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# Epidemiology and Management of Almond Diseases

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## Interpretive Summary:

Our research in 2007 and continuing in 2008 on the evaluation of new fungicides against major foliar and fruit diseases of almond in California focused on the management of brown rot blossom blight, anthracnose, shot hole, and scab as well as on the etiology of a new russeting disorder of fruit. *Alternaria* leaf spot is discussed in a separate report. Highly effective fungicides were identified that will help to prevent the selection and build-up of resistant pathogen populations when applied in rotation or mixture programs. In a Solano Co. field trial with a high disease pressure of brown rot blossom blight, all single-fungicide, mixture, pre-mixture, or rotation programs evaluated significantly reduced the incidence of disease. The lowest incidences were found with Scala, Vanguard, Enable, and the experimental Inspire, as well as with some of the pre-mixes (i.e., Pristine, Adament, Distinguish). The incidence of shot hole was most effectively controlled by strobilurin fungicides in single-fungicide, mixture, and pre-mixture programs. In a field trial in Butte Co., the incidence of brown rot and scab was low in the untreated control, but all rotation programs evaluated significantly reduced the disease. In research on the management of scab, dormant applications with liquid lime sulfur or copper-oil delayed sporulation of the pathogen on overwintering twig lesions and thus, reduced inoculum production. This was repeated in the 2008 season. In a

trial in Butte Co., petal fall applications with Bravo, Captan, and Maneb were very effective in reducing the disease, whereas late spring applications (early May), with selected fungicides generally were ineffective. Resistance to strobilurin fungicides was commonly found in *Cladosporium (Fusicladium)*, *carpophilum* populations in six orchards in Northern California, emphasizing the importance of having several fungicide classes available that are active against a specific pathogen and the need to employ resistance management strategies whenever several alternatives to manage a disease are available. In studies on the etiology of a new russetting, powdery mildew-like disease, fungicide treatments indicated that a fungal organism causes the disorder. Probably, the putative pathogen is a powdery mildew fungus because powdery mildew-specific fungicides (e.g., Quintec, V-10118), also effectively reduced the incidence of this disorder. In growth chamber studies, the disorder could not be reproduced by exposing potted plants to field-infected symptomatic fruit.

## **Objectives:**

### Epidemiology

- 1) Host-pathogen interactions: Effect of pH modulation as a pathogenicity factor for development of almond anthracnose (a manuscript has been submitted for publication in a scientific journal).
- 2) Evaluate constitutive vs. adaptive processes of ammonia production in *Colletotrichum acutatum*.
- 3) Evaluate pH changes in resistant (e.g., Nonpareil), and susceptible (e.g., NePlus Ultra), genotypes.
- 4) Develop wetness-temperature models for predicting anthracnose.
- 5) Publish results of environmental modeling:
- 6) Evaluate fungi associated with kernel discolorations in collaboration with T. Gradziel.
- 7) Characterize the etiology of the newly described almond fruit russetting disorder.
- 8) Apply powdery mildew-specific fungicides (no activity against other fungi), (e.g., quinoxyfen, V-10118), and broad-spectrum fungicides (wetable sulfur, myclobutanil, azoxystrobin, pyraclostrobin/boscalid), in affected orchards.
- 9) From fungicide efficacy data deduce putative cause of disorder (fungal, specific fungi, non-fungal).
- 10) Greenhouse inoculation studies using infected almond fruit from the field as inoculum sources.
- 11) DNA amplification with powdery mildew-specific primers.

### Disease Management Strategies:

- 1) Evaluate new fungicides and develop efficacy data based on spectrum of activity, systemic action, and persistence.
- 2) Continue evaluations on brown rot, shot hole, scab, and anthracnose.
- 3) Evaluate new fungicides against almond leaf rust.

- 4) Use information on the characteristics of fungicides to develop effective rotation programs for anthracnose and brown rot management, as well as other diseases of almond.
- 5) Evaluate persistence and post-infection activity of selected fungicides in field/laboratory studies for management of brown rot and anthracnose.
- 6) Continue to develop a minimum application fungicide program for maximum disease control of major foliar diseases.
- 7) Compare the single-application delayed bloom spray program with a two-application program.
- 8) Develop baseline sensitivities of fungal pathogen populations against new fungicides and determine shifts in fungicide sensitivity.
- 9) Characterize baseline sensitivities of *Monilinia*, *Cladosporium*, and *Colletotrichum* spp. against new fungicides including DMI and strobilurin fungicides.
- 10) Determine extent of strobilurin resistance in populations of *Cladosporium carpophilum* from several locations in California.
- 11) Evaluate almond genotype susceptibility to foliar diseases including brown rot that develop naturally in the almond variety orchard at UC Davis under simulated rainfall as part of an ongoing collaboration with T. Gradziel.

