot design. Both experiments were initiated in September and December; canker length was measured and tissue samples taken for recovery of the fungus in August. Full- and half-depth wounds were equally susceptible, scratch wounds less so; the number of punctures per wound did not affect incidence of infection but incidence decreased with increasing wound age (Fig. 2).

Survival of inoculum on bark surface - Ascospores (sexual spores) and endoconidia (asexual spores) were placed onto the bark surface of tertiary branches of cultivar Mission almond trees on November 9, 1989. Eight each full-depth puncture wounds were made in bark where the inoculum was located and at companion noninoculated sites at the following intervals, in days: 0, 2, 7, 14 (November), 30 (December), 61 (January), 103 (February), 141 (March), 165 (April), 190 (May), and 222 (June). In addition, inoculated and companion noninoculated control sites were wounded during rains on 13 and 30 January. There were four replications of each treatment (wounding date) in a randomized complete block design. Canker extension was measured and sample tissues were collected for culture of the pathogen in August. All sites wounded 0, 2, 7, and 14 days after inoculation and one site wounded during rain on 30 January became infected with *C. fimbriata*. Cankers did not develop at any other inoculated or any noninoculated control sites.

Comments - Assuming that the principle means of dissemination of *C. fimbriata* is by insects, as has been shown in previous studies, we postulate that insects inadvertently scatter spores along bark surfaces during fall when insects are active and the fungus is reproducing on exposed cambial surfaces of large bark injuries. Spores then may be washed into wounds by rain or heavy dews. Thus, pruning just prior to rains would provide fresh bark and pruning wounds as infection sites and rain water would act as the disseminating agent for the fungus.

IIIa. EFFECT OF BLOOM DISEASE CONTROL ON YIELD

Bloom diseases - brown rot, shot hole, and jacket rot - occur in years of high spring rainfall and can cause serious loss in yield. Usually, fungicide efficacy trials examine the effects of individual materials against one disease. Although this provides much-needed information about the activity of the fungicides and aids in decisions on which materials are useful in combating which diseases, most growers apply more than one fungicide during a season. There are several registered materials and thus several possible combinations from which to choose. Our intent with this experiment was to compare the disease control capabilities and effects on yield of several combinations of treatments that might be used by growers.

Procedures - The experiment is located in a commercial orchard in Kern County. The trees are mature, about 10 years old, and are planted 1 Merced: 2 Nonpareil: 1 Mission: 2 Nonpareil. Six fungicide combinations were selected on the basis that any may be expected to provide some control of the three major bloom diseases and all the materials are registered. The combinations and a nontreated control comprised seven treatments which were replicated four times and arranged in a randomized complete block design. There were approximately 50 Merced and 100 Nonpareil trees per replication (one and two rows of Merced and Nonpareil, respectively). Trees will be treated with the same materials every year for five consecutive years, beginning in 1989. Disease and yield measurements are taken each year.

Results - Brown rot and botrytis jacket rot were not observed in trees of either cultivar in 1989 or 1990. Shot hole, though present, occurred at extremely low incidence, and there were no significant differences in average pounds nutmeats per tree among treatments (Table 7).

IIIb. SURVEY OF MICROFLORA INHABITING ALMOND FLOWERS AND FRUIT IN A TRADITIONALLY AND ORGANICALLY FARMED ORCHARD

Microorganisms - yeasts, fungi, and bacteria - are natural inhabitants of plant surfaces. Taken together, they form a mixed population that also may include pathogens and beneficial antagonists. The composition of this microbial population varies in number and composition in response to various environmental factors. As interest in reduced use of pesticides increases, better knowledge of the natural population of microorganisms may contribute to disease control systems that depend less upon the use of fungicides.

Any two orchards may be expected to have some differences in the microflora inhabiting them, and orchards farmed in very different ways may exhibit some

distinct differences. In Merced County, two almond orchards of the same age, cultivar, and planting design and located next to each other have been farmed differently for about seven years. One has been farmed using traditional practices including pesticide application for insect and disease, use of inorganic fertilizers, and herbicides for weed management down the tree row. The other orchard has been farmed without pesticides, herbicides, or fertilizers and with a full cover crop. We monitored microbial populations in these two orchards during spring and early summer of 1990.

