



# **Biology and Control of Powdery Mildew**

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# PM FUNGUS (*Erysiphe necator*)

## ■ Obligate parasite

◆ “Eats” only live host tissue (all green tissues), dies without it

◆ Grapes (*Vitis* spp.) + few closely related species

- Individual PM fungi have limited host range (many plants have their “own” PM)







# POWDERY MILDEW: CULTIVAR SUSCEPTIBILITY

- Fungus native to E. North America, hence:
- All *V. vinifera* (European origin) highly susceptible
  - ◆ Chardonnay is a “poster child”
- “Natives”, hybrids less susceptible than *V. vinifera*
  - ◆ Great range of S/R, depending on parentage

# PM DISEASE CYCLE: OVERWINTERING SOURCE

- In NE, other cold-winter climates:  
“chasmothecia” (a.k.a. “cleistothecia”)—  
resting spores on vine surface













# POWDERY MILDEW: WHY SO COMMON?

- Unlike other fungal diseases, does not need free water (rain, dew) to cause infection
  - ◆ Temperature is the primary—but not only--environmental factor governing disease development

# POWDERY MILDEW: EFFECT of TEMPERATURE on DISEASE SPREAD

<u>Temp., °C (°F)</u>	<u>“Generation time”* (days)</u>
8 (48)	25
12 (54)	18
15 (59)	11
17 (63)	7
23 (74)	6
26 (79)	5
30 (86)	6
32 (90)	not active
≥35 (95)	lethal

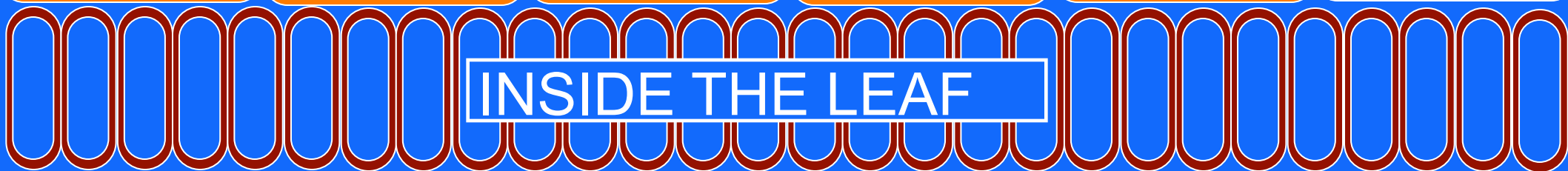
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\* Latent period



Epidermis

INSIDE THE LEAF

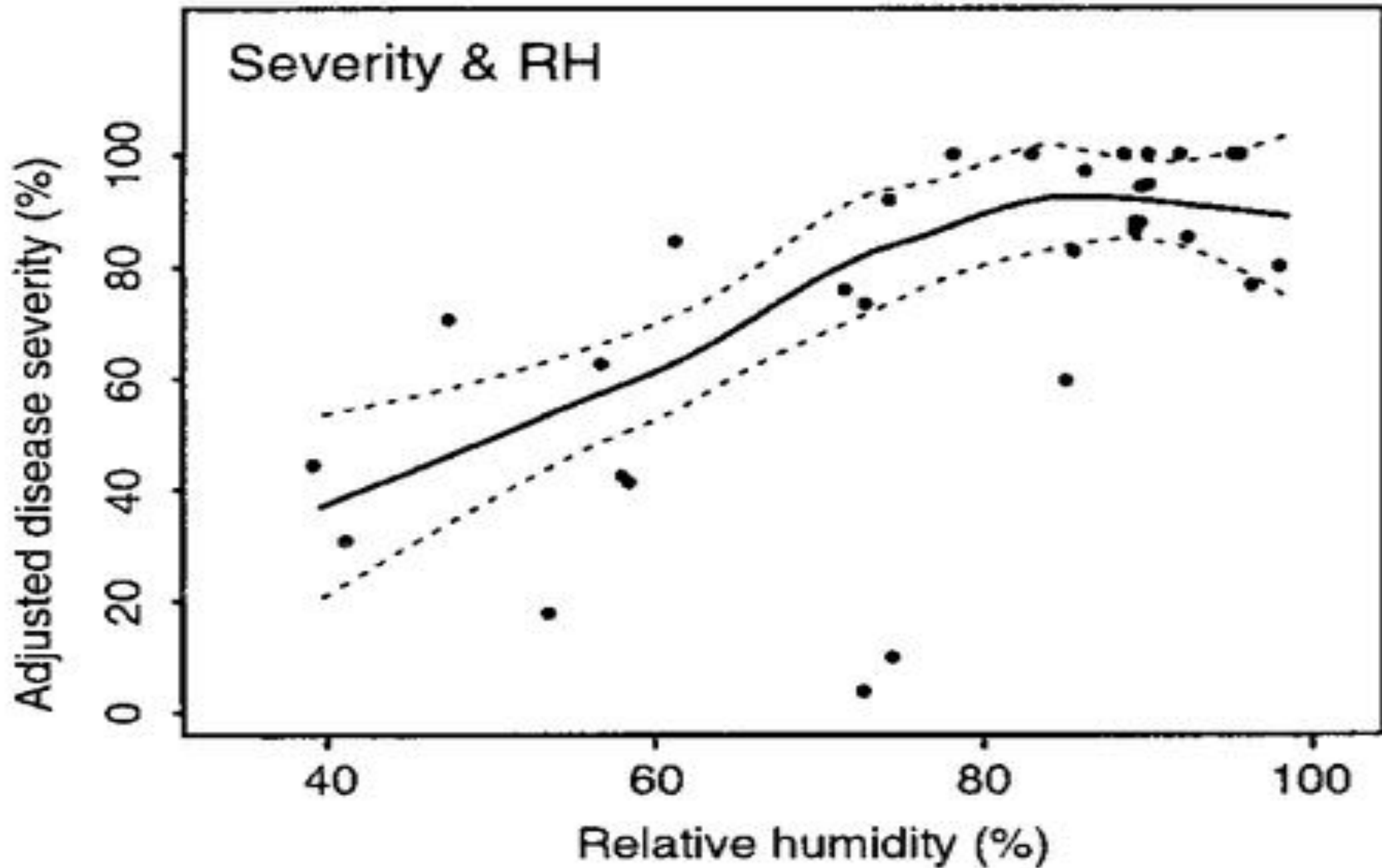


# POWDERY MILDEW: OTHER ENVIRONMENTAL EFFECTS

## ■ Atmospheric humidity

- ◆ Disease often most severe near bodies of water, other vineyard sections subject to high humidity





