Low-input Management for Diseases

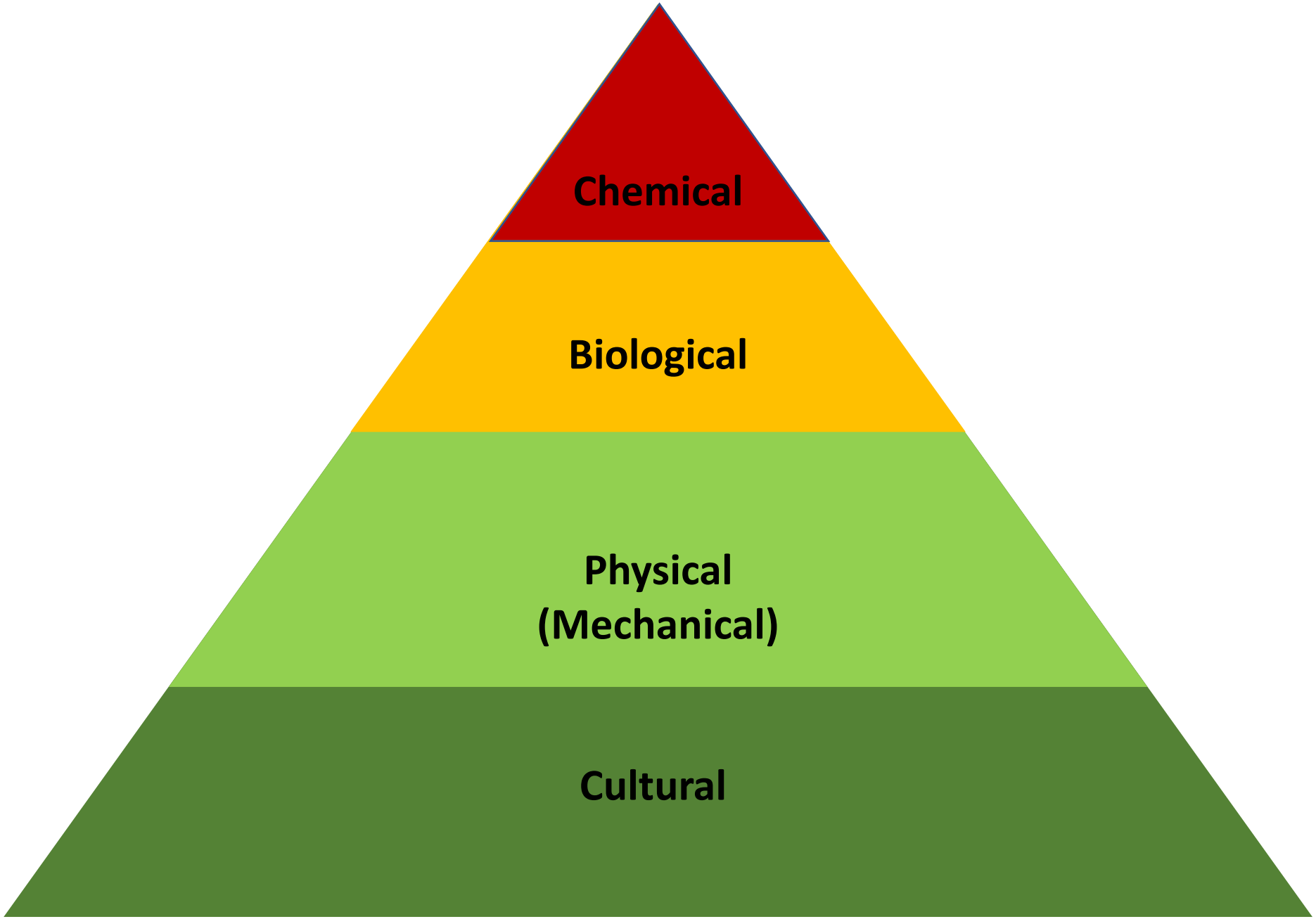
Dr. Suzanne Slack

Iowa State University

Pillars of IPM

- Action thresholds
  - How much damage is actually okay?
- Monitor and identify all pests
  - What is actually out there at what time?
- Prevention
  - Keep pests away before they establish
- Control
  - Multiple steps in a triangle

IPM Triangle



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Cultural control for diseases

- Soil Preparation
- Plant selection
- Rotation
- Interplantings
- Planting dates
- Trap crops

Cultural for diseases… in orchards

- Soil Preparation – ONE time in life of perennial
- **Plant selection – most important!**
- Rotation – every 20 years
- Interplantings – hard to do correctly
- Planting dates – one time!
- Trap crops – can be used (roses or monitor plants)

Physical for diseases

- Traps
- Barriers
- Pruning and raking
- Water sprays to remove pests
- Heat treatment

Physical for diseases… in orchards

- Traps – maybe if insect vectored
- Barriers – maybe if insect vectored
- **Pruning and raking – the best**
- Water sprays to remove pests – literally the worst thing you can do
- Heat treatment – some data supports this, depends on the pathogen

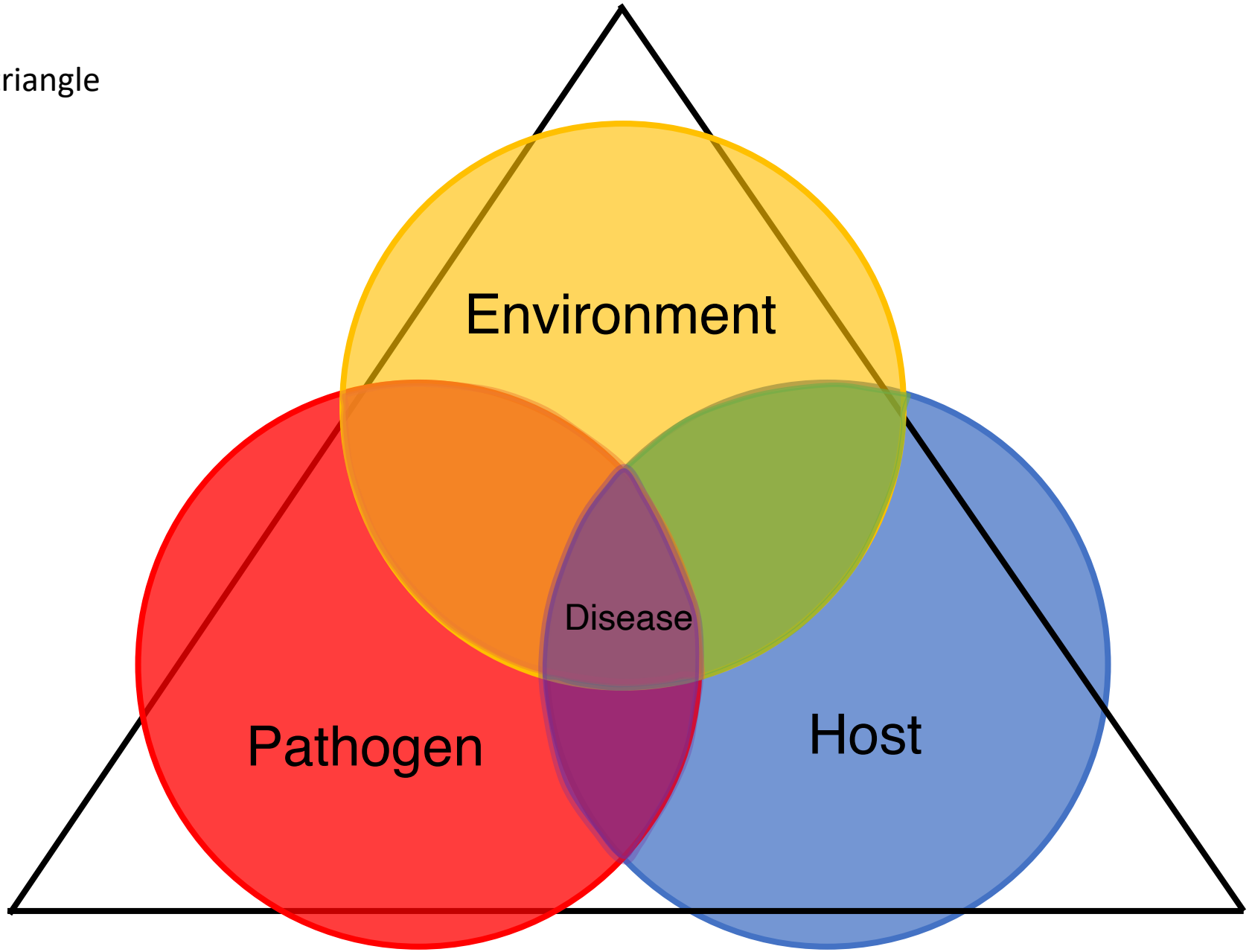
Biological for diseases

- Manipulating the microbiome to disadvantage pathogen
- Addition of predators
- Naturally occurring antimicrobials
- Boosting defense in the host