Sample collection and culture - Each orchard was divided into quadrants and 25 Carmel trees in each quadrant were selected as sample trees. Four flowers were removed from each tree and combined in plastic bags to make a 100-flower sample from each quadrant. Collections were made at pink bud (1 March), early bloom (5 March), full bloom (8 March), and petal fall (13 March). Fruit were collected beginning 19 April and every third week until the last collection on 3 July. Two fruit per tree (50 fruit/quadrant) and one fruit per tree (25 fruit/quadrant) were collected on the first two and last four fruit collection dates, respectively. Samples were stored on ice for the trip to the laboratory then processed immediately upon return. Flowers and fruit were washed with sterile deionized water containing two drops Tween 20/100 ml. Flowers were washed in the collection bags with 50 ml wash water and shaken vigorously by hand for ten minutes. Fruits were placed into sterile plastic jars, covered with wash water (50 to 200 ml), and shaken on a rotary shaker for 30 minutes. One to three ten-fold serial dilutions were made and 0.1 ml of each dispensed onto each of three culture plates with the following media: acidified potato dextrose agar (aPDA), Kings Medium B and Miller-Schroth medium. Seeded plates were incubated at room temperature for four to seven days and colonies were identified and counted. Data are presented as average number of propagules per flower or fruit.

Microorganisms found - *Cladosporium* and *Penicillium* species were the most common and numerous fungi present (Table 8). Far less frequent and numerous were species of *Alternaria, Fusarium, Epiccocum, Botrytis*, and *Aspergillus*. Species of *Phoma, Paecilomyces, Coniothyrium, Botryosphaeria, Rhizopus*, and several unidentified fungi were seen occasionally. *Monilinia laxa* and *M. fructicola* (the brown rot pathogens) and *Stigmina carpophila* (the shot hole fungus) were not present. Several species of yeast and bacteria (unidentified) were found. Generally, populations were very low from pink bud until mid-April, and generally there were higher populations and a greater variety of fungi and yeasts on samples taken from the organically than from the traditionally farmed orchard. Bacterial populations showed the greatest shifts in numbers, ranging from nondetectable to too many to count on any dilution plate. We did not observe any antagonists from either orchard during this season.

Comments - No conclusions can be drawn as yet. In the future we will not attempt to monitor bacterial populations but will restrict our interest in bacteria to searching for antagonists.

IV. EFFECT OF SHOT HOLE INFECTION ON ALMOND FRUIT

Shot hole, caused by the fungus *Wilsonomyces carpophilus* (aka *Stigmina carpophila*), produces lesions on leaves, fruit, and occasionally young shoots of almond trees. When severe, leaf drop ensues, and this can lead to fruit drop and

chronic weakness. Fruit may bear many lesions on the hull without sustaining any apparent damage. Gumming is associated with fruit infection, but often the nutmeats of fruit with gumming hulls are healthy. The direct effect of shot hole infection on fruit has not been investigated.

Inoculation of flowers and fruit - The experiments were conducted on cultivar Mission almond trees at the Kearney Agricultural Center, Parlier, California. An environment of free moisture on fruit surfaces, a condition favorable to infection, was provided using an automatic misting system. Mist was produced for 2 to 5 minutes (longer periods were needed in late spring) at 15 minute intervals for 48 hours. Although some run-off was observed, in most instances the plant surfaces were wet but water did not drip.

