IMP options for Fungal Grape Disease Management

Mizuho Nita, Ph. D.
(sounds like me-zoo-ho, or Navajo)
Research/Extension Grape Pathologist
Virginia Tech, Alson H. Smith, Jr.
Agricultural Research and Extension Center
595 Laurel Grove Rd.
Winchester, VA 22601
Phone: 540-869-2560 ext. 33
Email: nita24@vt.edu

IPM Workshop, March 25th, 2011
Handouts for today

Please study them after you go home.

Guidelines for Developing an Effective Fungicide Spray Program for Wine Grapes in Virginia, 2010

Mizuho Nita, Ph. D.
Research/Extension Grape Pathologist
Virginia Tech, AHS AREC
585 Laurel Grove Rd.,
Winchester, VA 22602
Phone: 540-869-2560 ext. 33
Email: nita24@vt.edu

The purpose of these guidelines is to help wine grape growers develop an effective spray program for their production. The targeted diseases are black rot (ER), Botrytis bunch rot, and Phomopsis cane and fruit blight. The guidelines do not include control strategies for the targeted diseases.

Notes for Vineyard IPM program 2010

Mizuho Nita, Ph. D. (sounds like me-zoo-ho)
Research/Extension Grape Pathologist
Virginia Tech, AHS AREC
585 Laurel Grove Rd.,
Winchester, VA 22602
Phone: 540-869-2560 ext. 33
Email: nita24@vt.edu


Virginia Tech's "Grape diseases and insects in vineyards" (Pest Management Guide or PMG) http://pubs.ext.vt.edu/456/456-017/Section-3_Grapes-2.pdf

It is very important for you to understand that the high humidity in the summer in Virginia is favored by many disease organisms (pathogens) that can cause diseases on grape. In addition, many French varieties (V. vinifera) are susceptible to many diseases because the majority of these disease organisms are native in here. Therefore, you need to think about disease management, if you want to have a profitable vineyard operation.
Outlines

- IPM Step #1
  - Disease ID
- Step #2
  - Environmental monitoring
- Step #3
  - Disease biology
- Step #4
  - Critical timing
- Step #5
  - Selection of the best tool
Fungal diseases are very common in Pennsylvania vineyards

- Due to high humidity (rain and relative humidity) during the growing season
- Variety selection
  - French varieties such as ‘Chardonnay’ can be grown due to relatively milder winters

A commercial vineyard in Loudoun county, VA
Can you grow wine grape in VA without chemical management?
Powdery mildew dominated this year.

Treated

Untreated

Chardonnay 2010
There are many grape disease, but these are the major fungal diseases in VA that need to be managed

- Downy Mildew
- Powdery Mildew
- Black Rot
- Phomopsis cane and leaf spot
- Botrytis gray mold

Black rot
IPM Step #1: The identification of the disease symptoms

The infection conditions and chemical to be used are different!
Downy Mildew

- It can infect leaves and berries, berry infection can cause serious damage
- Heavy leaf infection can cause a defoliation

Oily spot appearance on upper surface

Pictures taken from Organic grape production guide: OSU, Ellis and Nita 2004
Downy Mildew
Powdery Mildew

- It can infect leaves and berries, berry infection can cause serious damage
- Infection of berries during early season can increase the risk of other diseases

It can be found on the both upper and lower surface, but more commonly found on the upper surface.

Pictures taken from Organic grape production guide: OSU, Ellis and Nita 2004
Powdery Mildew
Phomopsis Cane and Leaf Spot

- It can infect leaves, canes, rachis, and berries (up to 30% loss of yield has been reported), it can cause premature drop of berries
- Even though it does not cause major damage, it can cause a slow decline of vines
Phomopsis cane and leaf spot
Black Rot

- It can infect leaves and berries, berry infection can cause serious damage
- Infected berries will produce spores next year
Black Rot
Botrytis

- It can cause damage to berries, and can be very significant
Botrytis Bunch Rot
How these disease occur?

- Pathogens need to have a certain conditions to infect and cause disease

Host (grape)
The management of disease = aiming to break the disease triangle

- Use of Genetic Resistance
  - Variety Selection
- Cultural Control
  - Site selection
  - Sanitation
    - Pruning methods
    - Vine training methods
- Chemical Control
  - Use of fungicide
- Biological Control
  - Some agents are available, but results are not consistent

Integrated Pest Management (IPM)
Why IPM?

