Project Number: 82-T8
Project Title: Almond Diseases - Hull Rot, Shot Hole, Brown Rot

# 1982 Annual Report

Project: Almond Diseases

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## I. OBJECTIVES

A. Shot hole

1. Epidemiology of the shot hole fungus.
2. Timing of fungicide sprays on disease incidence and crop yield.

B. Hull rot

1. Establishing a temporary tolerance for dichlorvus.
2. Testing of dichlorvus for control of hull rot disease through elimination of the vectors of *Rhizopus* and *Monilinia* spores.

C. Brown rot

1. Fitness of the benomyl-resistant *M. laxa*, obtained from apricots. Funds from sources other than the Almond Board.
2. Survey of benomyl-resistant *M. laxa* in almond orchards.

## II. INTERPRETIVE SUMMARY

Shot hole disease on almonds caused by the fungus *Coryneum beijerinckii* (*Stigmina carpophilum*) is controlled with annual fungicide spray treatments during bloom period. However, the effectiveness on timing of the fungicide applications in controlling disease incidence and/or severity and its relationship to crop loss are not well understood. Preliminary results obtained from three field test plots set up during the 1982 growing season showed that two or more bloom-time fungicide spray applications gave effective control of shot hole disease levels and significantly reduced the amount of crop loss due to shot hole. Where single applications were made, a petal fall spray was more effective

than a pink bud or dormant copper application in controlling disease levels and reducing crop loss. Further studies on correlation between disease severity and crop losses are needed during the 1983 growing season to confirm our 1982 findings. Critical studies of shot hole symptoms this year revealed for the first time, spur and leaf blighting on diseased trees. Also, examination of diseased leaves, fruits and twigs revealed the presence of shot hole spores and new infections throughout the season on nonsprayed trees. Studies winter and spring 1983 are aimed at locating overwintering sites of the fungus, identifying sources of primary inoculum, and characterizing yield losses.

Almond hull rot is caused by infection of Monilinia and Rhizopus fungi at hull split (early July) which results in stick tights, kill of fruiting wood, and difficulties in removing hulls in commercial hullers. Suggested control measures are: early harvest or two harvesting periods, reduction in vigor of trees to make possible a single harvest, and procedures which will result in more uniform hull split and early drying of hulls. The disease is more severe in vigorous orchards with high crop yields and in these orchards we find insects (nitidulids) as vectors of spores of the fungi from infected hulls to newly splitting hulls over a period of 4 to 6 weeks. Plans are to spray dichlorvus or "Ambush®" repeatedly during the hull split period and determine if control of insects can reduce hull rot in a commercial orchard.

Brown rot blossom blight of almonds is caused by M. laxa and at times M. fructicola while hull rot is caused primarily by M. fructicola. Benomyl has been used since 1972 to control blossom blight and thiophanate methyl (another benzimidazole fungicide) has been registered for use. Benomyl-resistant M. laxa has been detected in apricot orchards. Preliminary surveys indicated benomyl-resistant *M. fructicola* in almond orchards but not *M. laxa*. Surveys are planned in orchards with severe blossom blight for benzimidazole-resistant *Monilinia*. The fitness of the benomyl-resistant *M. laxa* to infect and survive in the orchard under current pest management programs is being studied.

## III. EXPERIMENTAL PROCEDURES

### A. Shot hole

Three spray test plots were set up during the 1982 growing season to determine the effectiveness of timing on controlling disease incidence and/or crop loss. Plot 1 (Table 1) was located in Arvin on the Den Surber orchard. The plot was a randomized block design with 10 treatments and 10 single tree replications. Disease ratings were made by collecting 200 leaf clusters on each of 10 trees for each treatment on April 1, 1982. Ratings were also made on 60 almond hulls on each of 10 trees for each treatment (April 1, 1982). Plot 2 (Table 2) was located in Turlock on the JACL orchard. Again randomized complete block design was used with 8 treatments, 3 replications, and 3 trees per replication. Disease ratings were made on the hulls on May 12, 1982 and yield data collected on September 16, 1982. Plot 3 (Table 3) was made in Arvin in the Tejon orchard planted in a 24-ft diamond planting (87 trees/A). The experiment was set up as a parallel plot design with 2 treatments, 14 replications with 5 trees per replication. Disease data were not collected. Yield data were collected by harvesting on September 9 & 10, 1982.

