

# Biology and Control of Powdery Mildew

Wayne Wilcox

Dept. Plant Pathology

Cornell Univ., NY State Agric. Expt. Sta.

Geneva, NY

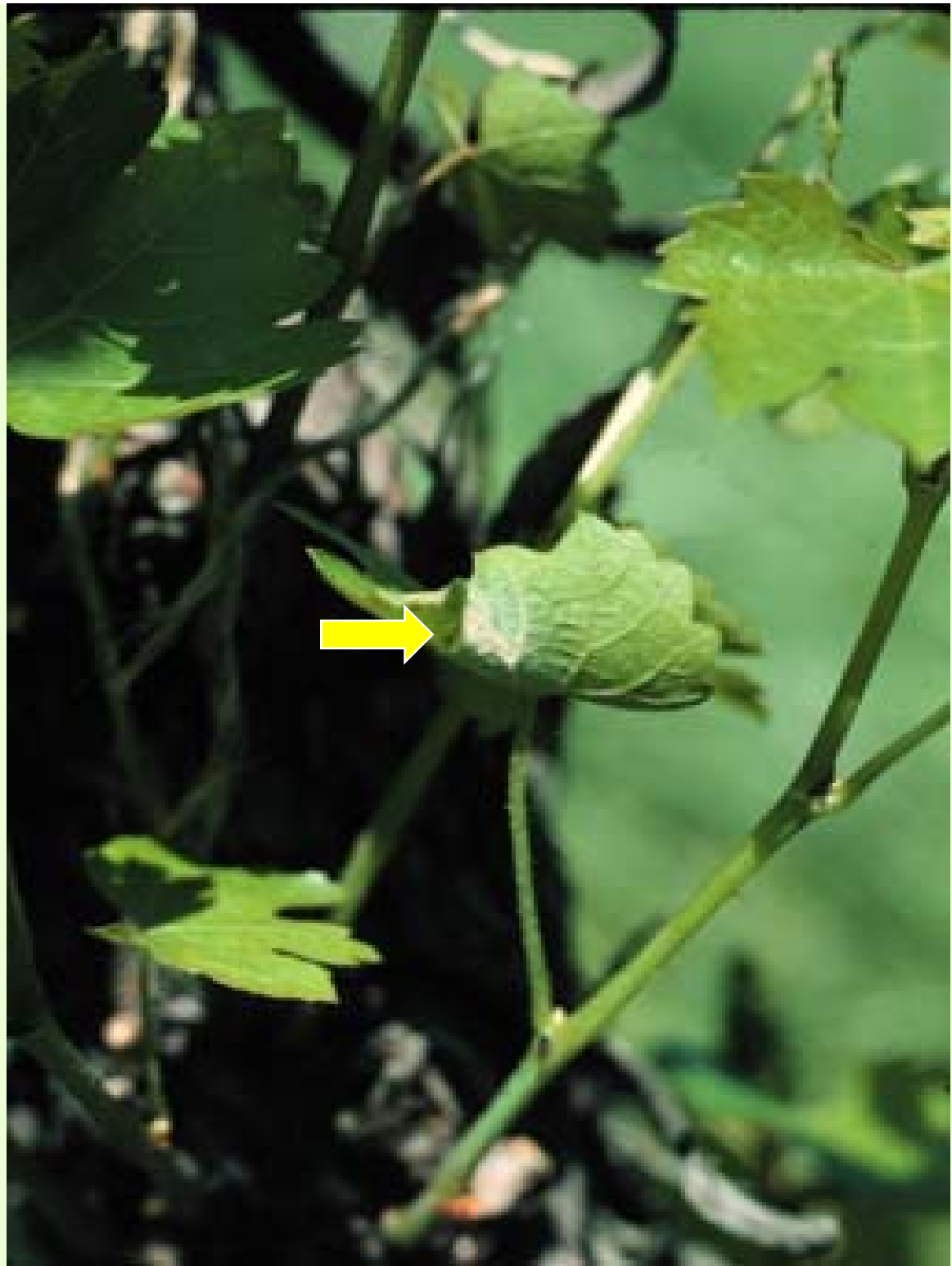














# POWDERY MILDEW: EFFECT of TEMPERATURE on DISEASE SPREAD

<u>Temp, °F</u>	<u>Generation time (days)</u>
46	25
54	18
59	11
63	7
74	6
79	5
86	6
90	not active
≥95	lethal

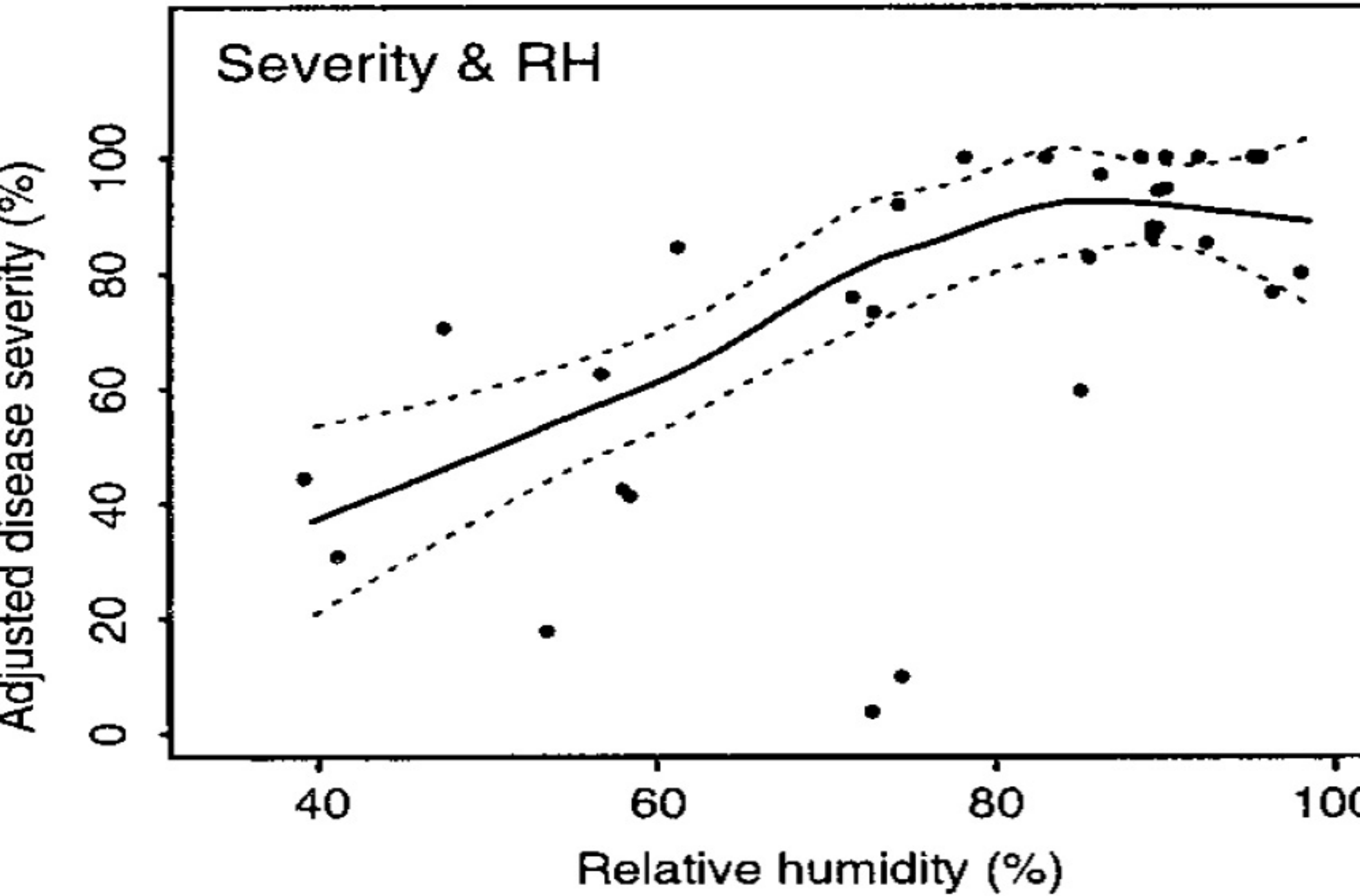
# POWDERY MILDEW: OTHER ENVIRONMENTAL EFFECTS

## v Atmospheric humidity

### o Disease often most severe:

Φ Humid seasons

Φ Near bodies of water, other vineyard sections subject to high humidity





# POWDERY MILDEW: OTHER ENVIRONMENTAL EFFECTS

## v Light Exposure

- o Disease “more severe” where shaded
  - o Poorly quantified, little formal examination