- To save your money and time
  - Proper viticulture practice will reduce the risk of disease, increase yield, and prolong life of your vines

- To save the environment and your money and time
  - Proper disease management practice will reduce the risk of chemical misuse and development of resistant isolates, and save you (and chemical companies) money.
IPM Step #2
Weather monitoring

- You can obtain weather information from various sources.
  - Websites
    - Weather Underground
    - Weather Channel
    - Extension service’s weather stations
  - On-site weather station
    - Costs $500-$3,000
    - It is better to have easy connection to your computer or the internet
Website Examples

- http://www.wunderground.com
- http://www.weather.com/
- http://weather.weatherbug.com/

Monday, February 28, 2011

Pierce's Disease (PD) risks for 2011

We are having a series of warm days in the last few weeks, and that made me wonder about the risk of PD for this year. As you might have heard from our colleagues Dr. Doug Pfeiffer and Dr. Chris Bergh, you can predict the risk of outbreak or Pierce's Disease (PD) by monitoring winter time temperature. When your area receive more than 3 nights (or days) with temperature below 15F (-9.4C), the risk of PD outbreak will be low. It is determined by the number of nights (or days) during the winter months, and it does not happen as three consecutive nights. Here are records of 2011 winter from Virginia Cooperative Extension's mesonet weather stations.

<table>
<thead>
<tr>
<th>Location</th>
<th>Days &lt; 15F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Shore AREC, Accomack Co.</td>
<td>1</td>
</tr>
<tr>
<td>Tidewater AREC, Virginia Beach</td>
<td>1</td>
</tr>
<tr>
<td>Eastern Virginia AREC, Warsaw, Richmond Co.</td>
<td>3</td>
</tr>
<tr>
<td>Northern Piedmont AREC, Orange Co.</td>
<td>5</td>
</tr>
<tr>
<td>AHS AREC, Frederick Co.</td>
<td>5</td>
</tr>
<tr>
<td>Claytor Nature Study Ctr, Bedford Co.</td>
<td>1</td>
</tr>
<tr>
<td>Kentland Farm, Montgomery Co.</td>
<td>10</td>
</tr>
</tbody>
</table>

**Hourly Observations**

<table>
<thead>
<tr>
<th>Time (EDT)</th>
<th>Temp.</th>
<th>Dew Point</th>
<th>Humidity</th>
<th>Sea Level Pressure</th>
<th>Visibility</th>
<th>Wind Dir</th>
<th>Wind Speed</th>
<th>Gust Speed</th>
<th>Precip</th>
<th>Events</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 AM</td>
<td>57.4</td>
<td>30.0</td>
<td>35%</td>
<td>29.85 in</td>
<td>10.0 miles</td>
<td>WSW</td>
<td>5.8 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>12:20 AM</td>
<td>59.0</td>
<td>31.6</td>
<td>35%</td>
<td>29.86 in</td>
<td>10.0 miles</td>
<td>WSW</td>
<td>8.1 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>1:00 AM</td>
<td>59.7</td>
<td>29.7</td>
<td>32%</td>
<td>29.88 in</td>
<td>10.0 miles</td>
<td>West</td>
<td>21.9 mph</td>
<td>27.6 mph</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>1:20 AM</td>
<td>56.5</td>
<td>31.8</td>
<td>39%</td>
<td>29.99 in</td>
<td>10.0 miles</td>
<td>NW</td>
<td>10.4 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>3:00 AM</td>
<td>52.7</td>
<td>38.3</td>
<td>54%</td>
<td>29.92 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>13.8 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>3:20 AM</td>
<td>50.9</td>
<td>37.4</td>
<td>60%</td>
<td>29.93 in</td>
<td>10.0 miles</td>
<td>NW</td>
<td>12.7 mph</td>
<td>17.3 mph</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>4:00 AM</td>
<td>48.5</td>
<td>38.3</td>
<td>68%</td>
<td>29.94 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>15.0 mph</td>
<td>18.4 mph</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>4:20 AM</td>
<td>47.1</td>
<td>37.9</td>
<td>70%</td>
<td>29.93 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>9.2 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>4:40 AM</td>
<td>44.8</td>
<td>37.4</td>
<td>75%</td>
<td>29.94 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>5.8 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>5:00 AM</td>
<td>44.1</td>
<td>36.7</td>
<td>75%</td>
<td>29.95 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>3.5 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>5:20 AM</td>
<td>42.4</td>
<td>36.5</td>
<td>79%</td>
<td>29.98 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>6.9 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>5:40 AM</td>
<td>43.9</td>
<td>36.9</td>
<td>70%</td>
<td>29.97 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>10.4 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>6:00 AM</td>
<td>46.6</td>
<td>38.3</td>
<td>67%</td>
<td>29.98 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>8.1 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>6:20 AM</td>
<td>44.2</td>
<td>35.5</td>
<td>72%</td>
<td>29.99 in</td>
<td>10.0 miles</td>
<td>NW</td>
<td>8.1 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>6:40 AM</td>
<td>44.4</td>
<td>35.1</td>
<td>71%</td>
<td>30.00 in</td>
<td>10.0 miles</td>
<td>NW</td>
<td>4.6 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
<tr>
<td>7:00 AM</td>
<td>45.5</td>
<td>35.6</td>
<td>68%</td>
<td>30.01 in</td>
<td>10.0 miles</td>
<td>NNW</td>
<td>6.9 mph</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td>Mostly Cloudy</td>
</tr>
</tbody>
</table>
Examples of weather stations

