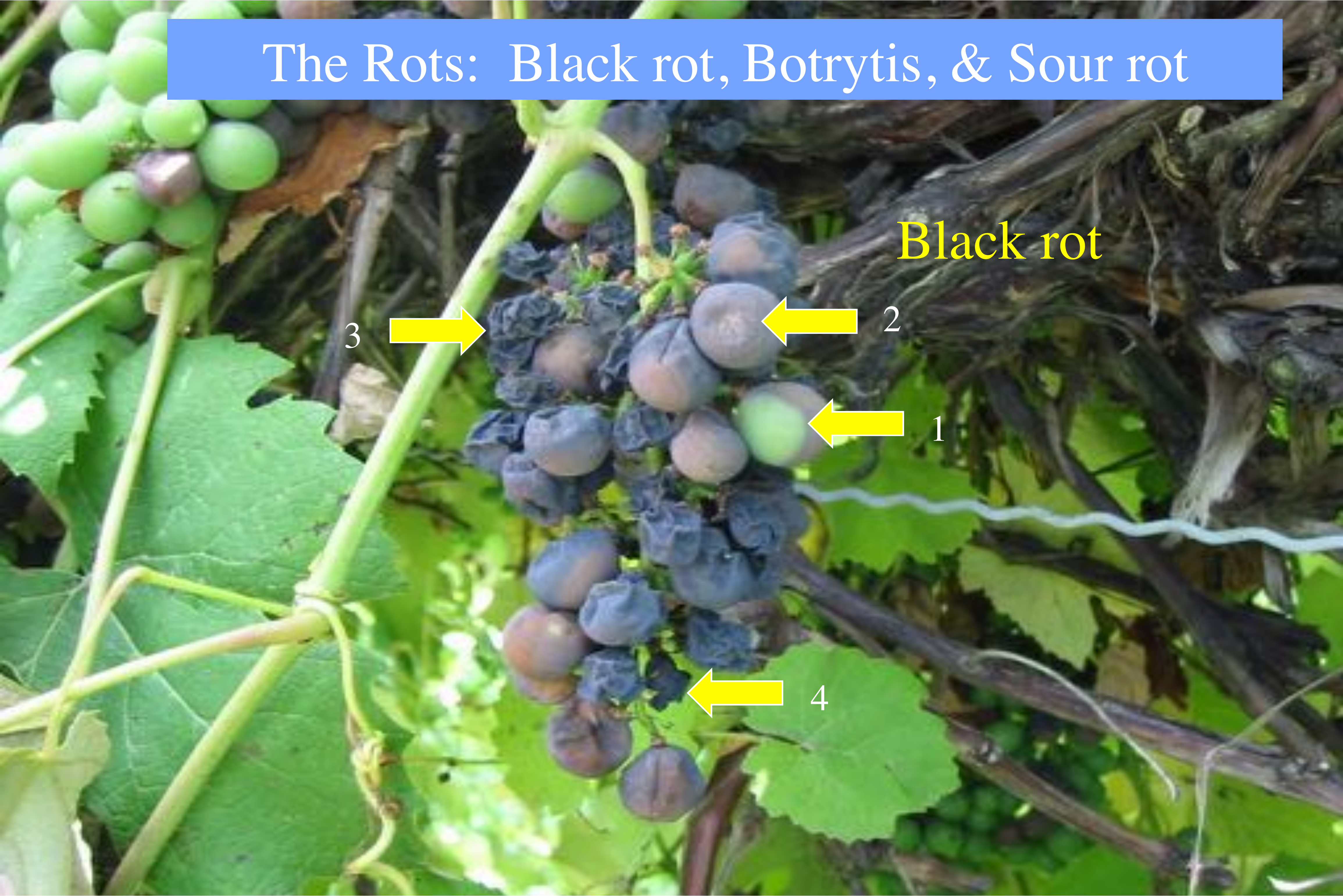
The Rots: Black rot, Botrytis, & Sour rot



BLACK ROT

DISEASE CYCLE

BLACK ROT: NEEDS RAIN!

- Spore discharge and dispersal
  - Ascospores (sexual form, overwintering only) need rain for discharge, wind for dispersal
  - Asexual conidia (overwintering & <u>current season</u> sources = DISEASE SPREAD), exuded in gelatinous mass from fruiting bodies (pycnidia) in high RH, dispersed by splashing raindrops
- Spore germination and infection

BLACK ROT: EFFECTS of TEMP x WETNESS DURATION on INFECTION

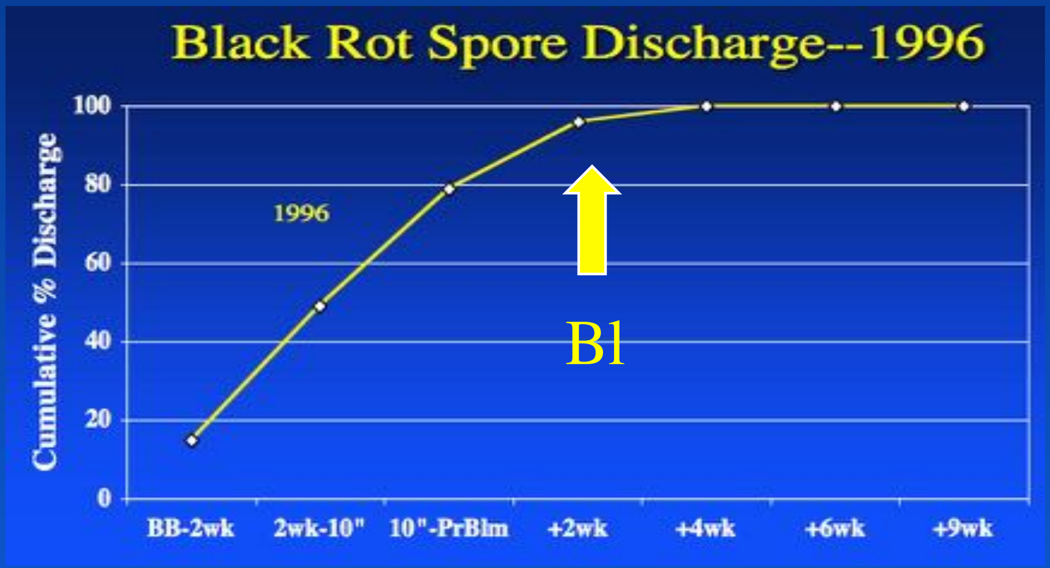
Temp, °C (°F)	Min. hr. wetness required
10 (50)	24
13 (55)	12
16 (61)	9
18 (65)	8
21 (70)	7
24 (75)	7
28 (80)	6
29 (84)	9
32 (90)	12

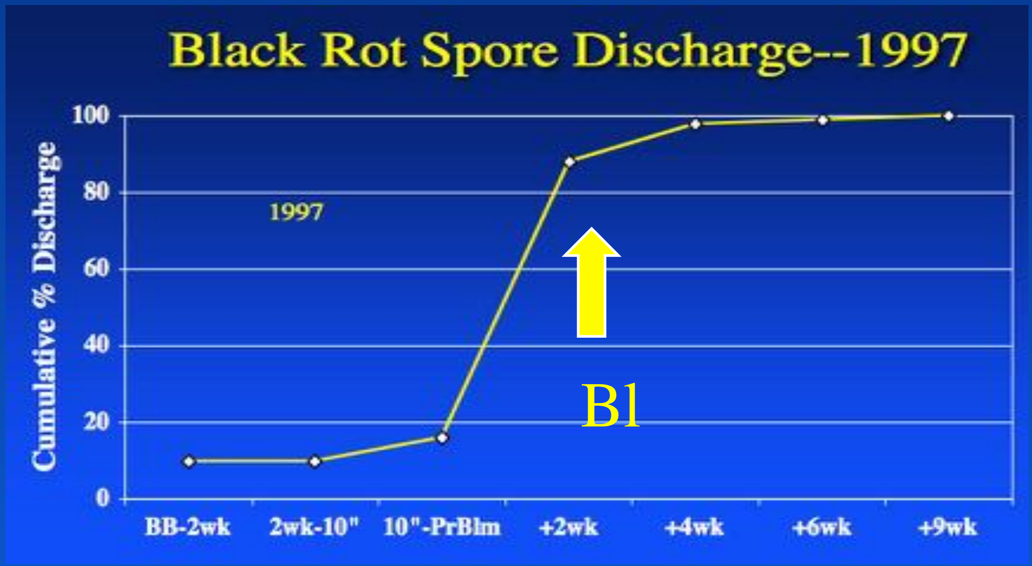
BLACK ROT

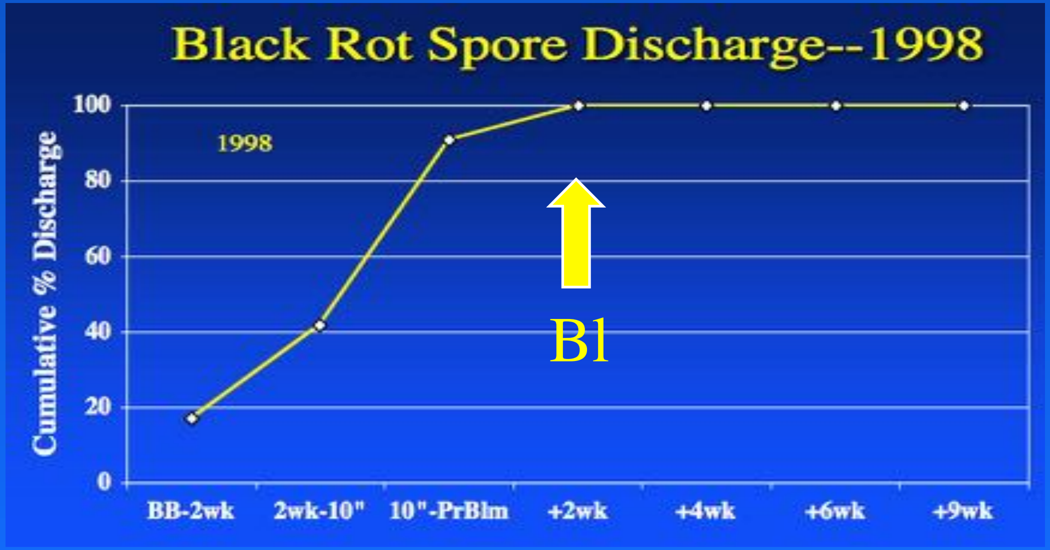
PERIOD OF <u>TYPICAL</u> OVERWINTERING INOCULUM AVAILABILITY

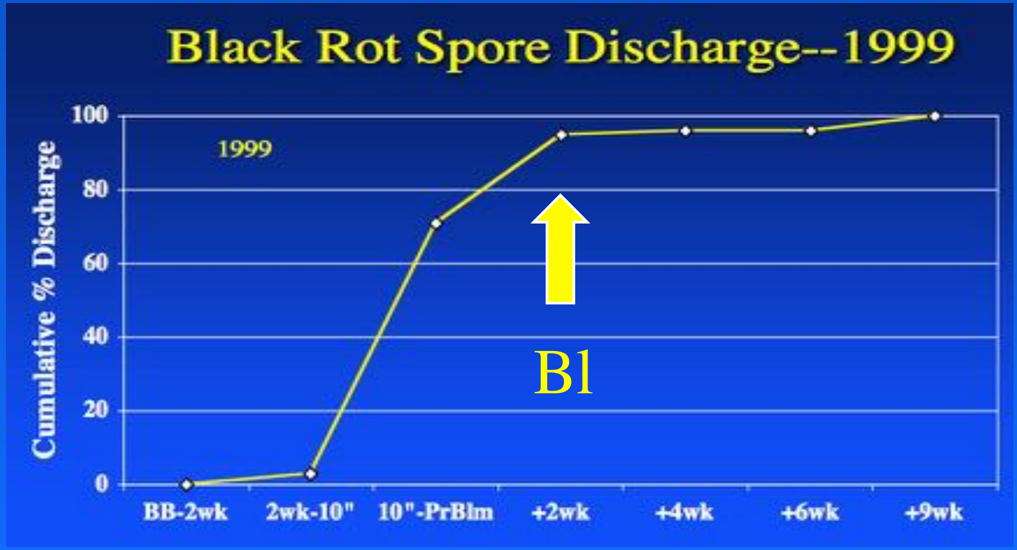
(COMMERCIAL PRUNING OPERATIONS)

