Fire Blight Management: Climate Change Considerations and Alternatives to Antibiotics

Quan Zeng
Connecticut Agricultural Experiment Station
12-17-2024

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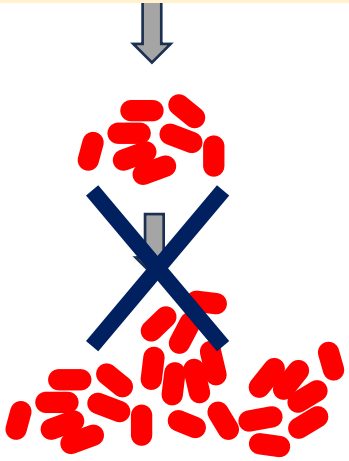
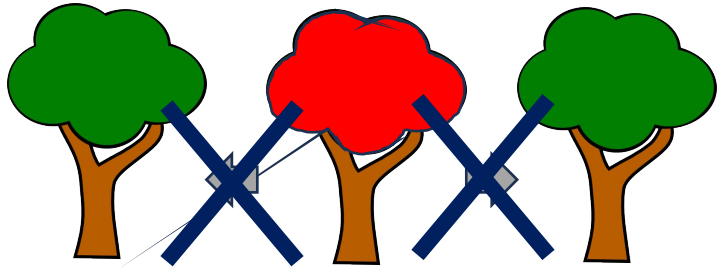
Fire blight, a devastating disease of apple and pear

- Caused by a bacterial pathogen *Erwinia amylovora* (Ea).
- Infect plants of Rosaceae family: apple, pear, quince, loquat, Indian hawthorn, crab apple, rose, mountain ash, service berry, raspberry, blackberry.
- Can lead to yield reduction – flower infection; and death of trees – trunk / rootstock infection

Pathogen **amplification** and **spread**

A successful fire blight management = using the right tools to stop the pathogen amplification and spread.





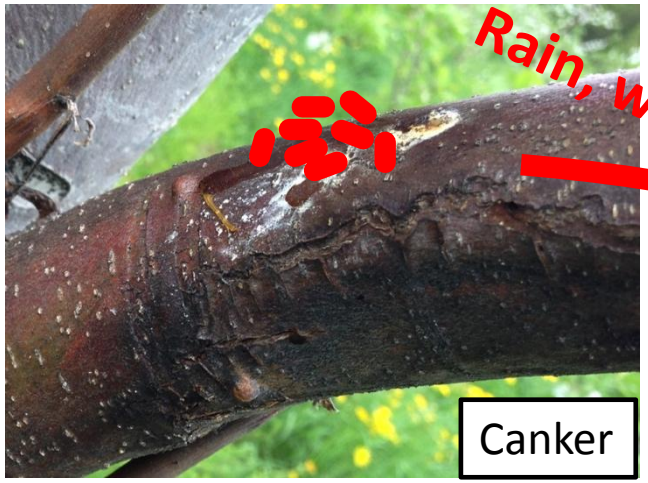
Two stages of fire blight

Pathogen: *Erwinia amylovora*

Blossom blight

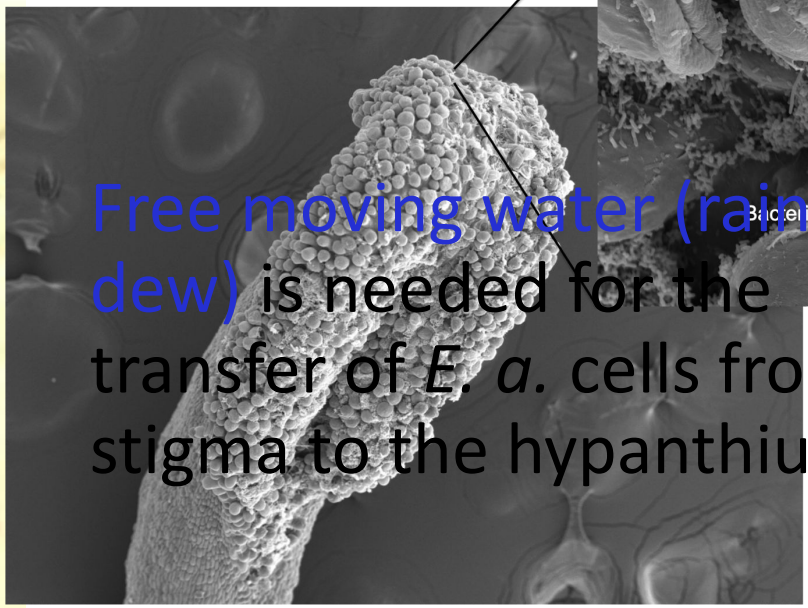
Shoot blight

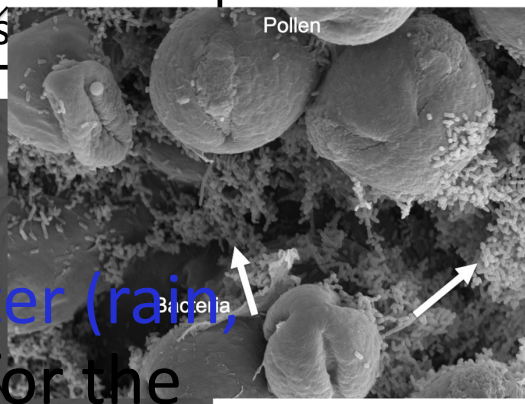
Blossom blight infection



Rain, wind, or insect

Bloss





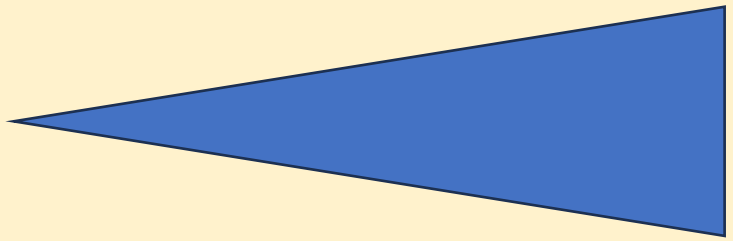
E. amylovora grows ***epiphytically*** on floral stigmas up to 10^{6}-10^{7} cells per flower

Free moving water (rain, dew) is needed for the transfer of *E. a.* cells from stigma to the hypanthium

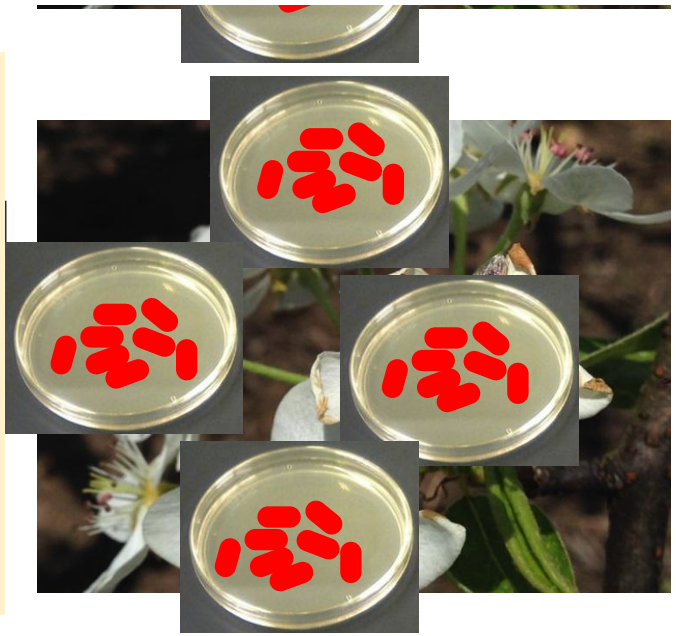
Blossom blight in an orchard

What management measures can we take?

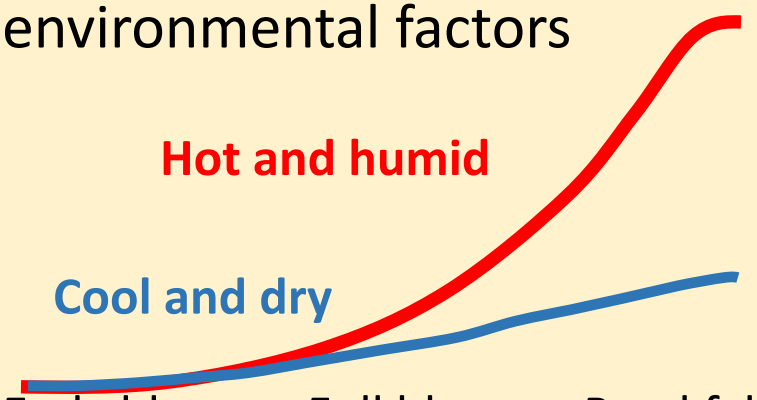
Overall pathogen population at orchard level



Early bloom Full bloom Petal fall



Heavily affected by environmental factors



Early bloom Full bloom Petal fall

1. Orchard sanitation:

1. Prune off cankers from the previous season as best as you can
2. Delayed dormant copper spray to kill any bacteria from any missed cankers.