# POWDERY MILDEW: OTHER ENVIRONMENTAL EFFECTS

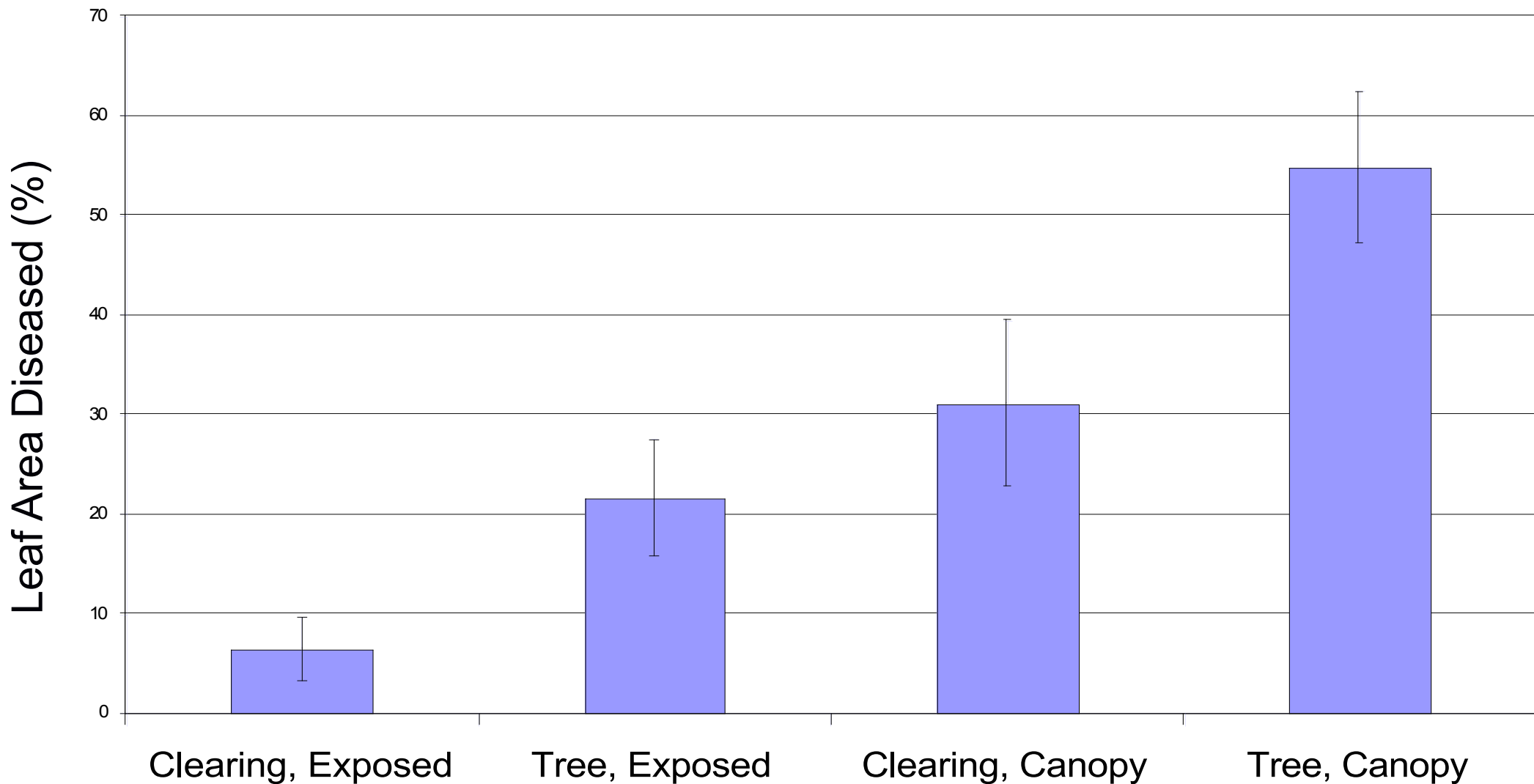
## ■ Sunlight Exposure

- ◆ Disease much more severe on shaded tissues
  - ✦ Inside dense canopies
  - ✦ Near trees
  - ✦ Prolonged cloudiness

Chardonnay, 4 light levels: Tree shade, inner canopy (1) or outer canopy (2); Clearing, inner (3) or outer canopy (4)



# Severity of Powdery Mildew on Foliage of cv. Chardonnay Vines Subjected to Different Forms of Natural Shade '05



# ENVIRONMENTAL EFFECTS: SUN-EXPOSED *vs.* SHADED

## ■ Leaf temperature

- ◆ 2 to 23°F (avg. 9°F) higher for sun-exposed
  - ◆ Fungal development: 77-83° = optimum; 90° = maximum; ≥95° = lethal

# ENVIRONMENTAL EFFECTS: SUN-EXPOSED *vs.* SHADED

## ■ UV-B Radiation

- ◆ Inner canopy, no trees--8% of exposed
- ◆ Inner canopy, trees--2% of exposed

Powdery mildew fungus grows on plant surface!




**Unpigmented (= No suntan!)**





UV filter: Removed 92% of UV-B, allowed longer (heat-producing) wavelengths to pass through

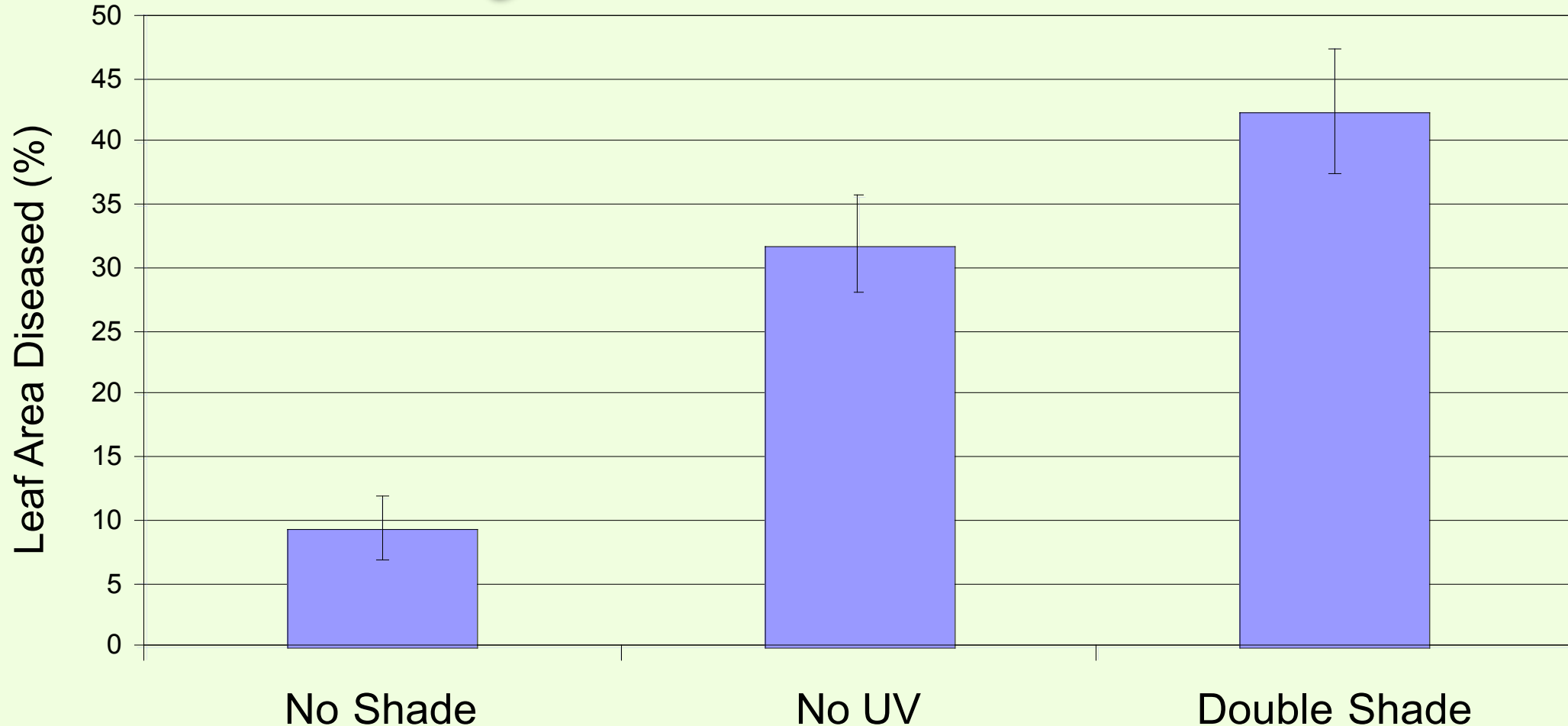




Heat+, UV-

Double shade (Heat-, UV-)

