Early-season flower and cluster disease control

Bryan Hed
Department of Plant Pathology
Penn State University
Grape disease control can be challenging in Pennsylvania

- Eastern U.S. = ground zero for major pathogens
- Wet, warm climate
- Varieties with maximum susceptibility

- Review of pathogen/disease biology, symptoms
- Chemical and cultural control measures
- Resistance management/recommendations
Powdery Mildew; *Uncinula necator*

- Affects all cultivated grapes, every season, wherever they are grown
- Affects all green tissues of the vine
- Can cause severe economic damage
Powdery mildew signs and symptoms; Leaves

- Greyish-white powder on upper (sometimes lower) surface
- Cupping, chlorosis, abscission
Powdery mildew

Signs and Symptoms; Fruit

Greyish-white powder on surface

Infections at bloom can cause poor fruit set
Powdery mildew signs and symptoms; fruit

Splitting of berries as they expand leaves them open to rot complex organisms
Powdery Mildew; Primary Infection Cycle

- Cleistothecia swell, split open during spring rain, ascospores released (0.1” rain, >50F)
- Ascospores blown to emerging tissue
- Can infect wet or dry tissue.
- Ascospore supply exhausted shortly after bloom.

Courtesy APS (W. Gärtel)  

Courtesy APS (B. Kendrick)
Powdery Mildew; Secondary Infection Cycles

- Spores (conidia) from primary infections wind dispersed
- Rainfall not required
- Generation time only 5-7 days under ideal conditions (60-80°F)

Courtesy APS (W. Gärtel)
To manage powdery mildew on leaves, shoots, and rachises,

• Susceptible all season
• Pre bloom infections provide inoculum for developing flowers/fruit.
• Mid-late season infections can lead to defoliation, inhibit fruit/cane maturation
  - Sensitive hybrids and vinifera may need protection until veraison or beyond
Powdery Mildew Management; Fruit

- **Peak** fruit susceptibility period is limited
  - Concord: immediate pre-bloom to 2-3 weeks post bloom
  - Sensitive hybrids and vinifera: immediate pre-bloom to 4 weeks post bloom

- Best materials
- Full rates
- Best coverage
- Tighter intervals
Powdery Mildew; Chemical Control

• **Strobilurins;** Flint, Sovran, Abound, Pristine
  - broad spectrum, rainfast
  - very prone to development of resistance
    (rotate, limit number of sprays, tank mix with sulfur)

• **SIs;** Rally, Elite, Orius, Rubigan, Vintage, Mettle, Tebuzol, Procure, *Inspire Super, *Revus Top, *
  *Quadris Top
  - rainfast
  - efficacy slipped in some due to resistance (?)
  - Rubigan/Vintage production stopped
  - *Difenzoconazole* new, more active, effective.
Powdery Mildew; Chemical Control

- Quintec (quinoxyfen), Vivando (new in 2012; metrafenone)
- Rainfast
- Control only pm.
- Prone to development of resistance.

- New:
  - Torino (cyflufenamid)
  - Luna Experience (fluopyram + tebuconazole)
Powdery Mildew; Chemical Control

Old standards

• Sulfur
  - Most effective at high rates/short intervals
  - Little effect of temperature on efficacy
  - Phytotoxicity (Concord, red hybrids); > 14 d from oil application.
  - some formulations organic
  - subject to wash off by rain (sticker can help)
  - some post infection activity
  - Tank mix with strobilurins in vineyards with resistance.

• Copper and lime
  - moderate efficacy (best on downy mildew)
  - Don’t mix with some pesticides
  - Phytotoxicity
  - some formulations organic
  - subject to wash off by rain (sticker can help)
Powdery Mildew; Alternatives

- **Nutrol (Monopotassium phosphate):** a fertilizer (K, P)
  - post infection; little/no protective activity
  - apply often: weekly at half rates better than biweekly at full rates
  - moderate efficacy
  - inexpensive
  - good coverage critical
  - use spreader

- **Kaligreen, Armicarb, Milstop (Potassium bicarbonate):**
  - similar to Nutrol, but
    - more expensive
  - organic formulations
Powdery Mildew; Alternatives

- **Oils**
  - JMS Stylet oil, Purespray (green and foliar), Ultra Fine Sunspray oil, Soybean oil: eradicants, short protective period, effective at 14 day intervals, good coverage critical, inhibit photosynthesis

- **Plant extracts**
  - EF400, Vineyard Magic
  - GC-3
  - Citrex
  - Sporan
  - Regalia

- **Biologicals: Bacillus**
  - Serenade; fair/good control of pm in rotations with SIs and strobies, Serenade/Sulfur combination
  - Sonata
  - Taegro

- **Most are allowable in organic production systems.**
Sunlight...kills powdery mildew

Progress of powdery mildew on Concord leaves
August - September
Powdery Mildew; Cultural Control

- Maximize air circulation and sun exposure, reduce RH:
  - Leaf removal, trellis system
  - proper site selection
- Excellent weed control
- Nitrogen management to limit shoot growth
Downy Mildew: *Plasmopara viticola*

- Not actually a fungus
- Yellow “oil” spots (spring), red/brown angular spots (late summer)
- Lesions limited by veins, die as they age, leaf abscission
Downy Mildew Signs and Symptoms; Underside of Leaves

Downy sporulation on underside of leaf
Downy Mildew; Shoots

- Tissues thicken
- White downy sporulation
- Tissues blacken and die
Downy Mildew; Inflorescences

When infected pre-bloom... flowers develop white sporulation, turn brown and die.