# POWDERY MILDEW: EFFECT OF SUN EXPOSURE

(cv. Chancellor; Geneva, NY 2005)

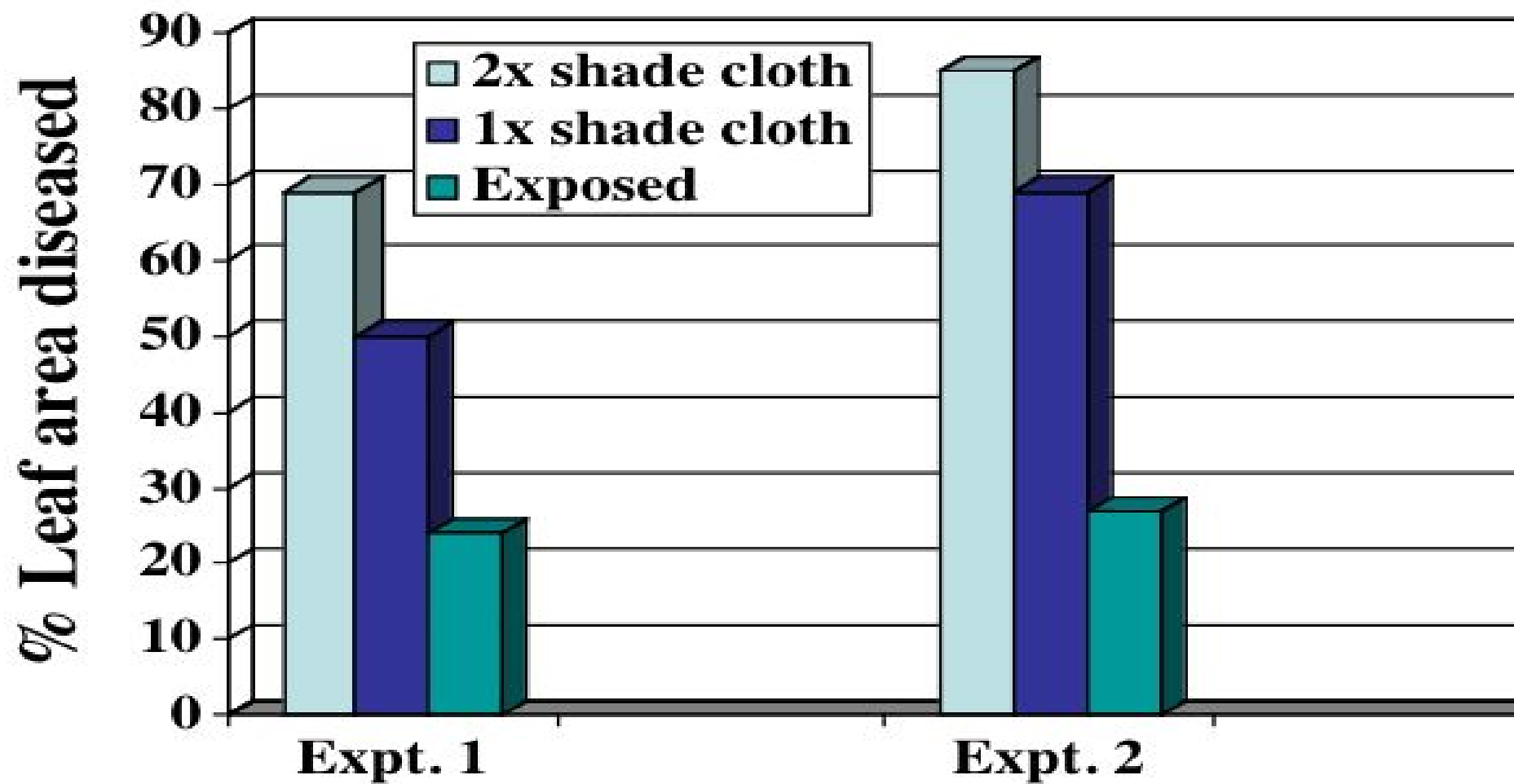
- v Vines covered with:
  - o 1 layer of shade cloth
    - Φ Admitted 30-40% of available solar radiation
  - o 2 layers of shade cloth
    - Φ Admitted 20% of available solar radiation



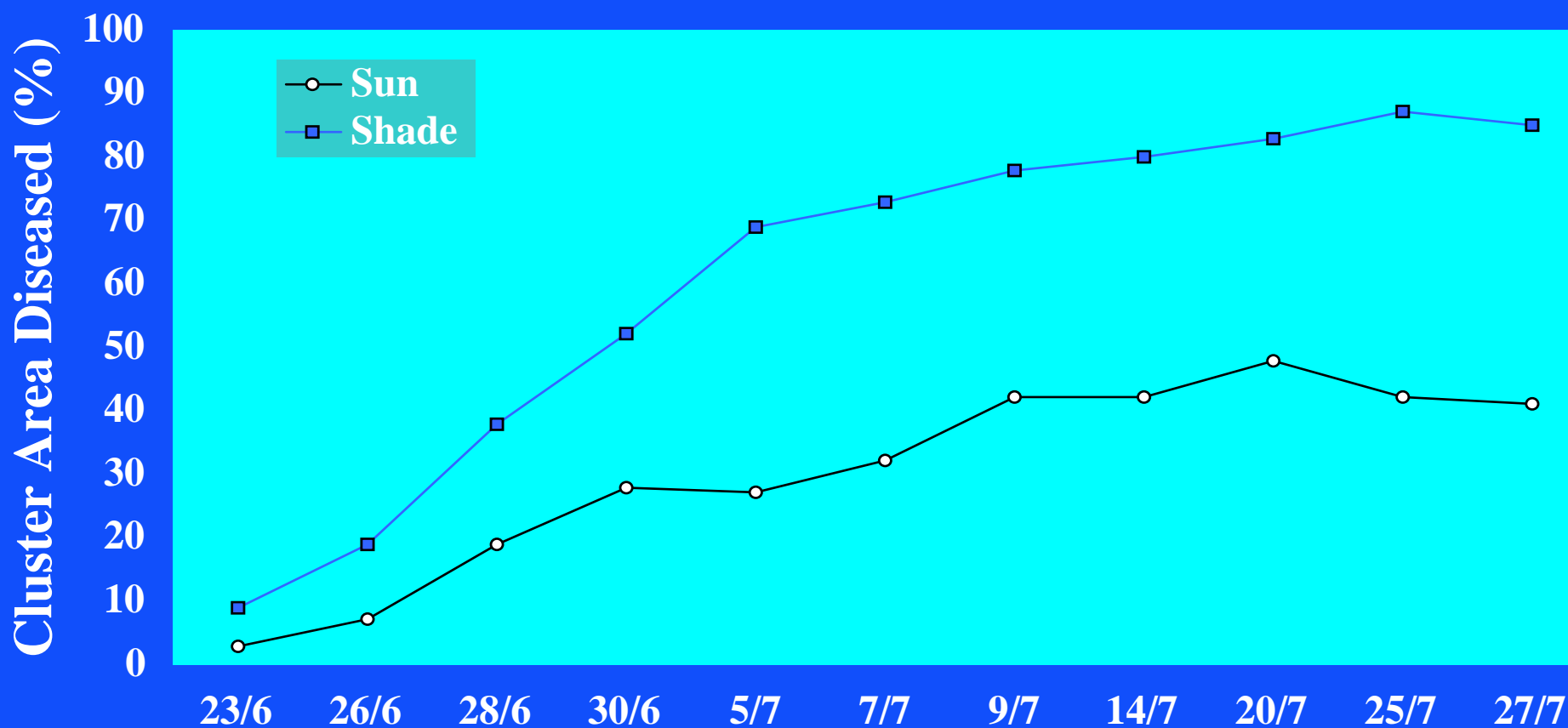




# EFFECT OF SUN EXPOSURE: DISEASE SEVERITY (Shade cloth expts.)



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



# POWDERY MILDEW: EFFECT OF NATURAL SHADING

(cv. Chardonnay; Geneva, NY 2005)

- v Two sets of vines
  - o 1) Immediately west of tall pine trees
    - o Shaded in morning
  - o 2) Away from trees
    - o Well-exposed, sun not blocked