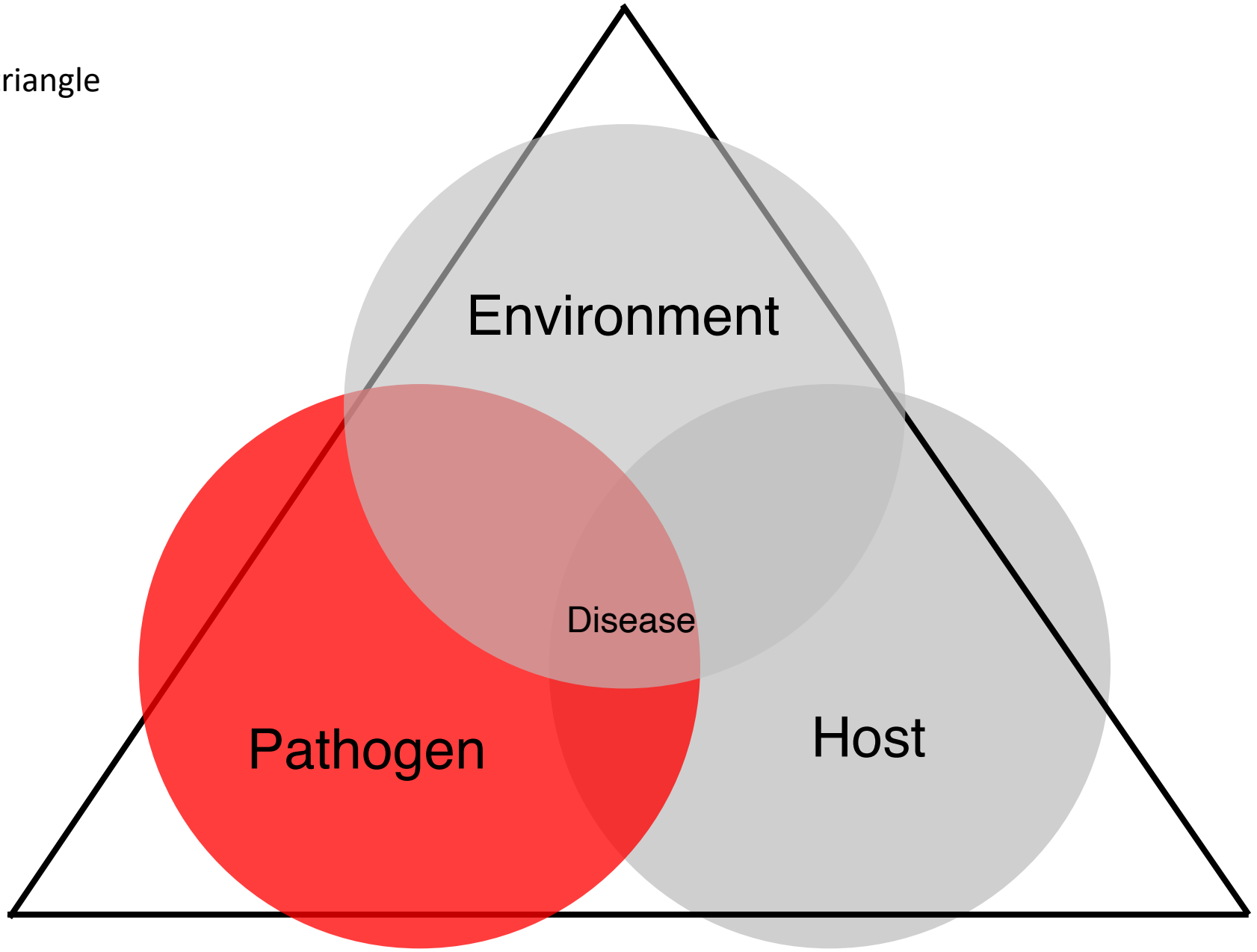
Chemical options for diseases

- Lots of options
- Really a spectrum of control options.
- For tree fruit we have broad spectrums and systemics

Disease triangle



Disease triangle



Types of plant disease causing agents

Fungi

Bacteria

Viruses

Oomycetes

Botrytis on strawberry

Papaya ringspot virus symptoms on papaya fruit. From APSnet Educ Ctr(Courtesy of S. Ferreira, copyright-free)

Fire blight on apple

Dead summer squash plant caused by Phytophthora blight attacking the crown
Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

Fungicides will not control bacteria

- Not many chemicals available for bacterial diseases
  - Copper, biologicals (host defense promoters) and some antibiotics

Fire blight

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Leaf or fruit spots

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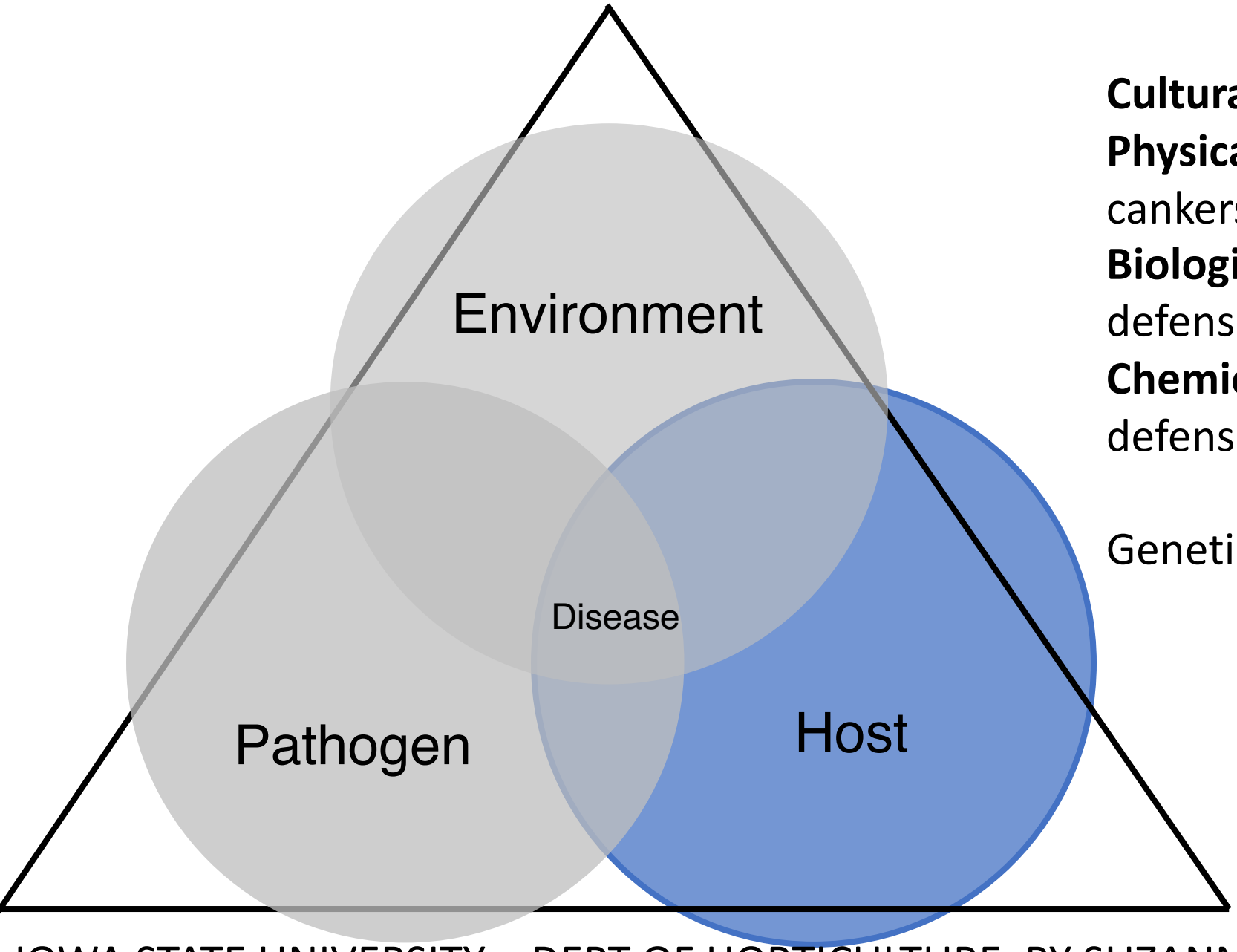
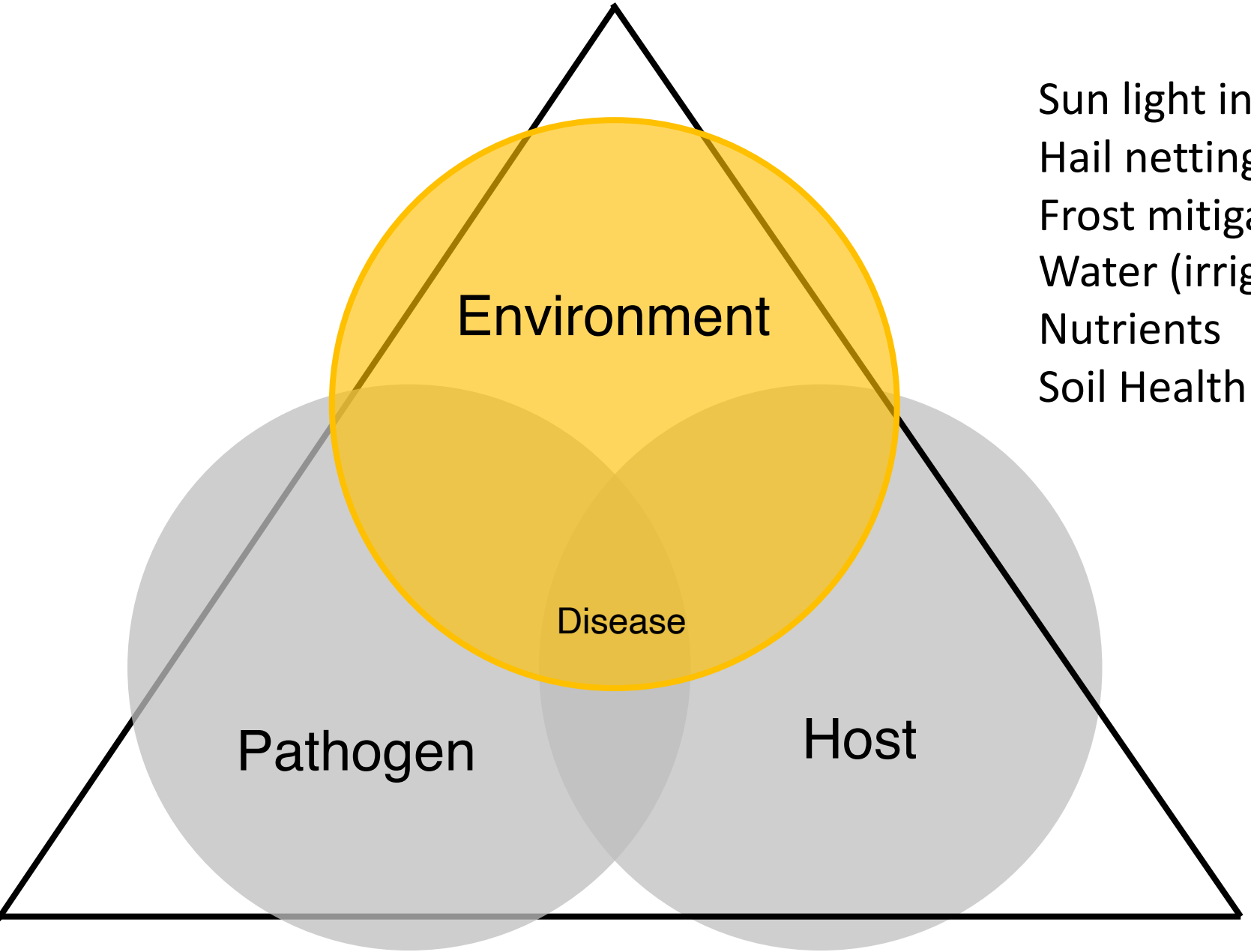