The fungus was grown on acidified potato dextrose agar for four to six weeks. On the day of inoculation, conidia were collected in sterile deionized water and conidial concentrations adjusted to 10^3, 10^4, and 10^5 conidia/ml. Approximately 0.5 ml of inoculum suspension was applied, using a hand-held hand pump spray bottle, to each flower or fruit. These three inoculum concentrations and a noninoculated control comprised the four treatments in each experiment. There were four replications, one in each of the four quadrants of a tree. Each replication was situated on one to three branches, depending upon availability of fruit. During and shortly after bloom, 75 to 100 blossoms per replication were used because the number that would eventually be pollinated and retained could not be determined at the time of inoculation. As the season progressed and viable fruit could be identified, 25 to 30 fruit per replication were inoculated. Misting began immediately after inoculation was completed and continued for 48 hours. This procedure was repeated at weekly intervals beginning at full bloom (16 March) and ending when fruit were full sized (26 April). Similar inoculations were made on 2 and 18 May in a separate experiment which included inoculum concentration treatments 10^4 and 10^5 conidia/ml and a noninoculated control. Test trees were located in one row, and one tree, randomly assigned, was used on each inoculation date.

Data collection - Length of 20 fruit taken randomly from the experimental tree was measured at each inoculation date, and fruit were observed twice weekly for evidence of infection. Beginning 24 April and weekly thereafter, fruit were tested for retention on the tree. Each fruit was tapped lightly, and those that fell were collected, measured, and fruit lesions counted. Tissues from representative lesions were cultured for recovery of *W. carpophila*. All remaining fruit from all treatments were counted on 10 May and 13 June 1990 for inoculation dates 16 March through 26 April and 2 and 18 May, respectively. On 29 May 1990, five fruit from each replication of all treatments were removed and examined for symptoms.

Comments - Natural fruit drop, due presumably to lack of pollination, was extremely great in 1990. Almost all fruit was lost from the entire tree in one treatment (29 March) and thus data from that inoculation is not reported. Significantly larger percentages of fruit drop were encountered in treatments inoculated with 10^5 conidia/ml on 5 and 12 April than with other concentrations or the noninoculated control. There were no significant differences in fruit drop among treatments on other dates (Table 9). Fruit that dropped were shorter than healthy fruit that remained. Most dropped fruit bore a large, slightly

sunken brown lesion. Eighty percent of fruit with sunken lesions tested positive for presence of the shot hole pathogen. Generally, percent infected fruit and number lesions per fruit increased significantly with increasing levels of inoculum (Table 10). Fruit were essentially resistant to infection by early may. Many of the lesions observed on fruit in May were extremely small and were difficult to identify with certainty.

Almond fruit were most susceptible to infection during the four weeks beginning at emergence from the shuck. Shot hole fungus appeared to cause drop of young fruit if such fruit were infected with relatively high concentrations of inoculum when emerging from the jacket. Inoculation with lesser amounts of inoculum or other bloom or fruit growth stages resulted in typical shot hole lesions but the fruit were retained on the tree.

Table 1. Almond hull rot 1990. Inoculation of fruit on tree. 20 fruit/rep. 10^3 spores/ml *Rhisopus stolonifer*, 0.1 ml/fruit. Harvested 13 August 1990.

Cut-Off Treatment	$\bar{X}$ Percent Infected Fruit, Date Inoculated			
	13 July	19 July	26 July	2 August
4	1.7 a[v]	3.3 a	13.3 a	0.0
5	5.1 ab	77.0 b	20.7 ab	1.7
6	3.3 a	75.0 b	46.1 bc	8.3
7	20.3 b	83.9 b	66.6 c	13.9
8	47.8 c	85.9 b	55.0 c	15.0
LSD =	18.8	22.9	23.8	N.S.
r^w	0.79	0.74	0.67	0.66
r^x	0.80	0.75	0.69	0.66
r^y	-0.11	-0.22	0.08	0.00
r^z	0.12	0.19	0.27	0.21

[v] Actual percentages given, ANOVA and DMRT performed on arcsine transformed data. LSD derived from analysis of non-transformed data.

[w] Correlation to irrigation cut-off, data not transformed.

[x] Correlation to irrigation cut-off, arcsine.

[y] Correlation to percent hull moisture, arcsine.

[z] Correlation to percent hull split, arcsine.

Table 2. Almond hull rot, 1990. Percent hull split. Derived from Goldhamer's data.