- **WatchDog Weather Stations**
  - [http://www.specmeters.com](http://www.specmeters.com)
  - You can purchase grape disease models...

- **Onset Hobo Weather Stations**
  - [http://www.onsetcomp.com](http://www.onsetcomp.com)

Note: sensors on these stations are not meant to last long. You may need to either purchase them or recalibrated every so often.
Weather stations cont.

- These stations can be connected to your computer via wire, wireless, cell phone, etc.
- Some come with option to publish it onto a website(s), such as weather underground.
What can you do with the weather data?

Figure 2. Estimated leaf wetness and temperature during wetness event at Winchester Location

Leaf wetness (hr)

Date


LW estimate hr

Temp (F) during LW

Temperature (F)
You can estimate infection conditions!

<table>
<thead>
<tr>
<th>Date</th>
<th>Stage</th>
<th>Wet hours</th>
<th>Temperature</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/6/10</td>
<td>50% bud break</td>
<td></td>
<td></td>
<td>3 weeks ahead of the last year</td>
</tr>
<tr>
<td>4/8/10</td>
<td>100% bud break</td>
<td>2.5</td>
<td>60</td>
<td>Not a significant disease risk</td>
</tr>
<tr>
<td>4/13/10</td>
<td>2-3 inches</td>
<td>23.5</td>
<td>47</td>
<td>Low risk black rot and Phomopsis</td>
</tr>
<tr>
<td>4/16/10</td>
<td>3 inches</td>
<td>&lt; 1hr</td>
<td></td>
<td>Not a significant disease risk</td>
</tr>
<tr>
<td>4/21/10</td>
<td>3 inches</td>
<td>4.7</td>
<td>52</td>
<td>Not a significant disease risk</td>
</tr>
<tr>
<td>4/25/10</td>
<td>5 inches</td>
<td>11</td>
<td>59</td>
<td>Low risk of black rot, Phomopsis, and downy mildew</td>
</tr>
<tr>
<td>4/26/10</td>
<td></td>
<td>27</td>
<td>58</td>
<td>Low - medium risk of black rot and Phomopsis</td>
</tr>
<tr>
<td>5/3/10</td>
<td>10 inches</td>
<td>8.6</td>
<td>72</td>
<td>Downy mildew; low risk of black rot and Phomopsis</td>
</tr>
<tr>
<td>5/10/10</td>
<td></td>
<td></td>
<td></td>
<td>Frost!!</td>
</tr>
<tr>
<td>5/11/10</td>
<td></td>
<td>21</td>
<td>55</td>
<td>Black rot and Phomopsis</td>
</tr>
<tr>
<td>5/12/10</td>
<td>12-14 inches</td>
<td>18</td>
<td>64</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>5/14/10</td>
<td></td>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; observation of Phomopsis</td>
</tr>
<tr>
<td>5/15/10</td>
<td></td>
<td></td>
<td></td>
<td>Some leaves maybe showing downy symptoms</td>
</tr>
<tr>
<td>5/17-19/10</td>
<td></td>
<td>55</td>
<td>58</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>5/22/10</td>
<td></td>
<td>19</td>
<td>70</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>5/24/10</td>
<td>50% Bloom</td>
<td>&lt; 1hr</td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; observation of black rot, downy mildew, powdery mildew</td>
</tr>
<tr>
<td>5/31, 6/1, and 6/5</td>
<td></td>
<td>&lt; 1hr</td>
<td></td>
<td>Not significant events</td>
</tr>
<tr>
<td>6/6/10</td>
<td></td>
<td>3.5</td>
<td>72</td>
<td>Downy mildew</td>
</tr>
<tr>
<td>6/7/10</td>
<td>BB</td>
<td>1</td>
<td>59</td>
<td>Not a significant event</td>
</tr>
<tr>
<td>6/9/10</td>
<td></td>
<td>12</td>
<td>63</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>6/12/10</td>
<td>BB-Pea</td>
<td>11.5</td>
<td>73</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>6/14/10</td>