How can we manipulate the Host?

Cultural: plant selection
Physical: not much but removing cankers, leaves, and fruit mummies
Biological: probiotics and natural defense inducers
Chemical: synthetic hormone mimics for defense

Genetics – resistant hosts



Environmental factors we can manipulate:

Sun light intensity (Surround/shade cloth)
Hail netting
Frost mitigation (air movers)
Water (irrigation)
Nutrients
Soil Health

Cultural impacts on soil microbes, **mulching**

(B−): non-fertilized bare soil

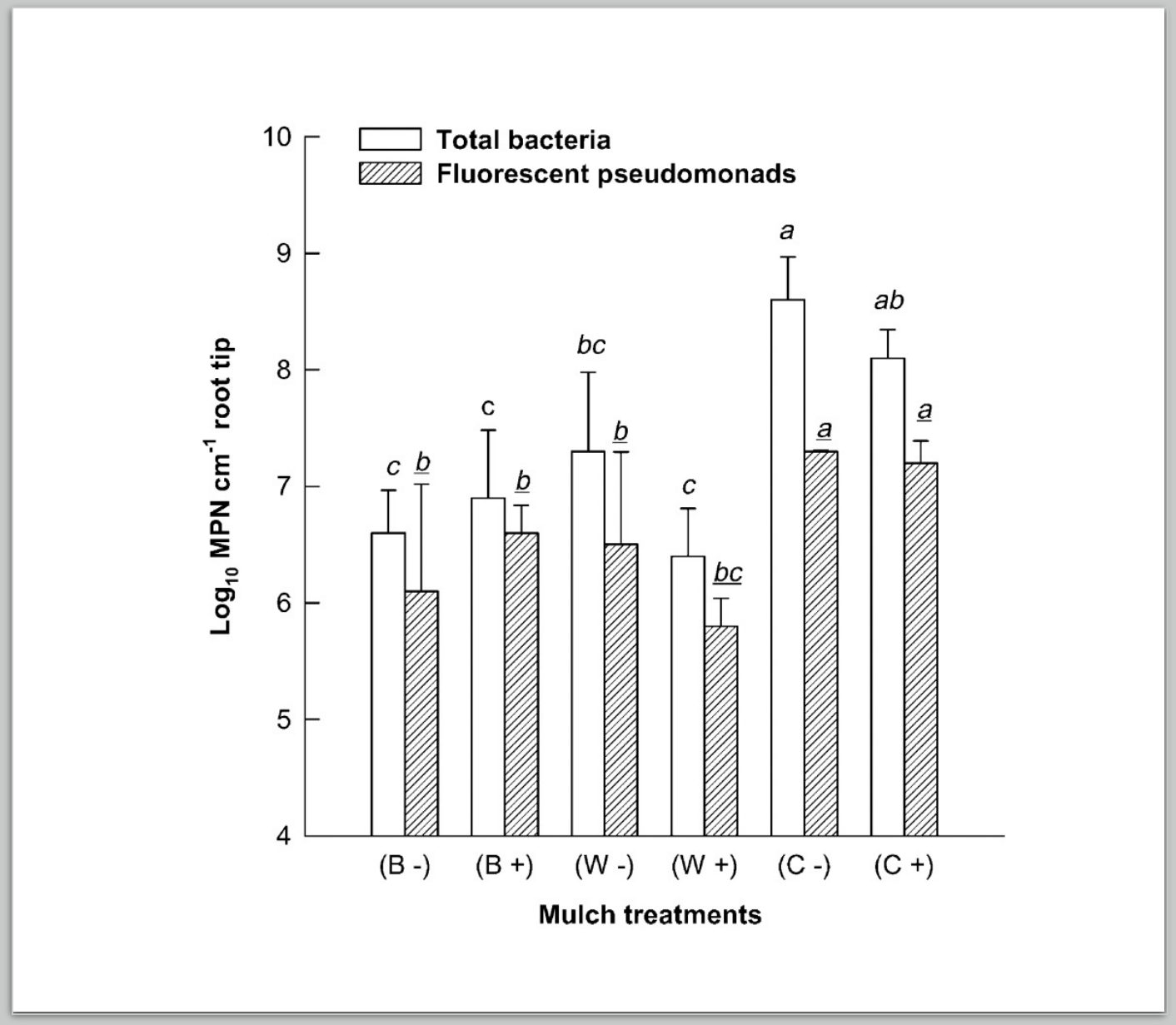
(B+): fertilized bare soil

(W−): non-fertilized ground wood pallet mulch

(W+): fertilized ground wood pallet mulch

(C−): non-fertilized composted yard waste

(C+): fertilized composted yard waste



Tiquia, S. M., Lloyd, J., Herms, D. A., Hoitink, H. A., & Michel Jr, F. C. (2002). Effects of mulching and fertilization on soil nutrients, microbial activity and rhizosphere bacterial community structure determined by analysis of TRFLPs of PCR-amplified 16S rRNA genes. *Applied soil ecology*, *21*(1), 31-48.

Fire blight (Pears, apples, raspberry)

- Late spring/early summer
- Bacteria: *Erwinia amylovora*
- Prone to sudden epidemics
- Kills plants quickly

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Fire blight

- Cultural
  - Some cultivars better than others (no true resistance)
- Physical
  - Cut out active strikes at least 6 inches below visible damage
  - Clean shears with bleach or rubbing alcohol
  - Remove cankers and dying trees promptly
- Biological/Chemical
  - Coppers in early spring
  - Antibiotics and biological controls (many options)