BLACK ROT SPORE TRAPPING (AIR-BORNE ASCOSPORES), Hand-pruned vineyard









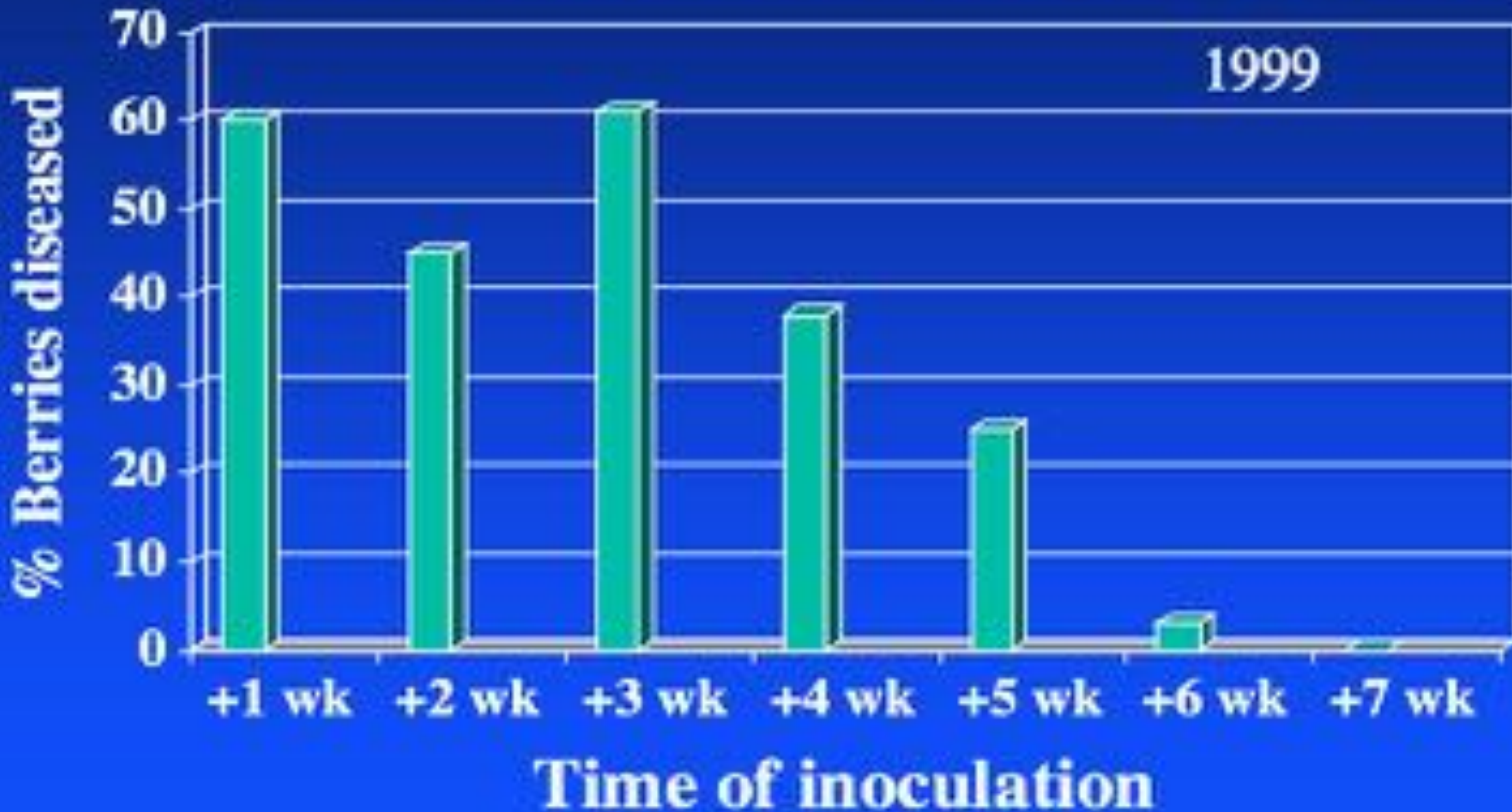
BLACK ROT: PERIOD OF TISSUE SUSCEPTIBILITY

- Leaves: Only while young and expanding
  - Fully-expanded leaves (node position #6 and lower): fungus penetrates but remains subcuticular, does not colonize further

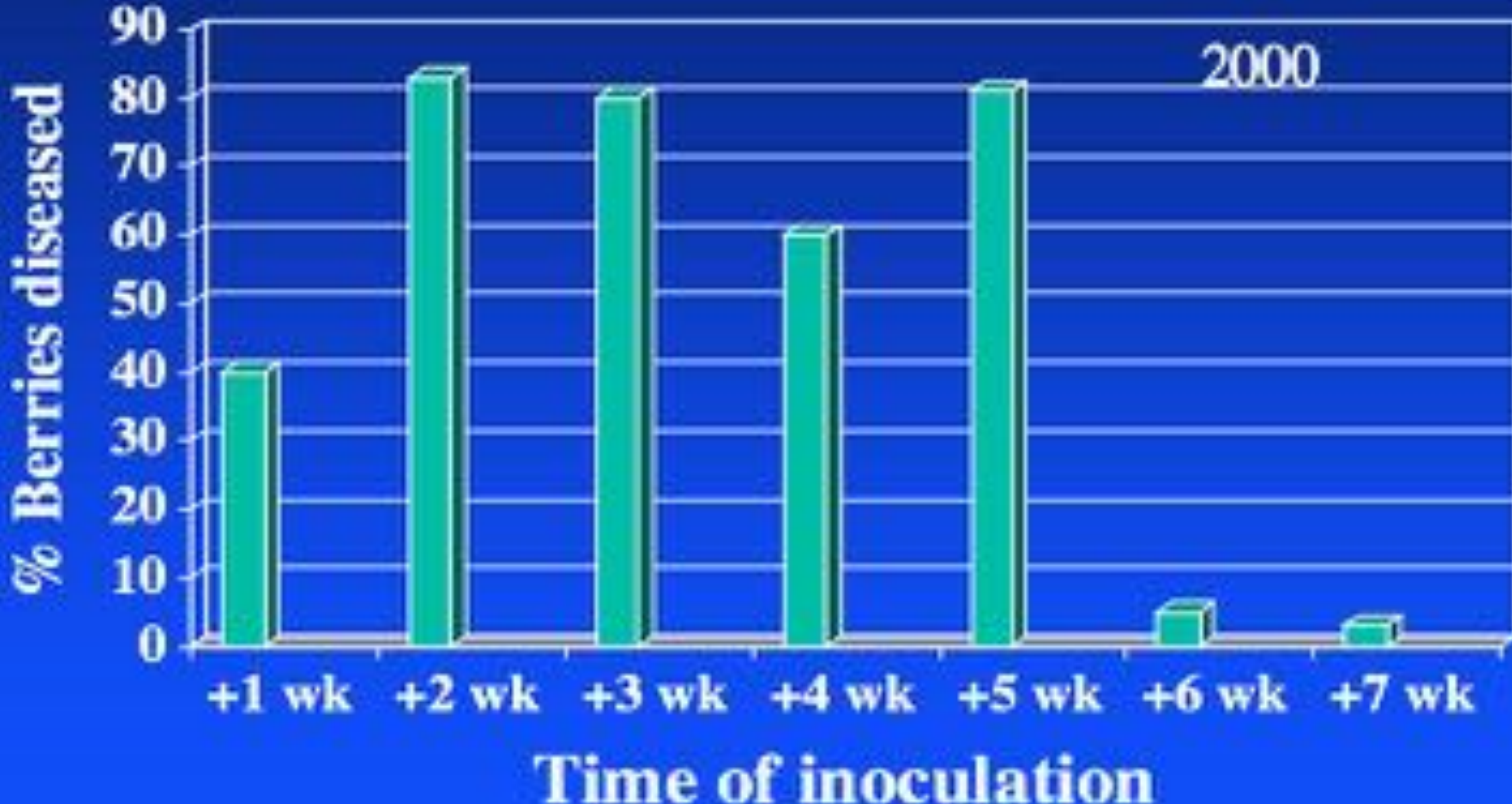
BLACK ROT: PERIOD OF TISSUE SUSCEPTIBILITY

- Berries
  - Concord
    - Highly susceptible capfall thru 2-4 wk later
    - Some susceptibility until 4-5 wk postbloom
  - Chardonnay, Riesling
    - Highly susceptible until 3-5 wk postbloom
    - Some susceptibility until 6-7 wk postbloom

BLACK ROT: PERIOD OF BERRY SUSCEPTIBILITY (cv. Chardonnay)



BLACK ROT: PERIOD OF BERRY SUSCEPTIBILITY (cv. Chardonnay)



BLACK ROT: PERIOD OF BERRY SUSCEPTIBILITY

- Affects critical period for fungicidal protection
  - Protection during early post-bloom period is CRITICAL

BLACK ROT CONTROL: SPRAY TIMING, 1995-99 (cv. 'Aurore', Dresden, NY)

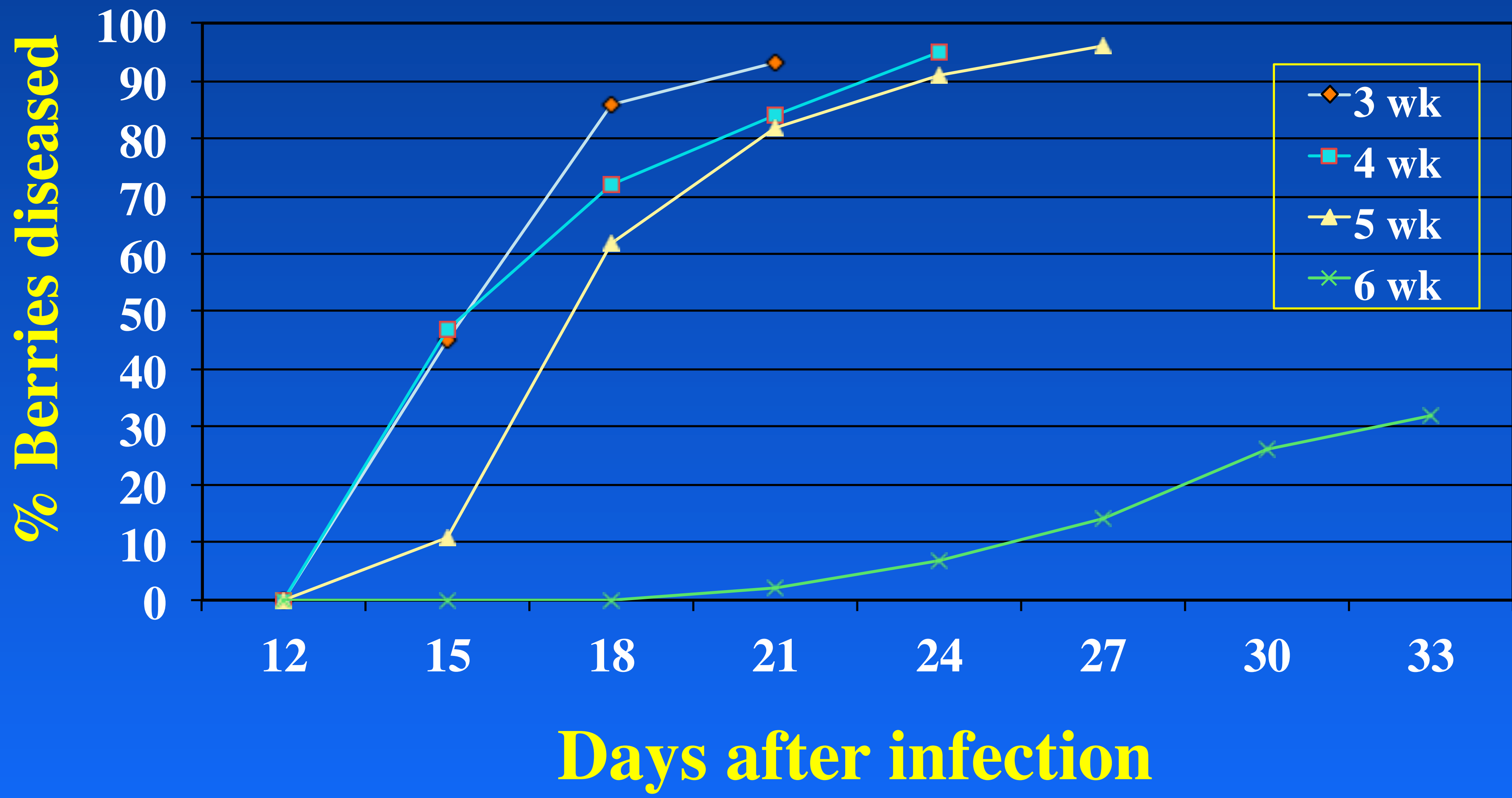
	% Control (clusters infected), yr				
Spray timing	1995	1996	1997	1998	1999
None	(99)	(60)	(35)	(82)	(93)
1, 2, 3*	14	55	81	79	61
1, 2, 3*, 4	55	93	100	100	100
1, 2, 3*, 4, 5 ..	99	98	100	100	100
2, 3*, 4, 5 ..	100	100	97	100	99
3*, 4, 5 ..	98	100	100	100	100
4, 5..	58	92	99	95	100