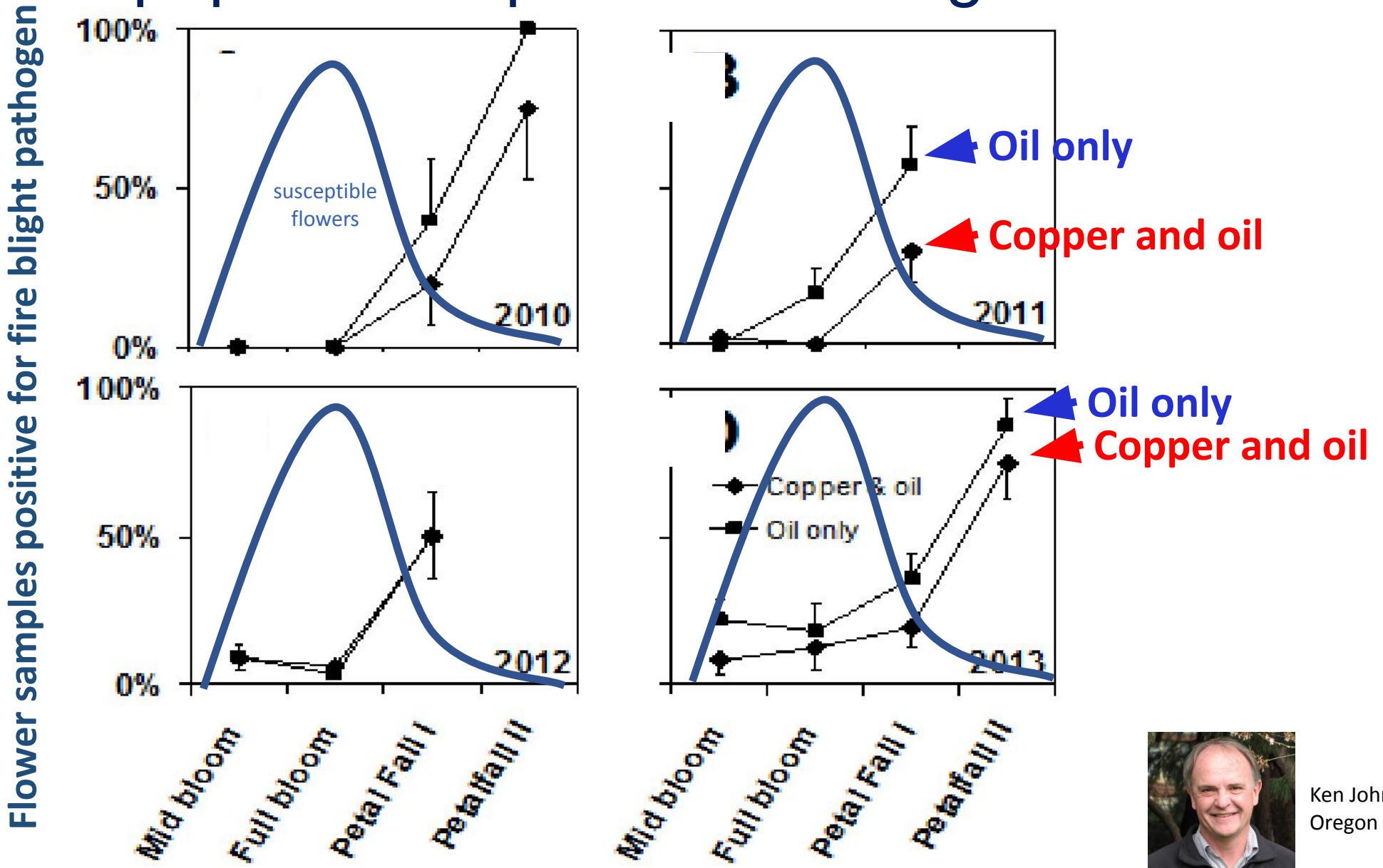
Delayed dormant copper

- Only required for blocks with fire blight history.
- Helps to sanitize the orchard, kill any bacterial ooze produced from any left-over cankers.
- Also helps with apple scab control.
- Apply at ***green tip / tight clusters*** to avoid phytotoxicity, 1 application per season.
- Fixed copper at 15% metallic copper equivalent.
- **Oil** helps penetration into canker.

One application of dormant copper can reduce *E. amylovora* population up to 50% during bloom

Each year, twelve commercial Bartlett pear orchards in northern California were surveyed during the bloom period

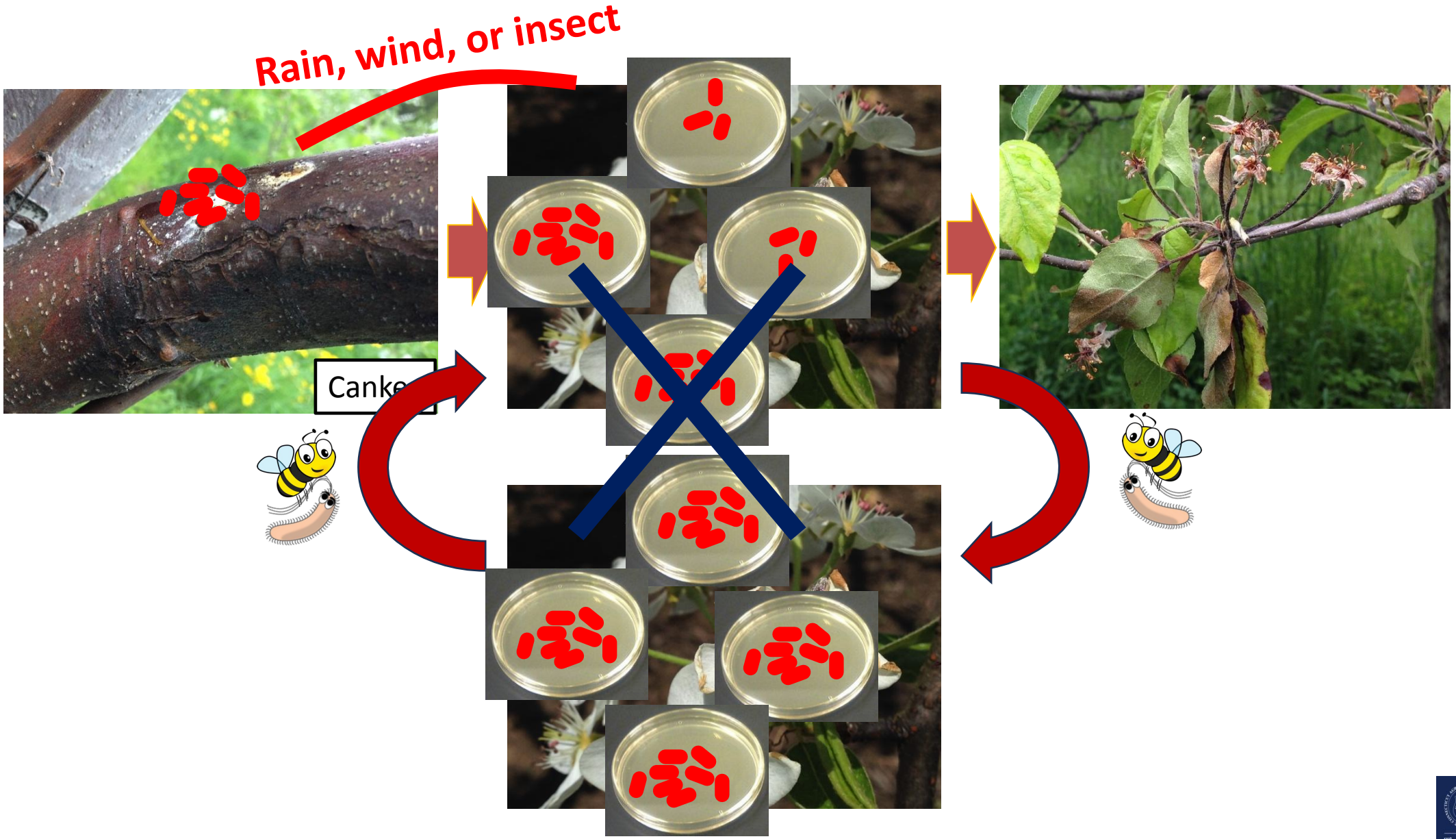
All orchards received multiple antibiotic sprays



Rachel Elkins
UC-ANR
Lakeport

Ken Johnson
Oregon State

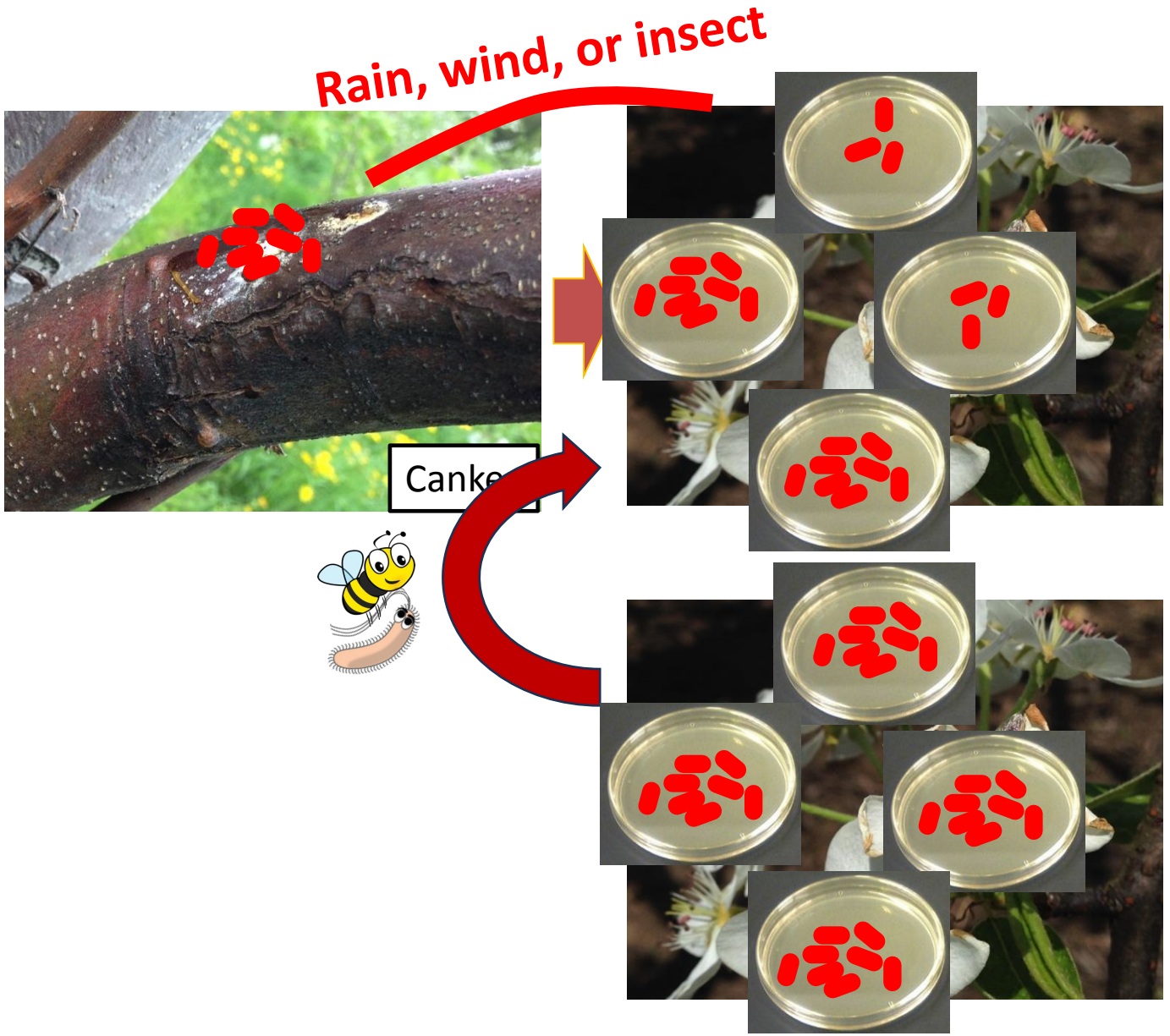
2. Management during bloom



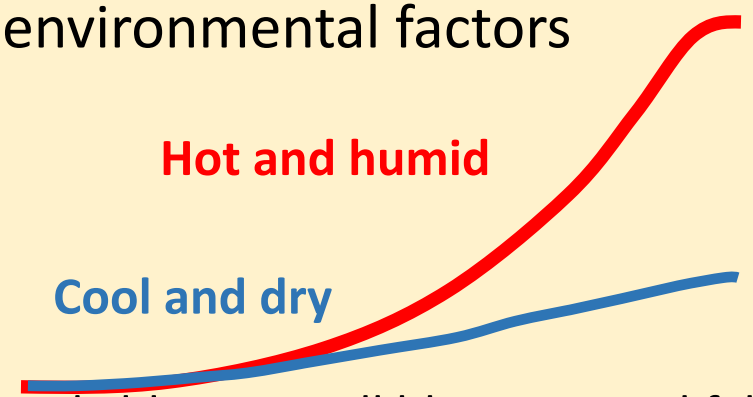
Antibiotics

- Streptomycin (24 fl oz/A) for the 1st spray.
- Tank mix with Regulaid (1pt). It helps strep to disperse and absorb. Be wary of russeting risk of Regulaid+captan.
- **Apply in late afternoon** as much as possible. Reasons: slow drying helps strep uptake, no UV degradation, Ea grows at night!
- Spray must dry before rain occurs.
- Good spray coverage to all open flowers.
- If 2rd application is needed, consider using Kasugamycin (Kasumin, 64 fl oz/A).