In the collection of yield data, each treatment was harvested and let dry on the orchard floor. The total weight of hull, shell and meat was taken and a four-pound sample removed. The four pound samples were hulled and shelled and the meats dried again before the final meat weight was taken.

B. Hull rot of almond

Nitidulid beetles and other insects have been implicated in vectoring the causal agents of the hull rot disease. These insects visit the initially infected hulls (early July) and carry the spores of _Rhizopus_ and _Monilinia_ to newly splitting almond hulls. This process continues during the hull split period from the middle of July through two- to six-week period with those orchards with the longest hull split period showing the greatest disease problem. Spraying an insecticide such as dichlorvus during the hull split period has been planned.

Because dichlorvus is not registered for use on almonds, a special request has been made to the Federal IR-4 program to obtain a temporary tolerance which would permit the experimental testing of dichlorvus. Crops treated would be saleable but the hull would not be sold as feed. Spray applications made during 1981 provided estimated dichlorvus residue data on almond meats and hulls. Request for a temporary tolerance was made through the IR-4 office in Davis, California, in February 1982. The procedures required for approval were not completed for application during the 1982 hull split period. Plans are being made to file for temporary tolerance of dichlorovus for the 1983 season.

C. Brown rot

Benomyl (Benlate 50W) has been used commercially since 1972 to control brown rot caused by _Monilinia fructicola_ and _M. laxa_. The first evidence of benomyl-resistant _M. fructicola_ occurred in 1977. Benomyl resistance in _M. laxa_ was first detected in 1980 from rotted apricot fruit and later from sporodochia found on blighted apricot twigs from San Benito and Contra Costa counties, respectively. Delay in development of benomyl-resistant _M. laxa_ could be attributed to the host specificity of the _Monilinia_ species and the number of benomyl applications. *M. fructicola* is important on peaches and nectarines causing both blossom blight and fruit rot with growers using from one to three applications during bloom followed by one to three preharvest applications. The blossom blight phase of *M. laxa* almonds has been important and growers generally use one and possibly two applications during the blossoming period. Thus, reduced selection pressure in the field could be a significant factor in delayed detection of benomyl-resistant *M. laxa* isolates. Benomyl-resistant *M. laxa* have not been detected from previous surveys.

Pathogenicity of benomyl-resistant *M. laxa* isolates from apricot, resistant to 1.0 mg/L benomyl, was confirmed on apricot fruit and almond twigs. Investigations designed to determine the fitness of the beonomyl-resistant *M. laxa* isolates are in progress along with pathogenicity tests conducted on unopened almond blossoms. Preliminary surveys were made in an almond orchard located in Sacramento and San Joaquin valleys for benomyl-resistant *M. laxa* and *M. fructicola*.

IV. RESULTS, DISCUSSION AND PUBLICATIONS

Results from the fungicide-timing studies are summarized below. All data were analyzed using analysis of variance at 5% significance level and treatment means were separated by Duncan's Multiple Range Test at the 5% significance level.

Surber Test Plot

Results from the Surber test plot are presented in Table 1. From these data the following general observations can be made.

1. Shot hole disease incidence was effectively controlled by two or more fungicide applications.
2. No added disease control was obtained by the addition of dormant copper to three ziram applications during bloom.

3. Single ziram or dormant copper applications gave some disease control over the nonsprayed plot.
4. Full bloom and petal fall ziram applications gave better control of hull infections than pink bud applications.

Turlock Test Plot

Results from the Turlock test plot are presented in Table 2. From these data the following general observations can be made.