*Immediate prebloom (+/-); addl sprays @ 2-wk intervals

BLACK ROT: BERRY AGE vs. INCUBATION PERIOD

- IP affects rate of disease spread
- Need to know to determine, “What went wrong?”
  - 2 - 3 weeks when berries are young
  - 3 - 5 weeks as berries become resistant

BLACK ROT: EFFECT OF BERRY AGE ON INCUBATION PERIOD (cv. Riesling)

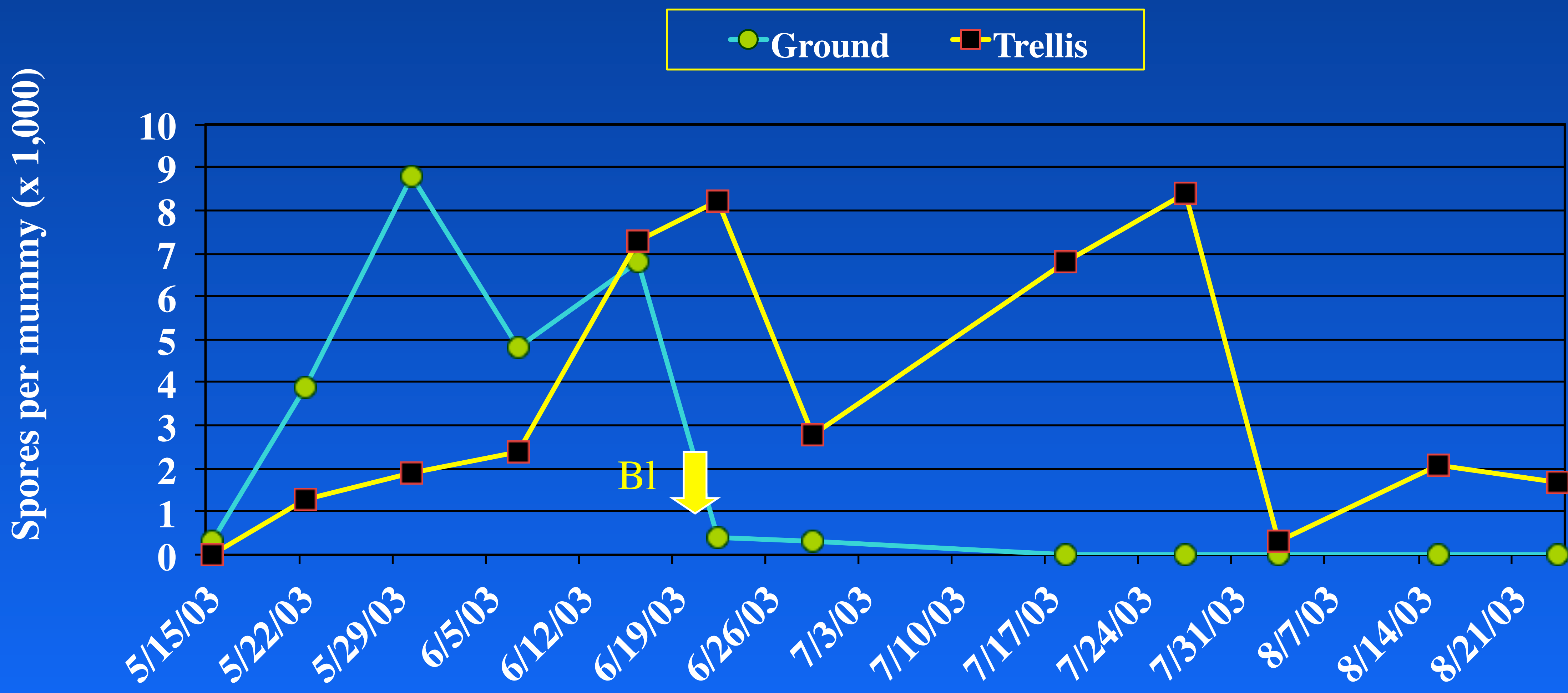


BLACK ROT

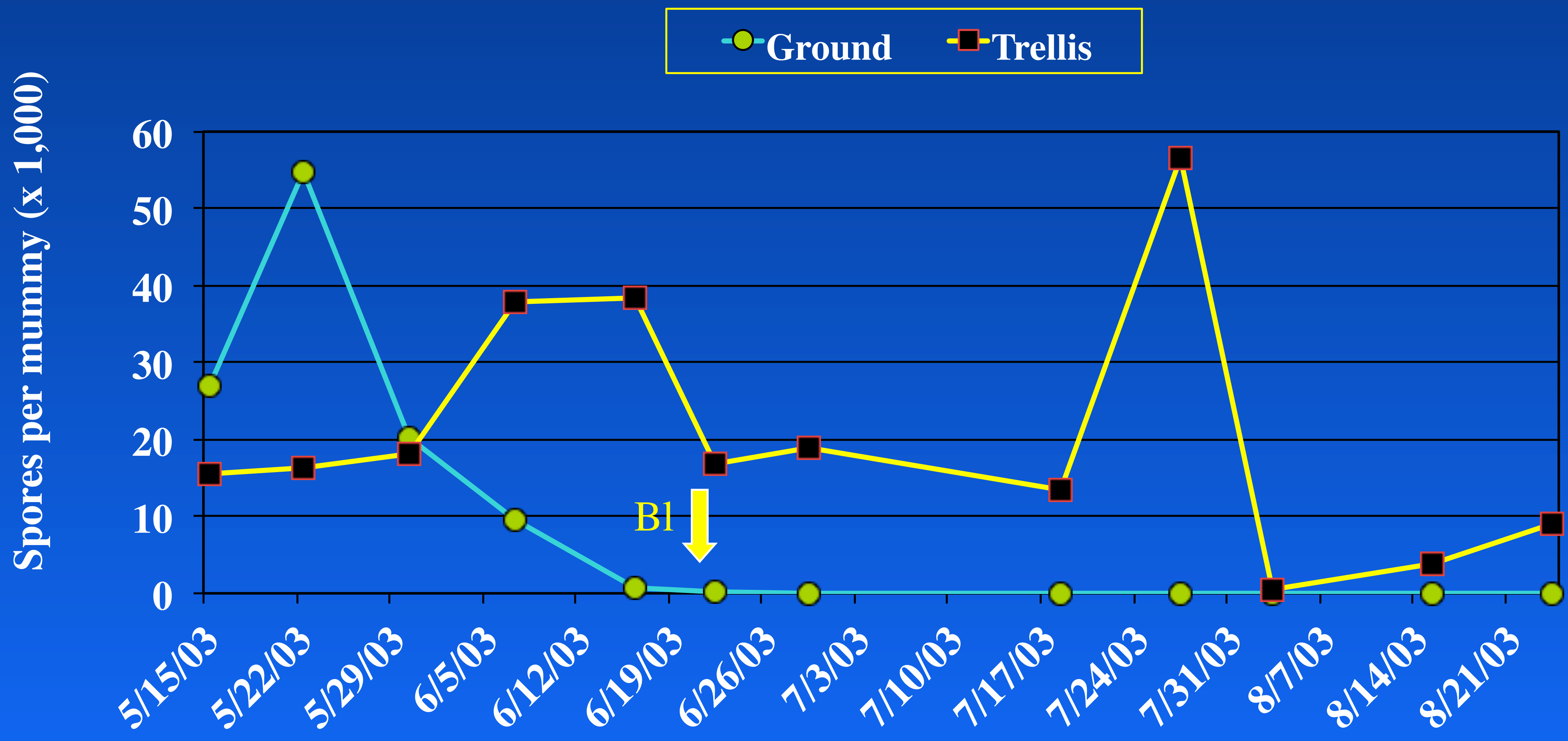
IMPORTANCE OF SANITATION

(Removal of mummies from the trellis during pruning)

ASCOSPORES (air-borne) FROM MUMMIES: GROUND vs. TRELLIS



CONIDIOSPORES (splash-dispersed) FROM MUMMIES: GROUND vs. TRELLIS



BLACK ROT: IMPORTANCE OF SANITATION (Removal of mummies from trellis)

- Mummies in trellis (versus on the ground)
  - Produce spores until +/- veraison *vs*. 1-2 wk postbloom
  - Produce 10-20x as many spores over the season
  - Produce spores right next to new fruit (splash dispersal)

BLACK ROT: FUNGICIDES

- Mancozeb, ziram, ferbam
  - Old standards, good control under most commercial conditions
  - Strictly <u>protectant</u> activity on surface of fruit, leaves
    - Must be present when infection period begins
    - Subject to washoff

BLACK ROT: FUNGICIDES

- Mancozeb, ziram, ferbam
  - Standards, good control under most commercial conditions
  - Strictly protectants, subject to washoff
- DMI fungicides
  - Triazoles (myclobutanil, tebuconazole, difenoconazole, etc.) = Excellent

BLACK ROT: FUNGICIDES

- Strobilurin (QoI) fungicides
  - All are very good, equivalent
  - More rainfast than mancozeb, etc.
    - Allows longer spray intervals

BLACK ROT CONTROL (extreme pressure)

cv. 'Aurore'; Dresden, NY

Material (a.i.)	% Black rot Clusters	% Black rot Berries
None	99	53
Penncozeb (mancozeb)	53	8
Abound (azoxystrobin, QoI) ...	17	1
Rally (myclobutanil, DMI)	0	0

6 sprays @ 2-wk intervals, 3 prebloom + 3 postbloom

BLACK ROT: FUNGICIDES

- Captan, copper, sulfur
  - Only fair to poor (sulfur)
  - Potential weakness for organic producers
    - MUST emphasize importance of sanitation


A COMMERCIAL ORGANIC VINEYARD!

BLACK ROT--MANAGEMENT PROGRAMS

- Sanitation
  - No mummies in the trellis
  - Cultivate, mulch mummies if "organic'
- Fungicide program
  - Start of bloom thru +4 wk (some "clean" vineyards are OK w/+2 wk, but a bit of a gamble)
  - If high inoculum, begin 2+ wk prebloom
  - Dormant lime sulfur for "organic"??