<td></td>
<td>13.5</td>
<td>73</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>6/16/10</td>
<td>Pea</td>
<td>11</td>
<td>75</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>7/6-7/8/10</td>
<td>Berry touch</td>
<td></td>
<td></td>
<td>~100F temperature: should slow down powdery mildew</td>
</tr>
<tr>
<td>7/10/10</td>
<td></td>
<td>13.5</td>
<td>75</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
<tr>
<td>7/13/10</td>
<td></td>
<td>15</td>
<td>77</td>
<td>Downy mildew, Black rot, and Phomopsis</td>
</tr>
</tbody>
</table>
IPM example: Black rot infection risk can be estimated based on the weather conditions → Adjust your spray program based on the risk

<table>
<thead>
<tr>
<th>Temperature in °F</th>
<th>Temperature in °C</th>
<th>Minimum Leaf Wetness Duration (hr) for Light Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>55</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>60</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>65</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>70</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>75</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>80</td>
<td>27</td>
<td>6</td>
</tr>
<tr>
<td>85</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>90</td>
<td>32</td>
<td>12</td>
</tr>
</tbody>
</table>

• Data represent a compilation from several experiments with the cultivars Concord, Catawba, Aurora, and Baco noir (Ellis et al., 1989, Spotts 1980 etc)
• Leafwetness is the period when leaves are wet (moist). It is not the same as the duration of rain.

We really need to know about pathogens and their biology to apply IPM practice
IPM Step #3: Know your pathogen

- I will use Phomopsis cane and leaf spot as an example
- Noemi will cover powdery mildew and downy mildew
- Bryan will cover rots (black rots, Botrytis, and others)
Phomopsis Cane and Leaf Spot

- It is a fungal disease caused by *Phomopsis viticola*.
- The fungus tends to be active in cool to warm temperature.
- It can infect leaves, canes, rachis, and berries (up to 30% loss of yield has been reported)
- Even though it does not cause major damage, it can cause slow decline of vines
Phomopsis Disease Cycle

Winter

Spring (April to June)

Fall

Summer

Figure taken from NY Grape IPM Disease Identification Sheet
<table>
<thead>
<tr>
<th>Temperature in °F</th>
<th>Temperature in °C</th>
<th>Minimum Leaf (cane) Wetness Duration (hr) for Light Infection (5-15% severity)</th>
<th>Minimum Leaf (cane) Wetness Duration (hr) for Moderate Infection (15-25% severity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>7</td>
<td>42</td>
<td>&gt;48</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>55</td>
<td>13</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>60</td>
<td>16</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>65</td>
<td>18</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>70</td>
<td>21</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>75</td>
<td>24</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>80</td>
<td>27</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>85</td>
<td>29</td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td>90</td>
<td>32</td>
<td>Little or no infection</td>
<td>Little or no infection</td>
</tr>
</tbody>
</table>