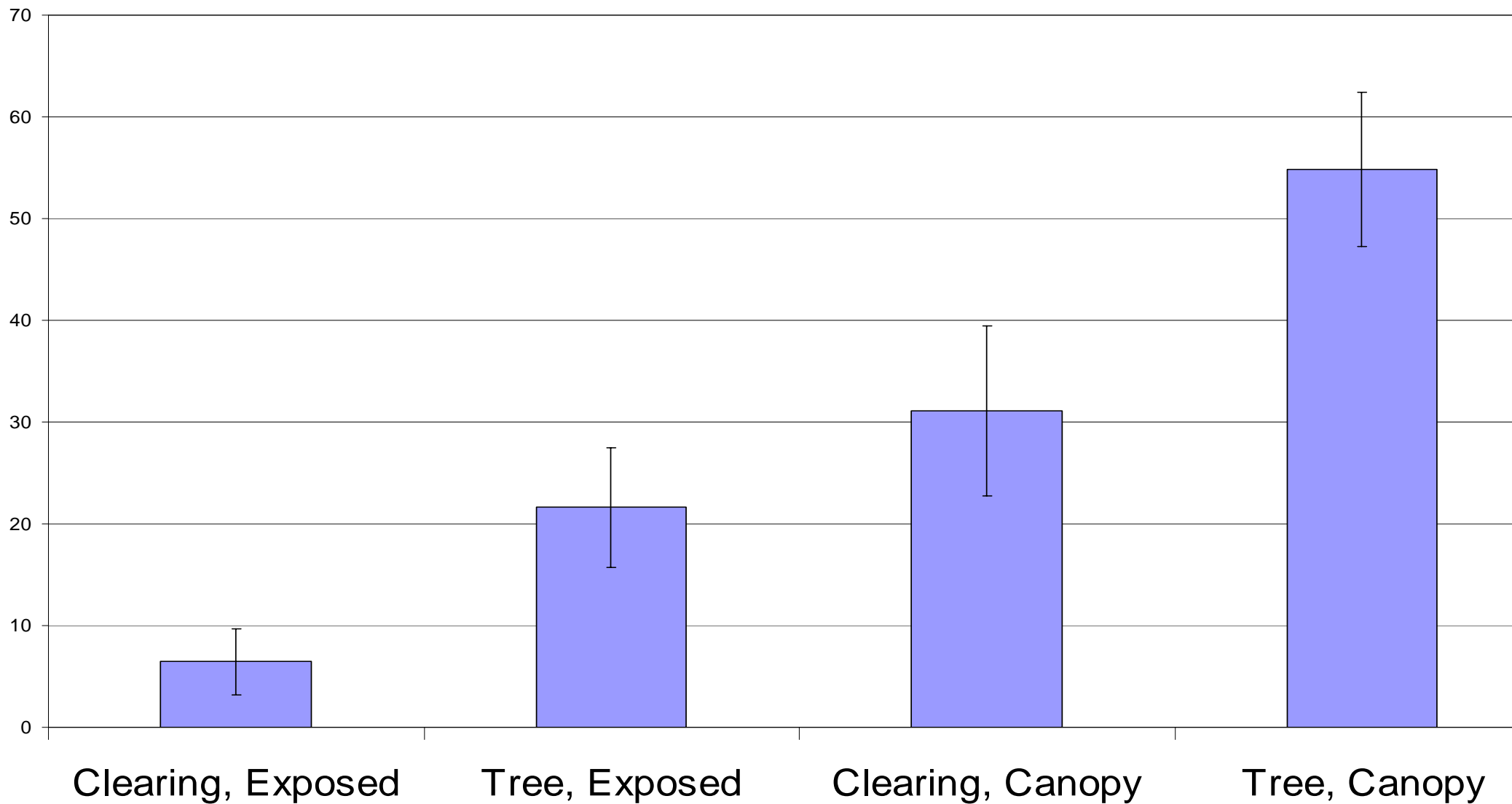
# POWDERY MILDEW: EFFECT OF SUN EXPOSURE

(Chardonnay; Geneva, NY 2005)

- √ Two sets of vines
  - ∪ 1) Immediately west of tall pine trees
  - ∪ 2) Away from trees
- √ **Inoculated two subsets of shoots on each**
  - ∪ i) **Center of canopy**
    - Φ Shaded by grape foliage
  - ∪ ii) **Outer edge of canopy**
    - Φ Exposed to full sun



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





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

- ✓ Air temperature--No difference
- ✓ Relative humidity--No difference
- ✓ Leaf temperature: 2 to 23°F higher for sun-exposed
  - Φ Fungal development:
    - 75-85°F = optimum
    - 90°F = growth stops
    - $\geq 95^\circ\text{F}$  = lethal

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

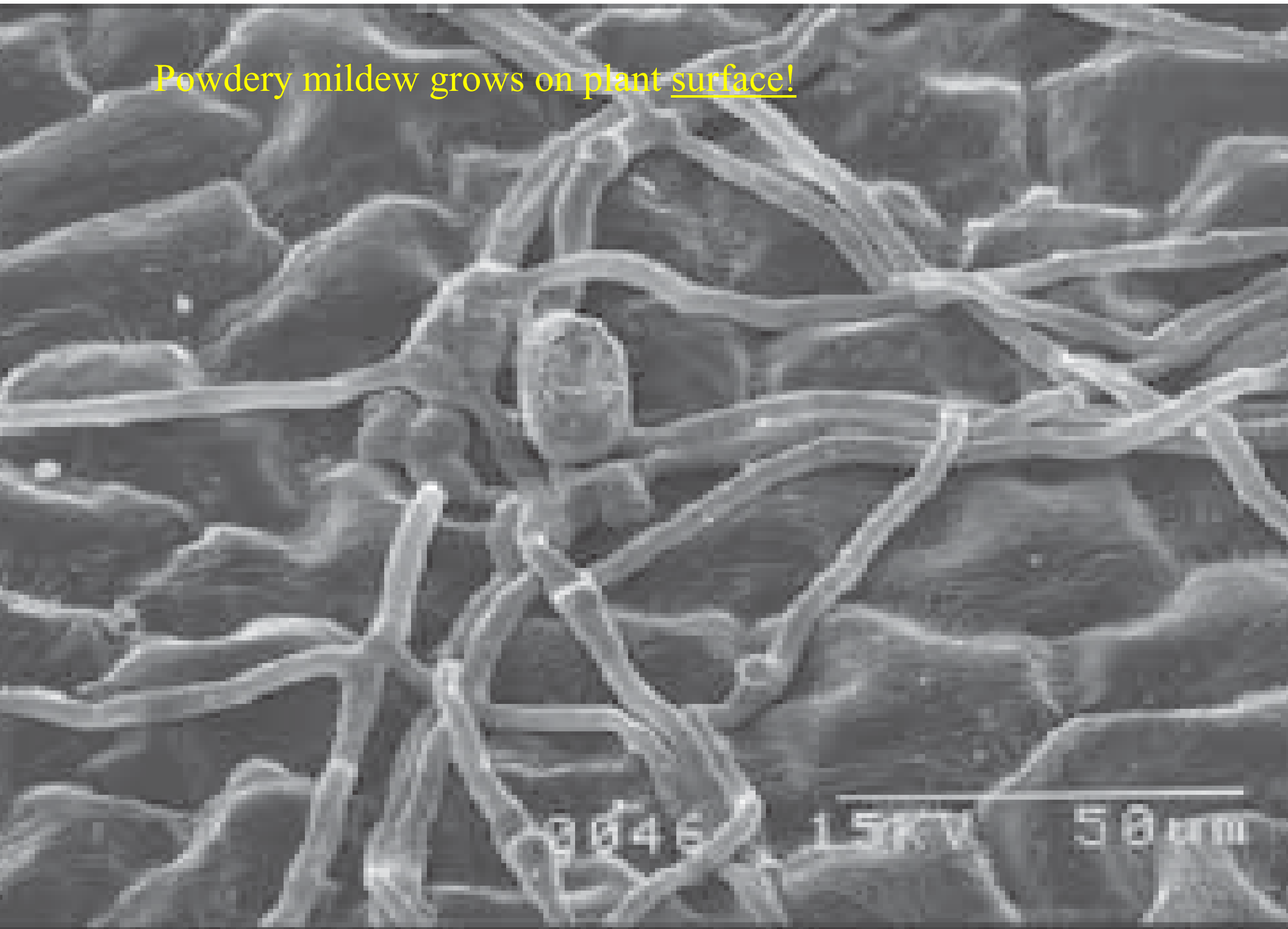
## √ UV-B Radiation

- ∪ Single shade cloth--25% of exposed
- ∪ Double shade cloth--8% of exposed

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

Powdery mildew grows on plant surface!