Date	Cut-Off Treatment	$\bar{X}$ Percent Hull Split 3 July	10 July	17 July	25 July	1 August
6/26	1	0.0	0.0	0.0	0.0 c	0.0 d
7/03	2	0.0	0.0	1.7	11.7 bc	18.3 cd
7/10	3	0.0	3.3	3.3	11.7 bc	15.0 cd
7/17	4[1]	0.0	0.0	10.0	28.3 bc	33.3 bcd
7/25	5	0.0	1.7	18.3	40.0 ab	33.3 bcd
8/01	6	0.0	0.0	10.0	28.3 bc	80.0 ab
8/08	7	0.0	0.0	23.3	78.3 a	91.7 a
8/15	8	0.0	1.7	15.0	58.3 abc	60.0 abc
	LSD =	N.S.	N.S.	N.S.	35.4	35.3
	r^a		0.03	0.53	0.76	0.78

[1] Analysis of treatments 4-8, arcsine, N.S. all dates. Means followed by the same letter do not differ significantly according to analysis of variance and Duncan's multiple range test.

Table 3. Almond hull rot 1990. Natural infection at harvest. 17 August 1990, the day after trees shaken. All wilted shoots on each of four center trees/rep. Fruit collected from beneath four trees, then 100 of these fruit evaluated for each rep.

Cut-Off Treatment	$\bar{X}$ No. Wilted Shoots/Tree	$\bar{X}$ Percent Fruit Having: Rhizopus	Aspergillus	Clean
1	0.0 b[z]	1.3 b	7.0	91.7 a
2	0.0 b	0.0 b	20.3	79.7 ab
3	1.3 b	1.0 b	21.7	77.3 ab
4	6.3 b	1.0 b	25.3	73.7 ab
5	7.3 b	0.7 b	33.7	65.7 b
6	16.3 b	0.3 b	38.3	61.3 b
7	59.0 a	5.7 a	38.3	56.0 b
8	70.0 a	8.3 a	40.3	51.3 b
LSD =	27.9	3.7	N.S.	20.9
r^4	0.76	0.60	0.69	-0.75

[z] Means followed by same letter do not differ significantly according to analysis of variance and Duncan's multiple range test.

Table 4. Almond hull rot 1990. Inoculation of detached fruit with *Rhizopus stolonifer*.

Cut-Off Treatment	16 July[x] Index[y]	16 July[x] % Hull Moisture	25 July[x] Index	25 July[x] % Hull Moisture	1 August[x] Index	1 August[x] % Hull Moisture
1	1.0 b[z]	76.8 c	11.1 c	74.0 b	1.5	71.1
2	2.4 a	78.2 abc	1.0 c	75.8 b	1.7	70.7
3	1.9 ab	77.4 bc	1.0 c	75.9 b	1.9	67.7
4	1.9 ab	79.1 abc	1.1 c	77.9 ab	2.2	72.4
5	1.9 ab	79.9 a	1.6 bc	81.1 a	2.5	71.0
6	2.4 a	78.7 abc	2.3 b	82.2 a	2.2	73.9
7	2.4 a	80.3 a	2.3 b	81.2 a	2.9	74.1
8	2.7 a	79.2 ab	3.3 a	80.6 a	2.5	76.1
LSD =	1.4	2.1	0.7	0.04	N.S.	N.S.
r = (arcsine for % moisture)	0.52	0.58	0.84	0.73	0.57	0.50
r = (correlation of disease rating to % hull moisture)	0.53		0.50		0.37	

[x] Date hulls collected from trees and inoculated in laboratory.

[y] Amount of fungal growth after 5 day incubation in closed ziplock bags at room temperature. 1 = no growth, 4 = profuse growth.

[z] Means followed by same letter do not differ significantly according to analysis of variance and Duncan's multiple range test.

Table 5. Almond hull rot 1990. Inoculation of detached fruit with *Rhizopus stolonifer* after several drying periods.

		15 Fruit/Treatment	
Drying Time, hr	% Hull Moisture	% *Rhizopus*	$\bar{X}$ Severity
0	72.9	93.3	2.2
2	61.9	100.0	1.5
4	50.8	100.0	3.6
6	52.4	100.0	2.2
8	41.0	100.0	2.7
16	19.2	100.0	2.9*
24	8.1	20.0	1.5*
36	4.2	0.0	0.0
48	<1.0	0.0	0.0
72	<1.0	0.0	0.0

* Looks like naturally-occurring hull rot - dense, compact growth and sporulation between hull and shell.