Botrytis Bunch Rot

BOTRYTIS IN VINES: TWO IMPORTANT CONCEPTS

- *B. cinerea* is a "weak" pathogen, prefers tissues that are:
  - Injured
  - Very young, succulent
  - Senescent
    - OLD BLOSSOM PARTS
    - RIPENING FRUIT

BOTRYTIS IN VINES: TWO IMPORTANT CONCEPTS

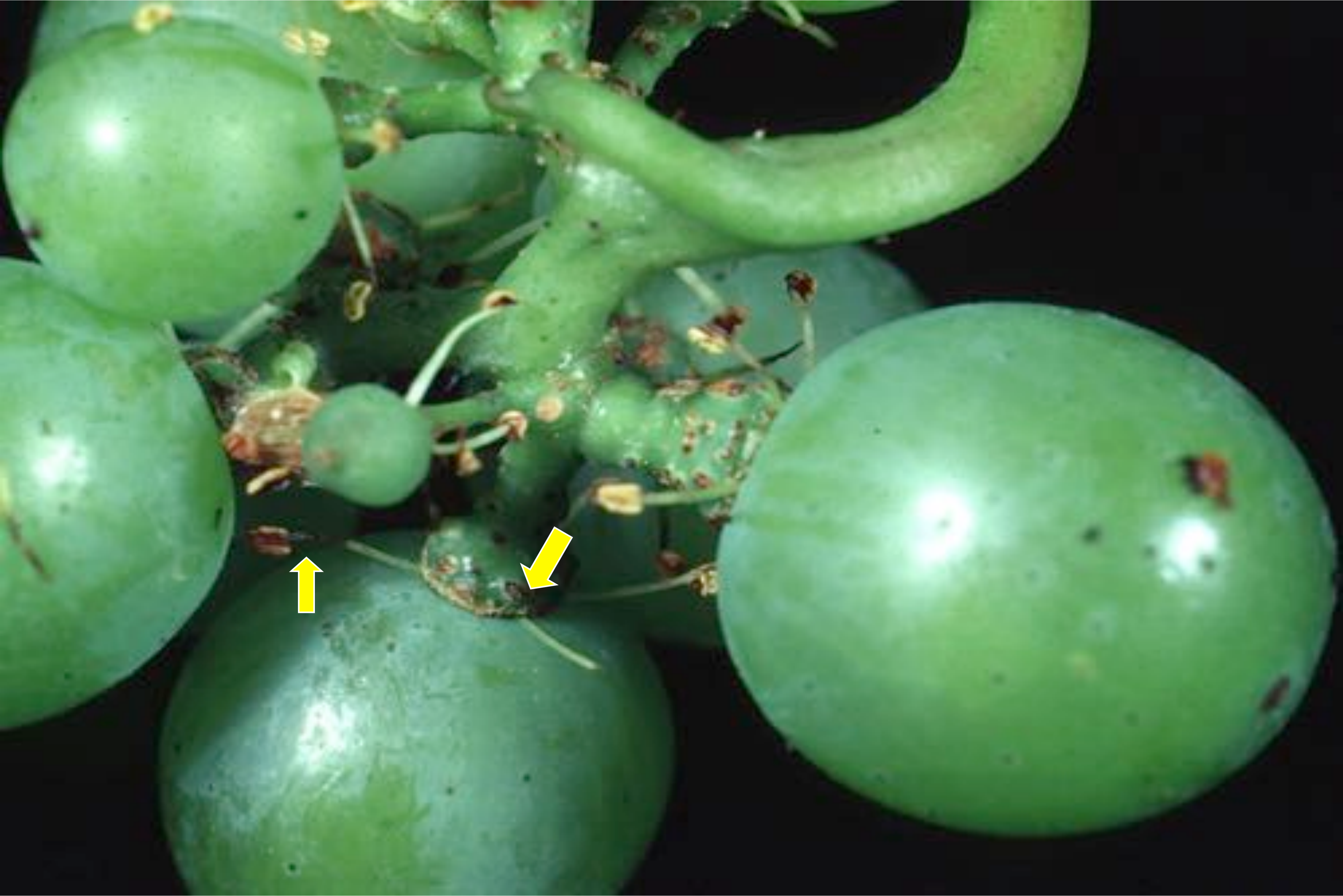
- *B. cinerea* is most active when conditions limit the evaporation of water
  - High relative humidity
  - Poor air circulation around bunches
  - Low wind speeds

BOTRYTIS IN VINES: DISEASE CYCLE

- Can infect ripening (senescing) berries via wounds or directly by growth from another source in contact with the berry
  - Old blossom “trash” trapped within cluster
  - Other diseased berries touching within compacted clusters

BOTRYTIS IN VINES: DISEASE CYCLE

- Can also infect young berries through floral organs, receptacle (cap scars), pedicels
  - Rain
  - 59-77°F = optimum (range = 2-86°F)



BOTRYTIS IN VINES: DISEASE CYCLE

- Can also infect young berries through floral organs, receptacle (cap scars), pedicels
  - Rain
  - 59-77°F = optimum (range = 2-86°F)
- Early berry infections remain latent ("dormant"), <u>can</u> become active as berries begin to ripen (senesce)

LATENT INFECTION IMPORTANCE: WINE GRAPES

- Early (latent) infections (*=1° infection*)
  - Relatively little direct loss
  - BUT serve as potentially important source for pre-harvest 2° spread thru highly susceptible (senescent) tissue
    - Much worse thru tight clusters (berry-to-berry contact)

DISEASE SPREAD EXPERIMENTS

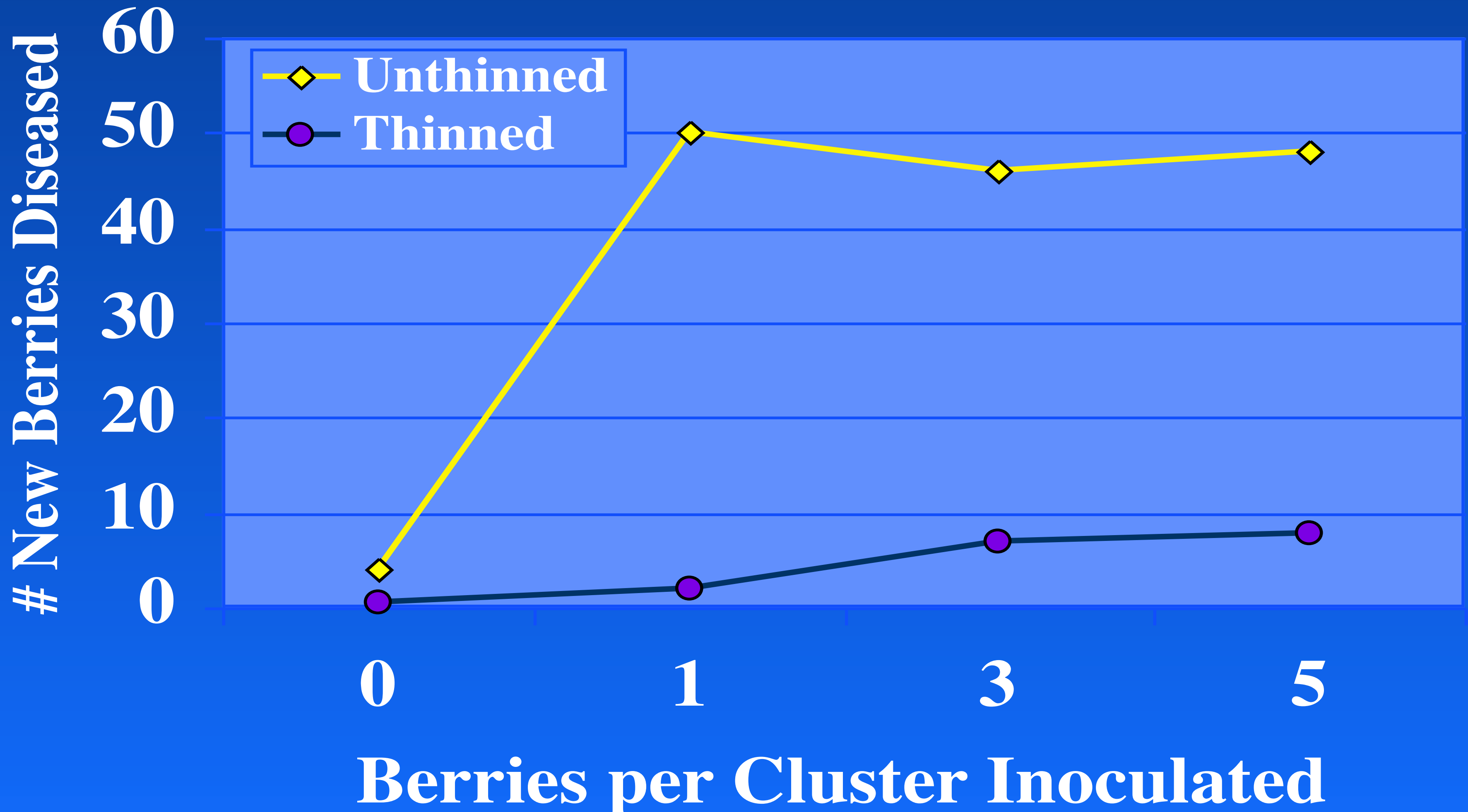
- Inoculated 0, 1, 3, or 5 individual berries/ cluster 10 days post-veraison
  - Provided discrete diseased berries with sporulation 1 wk later
  - Simulated activation of a few latent infections during preharvest period

2° Spread Expt. Inoculations

DISEASE SPREAD EXPERIMENTS

- Inoculated 0, 1, 3, or 5 berries/cluster at veraison, evaluated at harvest
- Examined interaction with cluster architecture
  - Tight-clustered Pinot noir clone 29: Natural (unthinned) vs. thinned

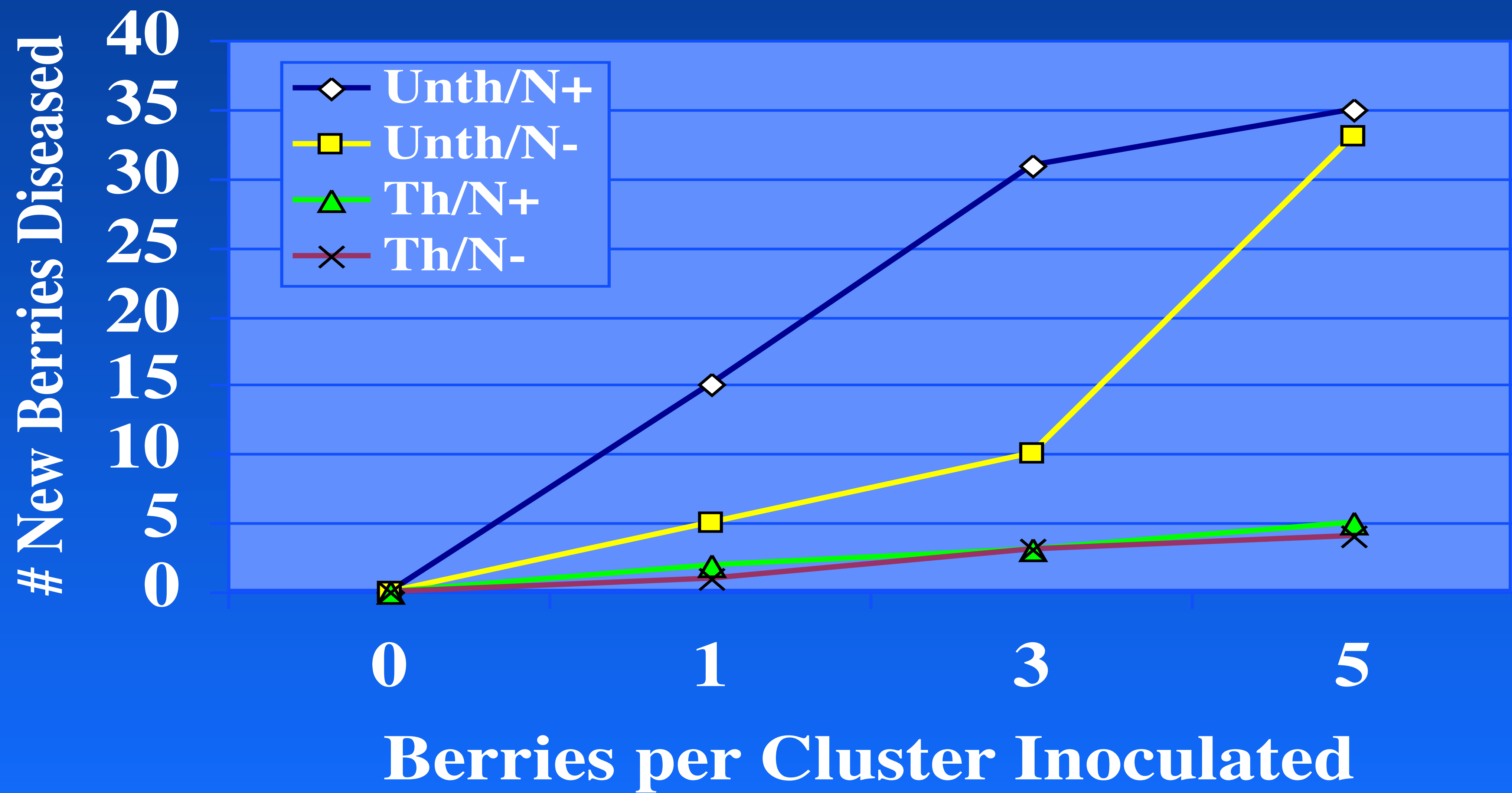
EFFECT of CLUSTER TIGHTNESS on DISEASE SPREAD (Pinot noir 29; Geneva, NY)



