Almond disease management in the San Joaquin Valley: Spring- and Summer-time diseases

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Overview of presentation

• Overview of leaf and blossom diseases of recent economic importance
• Currently registered and new fungicides for almond
• Comparative efficacy of registered and new fungicides
• Management of spring- and summer-time diseases
• Management of resistance
Common foliar and fruit diseases of almond in California

- Brown rot
- Blossom blight
- Green fruit rot/Jacket rot
- Shot hole
- Anthracnose
- Scab
- Alternaria leaf spot
- Rust
- Hull rot
Shifts in Almond Horticulture

- Low density
- High volume, short irrigation
- Low/Moderate fertilization

Less conducive environments, susceptible host

- High density plantings
- Low volume, long irrigation
- High fertilization

More...
Chemical disease control in almond production

- There is an increasing arsenal of fungicides being introduced.
- Many of the new developments are pre-mixtures.
- Using the proper material is becoming more difficult and requires an increasing knowledge on the modes of action (fungicide classes), spectrum of activity, efficacy, and best usage strategies.

- **Goal:** Use each class only once per season or rotate between pre-mixtures containing different classes.


**Fungicides for Managing Almond Diseases**

### Single-fungicides - Inorganics and Conventional Synthetics

**Inorganics**
- Copper, Sulfur
  - 1960s

**Dithiocarbamates**
- Ziram, (Maneb)
  - 1940s

**Phthalimides**
- Captan
  - 1950s

**Isophthalonitriles**
- Bravo, Echo, Equus
  - 1960s

**Guanidines**
- Syllit
  - 1960s

**Benzimidazoles**
- Topsin-M, T-Methyl
  - 1970s

**Dicarboximides**
- Rovral, Iprodione, Nevada
  - 1980s

**Sterol inhibitors (DMIs)**
- Rally, Laredo, Orbit, Indar, Quash, Inspire
  - 1970s – 1980s

**SDHIs**
- Endura, Luna Privilege Xemium?
  - 1960s

**Anilinopyrimidines**
- Vangard, Scala
  - 1990s

**Polyoxins**
- Ph-D
  - 1960s

**New in 2010 and beyond:**
- Ph-D, Inspire, Quash, SDHIs sold only in combination.

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- Multi-site mode of action
- Single-site mode of action
- Reduced risk fungicides
New Bayer Fungicides

Adament
FRAC 3/11

Luna Experience
FRAC 3/7

Luna Sensation
FRAC 7/11

Luna Tranquility
FRAC 7/9

Luna Privilege – Fluopyram FRAC 7

Elite
Tebuconazole FRAC 3

Gem
Trifloxystrobin FRAC 11

Scala
Pyrimethanil FRAC 9

Rovral
Iprodione FRAC 2
New Syngenta Fungicides

**Inspire XT**
- FRAC 3/3
- Difenconazole – Inspire
- FRAC 3
- Cyprodinil – Vangard
- FRAC 9

**Quadris Top**
- FRAC 3/11
- Propiconazole – Tilt
- FRAC 3
- Azoxystrobine – Abound
- FRAC 11

**Inspire Super**
- FRAC 3/9

**Quilt Xcel**
- FRAC 3/11
New BASF Fungicides

- Cabrio - Pyraclostrobin  
  FRAC 11
- Xemium - Fluxapyroxad  
  FRAC 7
- Endura - Boscalid  
  FRAC 7

BAS703  
FRAC 7/11

New Valent Fungicides

- Quash  
  Metconazole  
  FRAC 3

New Arysta Fungicides

- Elevate  
  Fenhexamid  
  FRAC 17
- Ph-D  
  Polyoxin-D  
  FRAC 19
Fungicides for Managing Almond Diseases

Conventional Synthetic Fungicides – Pre-mixtures

- **Pristine** 7+11 2000s
- **Luna Sensation BAS703?** 7+11 2012s
- **Inspire XT** 3+3 2012s
- **Inspire Super** 3+9 2011s
- **Adament** 3+11 2007
- **Quilt Xcel** 3+11 2011s
- **Quadris Top** 3+11 2011s
- **New**

3 DMIs 7 SDHIs 9 Anilinopyrimidines (APs) 11 Qols

Natural Products

- **Regalia, Actinovate, Cerebrocide** 2000s

Natural products from plant extracts that potentially will be OMRI approved were evaluated for organic farming of almonds.
Disease cycle of *Monilinia laxa* on almond and preharvest control measures

= Timing of control measure
Shot hole of almond - Disease cycle in California

Winter
- Infected leaves, twigs and buds
- Primary inoculum

Spring
- Infection of leaves and blossoms
- Production of secondary, tertiary, ..... inoculum

Fall
- Infection of leaves, twigs, fruit, and buds

Summer

If inoculum is present at critical levels from disease in the previous fall or from disease in the spring and if climatic conditions favor disease progress, fungicides will need to be applied.