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

- √ Pruning/training effects on PM
  - √ “Optimal” levels of sun exposure should reduce PM pressure

# 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*
    - Φ When to intensify *vs.* relax spray programs

# POWDERY MILDEW

PERIOD OF HOST  
SUSCEPTIBILITY



# Chardonnay



**21 June  
prebloom  
Brix=nd**



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



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



**2 August  
Brix=4.2**



**15 August  
Brix=4.8**



**29 August  
Brix=9.3**

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

Treatment, rate /A	Spray dates	# Sprays	% Area infected	
			Clusters	Leaves
Untreated.....	none	0	25.8	73.2
Abound, 12 fl oz.....	10 Jun-19 Aug	6	1.3	16.7
Abound, 12 fl oz.....	24 Jun, 8 Jul	2	2.5	57.9

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

# Chardonnay



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prebloom  
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**Uninfected**



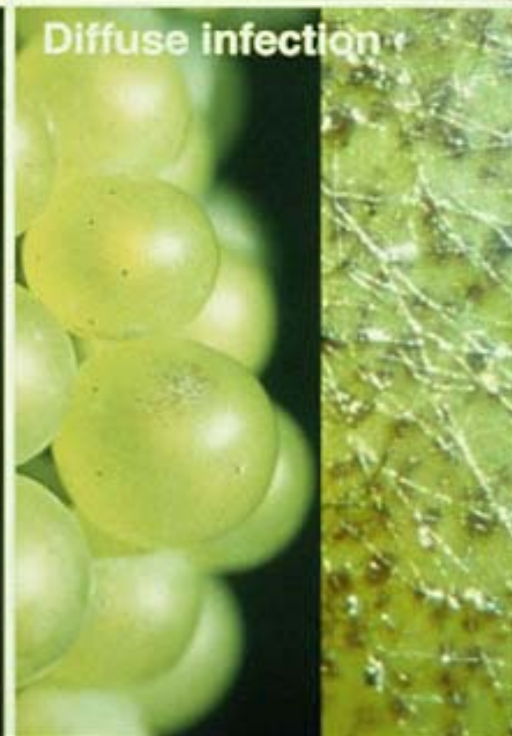
**Diffuse infection**



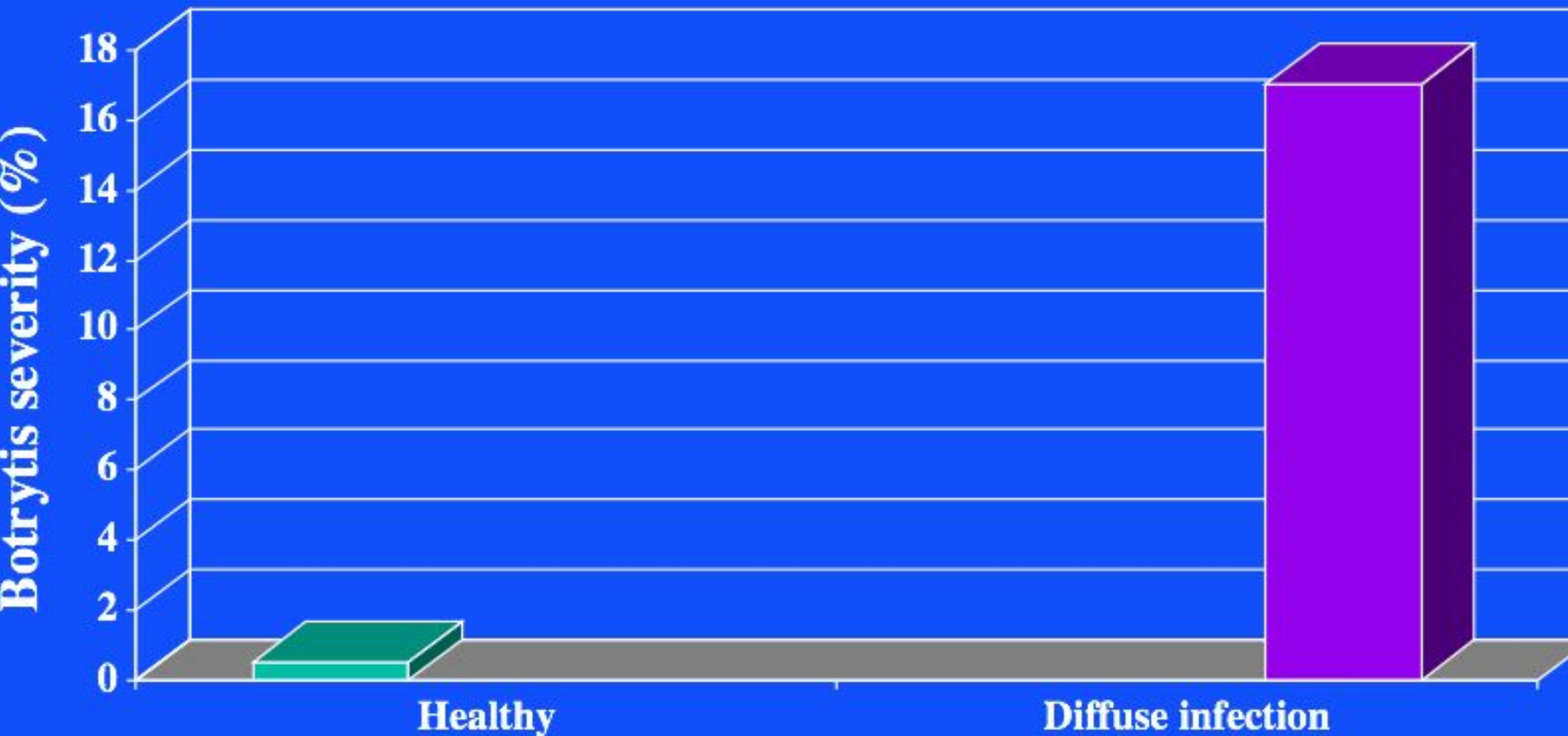
**Uninfected**



**Diffuse infection**



# Effect of Diffuse Powdery Mildew Infections on Botrytis Development



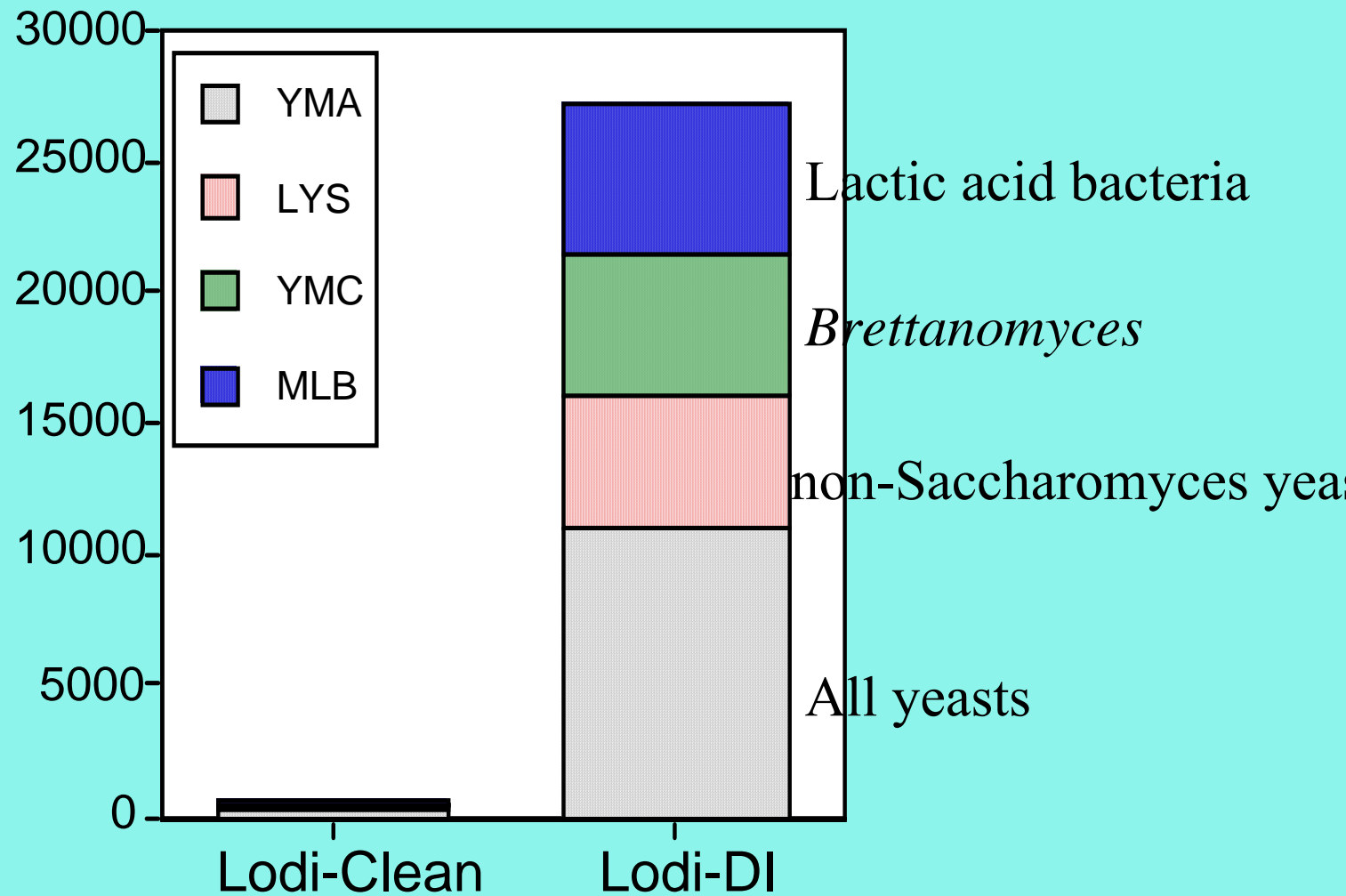


Fig. 2. Microflora of Pinot Noir berries from Lodi, NY, with and without diffuse powdery mildew. Fruit were harvested ripe lots of 100 berries per treatment were plated on 4 selective media. Heights of bars indicate the number of colony-forming units per 100 ul sample, and represent the following: YMA yeasts; LYS = non-Saccharomyces yeasts, presumably *Kloeckera*; YMC = *Brettanomyces* and *Dekkera* yeasts; an = lactic acid bacteria. Total microflora can be estimated by combining counts from YMA and MLB.





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