Table 6. Susceptibility of almond pruning wounds to infection by *Ceratocystis fimbriata*.

	$\bar{X}$ Canker length, cm	
	1988-1989	1989-1990
Month inoculated[y]		
September	-	6.0 a
October	-	6.5 a
November	5.7 a[z]	10.9 b
December	17.7 b	9.8 b
January	12.0 ab	10.5 b
February	12.9 ab	-
P = 0.05, LSD =	10.5	2.7
Wound age (days) when inoculated		
0	26.4 a	12.0 a
2	14.5 b	8.2 b
7	7.5 b	7.4 b
14	7.3 b	7.2 b
P = 0.05, LSD =	7.6	1.9

[y] Approximately 0.25 ml suspension of 10^4 endoconidia/ml placed onto exposed bark, cambium and outer wood of one fourth to one half the circumference of each pruning cut.

[z] Means followed by the same letter do not differ significantly, P = 0.05, according to analysis of variance and Duncan's multiple range test. There were six replications of each treatment; reported means are averages of all data for that month or wound age.

Table 7. Almond bloom disease control and yield. Tejon Ranch, Kern County, 1990.

Treatment	$\bar{X}$ lbs Nutmeats/Tree		(Shot Hole) $\bar{X}$ % Healthy Fruit[y]	
	Merced	Nonpareil	Merced	Nonpareil
1. Cap-Cap-Cap	29.9[z]	17.5	94.2	98.0
2. Cu -Cap-Cap-Cap	32.8	17.0	95.3	98.0
3. Rov-Rov-Rov	31.2	18.6	94.8	97.3
4. Rov-Rov-Zir	29.3	18.8	96.7	98.5
5. Cu -Rov-Rov	28.5	17.0	94.3	97.0
6. Top/Cap-Rov-Zir	31.3	18.2	96.5	97.5
7. Control	33.2	19.1	92.0	93.8
P = 0.05, LSD =	N.S.	N.S.	N.S.	N.S.

[x] Explanation of code:

Cap = Captan 50W
Cu = Kocide 101
Rov = Rovral 50W
Top = Topsin M 70W
Zir = Ziram 76W

The position in the array designates the application date:

Position	Growth Stage
First	Dormant
Second	Pink bud
Third	Full bloom
Fourth	2 weeks after full bloom

[y] Evaluated 30 May 1990. Shot hole present, brown rot and jacket rot not observed.

[z] Arcsine data analyzed, actual percentages reported.

Table 8. Almond microflora survey 1990. Merced County, Carmel. Summary of fungi and yeasts present.

	$\bar{X}$ No. Propagules/Flower or Fruit (X 10^2)													
	Cladosporium		Penicillium		Aspergillus[x]		Others[y]		Occasional[z]		Total Fungi		Yeast	
Date Collected	Org	Trad	Org	Trad	Org	Trad	Org	Trad	Org	Trad	Org	Trad	Org	Trad
1 March (full pink)	30.4	15.5	.009	0.0	0	0			0.0	0.0	30.41	15.5	Many	Many
5 March (pink bud)	12.0	23.0	4.2	2.0	0	0	3.0	5.0	0.0	0.0	19.2	30.0	245	498
(whole flower)	42.0	12.0	33.0	0.0	0	0	2.5	19.5	0.0	0.0	77.5	31.5	245.0	624.0
8 March (whole flower)	42.1	31.3	0.7	2.0	4.2	0	4.8	5.7	0.0	0.08	47.6	39.1	160	328
13 March (whole flower)	23.9	19.0	2.7	7.4	0	0.1	1.4	2.4	6.4	5.1	34.4	33.9	Many	181.6
FRUIT														
19 March	10.7	10.7	0.0	0.0	0	0	0.8	0.9	2.9	1.3	14.4	12.9	67.1	75.9
9 April	106.7	116.0	0.0	0.52	0	0	9.7	2.1	0.2	0.2	116.6	118.8	16.1	74.1
3 May	3290	1237	1219	101	19.2	0	86.4	39.2	6.8	13.2	4515.8	1390.4	2117	5280
24 May	8808	2112	0.0	136	0	13.6	108.0	28.0	40.0	20.0	8956	2296	18,104	8056
13 June	14,592	11,576	11,696	520	600	16.8	944	100	0.0	16.0	27,232	12,212	6224	12,576
3 July	17,496	5992	0.0	8400	2	21.6	160	40	4.0	0.0	17,660	14,432	20,056	10,912