# Severity of Powdery Mildew on Foliage Subjected to Different Light Treatments (cv. Chancellor; Geneva, NY 2006)



# POWDERY MILDEW: CULTURAL CONTROL

- Canopy management to provide good ventilation, sun exposure
  - ◆ Training system, shoot thinning, leaf pulling

# CULTURAL CONTROL: CHARDONNAY

- Two training systems
  - ◆ Vertical Shoot Positioning
  - ◆ Umbrella-Kniffen

# NEW YORK STATE VARIABLE TRAINING

UMBRELLA - KNIFFEN



VERTICAL SHOOT POSITIONING



# CULTURAL CONTROL: CHARDONNAY

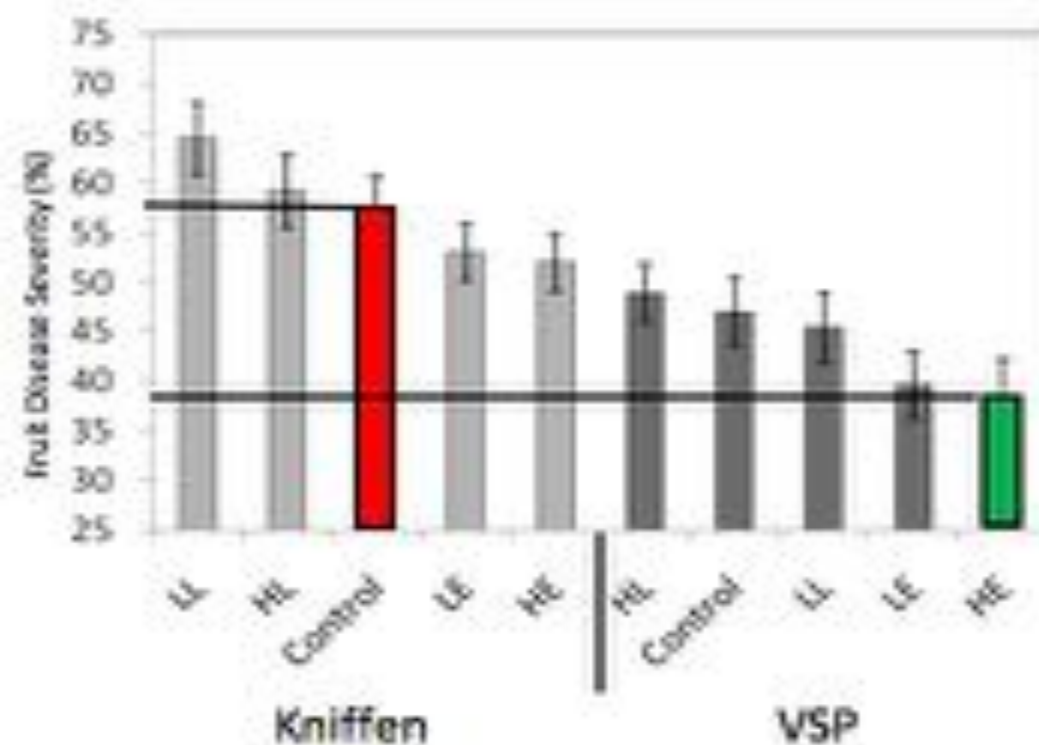
## ■ Two training systems

- ◆ VSP
- ◆ Umbrella-Kniffen

## ■ Five leaf-removal treatments

- ◆ **EARLY** (2 wk post-bloom) or **LATE** (5 wk post-bloom)  
X
- ◆ **HEAVY** (2 leaves above/below cluster) or **LIGHT** (1 leaf above/below)
- ◆ **None** (control)

## Powdery Mildew Severity on Clusters of cv Chardonnay: 2 Training Systems x 5 Leaf-Pulling Treatments



Term	Estimate	Std Error	Prob> t
Training[Kniffen]	6.79	1.07	<0.0001
Leaf Pull[Control]	0.96	2.32	0.6780
Leaf Pull[Light Early]	-4.98	2.32	0.0325
Leaf Pull[Heavy Early]	-5.63	2.30	0.0153
Leaf Pull[Light Late]	3.78	2.33	0.1063
Leaf Pull[Heavy Late]	2.67	2.51	0.2899

### Binary Code

First letter is severity of leaf removal; H = heavy leaf pull, removal of the two leaves above and below the cluster. L = light leaf pull, removal of one leaf above and below the cluster.

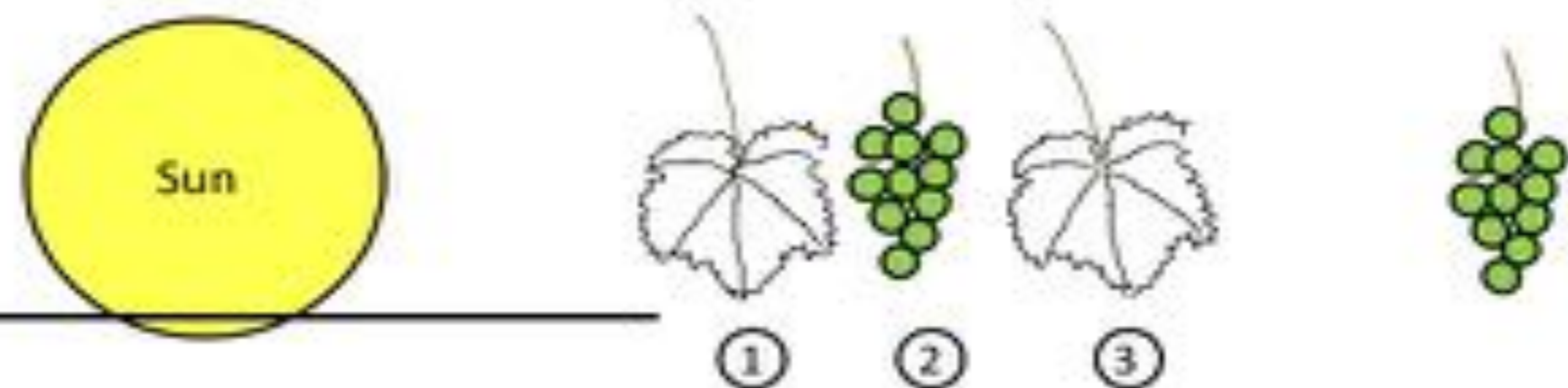
Second letter is timing of leaf removal; E = early leaf pull, removal of leaves four weeks post bloom. L = late leaf pull, removal of leaves six weeks post-bloom.



