New insights on the biology of fire blight bacteria

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UNIVERSITY OF CONNECTICUT
1881

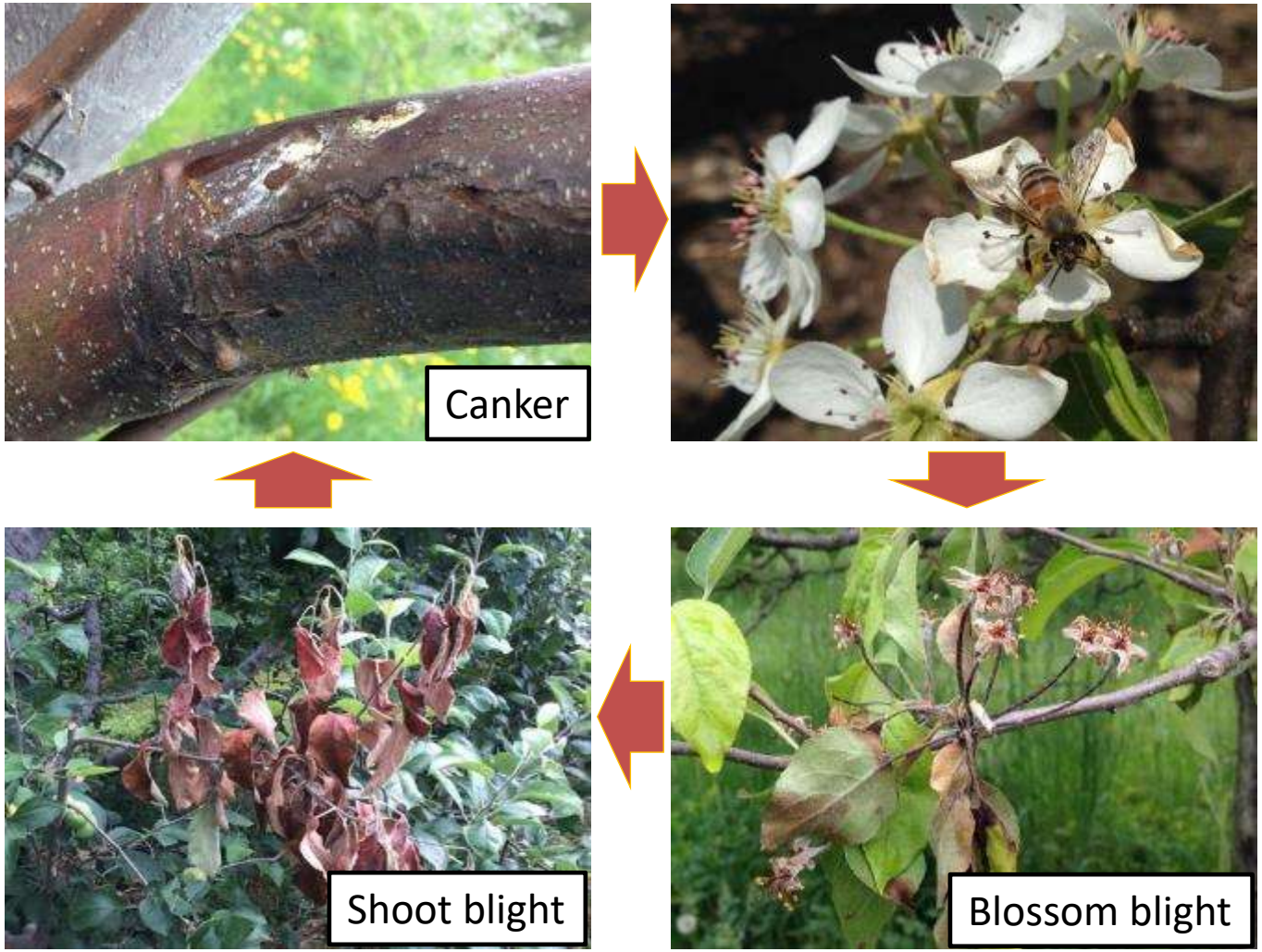
Fire blight, a devastating disease of apple and pear

- 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

Uniqueness of fire blight compared to other diseases caused by fungi

- The bacterial pathogen grows very fast under favorable conditions. Doubling time =20 mins.
- Antibiotics have to be the main disease control material. Most antibiotics are reserved for medical use.
- Most of the life cycle of Ea is within plants. External application of bactericide can not target the internally present pathogen.
- Bacteria do not have penetration pegs like fungi, therefore need entry points to enter hosts. “windows of critical infection period”.

Fire Blight Disease Cycle



Factors affecting incidence and severity of fire blight in orchards

- Geographic location: warm bloom periods = Higher risk
- Tree age: orchards 3-8 year old = Higher risk
- Cultivar susceptibility (Asian pears, hard cider, quince)
- Tree nutrition: High nitrogen = Higher risk

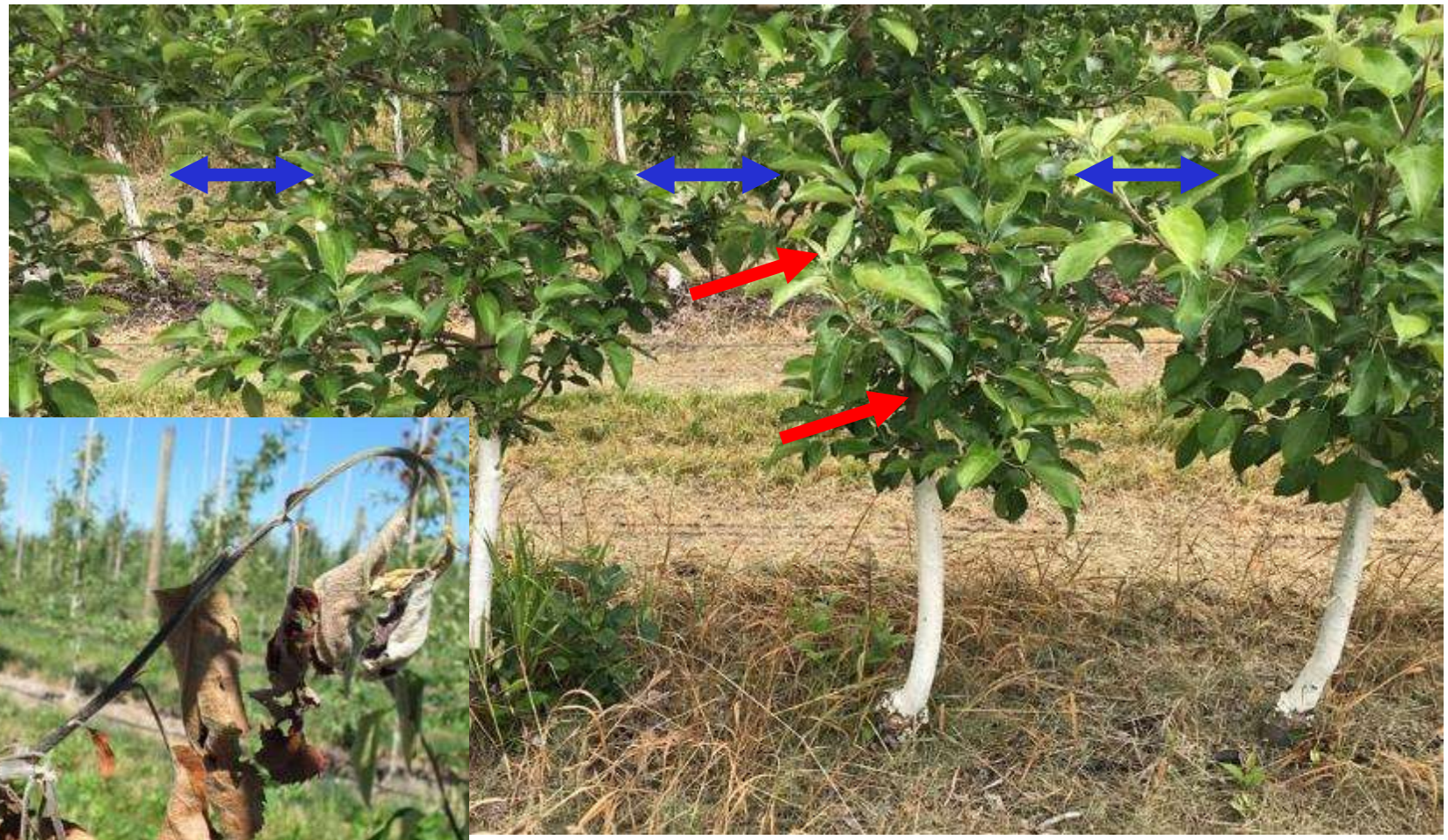
New challenges:

- Adoption of high-density planting

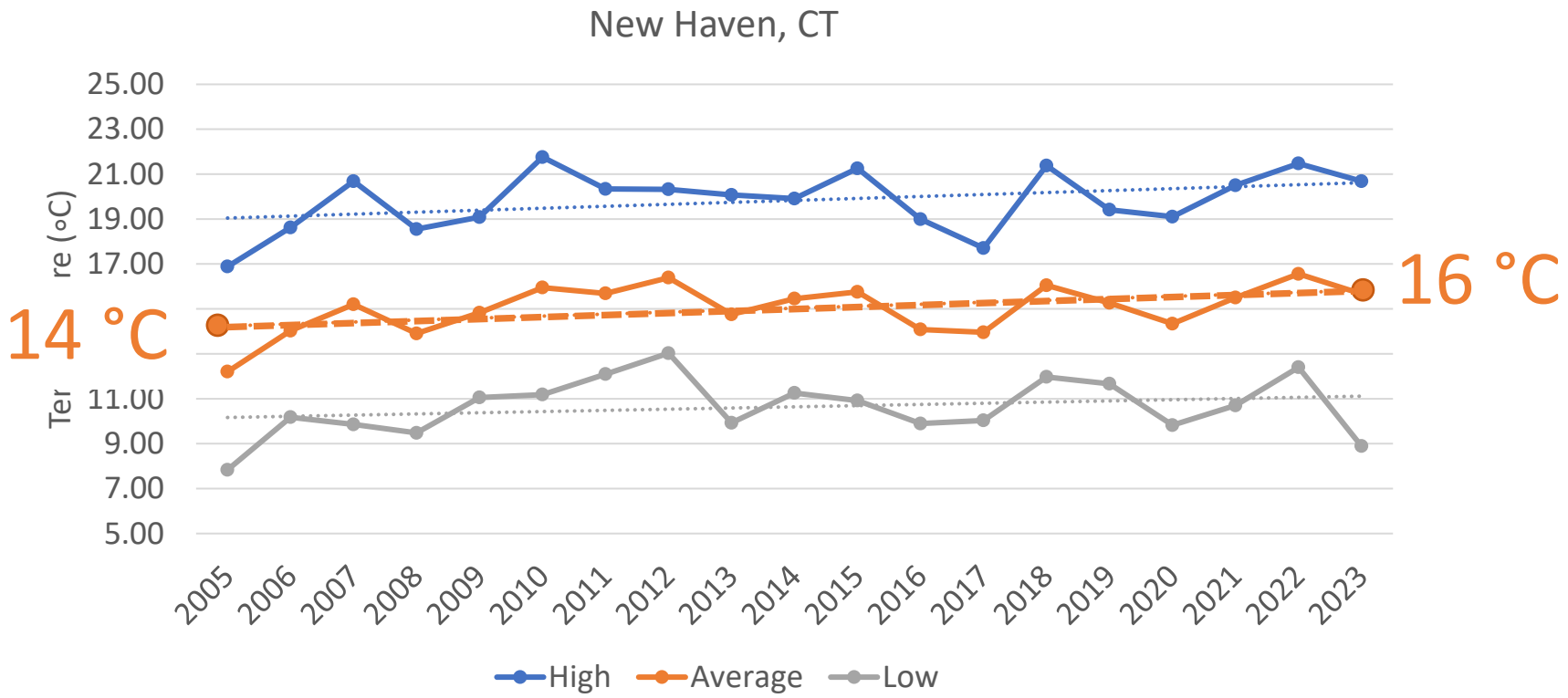
Shorter distance from shoot tips to central leader

Trees closer to each other, more likely for between tree spread

- Global warming



Average temperature during bloom (May)