= fungicide timing for optimal management
## Brown rot and shot hole trial, Solano Co.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2-25</th>
<th>3-4</th>
<th>3-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

### Single treatments

- **Actinovate 12 oz + Breakthru 6 fl oz**
- **Luna Privilege 4 fl oz**
- **Enable 2F 6 fl oz**
- **Syllit 3.4FL 48 fl oz**

### Pre-mixtures

- **Adament 50WG 6 oz**
- **Luna Sensation SC 4 fl oz**
- **Inspire Super EW 10 fl oz**
- **Quilt Xcel 14 fl oz**
- **Inspire XT EC 7 fl oz**

### Rotations

- **Scala 600SC 12.8 fl oz**
- **Luna Sensation SC 4 fl oz**
- **Rovral 4F 16 fl oz**
- **Quash 2DC 5 fl oz**
- **Abound 2F 12.3 fl oz**

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**UC Davis, cv. Drake**
Management of Botrytis Blossom Blight (Jacket Rot/Green Fruit Rot)

Data from 2009 – Drake almond (Solano Co.)
Management of Brown Rot Blossom Blight and Shot Hole

Most effective new fungicides:

- **Brown rot**: Tilt, Quash, Elite, Indar, Scala, Vangard
  - Pre-mixtures: Adament, Luna Sensation, as well as Inspire Super, Inspire XT, and Quilt Xcel

- **Shot hole**: Pristine, Quadris Top, Quilt Xcel, Syllit, (Abound, Gem, Rovral, Luna Sensation), Bravo, Rovral

- **Jacket Rot**: Scala, Vangard, Pristine, Inspire Super, Luna Sensation, BAS703, Bravo, Rovral

- **Natural products/biocontrols**: Actinovate, Regalia, and Cerebrocide showed some activity, but were not as effective as most fungicides. Actinovate was the most consistent
Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut, Strawberry, and Vine Crops 2010

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www.uckac.edu/plantpath

Statewide IPM Program
www.ipm.ucdavis.edu
### Fungicide treatment timings for almond

<table>
<thead>
<tr>
<th>Disease</th>
<th>Dormant</th>
<th>Pink Bud</th>
<th>Full Bloom</th>
<th>Petal Fall</th>
<th>Spring 2W</th>
<th>Spring 5W</th>
<th>Summer May</th>
<th>Summer June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracnose</td>
<td>-</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Brown Rot</td>
<td>-</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Green Fruit Rot</td>
<td>-</td>
<td>-</td>
<td>+++</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Leaf Blight</td>
<td>-</td>
<td>-</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Scab</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+/-</td>
</tr>
<tr>
<td>Shot Hole</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rust</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Alternaria</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Hull Rot</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>July</td>
</tr>
</tbody>
</table>

+++ = most effective, ++ = moderately effective, + = least effective, and - = ineffective.

Scab timings should follow sporulation of twig infections and conducive environments.

## Relative efficacy of Bayer fungicides for management of spring-time foliar diseases of almond

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Class</th>
<th>Mode of action</th>
<th>BB blight</th>
<th>Jacket rot</th>
<th>Anthrac-nose</th>
<th>Shot hole</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adament</td>
<td>SBI/QoI</td>
<td>Multiple</td>
<td>++++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Luna Sensation</td>
<td>QoI/SDHI</td>
<td>Multiple</td>
<td>+++</td>
<td>++++</td>
<td>+++</td>
<td>++++</td>
</tr>
<tr>
<td>Gem</td>
<td>QoI</td>
<td>Single</td>
<td>+++</td>
<td>-</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Rovral</td>
<td>Dicarboximide</td>
<td>Multiple</td>
<td>+++</td>
<td>+++</td>
<td>-</td>
<td>+++</td>
</tr>
<tr>
<td>Scala</td>
<td>Anilinopyrimidine</td>
<td>Single</td>
<td>++++</td>
<td>+++</td>
<td>?</td>
<td>++</td>
</tr>
</tbody>
</table>