DISEASE SPREAD EXPERIMENT, CHARDONNAY

- Inoculated 0, 1, 3, or 5 berries/cluster at veraison
- Examined interaction with:
  - Cluster architecture
  - Berry nitrogen
    - Five weekly sprays of urea (9 kg/ha) beginning at veraison
      - Increased assimilable N in berries (303 *vs.* 235 mg/L) w/o increasing canopy growth

EFFECT of CLUSTER TIGHTNESS, N on DISEASE SPREAD (CHARDONNAY; Geneva, NY)



BOTRYTIS BUNCH ROT: LATENT INFECTIONS

- Primary infections typically occur near flowering
  - "Most" remain latent through harvest
  - "A few" can become active post-veraison
    - Important as source of secondary spread
    - Factors that promote activation of latent infections are not well understood

FACTORS PROMOTING LATENT INFECTION ACTIVATION

- High humidity as berries become ripe
- High available water in soil
- High N availability

BOTRYTIS IN VINES: MANAGEMENT

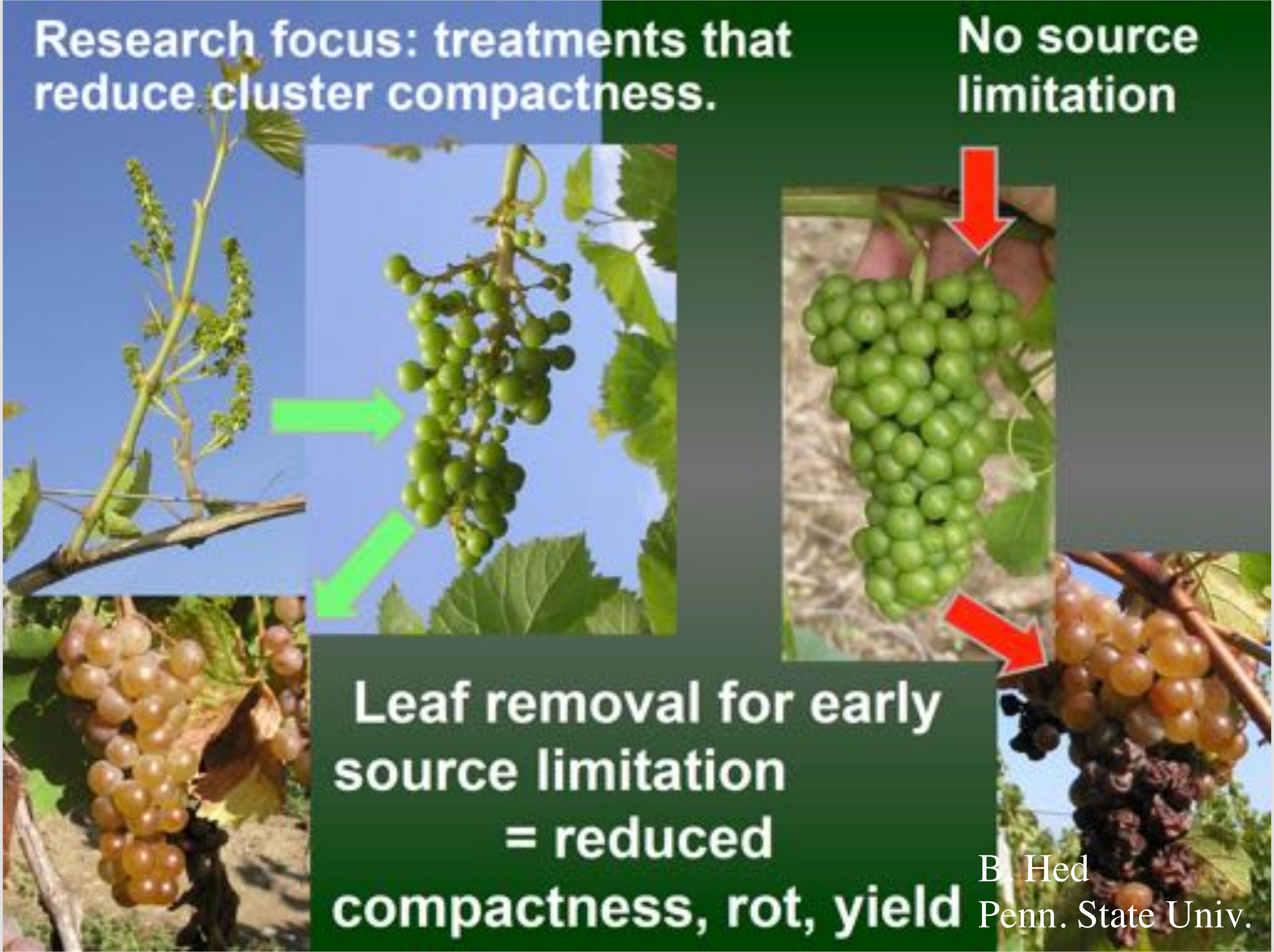
- Cultural
  - Promote lower RH, good air movement in cluster zone
    - Canopy management, leaf removal around cluster zone
      - Also improves spray deposition
  - Avoid excessive irrigation, nitrogen
  - LOOSEN CLUSTERS (how, safely?)

CLUSTER LOOSENING TECHNIQUES: PGR — GIBERELLIC ACID

- Routine on seedless table grapes, periodic revisiting on wine grapes
- Efficacious
  - Looser clusters, significantly less rot
- Potentially problematic
  - Reduced crop, return bloom
  - Reaction cultivar specific
    - Rate = 1.0 to 40.0 g / ha, depending on cv.

CLUSTER LOOSENING via LEAF REMOVAL at “TRACE” BLOOM

- Theory: Starve clusters of photosynthates, reduce set, looser clusters
- Being investigated w/some success by several researchers worldwide
- Potential for mechanization?


Research focus: treatments that reduce cluster compactness.
No source limitation
Leaf removal for early source limitation
= reduced compactness, rot, yield
B. Hed
Penn. State Univ.

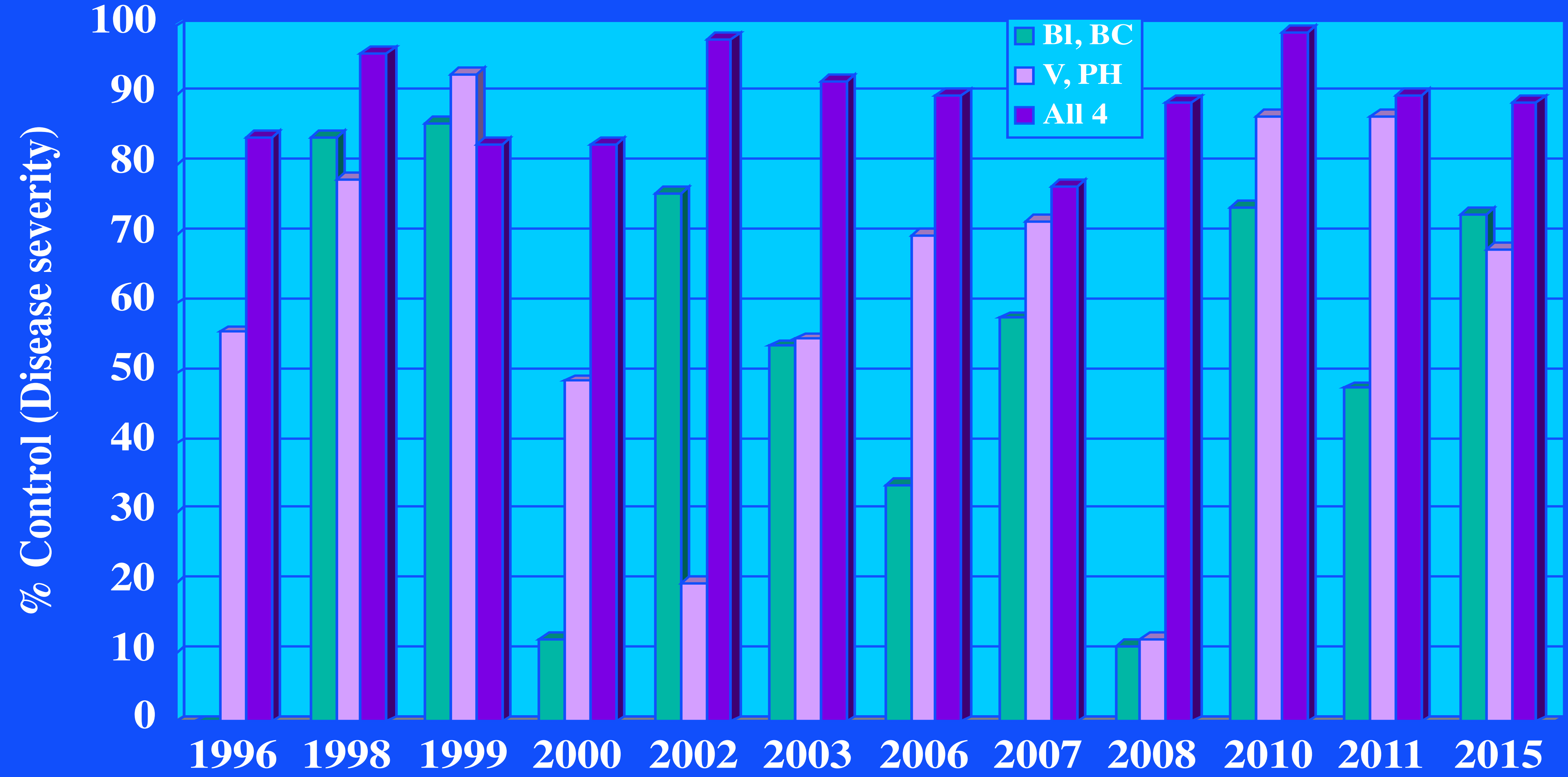
CLUSTER LOOSENING TECHNIQUES: TBLR

- Most reports = Efficacious
  - Clusters loosened, BBR control comparable to standard fungicide program, modest negatives
- Potential problems identified
  - Reduced yield/cluster [leave more buds = clusters?]
  - Logistics, too much labor [improved mechanization?]
  - Erratic/cv.-specific reactions