White downy sporulation appears.

Rachis thickens, curls (epinasty)
Young fruit: white downy sporulation appears, tissue destroyed

Older fruit...
Downy Mildew; Primary Cycle

- Over-winters as oospores in infected leaves on vineyard soil
- **Primary cycle;** 2-3 weeks before bloom (5-6 leaf stage) to fruit set
  - spores released at 0.1” rain, >52F
  - splashed from soil to canopy
  - requires wet leaf surface for infection
Infections sporulate at night, >95% RH
spores blown to wet plant surfaces, infect

4-5 day generation time under ideal conditions

Epidemics occur in warm, wet summers
Hot, dry weather inhibits development; can reactivate if wet in fall
Downy Mildew; Management

- Leaves can be infected all season; less susceptible after fully expanding.

- Clusters susceptible as soon as pathogen is active (5-6 leaf stage).

- Fruit resistant 2-4 weeks after bloom but...

- Rachises still susceptible after fruit are resistant (2-3 weeks longer?)

- Late season sprays (leaf infections) may be necessary if disease reactivates.
Mancozeb, ziram
- protectant
- low resistance risk
- less rainfast

Captan; do not apply with other EC formulations, oils, organo-silicate surfactants.

Copper; toxic to some varieties, add lime
Downy Mildew; Chemical control

- **Ridomil** *(w copper/mancozeb)*
  - sold only as a mix with cu or mz
  - systemic, rainfast
  - post infection activity
  - only controls downy
  - very prone to development of resistance

- **Strobilurins** *(Qols)*
  - protectant, rainfast
  - Abound and Pristine very effective
  - Sovran moderately effective
  - Flint least effective
Downy Mildew; Chemical control

- **Phosphorus acid** (ProPhyt, Phostrol, Fosphite, Topaz, Rampart, etc)
  - only controls downy
  - good post-infection activity
  - highly systemic; rainfast
Downy Mildew; Chemical control

- **Gavel 75 DF** (zoxamide + mancozeb)

- Protectant – no curative activity

- Combination of two chemistries for resistance management, same PHI as mancozeb (66 d)

- Labeled for downy mildew, Phomopsis; some control of black rot (though not currently labeled for it).

- Rainfast – bonds to cuticle
Downy Mildew; Chemical control

• **Presidio** (fluopicolide)

• Resistance risk high; label requires a tank mix with another chemistry for downy mildew.

• Protectant, post-infection, antisporulantal activity

• Only controls downy mildew

• Rainfast 2 hours after application
Downy Mildew; Chemical control

- **Revus 2SC** (mandipropamid)
- Risk of resistance moderate
- Protectant, post-infection, antisporulant activity
- Only controls downy mildew
- Rainfast
Downy Mildew; Chemical control

- **Reason 500 SC**; QoI, fenamidone; downy mildew control only

- **Quadris Top**; azoxystrobin + difenoconazole; broad spectrum

- **Ranman**; cyazofamid; effective alone and mixed with phosphorous acid.

- **Zampro**: New for 2013, Initium + dimethomorph
Maximize air circulation, sunlight penetration to speed drying within canopies
- appropriate trellis, canopy management
- site; good air, soil drainage
- good weed control

Spring cultivation to bury over-wintering sources of inoculum

Early sucker control
• *Phomopsis viticola*
• Small lesions; dark center, yellowish halo
• Coalesce = larger necrotic areas, abscission
• Basal tissues most affected
Phomopsis signs and symptoms

- Black, scabby, lesions
- Shoot/rachis becomes brittle…

…rachis infections most economically important
After ripening: berries turn brown with numerous black pycnidia

Berries shrivel, become mummified
Phomopsis; Biology

- Over-winters on canes/rachises
- **More spores released from dead than live wood**
- Spores spread by spring rain
- Infection can occur at low temps (45F)
- Shoots/leaves susceptible while expanding - most infection occurs early season.
Phomopsis; Biology

Rachises: susceptible from first emergence

Fruit: susceptible bloom until veraison

• Green fruit infections latent until ripening
• Disease development dependant on…
  - over-wintering inoculum load
  - prolonged rainfall periods in spring
• Few spores available by mid July; infection risk low after pea sized berries (MSU and Cornell).
Phomopsis; Chemical Management