#### **Materials and Methods:**

##### Fungicide Evaluations for Management of Brown Rot, Shot Hole, and Gray Mold in an Experimental Orchard

Field trials were conducted at UC Davis on cv. Drake. Treatments were done as single-fungicide, mixture, or pre-mixture programs (as shown in Table 1). Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. For brown rot evaluation, the number of brown rot strikes per tree was counted for each of five single-tree replications. Incidence and severity of shot hole were based on 25-30 fruit from each of five single-tree replications from each treatment. In additional studies, field-treated blossoms were taken to the laboratory, placed on moist vermiculite, and inoculated with conidia of *M. fructicola* (10,000 conidia/ml). The incidence of stamen infections was determined after 5 days of incubation at 20C. Treated flower petals were also collected and incubated on moist vermiculite for 5 days at 20C for the development of natural incidence of gray mold. Data were evaluated using an analysis of variance and LSD mean separation ( $P > 0.05$ ).

##### Fungicide Evaluations for Management of Brown Rot, Anthracnose, and Scab in Commercial Orchards

In a field trial in Butte Co. on cv. Peerless, treatments were done as rotation programs (as shown in Table 2). Treatments were applied using an air-blast sprayer at a rate of 100 gal/A at full bloom, petal fall/shuck split, and 5-wk after petal fall. Incidence of disease based on 100 blossoms or fruit from each of four single-tree replications from each treatment. Data were evaluated using an analysis of variance and LSD mean separation ( $P > 0.05$ ).

Specifically for scab management, a second large-scale field trial was conducted in Butte Co. using a split-split plot design. The main plots consisted of rows treated or not treated with liquid lime sulfur on January 20, 2007. Sub-plots were established that were not treated or treated on March 25, and April 11, 2007 with a rotation of Bravo and Captan, Captan and Maneb, or only with Maneb. Finally, on May 3, 2007, sub-sub plots within the sub-plots received either no treatment or treatments with Pristine, Microthiol, or Captan. Inspire was evaluated in a smaller test at the same location. The effect of liquid lime sulfur on sporulation of scab lesions was evaluated on March 23, April 11, April 26, and May 3, 2007. The incidence (percent diseased fruit), and severity (number of lesions/fruit), of scab was evaluated on July 18, 2007 on 24 fruit for each of the single-tree replications. Data were evaluated using an analysis of variance and LSD mean separation ( $P > 0.05$ ).

#### In Vitro Sensitivity of Cladosporium Carpophilum Isolates to Azoxystrobin

Isolates were collected from seven orchards in Butte and Kern Co. using the spiral gradient dilution method, the inhibition of conidial germination on azoxystrobin-amended agar media was evaluated after ca. 20 h of incubation. Boscalid and difenoconazole were evaluated in mycelial growth assays. A baseline sensitivity range study was initiated for difenoconazole using selected populations of *C. carpophilum*.

#### Etiology of a New Putative Powdery Mildew-Like Fruit Russeting Disease of Almonds

A fungicide trial was established in a cv. Ruby orchard in Colusa Co. where a high level of disease was observed in 2006. Powdery mildew-specific fungicides (no activity against other fungi) (e.g., quinoxyfen - Quintec, V-10118), and broad-spectrum fungicides (wetable sulfur, pyraclostrobin/boscalid – Pristine, myclobutanil - Laredo, trifloxystrobin – Gem, and iprodione - Rovral), were applied on 28 March and 24 April 2007 using an air-blast sprayer at a rate of 100 gal/A. Treatment dates were based on fruit infection periods for powdery mildew fungi of peach and cherry. The goal was to deduce the putative cause of the disorder (fungal, specific fungi, or non-fungal), from efficacy data. Incidence of disease was evaluated on 18 July 2007 and was based on 200 fruit from each of four single-tree replications for each treatment. Data were evaluated using an analysis of variance and LSD mean separation ( $P > 0.05$ ).