1. A petal fall spray was more effective than a pink bud spray in controlling hull infections and in reducing crop loss.
2. Significant reductions in crop losses are obtained when fungicidal sprays are applied to control shot hole disease incidence.
3. A new chemical, Bravo 500, was shown to significantly reduce disease levels and crop loss.

Tejon Test Plot

Results from the Tejon test plot are presented in Table 3. The three ziram spray treatment plot resulted in a 21% reduction in crop loss over the nonsprayed plot. On a meat weight basis, the three ziram spray treatment yielded an average of 24.34 meat lbs/tree, whereas the check gave a yield average of 20.08 meat lbs/tree. Conversion to a per acre basis, bases on 24 ft diamond spacing, shows a 370.78 lb/A increase with three ziram applications over the check.

Studies to date have shown that timing of bloom time fungicide sprays has a significant effect on shot hole disease incidence and severity as well as on crop yields. Where two or more fungicide applications were made during the bloom period, yield losses due to shot hole were significantly reduced. Likewise, late bloom sprays (at full bloom or petal fall) gave better control of shot hole disease levels than an early bloom spray (at pink bud or popcorn).

During the 1983 season, we will continue studies on disease severity and crop loss to confirm our results from 1982 tests. In addition, we will continue our studies on the disease cycle of shot hole on almonds, which includes locating overwintering sites of the fungus, sources of primary inoculum, and mechanisms by which shot hole disease incidence results in crop loss.

## V. PUBLICATIONS

Highberg, L. 1982. Research update on shot hole and brown rot: Shot hole. Almond Facts. Nov/Dec. p. 60-61.

TABLE 1. Fungicides and application timing on control of shot hole leaf and hull infections on Thompson almond

| Treatment/Timing[a] | Leaf clusters with shothole[b] | Avg. lesions per hull[c] |
|---|---|---|
| | % | no. |
| Kocide - dormant plus Ziram - PB,FB,PF | 3.0 w | 0.12 f |
| SPCP - dorman plus Ziram - PB,FB,PF | 3.7 w | 0.10 f |
| Ziram - PB,FB,PF | 8.2 wx | 0.34 f |
| Ziram - FB,PF | 9.4 wx | 0.48 fg |
| Ziram - PB,FB | 8.8 wx | 1.02 gh |
| Ziram - PB | 13.3 x | 1.81 ij |
| SPCP - dormant | 16.3 xy | 2.22 j |
| Kocide - dormant | 22.3 y | 2.14 j |
| Ziram - PF | 43.5 z | 1.44 hi |
| Check | 42.8 z | 3.44 k |

[a]Chemical formulations and rates applied were: Kocide 101 77%, 4 pounds; sodium pentachlorophenate (SPCP) 79%, 4 pounds; and ziram 76%, 4 pounds per 100 gallons of water. Six gallons of spray were applied with a hand gun on each tree at dormant (Jan. 5). Pink bud = (PB) (Feb. 18), full bloom = (FB) (Feb. 25) and petal fall (PF) (Mar. 23) at the Surber orchard in Arvin, CA.

[b]200 leaf clusters on each of 10 trees were collected on April 1 and read for the presence of shot hole symptoms.

[c]60 fruits were collected on each of 10 trees for each treatment on April 30 and read for shot hole lesions.

[d]Means separated by Duncan's multiple range test at 5% significance level.

TABLE 2. Fungicides and application timing on shot hole disease incidence and yield reduction on Nonpareil almond

| Treatment/Timing[a] | Infected fruit[b] | Avg. lesions 60 fruit/rep[b] | Yield* meat per acre[c] |
|---|---|---|---|
| | % | no. | lbs. |
| Ziram - PF | 11 a | 24 a | 1966 a |
| Captan - PF | 10 a | 27 a | 1657 a |
| Captan - PB | 95 c | 822 c | 961 b |
| Kocide 101 dormant | 99 c | 1045 cd | 957 b |
| Vangard - PB | 96 c | 810 c | 948 b |
| Bravo - PF | 77 b | 507 b | 917 bc |
| Ziram - PB | 99 c | 832 c | 902 bc |
| Check | 100 c | 1141 d | 486 c |

[a]Fungicide applied with a semi-concentrate airblast sprayer. Amounts of chemicals used are proprietary formulations per acre of ziram, 8 lbs; captan 50W, 8 lbs; Vangard 10W, 20 oz; Bravo 500, 6 pts; and Kocide 101, 77% 16 lbs. Timing was at dormant 1/25/82; pink bud, Feb 27; and petal fall (PF) Mar 28.