increased by ~2°C in the past 18 years

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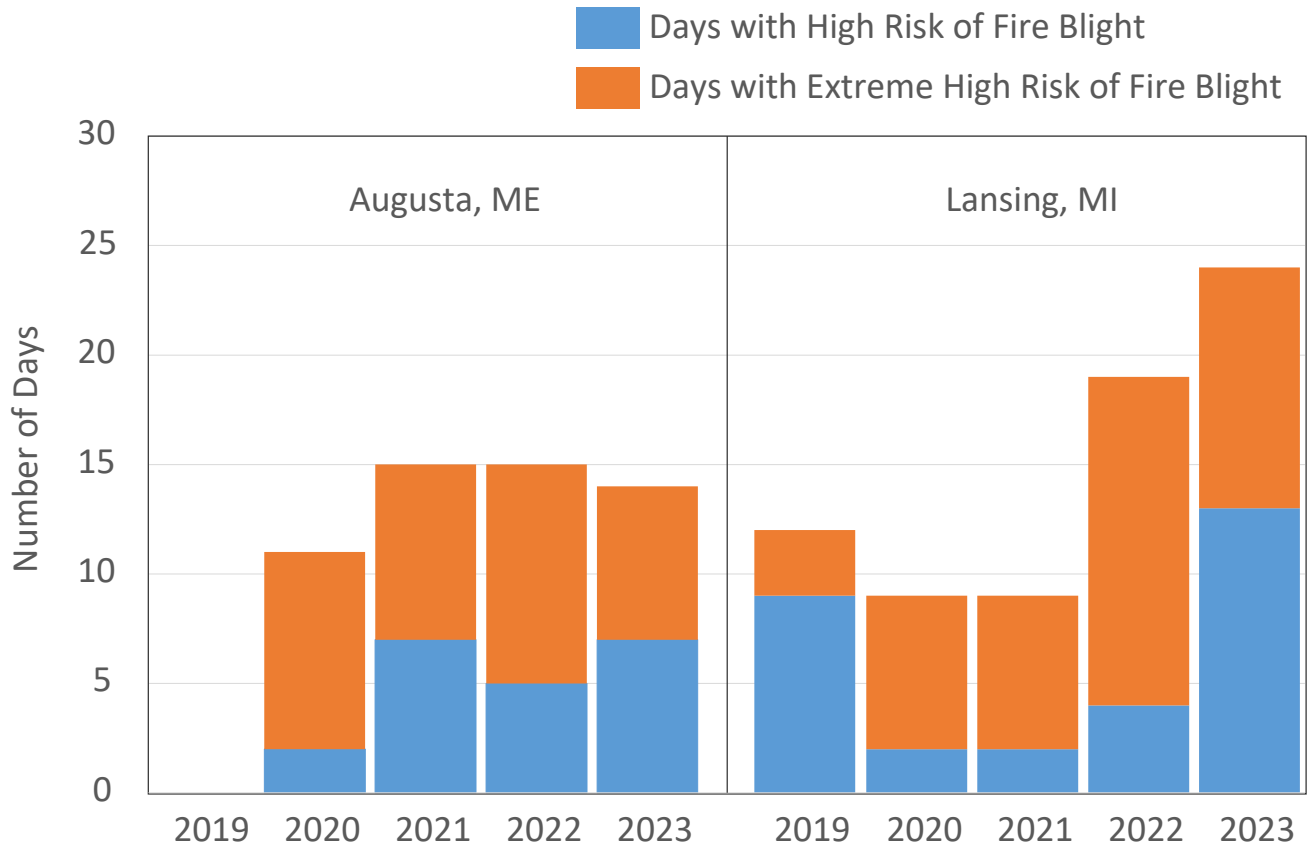
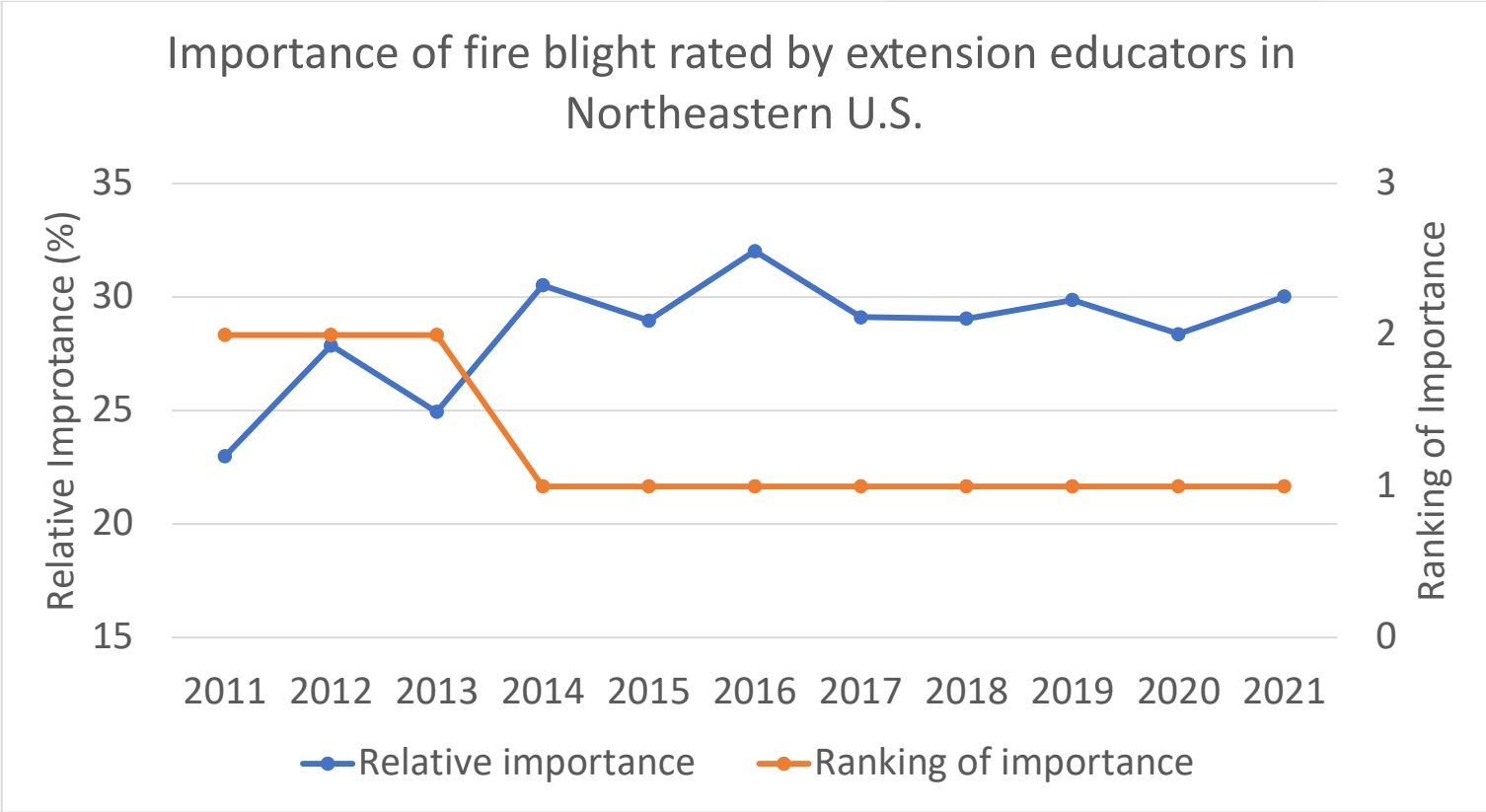
Number of high risk / extreme high risk days – Cougar blight model



Importance of fire blight in the Northeast increased over the past decade



Northeastern IPM Center

Fruit Working Group

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New challenges:

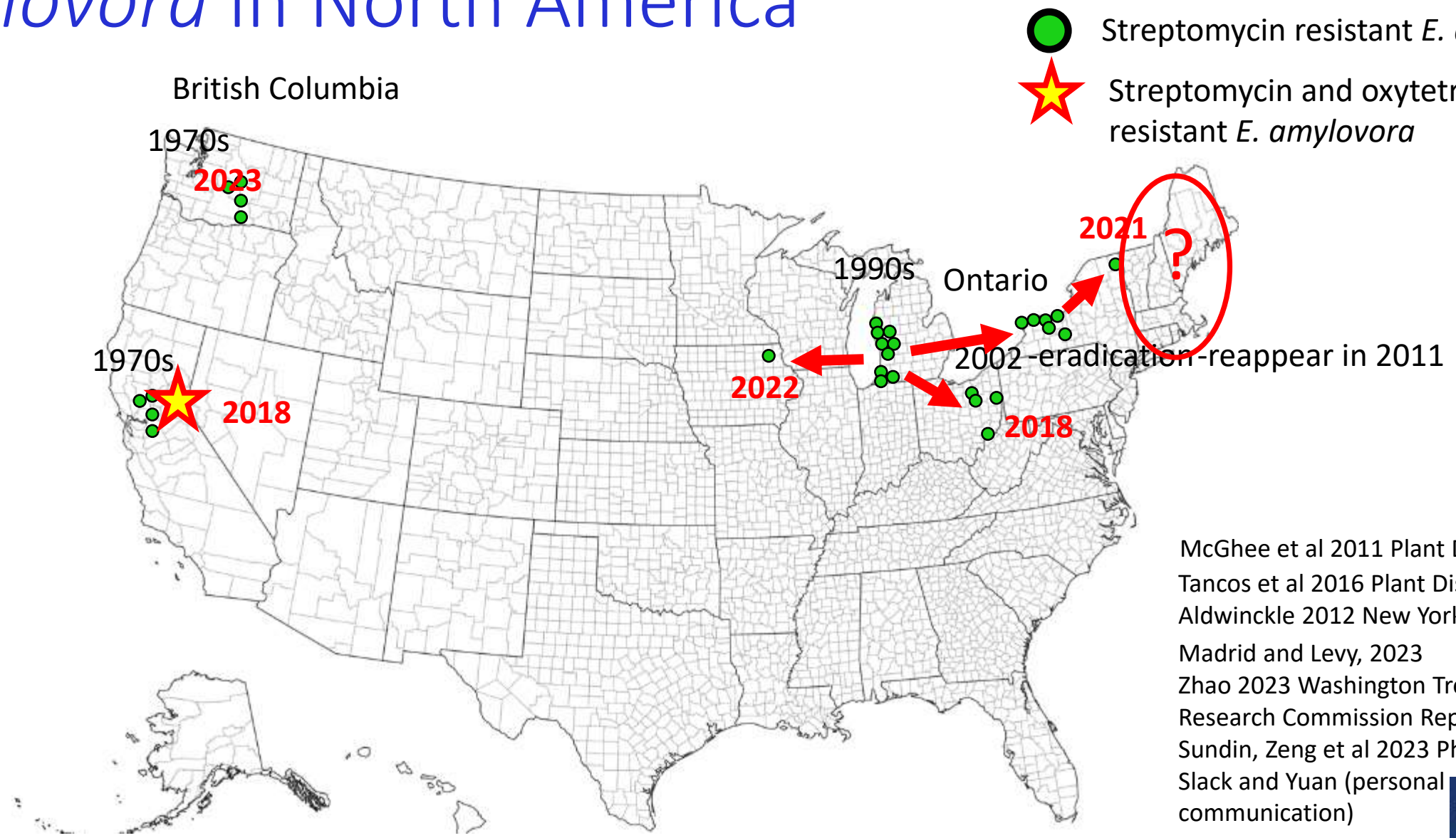
- Adoption of high-density planting

Shorter distance from shoot tips to central leader

Trees closer to each other, more likely for between tree spread

- Global warming
- Development and spread of strep resistance in Ea populations.