Blossom blight infection

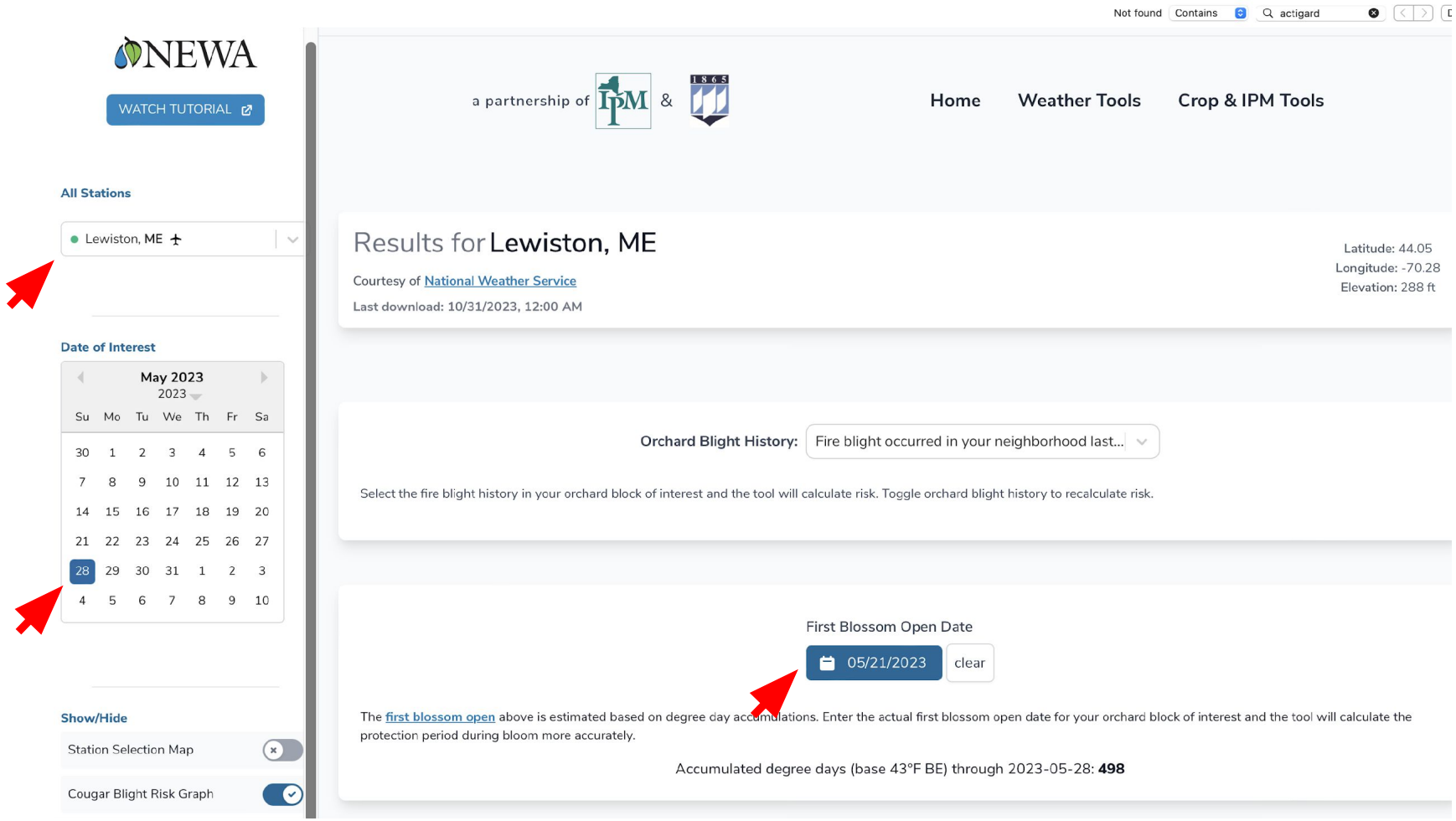


Heavily affected by environmental factors



NEWA Cougar Blight model

https://newa.cornell.edu/fire-blight



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NEWA Cougar Blight model

Results Table

Download CSV

Forecast Details

Date (2023)	Cougar Blight V8 Daily TRV Risk Levels: Marginal / High / Extreme	Infection Potential EIP value Risk Levels: Low / Moderate / High / Infection
May 26	20	2
May 27	206	60
May 28	709	185
May 29	735	198
May 30	750	209
May 31	741	262
June 1	714	325
June 2	1000	281

* Indicates incomplete accumulation of the 4-day DH total. The DH value may reach "Caution", "High" or "Extreme" levels before spanning the 4-day accumulation cut-off time of Cougarblight.

Wetness Events Table

Download CSV

Events: Dry Wet

Avg Temp (°F): ≤ 60 > 60

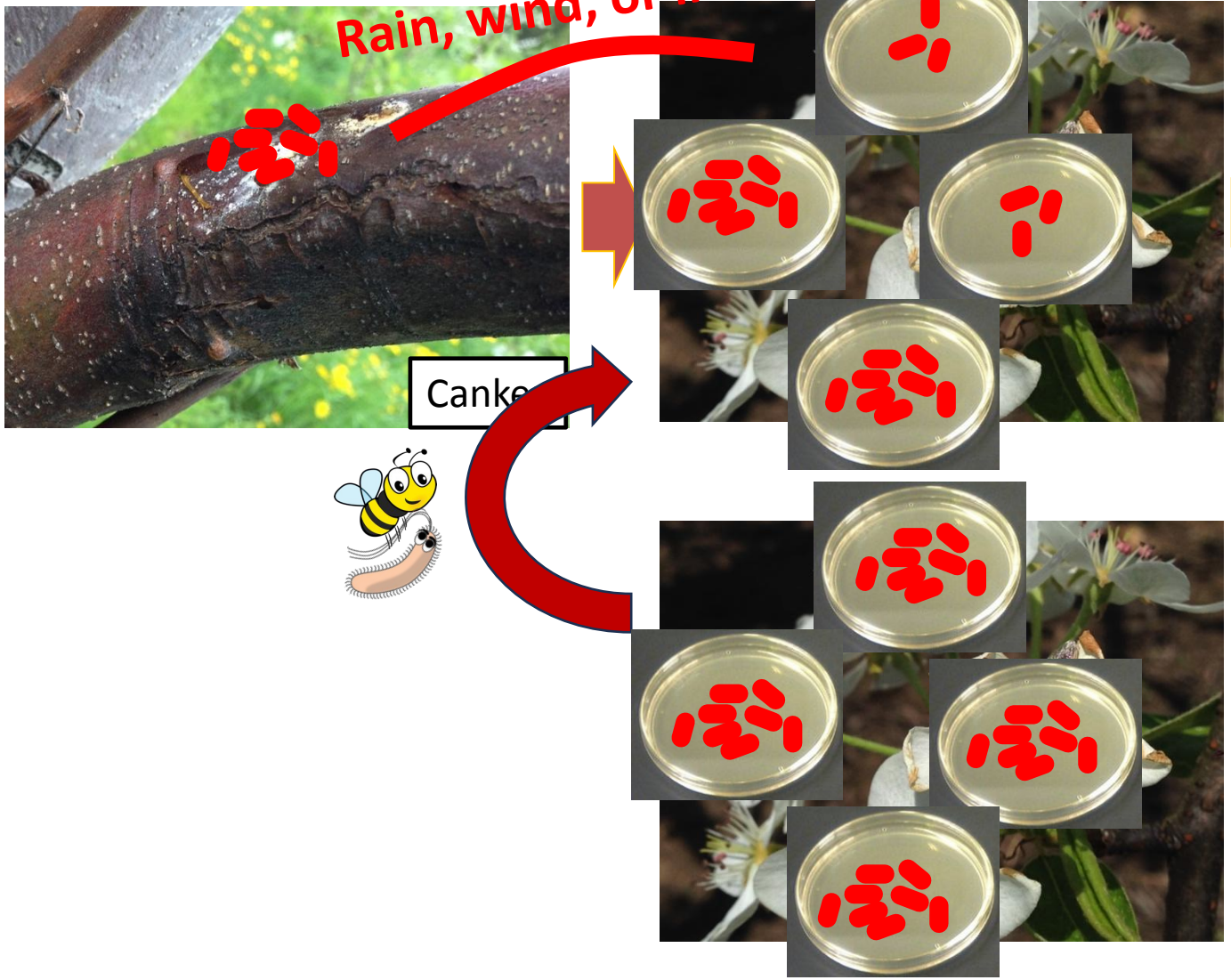
Date (2023)	Rain Amount	Dew	Leaf Wetness (hours)	Hours > 90% RH	RH max/min	Avg Temp (°F)
May 26	0.00	yes	8	7	100/34	52
May 27	0.00	yes	6	6	100/24	59
May 28	0.00	yes	4	2	97/13	70
May 29	0.00	yes	3	2	97/28	57
May 30	0.00	yes	10	8	100/31	55
May 31	0.00	yes	8	7	100/43	61
June 1	0.00	yes	8	3	93/31	71
June 2	0.01	yes	14	6	100/40	72

Management Guide

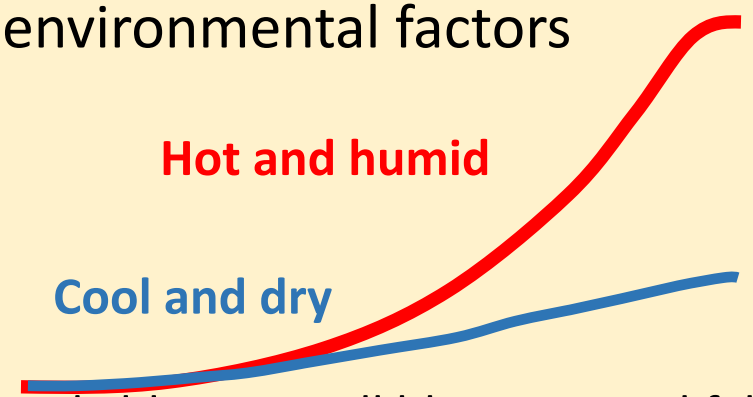
CYCLE	MANAGEMENT
Blossom blight	Blossom blight risk predictions begin at **first blossom open**. If bloom in your orchard has not yet occurred, continue to check fire blight risk predictions and monitor bloom daily. Infection cannot occur without open blossoms. Most serious fire blight epidemics begin with infection during bloom. Certain antibiotics can effectively protect against blossom infections when applied shortly before or immediately after they occur. The Cougarblight and Infection Potential risk levels are based on the principle that 1. a certain number of heat units must accumulate during bloom for a threshold level of inoculum to be reached; 2. a wetting event is necessary after this point to wash the bacteria to their infection sites; and 3. the average temperature is above 60F.