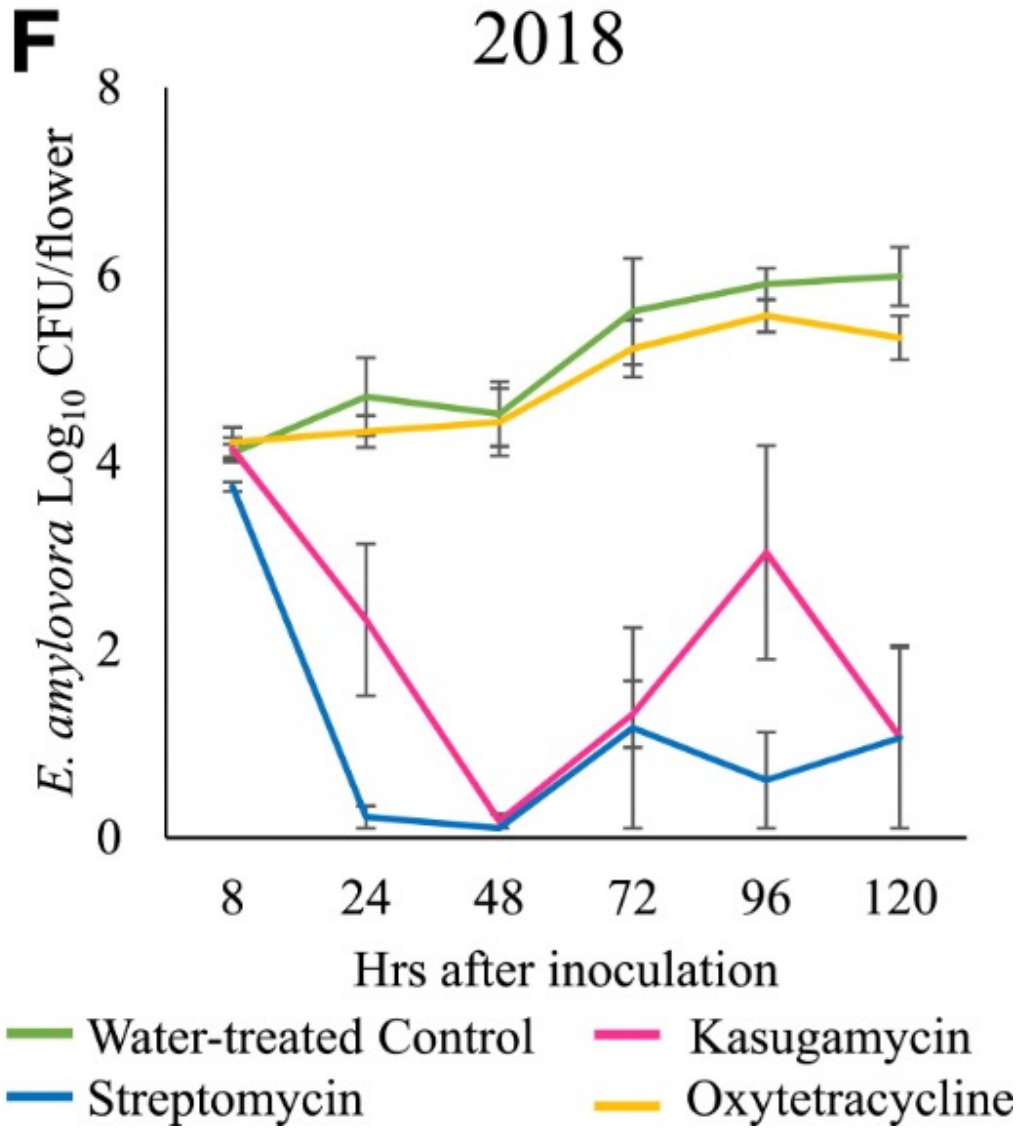
Streptomycin is the cheapest, but…

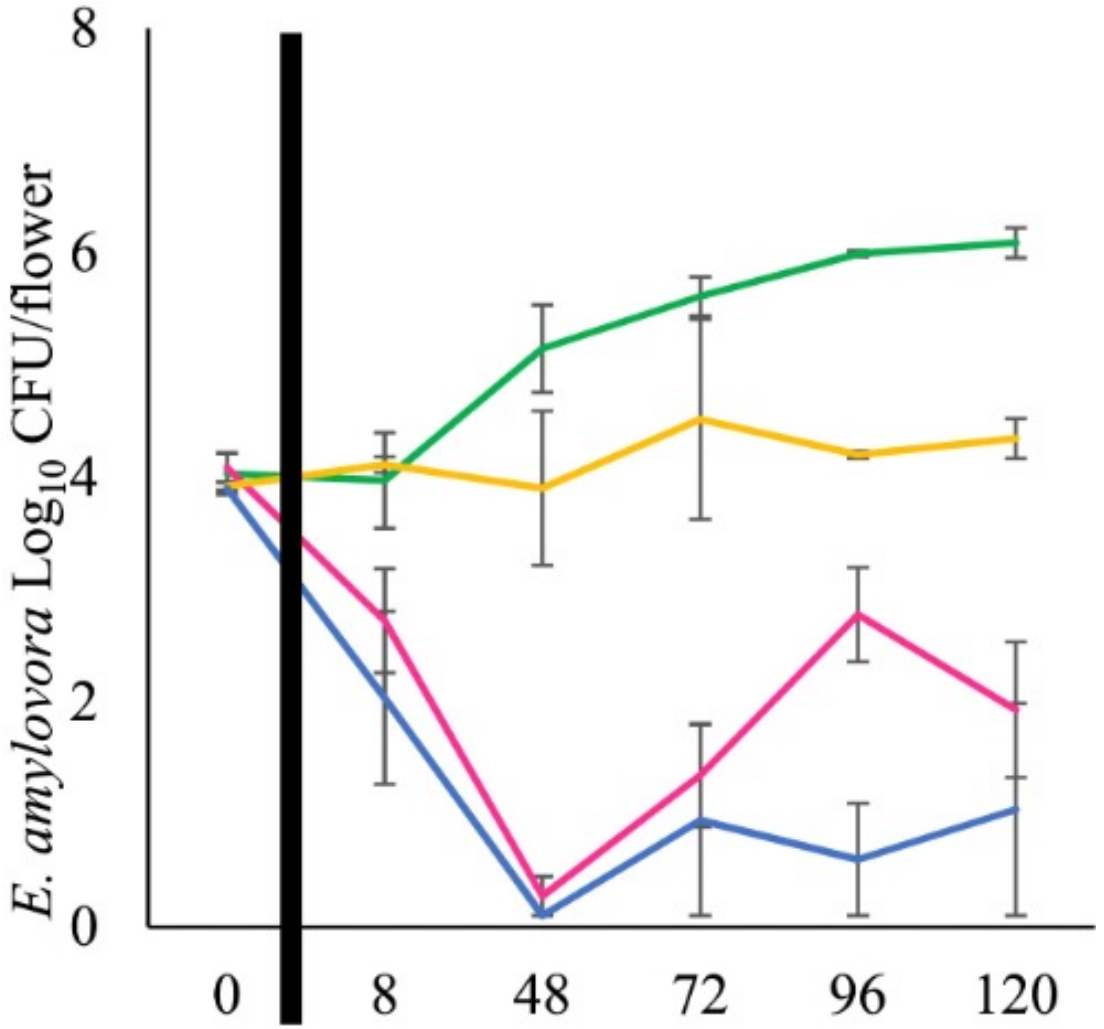
- Resistance issues (I found it in Iowa, so it's here)
- Broad spectrum (will kill beneficials)
- Long lasting (double edged, killing those beneficials)

- What are some friendlier alternatives?

Broad spectrum antibiotics

- Two others: kasugamycin and oxytetracycline
- Resistance rare in Oxy, nearly impossible with Kasug
- Low environmental permeance. Just long enough to do the job.
  - UV sensitive and readily breaks down
- Not systemic (double edge)





Slack et al., 2021

Plant manipulators

- Prohexidione Calcium (apogee, kudos, etc)
  - Can be used in low amounts to not stunt young trees
  - Can be used in large amounts to stunt big trees

- Systemic acquired resistance inducers (SARIs)
  - Turn on the plant's defenses

  - The bacteria that causes fire blight does not trigger defense; the trees do not respond to dying

Systemic acquired resistance inducers (SARIs)

- Lifegard (Bacillus mycoides isolate J)
- Regalia (extract of giant knotweed)
- Actigard (ASM)

Acibenzolar-S-methyl (ASM)

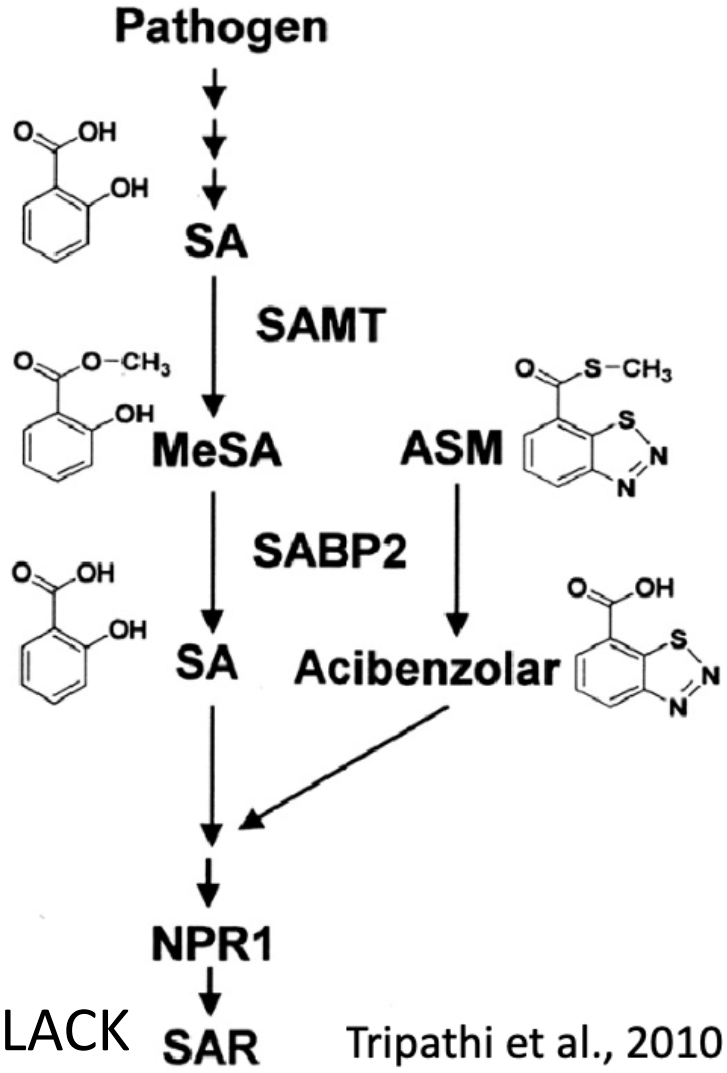
Synthetic analog of salicylic acid (SA)

Activates *NPR1*

- Positive regulator of systemic acquired resistance (SAR)

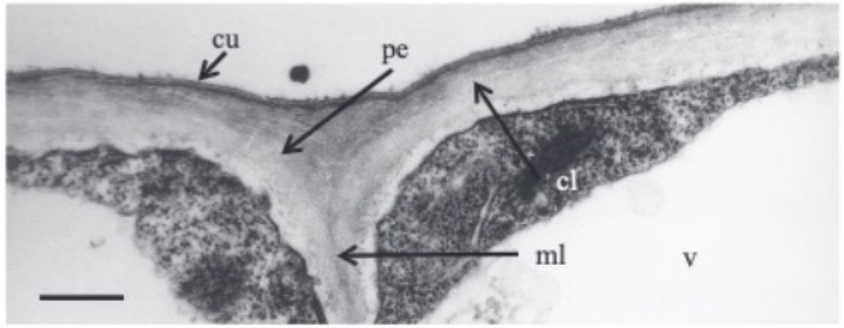
"Trick" a plant to think there is a pathogen present