- Data represent a compilation from several experiments with the cultivars Concord and Catawba. (Erincik et al., 2003, Nita et al., 2007)
- Leafwetness is the period when leaves are wet (moist). It is not the same as the duration of rain.
IPM Step #4: Identify the critical timing for infection

- Younger leaves, canes and rachis are more susceptible than matured one.
- Phomopsis fungus can be active in lower temperature (in 40’s)
- Thus, it is important to protect your young shoots!
- Knowing this timing of application of the fungicide is an important part of the IPM approach for Phomopsis management
Critical timing for Phomopsis management comes early

- What you see later in the season happened at the beginning of the season!
IPM Step #5: Selecting the best tool for management for you and your vines.

- **Site selection**
  - This disease needs rain events for its dissemination of spores + the host tissues need to be wet for a certain length of time
  - Good air circulation will lower the risk

- **Selection of resistant vines**
  - Some varieties are more like tolerant to this disease (can get disease, but yield won’t be affected)
  - Example: many of American grapes

- **Vine training method**
  - Good air circulation, although, at early in the season, these vines are pretty open anyway.

- **Sanitation by removing infected canes from your vines, selective pruning to cut out heavily infected canes**
  - Once infected, canes can produce spores at least two years.
IPM Step #5: Selecting the best tool for management for you and your vines.

- Preventative fungicide application (**Mancozeb**, Captan, or Ziram) starting from 1-3 inch growth stage
- There are **no** fungicides with curative (kick-back) activities against Phomopsis infection.
- Often time black rot fungicides will work against Phomopsis (but not Rally or Sterol-inhibitors); thus, applications specific to Phomopsis may be required only when shoots are short.
- The grape berries does **NOT** become resistant and the fungus can produce spores during summer; however, it tends to produce less spores during summer, it is often too warm for a significant infection to take place, and/or the canopy prevents spores to be moved around. These are possible reasons why we do not see many fruit rots.
- Dormant season application of lime sulfur (10 gal/100 gal/A) helps, but does not let you skip the spray in season.
What if we have a curative material against Phomopsis?

- Curative or kick-back activity materials work after infection period. (often time it is mistakenly called as a systemic material.)
- Unfortunately, we do not have any.
- However, if someone comes up with one, we can apply after the infection period.
- Thus, weather monitoring will be even more critical.
- Examples: mycrobutanyl (Rally) and Azoxystrobin (Abound) for black rot management
Critical timing and symptom development are typically different

- Critical timing for infection typically takes place one week to a few weeks prior to symptom development of the disease.
- i.e., if you have seen the disease, it maybe too late to react.
- Thus, keeping disease infection risk low during the critical timing for the disease is the best approach.
Disease Progress Curve

Typical polycyclic disease development

- Lag period
  - Population is building up
  - Probably we cannot see the development
  - It seems that for BR, PM, and DM, this period corresponds to bud break to bloom.
  - (Reproduction time:
    - 2-3 wks for BR, 1-2 wks for PM and DM)

If you have infected berries from the previous year, you are basically staring BR disease progress from here.
The way disease management should work

- Idea of disease management is to increase the lag period to the point that the development of the disease is not economically significant (lines B and C).
- In the case of berry protection for BR, PM and DM, you can push the lag period to the point when the berries become resistant (4-5 wk after bloom, line D)
Vine training system

- So many pathogens require water to germinate, penetrate, and establish itself into the grape tissue.
- The longer the wetness, the more risk of disease development.
- A vine with GDC or Lyre tends to have more leaves with less air circulation = higher risk than VSP or Cane pruning.
  - HOWEVER, GDC and Lyre can produce more fruits per vine!
  - The best training system may differ by variety.
  - Your equipments may have some limitation.
- Site selection and variety selection is ideal, but you may not have much choice...
What is your priority?

- Increase your yield
  - Quality
  - Quantity

- Disease management need to make sense to you in terms of
  - Economy
  - Ecology

- Please spend time during off season to be better prepare for 2011 season!!
Resources on Grape Disease Management

- My blog
  - Updated almost daily during the season
  - Please refer to my handout for URLs
Resources on Grape Disease Management

- Fungicide application guideline
  - With pictorial keys for the target host stage
Resources on Grape Disease Management

Virginia Tech’s Pest Management Guide or PMG

- It covers not only diseases, but also insect and weeds.