[x] A. niger.

[y] Alternaria, Fusarium, Epicoccum, Botrytis, Aspergillus.

[z] Phoma, Paecilomyces, Coniothyrium, Botryosphaeria, Rhizopus, Unidentified.

Table 9. Effect of shot hole on almond fruit. Kearney Agricultural Center, 1990, Cultivar Mission.

Number conidia/ml[y]	$\bar{X}$ Percent Fruit Dropped[x], Date Inoculated								
	MARCH			APRIL				MAY	
	16	23	26	5	12	19	26	2	18
10^5	91.7	82.3	78.4	87.1 a[z]	59.0 a	8.6	7.1	5.1	1.0
10^4	92.0	86.6	94.7	54.6 b	37.1 b	15.6	2.6	1.3	2.1
10^3	86.6	87.9	89.0	40.4 c	30.4 b	10.6	1.7	-	-
Control	88.7	87.6	87.5	59.1 b	23.6 b	6.1	2.4	7.2	1.0
P = 0.05, LSD =	N.S.	N.S.	N.S.	11.5	16.3	N.S.	N.S.	N.S.	N.S.

[x] Remaining fruit counted 10 May 1990 (inoculation dates 16 May through 26 April) and 13 June (inoculation dates 2, 18 May).

[y] Approximately 0.5 ml/flower or fruit. Inoculation followed by 48 hr misting period.

[z] Means followed by the same letter do not differ significantly according to analysis of variance and Duncan's multiple range tests. Analysis performed on arcsine transformed data, actual percentages reported.

Table 10. Incidence of shot hole on almond fruit. Kearney Agricultural Center, 1990, Cultivar Mission.

Number conidia/ml[y]	X̄ Percent Infected Fruit[w], Date Inoculated								
	MARCH			APRIL				MAY[x]	
	16	23	26	5	12	19	26	2	18
10^5	10.0	20.0 b	65.6 b[z]	90.0 b	100.0 b	100.0 b	95.0 d	29.6	42.3
10^4	5.1	0.0 a	47.4 b	75.0 b	95.0 b	100.0 b	55.0 c	18.4	35.0
10^3	0.0	5.1 a	17.5 a	65.0 b	77.5 b	95.0 b	25.0 b	-	-
Control	5.1	0.0 a	0.0 a	25.6 a	30.0 a	35.0 a	0.0 a	14.6	31.5
P=0.05, LSD =	N.S.	13.3	28.6	27.2	32.6	73.4	24.0	N.S.	N.S.
r =	0.26	0.53	0.88	0.77	0.79	0.73	0.94	0.51	0.30
	X̄ Number Lesions/Fruit								
	0.3	0.2 a	3.3 a	19.5 a	30.4 a	38.4 a	12.1 a	1.0	0.8
10^4	0.0	0.0 b	1.3 ab	15.1 ab	25.3 a	25.3 ab	2.5 b	0.6	0.3
10^3	0.0	0.0 b	0.2 b	4.8 ab	13.2 ab	9.1 bc	0.9 b	-	-
Control	0.0	0.0 b	0.0 b	0.2 b	3.6 b	2.0 c	0.0 b	0.3	0.1
P=0.05, LSD =	N.S.	0.2	2.4	14.9	17.7	18.0	4.0	N.S.	N.S.
r =	0.4	0.56	0.61	0.74	0.66	0.83	0.81	0.52	0.76

[w] Five fruit per rep collected 29 May 1990 for inoculation dates 16 March through 26 April. Collection for 2 and 18 May was made 13 June 1990. In some treatments, fewer than 5 fruit remained.