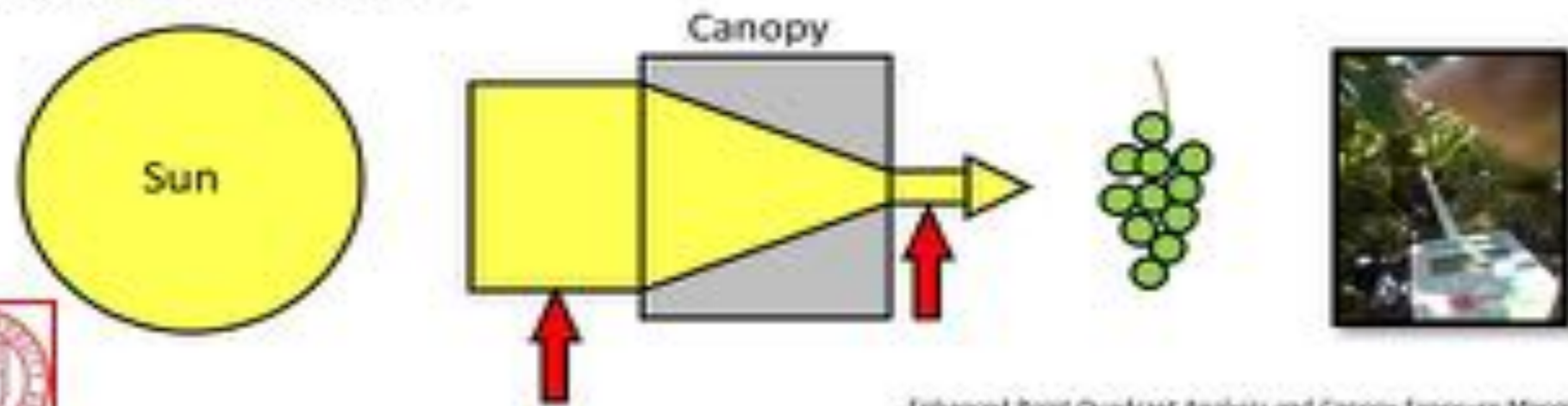
# EFFECT OF CLUSTER EXPOSURE ON SPRAY DEPOSITION

If light gets in, sprays get in  
(and *vice versa*)

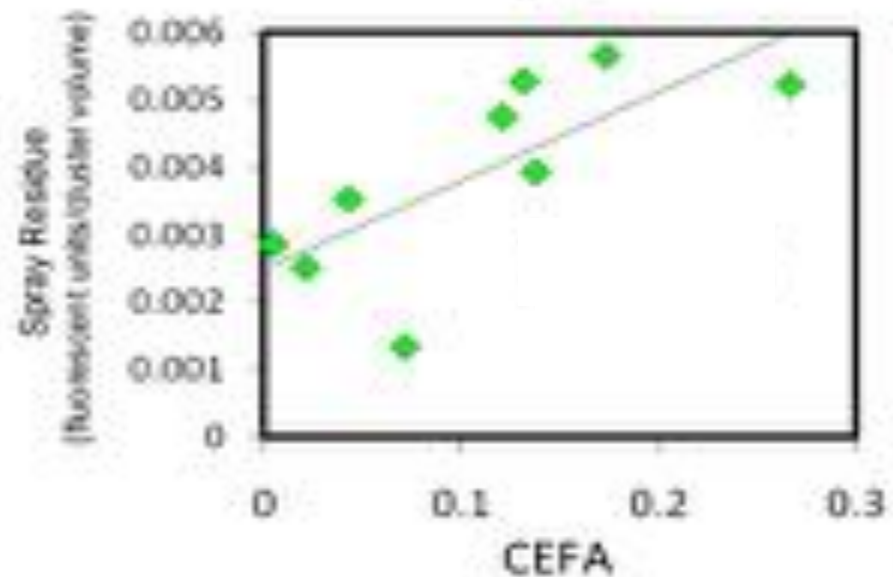
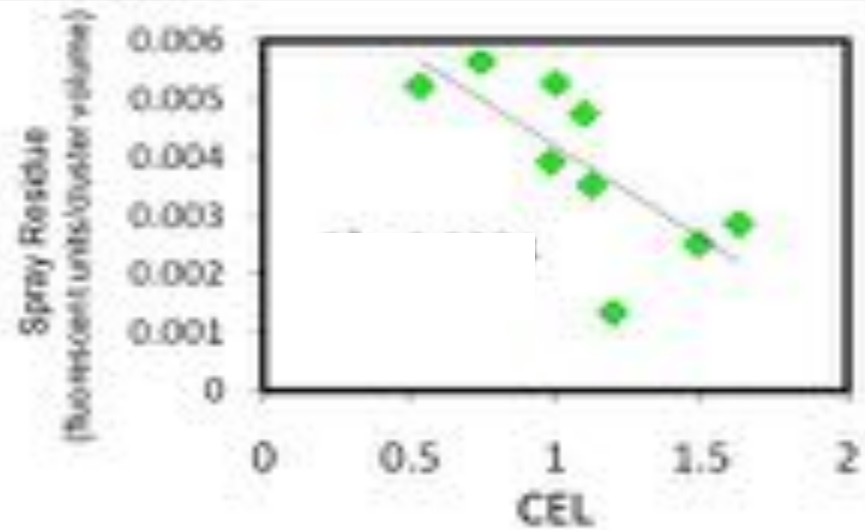
Cluster Exposure Layer (CEL) – Number of shading layers between clusters and the nearest canopy boundary.



Cluster Exposure Flux Availability (CEFA) – The proportion of above canopy photon flux that reaches clusters.