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### Diseases and Insects in Vineyards

**Douglas G. Pfeiffer**, Extension Entomologist, Virginia Tech  
**Anton B. Bandoin**, Plant Pathologist, Virginia Tech  
**J. Christopher Bergh**, Extension Entomologist, Alson H. Smith Jr. AREC  
**Mizuho Nita**, Extension Plant Pathologist, Alson H. Smith Jr. AREC

Additional information on pest and beneficial species identification is available online at [http://www.virginiafruits.ento.vt.edu/](http://www.virginiafruits.ento.vt.edu/).

**Application rates:** The rate per acre column gives rates for low-volume or concentrate applications. Sprays may be applied as semi-concentrate (40-100 gal/A) or concentrate (10-40 gal/A) sprays. Use caution with more concentrated sprays; the smaller droplet sizes associated with low-volume application are more prone to drift. Amount of pesticide to be applied for dilute applications (usually 100 gal/A early in early season, 200 gal/A in mid season, and 300 gal/acre in late season) is usually given on the label.

#### Table 3.1 - Disease and Insect Control

<table>
<thead>
<tr>
<th>Pest</th>
<th>Chemical and Formulation</th>
<th>Rate/Acre</th>
<th>Spray Timing and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dormant</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthracnose (Bird’s eye rot), Powdery Mildew, Phomopsis</td>
<td>Lime sulfur solution</td>
<td>10.0 gal</td>
<td>Only necessary where anthracnose, Phomopsis, or powdery mildew have been a serious problem. Lime sulfur can reduce overwintering inoculum of these diseases.</td>
</tr>
</tbody>
</table>
| Mealybugs | Applaud 70DF  
Venom 20SG  
Assail 30SG  
Provado Solupak  
Baythroid 2EC  
Movento 2SC | 9.0-12.0 oz  
0.44-0.66 lb (foliar)  
1.13-1.32 lb (soil)  
2.5 oz  
0.8-1.0 oz  
2.4-3.2 fl oz  
6.0-8.0 fl oz | If a problem at harvest in the previous year. If a delayed dormant spray does not provide a adequate control, a summer application may be made. Baythroid targets only crawlers. Movento prebloom only in table grapes. |
| **Bud Swell** | Grape flea beetle | Danitol 2.4EC or | 8.0 fl oz | If adult beetles are present in damaging numbers. See Table 3.4 for Restricted Entry. |
Thank you for your attention!!

Any Questions?
Supplemental slides

- Next few slides are for the other major fungal diseases for grape grown in PA and other eastern states.
Black Rot
Black Rot

- It is a fungal disease caused by *Guignardia bidweillii*.
- The fungus tends to be active in relatively higher temperature ranges.
- The fungus produces two types of spores: ascospores (airborne and rain splashed) early in the season and conidia (rain splashed) in later.
- It can infect leaves and berries, berry infection can cause serious damage

Picture taken from Organic grape production guide OSU, Ellis and Nita 2004
Black Rot Disease Cycle

Winter

Fall

Summer

Spring (May to June)

Figure taken from NY Grape IPM Disease Identification Sheet
# Black Rot Infection Conditions

<table>
<thead>
<tr>
<th>Temperature in °F</th>
<th>Temperature in °C</th>
<th>Minimum Leaf Wetness Duration (hr) for Light Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>55</td>
<td>13</td>
<td>12</td>
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<tr>
<td>60</td>
<td>16</td>
<td>9</td>
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<tr>
<td>65</td>
<td>18</td>
<td>8</td>
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<tr>
<td>70</td>
<td>21</td>
<td>7</td>
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<td>75</td>
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<td>80</td>
<td>27</td>
<td>6</td>
</tr>
<tr>
<td>85</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>90</td>
<td>32</td>
<td>12</td>
</tr>
</tbody>
</table>

- Data represent a compilation from several experiments with the cultivars Concord, Catawba, Aurora, and Baco noir (Ellis et al., 1989, Spotts 1980 etc)
- Leafwetness is the period when leaves are wet (moist). It is not the same as the duration of rain.
Black Rot Management

