Fungal foliar disease management

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POSTBLOOM FRUIT DROP
Postbloom fruit drop

- Preferred climate is humid, subtropical
- Fungus moves with rain-splash, wind-borne rain
  - Human activities such as equipment movement and workers with petals can also move fungus
- Disease more severe in areas with multiple blooms
  - Multiple blooms promoted by other diseases
Symptoms

- Peach to orange-colored lesions on petals
  - Can blight entire blossom or cluster when severe
- Fruit and petals fall leaving button
  - Can last up to 18 months on tree
  - Diagnostic for disease
- Leaves around infected flowers often twisted and small
  - Can look like a rosette
Symptoms
Post-bloom fruit drop disease cycle

*Colletotrichum acutatum*
Disease cycle highlights

- Fungus survives on leaf surfaces, twigs, and buttons in specialized structures.
- Structures germinate and form new spores with moisture and petal extracts.
- Spores are dispersed to new flowers via rain splash.
- Germinate with moisture in 12-24 hours, infect in 24-48 hours.
  - New symptoms and spores in 4 to 5 days.
Development of new PFD advisory system

- Project in collaboration with Natalia Peres and Clyde Fraisse
- To simplify PFD predictions from PFD-FAD
  - Less data collection required
  - Automatically pulls in weather data
- Based off of the FAWN system
  - Some stations with leaf wetness probes
  - Mostly calculated from available models
Homepage of new PFD advisory system

- Hosted on Agroclimate.org
  - Under tools/crop diseases
  - Similar to Strawberry Advisory System (SAS)
  - Each circle represents a FAWN weather station
Criteria to select on model

- St. Lucie West station selected
  - Blue check
- Need to indicate bloom intensity
  - Will I recoup costs if application made?
- Flowering stage
- Last fungicide application

Sufficient bloom
Many open flowers, some pinhead or button bloom remaining
None
If there is an infection event

- Conditions could allow for infection event
- Still need sufficient bloom
- Fungicide applications minimum 7 days apart
Disease simulation tab

- Graphical representation of infection risk
  - Can select time frame
- Forecasted risk (from NOAA weather data) for three days from actual date
  - Help plan if infection will be favored by weather in near term
Infection risk levels

- **High risk (red area)**
  - Index above 0.51; Spray as soon as possible

- **Moderate risk (yellow area)**
  - Index between 0.21 -0.5; Spray recommended

- **Low risk (green area)**
  - Index between 0-0.2; No spray recommended
Problem with station

- Problem with leaf wetness estimates
  - Should see an increase in infection index overnight from dew

- Please let us know ASAP if there is a problem
Daily summary of data

- Gives leaf wetness, temperature, PFD index and risk level
  - Weather variables daily average
  - PFD index max. daily value
Weather data

- Can look at the weather data for every 15 min.
  - Temperature, relative humidity, rainfall, leaf wetness

- Find out when drying periods occur
  - After 4 hours of drying, PFD Index resets to zero
With an account

- Can mark specific blocks of interest
  - Map and satellite views
  - Use map to find block and satellite to mark

- Specific risk assessment for location
Will send alerts

- SMS alerts for each location
- E-mail notification
- Can choose both
How do application timings compare?

- Fort Meade grove in 2017
  - Valencia on Swingle with history of PFD
  - Headline at 15.5 fl. oz./acre

- Four timing treatments:
  - No applications
  - Weekly for three applications
    - March 8th, 15th, 22nd
  - PFD-FAD (fungicide application decision)
    - Two applications recommended on March 15th, 24th
  - New PFD model
    - No applications recommended
Flower incidence

- Data collected March 27th
Post-application buttons

- Button data collected June 8-9\textsuperscript{th}

![New buttons bar chart](chart.png)
Number of fruit

Data collected July 20th

Timing method

New model
PFD-FAD
Weekly
UTC

Number of fruit

Timing method

New model
PFD-FAD
Weekly
UTC
Conclusions

○ New model was released this week for the 2018 PFD season
  – Fewer data inputs; easier to use
  – Login system should make block-by-block planning easier
  – When infection triggered should make fungicide recommendation

○ Working with programmer to detect and fix bugs
  – Expect occasional difficulties with program first year
    • Want your feedback on problems and ways to improve
Model performance conclusions

- 2017 season had low PFD incidence
- New model did not recommend a spray
  - There were no disease intensity differences among treatments
  - Means that the ‘no application’ recommendation was correct
  - Cost savings of three applications compared to weekly applications
  - Repeating experiment in 2 locations in 2018
    • Validation is an important part of model design
Control options

- Remove declining trees to reduce inoculum
  - Prune out HLB-affected branches if only 1 or 2 per tree?