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)

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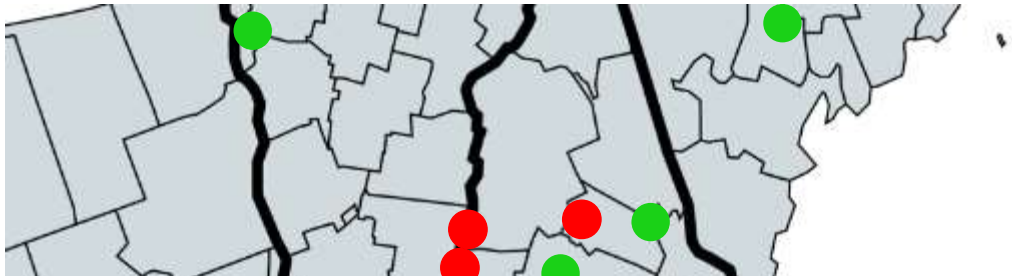
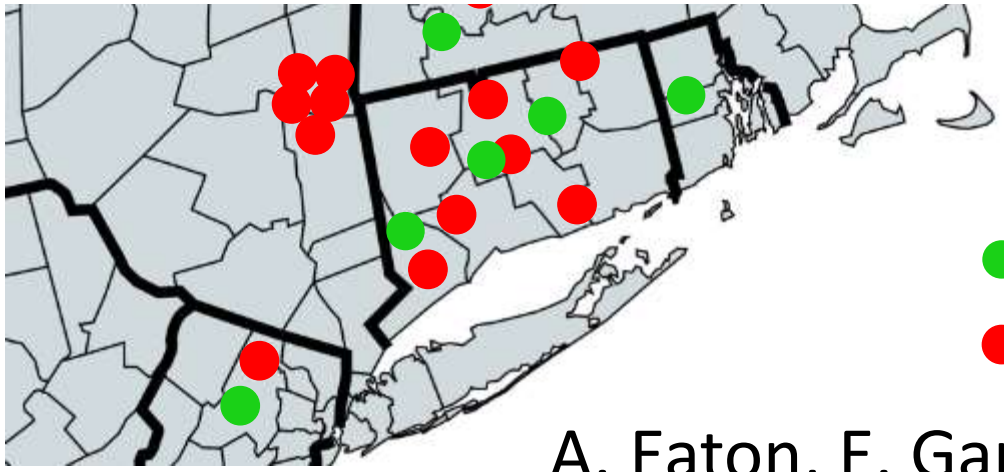
Streptomycin resistance survey in New England

- Fire blight samples collected in New England, New York, New
- No streptomycin resistant *Erwinia amylovora* were isolated !



apple and pear, 7 from ornamental plants



- 2015-2016 survey
- 2021-2023 survey

A. Eaton, E. Garafallo, H. Fulbert. M. Concklin. E.

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New insights on the biology of fire blight bacteria

What environmental conditions affect fire blight infection?

- Mostly focused on temperature, “Degree Hours >65°F”
- Mostly for Blossom Blight

New insights on the biology of fire blight bacteria

Water intensifies the

1. blossom blight infection,
2. shoot blight infection,
3. canker formation.

Form of water

1. **External water (outside plants)**

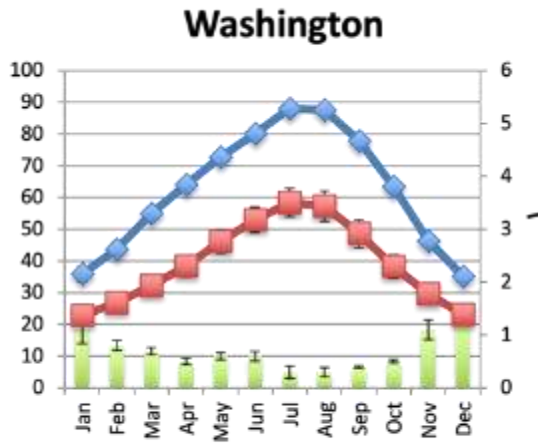
- Rain

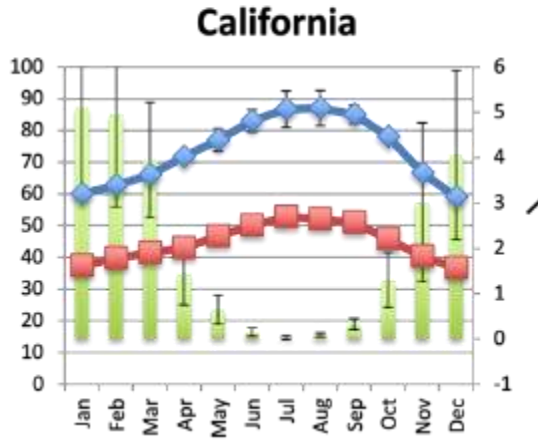
- Relative humidity (RH)