- Really important for some disease management

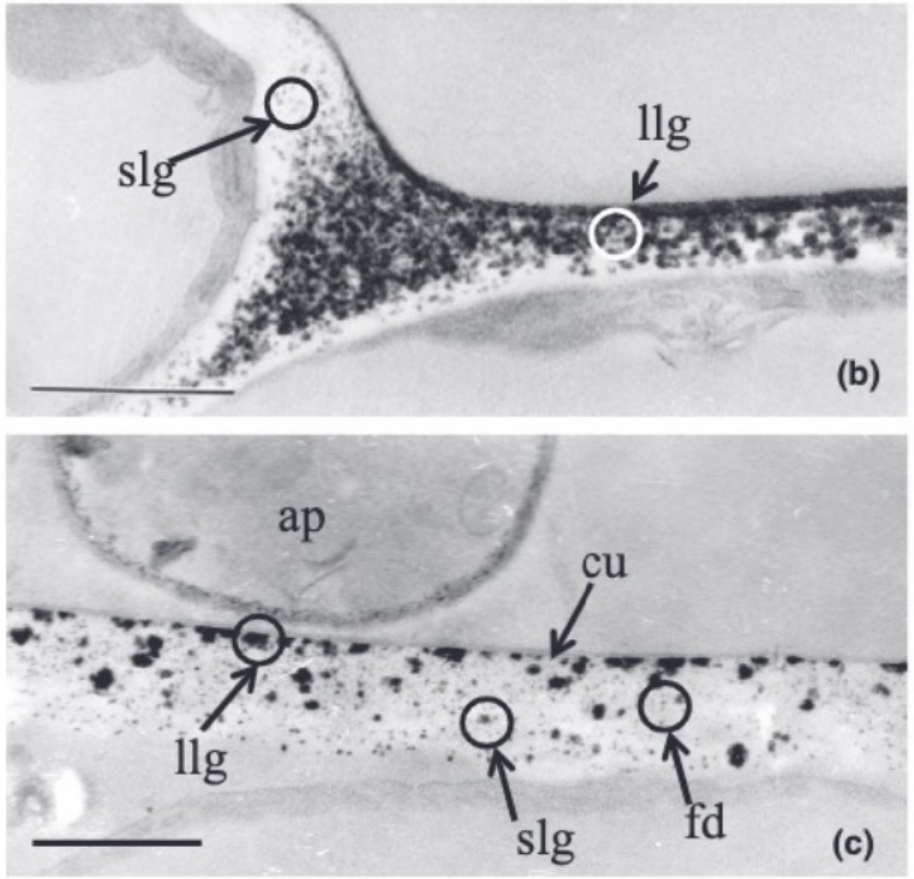


Tripathi et al., 2010

ASM promotes lignin deposits in plant cell wall



Before ASM



After ASM

Park et al., 2019

Actigard (ASM) Label

7.7 Pome Fruit Crop Group 11-10

Crops (Including all cultivars, varieties, and/or hybrids of these)		
Apple Azarole Crabapple Loquat	Mayhaw Medlar **Pear** Pear, Asian	Quince Quince, Chinese Quince, Japanese Tejocote

Target Pest	Rate (oz/A)	Application Timing	Use Directions
Suppression Only: Fire Blight (*Erwinia amylovora*)	**Foliar Application:** 1.0 – 2.0	Apply 2-3 applications between 20% bloom and petal fall depending on the environmental conditions. Additional applications may be made during subsequent infection periods.	**Suppression:** Apply Actigard 50WG Plant Activator in a tank mix or rotation with antibiotic products. Apply 1.0 – 2.0 oz/A in a tank mix with a fire blight treatment (generally an antibiotic) that is standard in your area.

continued...

Lifegard Label

Pome Fruits (Crop Group 11-10) Apple; azarole; crabapple; loquat; mayhaw; medlar; pears (including Asian); quinces (including Chinese, Japanese); tejocote; cultivars, varieties and/or hybrids of these	
Target disease/pathogen (bacteria & fungi)	**Additional information**
Fire blight (*Erwinia amylovora*)	*For fire blight control*: Begin applications when green tissue is present, prior to infection period. If no pre-bloom applications have been made, then combine applications with other standard bloom sprays targeting fire blight.
Flyspeck (*Zygophiala jamaicensis*) Glomorella leaf spot, bitter rot (*Colletotrichum gloeosporioides* species complex) Sooty blotch disease complex*	*For summer disease control*: Apply starting at petal fall through the cover sprays on a 10- to 14-day schedule. Apply in an alternating or tank-mix program with labeled fungicides as part of a disease management program
Powdery mildew (*Podosphaera leucotricha*) Cedar apple rust (*Gymnosporangium juniperi- virginianae*) Apple scab (*Venturia inaequalis*)	Apply starting at petal fall through cover sprays on a 7 to 14-day schedule. Apply in an alternating or tank-mix program with labeled fungicides as part of a disease management program.

Regalia Label

Crop	Target Disease	Application Method	Product Use Rate per Application	Application Instructions
Pome Fruits Apple Crabapple Loquat Oriental Pear Pear Quince	Powdery Mildew *(Podosphaera leucotricha)* Alternaria Blotch *(Alternaria mali)* Apple Scab *(Venturia inaequalis)* Suppression only Bitter Rot (*Colletotrichum* spp.) Cedar-Apple Rust *(Gymnosporangium juniperi-virginianae)* Suppression only Fire Blight *(Erwinia amylovora)* Suppression only Flyspeck *(Zygophiala jamaicensis)* Sooty Blotch *(Geastrumia polystigmati)* *(Leptodontium elatius)* *(Peltaster fructicola)* White Rot *(Botryosphaeria dothidea)*	Foliar	1–4 quarts per acre	For foliar applications, apply this product in 50–100 gallons of water per acre. Do not exceed 1.0% v/v of the applied solution. Repeat applications on 7–10 day intervals. Additional sprays beyond second cover may be needed on susceptible varieties, or when environmental conditions are conducive to rapid disease development. Use high label rate and shorter spray intervals when conditions are conducive to rapid disease development. Use caution when selecting spray adjuvants. Select only those adjuvants which through prior experience do not affect fruit finish when combined with this product. Avoid excessive amounts of water that result in runoff of spray material. Fire Blight – For suppression, apply 1–2 quarts of this product in 50–100 gallons of water per acre beginning at green tip through bloom. Following bloom, this product can be applied at 2-4 quarts per acre. For maximum control, use this product prior to infection events. During periods of rapid development and frequent infection periods, use spray intervals of 3–7 days.

Label cont.

Crop	Target Disease	Application Method	Product Use Rate per Application	Application Instructions
Pome Fruits *(cont.)*	Powdery Mildew *(Podosphaera leucotricha)* Alternaria Blotch *(Alternaria mali)* Apple Scab *(Venturia inaequalis)* Suppression only Bitter Rot (*Colletotrichum* spp.) Cedar-Apple Rust *(Gymnosporangium juniperi-virginianae)* Suppression only Fire Blight *(Erwinia amylovora)* Suppression only Flyspeck *(Zygophiala jamaicensis)* Sooty Blotch *(Geastrumia polystigmati)* *(Leptodontium elatius)* *(Peltaster fructicola)* White Rot *(Botryosphaeria dothidea)*			Apply in sufficient water to provide full coverage. For improved Fire Blight performance, use this product in a rotational program with copper or antibiotics registered for Fire Blight control such as but not limited to oxytetracycline or streptomycin. Proper orchard cultural practices are essential to eliminate Fire Blight-infected tissue from the orchard to assure good performance of any crop protection product. Remove and destroy dead and diseased wood from the orchard prior to and during the growing season. Scab – For suppression, apply 1-2 quarts of this product in 50–100 gallons of water per acre at green tip and through bloom when environmental conditions become favorable for primary Scab development and repeat on a 7–10-day interval or as needed. Use this product in a tank mix or rotational program with other fungicides labeled for Scab control. Following bloom, this product can be applied at 2–4 quarts per acre.
Some sensitive tree fruit varieties have exhibited petal staining and/or necrosis after application of higher use rates. To minimize petal staining and/or necrosis: • Use adjuvants that improve coverage, not penetration; follow the manufacturer's mixing instructions. • Use adjuvants that through prior experience do not affect petal integrity when combined with this product. • Apply 1 quart of this product in 50–100 gallons of water per acre in Pome Fruit, from 10% bloom to full bloom.				