- Fungicides
  - Strobilurin containing fungicides – Abound, Gem, Headline, Quadris Top, Pristine, Priaxor
    - Best combined with Ferbam
    - Strict label limits for these fungicides for resistance management

- 2015-2016 trial data with newer pre-mix fungicides Pristine, Priaxor, and Quadris Top

- Low volume ground and aerial applications are options
2016 TRIAL RESULTS
Trial details

- Navel oranges in Polk City area
  - Heavily infected with HLB
  - Off-season bloom on most trees
  - Trees hedged in January
    - Consequence much of bloom concentrated at the middle to end of March
    - More uniform than previous year
  - Trees selected for uniform disease pressure
    - HLB and PFD

- Applications made on recommendation of PFD model
- Applications on March 16 and 22
Buttons in $0.25\text{m}^2$/tree side
April 20$^{\text{th}}$, 2016

No significant difference
<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Rate/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadris Top</td>
<td>Azoxystrobin + difenoconazole</td>
<td>15.4 fl oz. 0.25% v/v</td>
</tr>
<tr>
<td>Abound</td>
<td>Azoxystrobin</td>
<td>15.5 fl oz. 0.25% v/v</td>
</tr>
<tr>
<td>Ferbam</td>
<td>Azoxyystrobin</td>
<td>15.5 fl oz. 6 lb</td>
</tr>
<tr>
<td>Headline</td>
<td>Pyraclostrobin</td>
<td>15 fl oz.</td>
</tr>
<tr>
<td>Priaxor</td>
<td>Pyraclostrobin + fluxapyroxad</td>
<td>6 fl oz. 16 fl oz.</td>
</tr>
<tr>
<td>Topsin M</td>
<td>Thiophanate-methyl</td>
<td>2.0 lb</td>
</tr>
<tr>
<td>Ferbam Granuflo</td>
<td>Ferbam</td>
<td>4 lb</td>
</tr>
<tr>
<td>Ferbam Granuflo</td>
<td>Ferbam</td>
<td>5 lb</td>
</tr>
<tr>
<td>Untreated control</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
Buttons in 0.25m$^2$/tree side
April 20th, 2016

Number of new buttons per tree side (0.25 m$^2$)

Fungicide treatment

- Quadris Top + Activator 90
- UTC
- Headline
- Ferbam 4
- Ferbam 5
- Pristine
- Priaxor + Cohere
- Abound + Activator 90
- Topsin M
- Quadris Top + Abound + Activator 90
- Headline + Ferbam

A
AB
ABC
ABC
BCD
BCD
B-E
C-F
D-G
EFG
FG
G
Number of fruit per tree side
June 24-28^{th}, 2016

Navel Fruit Polk City 2016

<table>
<thead>
<tr>
<th>Fungicide treatment</th>
<th>Number of fruit per tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headline + Ferbam</td>
<td>A</td>
</tr>
<tr>
<td>Pristine + Ferbam</td>
<td>AB</td>
</tr>
<tr>
<td>Priaxor + Cohere</td>
<td>AB</td>
</tr>
<tr>
<td>Headline + Abound + Activator 90</td>
<td>AB</td>
</tr>
<tr>
<td>Topsin M</td>
<td>AB</td>
</tr>
<tr>
<td>Quadris Top + Activator 90</td>
<td>BC</td>
</tr>
<tr>
<td>Ferbam 4</td>
<td>CD</td>
</tr>
<tr>
<td>Ferbam 5</td>
<td>DE</td>
</tr>
<tr>
<td>UTC</td>
<td>F</td>
</tr>
</tbody>
</table>
Conclusions

- No difference in the number of buttons prior to trial initiation.
- The number of buttons from 2016 infection, does not always match fruit counts.
- All treatments significantly better than UTC.
- Topsin M did not perform better than strobilurin containing fungicides.
- Ferbam is best when mixed with other fungicides.
  - Similar conclusion to Pete Timmer’s work in 1990s.
- Will be looking at pre-harvest fruit drop.
Cost analysis details