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

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# POWDERY MILDEW CONTROL: EFFECT OF CARRYOVER INOCULUM

(Chardonnay; Geneva, NY 2002-03)

<i>Sept. 2002</i>	April 2003	Sept. 2003
<i>Foliar PM</i>	Cleistothecia	Cluster PM
<u>% Severity</u>	per kg bark	<u>% Severity*</u>
1	1,300	11
17	5,300	22
28	28,700	48

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\*Two sprays only, applied immediate prebloom and fruit set



# POWDERY MILDEW

FUNGICIDES

# POWDERY MILDEW FUNGICIDES: SULFUR

## ✓ ADVANTAGES

- ✓ Inexpensive
- ✓ Effective
- ✓ No resistance concerns

# POWDERY MILDEW FUNGICIDES: SULFUR

## v ADVANTAGES

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- u No resistance

## v DISADVANTAGES

- u Relatively short residual activity
  - Φ Can wash off
- u Injury on some red natives & hybrids

# SULFUR: EFFECTS OF RAIN, RATE, & SURFACTANT (Field trials; cv. Rosette)

Material, rate/A*	<u>% Control (Disease severity)</u>			
	<u>Foliage</u>		<u>Clusters</u>	
	2004	2005	2004	2005
Microthiol, 5 lb.....	68 b	67 c	47 c	76 n.s.
“ + surfactant, 0.03%..	84 a	80 b	64 b	73
Microthiol, 10 lb.....	87 a	89 a	76 a	77

\* Applied at 14-day intervals, hooded boom sprayer; 50 gpa prebloom, 100 gpa post-bloom



# POWDERY MILDEW FUNGICIDES: STEROL INHIBITORS (DMIs)

## ✓ ADVANTAGES

- Very effective at low use rates
- **Locally systemic (rainfast)**
- Protective + post-infection activities
- Relatively long application intervals

# POWDERY MILDEW FUNGICIDES: STEROL INHIBITORS (DMIs)

## ∨ DISADVANTAGE

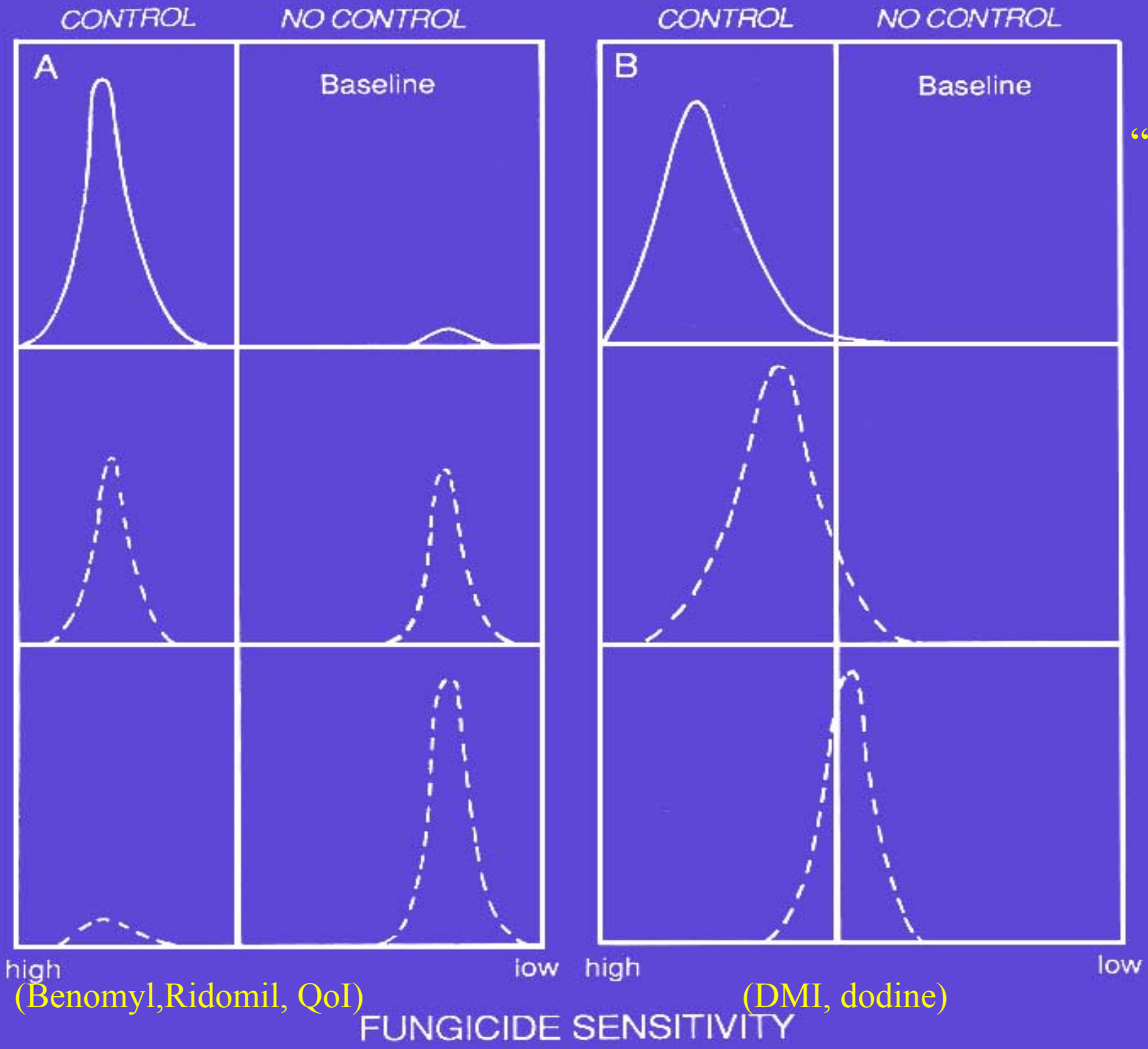
- ∪ Resistance is widespread in much of world
- ∪ Still provide control, but not as effective as in past

# FUNGICIDE (PESTICIDE) RESISTANCE

- v Results from the
  - v SELECTION
  - v of INDIVIDUALS
  - v in a POPULATION

“Qualitative”  
(or nothing)