[x] Data taken from similar but separate series of experiments.

[y] Approximately 0.5 ml/flower or fruit. Inoculation followed by 48 hr misting period.

[z] Means followed by the same letter do not differ significantly according to an analysis of variance and Duncan's multiple range test.

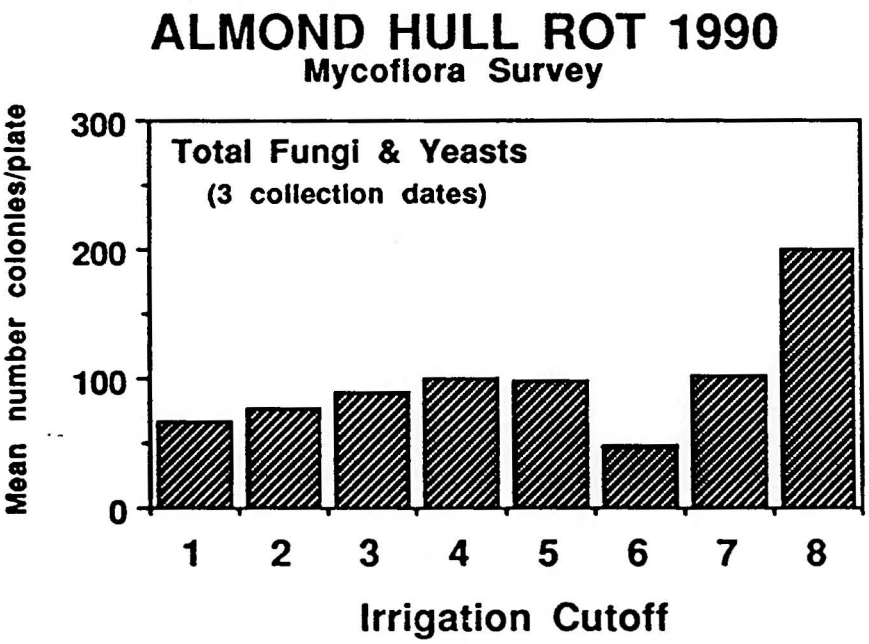
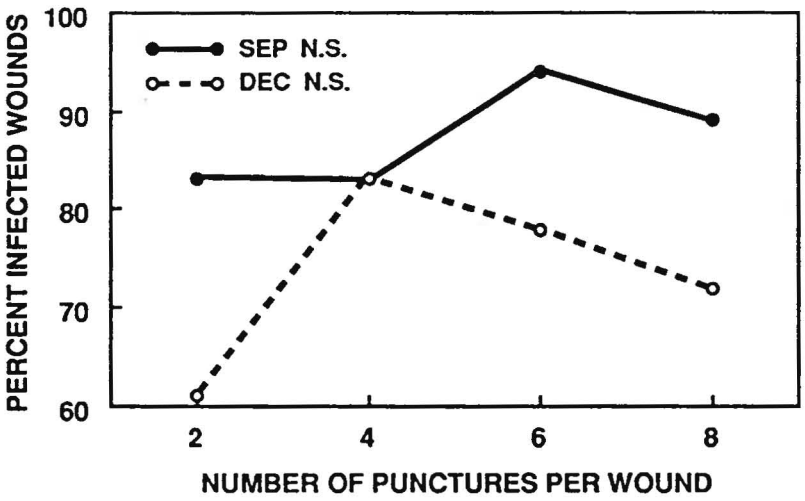
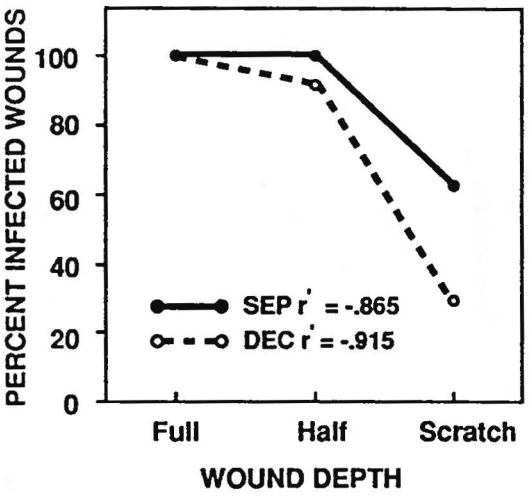
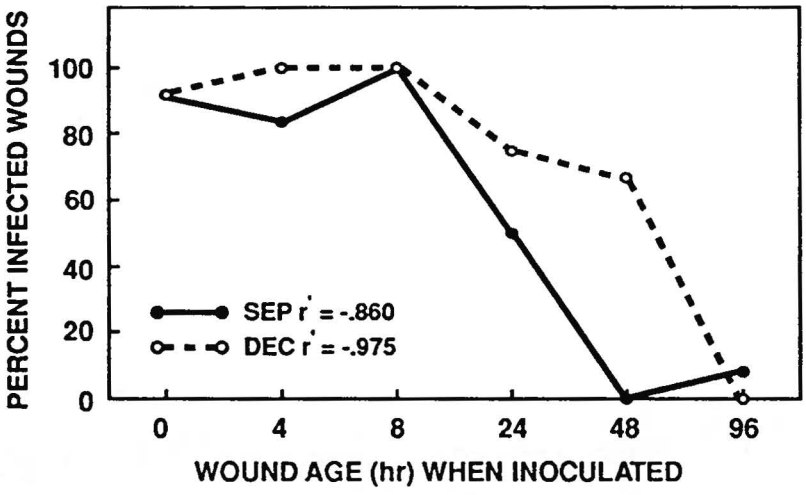