- Conducted with Ariel Singerman
- Navel prices high in 2016-2017
  - If fruit has a lower price, a profit may not be realized from more expensive treatments
- All pesticide prices based on retail prices in March through April 2017
- Yield and economic analysis based on per tree basis
  - No fixed costs considered in analysis including labor and application costs
## Cost analysis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ave. # of fruit/tree</th>
<th>Boxes/tree</th>
<th>Revenue/tree ($)</th>
<th>Cost/tree ($)</th>
<th>Profit/tree ($)</th>
<th>Ranking Yield</th>
<th>Ranking Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headline + Ferbam</td>
<td>150</td>
<td>0.55</td>
<td>9.52</td>
<td>1.33</td>
<td>8.18</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Abound + Ferbam</td>
<td>148</td>
<td>0.54</td>
<td>9.38</td>
<td>1.17</td>
<td>8.20</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Pristine</td>
<td>143</td>
<td>0.53</td>
<td>9.08</td>
<td>1.27</td>
<td>7.81</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Topsin M</td>
<td>141</td>
<td>0.52</td>
<td>8.97</td>
<td>0.67</td>
<td>8.30</td>
<td>4</td>
<td>1</td>
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<tr>
<td>Priaxor + Cohere</td>
<td>136</td>
<td>0.50</td>
<td>8.62</td>
<td>0.80</td>
<td>7.83</td>
<td>5</td>
<td>4</td>
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<tr>
<td>Headline</td>
<td>128</td>
<td>0.47</td>
<td>8.10</td>
<td>0.88</td>
<td>7.22</td>
<td>6</td>
<td>6</td>
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<tr>
<td>Quadris Top + Abound + Activator 90</td>
<td>125</td>
<td>0.46</td>
<td>7.91</td>
<td>0.92</td>
<td>6.99</td>
<td>7</td>
<td>7</td>
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<tr>
<td>Ferbam 5lb.</td>
<td>109</td>
<td>0.40</td>
<td>6.92</td>
<td>0.77</td>
<td>6.15</td>
<td>8</td>
<td>8</td>
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<tr>
<td>Abound + Activator 90</td>
<td>88</td>
<td>0.32</td>
<td>5.55</td>
<td>0.73</td>
<td>4.83</td>
<td>9</td>
<td>10</td>
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<tr>
<td>Ferbam 4lb.</td>
<td>87</td>
<td>0.32</td>
<td>5.54</td>
<td>0.69</td>
<td>4.85</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Quadris Top + Activator 90</td>
<td>84</td>
<td>0.31</td>
<td>5.31</td>
<td>0.86</td>
<td>4.46</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>UTC</td>
<td>32</td>
<td>0.12</td>
<td>2.04</td>
<td>0.00</td>
<td>2.04</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>
Trial details

- Valencia oranges in Fort Meade area
  - Infected with HLB but relatively healthy
  - Off-season bloom on most trees
  - Trees in block were slow to bloom compared to others in area
  - Trees selected for uniform disease pressure
    - HLB and PFD

- Applications made on recommendation of PFD model

- Applications on March 17, 23, and April 1
Buttons in $0.25m^2$/tree side
May 27th, 2016

- Topguard 5
- Rhyme 5
- Topguard + Ferbam
- UTC
- Luna Sensation 7
- Rhyme 7
- Topguard 8
- Quadris Top
- Luna Sensation 5

No significant difference
| Product               | Active Ingredient                                      | Rate/acre |  |
|-----------------------|--------------------------------------------------------|-----------|
| Rhyme 2.08 SC         | Flutriafol                                              | 5 oz.     |
| Rhyme 2.08 SC         | Flutriafol                                              | 7 oz.     |
| Topguard EQ 4.3SC     | Flutriafol + azoxystrobin                               | 5 oz.     |
| Topguard EQ 4.3SC     | Flutriafol + azoxystrobin                               | 8 oz.     |
| Topguard EQ 4.3SC     | Flutriafol + azoxystrobin Ferbam                       | 5 oz.     |
| Topguard EQ 4.3SC     | Ferbam                                                  | 5 lb      |
| Quadris Top           | Azoxystrobin + difenoconazole                          | 15.4 fl oz.|
| Luna Sensation        | Trifloxystrobin + fluopyram                            | 5 oz.     |
| Luna Sensation        | Trifloxystrobin + fluopyram                            | 7 oz.     |
| Untreated control     | --                                                      | --        |
Buttons in 0.25m$^2$/tree side
May 27$^{th}$, 2016

Valencia New Buttons Fort Meade 2016

Number of new buttons per tree side (0.25 m$^2$)
Number of fruit per tree side
June 30th-July 1st, 2016

Valencia Fruit Fort Meade 2016

Number of fruit per tree side

Fungicide treatment

- Topguard + Ferbam
- Topguard 8
- Quadris Top
- Luna Sensation 5
- Topguard 5
- Luna Sensation 7
- Rhyme 7
- Rhyme 5
- UTC
Conclusions