FREQUENCY OF GENOTYPES



“Quantitative”  
(Shades of g

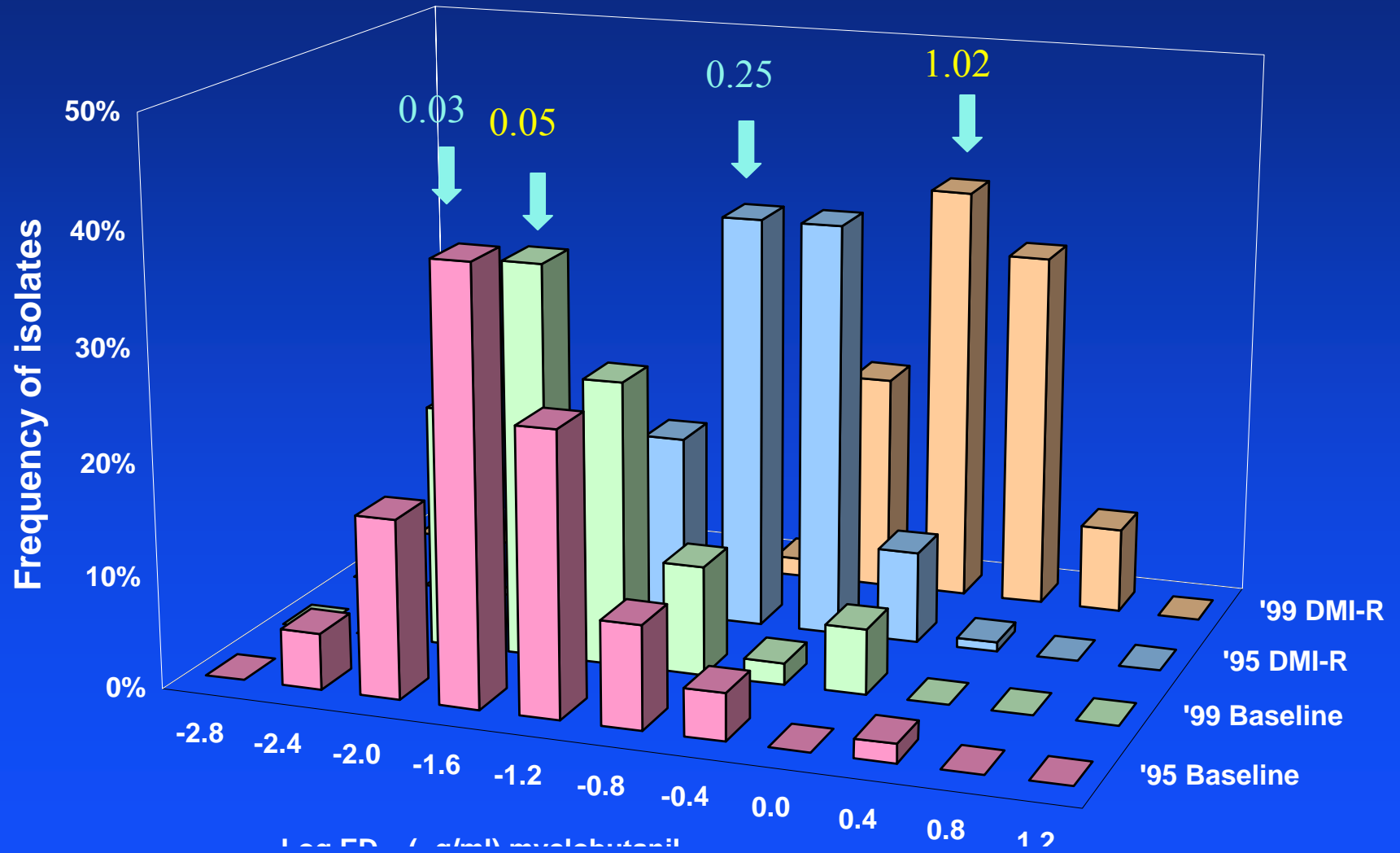
(Benomyl, Ridomil, QoI)

(DMI, dodine)

FUNGICIDE SENSITIVITY



# Distribution of Sensitivities to Myclobutanil, 1995 vs. 1999



# EFFECT OF RATE ON POWDERY MILDEW CONTROL: DMI-RESISTANT VINEYARD POPULATION (cv. 'Seyval', Finger Lakes, NY)

<u>Treatment, rate/A</u>	<u>%Disease control, fungus type</u>		
	<u>All</u>	<u>Susceptible</u>	<u>Resistant</u>
Untreated .....	(68% cluster area infected)		
Nova, 4 oz.....	84		
Nova, 2 oz.....	49		

6 sprays @ 2-wk intervals

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	<u>All</u>	<u>Susceptible</u>
Untreated .....	(68% cluster area infected)	
Nova, 4 oz.....	84	94
Nova, 2 oz.....	49	89

6 sprays @ 2-wk intervals

# EFFECT OF RATE ON POWDERY MILDEW CONTROL: DMI-RESISTANT VINEYARD POPULATION (cv. 'Seyval', Finger Lakes, NY)

<u>Treatment, rate/A</u>	<u>%Disease control, fungus type</u>		
	<u>All</u>	<u>Susceptible</u>	<u>Resistant</u>
Untreated .....	(68% cluster area infected)		
Nova, 4 oz.....	84	94	79
Nova, 2 oz.....	49	89	29

6 sprays @ 2-wk intervals



# DMI RESISTANCE MANAGEMENT RECOMMENDATIONS

- ✓ Maximum of 3 applications per year
  - <50% of all PM sprays

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  - <50% of all PM sprays
- ✓ Tank mix w/sulfur (inexpensive)
- ✓ Rotate with effective unrelated materials
  - Sulfur, strobilurins (QoI), Quintec
  - Several new powdery mildew-specific materials under development

# DMI RESISTANCE MANAGEMENT RECOMMENDATIONS

- ✓ Maximum of 3 applications per year
  - <50% of all PM sprays
- ✓ Tank mix w/sulfur (if inexpensive)
- ✓ Rotate with effective unrelated materials
- ✓ **Utilize full recommended rates**
  - Provide full spray coverage
    - ⊕ Fungus responds to rate on the vine, not in the tank!



# POWDERY MILDEW FUNGICIDES: STROBILURINS

- ✓ Abound, Sovran, Flint, Pristine
- ✓ Most important group of new fungicides since DMIs
- ✓ Relatively broad spectrum, v. good to exc. against PM

# POWDERY MILDEW FUNGICIDES: STROBILURINS (QoI)

- ✓ RESISTANCE RISK IS VERY HIGH
  - ✓ Multiple powdery mildew failures in NY beginning 2002

# STROBILURIN (QoI) RESISTANCE IN NEW YORK

- √ In 2002, serious PM cluster infections appeared suddenly in treated vineyards, at multiple commercial sites
  - ∪ Extremely susceptible varieties (Chardonnay, Pinot gris)
  - ∪ Total 15 - 20 applications since registration

# STROBILURIN (QoI) RESISTANCE IN NEW YORK

- √ In 2002, serious *Uncinula* cluster infections appeared suddenly in treated vineyards, at multiple commercial sites in NY
  - ∪ Extremely susceptible varieties (Chardonnay)
  - ∪ Total 15 - 20 applications since registration
  - ∪ **Not all users had problems**
    - Φ Few problems for those who had regularly tank mixed w/sulfur



# POWDERY MILDEW CONTROL, 2002

(cv. CHARDONNAY, FINGER LAKES, NY)

<u>Treatment, rate/A</u>	<u>% PM, Cluster area</u>
None .....	80 a
Standard* .....	51 b
Pristine, 8.4 oz.....	9 c

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\*Rubigan/ 2 Abound/ Rubigan/Abound/ 2 sulfur

\*\*Pyraclostrobin (QoI) + boscalid (carboxyanilide)

# POWDERY MILDEW CONTROL, 2002

(cv. CHARDONNAY, FINGER LAKES)

<u>Treatment, rate /A</u>	<u>% PM, Cluster area</u>
None .....	80 a
Standard* .....	51 b
<b>Pristine, 8.4 oz.....</b> .....	<b>9 c</b>
strobie component, 5.4 oz....	56 b
<b>boscalid component, 3.0 oz..</b>	<b>3 c</b>

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\*Rubigan/ 2 Abound/ Rubigan/Abound/ 2 sulfur

\*\***Pyraclostrobin (QoI) + boscalid (carboxyanilide)**

RATE EFFECT?