### **Results and Discussion:**

#### Fungicide Evaluations for Management of Brown Rot, Shot hole, and Gray Mold in an Experimental Orchard

Blossom blight in the Solano Co. trial, as evaluated by the number of infected spurs (twig strikes), per tree, was significantly reduced under high disease pressure conditions by all treatments (Table 1). Disease was reduced from 90.8 strikes per tree in the control to 6.0 to 51.6 strikes in the treatments. Among the single-fungicide programs with registered materials, Scala, Vanguard, and Enable were the most effective. The experimental fungicide Inspire was similarly efficacious. All mixtures, pre-mixtures, and

the rotation program were highly effective. These results show that growers can effectively use fungicide pre-mixes or rotate fungicides for resistance management.

The incidence of shot hole disease was high in 2007 in our Solano Co. trial with 92.5% of the fruit infected in the untreated control. The most effective treatments among the single-fungicides and pre-mixes in a three-spray program included the strobilurins Abound (2.1% disease), the experimental Evito (20.8%), and Pristine (12.3% disease), as well as the Abound-Orbit mixture (7.6% disease) (Table 1).

A limited number of these fungicides were also evaluated in laboratory experiments. Blossoms were collected in the field after a single full bloom application, inoculated with *Monilinia laxa*, and evaluated for stamen infection. Among the single-fungicide programs, Vanguard was the most effective treatment with 5.5% of the stamens infected as compared to 91.8% in the control (Table 2). The strobilurins Gem and Evito were the least effective. The SBIs Orbit, Enable, and Inspire and the pre-mixtures Pristine, Adament, and Distinguish were of intermediate efficacy.

For control of gray mold on field-treated flower petals that were incubated in the lab for development of natural incidence of disease, the numerically most effective fungicides were Vanguard, Rovral, Pristine, as well as the Abound-Orbit mixture (Table 2).

Similar field trials were also conducted in 2008 with an emphasis on the evaluation of newly registered fungicides (e.g., Distinguish, Quash), and of several new fungicide pre-mixtures that are still under development. Results from some these trials are currently being summarized, other data are still pending.

Table 1: Efficacy of fungicide programs for management of brown rot and shothole of Drake almonds, Solano Co. 2007.

| Treatments*                 | Product Rate<br>(100 gal/A) | Brown rot**         |                  | Shothole on fruit*** |      |                     |      |
|-----------------------------|-----------------------------|---------------------|------------------|----------------------|------|---------------------|------|
|                             |                             | Strikes<br>per tree | LSD <sup>^</sup> | Incidence<br>(%)     | LSD  | Severity<br>Lesions | LSD  |
| Control                     | ---                         | 90.8                | a                | 92.5                 | a    | 6.5                 | a    |
| Inspire 250EC               | 7 fl oz                     | 9.0                 | d                | 32.2                 | fgh  | 1.0                 | defg |
| Orbit 3.6EC                 | 4 fl oz                     | 14.4                | cd               | 74.4                 | b    | 3.4                 | b    |
| Vangard 75WG                | 5 oz                        | 9.2                 | d                | 89.8                 | a    | 6.0                 | a    |
| Scala 500SC                 | 12 fl oz                    | 6.0                 | d                | 94.6                 | a    | 5.9                 | a    |
| Abound 2F                   | 12.8 fl oz                  | 19.6                | cd               | 2.1                  | j    | 0.0                 | g    |
| Gem 500SC                   | 3 fl oz                     | 27.4                | c                | 38.5                 | efgh | 1.6                 | cde  |
| Evito 480SC                 | 6 fl oz                     | 51.6                | b                | 20.8                 | hi   | 0.8                 | efg  |
| Rovral 4F                   | 16 fl oz                    | 16.4                | cd               | 29.7                 | gh   | 1.8                 | cde  |
| Enable 2F + Breakthru       | 6 fl oz + 0.125%            | 11.4                | d                | 66.8                 | bc   | 3.0                 | bc   |
| Inspire 250EC + Vangard     | 4 fl oz + 4 oz              | 6.8                 | d                | 50.4                 | cdef | 2.2                 | bcd  |
| Abound 2F + Orbit 3.6EC     | 3 fl oz + 4 fl oz           | 9.0                 | d                | 7.6                  | j    | 0.2                 | fg   |
| Pristine 38WG               | 14.5 oz                     | 8.8                 | d                | 12.3                 | ij   | 0.5                 | efg  |
| Adament 50WG                | 4 oz                        | 8.4                 | d                | 51.9                 | cde  | 2.3                 | bcd  |
| Adament 50WG                | 6 oz                        | 15.0                | cd               | 64.9                 | bcd  | 2.3                 | bcd  |
| Distinguish 480SC           | 12.8 fl oz                  | 6.2                 | d                | 55.2                 | bcde | 2.5                 | bc   |
| Enable 2F + Breakthru       | 6 fl oz + 0.125%            | 9.8                 | d                | 44.4                 | defg | 1.6                 | cdef |
| Enable 2F+Dithane+Breakthru | 6 fl oz + 6 lb + 0.125%     |                     |                  |                      |      |                     |      |