Apple Scab

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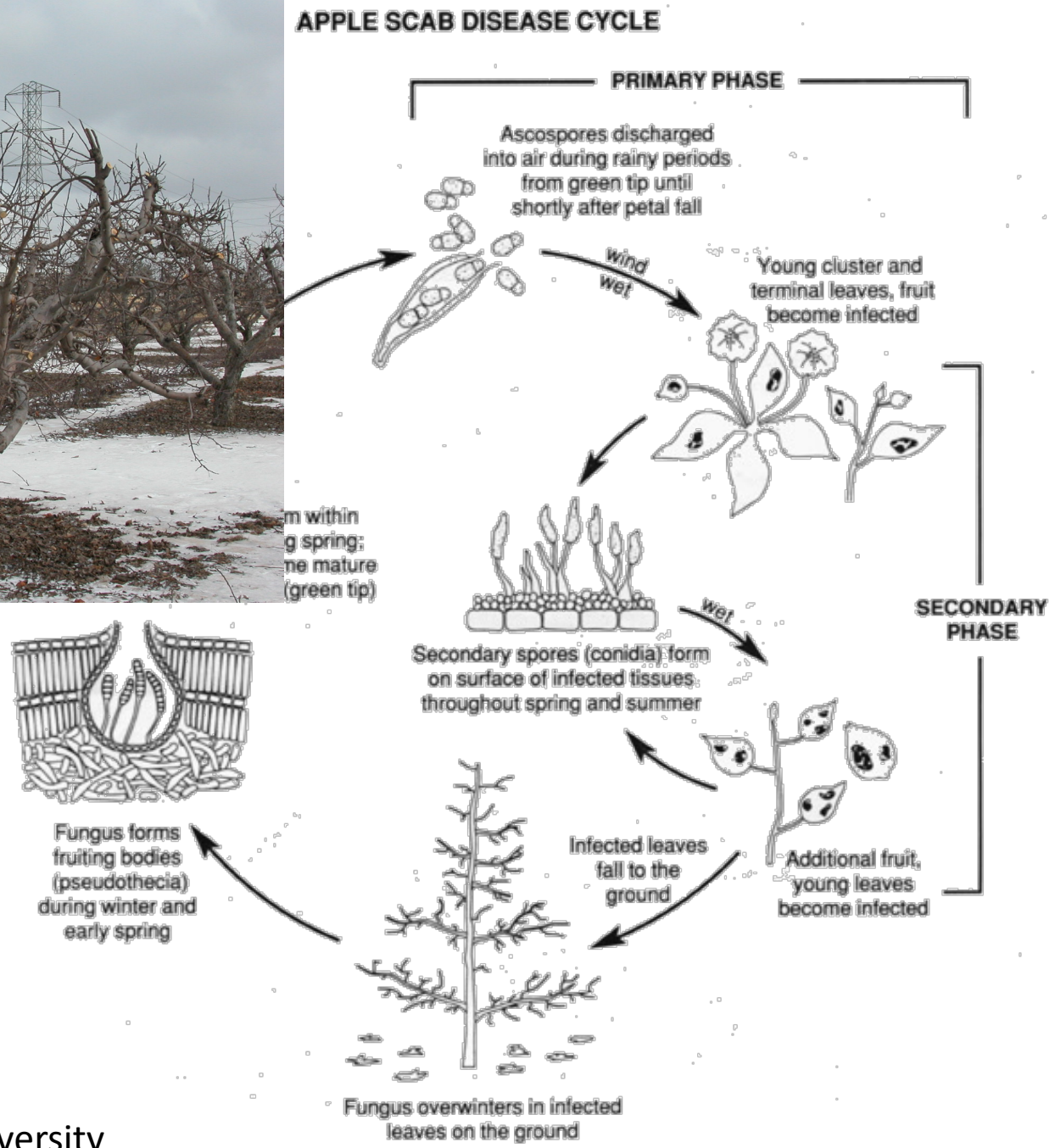
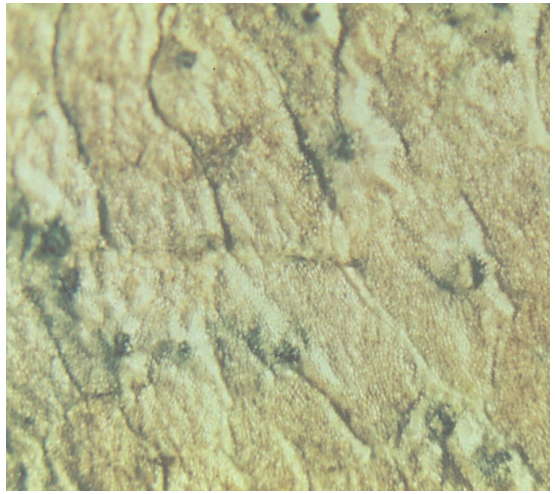


Slide Made by George Sundin, Michigan State University

Pseudothecia on leaf litter in spring



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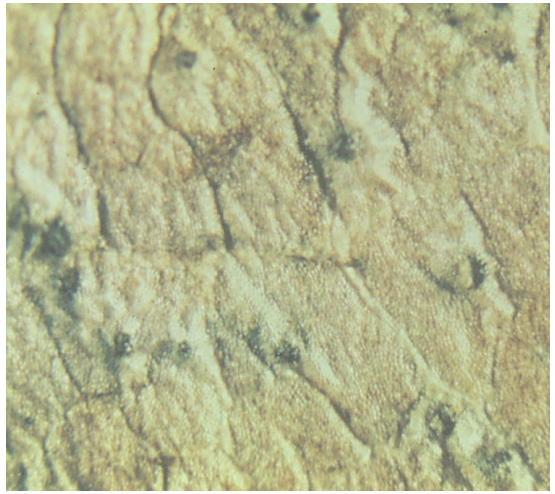
Sundin

Pseudothecia on leaf litter in spring



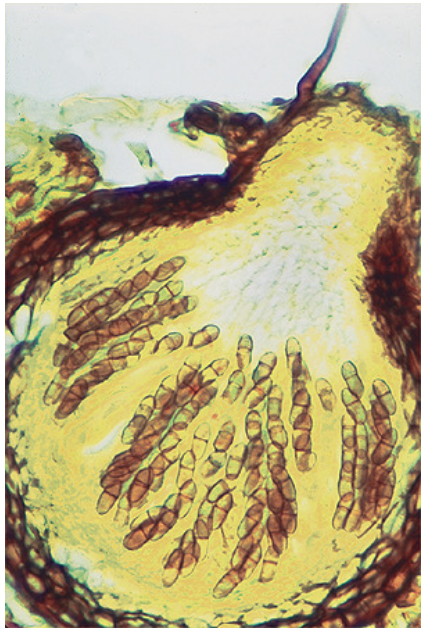
Slide Made by George Sundin, Michigan State University

Sundin

Apple scab infection event

- Leaves wet by rain
  - Pseudothecia thoroughly wet
  - Mature ascospores released
- Deposition of ascospores on susceptible tissue
- Spore germination
  - Only occurs when in contact with free water
  - Affected by temperature
- Spore germ tube growth, appressorium formation (penetration structure)
  - Affected by temperature