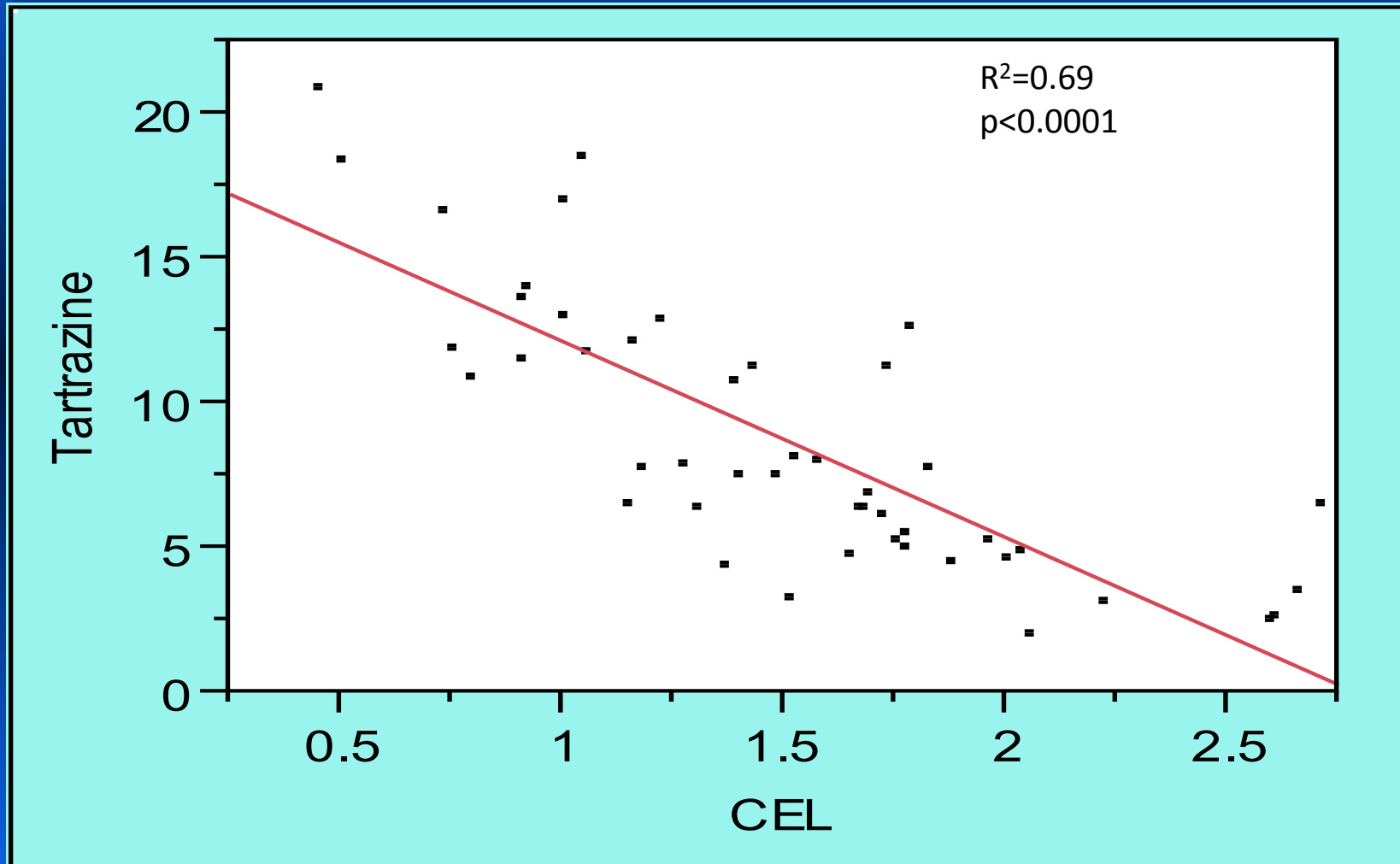


# Spray residue as a function of canopy density, as measured by CEL and CEFA



# Spray deposition vs. Cluster exposure

(airblast sprayer, 50 gpa; 5 NY vineyards, July 2011)



# SUN-EXPOSED *vs.* SHADED: PRACTICAL IMPLICATIONS

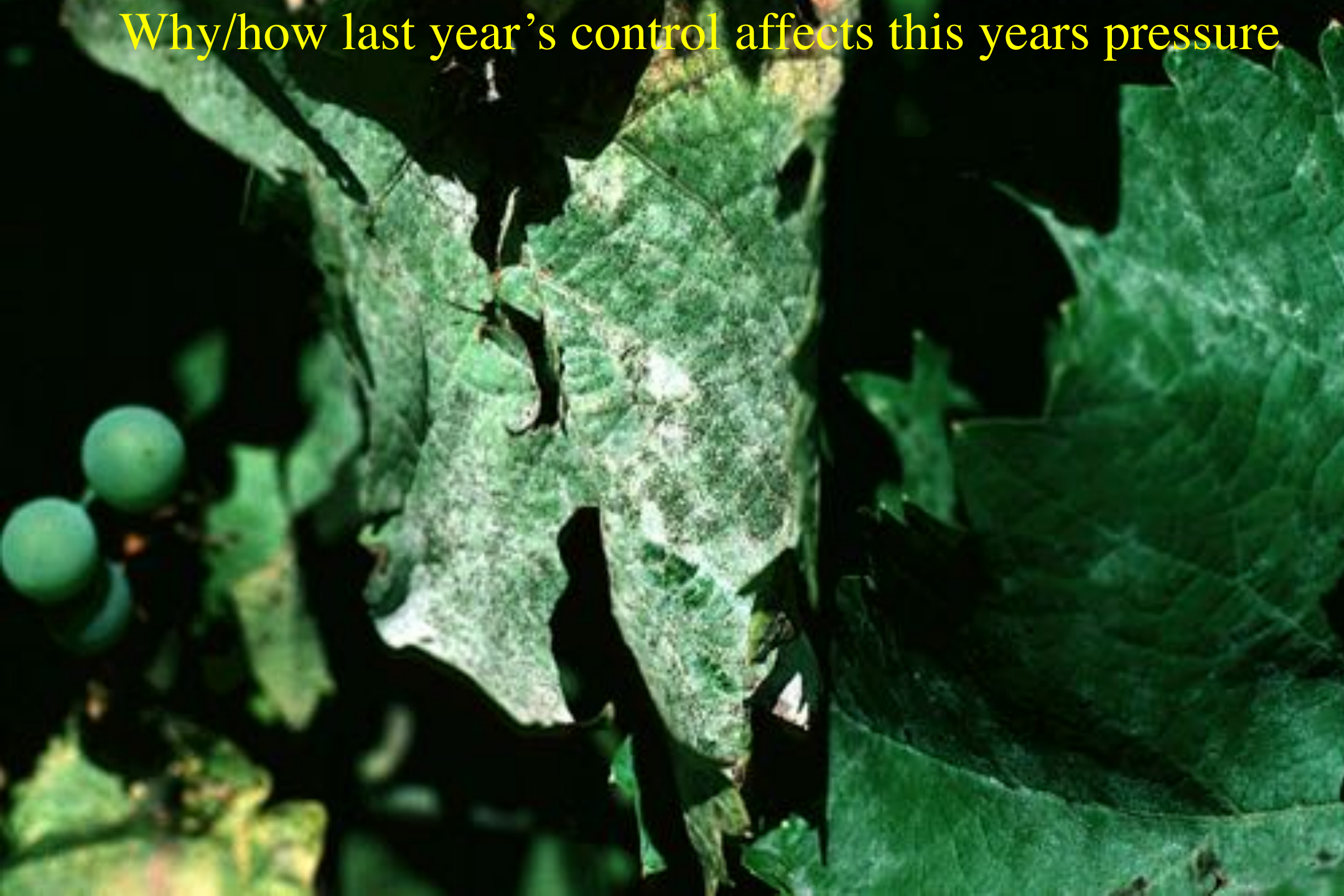
## ■ Pruning/training effects on PM

- ◆ “Optimal” levels of sun exposure should reduce PM pressure

## ■ Disease forecasting

- ◆ Prolonged cloudy/rainy periods/ seasons favor PM development and *vice versa*
  - ◆ When to intensify *vs.* relax spray programs

Why/how last year's control affects this years pressure



# POWDERY MILDEW CONTROL: EFFECT OF CARRYOVER INOCULUM (Chardonnay, Geneva 2002-03)

<i>Sept. 2002</i>	April 2003
<i>Foliar PM</i>	Chasmothecia
<u><i>% Severity</i></u>	<u>per kg bark</u>
1	1,300
17	5,300
28	28,700

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\*Sprays applied immediate prebloom through fruit set only

# POWDERY MILDEW CONTROL: EFFECT OF CARRYOVER INOCULUM

(Chardonnay, Geneva 2002-03)

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<i>Foliar PM</i>	Chasmothecia	Cluster PM
<u><i>% Severity</i></u>	per kg bark	<u><i>% Severity*</i></u>
1	1,300	11
17	5,300	22
28	28,700	48