# POWDERY MILDEWCONTROL, 2003: cv. CHARDONNAY, FINGER LAKES

<u>Treatment, rate/A</u>	<u>PM, % area</u>
None .....	98
BAS 500 (Pyraclostrobin), 3.9 oz .....	97
BAS 500 (Pyraclostrobin), 5.4 oz .....	94
BAS 500 (Pyraclostrobin), 6.8 oz .....	95

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7 sprays @ 2-wk intervals, 6 Jun - 27 Aug



Pyraclostrobin, highest rate



# QoI in Grapes: Resistance Management Recommendations

- √ Limit to 2 applications per season

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- ✓ Limit to 2 applications per season
- ✓ Use full rates and maintain excellent spray coverage

# QoI in Grapes: Resistance Management Recommendations

- √ Limit to 2 applications per season
- √ Use full rates and maintain excellent spray coverage
- √ Tank-mix with an effective, *economically-viable* companion material and rate
  - √ Sulfur
  - √ Boscalid



# POWDERY MILDEW FUNGICIDES: QUINTEC

- √ New chemical class
  - √ No cross-resistance, good rotational component
- √ Protective activity only
  - √ No post-infection, eradication
- √ Controls powdery mildew only

# POWDERY MILDEW FUNGICIDES: QUINTEC

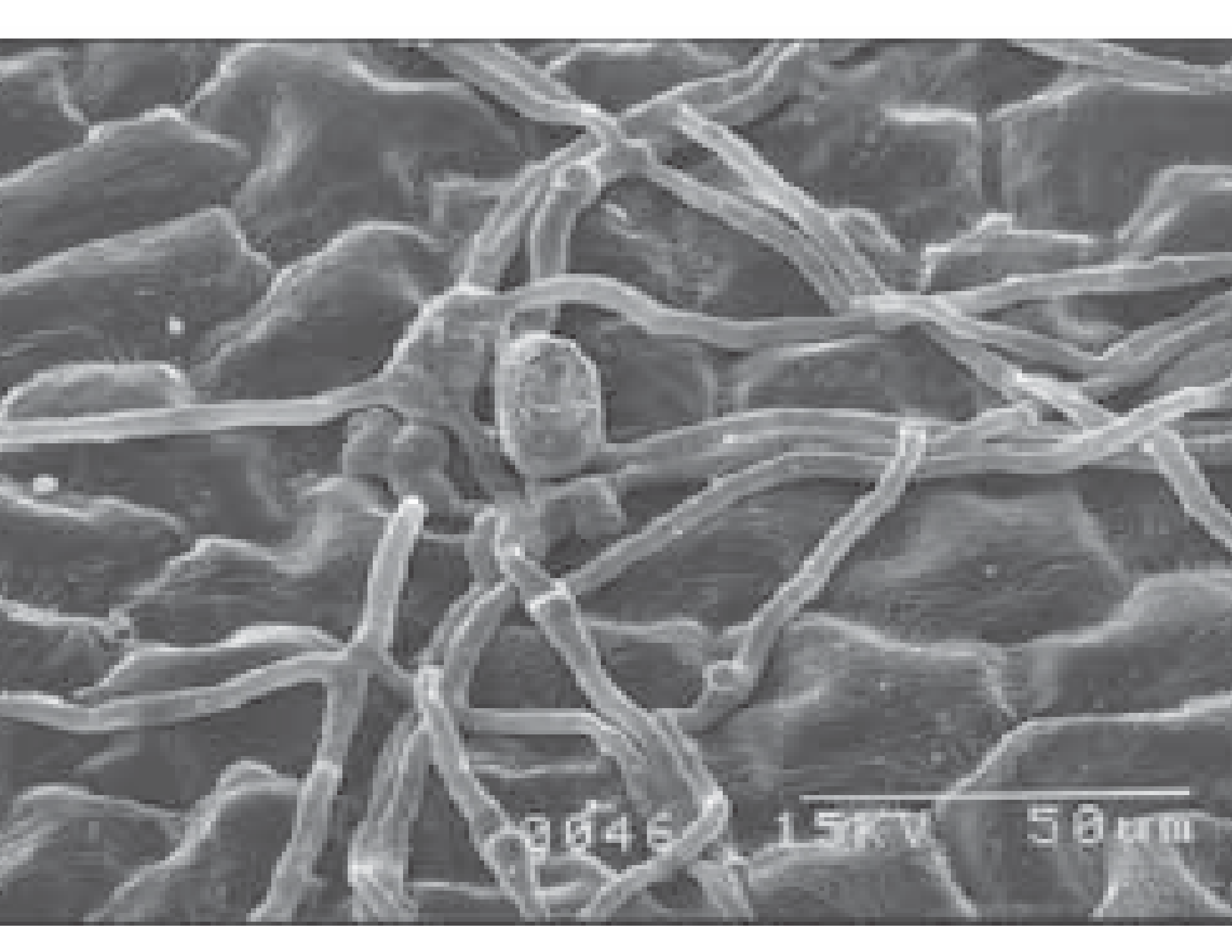
- ✓ New chemical class
- ✓ Protective activity only
- ✓ Controls PM only
- ✓ Consistently very good to excellent on *viniferas* hybrids, and natives in our trials
- ✓ Liquid; 3-4 fl oz/A @ 2-wk intervals
- ✓ No phyto or compatability problems

# POWDERY MILDEW FUNGICIDES: “ALTERNATIVE” PRODUCTS

- √ Primarily contact action, “body” of PM fungus is on outside of plant
  - √ Oils
  - √ Potassium salts (Armicarb, Kaligreen, Nutrol)
  - √ Hydrogen peroxide (Oxidate)

# POWDERY MILDEW FUNGICIDES: “ALTERNATIVE” PRODUCTS

- v Short-term “knock-down”, relatively little residual activity
- v Complete coverage is imperative