\* - Treatments were applied on 2-20 (full bloom), 3-1 (petal fall), and 3-15-07 (shuck split) at a rate of 100 gal/A. The last treatment program was a rotation (Enable+Breakthru on 2-20, Enable+Dithane+Breakthru on 3-1 and 3-15-07).

\*\* - For brown rot, the number of brown rot strikes per tree was counted on 5-24-07 for each of five single-tree replications.

\*\*\* - Incidence and severity of shot hole on 5-21-07 are based on 25-30 fruit from each of five single-tree replications.

<sup>^</sup> - Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ( $P > 0.05$ ).

### Fungicide Evaluations for Management of Brown Rot, Anthracnose, and Scab in Commercial Orchards

In our field trial in Butte Co. in 2007 where we evaluated different rotation programs, the incidence of anthracnose was very low. The incidence of brown rot and scab was also very low with 3.5% incidence for brown rot and 15.5% incidence for scab in the untreated control (Table 3). All programs were effective, reducing brown rot to 0-0.5% and scab to 0.75-2.75% incidence, respectively.

A large-scale field trial in Butte Co. was designed as a split-split plot design where the main plot received or did not receive dormant applications with liquid lime sulfur (LLS). Sub-plots received selected petal fall applications, and sub-sub-plots were treated with selected late spring applications of fungicides. In this plot, timing of petal fall treatments was based on the previously developed inoculum-based model for forecasting scab using twig infections (see below). Scab severity, but not scab incidence, was significantly reduced after dormant applications with LLS. Two petal fall applications with Bravo-Captan, Captan-Maneb, or with Maneb alone effectively reduced the incidence and severity of scab (Table 4A), whereas late-spring applications alone with

Table 2: Efficacy of fungicides for management of brown rot and gray mold of Drake almonds in laboratory studies 2007.

| Treatments*              | Product Rate<br>(100 gal/A) | Brown rot<br>infections** |                  | Gray mold***     |          |                    |     |
|--------------------------|-----------------------------|---------------------------|------------------|------------------|----------|--------------------|-----|
|                          |                             | (%)                       | LSD <sup>^</sup> | Incidence<br>(%) | LSD      | Severity<br>% Area | LSD |
| Control                  | ---                         | 91.8                      | a                | 94.4             | a        | 2.8                | a   |
| Inspire 250EC            | 7 fl oz                     | 39.7                      | cd               | 86.0             | bc       | 1.8                | bc  |
| Orbit 3.6EC              | 4 fl oz                     | 45.1                      | cd               | 83.1             | bc       | 1.6                | cd  |
| Vanguard 75WG            | 5 oz                        | 5.5                       | d                | 52.0             | ef       | 0.7                | fg  |
| Scala 500SC              | 12 fl oz                    | not done                  |                  | 80.9             | bc       | 1.2                | def |
| Gem 500SC                | 3 fl oz                     | 73.6                      | ab               | 89.8             | ab       | 2.3                | ab  |
| Evito 480SC              | 6 fl oz                     | 72.0                      | ab               | 94.4             | a        | 2.4                | a   |
| Rovral 4F                | 16 fl oz                    | not done                  |                  | 53.3             | ef       | 0.8                | fg  |
| Enable 2F + Breakthru    | 6 fl oz + 0.125%            | 48.2                      | cd               | 91.3             | ab       | 2.4                | ab  |
| Inspire 250EC + Vanguard | 4 fl oz + 4 oz              | not done                  |                  | 76.8             | cd       | 1.1                | def |
| About 2F + Orbit 3.6EC   | 3 fl oz + 4 fl oz           | not done                  |                  | 42.2             | f        | 0.6                | g   |
| Pristine 38WG            | 14.5 oz                     | 37.9                      | cd               | 49.5             | ef       | 0.8                | fg  |
| Adament 50WG             | 4 oz                        | 46.4                      | cd               |                  | not done |                    |     |
| Adament 50WG             | 6 oz                        | not done                  |                  | 75.0             | cd       | 1.5                | cde |
| Distinguish 480SC        | 12.8 fl oz                  | 31.8                      | cd               | 66.6             | de       | 1.0                | efg |

\* - Treatments were applied on 2-20-07 using an air-blast sprayer at a rate of 100 gal/A.