- Captan, Mancozeb, Ziram; inexpensive and effective
- Strobilurins less effective on shoots; efficacy on fruit infections better.
- Dormant applications (spring) of fixed copper (3 lbs/A) or lime sulfur (10 gal/A) can reduce overwintering inoculum...enhance seasonal control.
- Pre bloom sprays protect shoots, rachises, fruit
  - 1” shoot
  - rachises from 1st emergence
  - reduce pedicel infections...later fruit infections
- Immediate pre-bloom and 1st post-bloom sprays critical for fruit infections.
Phomopsis; Cultural Management;

• New vineyards; disease-free cuttings

• Reduce sources of inoculum
  - hand vs machine pruning
  - training system that minimizes older wood, maximizes canopy aeration, trains shoots upward

• Shred, plow under, or bury prunings
Botrytis
Bunch rot

• Late season condition, ripening.
• Complex cluster rot involving many factors
• Compactness determines susceptibility and spread within cluster (berry-berry contact)
Botrytis; Biology

- Colonizes/Over-winters on *any* plant debris in the vineyard.
- Spores present all season; most numerous during ripening
- Spores spread by rain/wind
- Germination, infection, sporulation take place at > 90% RH
Botrytis; Biology

After veraison...

- Latent infections may activate (injury?)
- Berries increasingly more susceptible to direct invasion or through wounds
- Retention of floral debris can contribute significantly to bunch rot development in tight clusters.
Botrytis; Chemical Control: all are good/excellent protectants, pm control/suppression

- Vangard (cyprodinil), Scala (pyrimethanil)
- Elevate (fenhexamid)
- Rovral (iprodione) - efficacy improved with surfactant
- Strobilurins - Flint effective at 3 oz rate, Pristine at 18.5-23 oz rate.
- Endura (boscalid) - effective at Botrytis rate (8 oz); less effective at powdery mildew rate (4.5 oz)
- Switch (relatively new) – cyprodinil (systemic) + fludioxonil (contact)

- Rotate, rotate, rotate!!!!!!!!!!!!!!!!!!!!!
Botrytis; Chemical Control Timing

- **Bloom**: control latent infection if weather wet.
- **Pre-close**: last chance to reach inside of compact cluster.
- **Veraison**: protect from direct invasion from outside cluster.
- **Pre-harvest**: controls spread until harvest, especially if wet.
Botrytis; Integrate Cultural Control

• Varietal selection?
• Improve aeration and light penetration around clusters - leaf pulling, shoot thinning, shoot positioning

• Avoid excessive nitrogen
• Wound management: birds, insects, pm, etc.
Cluster zone leaf removal

- Reduces shading
- Improves aeration, sunlight, and pesticide penetration
- $ - can be mechanized
- Timing makes a difference

<table>
<thead>
<tr>
<th>Leaf removal timing</th>
<th>% rot reduction over 3 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace bloom (reduces cluster compactness)</td>
<td>73</td>
</tr>
<tr>
<td>2-3 wks post bloom</td>
<td>49</td>
</tr>
<tr>
<td>Veraison (8 wks post)</td>
<td>14</td>
</tr>
<tr>
<td>No Leaf removal</td>
<td>*</td>
</tr>
</tbody>
</table>
Review of DM/PM resistance to QoIs

- Resistance risk is high!
- Strobies registered for 15 years; 15 applications = resistance(?) Limit number of applications to two per year
- VA tech study 2005: DM and PM resistance to strobies in VA, NC. PM resistance to DMIs.
- 2007: Strobies alone not recommended for dm/pm
- 2008: DM resistance found in southern PA
Components of resistance management

• Canopy management to maximize light, air, pesticide penetration/efficacy
• Sprayer: maximize efficiency, calibration
• Fungicide applications:
  - Rotate chemistries
  - Tank mixes with old standards
  - Maximize number of chemistries
  - Short intervals, every row, full rates
• Scouting: know your vineyard!
Recommendations

• Pre-bloom:
  - Sulfur, Oils? for pm
  - Mancozeb, Captan for dm, br, phom

• *Critical Period: Bloom + 2-4 weeks
  - Use best materials: new chemistries!
  - Strobies, DMIs (if working) + sulfur, man, ziram, captan, pa
  - Full rates, every row, appropriate volume, short intervals

• Mid summer:
  - New chemistries…only if clean.
  - Eradicants if disease present
  - PA for dm, S or oils for pm (phi?)
Many thanks to:

• Noemi Halbrendt, Mark Wheeler, John Griggs
• PA Wine Marketing and Research Board, Viticulture Consortium East
• BASF, Syngenta, Isagro, Agraquest, Gowan, Agratech, Marrone Bio Innovations, NuFarm Americas, Miller Chemical, Western Farm Service, JH Biotech, Certis, Monterey Ag Resources, Desert King International