ALMOND HULL ROT 1990
Mycoflora Survey
Total Fungi & Yeasts
(3 collection dates)
Mean number colonies/plate
300
200
100
0
1
2
3
4
5
6
7
8
Irrigation Cutoff

Figure 1


PERCENT INFECTED WOUNDS
100
90
80
70
60
SEP N.S.
DEC N.S.
2
4
6
8
NUMBER OF PUNCTURES PER WOUND


PERCENT INFECTED WOUNDS
100
80
60
40
20
0
SEP r' = -.865
DEC r' = -.915
Full
Half
Scratch
WOUND DEPTH


PERCENT INFECTED WOUNDS
100
80
60
40
20
0
SEP r' = -.860
DEC r' = -.975
0
4
8
24
48
96
WOUND AGE (hr) WHEN INOCULATED

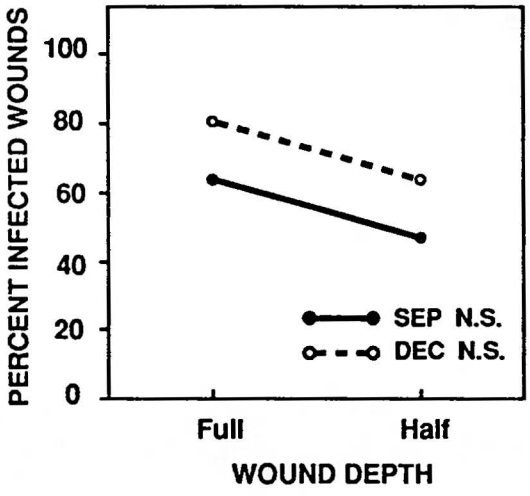

PERCENT INFECTED WOUNDS
100
80
60
40
20
0
SEP N.S.
DEC N.S.
Full
Half
WOUND DEPTH

Figure 2

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9240 South Riverbend Avenue
Parlier, California 93648
(209) 891-2500

January 24, 1991

Susan McCloud
Almond Board
P.O. Box 15920
Sacramento, CA 93813

Dear Susan:

I won't bore you with lamentations and excuses and explanations. Suffice it to say that my day-stretcher just wasn't up to the task. I hope this tardiness has not caused you any major embarrassment or disruption.

Sincerely yours,

Beth

Beth L. Teviotdale
Extension Plant Pathologist

BLT/dcm

Enclosure

cc: Themis J. Michailides