BOTRYTIS BUNCH ROT: MANAGEMENT

- Fungicides
  - When?
    - Protect against early latent infections?
    - Against *de* novo infections and 2° spread post-veraison?
    - Both?
  - Answer depends on climate (geographical and seasonal variations)

BOTRYTIS CONTROL: EFFECT OF SPRAY TIMING



BOTRYTIS BUNCH ROT: MANAGEMENT

- Fungicides
  - What?
    - <u>Most</u> standard fungicides relatively ineffective against *Botrytis*, <u>most</u> *Botrytis*-specific fungicides limited activity against unrelated pathogens

BOTRYTIS FUNGICIDES

- Anilinopyrimidines (APs)
  - Vangard (cyprodinil), Scala (pyrimethanil)
  - Readily absorbed
    - Internal activity
      - Post-infection
      - Suppression of latent infections
  - High resistance risk

BOTRYTIS FUNGICIDES

- Elevate (fenhexamid)
  - Originally <u>said</u> to remain on outside of berry (cuticle)—not true, has significant internal activity
    - Protectant
    - Post-infection, suppress latent infections
  - Moderate resistance risk

BOTRYTIS FUNGICIDES

- Rovral, generics (iprodione)
  - Absorbed
    - Demonstrated post-infection, anti-sporulant activities
  - Compromised activity due to resistance common <u>where used intensively</u>, not so otherwise

BOTRYTIS FUNGICIDES

- Strobilurin (QoI) fungicides
  - Flint (trifloxystrobin) registered @ 3 oz/A (vs. 1.5 – 2 oz/A for PM)
    - Protectant, antisporulant activities
    - NO internal (post-infection, etc.) activity
    - Activity against some additional bunch rot organisms
  - High resistance risk

BOTRYTIS FUNGICIDES

- Pristine (pyraclostrobin + boscalid)
  - Boscalid provides <u>most</u> of the Botrytis activity
    - Absorbed (hence, internal activity)
    - Protective + post-infection/latent suppr.
  - Pyraclostrobin has <u>modest</u> Botrytis activity
    - Protective (outside), no internal activity

BOTRYTIS FUNGICIDES

- SDHI (Group 7)
  - Boscalid (non-strobie component of Pristine)
  - Fluopyram (Luna Experience)
    - Presumed internal activity
  - Others in development


SOUR ROT
Photo courtesy W. McFadden-Smith

SOUR ROT

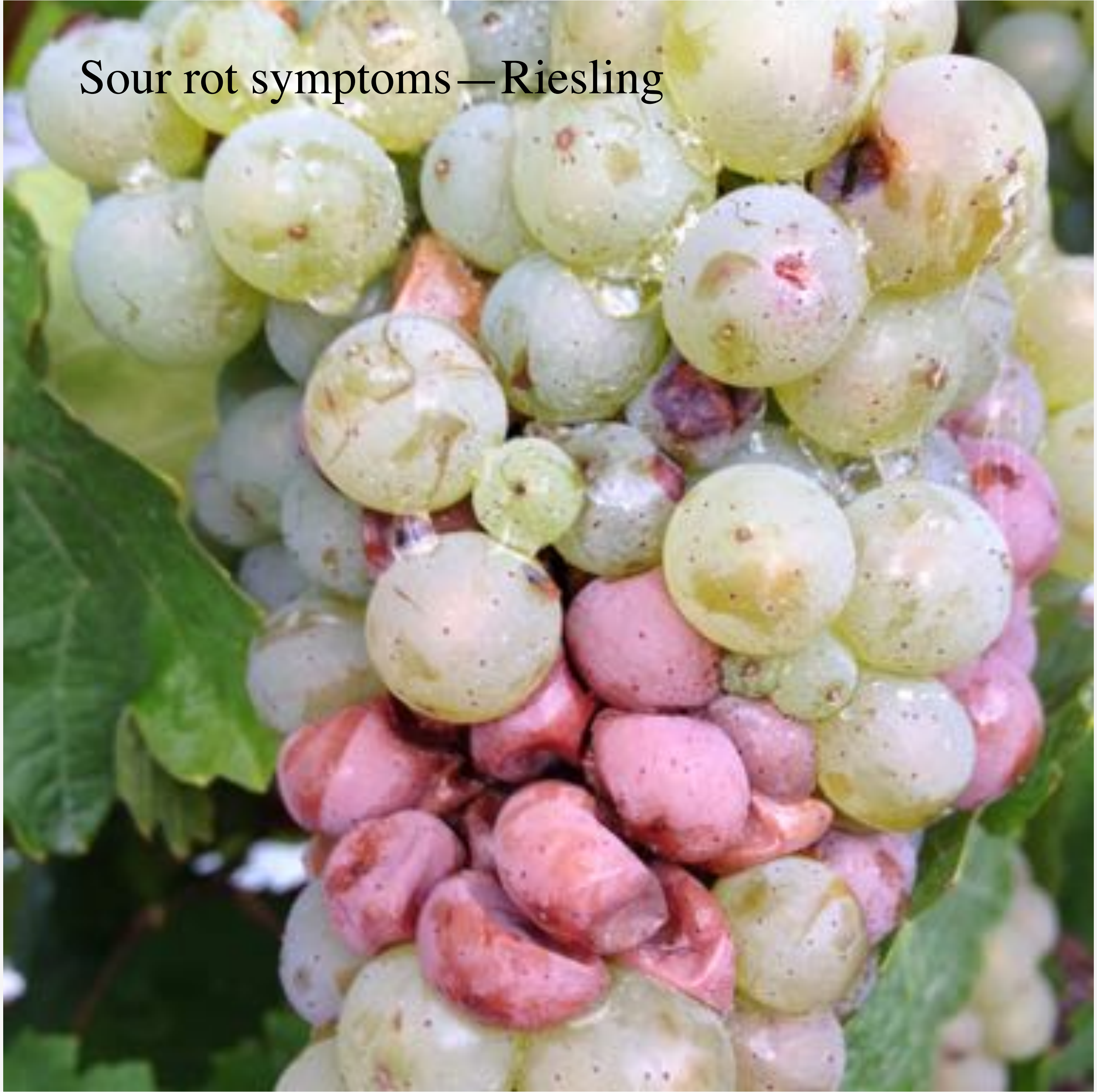
- Imprecise, colloquial term often used as a catch-all for ill-defined, non-Botrytis rots occurring pre- harvest
  - Sometimes attributed to filamentous fungi

Crop	Target Diseases	Product Use Rate per Application	Maximum Number of Applications per Season	Maximum Product Rate per Season	Minimum Time from Application to Harvest (PHI)
Grapes (except Concord, Worden, Fredonia, Niagara and related varieties)	Angular leaf spot (*Mycosphaerella angulata*) Anthracnose (*Elsinoe ampelina*) Black rot (*Guignardia bidwellii*) Downy mildew (*Plasmopara viticola*) Leaf blight (*Pseudocercospora vitis*) Phomopsis cane and leaf spot (*Phomopsis viticola*) Powdery mildew (*Uncinula necator*) Ripe rot (*Colletotrichum gloeosporioides*) **Aids in Control Only** Summer bunch rot (Sour rot) (*Cladosporium* spp. and *Aspergillus* spp.) **Suppression Only**	8 to 12.5 oz per acre	5	69 oz per acre	14 days

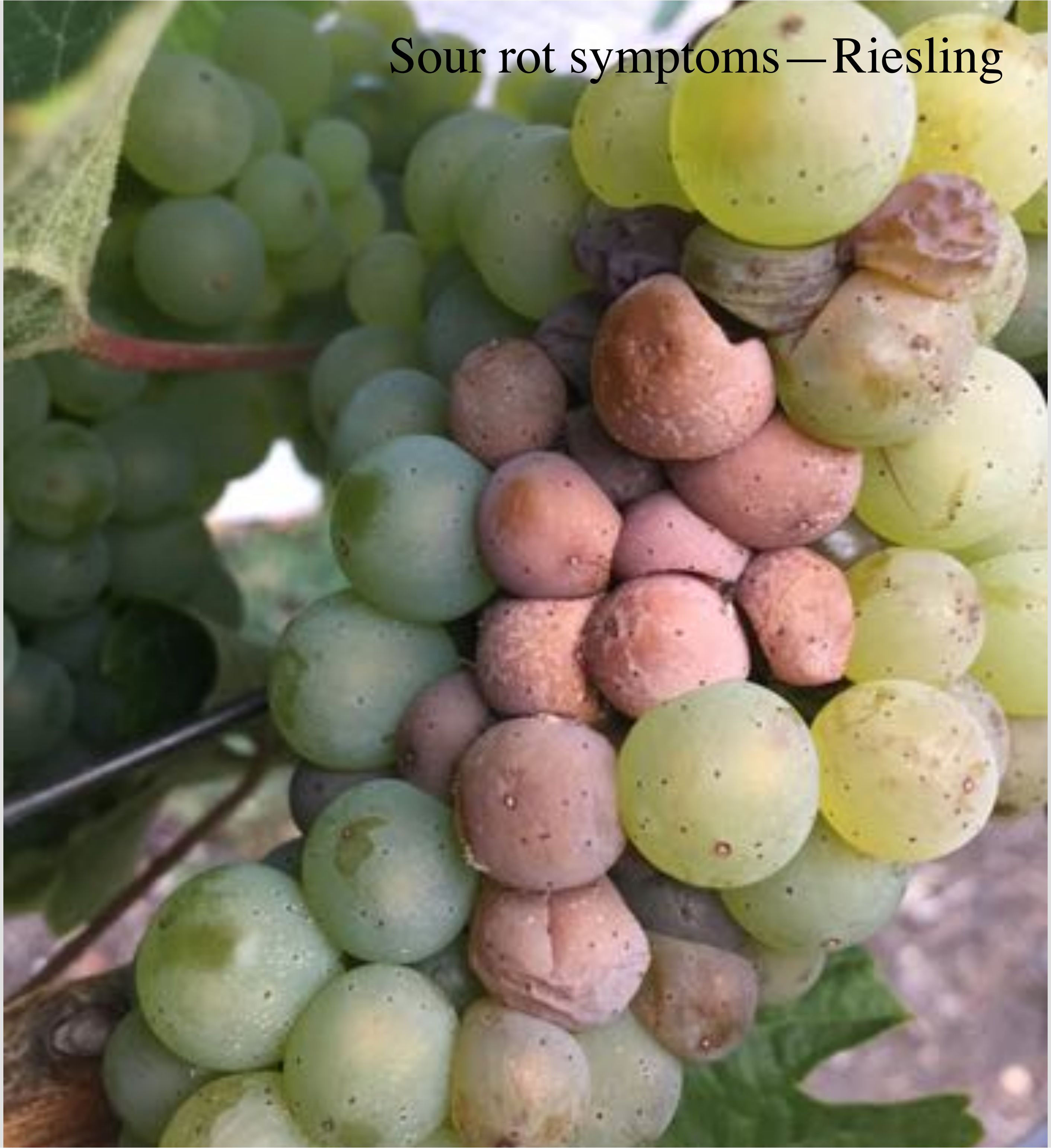
“TRUE” <u>SOUR</u> ROT

- Colonization by acetic acid-forming bacteria (*Acetobacter*, *Gluconobacter*)
  - <u>Vinegar smell</u> (Volatile acidity =VA)
  - No obvious signs of bacteria, just browning/discoloration of berries

Sour rot symptoms—Riesling



Sour rot symptoms—Riesling



Sour rot symptoms—Pinot noir

Photo courtesy W. McFadden-Smith

“TRUE” <u>SOUR</u> ROT

- Colonization by acetic acid forming bacteria (*Acetobacter*, *Gluconobacter*)
  - No obvious signs of bacteria
- May or may not show signs of mold growth
  - 2° colonizers favored by same conditions (rain, injury, sugar)