- No difference in the number of buttons prior to trial initiation
- The number of buttons for 2016 followed similar trend as fruit
- All treatments significantly better than UTC
- The addition of ferbam to Topguard treatment significantly improved performance
- Three best treatments all contained a mixture of strobilurin and DMI fungicides
Up-coming season

- Bloom should be more concentrated than last year
  - Still at least three waves of flowers
  - Not sure what Irma did to bloom
- Key to season will be timing of rain in relation to flowers
  - If have open flowers with rain, could be setting up initial round of infections
  - No more rain - no PFD
    - La Niña season like last year; supposed to be dry
  - If continues to rain – PFD very likely
- Would still conserve fungicides for largest bloom period
- Use a model to time applications
Recommended products

- Nearly all recommended products contain a strobilurin (Abound, Gem, Headline)
  - Rotation is difficult
  - Ferbam with a strobilurin is a good combination
    - Preformed well in several seasons of trials

- Premixes with alternate modes of action (in addition to a strobilurin)
  - Priaxor (SDHI), Pristine (SDHI), Amistar Top (DMI)

- Remember 4 applications of strobilurins within year is legal limit
  - 3 applications of ferbam
# Low volume rates*

<table>
<thead>
<tr>
<th>Product</th>
<th>Ground</th>
<th>Aerial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abound</td>
<td>No restrictions listed</td>
<td>No restrictions</td>
</tr>
<tr>
<td>Quadris Top</td>
<td>10 GPA (15 GPA recommended)</td>
<td>5 GPA (10 GPA recommended)</td>
</tr>
<tr>
<td>Headline</td>
<td>10 GPA (recommended)</td>
<td>10 GPA</td>
</tr>
<tr>
<td>Pristine</td>
<td>10 GPA (recommended)</td>
<td>10 GPA</td>
</tr>
<tr>
<td>Ferbam</td>
<td>No restrictions listed</td>
<td>Prohibited</td>
</tr>
</tbody>
</table>

*Provided as a guide. Always verify what is written on the label.
CITRUS SCAB
Symptoms
Citrus Scab Disease Cycle Caused by *Elsinoë fawcettii*
Citrus Scab Control

- Common control products
  - Enable
  - Strobilurin fungicides (Abound, Gem, Headline)
    - Good for first application because kills fungus in lesions from previous year

<table>
<thead>
<tr>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tangerines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grapefruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Other Controls

- Ferbam
- Copper - All formulations
  - Use later in the season as it is not as effective as other products
- If infestation is light, disease can be pruned out
# Grapefruit Spray Trial 2004

<table>
<thead>
<tr>
<th>Date</th>
<th>March 6-7</th>
<th>April 4-5</th>
<th>May 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prog. 1</td>
<td>Untreated control (UTC)</td>
<td>Untreated control</td>
<td>Untreated control</td>
</tr>
<tr>
<td>Prog. 2</td>
<td>Pristine 38WG (16 oz)</td>
<td>Pristine 38WG (16 oz)</td>
<td>Pristine 38WG (16 oz)</td>
</tr>
<tr>
<td>Prog. 3</td>
<td>Abound 2.08EC (12.4 floz)</td>
<td>Enable 2F (8.0 floz)</td>
<td>Kocide 2000 (4.5 lb)</td>
</tr>
<tr>
<td>Prog. 4</td>
<td>Gem F (2 floz)</td>
<td>Ferbam Granuflo (5.0 lb)</td>
<td>Gem F (2 floz)</td>
</tr>
<tr>
<td>Prog. 5</td>
<td>Endura 70WG (4.5 oz)</td>
<td>Headline 2.09EC (9.2 floz)</td>
<td>NuCop 50DF (4.0 lb)</td>
</tr>
<tr>
<td>Prog. 6</td>
<td>Abound 2.08EC (12.4 floz)</td>
<td>Ferbam Granuflo (7.5 lb)</td>
<td>Abound 2.08EC (12.4 floz)</td>
</tr>
<tr>
<td>Prog. 7</td>
<td>Abound 2.08EC (12.4 floz)</td>
<td>Ferbam Granuflo (7.5 lb)</td>
<td>Kocide 2000 (4.5 lb)</td>
</tr>
<tr>
<td>Prog. 8</td>
<td>Abound 2.08EC (12.4 floz)</td>
<td>Enable 2F (8.0 floz)</td>
<td>Abound 2.08EC (12.4 floz)</td>
</tr>
<tr>
<td>Prog. 9</td>
<td>Kocide 2000 (2 lb)</td>
<td>Kocide 2000 (2 lb)</td>
<td>Kocide 2000 (2 lb)</td>
</tr>
</tbody>
</table>
Severity Rating