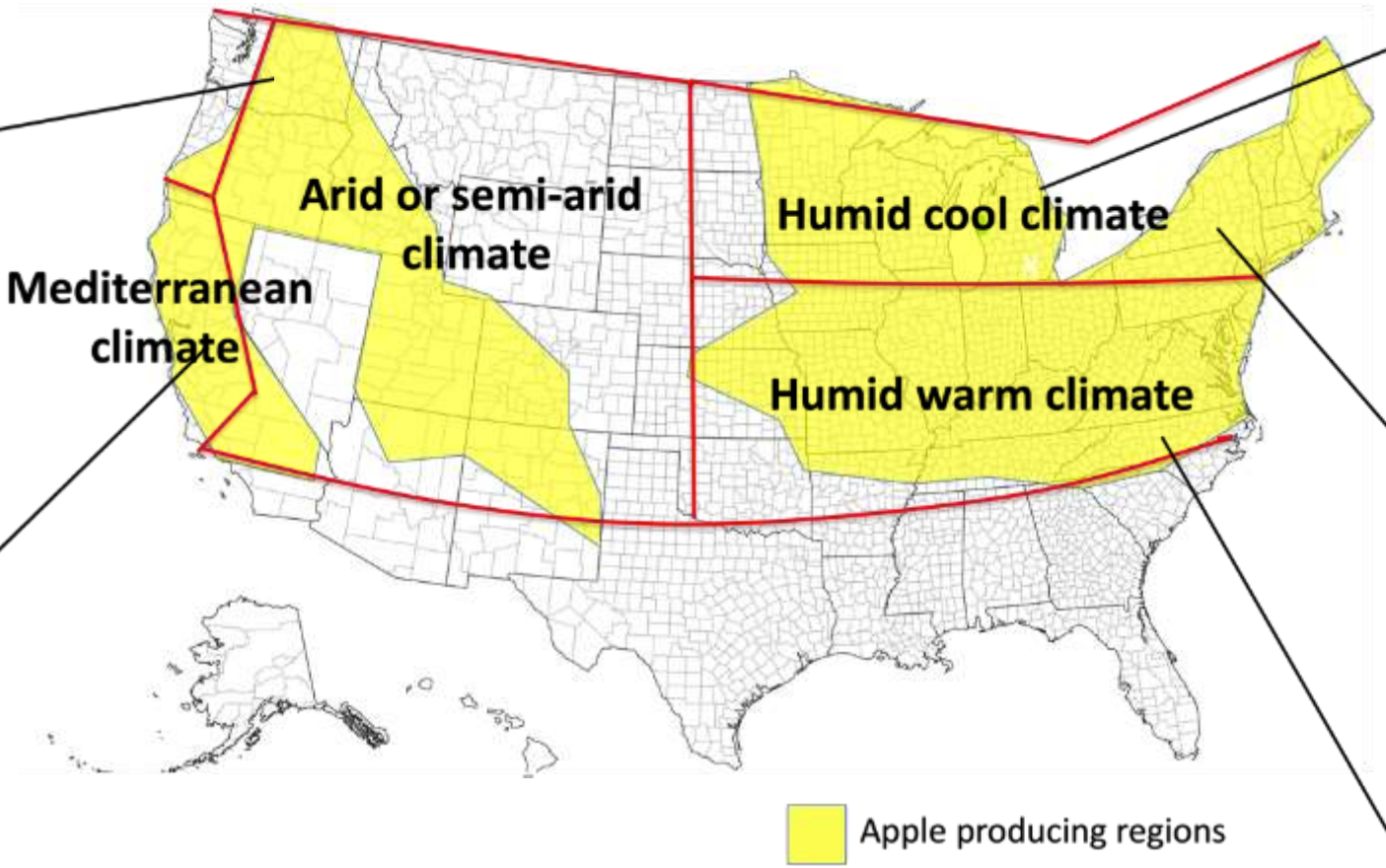
2. **Internal water (within plants)**

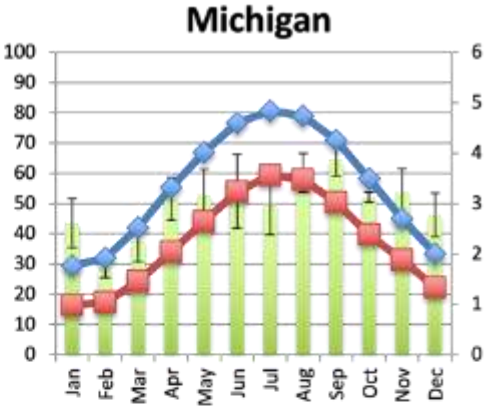
- Water potential in plant tissue (affected by day/night cycle, soil moisture, and weather)

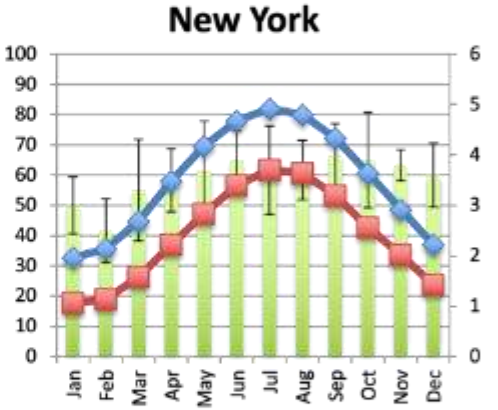
Humid eastern U.S.

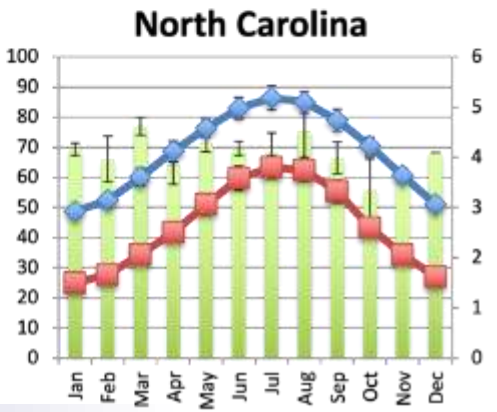












Average precipitation (inches)

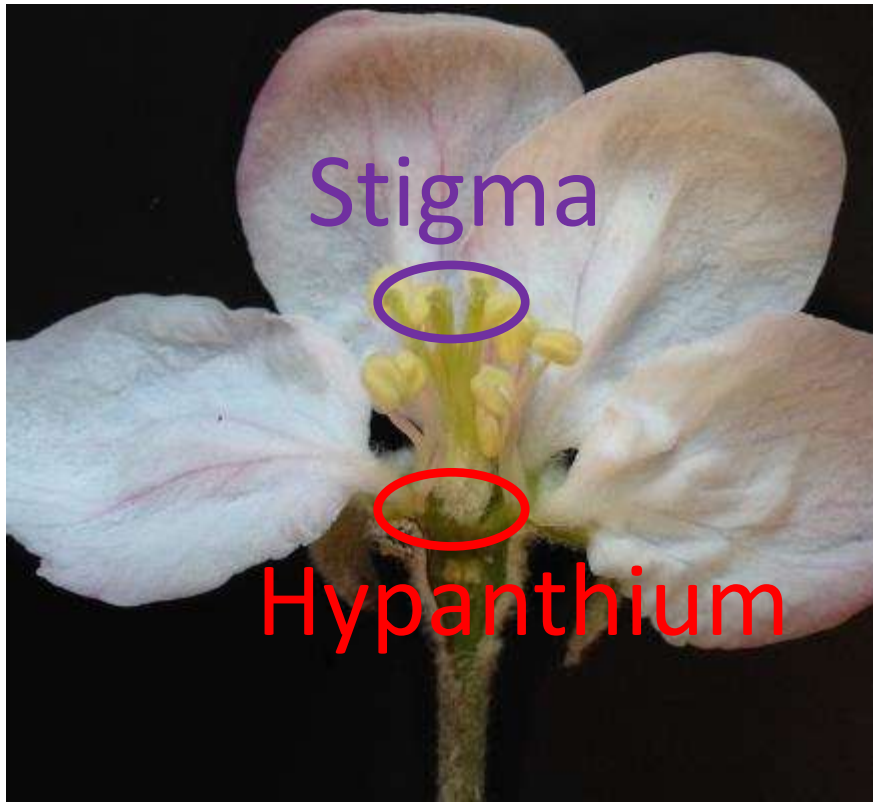
Average high (°F)

Average low (°F)

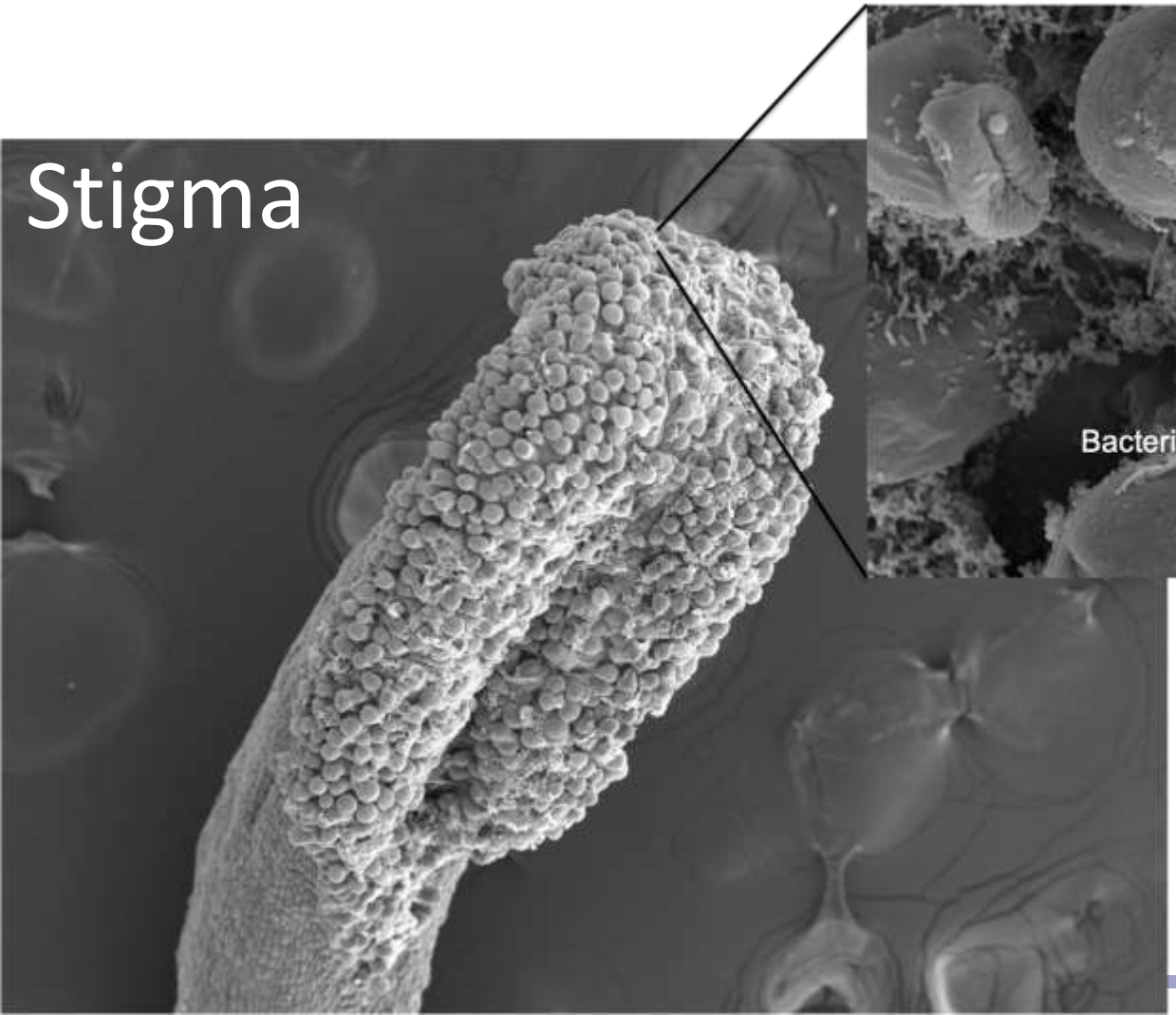
Fire blight bacterium loves water!