3.0kV

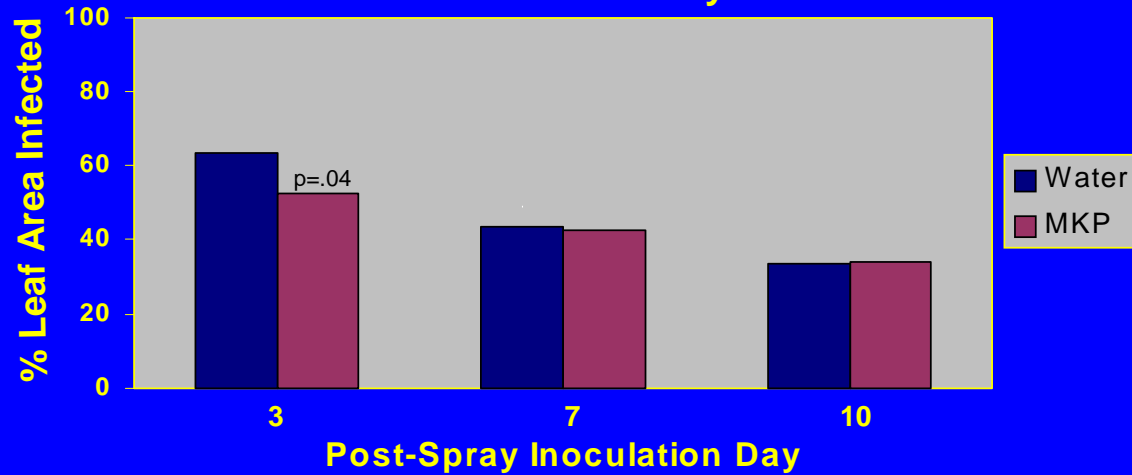
15KV

50um



## Protectant Assay of MKP

### Trial 1 - Severity

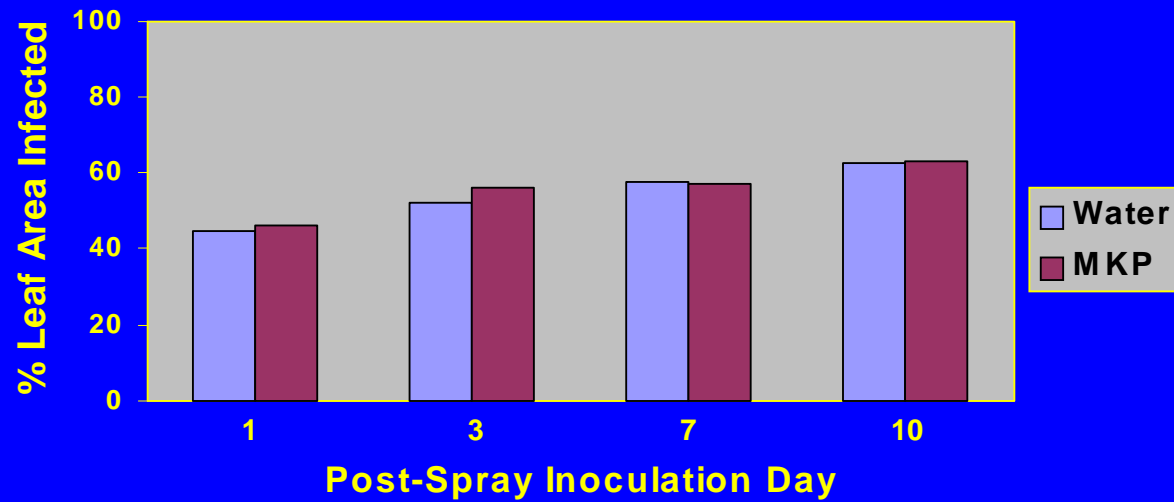


**MKP Spray  
Before  
Inoculation**



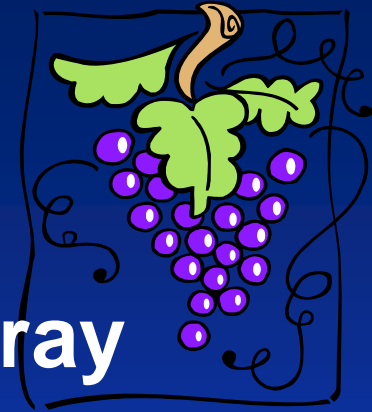
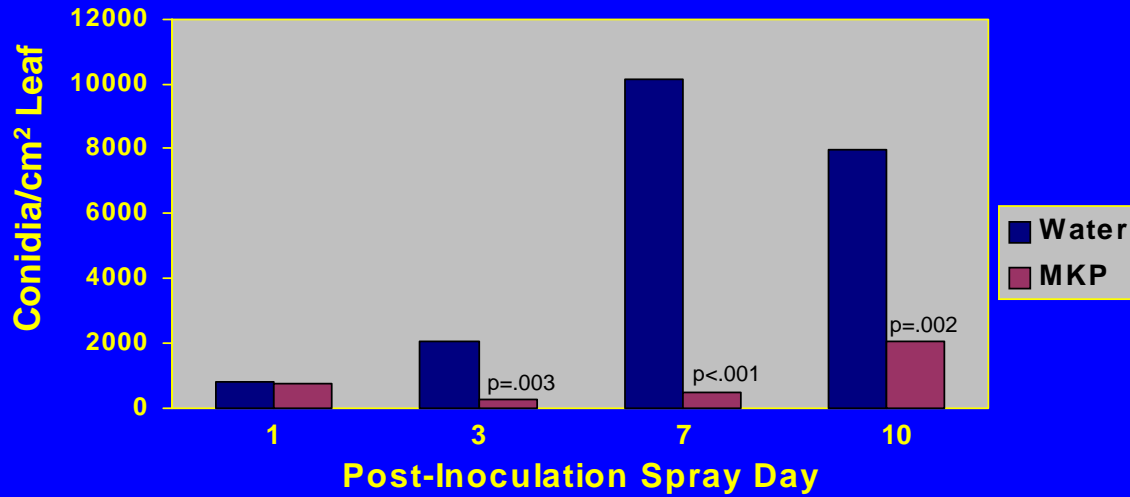
## Protectant Assay of MKP

### Trial 2 - Severity



## Post-Infection Assay of MKP

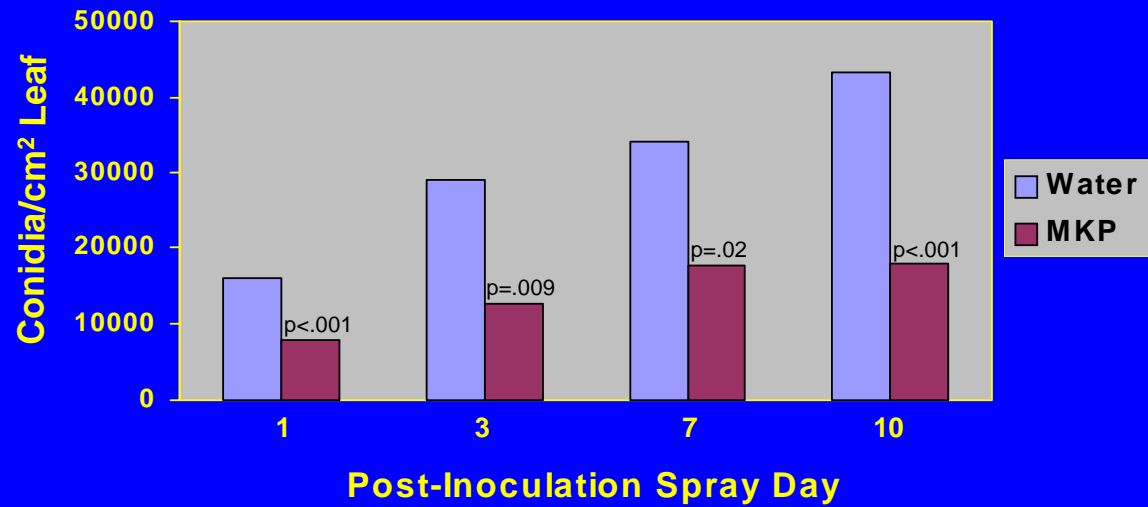
### Trial 1 - Sporulation



# MKP Spray After Inoculation

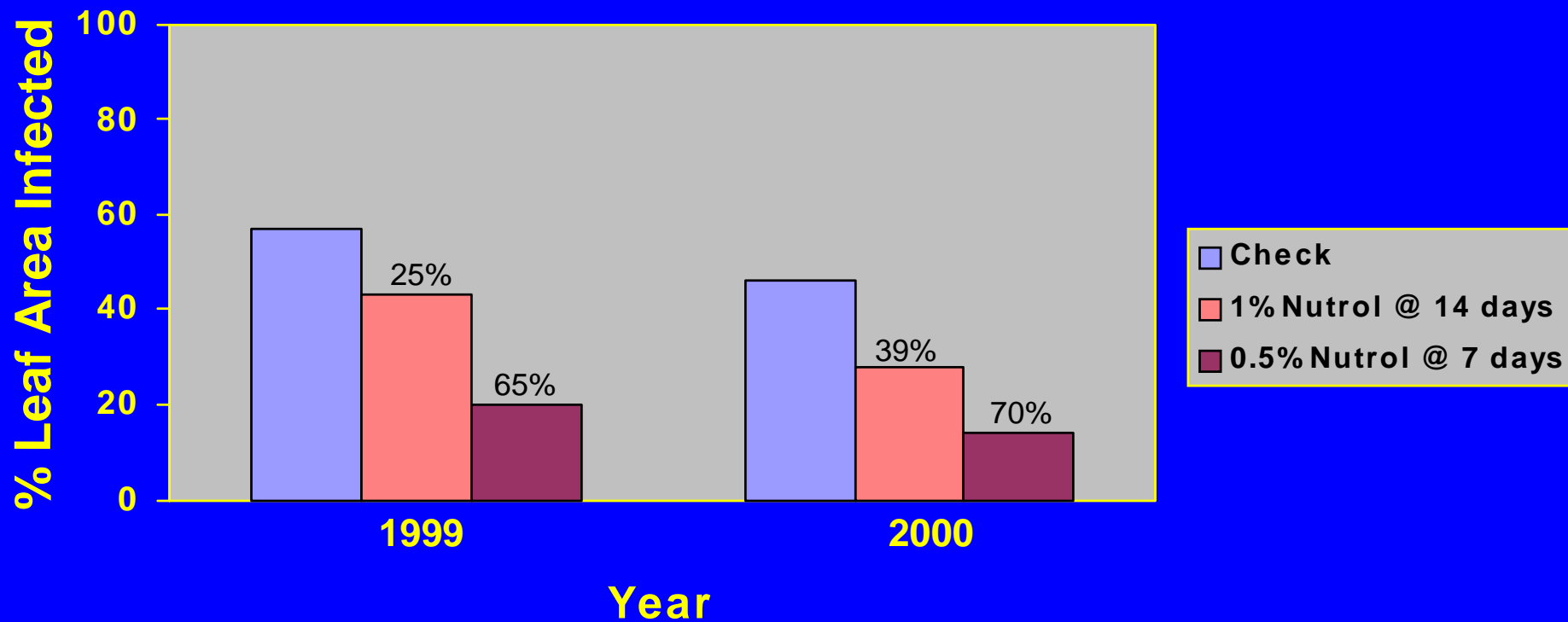
## Post-Infection Assay of MKP

### Trial 2 - Sporulation





## Effect of MKP (Nutrol) Spray Concentration and Frequency on Powdery Mildew Severity



cv. Rosette grapevines; Geneva, NY  
WF Wilcox and DG Riegel

**POWDERY MILDEWCONTROL, 2003: cv.  
ROSETTE, GENEVA (6 sprays @ 2-wk)**

Treatment, rate/A	PM, % area	
	Cluster	Leaf
None .....	47	75
Kaligreen, 2.5 - 5.0 lb* .....	12	45
Nutrol, 4 - 8 lb (+ surfactant)** .....	15	46
“Standard” *** .....	1	6

\*Approx. \$20 - \$40/A per application

\*\*Approx. \$4 - \$8/A per application

\*\*\*2 Rubigan/ 2 Pristine/ 2 Sulfur