Marginal or Low risk	If none of these conditions is met during bloom, risk is **'Marginal'** or **'Low'** and bactericides are not needed.
Moderate risk	Infection Potential EIP risk is **'Moderate'** and it is advisable to watch the forecast closely for continuing warm weather and rain.
High risk	If two conditions are met during bloom, risk is **'High'** and forecasted wetting events should be carefully considered and a bactericide applied just before (or after) a rain.
Extreme or Infection risk	If all three conditions are met, risk is **'Extreme'** or **'Infection'** and an antibiotic should be applied just before (or after) a rain.

How does climate change impact blossom blight infection?



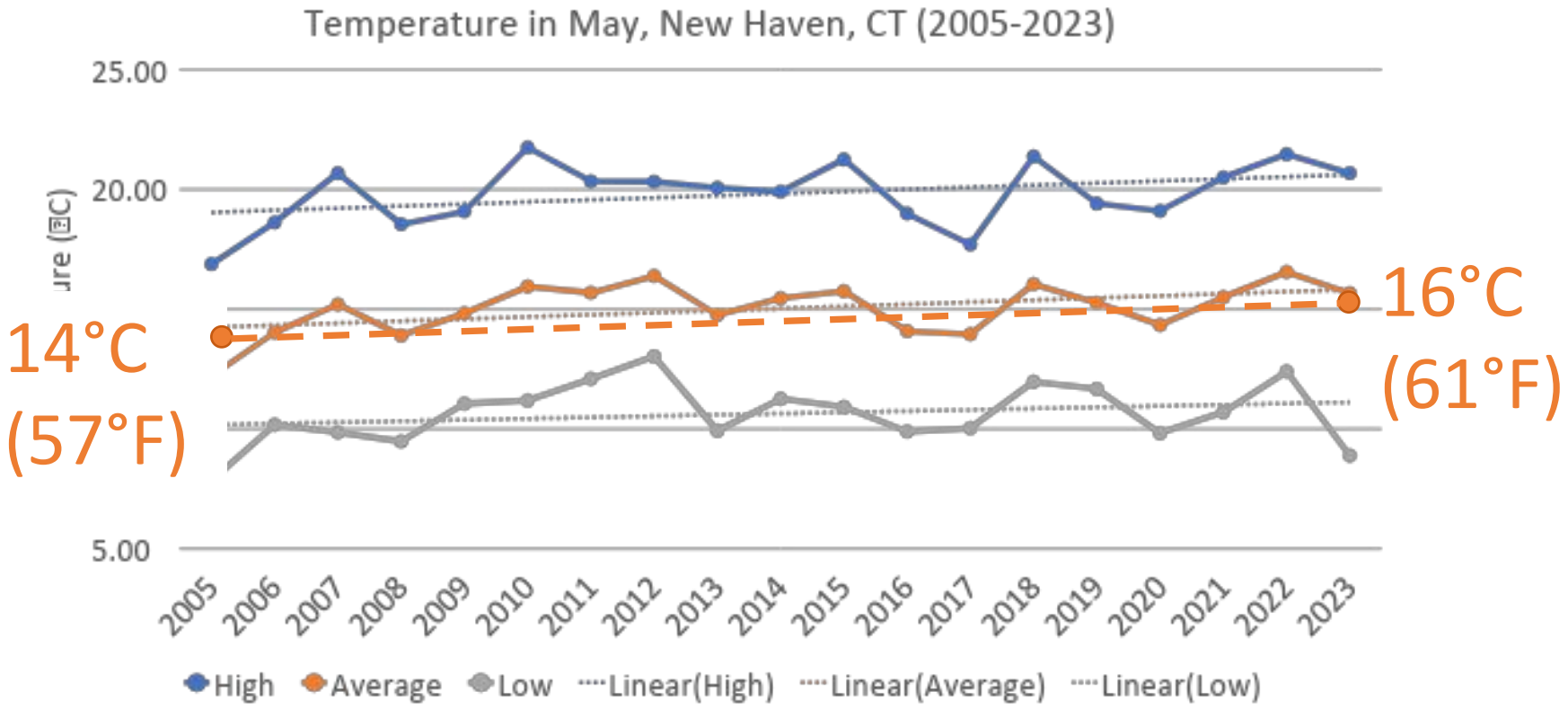
Heavily affected by environmental factors



How does climate change impact blossom blight infection?

- Temperature increases during bloom.

Increased by 2°C in the past 18 years (14 °C to 16°C)



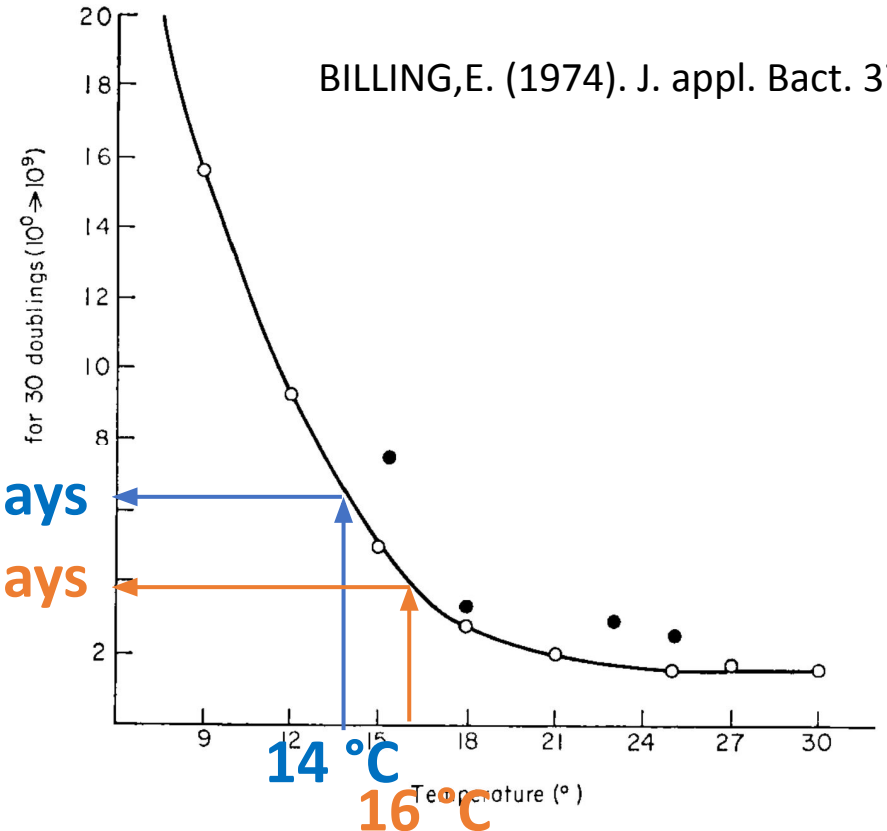
How does climate change impact blossom blight infection?

- Temperature increases during bloom.

Increased by 2°C in the past 18 years (14 °C to 16°C)

Time required for 30 doublings of *E. amylwora* cells at different temperatures

1 cell → 10^9 cells



BILLING,E. (1974). J. appl. Bact. 37,643-648.

2005 **6.2 days**

2023 **3.9 days**

14 °C

16 °C

Time required for 30 doublings reduced by ~2 days.

How does climate change impact blossom blight infection?

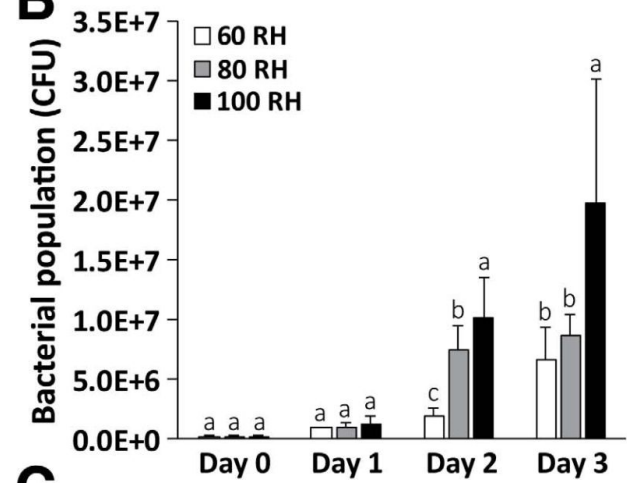
- Temperature increases during bloom.

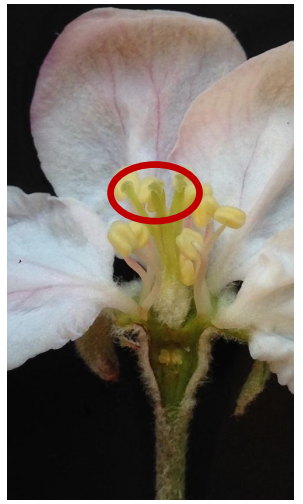
- More alarming: the increase in night temperature.

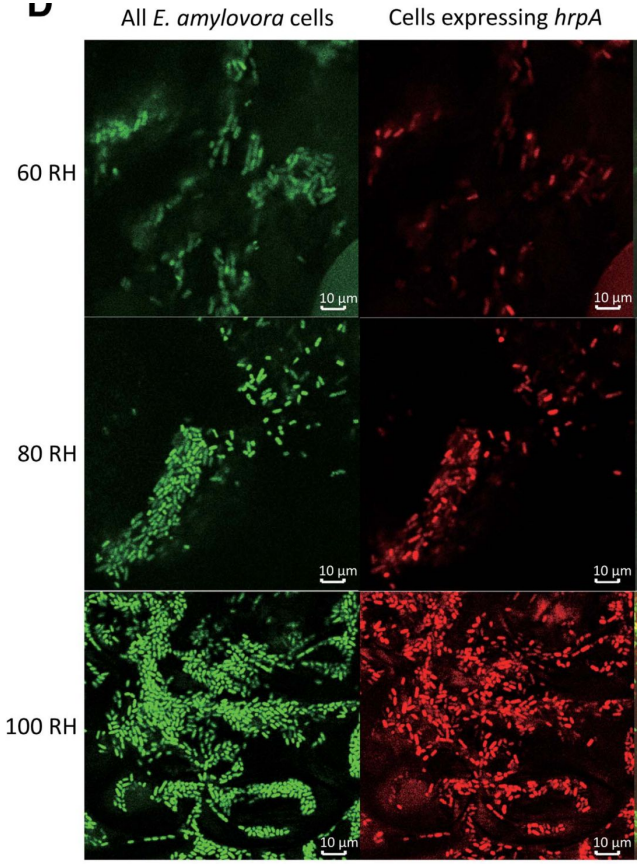
Why?

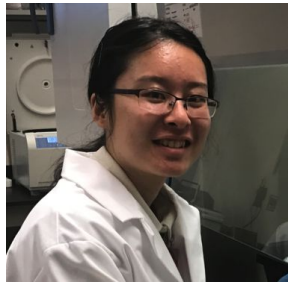
- Fire blight bacterium optimal growing conditions: ***1. high enough temperature (>65 °F)***, and ***2. high enough relative humidity/free moving water (>80% RH)***.

- Temperature is usually higher in the day but relative humidity is usually higher at night.