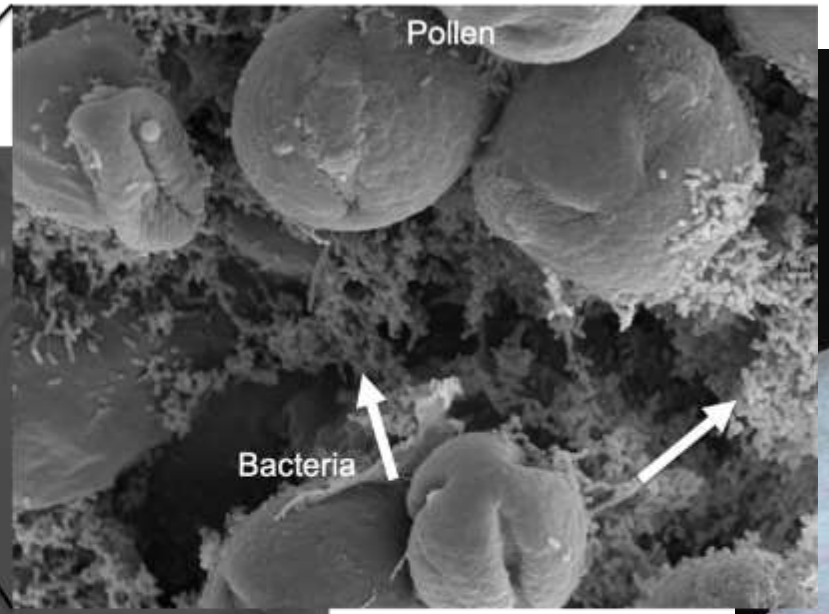
Grows well on stigma (low osmolarity), can not grow on hypanthium (high osmolarity).

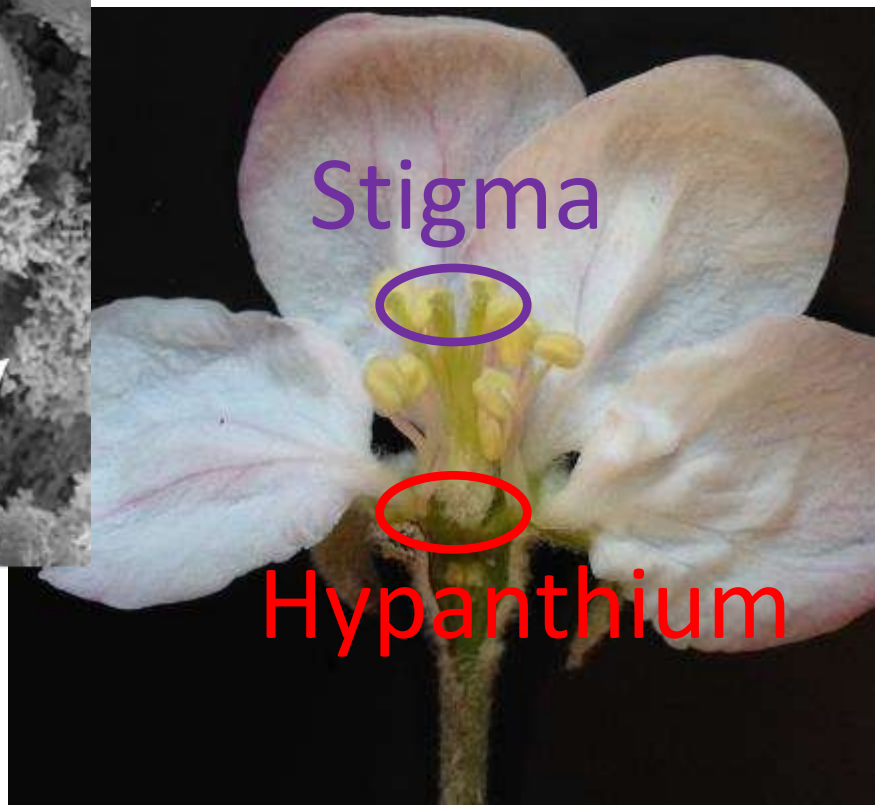
Lives in xylem tissue (water transportation tube).



Ea grows on stigma and infects through hypanthium

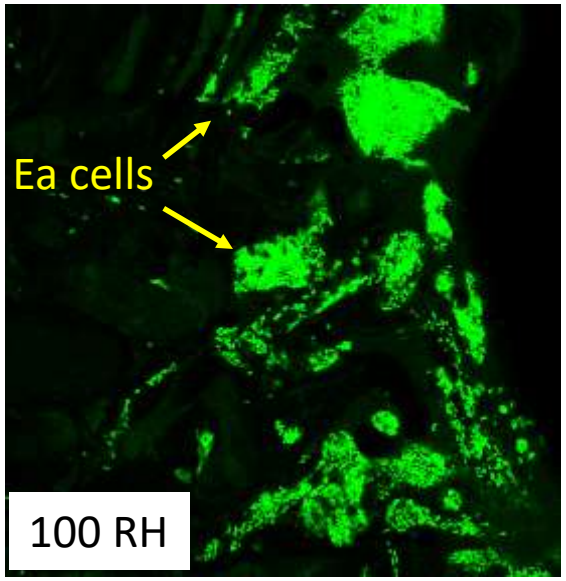


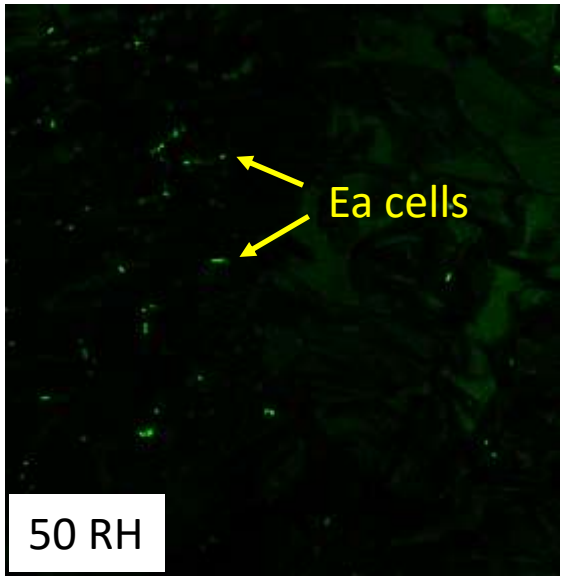




Water intensifies the blossom blight infection

- *E. amylovora* grows faster on stigma and is more virulent under wet conditions.