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\*Sprays applied immediate prebloom through fruit set only



# POWDERY MILDEW

PERIOD OF HOST  
SUSCEPTIBILITY

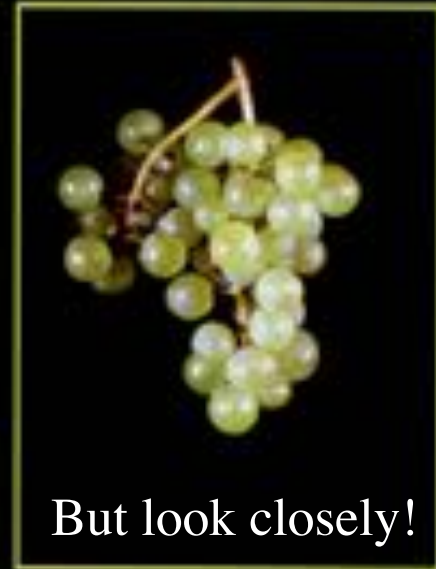
# Chardonnay



**21 June  
prebloom  
Brix=nd**



**4 July  
2mm fruit  
Brix=nd**



But look closely!

**17 July  
5mm fruit  
Brix=4.6**



**2 August  
Brix=4.2**



**15 August  
Brix=4.8**



**29 August  
Brix=9.3**

# POWDERY MILDEW CONTROL: EFFECT OF PRE-FLOWERING + 1st POST-FLOWERING **SPRAYS** (cv. 'Rosette', Geneva, NY)

Treatment, rate (a.i.)/A	Spray dates	# Sprays	% Area diseased	
			Clusters	Leaves
Untreated.....	none	0	26	73
<b>Abound, 14 fl oz.....</b>	<b>24 Jun, 8 Jul</b>	<b>2</b>	<b>2</b>	<b>58</b>
Abound, 14 fl oz.....	10 Jun-19 Aug	6	1	17

1st open flower = 24 Jun; Veraison = 20 Aug; Harvest = 15 Sep

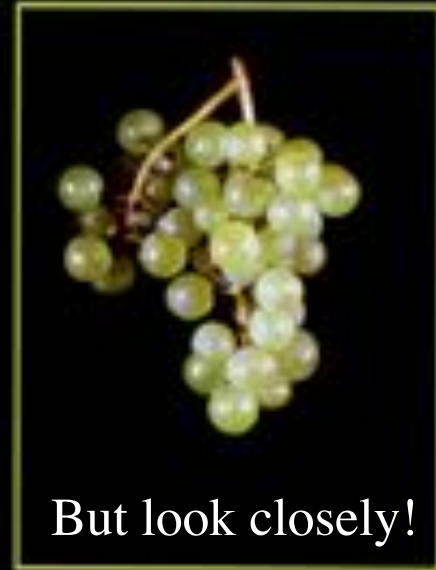
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Brix=4.8**



**29 August  
Brix=9.3**

Uninfected



Diffuse infection



Uninfected



Diffuse infection



# Effect of Diffuse Powdery Mildew Infections on Botrytis Development



# POWDERY MILDEW: SEASONAL SPRAY STRATEGY

- Early season (1- to 5-in)
  - ◆ *V. vinifera* only
  - ◆ Initiation of spray program guided by temp, rain events, need to control other pests/diseases (running the sprayer anyway?)

# POWDERY MILDEW: SEASONAL SPRAY STRATEGY

- Early season (1- to 5-in shoots)
  - ◆ Can wait for suitably warm temps
    - ◆ Most PM fungicides have some post-infection activity
    - ◆ Need to control early season insect pests or Phomopsis may dictate timing of first application (tank-mix PM fungicide)



# POWDERY MILDEW: SEASONAL SPRAY STRATEGY

## ■ 10-in shoots

- ◆ *V. vinifera* cultivars: delay no longer
- ◆ Susceptible hybrids (e.g., Seyval): a good idea
- ◆ Can continue to delay on natives, relatively R hybrids unless scouting reveals activity (e.g., on moderately S cultivars)

# POWDERY MILDEW: SEASONAL SPRAY STRATEGY

- Prebloom thru “fruit set + 2 wk”
  - ◆ **CRITICAL!!**
    - ◆ Best materials
    - ◆ Best application techniques
    - ◆ **DON’ T CHEAT**

# POWDERY MILDEW: SEASONAL SPRAY STRATEGY

- “Fruit set +2wk” thru bunch closure
  - ◆ Berries more resistant but still susceptible
  - ◆ Also need to maintain control on leaves
    - ✦ Don’t necessarily need “best” materials but still need something quite effective

# POWDERY MILDEW: SEASONAL SPRAY STRATEGY

- Mid- thru late summer
  - ◆ Maintain control of foliar infection as appropriate for:
    - ◆ Susceptibility/value of crop
    - ◆ Presence of disease in vineyard
    - ◆ Weather
    - ◆ Desire to make easier next year (1° inoculum)

# POWDERY MILDEW

FUNGICIDES

# POWDERY MILDEW FUNGICIDES: SULFUR

## ■ ADVANTAGES

- ◆ Inexpensive
- ◆ Effective
- ◆ No resistance
- ◆ “Organic”

# POWDERY MILDEW FUNGICIDES: SULFUR

## ■ Negatives

- ◆ Worker exposure
- ◆ Toxic to predacious mites
- ◆ Phytotoxic to some purple-fruited native and hybrid cultivars