Zhouqi Cui

Cui et al. MPMI. 34, 1119–1127

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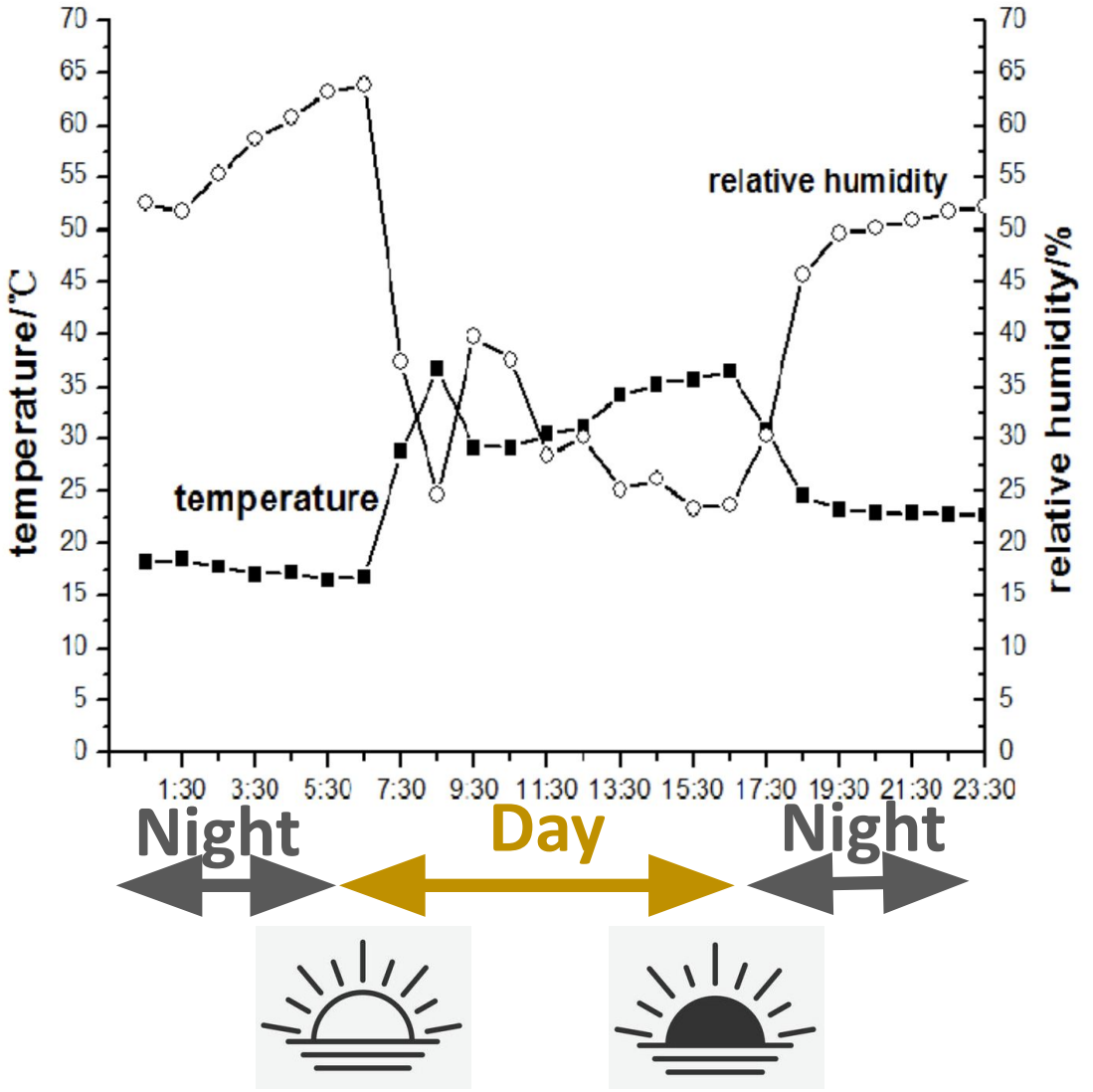
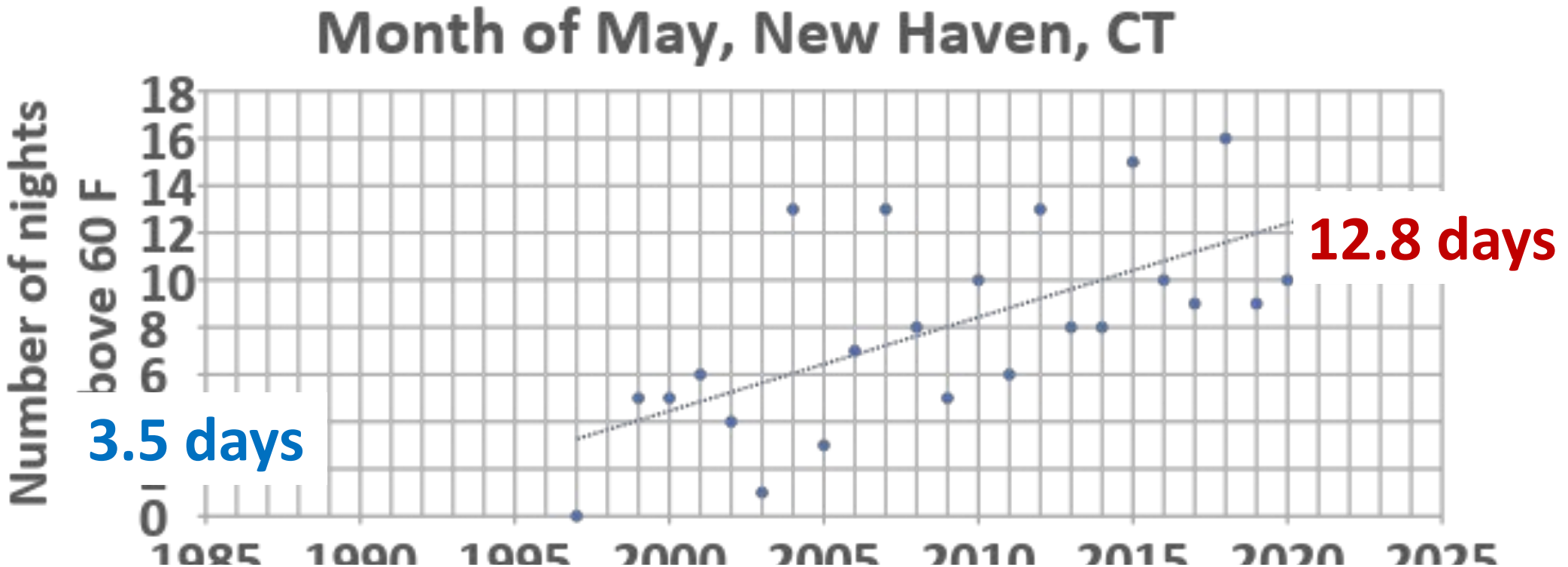


Number of days with night temperature above 60 degrees in May in the past 25 years, Hamden, CT



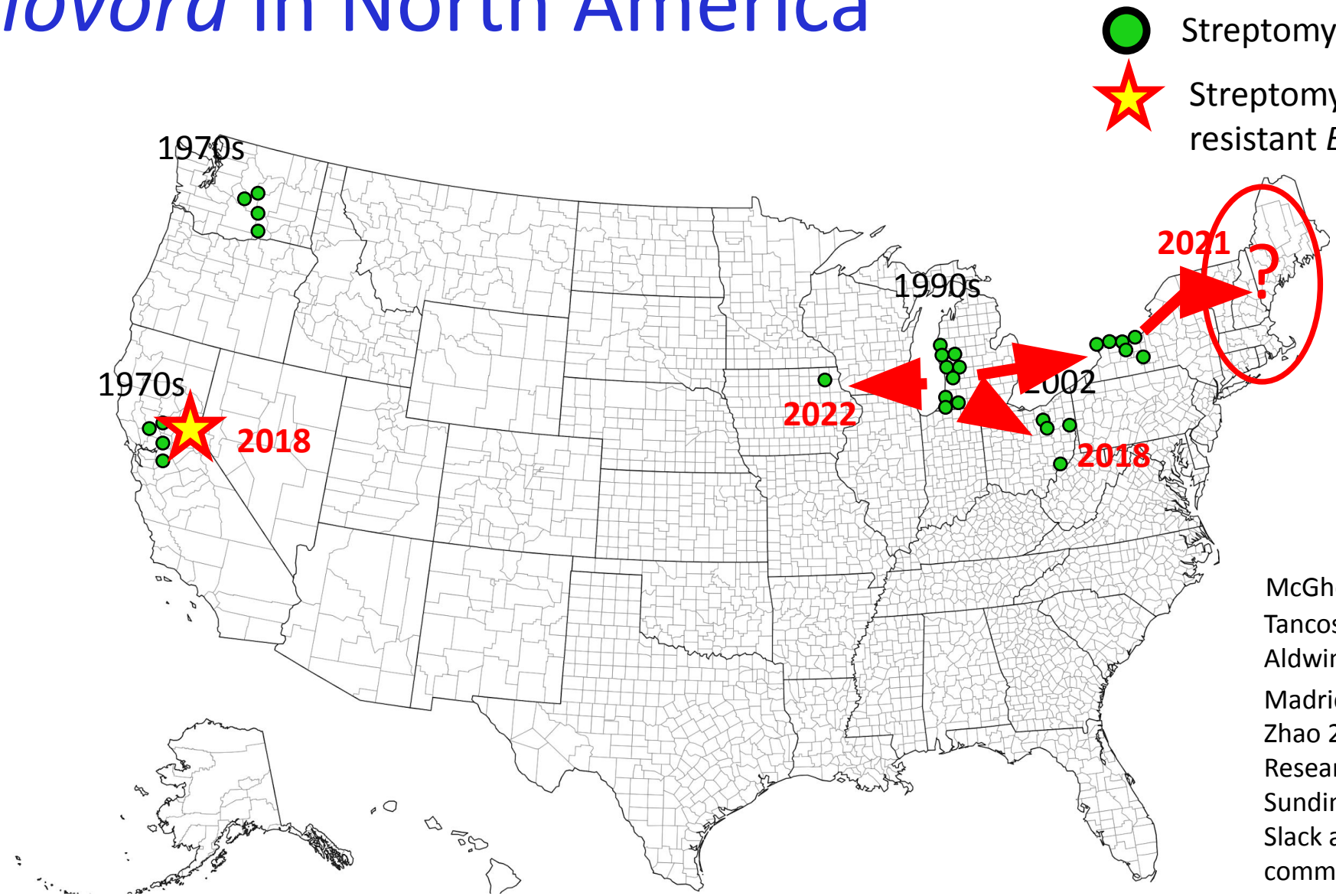
More warmer nights during bloom = High temperature and high RH
= More blossom blight infections!

Lack of non-antibiotic management materials

- Streptomycin resistance in *E. amylovora*
- Impact of antibiotics on the environment and human health
- Growing demand of organic fruits

We need alternatives to antibiotics!