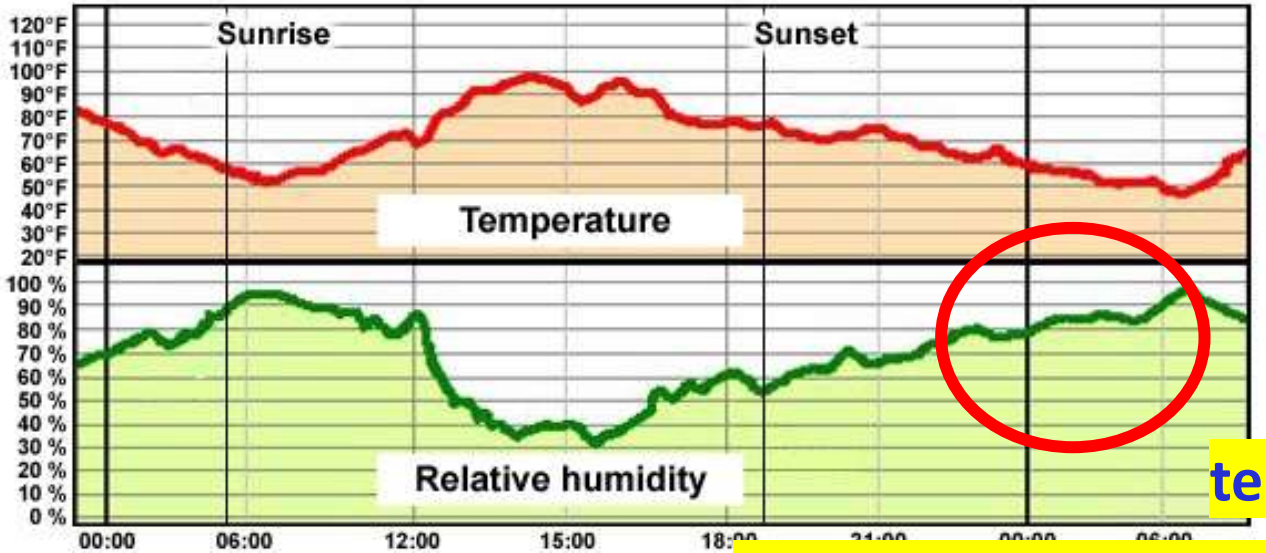




Cui and Zeng 2021

Water intensifies the blossom blight infection

- *E. amylovora* grows faster on stigma during night than during day.



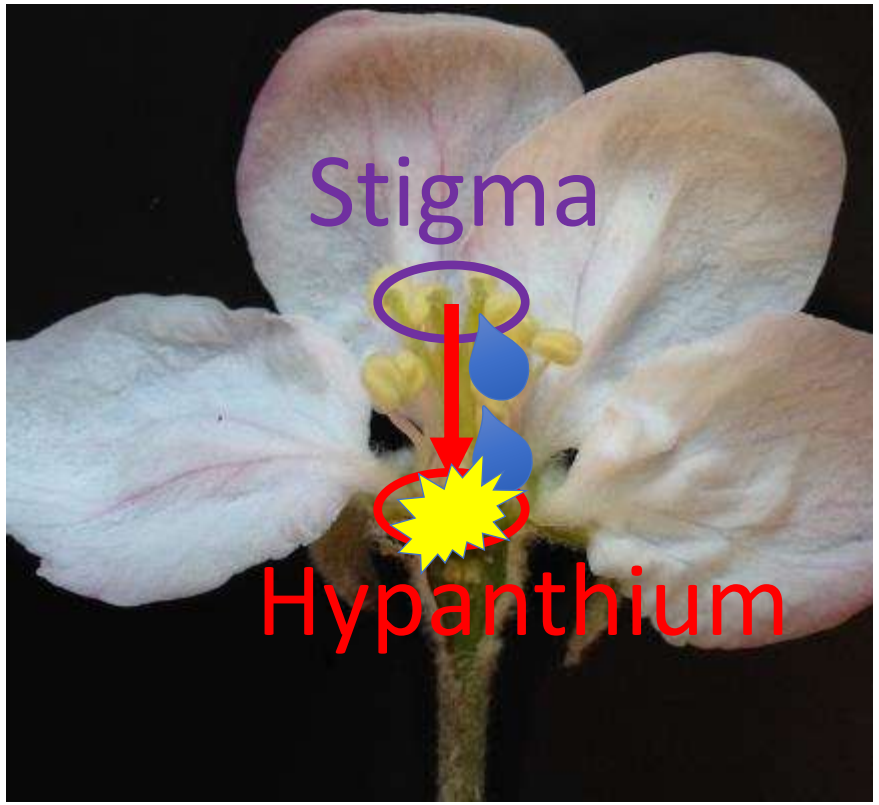
Flowers very wet, temperature not too low

Ea growth surge on flowers: ack and Sundin 2021

10PM-3AM

Water is essential for the infection to occur at hypanthium

- Free moving water (rain, dew, fungicide spray) is needed to bring Ea cells grown from stigma to hypanthium where infection occurs.
- Free moving water dilutes nectar, which helps Ea to survive the high sugar environment at hypanthium.



Pusey 2000 Phytopathology 90: 1352-57

Examples of water impact to blossom blight

Year1

Year2

Map | Results | More info

Fire Blight Risk Predictions for Glastonbury HS

Orchard Blight History: Fire blight occurred in your neighborhood last year.

Select the fire blight history in your orchard block of interest and the tool will calculate risk. Toggle orchard blight history to recalculate risk.

2014

Major FB outbreaks!

The first blossom open date above is estimated based on degree day accumulations. Enter the actual first blossom open date for your orchard block of interest and the tool will calculate the protection period during bloom more accurately.

Accumulated degree days (base 43°F) through 5/8/2014: 320 (22 days missing)

RH max/min	83/30	75/27	97/51	100/90	100/50	95/19	82/25	82/39
Temp avg F	52	52	52	56	69	66	65	59

NA - data not available | View Cougarblight Charts | Download Time: 5/14/2014 23:00

Map | Results | More info

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Orchard Blight History: Fire blight occurred in your neighborhood last year.

Select the fire blight history in your orchard block of interest and the tool will calculate risk. Toggle orchard blight history to recalculate risk.

2015

No FB!

First blossom open date:

The first blossom open date above is estimated based on degree day accumulations. Enter the actual first blossom open date for your orchard block of interest and the tool will calculate the protection period during bloom more accurately.

Accumulated degree days (base 43°F) through 5/5/2015: 311 (0 days missing)

"Where did all the fire blight go in 2015?"

My MFGA summer meeting presentation title.

EIP value	32	99	164	177	206	216	180	238
Wetness Events								
Rain Amount	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dew	No	No	No	No	No	No	Yes	Yes
Leaf Wetness Estimate (hours)	0	0	0	5	0	0	5	11
Hours >90% RH	0	0	0	0	0	0	10	10
RH max/min	77/27	78/28	73/39	81/31	77/25	80/37	95/60	98/54
Temp avg F	60	65	70	62	62	69	63	71

NA - data not available | View Cougarblight Charts | Download Time: 5/11/2015 23:00

Which year had more FB?