“TRUE” <u>SOUR</u> ROT

- Typically associated with large populations of *Drosophila* fruit flies (primarily *D. melanogaster)*

SOUR ROT DEVELOPMENT: ONTARIO RESEARCH (W. McFadden-Smith)

- No disease detected in field until rain (injuries, distribution of microorganisms) when berries ≥15°Brix
  - Confirmed by lab inoculations of *V. vinifera* berries at different Brix levels
  - Temp: Ideal = 68-77°F; moderate = 59-68°F; little = 50-59°F

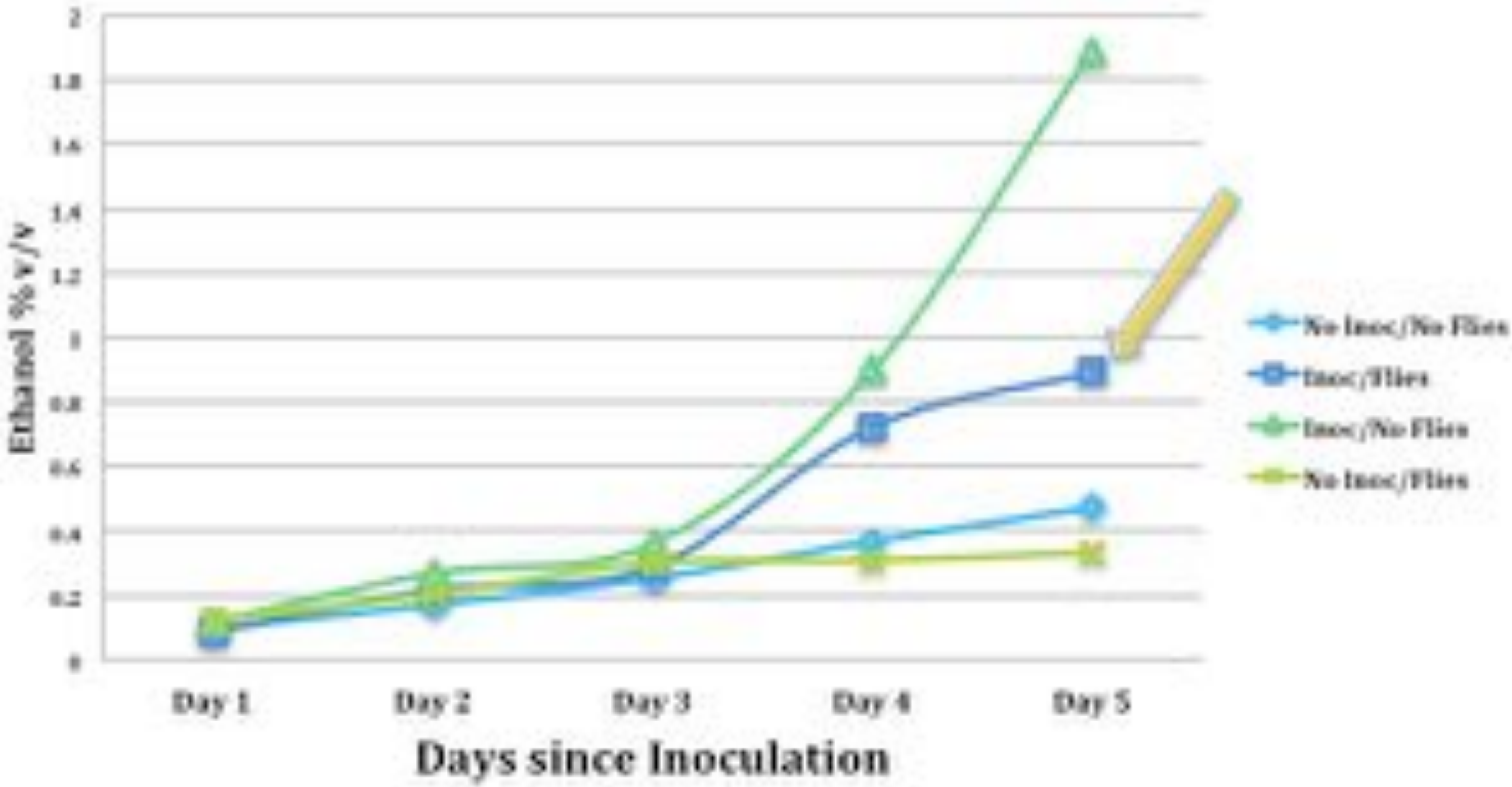
SOUR ROT DEVELOPMENT PROCESS (REPRODUCED IN OUR LAB)

- Acetic acid is final step in progression:
  - Injury
  - Colonization by yeast [*S. cerevisiae*] + AA bacteria [*A. aceti*]
  - Fermentation of juice to EtOH by yeasts
  - Oxidation of EtOH to AA by bacteria

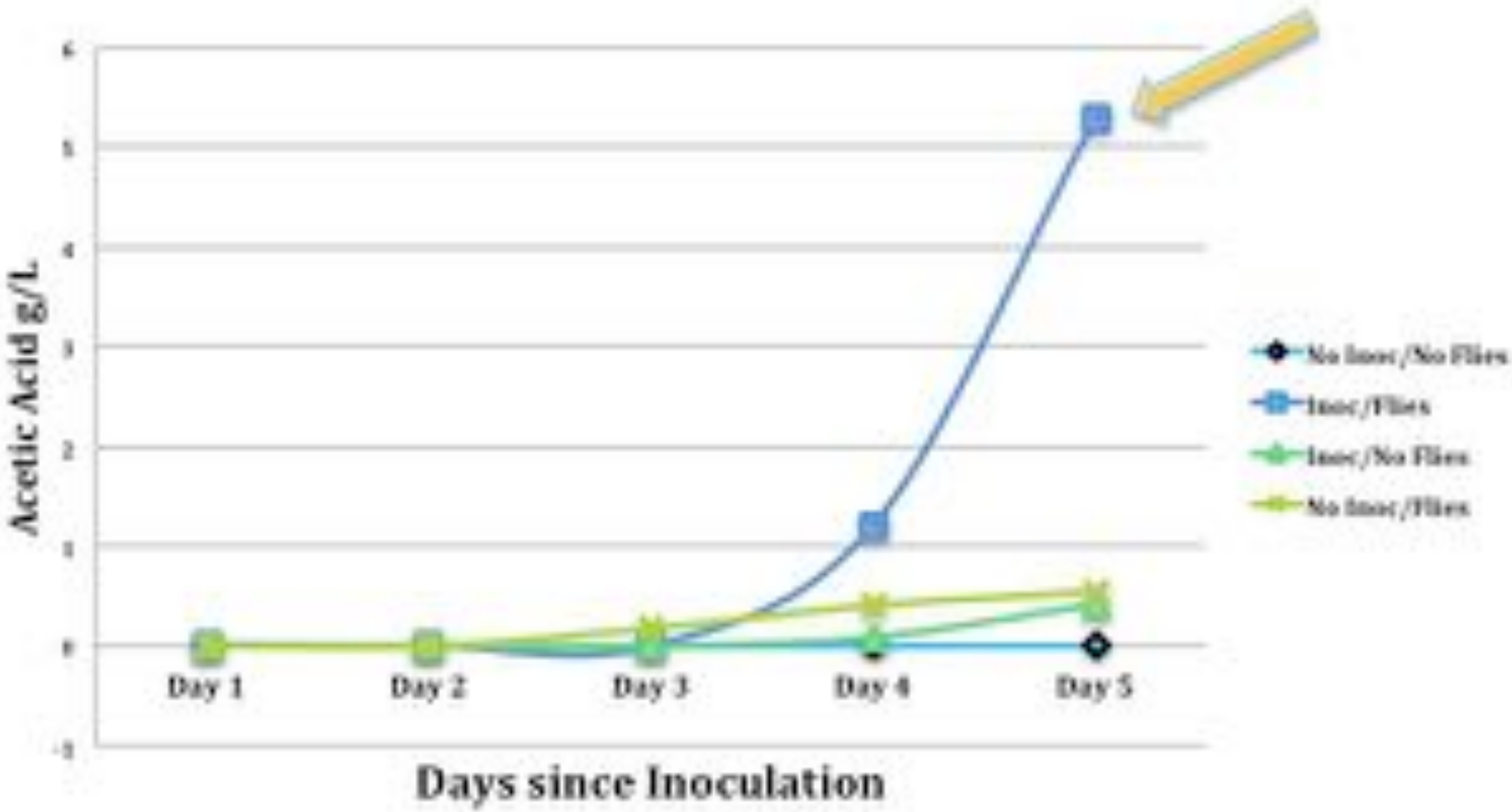
SOUR ROT: DEVELOPMENT PROCESS

- Acetic acid/VA is final step in progression:
  - Injury
  - Colonization by yeasts + AA bacteria
  - Fermentation of juice to EtOH by yeasts
  - Oxidation of EtOH to AA by bacteria
- <u>Fruit fly</u> activity <u>integral</u> part of the process

Ethanol Accumulation w/in Inoculated Berries



Acetic Acid Accumulation w/in Inoculated Berries



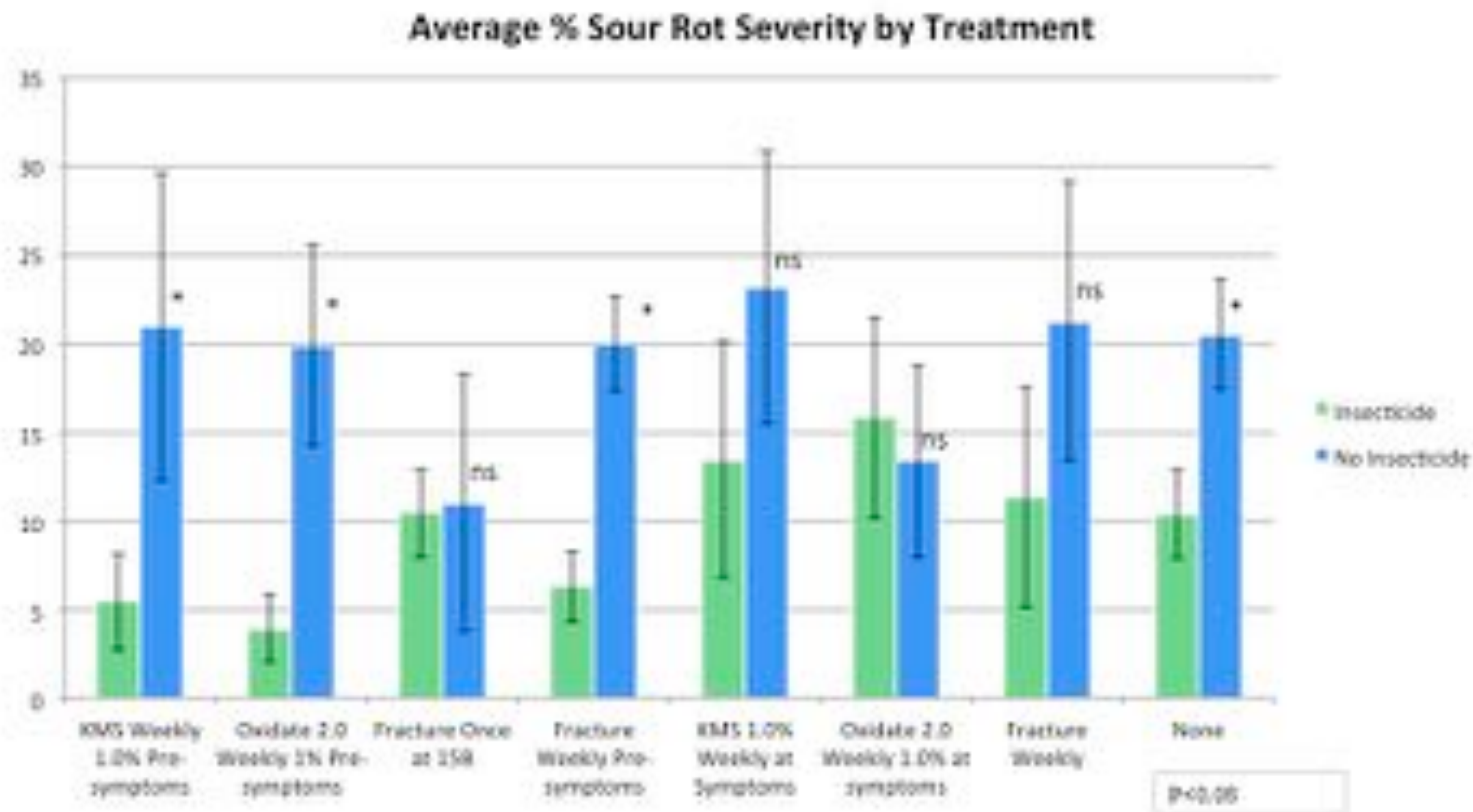
SOUR ROT CONTROL: THEORETICAL PRINCIPLES