- Sanitation by removing old bunches from the vines
  - The fungus survives in crop debris, hanging berries from the last year is known to be the best source of inoculum.
- Good air circulation
- The critical timing of protection is from pre-bloom to 5 weeks after bloom (probably 2-3 sprays), berries become resistant after this period.
  - Once infection takes place, it takes about 2 weeks to produce spores at an average temperature above 70F (21C) (takes about 3 weeks at 60F (15C)).
- Preventative fungicide application (Mancozeb, Sterol-inhibitors, Strobilurins)
- Curative fungicide application:
  - Myclobutanil is known to have a good curative (kick-back) activity against black rot fungus. It has an efficacy up to 6 days after infection.
  - Azoxystrobin does have some curative activity against black rot fungus; however, the efficacy is not as good as that of myclobutanil.
Powdery Mildew
Powdery Mildew

It is a fungal disease caused by *Uncinula necator*. The fungus does not require water for infection; however, high relative humidity is often related with high disease intensity.

- The fungus is active in wide range of temperature (mid-40’s to upper-80).
- High temperature (> 95F) inhibits activity of the fungus. If average temperature is above 90F for a while, disease development will be little or none.
- Diffuse sunlight promote disease development (leaves in shade of other leaves are good place for them).

Pictures taken from Organic grape production guide: OSU, Ellis and Nita 2004
Powdery Mildew Disease Cycle

Winter
fungus overwinters in dormant buds
ascus containing ascospores
infected buds give rise to young shoots completely covered by fungus
Summer
fungus sporulates on surface of green shoots and leaves
conidia and ascospores infect green tissue
conidia
Fall
cleistothecia are produced on leaves, shoots and berries in late summer
fungal on leaves, shoots and berries produces conidia that are spread by wind
Spring (May to June)
infected grape cluster
ascospores are released in spring
## Powdery Mildew Infection Conditions

- Cleistothecia requires rain (> 2.5 mm, or 0.1 inch, and more than 4 hr of wetness), and temperature between 43-75F (6 - 24C) to discharge ascospore. (A French study showed 0.1 inch, 2.5 hr, and >50 F).
- A French study showed that rain events during pre-bloom period had a correlation with more powdery mildew disease intensity later in the season.
- Early season protection of vines may be more important than we think.

<table>
<thead>
<tr>
<th>Temperature in °F</th>
<th>Temperature in °C</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>48</td>
<td>9</td>
<td>25</td>
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<tr>
<td>52</td>
<td>11</td>
<td>16</td>
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<tr>
<td>54</td>
<td>12</td>
<td>18</td>
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<tr>
<td>59</td>
<td>15</td>
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<tr>
<td>63</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>74</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>79</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>86</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>90</td>
<td>32</td>
<td>little or no development</td>
</tr>
</tbody>
</table>

*From Delp 1954*
Powdery Mildew Management

- **Good air circulation**
- **Chemical management**
  - The grape berries can become resistant to the infection by this fungus once it matures. It happens after 4-5 weeks after bloom for *V. vinifera* varieties. However, rachis tissue does not become resistant. Thus, the critical timing of protection is from pre-bloom to 4 weeks after bloom for protection of berries.
  - However, spring rain promote ascospore discharge: early season protection could be important
  - Preventative fungicide application: Sulfur, Fixed copper
  - Curative fungicide application: Stylet Oil [early season, some varieties shows phytotoxicity]; Sterol-inhibitor [Rally, note: there are evidence of chemical resistance in Europe, VA isolates showed some shift, but have not become insensitive yet], Potassium salt products [requires through coverage, expensive].
Downy Mildew
Downy Mildew

- It is a fungal disease caused by *Plasmopara viticola*. (It is technically not a fungus (belongs to Oomycete), but I refer it as a fungus for convenience.)
- The fungal activity heavily depends on availability of water. It is a typical wet season disease.
- The fungus is active in wide range of temperature (low-50’s to 85, 10 to 30C). The fungus produces two types of spores: oospore (for survival) and zoospore (rain splashed, and has a capability to swim to stomata!).

Pictures taken from Organic grape production guide: OSU, Ellis and Nita 2004
Downy Mildew Disease Cycle

- **Winter**: Fungus overwinters as oospores inside fallen leaves.