[b]Disease ratings were based on 60 fruit per replications collected on May 12, 1982.

[c]Yield data were obtained by harvesting 3 trees per replication in each treatment. Four-pound sample was taken from each replication, hulled, shelled, dried, and meat weighed.

[d]Means separated by Duncan's multiple range test at 5% significance level.

TABLE 3. Effect of fungicide application on crop yields on Nonpariel almonds

| | YIELD | |
|---|---|---|
| Treatment | meat lbs/tree | meat lbs/acre* |
| Ziram - popcorn petal fall, & 5 weeks after petal fall | 24.34 a | 2117.72 a |
| Check | 20.08 b | 1746.97 b |

[a]Proprietary formulation of ziram 76% was applied at popcorn, Feb 17; petal fall, Mar 10 and 5 weeks after petal fall, May 14. Sprays were applied with a semi-concentrate air blast sprayer.

[b]Yield data were obtained on nuts harvested on September 9 & 10, 1982, four-pound sample taken from each replication and hulled, shelled, meats dried and weighed.

[c]Means separated by Duncan's multiple range test at 5% level of significance.

B. Hull rot of almond

A temporary tolerance for experimentation of dichlorvus is expected for the 1983 season. The insecticide "Ambush" which is registered for use in almond orchards will also be considered. The test plots considered are in Caruthers (Tenneco Ranch) located in Fresno County and the Tejon Ranch located in Kern County. Projects will be run in cooperation with Mark W. Freeman and Mario Viveros, Farm Advisors in Fresno and Kern counties, respectively. An entomologist, consultant or cooperator, is required to insure effective experimental planning and interpretation of data.

Correlation should be attempted to show that: insecticides can reduce the hull rot disease, the timing of such sprays at hull split would also help control the NOW insect.

C. Brown rot

Current investigations showed that spores from benomyl-resistant isolates have reduced germination percentages and rates when compared to benomyl-sensitive isolates. A high percentage of benomyl-resistant *M. laxa* spores germinated but stopped growing after a period of time on synthetic media. Pathogenicity tests conducted on unopened almond blossoms showed that higher concentrations of benomyl-resistant *M. laxa* spores were required for infection than with benomyl-sensitive spores. These results suggested reduced fitness of benomyl-resistant *M. laxa*.

A survey conducted in 1982 prior to almond harvest was designed to help determine the incidence of benomyl-resistant *M. laxa* on blighted blossoms and rotted hulls. None of the *M. laxa* isolates obtained from the survey showed resistance to 1.0 mg/L benomyl. However, high percentages of *M. fructicola* isolates from hulls did exhibit benomyl resistance.

Further investigations utilizing benomyl-resistant _M. laxa_ include determining their ability to compete with benomyl-sensitive isolates. Continued monitoring of benomyl-resistant _M. laxa_ populations in the field along with results obtained from fitness studies could act as tools in extending the effective use of benomyl sprays in controlling brown rot blossom blight of almonds.

PUBLICATIONS


Canez, V. M. and J. M. Ogawa. 1982. Status of benomyl resistance in _Monilinia laxa_. California Plant Pathology No. 57, June issue.

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Ogawa, J. M., B. T. Manji, R. M. Bostock, V. M. Canez, and E. A. Bose. 1983. Detection and characterization of benomyl-resistant _Monilinia laxa_ on apricots. Plant Disease (submitted).