UTC | Kocide | Abound, Enable, Kocide | Abound, Ferbam, Abound | Abound, Enable, Abound | Abound, Ferbam, Kocide | Endura, NuCop | Gem, Pristine

0.0
0.5
1.0
1.5
2.0
2.5
Timing

○ Key to good scab control is timing
○ 1\textsuperscript{st} application at \(\frac{1}{4}\) flush expansion
  – Enable, ferbam or strobilurin fungicide
○ 2\textsuperscript{nd} application at petal fall
  – Different chemistry from 1\textsuperscript{st} application
○ 3\textsuperscript{rd} application 3 weeks post-petal fall
  – Copper can fit well in this application
MELANOSE
Symptoms
Melanose Disease Cycle Caused by *Diaporthe citri*

- Twig death
- Symptoms twigs
- Symptoms leaves and fruit
- **PYCNIDIA** on twigs
- Splash-dispersed to fruit leaves and twigs
- Infection 10-12h at 77-85°F free water
- **PERITHECIA**
- **ASCOSPORES**
- Old dead twigs
- 5-7 days
Melanose Control

- Common control products
  - Copper - All formulations
  - Strobilurin fungicides (Abound, Gem, Headline, Quadris Top and Pristine)
    - Reserved for hot weather

<table>
<thead>
<tr>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grapefruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Formulations and Products Rates Tested on Grapefruit (2015)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Metallic Cu (%)</th>
<th>Rate/acre</th>
<th>Metallic Cu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation SC</td>
<td>--</td>
<td>15.5 fl oz</td>
<td>--</td>
</tr>
<tr>
<td>Abound</td>
<td>--</td>
<td>15.5 fl oz</td>
<td>--</td>
</tr>
<tr>
<td>GWN-10073</td>
<td>--</td>
<td>1 qt</td>
<td>--</td>
</tr>
<tr>
<td>Kentan</td>
<td>40</td>
<td>5.0 lb</td>
<td>2</td>
</tr>
<tr>
<td>Badge X2</td>
<td>28</td>
<td>5.0 lb</td>
<td>1.4</td>
</tr>
<tr>
<td>Petroleum Oil</td>
<td>--</td>
<td>4% v/v</td>
<td>--</td>
</tr>
<tr>
<td>NuCop Ultra + AA</td>
<td>30</td>
<td>2.5 lb + 8 fl oz</td>
<td>0.75</td>
</tr>
<tr>
<td>NuCop Ultra</td>
<td>30</td>
<td>2.5 lb</td>
<td>0.75</td>
</tr>
<tr>
<td>Treatment</td>
<td>Metallic Cu (%)</td>
<td>Rate/acre</td>
<td>Metallic Cu/acre</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------</td>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>NuCop Ultra</td>
<td>30</td>
<td>1.75</td>
<td>0.525</td>
</tr>
<tr>
<td>Kocide 3000</td>
<td>30</td>
<td>2.5</td>
<td>0.75</td>
</tr>
<tr>
<td>Untreated Control (UTC)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
% Marketable Fruit

Equation SC (15.5 fl oz) A
Abound (15.5 fl oz) A
Badge X2 (5 lb) B
Kocide 3000 (2.5 lb) B
Nucop Ultra (1.75 lb) B
Nucop Ultra (2.5 lb) B
Oil (4% v/v) B
GWN-10073 (1 qt) B
Kentan (5 lb) B
UTC C
Phytotoxicity (leaves)

- Kentan (5 lb)
- Badge X2 (5 lb)
- Kocide 3000 (2.5 lb)
- Nucop Ultra + AA (2.5 lb +...)
- Nucop Ultra (1.75 lb)
- Nucop Ultra (2.5 lb)
- UTC
- Oil (4% v/v)
- Abound (15.5 floz)
- GWN-10073 (1 qt)
- Equation SC (15.5 floz)

Comparisons:
- a
- b
- bc
- bcd
- cd
- d
- e
- e
- e
- ef
## Formulations and Products Rates Tested on Grapefruit (2015)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (/acre)</th>
<th>Lb Metallic/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priaxor + Cohere</td>
<td>5.0 + 16.0 fl oz</td>
<td>--</td>
</tr>
<tr>
<td>Priaxor + Cohere + Kocide 2000</td>
<td>5.0 + 16.0 + 2.0</td>
<td>0.70</td>
</tr>
<tr>
<td>Priaxor + Cohere</td>
<td>7.0 + 16.0 fl oz</td>
<td>--</td>
</tr>
<tr>
<td>Priaxor + Cohere</td>
<td>9.0 + 16.0 fl oz</td>
<td>--</td>
</tr>
<tr>
<td>Quadris Top + Cohere</td>
<td>14.0 + 16.0 fl oz</td>
<td>--</td>
</tr>
<tr>
<td>Untreated Control</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
Melanose Control on Fruit (2015)