- **Spring (May to June)**: Moisture induces production of sporangium in spring. Sporangium liberates zoospores in water. Zoospores are rain-splashed to susceptible tissue, encyst and germinate by forming a germ tube which enters stoma of tissue.

- **Fall**: Yellow-brown spots appear on upper leaf surface, with white patches of sporulation on underside of leaf. Infected shoot with distorted growth.

- **Summer**: Infected cluster.

Figure taken from NY Grape IPM Disease Identification Sheet.
Downy Mildew Infection Conditions

- The optimal temperature for germination is around 64-76F (18-22C).
- Oospore requires rain to germinate to a fruiting structure sporangium. The process happens when temperature is above 52F (11C). The sporangium can be disseminated by wind or rain. Then, the sporangium can produce spores (zoospores).
- It only takes less than 90 min for zoospores to cause infection. (That’s why I don’t have a table this time...)
- Once infection takes place; it takes 8-15 days to produce mass of sporangia.
- Oopsores can survive throughout the season to produce sporangia.
Downy Mildew Management

- The critical timing of protection is from 2-3 weeks prior to bloom to 4 weeks after bloom for protection of berries.
- Good air circulation, removal of suckers (spores jumps from the ground to suckers, from suckers to lower leaves, ...)
- Preventative fungicide application: mancozeb, captan, fixed copper, and others
- Curative fungicide application: metalaxyl [Ridmil Gold MZ etc]; Phosphorus acid; Prophyte etc. These materials can have efficacy 1-3 days after infection event. (under experimental conditions, it has efficacy up to 5-6 days. However, DM can produce spores in 8 days or so under optimal conditions.)
- Downy mildew is a major concern on potato and other crop productions (Irish Famine was partially caused by downy mildew of potato).
  - Cases of chemical resistance on number of downy mildew fungicides are reported. However, it is not the case with grape in the US (unfortunately there is evidence of resistance to metalaxyl in Europe). Thus, let’s keep it that way. Please be careful with mode of action and mix it up.
Botrytis Bunch Rot
Botrytis

- It is a fungal disease caused by *Botrytis cinerea*.
- The fungus tends to be active in wide temperature ranges. The optimal temperature for germination is around 70°F (21°C).
- Moisture in the form of fog or dew and temperatures of 59 to 77°F are ideal for conidia production and infection.
- The fungus produces two types of spores: ascospores (rare: airborne) and conidia (airborne).
- The gray moldy appearance is due to mass of conidia.
- It has a wide range of hosts, strawberry and other small fruits, crop debris, etc...
Botrytis Disease Cycle

Winter

Spring (around bloom)

Fall

Summer
## Botrytis Infection Conditions

<table>
<thead>
<tr>
<th>Temperature in °F</th>
<th>Temperature in °C</th>
<th>Minimum Leaf Wetness Duration (hr) for Light Infection (10-20% incidence)</th>
<th>Minimum Leaf Wetness Duration (hr) for Moderate Infection (20-40% incidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>10</td>
<td>20</td>
<td>29</td>
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<td>55</td>
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<tr>
<td>90</td>
<td>32</td>
<td>22</td>
<td>32</td>
</tr>
</tbody>
</table>

- Data is based on study by Nair and Allen (1993)
- Leaf wetness is the period when leaves are wet (moist). It is not the same as the duration of rain.

Even though it takes only a few hours of wetness to have infection, this fungus seems to be not a good pathogen by itself. In field condition, it is often associated with longer hours (>15 hr) of wetness (or high RH).
Botrytis Management

- Canopy management ~ cluster management (leaf removal to promote reduce compactness, e.g., Vinoles), but you also need to avoid sunburn.
- Good air circulation
- Management of powdery mildew early in the season, and insect management (both are for preventing wounds on berries)
- Preventative fungicide application (Fenhexamid (Elevate), Boscalid (Endura), Trifloxystrobin (Flint), Iprodione (Roval), etc)
- These fungicides are tested for curative activity in the lab. They had some efficacy within 12 hr of infection; however, it is a lab experiment using detached berries (i.e., I wouldn’t risk your vines.)