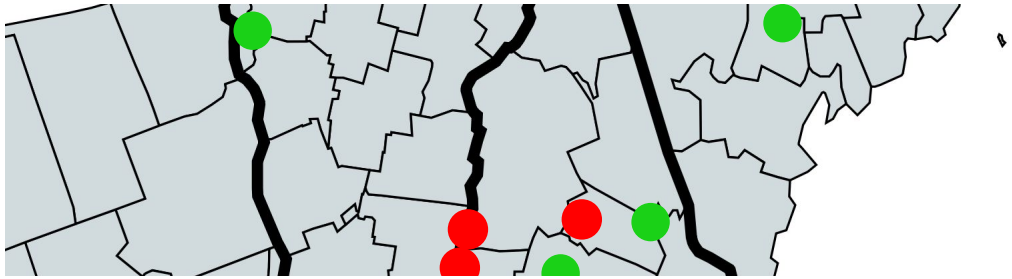
Distribution of streptomycin resistant *Erwinia amylovora* in North America



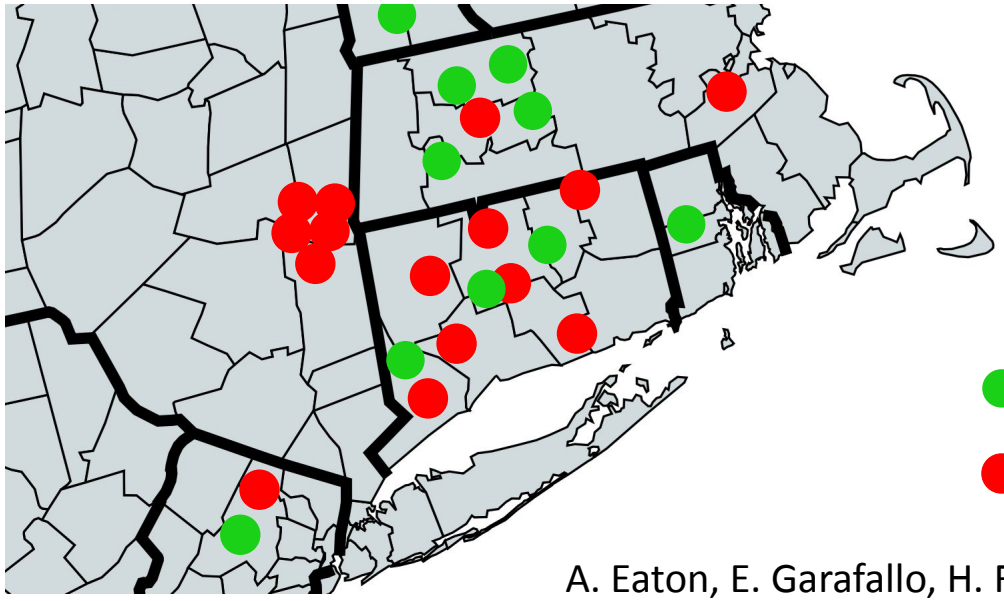
McGhee et al 2011 Plant Disease
Tancos et al 2016 Plant Disease
Aldwinckle 2012 New York Fruit Quarterly
Madrid and Levy, 2023
Zhao 2023 Washington Tree Fruit Research Commission Report
Sundin, Zeng et al 2023 Phytopathology
Slack and Yuan (personal communication)

Streptomycin resistance survey in New England

- Fire blight samples collected in New England, New York, New
- were collected from apple and pear, 7 from ornamental plants



No streptomycin-resistant *Erwinia amylovora*.



2015-2016 survey

2021-2023 survey

A. Eaton, E. Garafallo, H. Fulbert, M. Concklin, E. Lentz, D. Cooley, J. Clements, J. Leisle, E. Lentz

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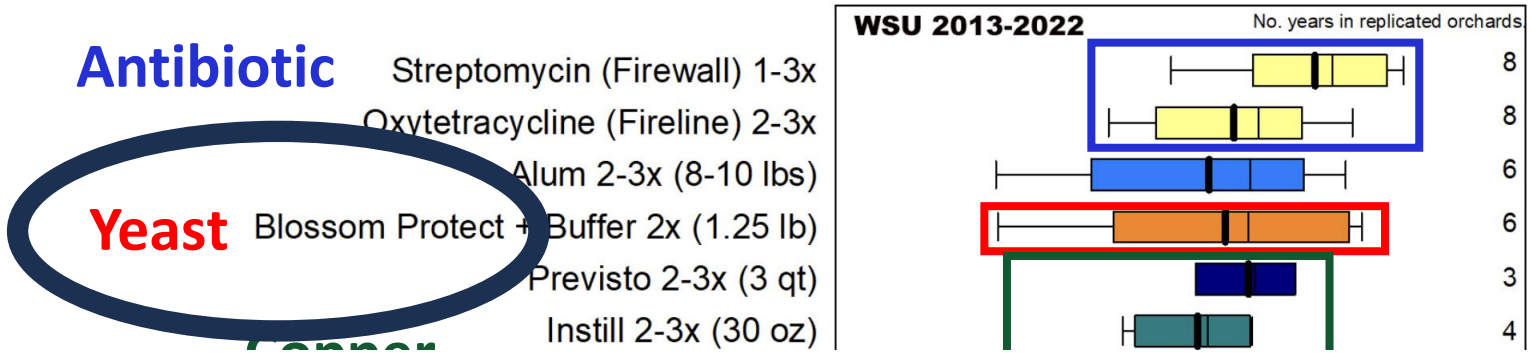
Bloom spray alternatives:

- **<u>Low-metallic coppers</u>**
  - Cueva
  - Previsto
  - Badge X2

- **<u>Contact sterilants</u>**
  - Oxidate
  - JetAg

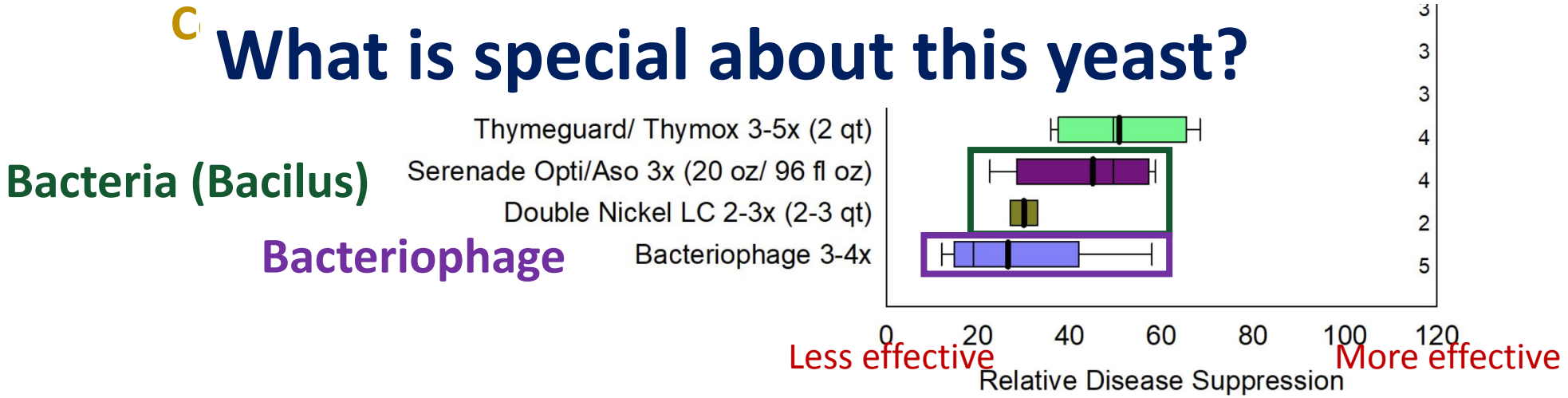
- **<u>Biologicals</u>**
  - Blossom Protect
  - Serenade Opti, Double Nickle, Stargus
  - Agri-Phage-Fire Blight

Efficacy of materials for blossom blight control



New Super Star of Fire blight Control?

What is special about this yeast?

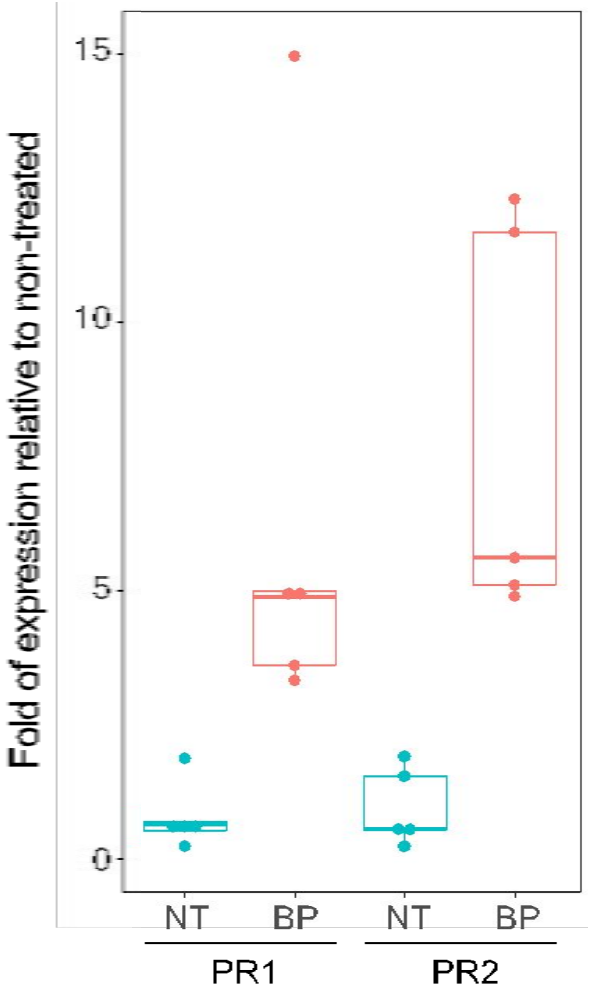


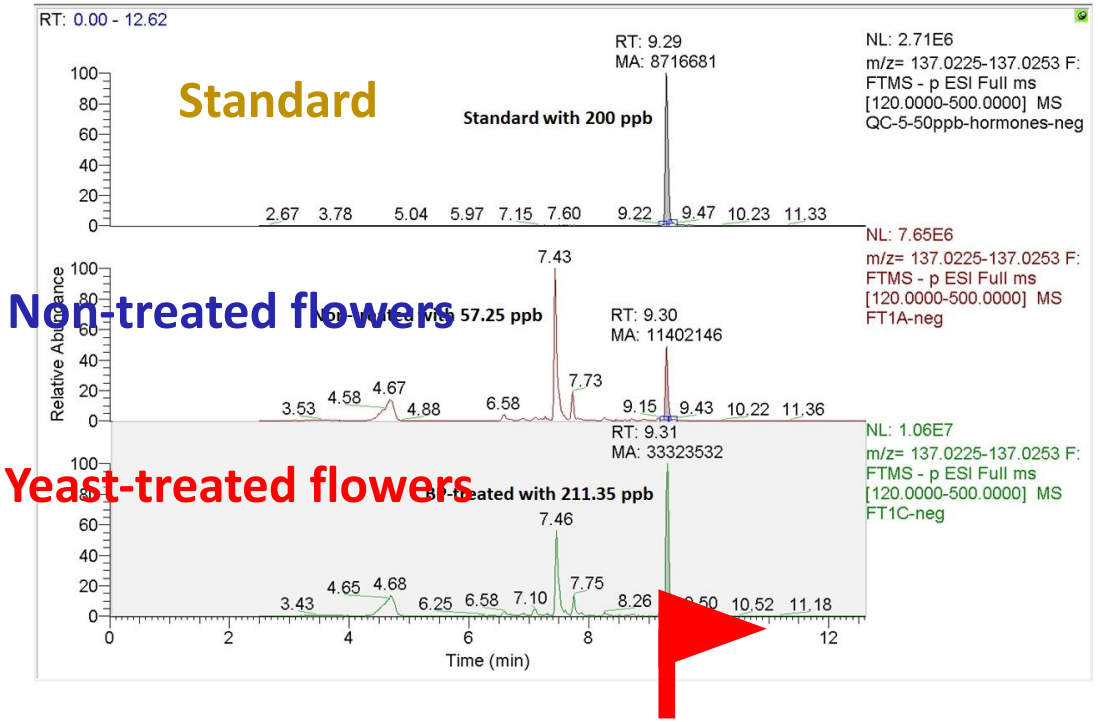
Tianna Dupont
Washington State Univ

Blossom Protect

- Two strains of *Aureobasidium pullulans* are the active ingredient (CF10 and CF40)
- Can tolerate high sugar concentration of the hypanthium and protect the hypanthium
- Can induce plant defense response.