• Highly effective fungicides are available for managing important diseases of almond.
• Pre-mixtures generally improve performance. They have an increased spectrum of activity because the individual ingredients complement each other. The efficacy, however, is rate-dependent.
Management of summertime foliar diseases of almond

Scab, Alternaria Leaf Spot, Rust and Hull Rot of Almond
Management of Scab

Disease cycle of *Venturia carpophila*  
(*Cladosporium carpophilum*)

- Overwintering twig lesions
- Conidia (asexual stage) production in the spring and throughout season
- Infection of twigs (<1 year old), fruit, and leaves
- Defoliation and weakening of trees during severe outbreaks
- Survival on fallen leaves over winter?
- Development of sexual fruiting bodies
- Mature ascostroma with asci and ascospores
- Dormant treatments
- Petal fall treatments
- Ascus with ascospores
- Healthy twig
- Survival on fallen leaves over winter?
Management of Scab

- Dormant treatments
- Petal fall treatments
Management of Scab: Dormant applications to reduce inoculum in the spring

<table>
<thead>
<tr>
<th>2008 Treatments</th>
<th>Jan.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>@</td>
</tr>
<tr>
<td>Oil 4 gal</td>
<td>@</td>
</tr>
<tr>
<td>Kocide 2000 6 lb</td>
<td>@</td>
</tr>
<tr>
<td>Liquid lime sulfur 16 gal</td>
<td>@</td>
</tr>
<tr>
<td>Kocide 2000 6 lb + Oil 4 gal</td>
<td>@</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2009 Treatments</th>
<th>Jan.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>@</td>
</tr>
<tr>
<td>Oil 4 gal</td>
<td>@</td>
</tr>
<tr>
<td>Kocide 2000 6 lb</td>
<td>@</td>
</tr>
<tr>
<td>Kocide 2000 6 lb + Oil 4 gal</td>
<td>@</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2010 Treatments</th>
<th>Jan.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>@</td>
</tr>
<tr>
<td>Kocide 3000 5 lb - Oil 4 gal</td>
<td>@</td>
</tr>
<tr>
<td>Kocide 3000 5 lb - Cohere</td>
<td>@</td>
</tr>
</tbody>
</table>

Delayed dormant treatments delay the onset and amount of sporulation on overwintering twig lesions but do not prevent the disease. Integrated petal fall treatments are still needed.
Management of Scab:
In-season applications timed after twig lesion sporulation

- Highly effective after-petal-fall applications: chlorothalonil (e.g., Echo, Bravo, Equus), Maneb (or in the future mancozeb), Captan, Ziram
- A shorter PHI for chlorothalonil has been requested and IR-4 studies were approved.
- New effective single-site fungicides for almond scab: Inspire, Quash, Ph-D (polyoxin-D), and Syllit (dodine),
- Pre-mixtures: Inspire Super, Quilt Xcel, and Luna Sensation.

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>4-2</th>
<th>4-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Ziram 76WDG 7-8 lb</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Syllit 3.4FL 3 pts</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Maneb 75WDG 8 lb</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Captan 80WP 8 lb</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Echo 720 6 pt</td>
<td>@</td>
<td>@</td>
</tr>
</tbody>
</table>

cv. Carmel, Butte Co.

Incidences (%)

- Eval. 6-19-09
# Efficacy of fungicide programs for management of scab of cv. Peerless almonds Butte Co. 2010