Priaxor + Kocide (5.0 floz + 2.0 lb)

UTC

Priaxor (5.0 floz)

Priaxor (7.0 floz)

Priaxor (9 floz)

Quadris Top (14.0 floz)
ALTERNARIA BROWN SPOT
Symptoms
Symptoms
Alternaria Brown Spot Disease Cycle
Caused by *Alternaria alternata*

1. Young leaves, fruit, and stems become infected.
2. Symptoms develop.
3. CONIDIA are produced on dead tissues in the canopy and orchard floor.
4. CONIDIA are dispersed airborne.
5. New infections occur on young leaves, fruit, and stems.
## Alternaria Brown Spot Control

- **Common control products**
  - Copper - All formulations
  - Strobilurin fungicides (Abound, Gem, Headline, [Quadris Top](#) and [Pristine](#))
    - If severity high, useful for early sprays but also when hot

<table>
<thead>
<tr>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tangerines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cultural Controls

- Ferbam
- Start with clean trees
- Increase air drainage in grove when planting
- Avoid excessive growth promotion
  - Too much nitrogen
  - Overwatering
  - Severe hedging
  - High vigour rootstocks
Alternaria Brown Spot on Sunburst (2009)

- Untreated control
- Quadris Top (10.0 floz) and Actigard (2 oz)
- Abound (15.4 floz)
- Actigard (2 oz)
- Quadris Top (10.0 floz)
- Kocide 3000 (3.5 lb)
- Headline (12 floz)
- Quadris Top (10.0 floz) and NIS
- Pristine (18.5 oz)
- BAS123 (6.5 oz)
<table>
<thead>
<tr>
<th>Program</th>
<th>April 20</th>
<th>May 21</th>
<th>June 16</th>
<th>July 7</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Boscalid (6.5 oz/acre) +</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
<td>Boscalid (6.5 oz/acre) +</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
</tr>
<tr>
<td></td>
<td>Kocide 3000 (2.5 lb/acre)</td>
<td></td>
<td>Kocide 3000 (2.5 lb/acre)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Boscalid (6.5 oz/acre)</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
<td>Boscalid (6.5 oz/acre)</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
</tr>
<tr>
<td>3</td>
<td>BAS703 (5.48 oz/acre) + Non-</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
<td>BAS703 (5.48 oz/acre) + Non-</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
</tr>
<tr>
<td></td>
<td>ionic surfactant (1 pint/acre)</td>
<td></td>
<td>ionic surfactant (1 pint/acre)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pristine (18.5 oz/acre)</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
<td>Pristine (18.5 oz/acre)</td>
<td>Kocide 3000 (3.5 lb/acre)</td>
</tr>
<tr>
<td>5</td>
<td>Untreated control</td>
<td>Untreated control</td>
<td>Untreated control</td>
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</table>
Efficacy on Minneola

**Disease Rating**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Program 1</th>
<th>Program 2</th>
<th>Program 3</th>
<th>Program 4</th>
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<tbody>
<tr>
<td>Untreated control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a</td>
<td>b</td>
<td>b</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c</td>
<td>c</td>
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**% Marketability**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Program 4</th>
<th>Program 3</th>
<th>Program 2</th>
<th>Program 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a</td>
<td>ab</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>c</td>
</tr>
</tbody>
</table>
# Programs with Quadris Top, 2010