Slide Made by George Sundin, Michigan State University



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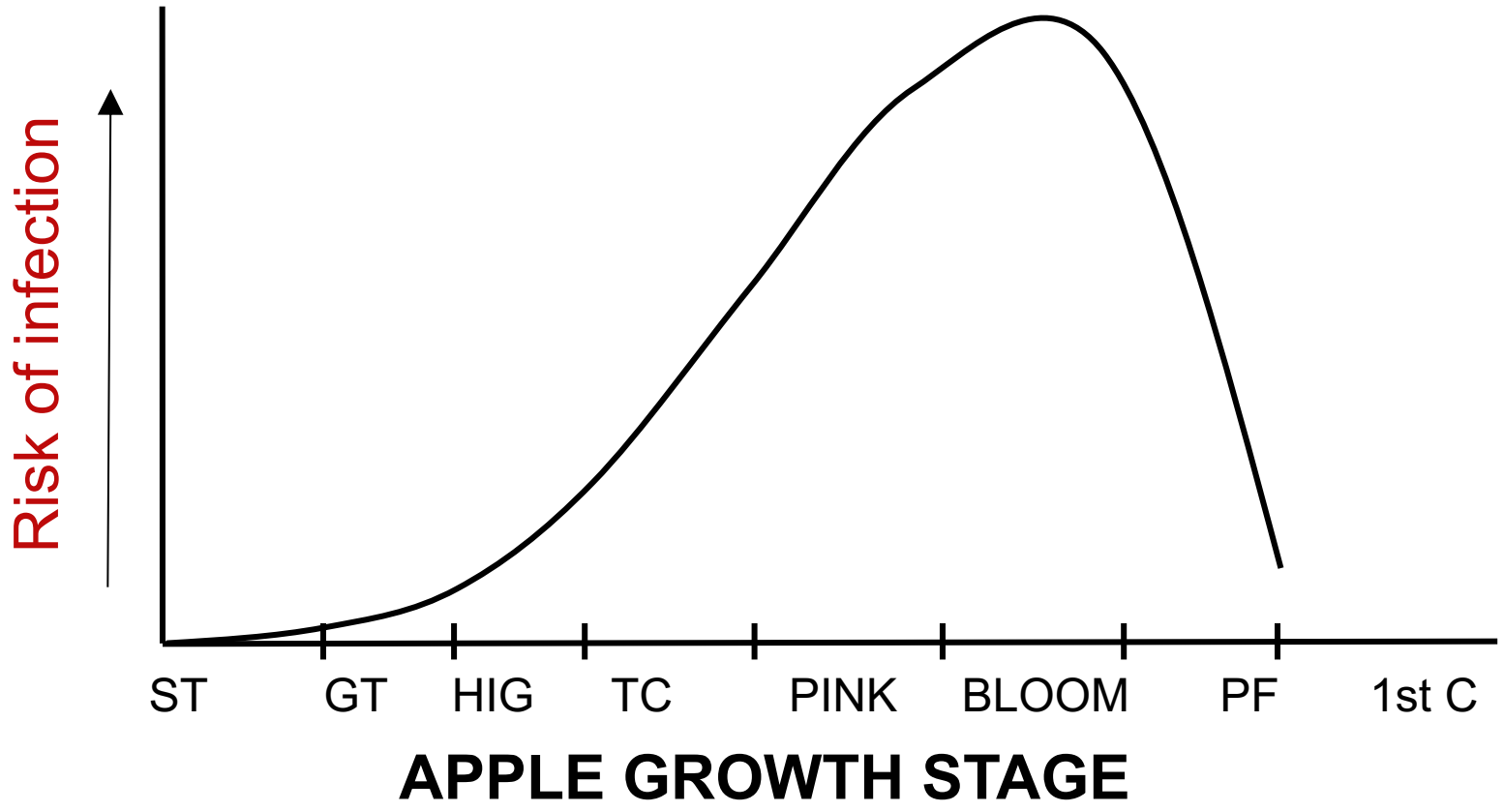
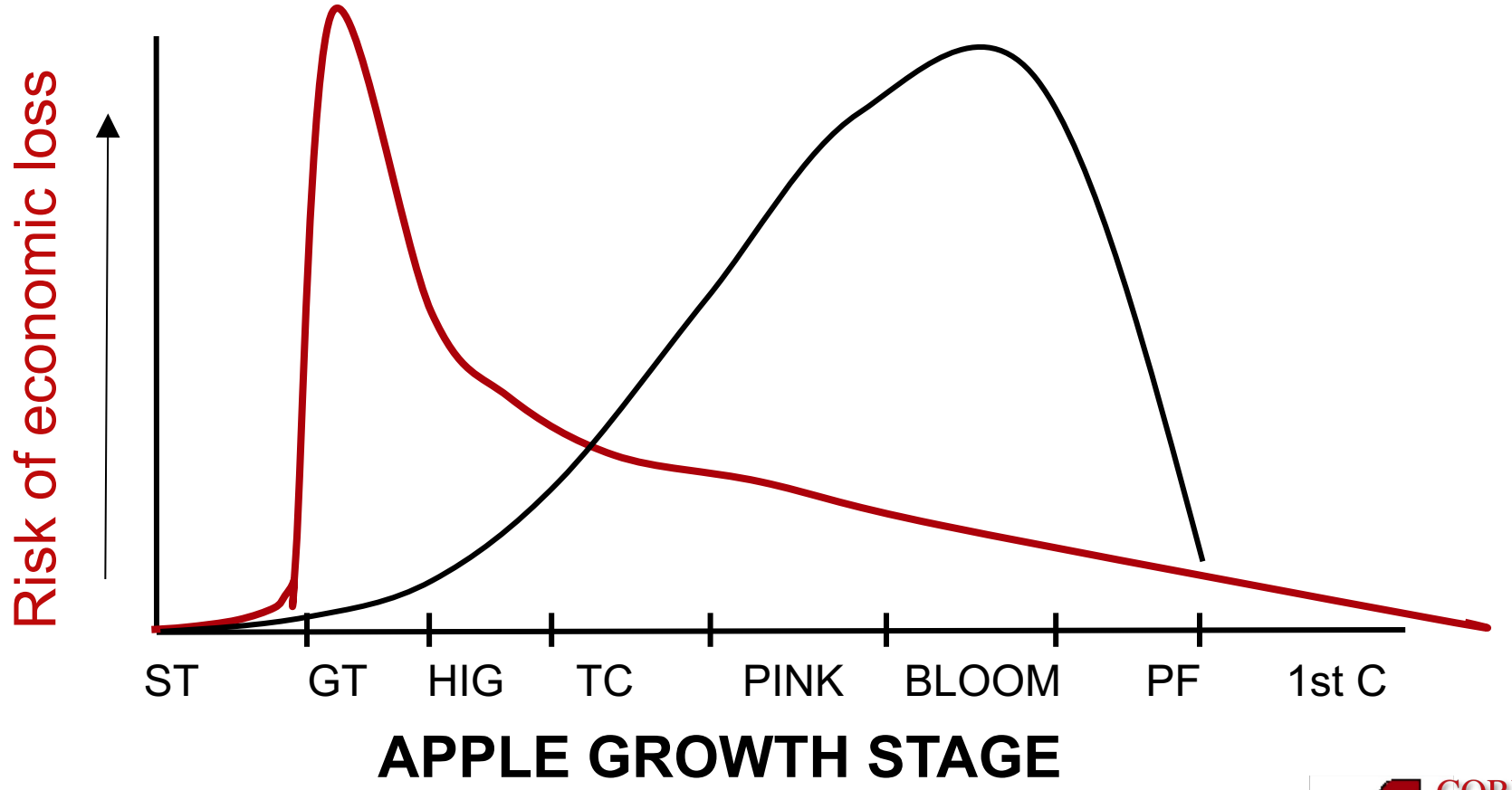
Apple Scab Infection Risk



Dave Rosenberger
CORNELL'S Hudson Valley LABORATORY

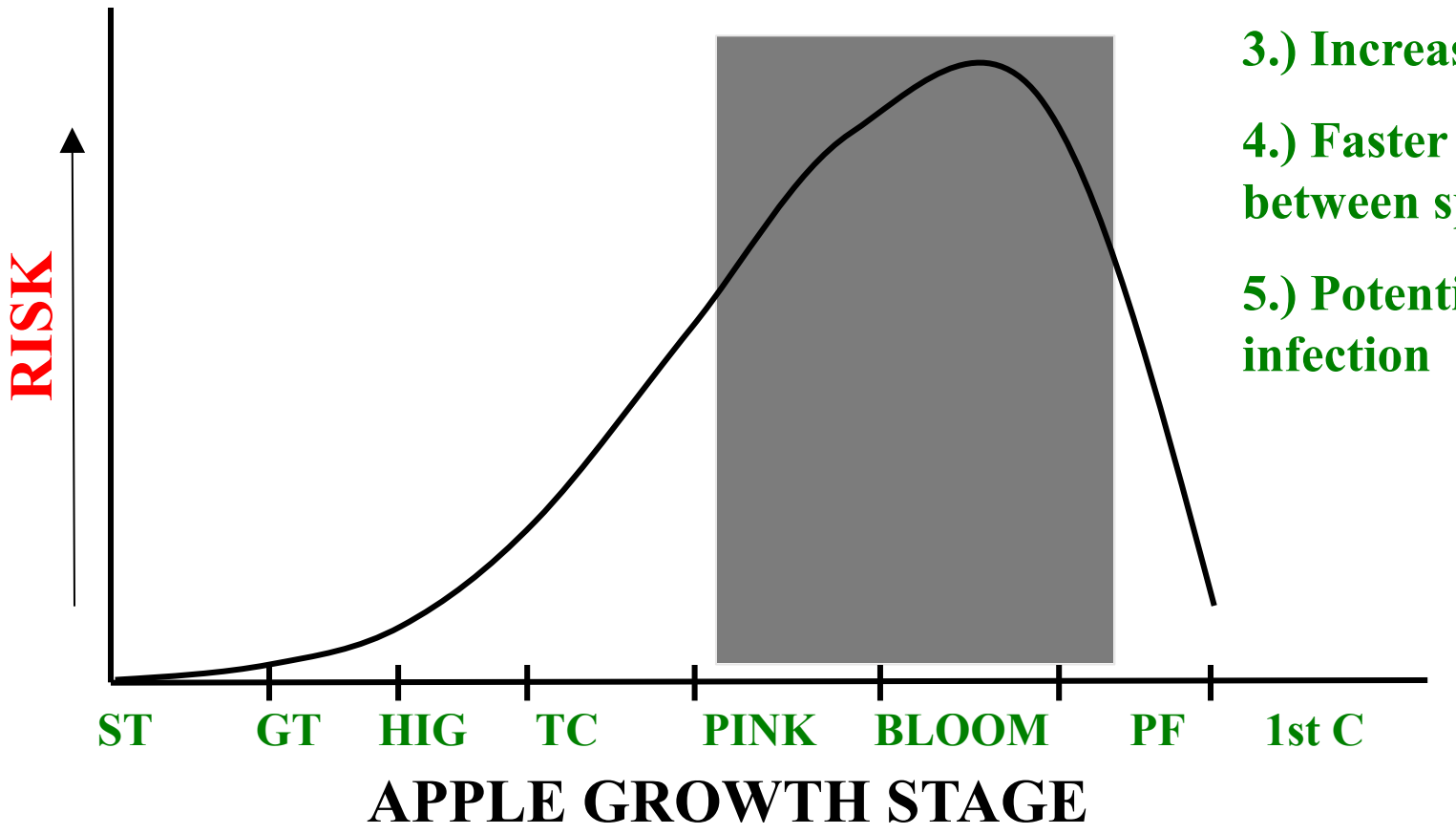
Apple Scab Infection Risk

Risk of economic loss: Infections incurred soon after budbreak pose the greatest risks in sprayed orchards.



CORNELL'S Hudson Valley LABORATORY

Pink to Petal Fall:
in general, a higher inoculum timing



1.) More spores to contend with

2.) Warming temps

3.) Increased green tissue

4.) Faster tree growth between sprays

5.) Potential fruit infection

Apple scab control with fungicides

- **Management during primary infection period; keep ahead of infection periods**
- **Use at-risk compounds when they are most appropriate (high disease pressure, rapid leaf growth)**
- **Use protectants early when leaf tissue area is small; in between at-risk fungicide sprays**

Slide Made by George Sundin, Michigan State University

Apple scab fungicides

- **Protective applications work best**
  - **Fungicide coverage of susceptible plant tissues prior to arrival of spores**

Slide Made by George Sundin, Michigan State University

Apple scab fungicides

- **After infection applications**
  - **Not recommended; allows fungal growth which promotes chances for mutation to fungicide resistance**
  - **Critical factor in resistance development and loss of SI and strobilurin fungicides**
  - **Few data exist for newer fungicides – (Aprovia, Inspire Super) – don't stretch beyond 24 hr from start of infection period**
  - **Fungicide susceptibility of spores vs. hyphae can be very different**

Slide Made by George Sundin, Michigan State University

Can low input spray schedules work?