Blossom Protect induces systemic acquired resistance in treated apple flowers

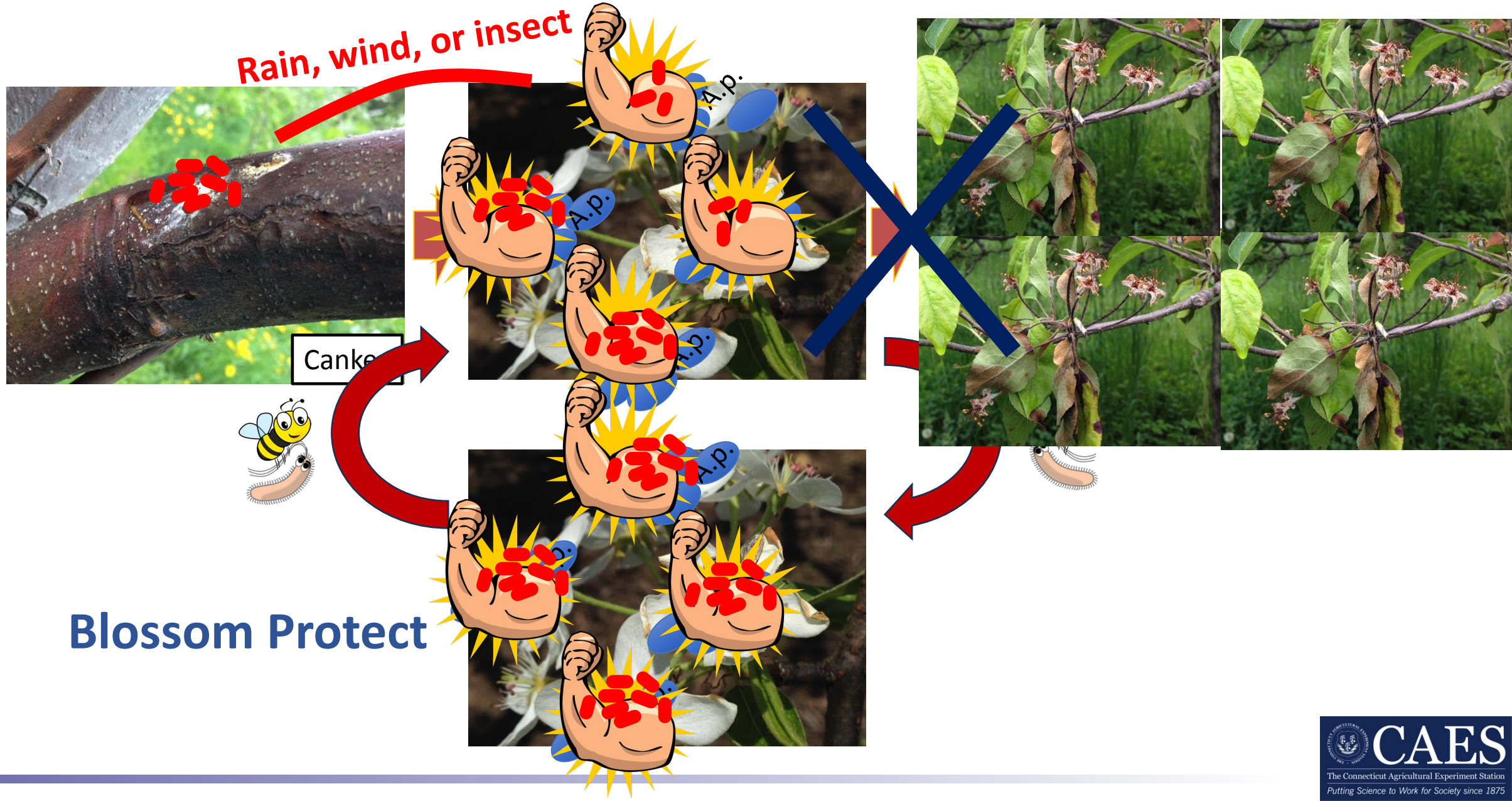




Salicilic acid, the plant defense hormone

Zeng et al Phytopathology 2023

Blossom blight infection



Percentage of blossom blight suppression

Year:	2015	2017	2018	2022	2023	2024	2019	2020	2021	2023	2023	
Location:	CT	CT	CT	CT	CT	CT	MI	MI	MI	MI	VA	**Average**
Treatments:												
Blossom Protect	21.3	36.5	88.5	77.8	62.8	51.2	91.1	28.2	81.3	65.4	80.4	**62.2**
Oxytetracycline							93.7	11.3				**52.5**
Streptomycin	57.4	61.6	88.5	89.7	48.3	91.4						**71.7**

Any room for improvement?

Integrated Pest Management!

George Sundin

Srdjan Acimovic

Non-antibiotic IPM of fire blight

Green tip | Petal open | 60% bloom | 80% bloom | Full bloom | Petal fall

Fixed copper + oil
1 x application

Blossom Protect
1 x application

Blossom Protect
1 x application

Oxdiate
or Cueva
or Previsto
1 x application

Oxdiate
or Serenade
1 x application

Blossom Protect:
1.25 lb of Blossom Protect tank mixed with 5 lb of Buffer Protect NT, per 100 gallons of water per acre.

Oxidate:
1:256 dilution, 100-200 gallons per acre.

Percentage of blossom blight suppression

Year:	2015	2017	2018	2019	2022	2023	2024	2019	2020	2021	2023	2023	
Location:	CT	CT	CT	CT	CT	CT	CT	MI	MI	MI	MI	VA	Average
Treatments:													
Blossom Protect	21.3	36.5	88.5	NA	77.8	62.8	51.2	91.1	28.2	81.3	65.4	80.4	62.2
IPM (Blossom Protect and Oxidate)	46.8	50.5	84.6	79.5	88.7	64.7	84.7						71.4
Oxytetracycline								93.7	11.3				52.5
Streptomycin	57.4	61.6	88.5	64.8	89.7	48.3	91.4						71.7

Reasons to use this program

- Prevent the development of strep resistance.
- Avoid using antibiotics, better marketing of your crop.
- Compatible with organic production.
- Application is based on tree phenology, not prediction models.

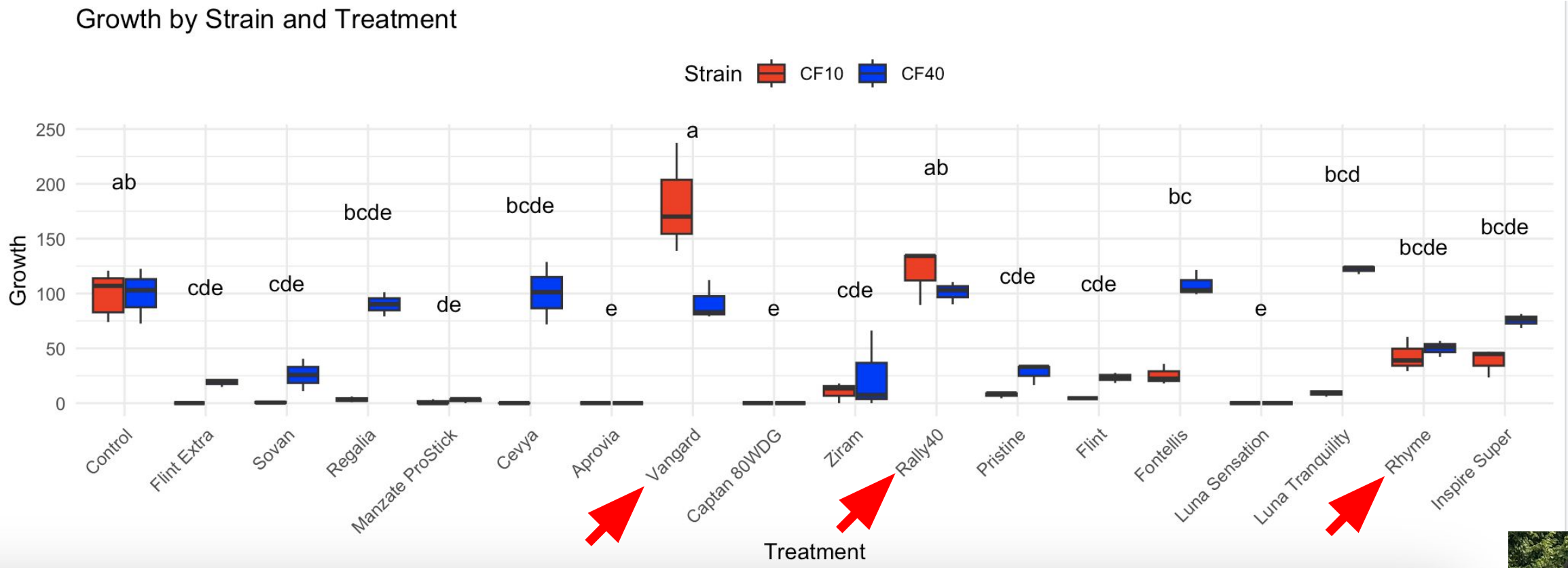
- *It provides an important management tool once strep resistant E. amylovora spreads to our region!*

Limitations:

- Price (materials and labor).
- Fruit russeting risk under humid conditions.
- Compatibility with scab fungicide application during bloom

Russeting

Compatibility with scab fungicides:



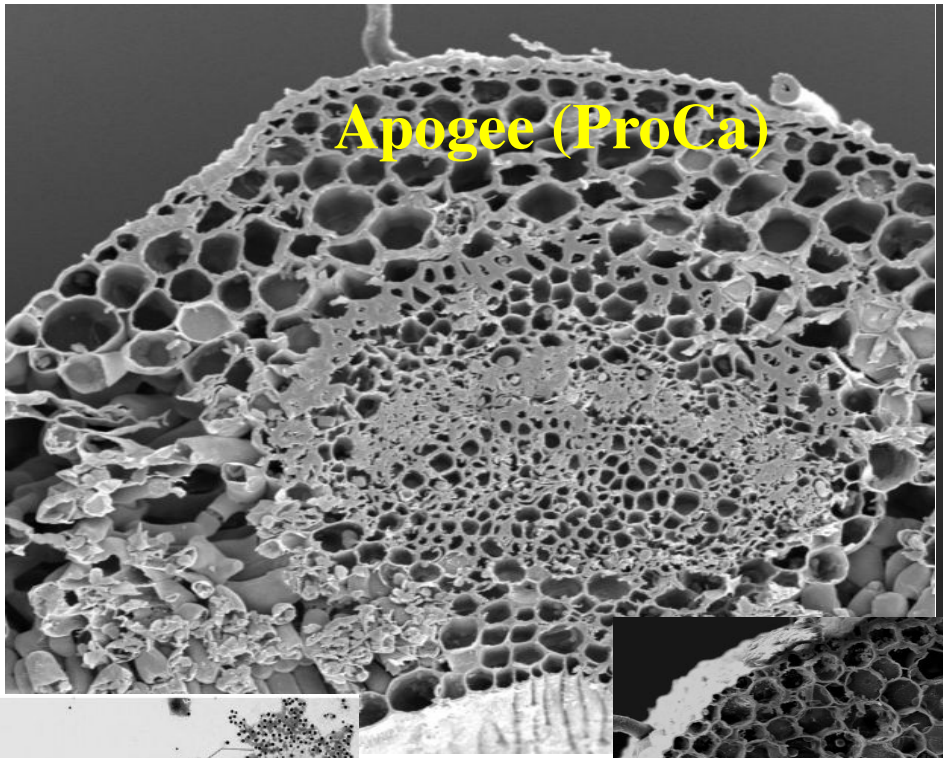
Jewell Jung

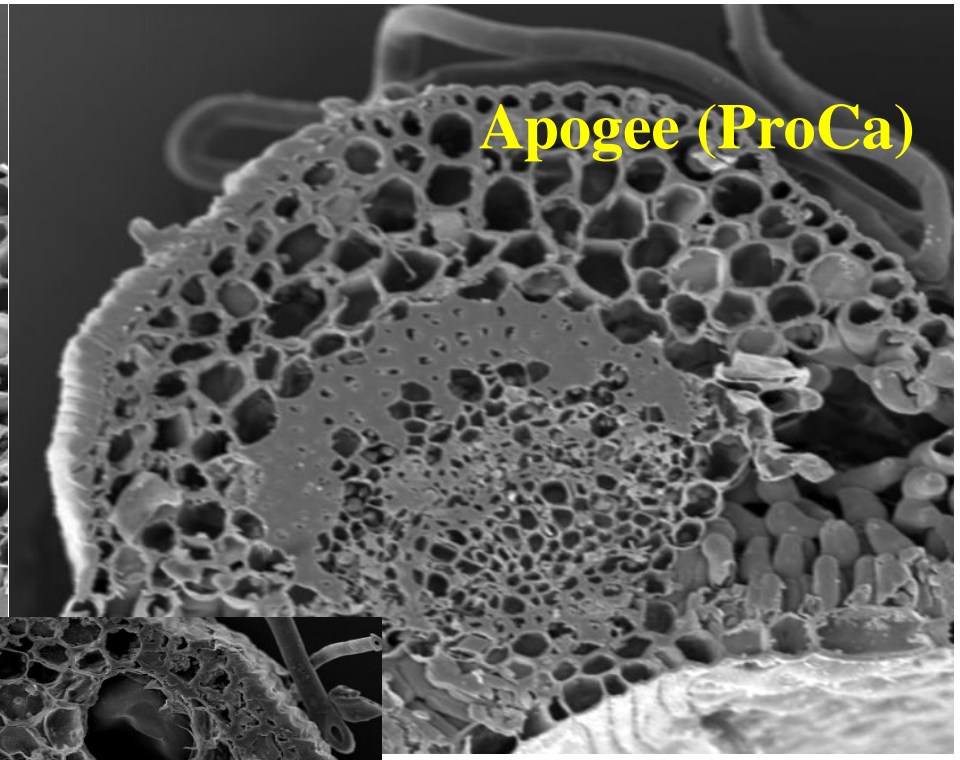
Other non-antibiotic materials for shoot blight management

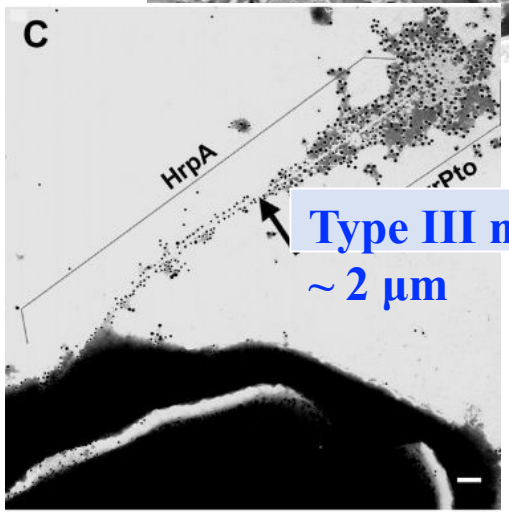
1. Prohexadione Ca (Apogee)

- Thicken cortical parenchyma cell wall, Ea virulent structure could not penetrate.
- Also induces systemic acquired resistance (SAR).

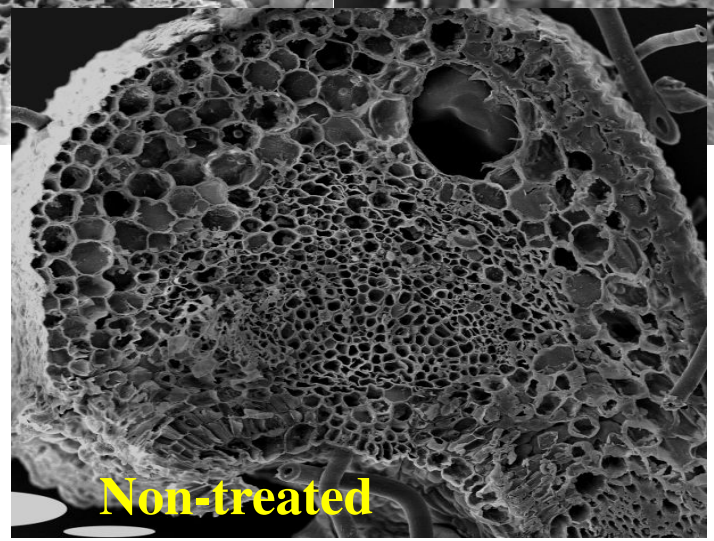
Yuan et al 2023 Phytopathology 113: 2152-2164







Type III needle = ~ 2 µm



George Sundin, MSU

Other non-antibiotic materials for shoot blight management

1. Prohexadione Ca (Apogee)
- Thicken cortical parenchyma of cells wall, Ea virulent structure could not penetrate.
- Also induces systemic acquired resistance (SAR).

2. Acibenzolar-S-methyl (Actigard 50WG)
- Activates systemic acquired resistance (SAR) in the plant

Yuan et al 2023 Phytopathology 113: 2152-2164

Other non-antibiotic materials for shoot blight management

1. Prohexadione Ca (Apogee)
   - Apply after petal fall for 3 times, 8 oz / 100 gallon
2. Acibenzolar-S-methyl (Actigard 50WG)
   - Apply during and after bloom, 8 oz / 100 gallon

	Mean no. strikes per 5 tree replicate set	
Treatment	**June 20th**	**August 9th**
Non-treated	27.7	95.7
Apogee (18 oz/A)	3.3***	9.8***

Keith Yoder, Virginia Tech

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Problem: In young high-density apple plantings, <u>shoot growth is inhibited at these rates!</u>
Suppression of fire blight = sacrifice the time to reach to the top wire.
Can we use reduced rates? No, reduced rates sacrifice disease suppression.

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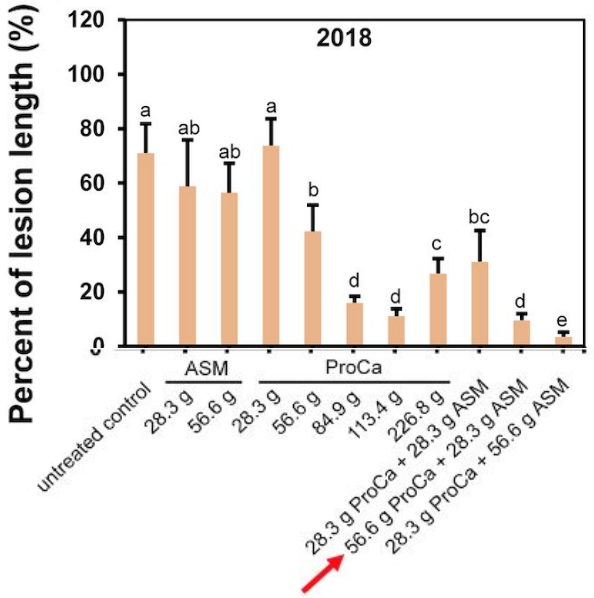
Problem: In young high-density apple plantings, shoot growth is inhibited at these rates!

Suppression of fire blight = sacrifice the time to reach to the top wire.

Can we use reduced rates? Reduced rates sacrifice disease suppression.

How about combining the two materials?

Combinations of low rates of ProCa and ASM for shoot blight management



George Sundin, MSU

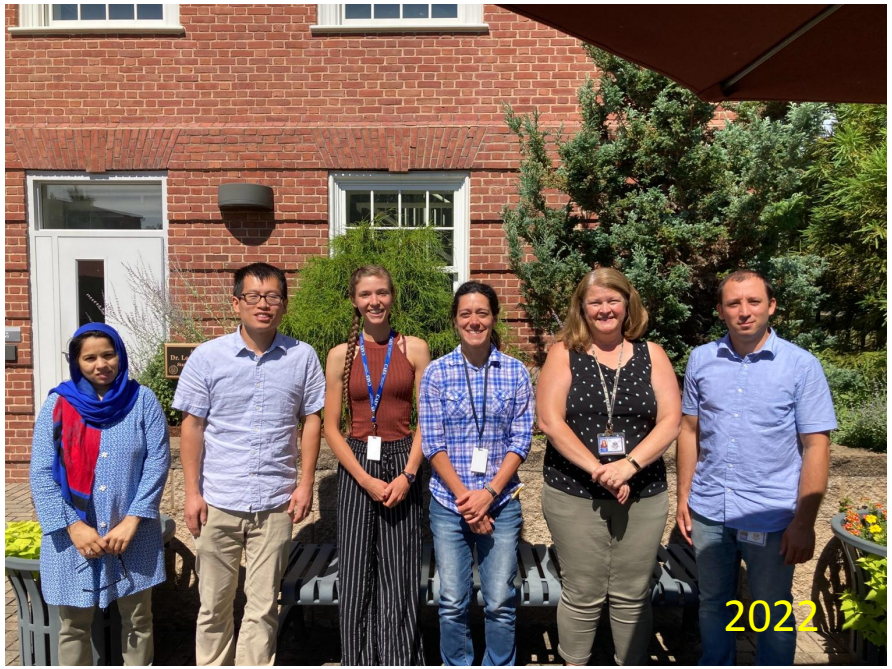
Post-Bloom Petal Fall - plant growth regulator application protocol for shoot blight:

Current protocol for balancing shoot growth and shoot blight suppression (for young high-density plantings):

- Four weekly applications of Apogee (2 oz) + Actigard (1 oz).
- Tank mix the two products
- 1st application at king bloom petal fall.
- Widely adopted in Michigan.

George Sundin, MSU

Acknowledgement



Collaborators

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