<table>
<thead>
<tr>
<th>Treatment</th>
<th>3 wkPF</th>
<th>5 wk PF</th>
<th>cv. Peerless</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>---</td>
<td>---</td>
<td>a</td>
</tr>
<tr>
<td>Syllit 4FL 2 pt</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Syllit 4FL 3 pt</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Dithane 75DF 6 lb</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Ph-D 11.2DF 6.2 oz</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Quash 50WG 3.5 oz</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Pre-mixtures and mixtures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adament 50WG 6 oz</td>
<td>@</td>
<td>@</td>
<td>b</td>
</tr>
<tr>
<td>Luna Sensation 500SC 5 fl oz</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Inspire Super 12 fl oz</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Quadris Top 14 fl oz</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Quilt Xcel 20 fl oz</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Ph-D 11.2DF 6.2 oz + Captan 80WP 3 lb</td>
<td>@</td>
<td>@</td>
<td>cd</td>
</tr>
<tr>
<td>Rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pristine 38WG 14.5 oz</td>
<td>@</td>
<td>---</td>
<td>cd</td>
</tr>
<tr>
<td>Indar 2F 6 fl oz + Dithane F45 192 fl oz</td>
<td>---</td>
<td>@</td>
<td>c</td>
</tr>
</tbody>
</table>

Incidence (%) | Lesions/fruit
--- | ---
0 | 0
20 | 2
40 | 4
60 | 6
80 | 8
100 | 10

*Note: The table shows the efficacy of different fungicide treatments for managing scab on cv. Peerless almonds in Butte Co. 2010. The results are presented as incidence (%) and lesions/fruit. The treatments are divided into single treatments, rotation, and pre-mixtures and mixtures. The letters (a, b, c, d) indicate statistically significant differences among treatments.*
Management of Scab

- **Dormant treatments** - In problem orchards, plan a delayed dormant treatment with LLS or copper-oil.

- **Petal fall treatments** – Bravo/Echo, Captan, Maneb, DMIs (*Inspire, Quash, Indar*, and pre-mixtures (*e.g.*, QoI+ SDHI = *Luna Sensation*).

- **Late-spring treatments** – Sulfur, Captan

**Fungicide resistance in *Cladosporium carpophilum* –**
- Widespread against benzimidazoles, QoIs
- High risk for DMIs and SDHIs
- Do not apply single-site mode of action fungicides once disease is developing.
- Plan for rotation programs and integrated strategies
Management of Scab: Cultural Practices

- **Planting: Varietal Susceptibility**
  - *Least Susceptible*: Nonpareil

<table>
<thead>
<tr>
<th>Practice</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting Design</td>
<td>Allow air circulation</td>
</tr>
<tr>
<td>Tree Pruning</td>
<td>Increase air movement and reduce RH</td>
</tr>
<tr>
<td>Irrigation Management</td>
<td>Reduce orchard RH</td>
</tr>
<tr>
<td>Clean Cultivation</td>
<td>Reduce orchard RH</td>
</tr>
<tr>
<td>Foliar fertilizers? (Monosodium phosphate + urea?)</td>
<td>Increase tree health</td>
</tr>
<tr>
<td>Avoid heavy late-summer/fall fertilization with N</td>
<td>Reduce production of highly susceptible host tissues</td>
</tr>
</tbody>
</table>
EFFICACY AND TIMING OF FUNGICIDES, BACTERICIDES, AND BIOLOGICALS FOR
DECIDUOUS TREE FRUIT, NUT, STRAWBERRY, AND VINE CROPS
2010

ALMOND
APPLE AND PEAR
APRICOT
CHERRY
GRAPE
KIWIFRUIT

PEACH
PISTACHIO
PLUM
PRUNE
STRAWBERRY
WALNUT

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Statewide IPM Program
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Management programs should be based on disease history of the orchard. Spring spray timings are based on sporulation of twig infections and environmental conditions.

Fungicide application timing for almond scab

<table>
<thead>
<tr>
<th>Dormant</th>
<th>Bloom</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pink bud</td>
<td>Full bloom</td>
<td>Petal fall</td>
<td>Two weeks</td>
</tr>
<tr>
<td>++</td>
<td>-</td>
<td>-</td>
<td>+++</td>
</tr>
</tbody>
</table>

Suggested management programs

<table>
<thead>
<tr>
<th>Petal Fall</th>
<th>Early Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormant</td>
<td>2-wk after</td>
</tr>
<tr>
<td>M1, M2</td>
<td>Chlorothalonil-M5</td>
</tr>
<tr>
<td>M1, M2</td>
<td>Maneb-M5</td>
</tr>
<tr>
<td>M1, M2</td>
<td>Chlorothalonil-M5</td>
</tr>
</tbody>
</table>

Resistance against QoI fungicides (FRAC Group 11) is widespread in populations of *C. carpophilum*. 
Alternaria leaf spot caused by the *A. alternata* complex