- Let’s look at some data from New York
- 8 sprays: 1-6 are bloom sprays and 7 and 8 are two covers.
  - **They stopped the study due to phytotoxicity
- Six scab infection events

Can low input spray schedules work?

Treatment programs (amt./A)	Timing*	Total number of fruit per ¼ of canopy (%)	Incidence of injury on cluster leaves (%)**	Incidence of apple scab on fruit (%)**
Untreated no water	na.	46.0 ± 2.9 a	13.4 ± 5.0 a	21.2 ± 1.6 a
Kocide 3000 6 lb Captec 4L 2 qt + Manzate Max 2.4 qt Ecoswing 2.0 pt + Kinetic -77 0.1%	1 2,3 4-8	16.3 ± 10.7 bcd	11.0 ± 5.1 a	0.0 ± 0.0 b
Kocide 3000 6 lb Captec 4L 2 qt + Manzate Max 2.4 qt Ecoswing 2.0 pts+ Kinetic -77 0.1%	1 2,3,5,7 4,6,8	32.5 ± 10.1 abc	14.5 ± 5.1 a	0.0 ± 0.0 b
Kocide 3000 6 lb Captec 4L 2 q t+ Manzate Max 2.4 qt Stargus 64 fl oz + NuFilmP 16 fl oz + Manzate Max 2.4 qt	1 2,3 4-8	50.0 ± 0.0 a	18.0 ± 4.5 a	0.0 ± 0.0 b
Kocide 3000 6 lb Captec 4L 2 qt + Manzate Max 2.4 qt Stargus 64 fl oz + NuFilmP 16 fl oz + Microthiol Disperss 10 lb	1 2,3 4-8	50.0 ± 0.0 a	14.5 ± 6.3 a	2.0 ± 2.0ab
Kocide 3000 6 lb Captec 4L 2 qt + Manzate Max 2.4 qt Stargus 64 fl oz + NuFilmP 16 fl oz + Regalia 64 fl oz	1 2,3 4-8	48.8 ± 0.0 a	11.0 ± 2.4 a	3.5 ± 3.5ab
Untreated,water application	na.	50.0 ± 0.0 a	11.0 ± 2.3 a	22.5 ± 1.9 a

Kerik Cox, PDMR

Can low input spray schedules work?

- Yes… but what about in high pressure?

- Timings for the next:
- A = 24 Apr (1/2-inch green tip); B = 1 May (tight cluster); C = 11 May (pink); D = 20 May (full bloom); E = 27 May (petal fall) and F = 4 Jun (fruit set).

- Enviroweather predicted 12 infection events from 28 Apr to 20 Jul

		% Infection	
		Terminals	
Treatment and product per acre	Timing	29 Jul	2 Sep
1–EcoSwing 2 pt + Silwet 8 fl oz / 100 gallon	A-F		
Captan 80WDG 2.5 lb	Covers	34.8 b*	48.3 b
2–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
EcoSwing 2 pt + Silwet 8 fl oz / 100 gallon	C		
Fontelis 20 fl oz	D		
EcoSwing 2 pt + Silwet 8 fl oz / 100 gallon	EF		
Captan 80WDG 2.5 lb	Covers	24.9 bc	40.0 b
3–Roper DF 3 lb	ABC		
LifeGard 4.5 oz / 100 gallon + Roper DF 3 lb	DEF		
Captan 80WDG 2.5 lb	Covers	27.5 b	39.2 b
4–Double Nickel 1 qt + Cueva 2 qt + Roper DF 3 lb	A-F		
Captan 80WDG 2.5 lb	Covers	33.4 b	42.2 b
5–Roper DF 3 lb	A-F		
Captan 80WDG 2.5 lb	Covers	33.4 b	43.5 b
6–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 3 fl oz + R-11 0.125% v/v	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 3 fl oz + R-11 0.125% v/v	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	3.8 e	5.3 d
7–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 4 fl oz + R-11 0.125% v/v	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 4 fl oz + R-11 0.125% v/v	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	6.2 de	7.6 d
8–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 3 fl oz	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 3 fl oz	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	9.6 d	8.2 d
9–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 4 fl oz	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 4 fl oz	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	9.4 d	8.0 d
10–Roper DF 3 lb + Vangard WG 5 oz	A		
Roper DF 3 lb + Captan 80WDG 2.5 lb	B		
Miravis 3.4 fl oz + Roper DF 3 lb	C		
Roper DF 3 lb + Captan 80WDG 2.5 lb	D		
Miravis 3.4 fl oz + Roper DF 3 lb	E		
Inspire Super 2.82 EW 12 fl oz	F		
Captan 80WDG 2.5 lb	Covers	8.5 de	6.8 d
11–Roper DF 3 lb + Vangard WG 5 oz	A		
Miravis 3.4 fl oz + Roper DF 3 lb	B		
Roper DF 3 lb + Captan 80WDG 2.5 lb	C		
Miravis 3.4 fl oz + Roper DF 3 lb	D		
Omega 13.8 fl oz	E		
Inspire Super 2.82 EW 12 fl oz	F		
Captan 80WDG 2.5 lb	Covers	8.8 de	11.0 d
12–Roper DF 3 lb	ABC		
Sulforix 2 qt / 100 gallon	DEF		
Captan 80WDG 2.5 lb	Covers	18.1 c	23.5 c
13–Untreated control		95.0 a	97.2 a

Outwater et al., 2021

		% Infection	
		Terminals	
Treatment and product per acre	Timing	29 Jul	2 Sep
1–EcoSwing 2 pt + Silwet 8 fl oz / 100 gallon	A-F		
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EcoSwing 2 pt + Silwet 8 fl oz / 100 gallon	C		
Fontelis 20 fl oz	D		
EcoSwing 2 pt + Silwet 8 fl oz / 100 gallon	EF		
Captan 80WDG 2.5 lb	Covers	24.9 bc	40.0 b
3–Roper DF 3 lb	ABC		
LifeGard 4.5 oz / 100 gallon + Roper DF 3 lb	DEF		
Captan 80WDG 2.5 lb	Covers	27.5 b	39.2 b
4–Double Nickel 1 qt + Cueva 2 qt + Roper DF 3 lb	A-F		
Captan 80WDG 2.5 lb	Covers	33.4 b	42.2 b
5–Roper DF 3 lb	A-F		
Captan 80WDG 2.5 lb	Covers	33.4 b	43.5 b

Outwater et al., 2021

6–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 3 fl oz + R-11 0.125% v/v	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 3 fl oz + R-11 0.125% v/v	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	3.8 e	5.3 d
7–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 4 fl oz + R-11 0.125% v/v	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 4 fl oz + R-11 0.125% v/v	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	6.2 de	7.6 d
8–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 3 fl oz	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 3 fl oz	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	9.6 d	8.2 d
9–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 4 fl oz	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 4 fl oz	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	9.4 d	8.0 d

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9–Roper DF 3 lb + Captan 80WDG 2.5 lb	AB		
Excalia 4 fl oz	C		
Inspire Super 2.82 EW 12 fl oz	D		
Excalia 4 fl oz	E		
Roper DF 3 lb + Captan 80WDG 2.5 lb	F		
Captan 80WDG 2.5 lb	Covers	9.4 d	8.0 d
10–Roper DF 3 lb + Vangard WG 5 oz	A		
Roper DF 3 lb + Captan 80WDG 2.5 lb	B		
Miravis 3.4 fl oz + Roper DF 3 lb	C		
Roper DF 3 lb + Captan 80WDG 2.5 lb	D		
Miravis 3.4 fl oz + Roper DF 3 lb	E		
Inspire Super 2.82 EW 12 fl oz	F		
Captan 80WDG 2.5 lb	Covers	8.5 de	6.8 d
11–Roper DF 3 lb + Vangard WG 5 oz	A		
Miravis 3.4 fl oz + Roper DF 3 lb	B		
Roper DF 3 lb + Captan 80WDG 2.5 lb	C		
Miravis 3.4 fl oz + Roper DF 3 lb	D		
Omega 13.8 fl oz	E		
Inspire Super 2.82 EW 12 fl oz	F		
Captan 80WDG 2.5 lb	Covers	8.8 de	11.0 d
12–Roper DF 3 lb	ABC		
Sulforix 2 qt / 100 gallon	DEF		
Captan 80WDG 2.5 lb	Covers	18.1 c	23.5 c
13–Untreated control		95.0 a	97.2 a

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Reducing sprays?

- Forecasting systems for fungal diseases more understood than bacteria
- Sooty blotch/ flyspeck model was developed at Iowa State!
- Models can allow us to safely “stretch” our covers, maybe 14 days, with better predictability.

Resources for biological/chemical control

- Midwest Fruit Pest Management Guide
  - https://ag.purdue.edu/hla/Hort/Documents/ID-465.pdf

- Check to see what is registered in your state.
  - State specialists can help get products labeled, ultimately up to the company.

- Email: Slacksuz@iastate.edu