\*\* - For brown rot evaluation, 7 blossoms from each of 4 single-tree replications were randomly collected on 2-21-07 and inoculated with conidia of *M. laxa* (10,000 conidia/ml). The incidence of stamen infections was evaluated after 5 days of incubation at 20C.

\*\*\* - Gray mold was evaluated on petals that were collected on 2-22-07 and incubated on moist vermiculite in the laboratory.

<sup>^</sup> - Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ( $P > 0.05$ ).

Pristine, Microthiol, or Captan had no significant effect in reducing the disease (Table 4B,C). The combination of petal fall and late spring applications generally improved the control, but there were no significant differences. A late spring application with Inspire was done at this location and this treatment was highly effective and reduced the disease to very low levels. Preliminary data obtained for this fungicide in 2006 had also indicated the high efficacy for managing scab. Thus, the fungicide Inspire will be evaluated again in 2008. In another trial in Kern Co. that was mainly established for the evaluation of fungicide programs against *Alternaria* leaf spot, three applications of fungicides, including Inspire, between May 8 and June 25, 2007, had no effect in reducing the incidence and severity of scab. This indicates the general ineffectiveness of treatments that are done in late spring.

Thus, for management of almond scab the most effective treatment timings are petal fall applications. Our data also indicate that after dormant applications with LLS the severity of disease was reduced. This could be correlated to a reduced spore inoculum production from overwintering scab lesions on one-year old twigs. Thus, in monitoring the onset of sporulation of twig lesions we found abundant sporulation on untreated

twigs in our Butte Co. trial on April 11, whereas on LLS-treated twigs only ca. 5% of the lesions sporulated at this time. On April 26, 2007, ca. 22% of the lesions were found to sporulate on the LLS-treated twigs. In trials on dormant applications that were done in cooperation with a PCA, pre-bloom applications with sulfur had no effect in delaying sporulation of twig lesions, whereas applications with copper-oil were found to be highly effective. As late as early June, the incidence of sporulating lesions was reduced by 90% as compared to untreated control trees. Thus, these dormant applications as effective inoculum reduction treatments warranted further research. In 2008, two large-scale field trials were conducted where dormant treatments with copper, copper-oil, wettable sulfur, or LLS were compared. Results from these trials on lesion sporulation are currently being summarized and efficacy data for scab control are pending. Our field trials in 2007 also confirmed that the existing inoculum-based model to optimize application timing was a highly effective strategy for timing scab fungicide treatments.



Table 3. Efficacy of fungicide programs for management of brown rot and scab cv. Peerless almonds Butte Co. 2007.

| Product*                   | Rate       | Application Dates |               |                 | Brown Rot Incidence** |        | Scab Incidence** |     |
|----------------------------|------------|-------------------|---------------|-----------------|-----------------------|--------|------------------|-----|
|                            |            | 2-23<br>FB        | 3-21<br>PF/SS | 4-11<br>5-wk PF | (%)                   | LSD*** | (%)              | LSD |
| Control                    | ---        | ---               | ---           | ---             | 3.50                  | a      | 15.50            | a   |
| Pristine 38WG              | 0.92 lb    | @                 | ---           | ---             | 0.25                  | b      | 1.25             | b   |
| Ziram 75WSP                | 8 lb       | ---               | @             | ---             |                       |        |                  |     |
| Captan 80WG                | 5 lb       | ---               | ---           | @               |                       |        |                  |     |
| Elite 45WP + Scala 400SC   | 6 fl oz    | @                 | ---           | ---             | 0.25                  | b      | 1.25             | b   |
| Echo 720SC                 | 4 pt       | ---               | @             | ---             |                       |        |                  |     |
| Captan 80WG                | 5 lb       | ---               | ---           | @               |                       |        |                  |     |
| Orbit 3.6EC + Vangard 75WG | 6 fl oz    | @                 | ---           | ---             | 0.00                  | b      | 0.75             | b   |
| Echo 720SC                 | 4 pt       | ---               | @             | ---             |                       |        |                  |     |
| Captan 80WG                | 5 lb       | ---               | ---           | @               |                       |        |                  |     |
| Vangard 75WG               | 5 oz       | @                 | ---           | ---             | 0.50                  | b      | 2.75             | b   |
| Captan 80WG                | 5 lb       | ---               | @             | ---             |                       |        |                  |     |
| Manex                      | 6 qt       | ---               | ---           | @               |                       |        |                  |     |
| Scala 400SC                | 12.8 fl oz | @                 | ---           | ---             | 0.00                  | b      | 1.75             | b   |
| Captan 80WG                | 5 lb       | ---               | @             | ---             |                       |        |                  |     |
| Manex                      | 6 qt       | ---               | ---           | @               |                       |        |                  |     |

\* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A.

\*\* - Incidence of brown rot was based on the number of infected shoots per 100 shoots evaluated, whereas incidence of scab was based on 100 fruit from each of four single-tree replications from each treatment.

\*\*\* - Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ( $P > 0.05$ ).

### In Vitro Sensitivity of Scab (*C. Carpophilum*) Isolates to Azoxystrobin

In vitro fungicide sensitivities were determined due to grower reports on the ineffectiveness of strobilurin fungicides, including the strobilurin-carboxamide pre-mixture Pristine. Strobilurin-resistant isolates of scab *C. carpophilum* were found in six orchards evaluated to date. The incidence of resistance ( $EC_{50}$  values  $>25$  mg/L), ranged from 80 to 100% indicating that, similar to 2006, strobilurin resistance is widespread. Boscalid, the second single-site mode of action ingredient of Pristine, is generally inactive against the pathogen. Evaluation of isolates collected in 2006 from several locations had revealed a wide range of sensitivities to boscalid. Additional testing of fungal isolates collected in 2007 is ongoing for other fungicides and a baseline is being developed for difenoconazole. Due to lack of availability of highly effective alternative fungicides, the strobilurin class of fungicides has been over-used, resulting in the widespread resistance. This stresses the need for our fungicide evaluation program to identify multiple fungicide classes that are active against a specific pathogen and the need to employ resistance management strategies whenever several alternatives to manage a disease are available. Furthermore, it emphasizes the use of currently registered multi-site materials for scab management.

Table 4. Efficacy of fungicide programs for management of scab on Carmel almond in Butte Co. 2007

A. Effect of petal fall treatments (3-25 and 4-11)

| Treatment*            | Applic. date |      | No dormant lime sulfur |        |      |     | w/ Dormant lime sulfur |     |      |     |
|-----------------------|--------------|------|------------------------|--------|------|-----|------------------------|-----|------|-----|
|                       | 3-25         | 4-11 | Inc. (%)**             | LSD*** | Sev. | LSD | Inc. (%)               | LSD | Sev. | LSD |
| Control               | ---          | ---  | 82.1                   | a      | 16.7 | a   | 63.3                   | a   | 7.6  | a   |
| Bravo W'stik 64 fl oz | @            | ---  | 20.1                   | b      | 1.5  | b   | 27.9                   | b   | 2.4  | b   |
| Captan 80WP 5.5 lb    | ---          | @    |                        |        |      |     |                        |     |      |     |
| Maneb 8 lb            | @            | @    | 15.9                   | b      | 1.4  | b   | 18.0                   | b   | 1.9  | b   |
| Captan 80WP 5.5 lb    | @            | ---  | 18.7                   | b      | 1.3  | b   | 19.2                   | b   | 1.7  | b   |
| Maneb 8 lb            | ---          | @    |                        |        |      |     |                        |     |      |     |