*Alternaria alternata, A. arborescens, A. tenuissima*
The modified DSV model for forecasting Alternaria leaf spot of almond

<table>
<thead>
<tr>
<th>Mean temperature (°C) during wetness</th>
<th>Leaf wetness duration (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-17</td>
<td>0-6 7-15 16-20 21 ---</td>
</tr>
<tr>
<td>17.1-20</td>
<td>0-3 4-8 9-15 16-22 23+</td>
</tr>
<tr>
<td>20.1-25</td>
<td>0-2 3-5 6-12 13-20 21+</td>
</tr>
<tr>
<td>25.1-29</td>
<td>0-3 4-8 9-15 16-20 23+</td>
</tr>
<tr>
<td>DSV</td>
<td>0 1 2 3 4</td>
</tr>
</tbody>
</table>

Disease severity values (DSV) as a function of leaf wetness duration and average air temperature during the wetness period.
Fungicide efficacy trial, Glenn Co. 2008

Cv. Carmel – 3 applications

<table>
<thead>
<tr>
<th>Single fungicides</th>
<th>Disease on leaves</th>
<th>Tree defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syllit 400SC 32 fl oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orbit 3.6EC 8 fl oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quash 50WDG 2.5 oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspire 2.08SC 7 fl oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyoxin D 11.3% 32 oz</td>
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<td></td>
</tr>
<tr>
<td>Polyoxin D 11.3% 16 oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-mixtures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adament 50WG 8 oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspire Super SC 16 fl oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A8122B-IO SC 7 fl oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pristine 38WG 14.5 oz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Disease on leaves and tree defoliation ratings with letters indicating significance levels:

- Control
- Syllit 400SC 32 fl oz
- Orbit 3.6EC 8 fl oz
- Quash 50WDG 2.5 oz
- Inspire 2.08SC 7 fl oz
- Polyoxin D 11.3% 32 oz
- Polyoxin D 11.3% 16 oz
- Adament 50WG 8 oz
- Inspire Super SC 16 fl oz
- A8122B-IO SC 7 fl oz
- Pristine 38WG 14.5 oz

Treatments were applied on 5-13, 6-6, and 6-23-08 using an air-blast sprayer at a rate of 100 gal/A. Evaluations were done on 8-12-08.

High incidence of QoI and carboxamide resistance in this orchard.
Management of Alternaria Leaf Spot - 2009

Applications: 5-12, 6-4, 6-24-10.
Incidence of QoI resistance 97%, incidence of carboxamide resistance 60%
Fungicide efficacy trial
– Alternaria leaf spot

Tree defoliation evaluated in August

Control

Polyoxin-D + Inspire Super
EFFICACY AND TIMING OF FUNGICIDES, BACTERICIDES, AND BIOLOGICALS FOR DECIDUOUS TREE FRUIT, NUT, STRAWBERRY, AND VINE CROPS 2010

ALMOND
APPLE AND PEAR
APRICOT
CHERRY
GRAPE
KIWIFRUIT

PEACH
PISTACHIO
PLUM
PRUNE
STRAWBERRY
WALNUT

Jim Adaskaveg
Professor
University of California, Riverside

Doug Gubler
Extension Plant Pathologist
University of California Davis

Themis Michailides
Plant Pathologist
University of California, Davis/Kearney Agricultural Center

Brent Holtz
Farm Advisor
University of California Cooperative Extension, Madera County

UC Davis, Dept. of Plant Pathology
www.plpnem.ucdavis.edu

UC Kearney Agricultural Center
www.uckac.edu/plantpath

Statewide IPM Program
www.ipm.ucdavis.edu
### ALMOND—TREATMENT TIMING
**FOR SCAB AND ALTERNARIA**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Dormant</th>
<th>Bloom</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pink bud</td>
<td>Full bloom</td>
<td>Petal fall</td>
</tr>
<tr>
<td>Scab</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Alternaria</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Fungicide options available for rotational and mixture programs for management of Scab and Alternaria leaf spot of almond

<table>
<thead>
<tr>
<th>Disease</th>
<th>Dormant</th>
<th>Bloom</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pink bud</td>
<td>Full bloom</td>
<td>Petal fall</td>
</tr>
<tr>
<td>Alternaria</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>M2³</td>
<td>---</td>
<td>---</td>
<td>1², 7/11²</td>
</tr>
<tr>
<td>Scab⁴</td>
<td></td>
<td>1², 7/11²</td>
<td>1², 7/11²</td>
<td>3, 7/11²</td>
</tr>
</tbody>
</table>
Summary *Management of Alternaria leaf spot*

1. Management programs should start with petal fall applications that include Rovral. The effectiveness of Rovral at this timing will depend on the occurrence of favorable environmental conditions for the disease in early spring.