- Minimize injuries
- Provide berry microclimate less conducive to pathogen growth
- Minimize pathogen populations
- Control fruit flies

2013, '15 SOUR ROT CONTROL TRIALS, cv. VIGNOLES (Geneva, NY)

- Sprayed alternate rows w/ or w/o insecticide for fruit flies
  - Weekly, starting ~15°Brix
- Within each row, anti-microbials (+ check)
  - Weekly, starting ~15°Brix
  - Weekly, after symptoms appeared

Control Trial 2015



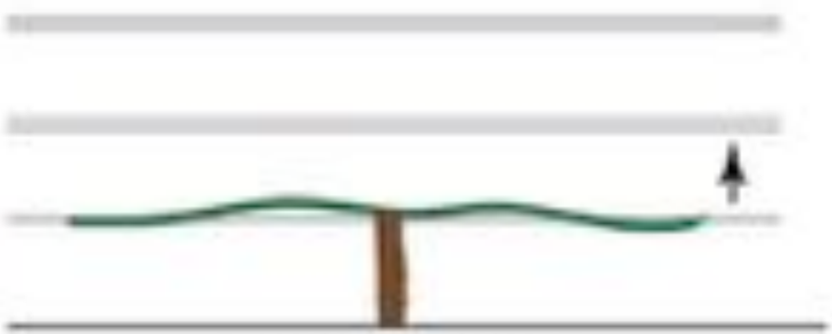
2015 SOUR ROT CONTROL TRIAL, SUMMARY

- Antimicrobials w/o insecticide: Avg. 4% control (vs. check)
- Insecticide w/o antimicrobial: 40% control
- Antimicrobials, *preventive* + insecticide: Avg. 74% control (vs. check)
- Antimicrobials, *post-symptom* + insecticide: Avg. 34% control (vs. check)

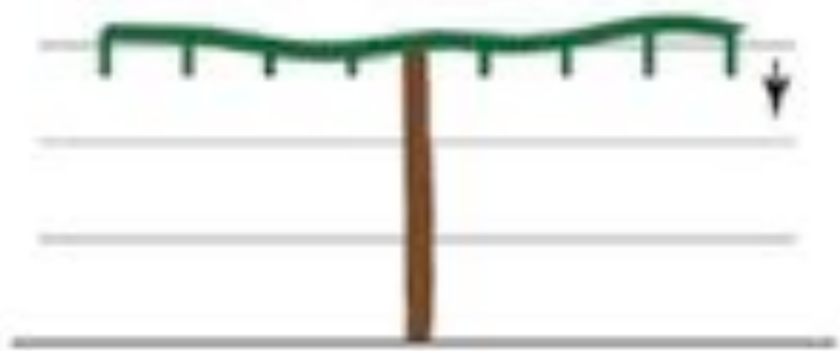
SOUR ROT CONTROL: THEORETICAL PRINCIPLES

- Minimize injuries
- Provide berry microclimate less conducive to pathogen growth
  - Canopy management

Two Training Systems, Commercial Vignoles Vineyard (Finger Lakes, NY)



Flat Cane VSP
(or Guyot)

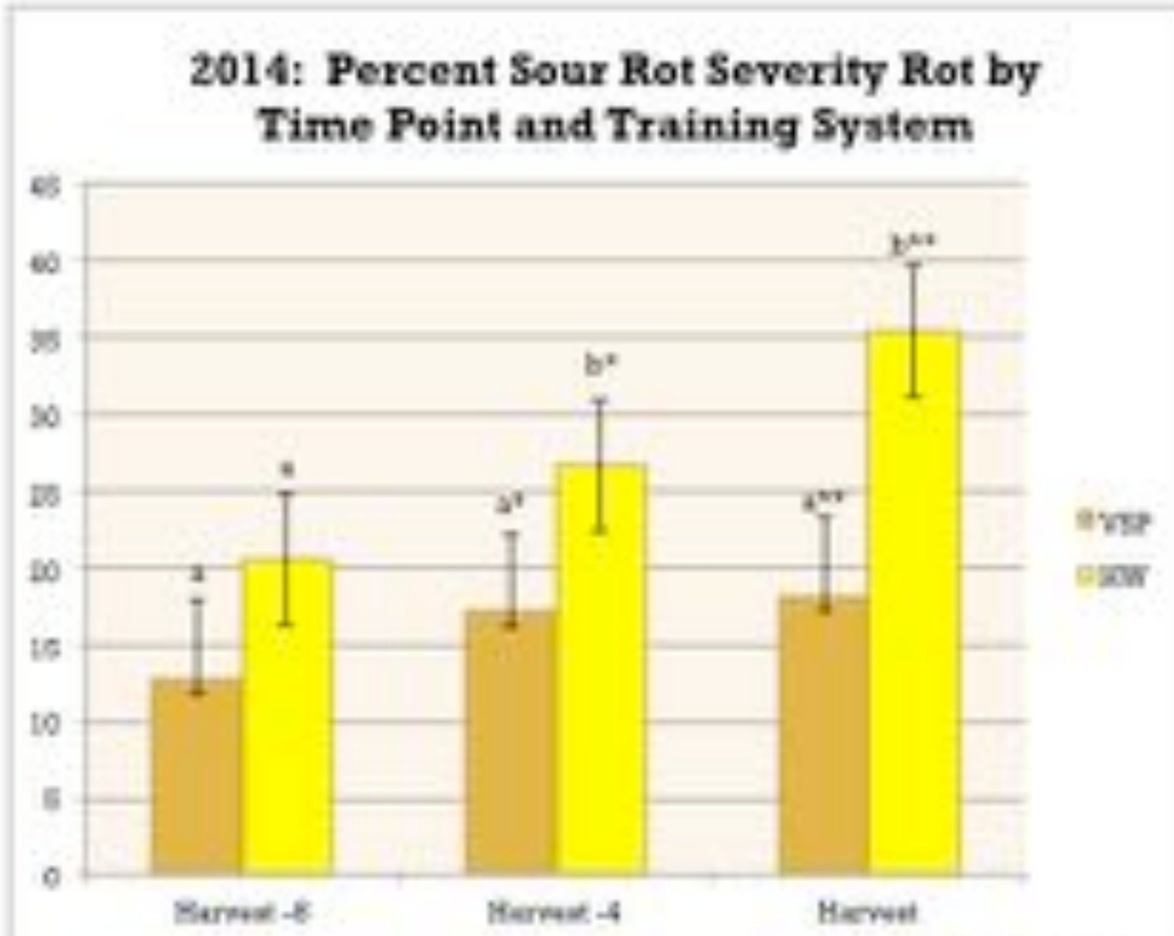


High Wire Cordon

Training Systems for New York Vineyards, Robert Pool, 2000, Cornell Fruit
http://www.fruit.cornell.edu/grape/pool/training.html

2014 Severity

- Significant change in severity over time in HW
- Statistical difference between training systems at Harvest-4 and Harvest.



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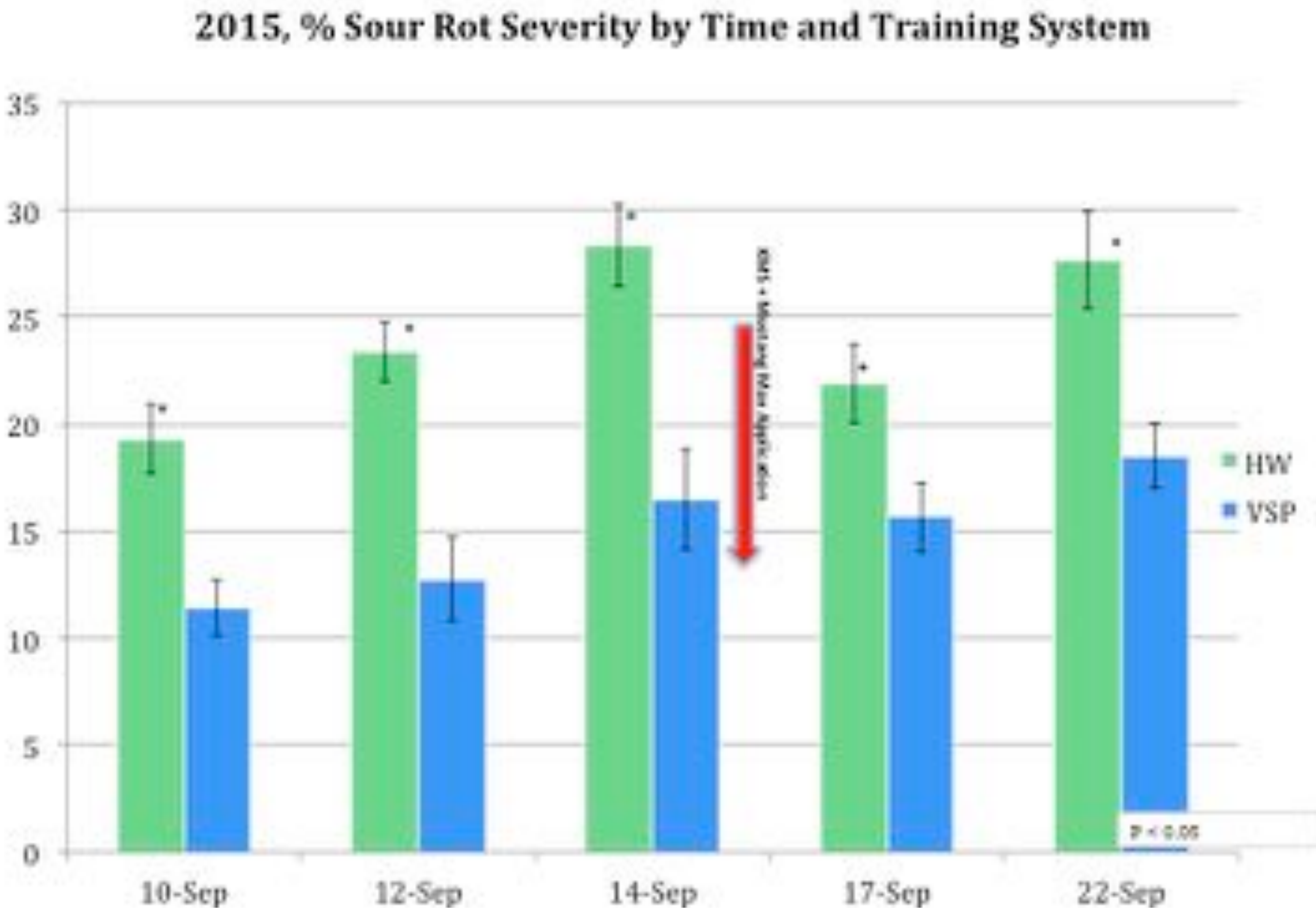

2015, % Sour Rot Severity by Time and Training System
35
30
25
20
15
10
5
0
10-Sep
12-Sep
14-Sep
17-Sep
22-Sep
HW
VSP
P < 0.05