<table>
<thead>
<tr>
<th>Date</th>
<th>April 1</th>
<th>May 4</th>
<th>June 2</th>
<th>June 14</th>
<th>July 9</th>
<th>Aug. 9</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Untreated</td>
<td>Untreated</td>
<td>Untreated</td>
<td>Untreated</td>
<td>Untreated</td>
<td>Untreated</td>
</tr>
<tr>
<td>Program 1</td>
<td>control</td>
<td>control</td>
<td>control</td>
<td>control</td>
<td>control</td>
<td>control</td>
</tr>
<tr>
<td>Program 2</td>
<td>Headline</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Headline (12 fl oz)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Headline (12 fl oz) + 2% 435 Oil</td>
</tr>
<tr>
<td>Program 3</td>
<td>Quadris Top (12 fl oz)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Quadris Top (12 fl oz)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Quadris Top (12 fl oz) + 2% 435 Oil</td>
</tr>
<tr>
<td>Program 4</td>
<td>Quadris Top (15.4 fl oz)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Quadris Top (15.4 fl oz)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Quadris Top (15.4 fl oz) + 2% 435 Oil</td>
</tr>
<tr>
<td>Program 5</td>
<td>Quadris Top (15.4 fl oz)</td>
<td>SA 123 (6 pints)</td>
<td>Quadris Top (15.4 fl oz)</td>
<td>SA 123 (6 pints)</td>
<td>SA 123 (6 pints)</td>
<td>Quadris Top (15.4 fl oz) + 2% 435 Oil</td>
</tr>
<tr>
<td>Program 6</td>
<td>SA 123 (6 pints)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>SA 123 (6 pints)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>Kocide 3000 (3.5 lb)</td>
<td>SA 123 (6 pints)</td>
</tr>
</tbody>
</table>
Efficacy on Murcott with Strobilurin Resistance

**Disease Rating**

- Untreated Control: a
- Program 2: b
- Program 6: b
- Program 3: c
- Program 4: c
- Program 5: d

**% Marketability**

- Program 5: a
- Program 3: b
- Program 4: bc
- Program 6: cd
- Program 2: d
- Untreated Control: e
Proportion of Population Sampled

- 2008 - 2012

- Resistant: 57.6%
- Susceptible: 42.4%
Production area: 17,510 acres
Production area: 17,510 acres

Resistance:

- > 25%
- 10 to 25%
- 5 to 10%
- < 5%
- < 50%
- 50 to 70%
- 70 to 90%
- > 90%
Cultivar

Susceptibility

○ Minneola
○ Dancy
○ Murcott
○ Orlando
○ Sunburst, Lee

\[ P < 0.0001 \]
\[ \chi^2: 72.78 \]
Related to QoI Exposure Number

The more applications per season, the more likely you will have resistant isolates.
Manage Tangerines As If Resistance Present

- Should use mixture fungicides with alternative modes of action (in Pest Management Guide)
  - Look at FRAC codes for recommended fungicides
- Frequent rotation with copper or other multisite fungicides like ferbam
- Sample spray program

<table>
<thead>
<tr>
<th>Quadris Top or Pristine</th>
<th>Copper</th>
<th>Opposite premix</th>
<th>Ferbam</th>
<th>Copper</th>
<th>Quadris Top or Pristine</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/3 or 11/7</td>
<td>M1</td>
<td>11/7 or 11/3</td>
<td>M3</td>
<td>M1</td>
<td>11/3 or 11/7</td>
</tr>
</tbody>
</table>
CITRUS BLACK SPOT
Cracked Spot and Hard Spot
False Melanose and Virulent Spot
Black Spot Disease Cycle Caused by *Phylllosticta citricarpa*
Leaves Are Nearly Symptomless

- On oranges, if chemical control used, symptoms rare
- Does not mean leaves are not infected
  - Certain proportion will harbor the organism
- When symptomatic trees removed, not likely removing disease from grove
- Need to balance between cost of lost trees, likely replant success with HLB, and cost of living with black spot
Spores of importance

- Only one spore type present in Florida
  - Only splash dispersed conidia present
  - Every other location with disease has two: ascospores and conidia

- Known to be abundant in the leaf litter
  - Present in high numbers all year
  - When in canopy, tend to move down more than splash up
  - Rain splash likely moves spores into lower canopy from leaf litter
Effects of Irma

- Irma likely moved black spot to new areas
  - Difficult to determine how far may have moved
  - May not see result for up to five years
    - Latent period of disease in groves
- If downwind of black spot groves at significant risk of outbreak
  - Should be scouting regularly for symptoms
  - Ask for FDACS multipest survey if concerned that disease in grove
- This is in addition to current spread
Current locations in Florida
Black spot program

- Fungicide applications should start mid-April to early-May
  - Dependent on April rainfall
- Monthly applications until September of fungicide
- Alternate copper (full rate of chosen product) with a strobilurin, a premix, or Enable
  - Preferable to alternate among modes of action
  - Strobs are Abound, Gem, Headline
  - Premixes are Pristine (SDHI), Amistar Top (DMI), and Priaxor (SDHI) and contain a strobilurin
- Coverage is key so at least 125 gal/acre and slow!
GREASY SPOT
Symptoms
Greasy Spot Disease Cycle
*Mycosphaerella citri*