2. Because field resistance against QoIs and SDHIs is occurring, late-spring/early-summer applications (based on the DSV model) have to be done with other materials at most locations.

3. New materials (Quash, Inspire - both group 3) and Ph-D - group 19) should be strictly used in rotations and mixtures for resistance management.

4. Other components of the integrated approach in disease management are highly critical for management of Alternaria leaf spot.
Guidelines for the Integrated Management of Alternaria leaf spot

<table>
<thead>
<tr>
<th>Practice</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond cultivar selection</td>
<td>Plant less susceptible cultivars</td>
</tr>
<tr>
<td>Planting design</td>
<td>Allow air circulation</td>
</tr>
<tr>
<td>Tree training</td>
<td>Allow air circulation and reduce dew formation</td>
</tr>
<tr>
<td>Foliar disease and mite control</td>
<td>Minimize amount of stressed and injured leaf tissue</td>
</tr>
<tr>
<td>Irrigation management</td>
<td>Reduce orchard RH</td>
</tr>
<tr>
<td>Orchard floor management</td>
<td>Reduce orchard RH and amount of senescing plant tissues colonized by Alternaria spp.</td>
</tr>
<tr>
<td>Chemical control</td>
<td>Rotate and mix 2 to 3 applications between mid-April and late-June based on DSV model</td>
</tr>
</tbody>
</table>
Management of Hull Rot

Susceptibility of almond fruit at different hull split stages to infection of *Rhizopus stolonifer*- Laboratory studies

- Hull is highly susceptible to infection during early to mid-split stages of nut development.
- Most susceptible at hull split stages b2 through e.
- Infection likely due to conducive environments.
- This information is important for the timing of fungicide applications.

Hull split stage*

- Hull is highly susceptible to infection during early to mid-split stages of nut development.
- Most susceptible at hull split stages b2 through e.
- Infection likely due to conducive environments.
- This information is important for the timing of fungicide applications.

* - UC-IPM Manual for Almonds
Management of hull rot caused by *Rhizopus stolonifer* - 2010

Application cv. Nonpareil: 8-13-10, Evaluation on 9-9-10
Applications cv. Winters: 8-31, 9-10-10, Evaluation on 10-1-10
## Management of Leaf Rust

**cv. Carmel**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>6-9</th>
<th>6-30</th>
<th>Evaluation on 7-28-09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>---</td>
<td>---</td>
<td>a</td>
</tr>
<tr>
<td>Luna Privilege (USF2015) 4 fl oz</td>
<td>@</td>
<td>@</td>
<td>a</td>
</tr>
<tr>
<td>Inspire EC 7 fl oz</td>
<td>@</td>
<td>@</td>
<td>b</td>
</tr>
<tr>
<td>Polyoxin-D 11.2DF 6.2 oz</td>
<td>@</td>
<td>@</td>
<td>b</td>
</tr>
<tr>
<td>Abound 2F 12.5 fl oz</td>
<td>@</td>
<td>@</td>
<td>c</td>
</tr>
<tr>
<td>Quash 50WG 3.5 oz</td>
<td>@</td>
<td>@</td>
<td>c</td>
</tr>
</tbody>
</table>

Applications applied after first symptoms
## Management of Leaf Rust, con’t

### 2010

<table>
<thead>
<tr>
<th>Treatment</th>
<th>4-29</th>
<th>5-18</th>
<th>6-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Ph-D 11.2DF 6.2 oz</td>
<td>---</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Tilt 3.6EC 8 fl oz</td>
<td>---</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Quash 50WG 3.5 oz</td>
<td>---</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Inspire EC 7 fl oz</td>
<td>---</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Abound 2F 12.5 fl oz</td>
<td>---</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Gem 500SC 3 fl oz</td>
<td>---</td>
<td>@</td>
<td>@</td>
</tr>
<tr>
<td>Bravo 96 fl oz</td>
<td>---</td>
<td>@</td>
<td>@</td>
</tr>
</tbody>
</table>