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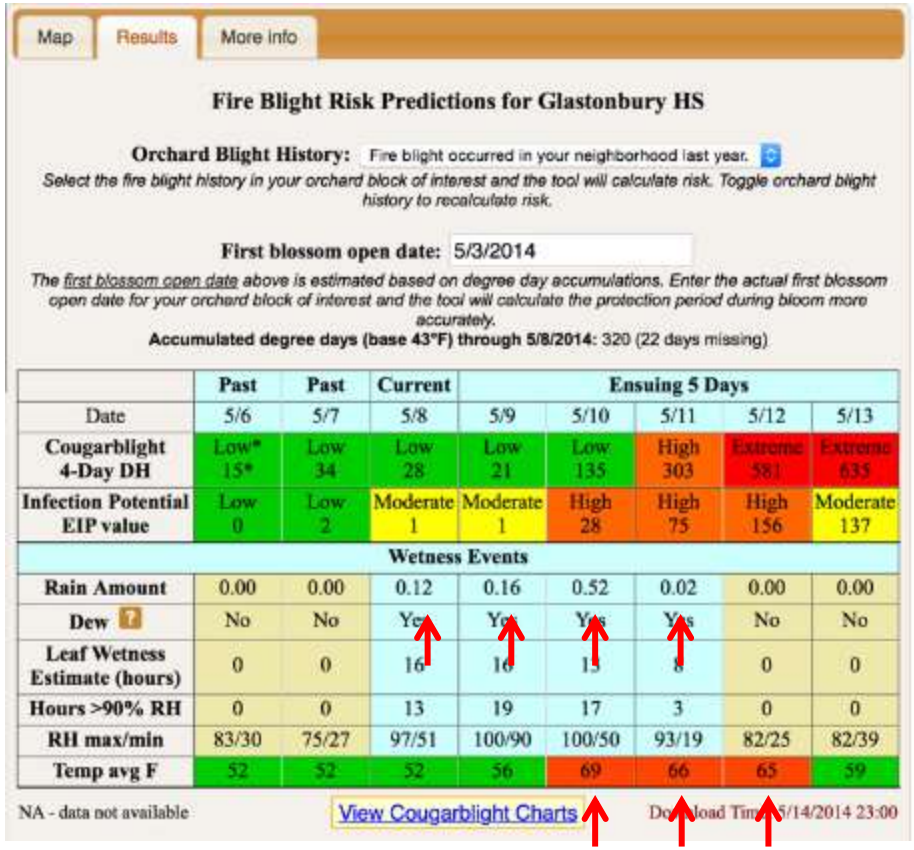
Examples of water impact to blossom blight

2014



Map | Results | More info

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Orchard Blight History: Fire blight occurred in your neighborhood last year.

Select the fire blight history in your orchard block of interest and the tool will calculate risk. Toggle orchard blight history to recalculate risk.

First blossom open date: 5/3/2014

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Accumulated degree days (base 43°F) through 5/8/2014: 320 (22 days missing)

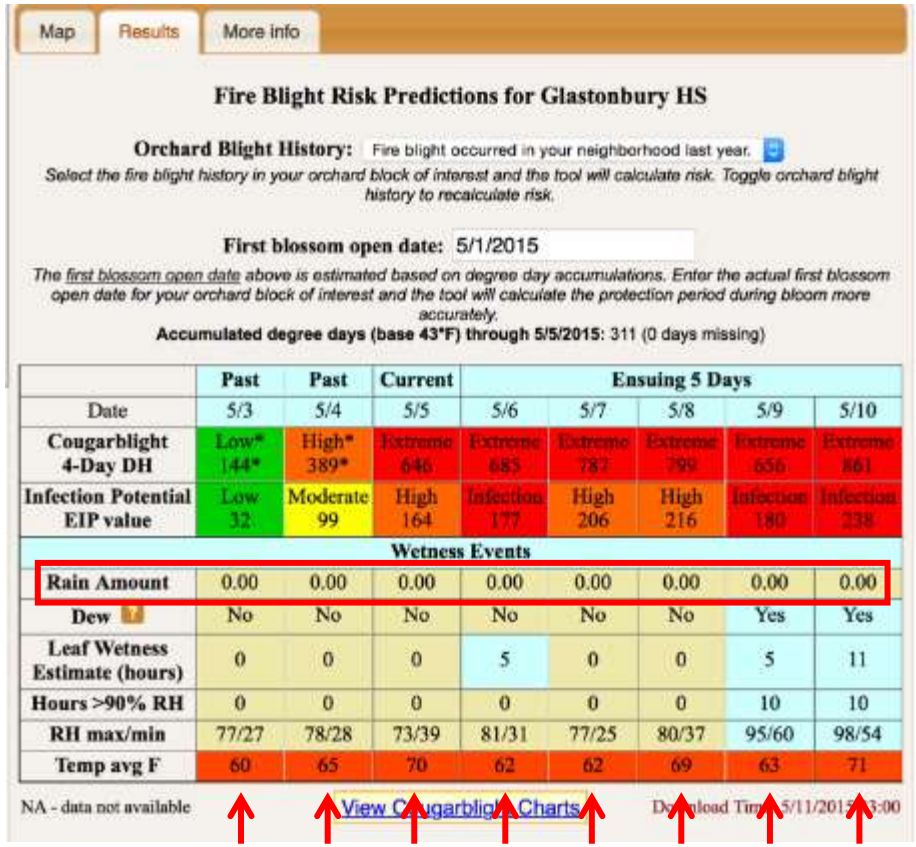
	Past	Past	Current	Ensuing 5 Days				
Date	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13
Cougarblight 4-Day DH	Low* 15*	Low 34	Low 28	Low 21	Low 135	High 303	Extreme 581	Extreme 635
Infection Potential EIP value	Low 0	Low 2	Moderate 1	Moderate 1	High 28	High 75	High 156	Moderate 137
Wetness Events								
Rain Amount	0.00	0.00	0.12	0.16	0.52	0.02	0.00	0.00
Dew	No	No	Yes	Yes	Yes	Yes	No	No
Leaf Wetness Estimate (hours)	0	0	16	16	15	8	0	0
Hours >90% RH	0	0	13	19	17	3	0	0
RH max/min	83/30	75/27	97/51	100/90	100/50	93/19	82/25	82/39
Temp avg F	52	52	52	56	69	66	65	59

NA - data not available

View Cougarblight Charts

Download Time: 5/14/2014 23:00

2015



Map | Results | More info

Fire Blight Risk Predictions for Glastonbury HS

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Select the fire blight history in your orchard block of interest and the tool will calculate risk. Toggle orchard blight history to recalculate risk.

First blossom open date: 5/1/2015

The first blossom open date above is estimated based on degree day accumulations. Enter the actual first blossom open date for your orchard block of interest and the tool will calculate the protection period during bloom more accurately.

Accumulated degree days (base 43°F) through 5/5/2015: 311 (0 days missing)

	Past	Past	Current	Ensuing 5 Days				
Date	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10
Cougarblight 4-Day DH	Low* 144*	High* 389*	Extreme 646	Extreme 685	Extreme 787	Extreme 799	Extreme 656	Extreme 861
Infection Potential EIP value	Low 32	Moderate 99	High 164	Infection 177	High 206	High 216	Infection 180	Infection 238
Wetness Events								
Rain Amount	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dew	No	No	No	No	No	No	Yes	Yes
Leaf Wetness Estimate (hours)	0	0	0	5	0	0	5	11
Hours >90% RH	0	0	0	0	0	0	10	10
RH max/min	77/27	78/28	73/39	81/31	77/25	80/37	95/60	98/54
Temp avg F	60	65	70	62	62	69	63	71

NA - data not available

View Cougarblight Charts

Download Time: 5/11/2015 23:00

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Implications to management

1. Watch out for those rainy, warm days during bloom!

2. Watch out for warm nights even without rain (humidity is high at night, plant water potential is high at night) during bloom!

Protect flowers with strep before 1. and 2.!

3. Tank mix strep with your fungicide sprays (artificial wetting events) during bloom, whenever is possible.