Sulfur injury

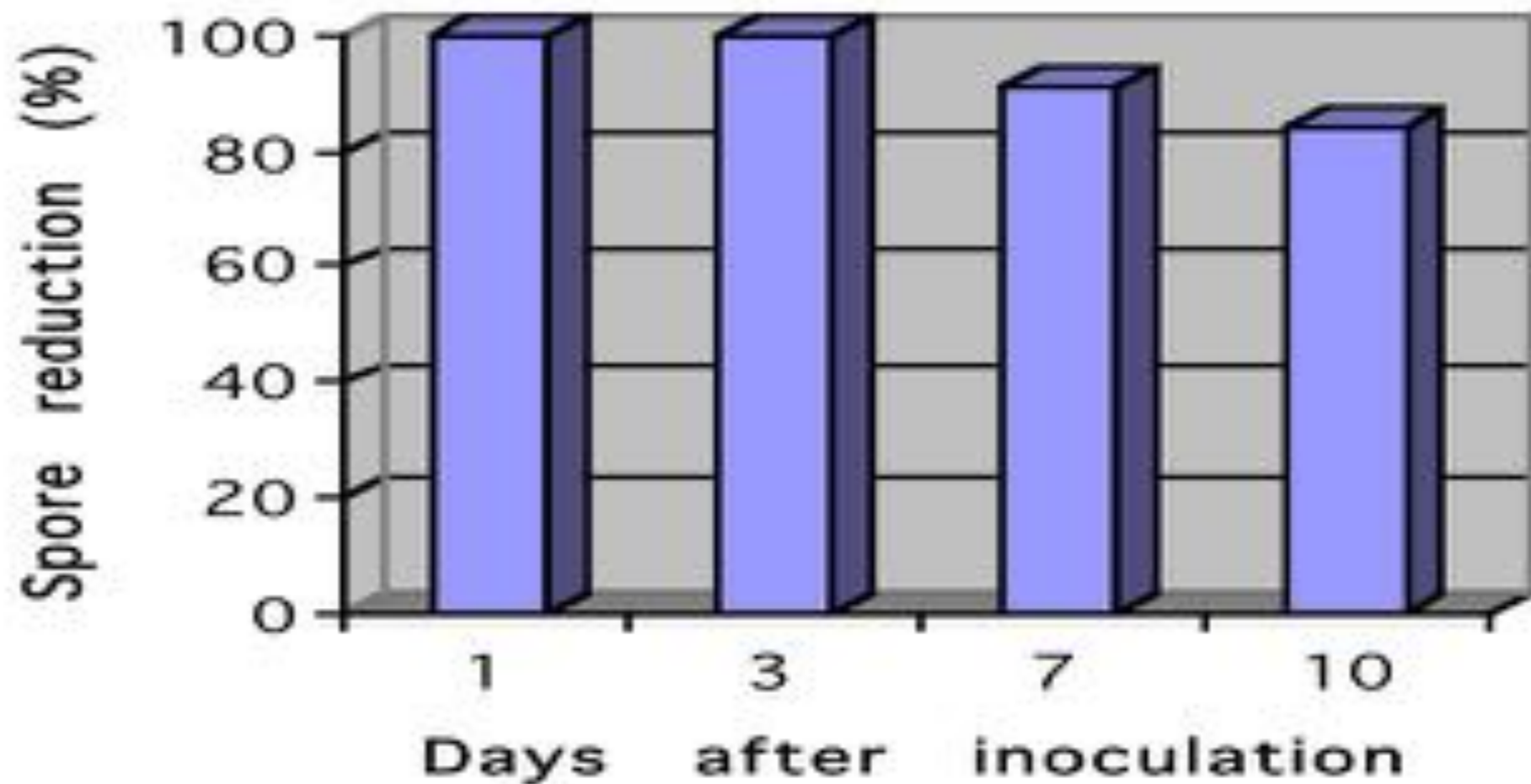




# POWDERY MILDEW FUNGICIDES: SULFUR

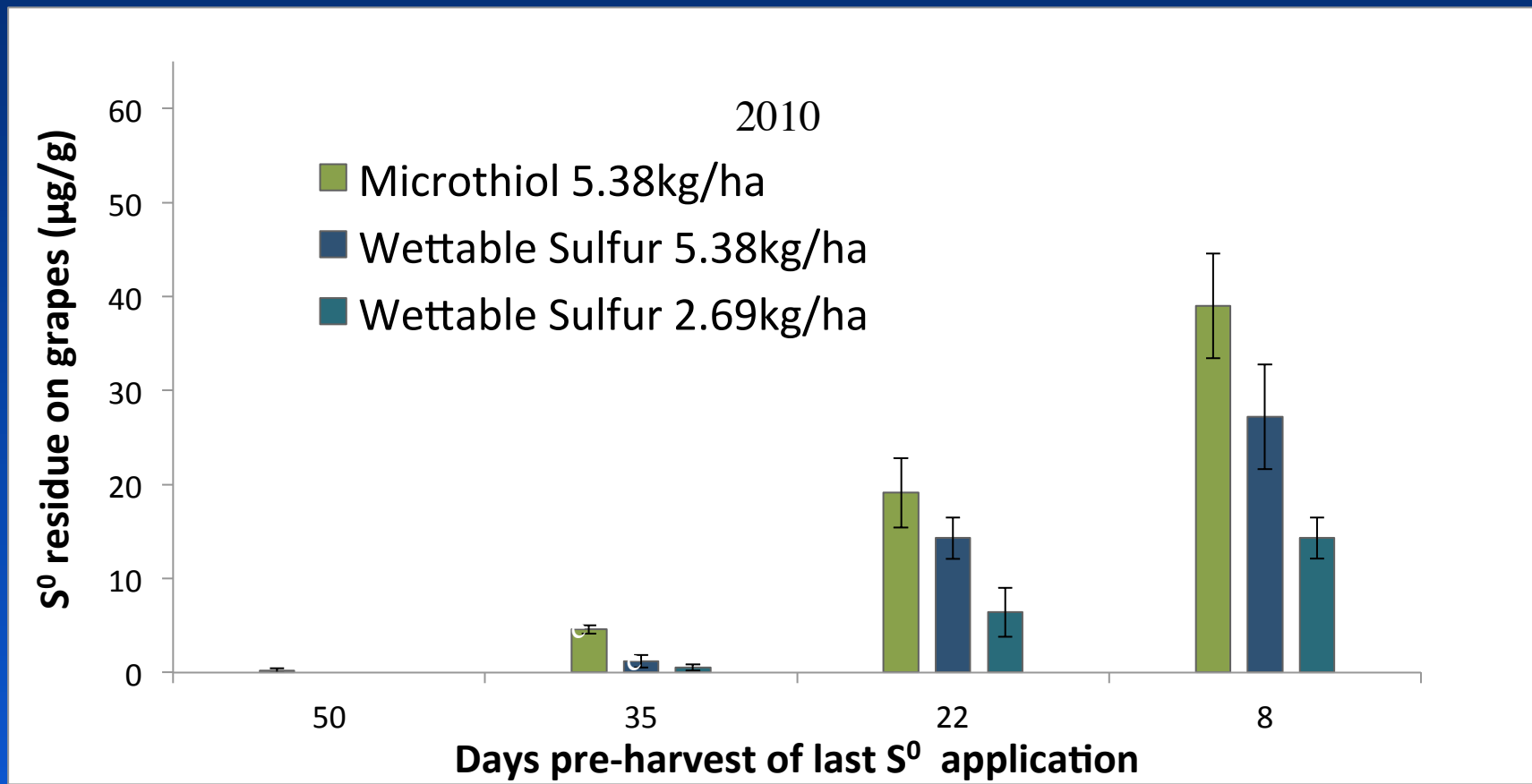
- Other potential negatives
  - ◆ “Poor activity at temps <65°F”
    - ◆ Not True
  - ◆ “Protective activity only”
    - ◆ Not True