### Pre-mixtures
- Adament 50WG 6 oz | ---  | @    | @    |
- Quadris Top 20 fl oz | ---  | @    | @    |
- Quilt Excel 14 fl oz | ---  | @    | @    |
- Pristine 38WG 14.5 oz | ---  | @    | @    |

### Rotations
- Manzate Pro-Stick 76.8 oz | @    | ---  | ---  |
- Ph-D 11.2 DF 6.2 oz | ---  | @    | ---  |
- Adament 50WG 6 oz | ---  | ---  | @    |
- Bravo 96 fl oz | @    | ---  | ---  |
- Quilt Excel 14 oz | ---  | @    | ---  |
- Quadris Top 20 oz | ---  | ---  | @    |
| Ph-D 11.2DF 6.2 oz | @    | ---  | ---  |
| Quash 50WG 3.5 oz | ---  | @    | ---  |
| Ph-D 6.2 oz + Quash 2.5 oz | ---  | ---  | @    |

Applications applied before first symptoms.

---

**cv. Carmel**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>1</th>
<th>2</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ph-D 11.2DF 6.2 oz</td>
<td>b</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tilt 3.6EC 8 fl oz</td>
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<tr>
<td>Inspire EC 7 fl oz</td>
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<tr>
<td>Abound 2F 12.5 fl oz</td>
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<tr>
<td>Gem 500SC 3 fl oz</td>
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<td></td>
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<tr>
<td>Bravo 96 fl oz</td>
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<td></td>
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<td>Adament 50WG 6 oz</td>
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<td>Quilt Excel 14 fl oz</td>
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<tr>
<td>Pristine 38WG 14.5 oz</td>
<td>c</td>
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<tr>
<td>Manzate Pro-Stick 76.8 oz</td>
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<td></td>
</tr>
<tr>
<td>Ph-D 11.2 DF 6.2 oz</td>
<td>c</td>
<td></td>
<td></td>
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<td></td>
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<tr>
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<td>Quadris Top 20 oz</td>
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<td>Ph-D 11.2DF 6.2 oz</td>
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<tr>
<td>Quash 50WG 3.5 oz</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Ph-D 6.2 oz + Quash 2.5 oz</td>
<td>bc</td>
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</tr>
</tbody>
</table>

Inclusions: a, b, c, d, e, f

Lesions/leaf:
0 20 40 60 80 100
Incidence (%): 1 2 3
Fungicide resistance in Alternaria and Cladosporium spp. on almond

**Alternaria spp.**

QoIs (strobilurins)
- 2003/04 resistance detected
- 2005 field (practical) resistance in Kern Co.
- 2007 field (practical) resistance in Northern CA

SDHIs (Carboxamides)
- 2007 resistance first detected in Northern and Southern CA
- Pristine not effective in some locations

**Cladosporium carpophilum**

QoIs (strobilurins)
- 2006 resistance detected
- 2008 practical resistance in many locations in Northern CA
Fungicide resistance management

Fungicide selection

• Limit use of each mode of action (class) to once per season
• Use pre-mixes, tank mixes, or alternate fungicides with different modes of action (classes of fungicides)
• Be sure to use fungicide pre-mixtures where both components have activity against a particular pathogen.
Anti-resistance strategies

“Minimize disease and pathogen survivors”

Do not compromise control by minimizing rates or coverage
Anti-resistance strategies for fungicide use on almonds
- Application of “Following the Rules” in Fungicide Stewardship -

- Rotate or mix fungicides of different mode of actions –
- Use labeled rates – For strobilurins, use upper label rates.
- Limit total number of applications – limit any single-site mode of action fungicide class to 1 or 2 per orchard per season (strobilurins perhaps to 1/season for scab and Alternaria).
- Educate yourself about fungicide activity, mode of action, and class - as well as resistance management practices.
- Start a fungicide program with multi-site mode of action materials (e.g., Captan, Bravo/Echo, Ziram, Rovral, Sulfur)
  - Reduce pathogen population size that is exposed to subsequent treatments. Probability of selecting for resistance is reduced.