B) Effect of late spring applications (5-3-07) with no dormant application of liquid lime sulfur\*\*\*\*

| Treatments*          | No petal fall applications |     |      |     | Bravo on 3-25<br>Captan on 4-11-07 |     |      |     | Captan on 3-25<br>Maneb on 4-11-07 |     |      |     |
|----------------------|----------------------------|-----|------|-----|------------------------------------|-----|------|-----|------------------------------------|-----|------|-----|
|                      | Inc. (%)                   | LSD | Sev. | LSD | Inc. (%)                           | LSD | Sev. | LSD | Inc. (%)                           | LSD | Sev. | LSD |
| Control              | 95.8                       | a   | 21.5 | a   | 22.9                               | a   | 1.8  | a   | 22.9                               | a   | 1.7  | a   |
| Pristine 38WG 0.9 lb | 93.8                       | a   | 19.1 | a   | 13.5                               | a   | 0.9  | a   | 18.8                               | a   | 1.5  | a   |
| Microthiol 20 lb     | 97.9                       | a   | 22.0 | a   | 22.9                               | a   | 1.7  | a   | 15.6                               | a   | 1.2  | a   |
| Captan 80WP 5 lb     | 97.9                       | a   | 19.1 | a   | 20.8                               | a   | 1.5  | a   | 25.0                               | a   | 1.8  | a   |

C) Effect of late spring applications (5-3-07) with a dormant application of liquid lime sulfur\*\*\*\*

| Treatments*          | No petal fall applications |     |      |     | Bravo on 3-25<br>Captan on 4-11-07 |     |      |     | Captan on 3-25<br>Maneb on 4-11-07 |     |      |     |
|----------------------|----------------------------|-----|------|-----|------------------------------------|-----|------|-----|------------------------------------|-----|------|-----|
|                      | Inc. (%)                   | LSD | Sev. | LSD | Inc. (%)                           | LSD | Sev. | LSD | Inc. (%)                           | LSD | Sev. | LSD |
| Control              | 88.5                       | a   | 12.7 | a   | 35.4                               | a   | 3.1  | a   | 11.5                               | a   | 0.8  | a   |
| Pristine 38WG 0.9 lb | 60.4                       | a   | 8.1  | a   | 18.8                               | a   | 1.7  | a   | 24.0                               | a   | 2.4  | a   |
| Microthiol 20 lb     | 56.3                       | a   | 6.1  | a   | 31.3                               | a   | 2.6  | a   | 15.6                               | a   | 1.2  | a   |
| Captan 80WP 5 lb     | 56.3                       | a   | 5.5  | a   | 26.0                               | a   | 2.1  | a   | 26.0                               | a   | 2.3  | a   |

\* - The trial was designed as a split-split plot. Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. Liquid lime sulfur was applied on 1-20-07.

\*\* - Incidence of disease on 7-18-07 was based on 25 fruit from each of four single-tree replications from each treatment. Severity was based on the number of lesions per fruit.

\*\*\* - Values followed by the same letter are not significantly different based on an ANOVA and LSD mean separation ( $P > 0.05$ ).

\*\*\*\* - Data for Maneb-Maneb petal fall treatments are not shown but were similar to treatments in the Captan-Maneb program.

## Etiology of a New Putative Powdery Mildew-Like Fruit Russeting Disease of Almond

In mid- to late spring of 2005, unusual russetting of almond fruit was observed by J. Edstrom on the Nickels Estate. In 2006, this disorder was more widely found throughout the Central Valley. In our 2006 field trials all fungicides evaluated, including powdery-mildew specific materials significantly reduced the incidence of the disorder. In 2007 at the same trial site, a low level of disease (2.3%) was found on untreated cv. Ruby control fruit. No disease was found on cv. Padre. Again, however, most of the fungicides evaluated significantly reduced the incidence of disease to 0-0.5% after two treatments between late March and late April. These results again indicate that the russetting of almond fruit is caused by a fungal organism. Furthermore, based on the activity of the powdery mildew-specific fungicides, it is likely that a type of powdery mildew fungus is involved. Previously, powdery mildew fungi reported from almond in California and other locations in the world include *Podosphaera leucotricha*, *P. tridactyla*, and *Sphaerotheca pannosa*. The almond fruit russetting infections can occur with apparently no obvious leaf infections. In growth chamber studies using potted almond plants, no symptoms were observed on fruit when plants were exposed to field-collected symptomatic fruit at different environmental conditions for up to one month. Possibly, specific environmental conditions and host maturity stage have to be present for the successful infection by the putative pathogen. Additional studies on the etiology of this disease will be conducted in the coming seasons.

### **Recent Publications:**

Diéguez-Uribeondo, J., Förster, H., and Adaskaveg, J. E. 2008. Visualization of localized pathogen-induced pH modulation in almond tissues infected by *Colletotrichum acutatum* using confocal scanning laser microscopy. *Phytopathology*, *submitted*.