## SULFUR: CURATIVE ACTIVITY



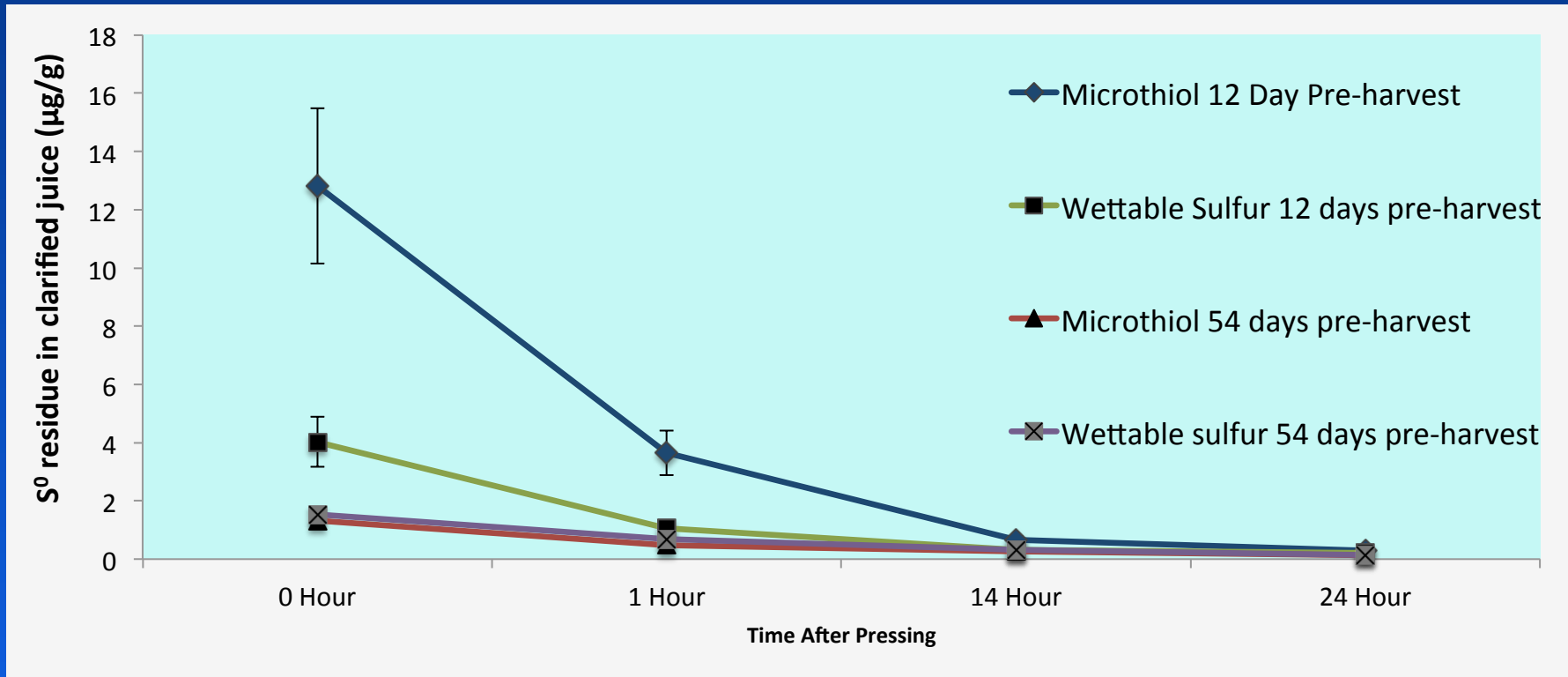
# POWDERY MILDEW FUNGICIDES: SULFUR

- Other potential negatives
  - ◆ “Poor activity at temps <65°F”
    - ✦ Not True
  - ◆ “Protective activity only”
    - ✦ Not True
  - ◆ “Risk of stinky wines (H<sub>2</sub>S)”
    - ✦ It depends



- At 5.4 kg/ha, more residue from Microthiol vs. wettable S
- Wettable S: 8 d @ 3 lb/A = 22 d @ 6 lb/A
- At 5.4 kg/ha (either formulation), residues < 10µg/g only w/≥35 days PHI

# Settling experiment (white vinification)



- Major differences immediately after pressing, but <1 µg/g after settling, regardless of starting level!

# POWDERY MILDEW FUNGICIDES: THE “BIG GUNS”

- Vivando (FRAC Grp. U8)
  - ◆ One of two consistent top performers in my trials
  - ◆ PM only
  - ◆ Appears to provide significant “vapor activity”
    - ◆ Improves coverage, essentially

GROUP 3 | 40 FUNGICIDES

PULL HERE TO OPEN ►



**RevusTop**<sup>®</sup>

syngenta.

## Fungicide

*Active Ingredients:*

Mandipropamid (CAS No. 374726-62-2) ..... 21.9%

Difenoconazole (CAS No. 119446-68-3) ..... 21.9%

*Other Ingredients:* ..... 56.2%

**Total:** ..... 100.0%

Revus Top is formulated as a suspension concentrate (SC).

Contains 2.08 pounds of mandipropamid active ingredient and 2.08 pounds of difenoconazole active ingredient per gallon.

**KEEP OUT OF REACH OF CHILDREN.**

### CAUTION

See additional precautionary statements and directions for use inside booklet.

EPA Reg. 100-1278

EPA Est. 100-NE-001

SCP 1278A-L1E 0514  
4039307

**2.5 gallons**  
Net Contents

TM

# POWDERY MILDEW FUNGICIDES: THE “BIG GUNS”

- Luna Experience (FRAC Grps. 3, 7)
  - ◆ One of two consistent top performers in my trials
  - ◆ PM + Botrytis (+ BR at highest rate)
    - ✦ Tebuconazole (“Elite”, Grp. 3) component
  - ◆ Appears to provide significant “vapor activity”



# POWDERY MILDEW FUNGICIDES: A “PRETTY BIG GUN”

## ■ QUINTEC (FRAC Grp. 13)

- ◆ Consistently excellent, one or two cases of resistance in eastern US
- ◆ PM only
  - ◆ Protective activity only (unlike previous two)
- ◆ Appears to provide significant “vapor activity”

# POWDERY MILDEW FUNGICIDES: “SDHI” (Group 7)

- First product (boscalid, component of Pristine) in 2003
- Several “2<sup>nd</sup> generation”, appear to be somewhat more active
  - ◆ Luna Experience
  - ◆ Aprovia (PM only)
  - ◆ Aprovia Top (+ BR, anthracnose)

# POWDERY MILDEW FUNGICIDES: TORINO (FRAC Grp. U6)

- Unique MOA (good rotational partner)
- PM only
  - ◆ Not quite as strong as other “PM-only”s, but still very good (“B+” vs. “A”)

# POWDERY MILDEW FUNGICIDES: SI/ DMI (FRAC Grp. 3)

## ■ Several, you know them

- ◆ Activity somewhat compromised by “partial” resistance, still largely effective depending on product & rate
  - ◆ Difenoconazole (e.g., Revus Top) consistently best
  - ◆ Flutriafol (Rhyme, TopGuard EQ) also looking strong

# POWDERY MILDEW FUNGICIDES: STROBILURINS (FRAC Grp. 11)

- RESISTANCE RISK IS VERY HIGH
  - ◆ Multiple PM failures nationwide when used alone
  - ◆ If using, I recommend only Pristine

# POWDERY MILDEW FUNGICIDES: “ALTERNATIVE” PRODUCTS

- Primarily contact action, “body” of PM fungus is on outside of plant
  - ◆ A number of materials are effective against PM that are ineffective against most other fungal pathogens, which grow inside infected organs

Powdery mildew grows on plant surface!



# POWDERY MILDEW FUNGICIDES: “TOPICAL” PRODUCTS

- Primarily contact action, “body” of PM fungus is on outside of plant
  - ◆ Oils
  - ◆ Potassium salts (Armicarb, Kaligreen, Nutrol)
  - ◆ Hydrogen peroxide (Oxidate)
  - ◆ Biological extracts (Milsana), fermentation products (Serenade, Sonata)



# POWDERY MILDEW FUNGICIDES: “TOPICAL” PRODUCTS

## ■ Oils

- ◆ JMS Stylet Oil more effective than others we've tested; has some protective activity also

## ■ Potassium salts

- ◆ All are equivalent, choose the cheapest

## ■ Biological extracts (Milsana), fermentation products (Serenade, Sonata)