- **Leaf drop**
  - Dead leaves orchard floor
  - Late winter

- **Nov. - Dec.**
  - Leaf & fruit symptoms
  - Infection through stomates

- **Spring**
  - Pseudothecia on decaying leaf
  - ASCOSPORES forcibly ejected airborne
  - Underside of leaf Epiphytic growth

- **Summer**
  - CONIDIA
Inoculum Production

- Primary inoculum from leaf litter
  - Ascospores (sexual) ejected during wetting events
  - Spores form in structures in partially decomposed leaf litter
  - Wetting and drying of litter important for spore formation
Greasy Spot Control

- Control products
  - Copper - All formulations
  - Strobilurin fungicides (Abound, Gem, Headline, Quadris Top and Pristine)
    - Only once a year for greasy spot
Further Products

- **Fungicides effective for greasy spot**
  - Enable – good substitute for copper if concerned with stippling

- **Petroleum oil**
  - Less consistent control on fruit than copper
  - Can be mixed with all other fungicides
## Copper Formulations and Products

### Rates Tested on Grapefruit

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Metallic Cu (%)</th>
<th>Rate /acre</th>
<th>Metallic Cu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR002 -- 1.5 pt</td>
<td>--</td>
<td>1.5 pt</td>
<td>--</td>
</tr>
<tr>
<td>AGR002 -- 3.0 pt</td>
<td>--</td>
<td>3.0 pt</td>
<td>--</td>
</tr>
<tr>
<td>Cueva</td>
<td>1.8</td>
<td>2.0 qt</td>
<td>--</td>
</tr>
<tr>
<td>Nu-Cop HB</td>
<td>50</td>
<td>2.5 lb</td>
<td>1.25</td>
</tr>
<tr>
<td>AMT 4000</td>
<td>--</td>
<td>4% v/v</td>
<td>--</td>
</tr>
<tr>
<td>AMT 4000 + Kocide 3000</td>
<td>30</td>
<td>3 % v/v + 0.75 lb</td>
<td>0.225</td>
</tr>
<tr>
<td>AMT 4000 + Kocide 3000</td>
<td>30</td>
<td>3 % v/v + 2.5 lb</td>
<td>0.75</td>
</tr>
<tr>
<td>Albaugh 114</td>
<td>--</td>
<td>1.75</td>
<td>--</td>
</tr>
</tbody>
</table>
## Copper Formulations and Products Rates Cont.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Metallic Cu (%)</th>
<th>Rate (lbs/acre)</th>
<th>Metallic Cu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albaugh 114</td>
<td>--</td>
<td>2.5</td>
<td>--</td>
</tr>
<tr>
<td>Albaugh 114</td>
<td>--</td>
<td>5.0</td>
<td>--</td>
</tr>
<tr>
<td>435 Petroleum Oil</td>
<td>--</td>
<td>4% v/v</td>
<td>--</td>
</tr>
<tr>
<td>Untreated Control (UTC)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Enable 2F</td>
<td>--</td>
<td>8 fl oz</td>
<td>--</td>
</tr>
<tr>
<td>Kocide 3000</td>
<td>30</td>
<td>2.5 lb</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Rind Blotch Control

- AMT + K (3% + 2.5 lb)
- Albaugh 114 (2.5 lb)
- Untreated Control
- AGR002 (3 pt)
- AGR002 (5 lb)
- NuCop HB (2.5 lb)
- Kocide 3000 (2.5 lb)
- Albaugh 114 (1.75 lb)
- AMT + K (3% + 0.75 lb)
- AMT 4000 (4% v/v)
- Enable 2F (8 fl oz)
- Cueva (2 qt)
\% Marketable Fruit

- Cueva (2 qt)
- Enable 2F (3\% + 0.75 lb)
- AMT 4000 (4\% v/v)
- AGR002 (1.5 pt)
- Albaugh 114 (1.75 lb)
- 435 petroleum oil (4\%)
- Untreated Control
- NuCop HB (2.5 lb)
- Kocide 3000 (2.5 lb)
- AGR002 (3 pt)
- Albaugh 114 (2.5 lb)
- Albaugh 114 (5 lb)
- AMT + Kocide (3\% + 2.5 lb)
Greasy Spot (Leaves)
Summary

- Disease incidence consistently increased over the four years of the trial.
- Despite conidia being only spore type present, enhanced leaf litter management improved disease management.
- Soilset had the greatest reduction in disease incidence and severity.
  - Urea did not have the same effect.
Acknowledgments

- Ke Zhang
- Tracey Hobbs
- Etelvina Aguilar
- André Bueno Gama
- Daniel Perondi
- Katia Rodrigues

Funding sources: