

Preparing for restrictions on multi-site fungicides and update on 2025 UV-C trials

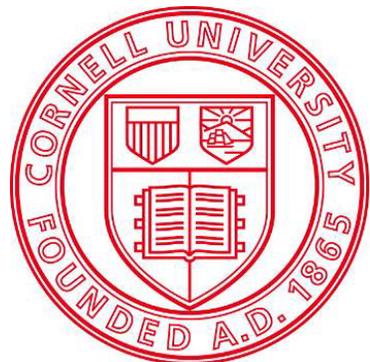
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School of Integrative Plant Science

Cornell University



Cornell
AgriTech

New York State Agricultural
Experiment Station



Preparing for multi-site fungicide restrictions



Regulatory changes for multi-site fungicide use

- 2025 – US EPA Mancozeb use restrictions in apple?
 - Aug 2024: Pesticide Registration Review: Proposed Decisions for Several Pesticides (Mancozeb and Malathion)
 - Nov 2024: Presented to EPA for an hour: PPE to allow hand thinning with mancozeb
 - Jan 2025 "We are currently reviewing public comments on the PID and plan to release an interim decision (ID) in late 2025 at the earliest." - Ben Tweed from EPA

Using biopesticide & single-site fungicides only



Use planting system to increase chance of success

I. Modern planting systems

Vertical Axis



Super Spindle



Super Spindle

- **Smaller trees**
- **Better fungicide coverage**
- **Faster drying time**
- **Less humid microclimate**
- **Less conducive to development of apple scab**

Use disease forecasting to increase chance of success

- I. Modern planting systems
- II. Using Decision Support Systems (DSS)

Decision Support System

- Aid by timing applications with to forecast infection events
- Infection threshold used to determine applications (15% ascospore release, >35 hours leaf wetness)

Infection Events Summary

Date (2019)	Infection Events	Average Temp (°F) for wet hours
May 5	combined	55
May 6	yes	51
May 7	no	52
May 8	no	-
May 9	no	-
May 10	yes	60
May 11	no	-
May 12	no	43

Infection events, shown in red above, are based on the [Revised Mill](#). The word "Combined" means the wetting event on this day is being

Ascospore Maturity Summary

Download CSV

Daily Discharge Thresholds: ≥ 10% > 20%

Date	Ascospore Maturity	Daily Ascospore Discharge	Cumulative Ascospore Discharge
May 5	50%	8%	41%
May 6	57%	<1%	42%
May 7	62%	10%	52%
May 8	66%	0%	52%
May 9	71%	0%	52%
May 10	76%	22%	74%
May 11	79%	0%	74%
May 12	81%	4%	78%

The Ascospore Maturity model predicts that 95% of the ascospores have matured. At this point, essentially all ascospores will be released after a daytime rain of greater than 1/10 inch with average temperature above 50°F

Biopesticide Integration Field Trial at Cornell

AgriTech 2019-2021

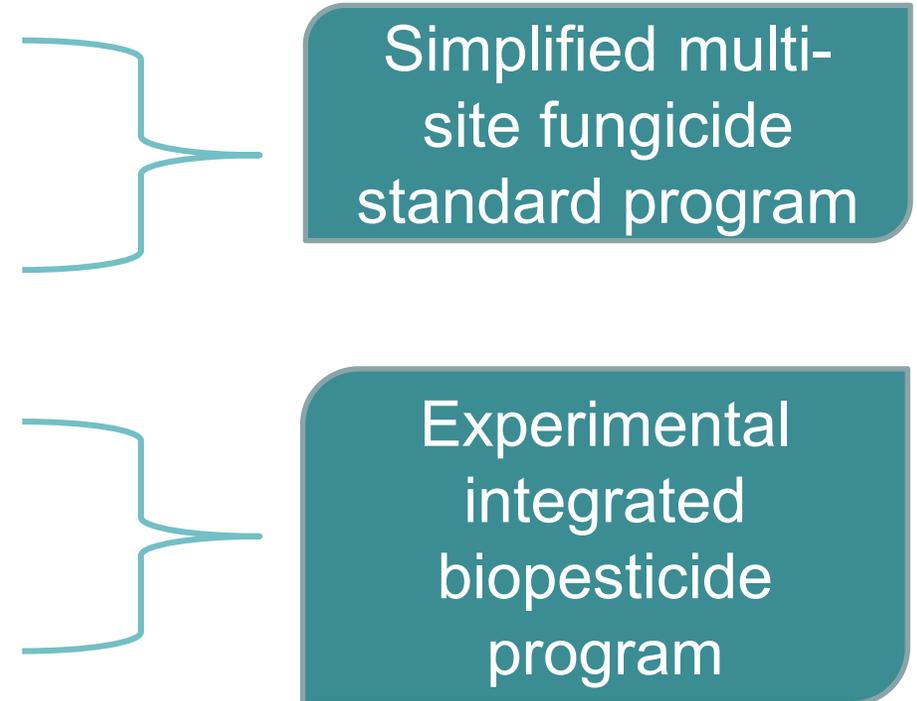
- Mature > 20 years
Buckeye 'Gala' on B.9
(VA)
 - Repeated Measures
Randomized complete
block (RCB): 4 single-tree
reps
- 4-year Buckeye 'Gala'
on G.935 (SS)
 - Repeated Measures
RCB: 4 rep panels w/ five
trees each



Biopesticide Integration Field Trial at Cornell

AgriTech 2019-2021

Program	Timing
Untreated Control (no fungicides)	-
Manzate Max (mancozeb) + Captec (captan) rotated biweekly with Aprovia (benzovindiflupyr)	Calendar timing (7-10 days)
Manzate Max + Captec rotated with Aprovia	DSS Forecast (15% ejection for single-site)
Serenade Opti rotated biweekly with Aprovia	Calendar timing (7-10 days; 8 applications)
Serenade Opti rotated with Aprovia	DSS Forecast (15% ejection for single-site)



Biopesticide Integration Field Trial at Cornell AgriTech 2022-2024

Program	Timing
Untreated Control (no fungicides)	-
Manzate Max (mancozeb) + Captec (captan) rotated biweekly with Aprovia (benzovindiflupyr), Flint Extra (trifloxystrobin) or Cevya (mefentrifluconazole)	Calendar timing (7-10 days)
Manzate Max + Captec rotated with Aprovia, Flint Extra or Cevya	DSS Forecast (15% ejection for single-site)
Double Nickel LC rotated biweekly with Aprovia, Flint Extra or Cevya	Calendar timing (7-10 days; 8 applications)
Double Nickel LC rotated with Aprovia, Flint Extra or Cevya	DSS Forecast (15% ejection for single-site)

Simplified multi-site fungicide standard program

Experimental integrated biopesticide program

Influence of Tree Architecture: Relative Humidity

> 90% Relative Humidity
conducive to infection

Vertical Axis

Weather sensors affixed to tree canopies Timeframe: April 12th- August 31st:

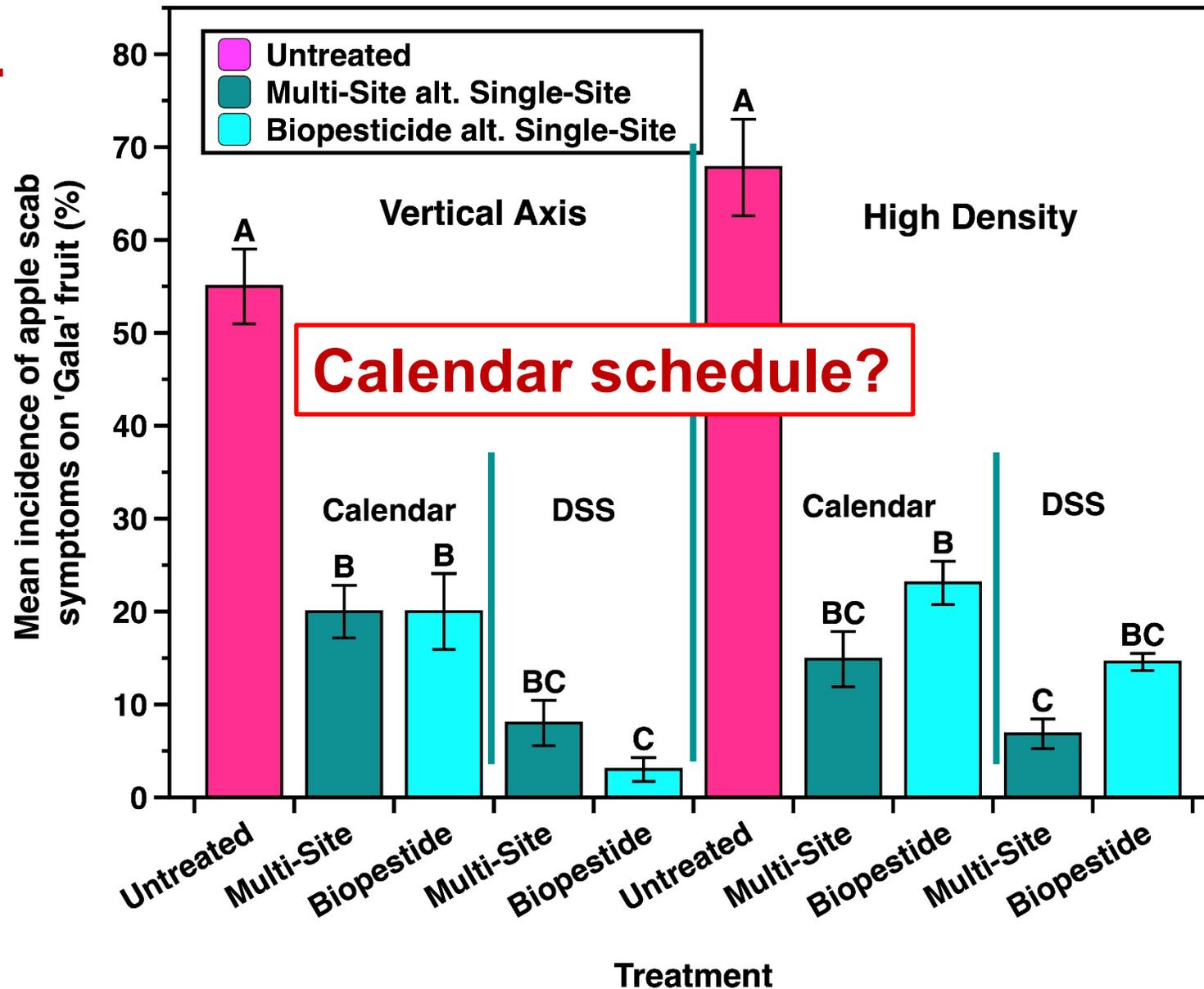
Super Spindle



	Orchard	Mean %RH	Days over 90% mean RH
2022			
	Vertical axis	70.53%	84 d
	Super spindle	67.69%	66 d
2023			
	vertical axis	72.78%	89 d
	super spindle	68.95%	28 d
2024			
	vertical axis	77.33	119 d
	super spindle	69.79	44 d



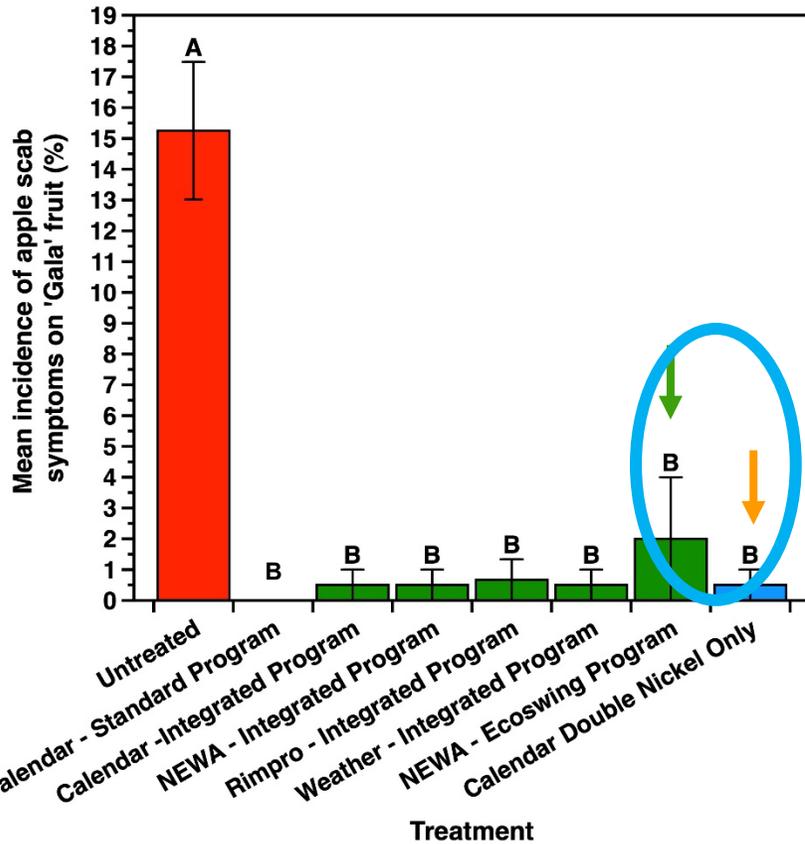
2024 Mean Incidence on Fruit



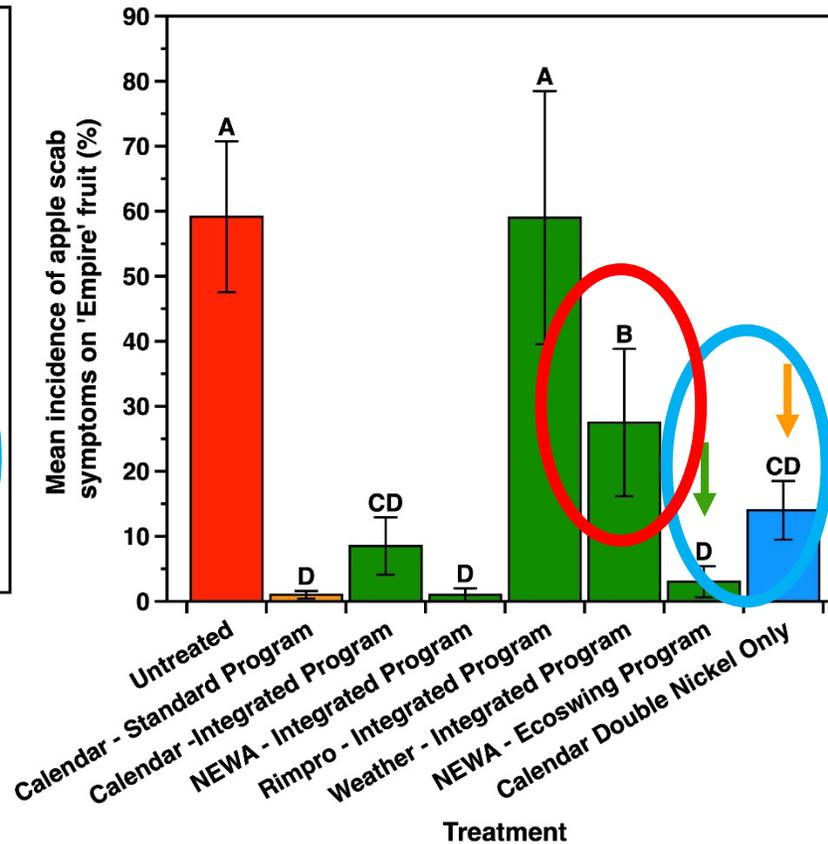
Using only biopesticides just more variable among plots/fields

2024 Mean Incidence on Fruit

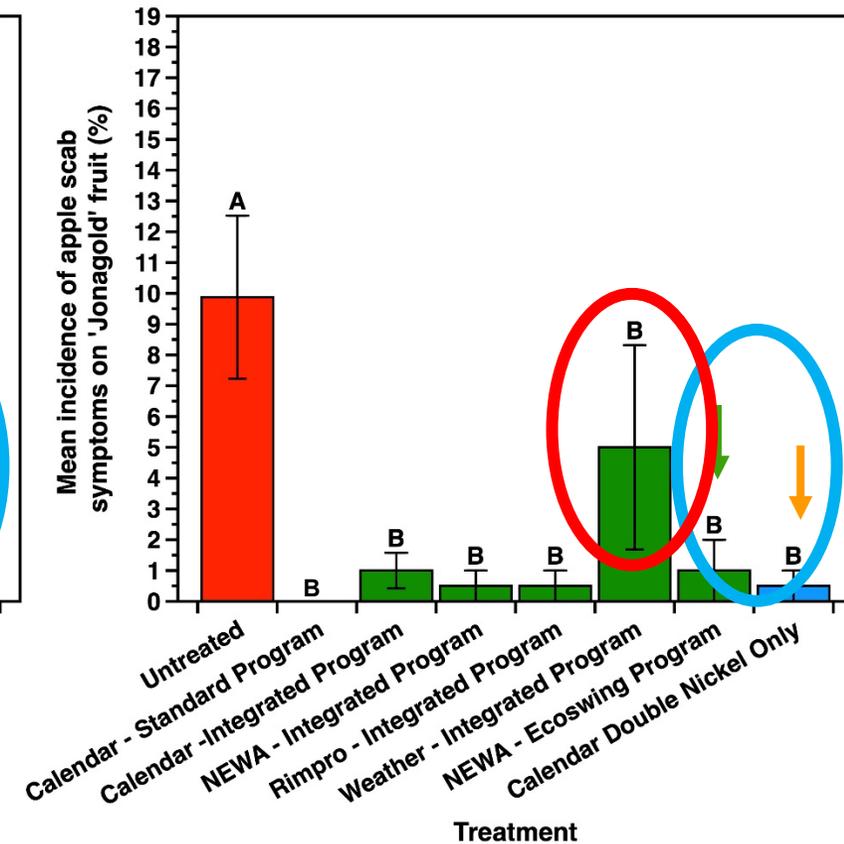
'Gala'



'Empire'



'Jonagold'



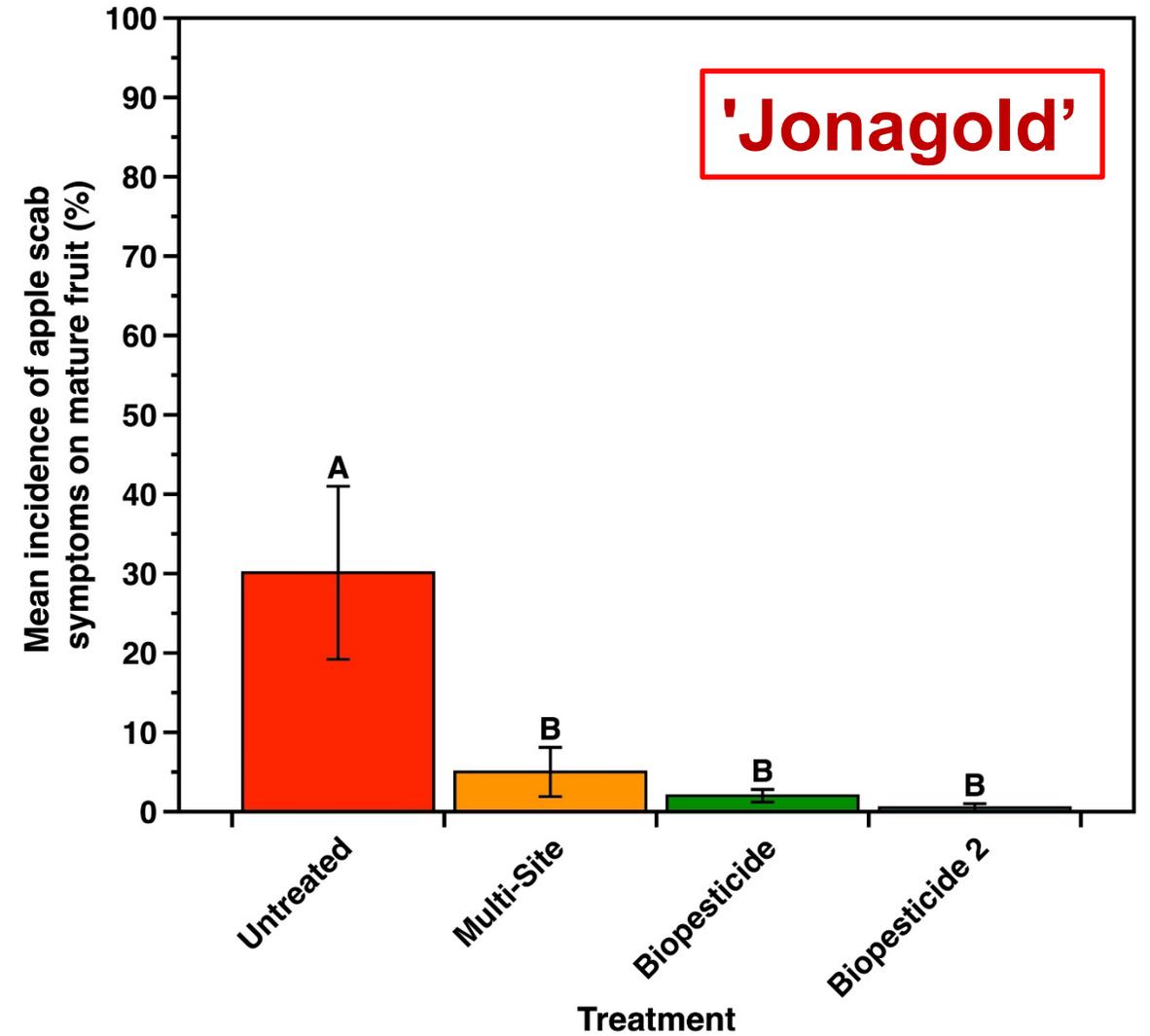
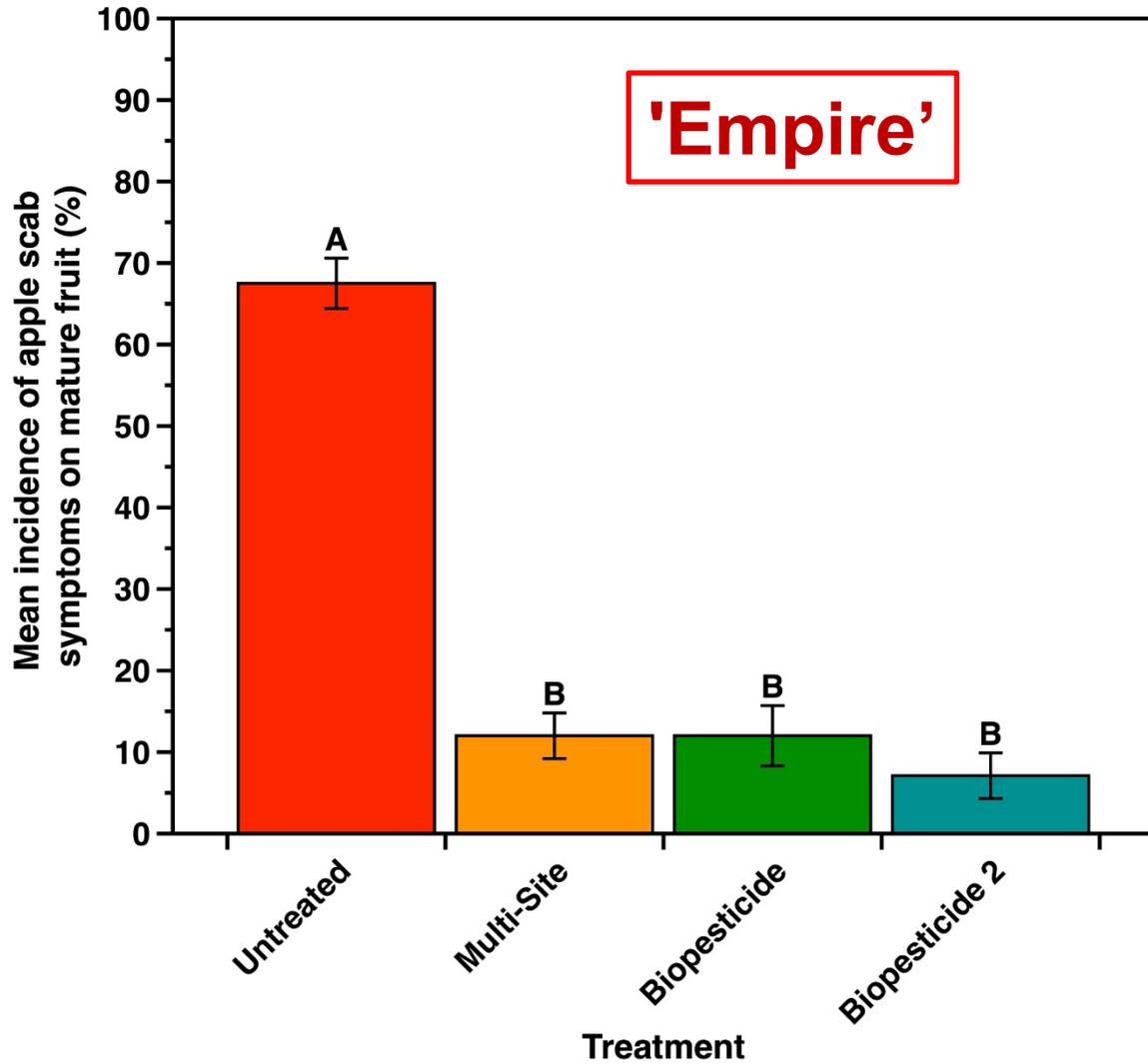
Biopesticide Integration Field Trial at Cornell AgriTech 2025...

Program	Timing
Untreated Control (no fungicides)	-
Manzate Max + Captec rotated with Aprovia, Flint Extra or Cevya	DSS Forecast (15% ejection for single-site)
Double Nickel LC rotated with Aprovia, Flint Extra, Merivon, or Cevya	DSS Forecast (15% ejection for single-site)

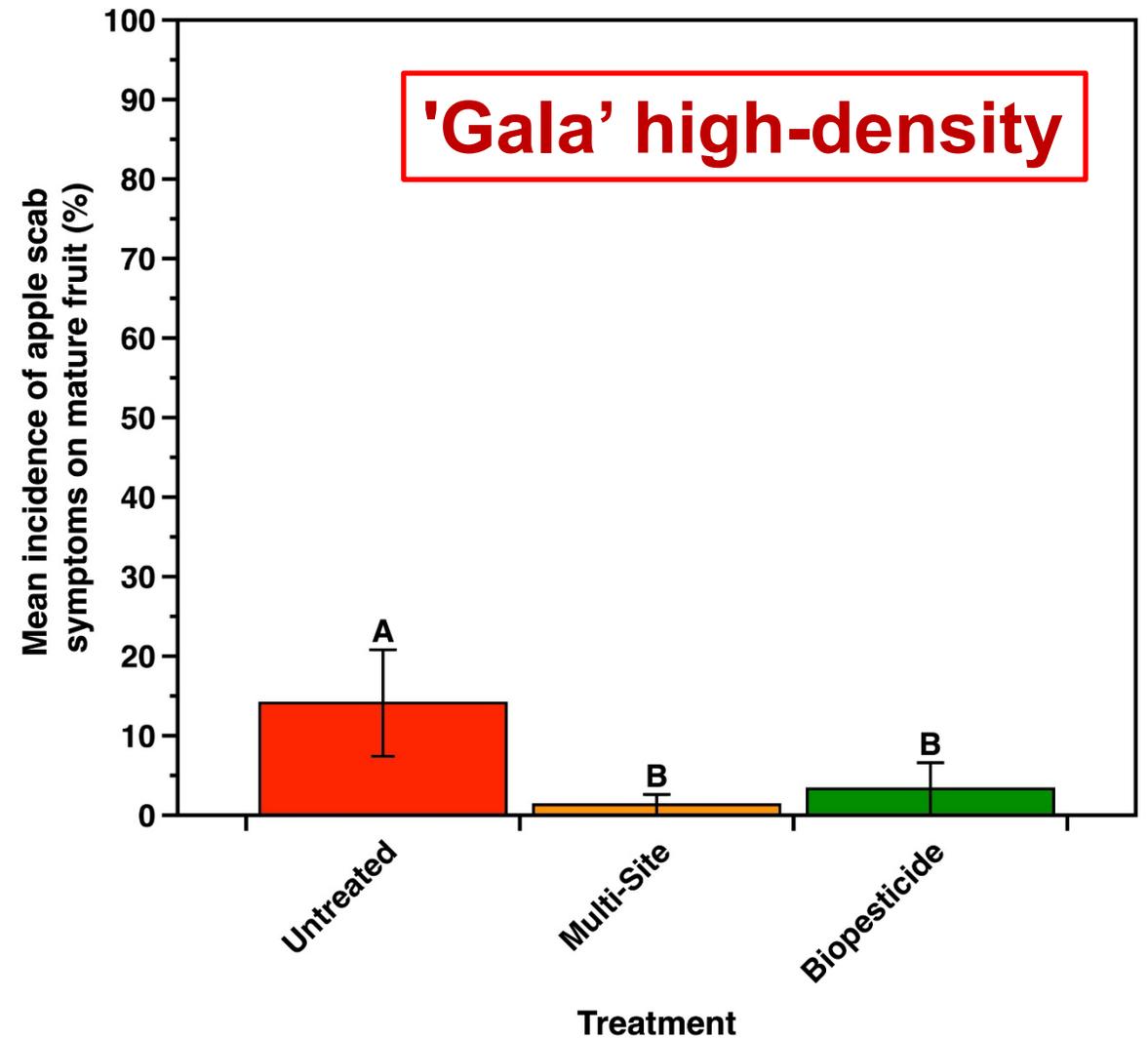
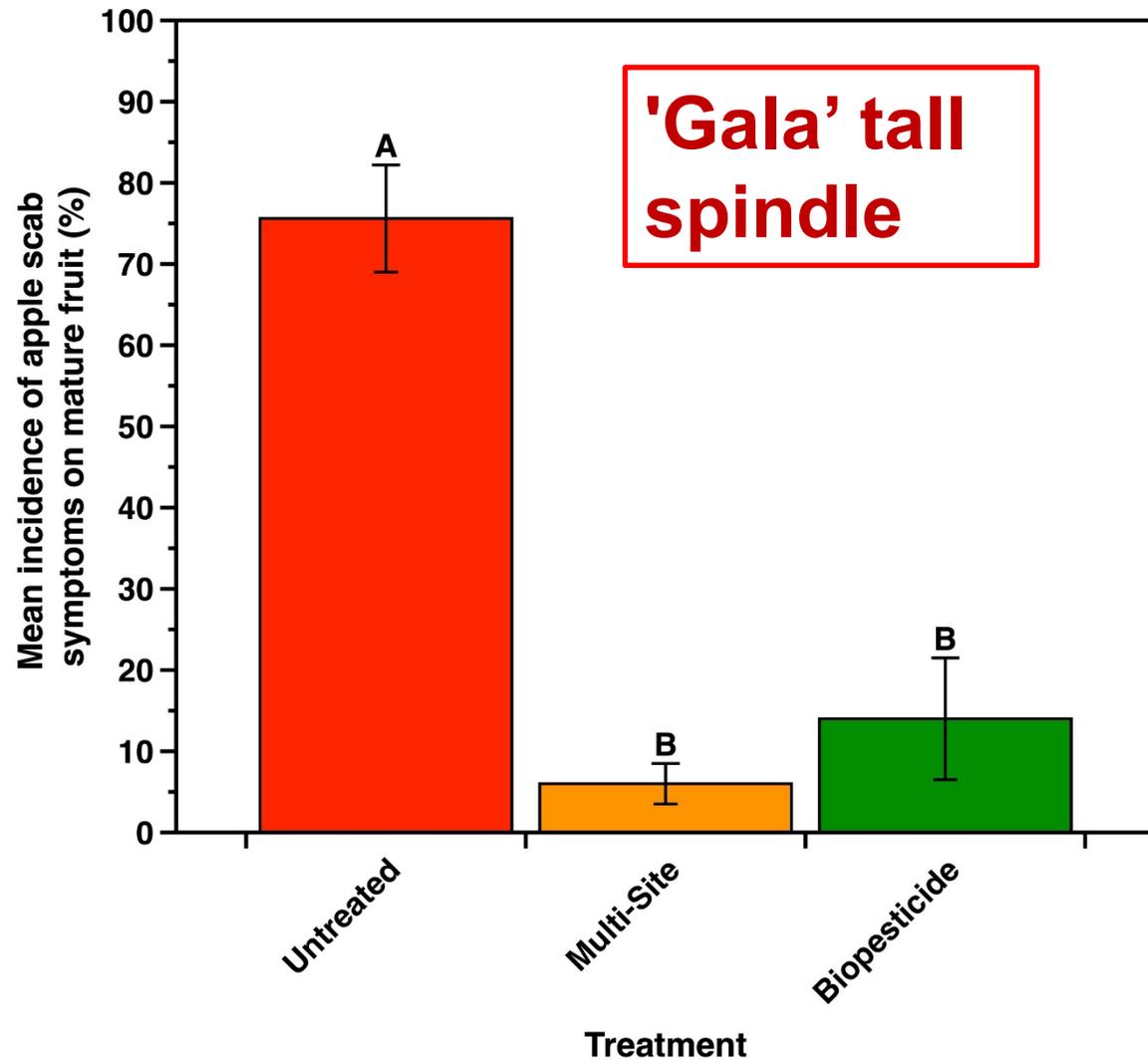
Simplified multi-site fungicide standard program

Experimental biopesticide replacement program

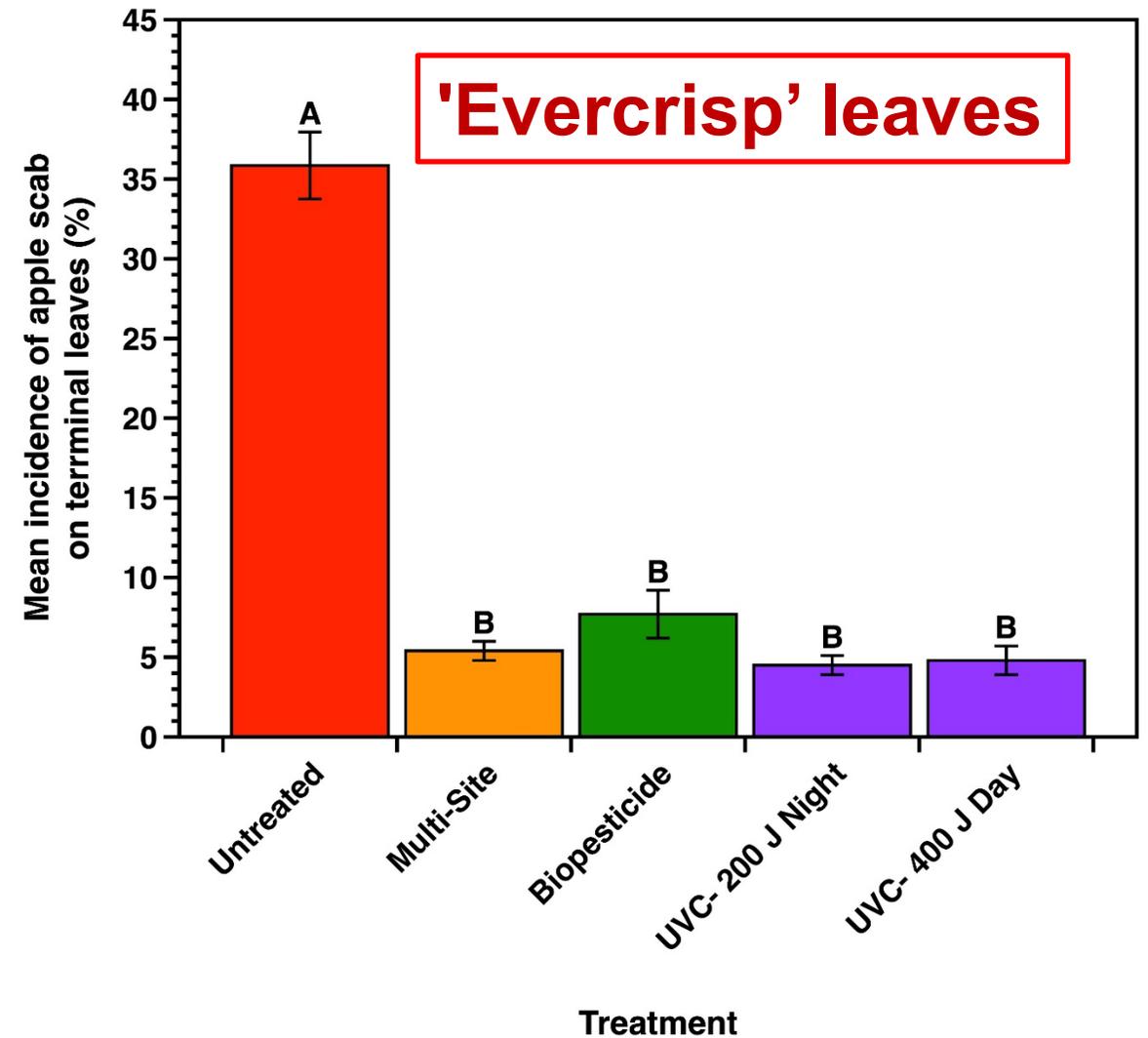
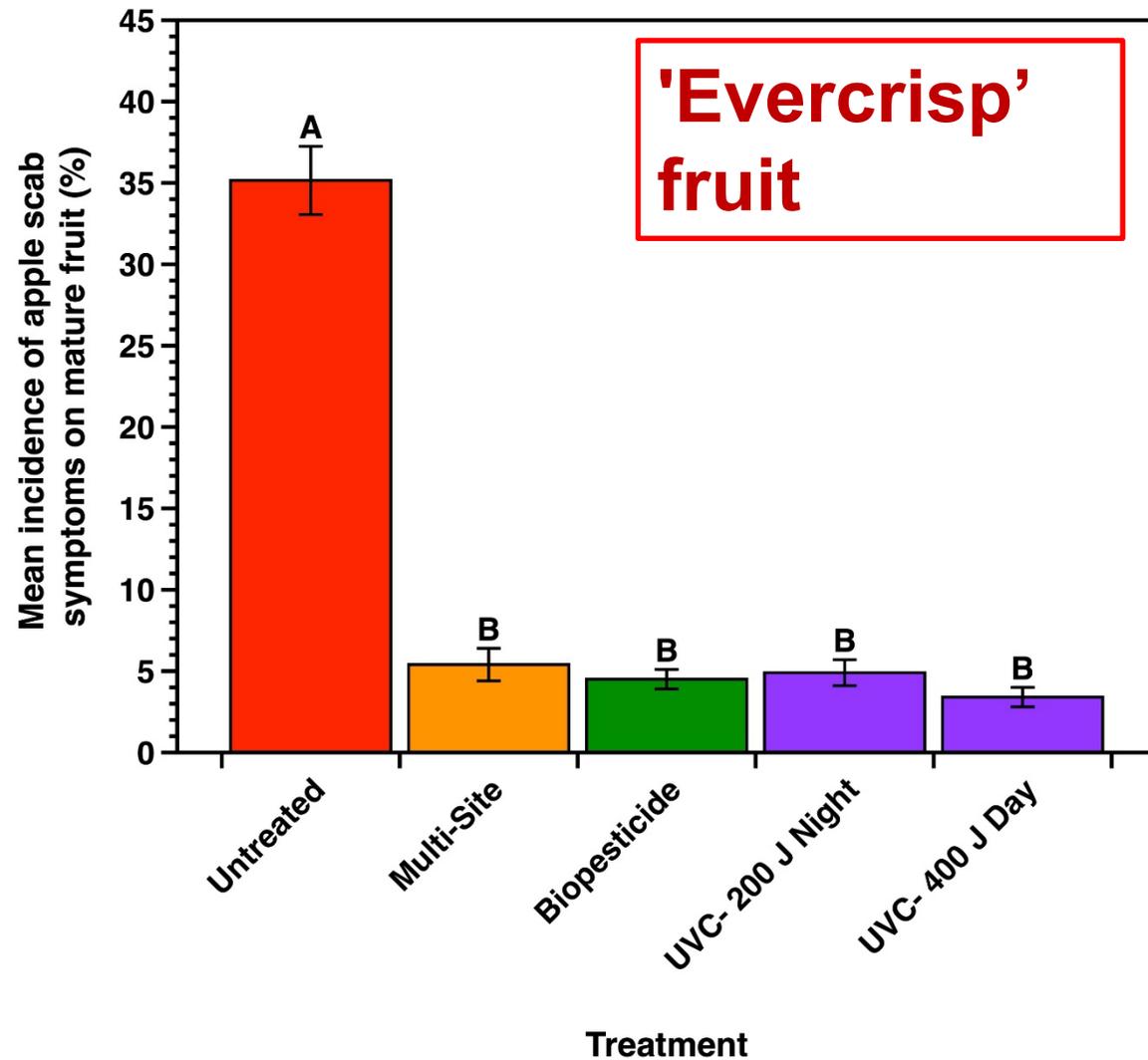
2025 Mean Incidence on Fruit



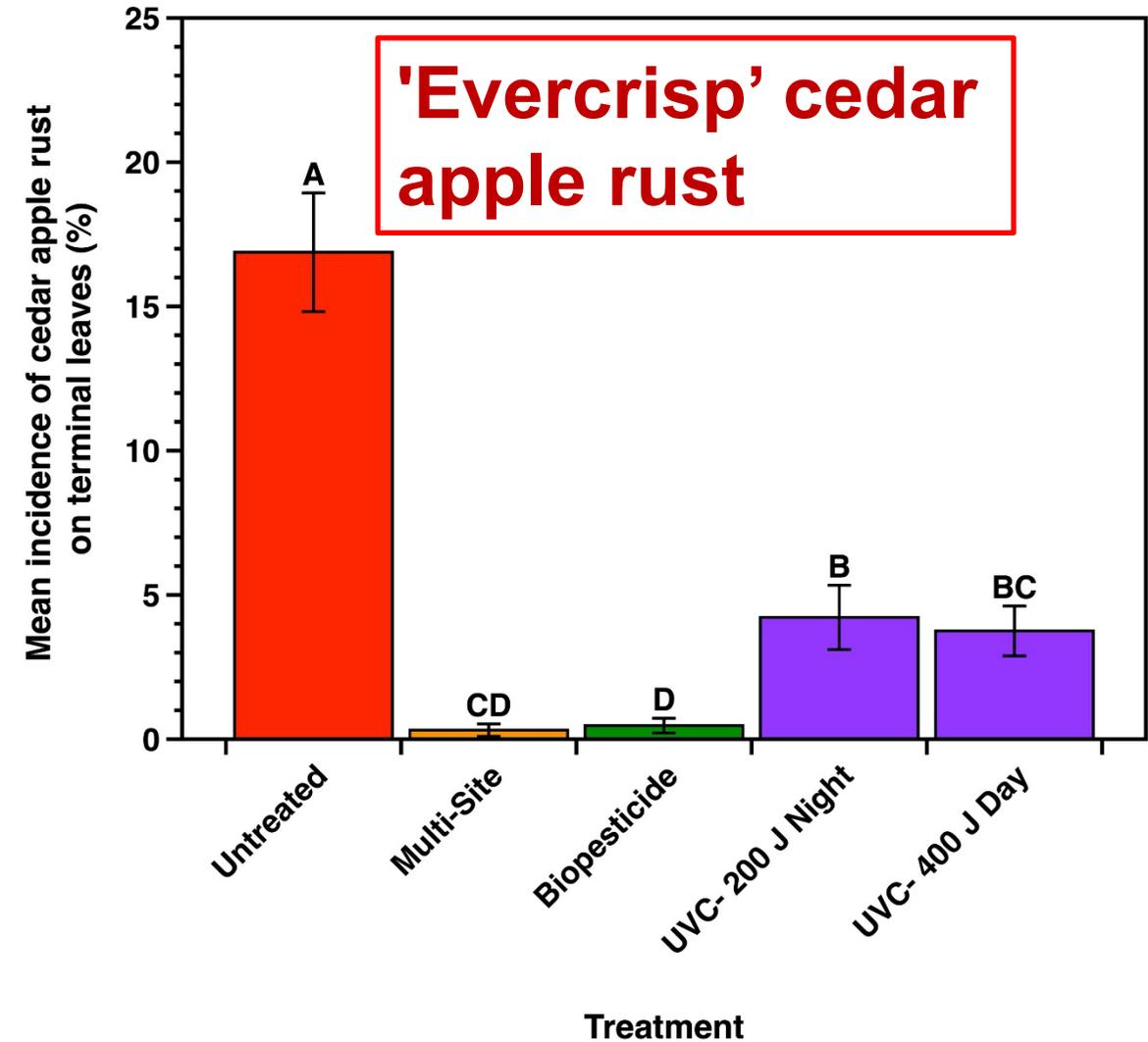
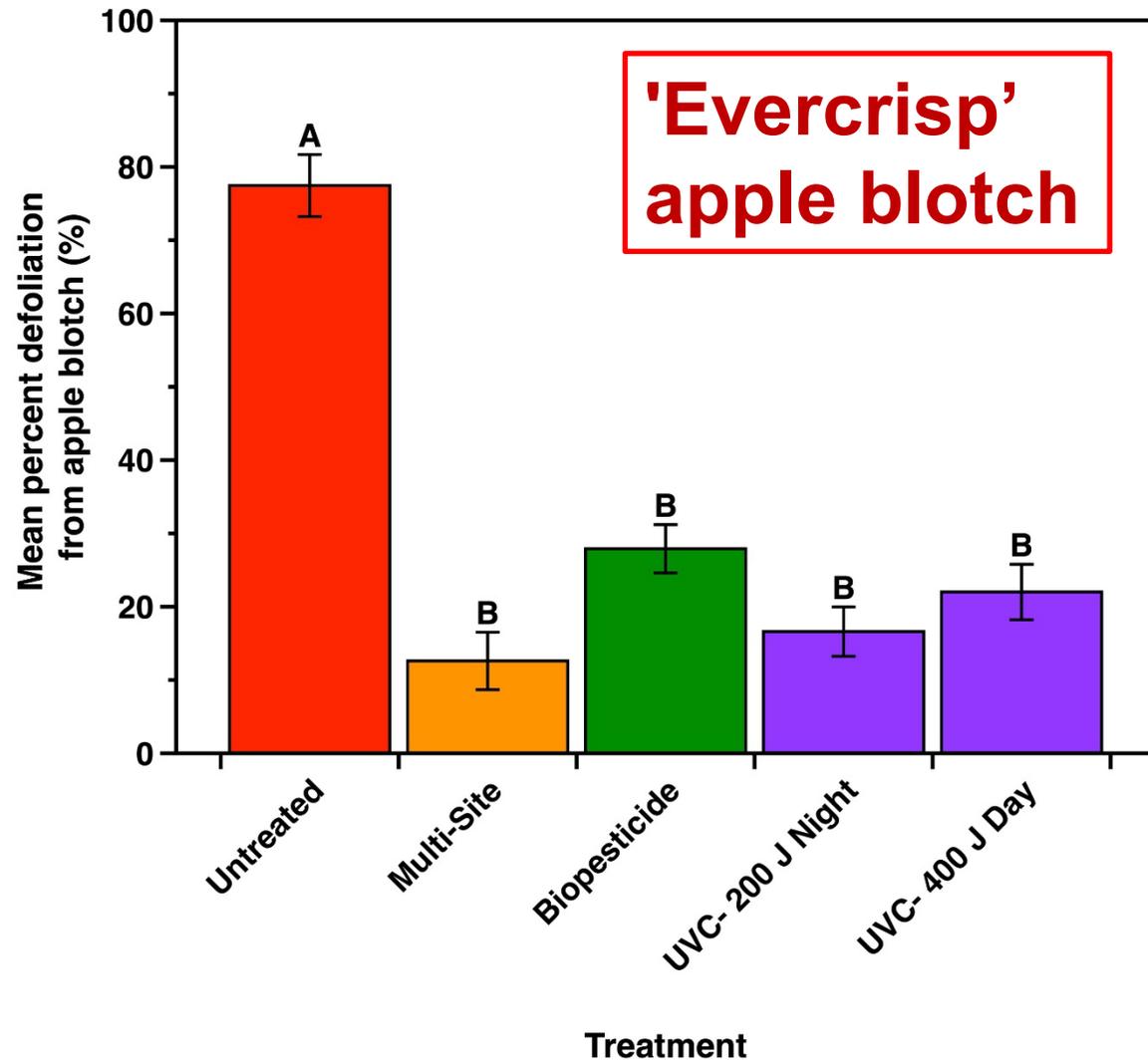
2025 Mean Incidence on Fruit



2025 Mean Apple Scab Incidence



Apple Blotch & Cedar Apple Rust 'Evercrisp' (2025)



Summary and Takeaways

- Could use biopesticides in alternation with a strong single-site fungicide to replace multi-site fungicides in apple
- Greatest potential in systems & varieties (non-'McIntosh' relatives) less conducive to disease development (super spindle) & forecasting using a DSS
- Both the Vertical Axis & High-density planting: excellent aeration
- Low apple scab pressure (< 7 infection periods): complete control possible in high orchards of susceptible varieties

Summary and Takeaways

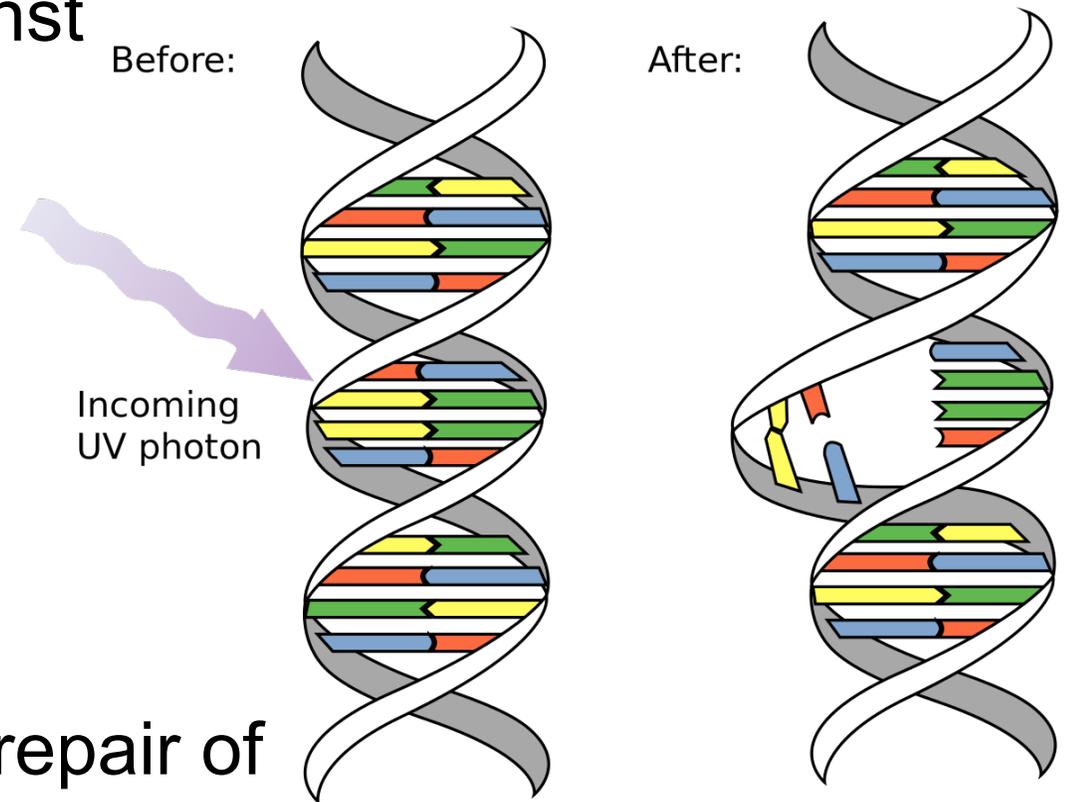
- In low pressure years and low risks systems: No appreciable difference between calendar and forecast timing
- East coast apple industry: rely on biopesticides integrated with single-site fungicides once restrictions occur (e.g. Captan Mancozeb)
- Can work with several biopesticides: Serenade, Double Nickel, Ecoswing
- Biopesticides also reduce fire blight inoculum

Updates on UV-C apple research



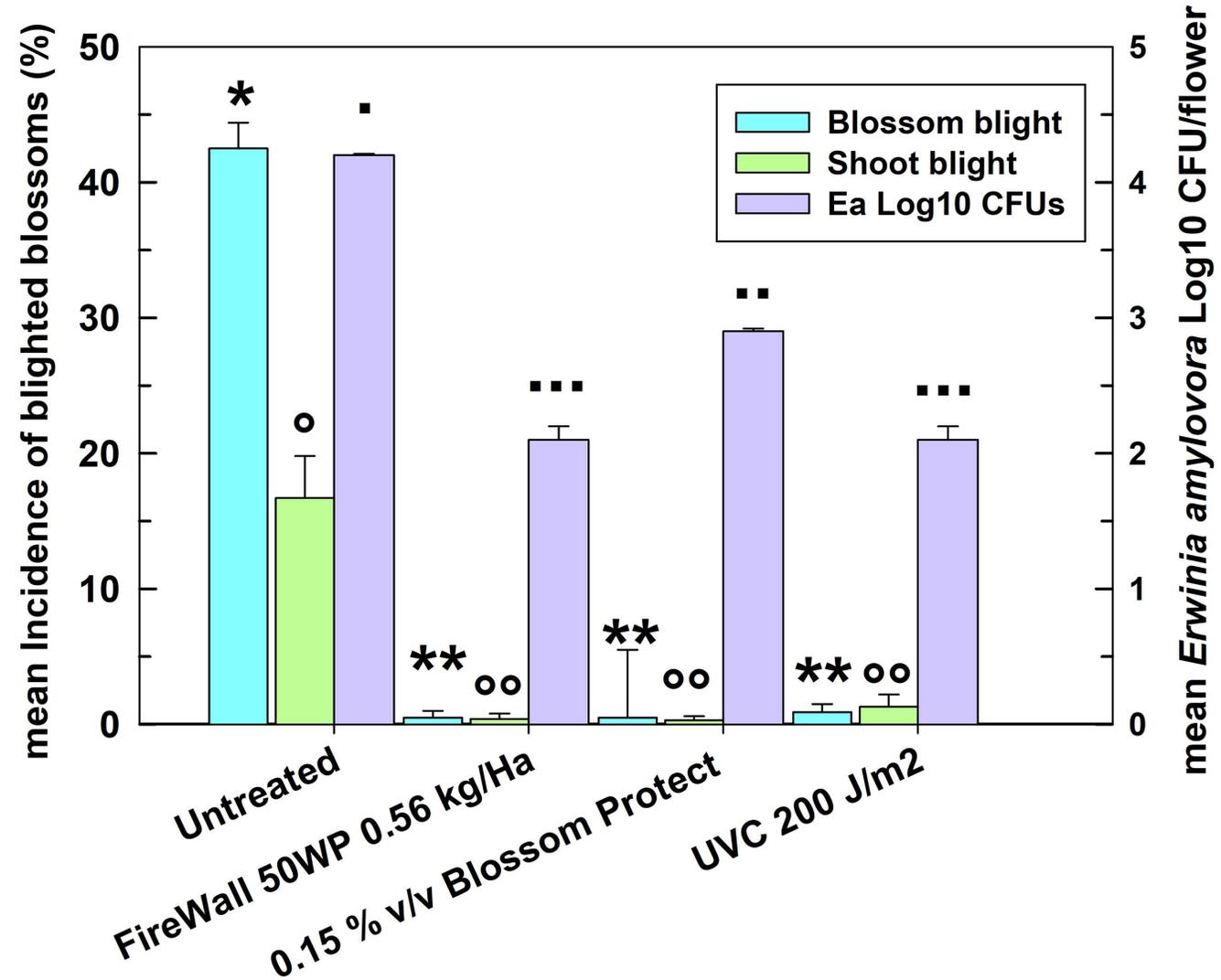
The use of germicidal light in agriculture

- Germicidal (UV-C) light is effective against transparent bacteria, algae
 - Medicine, aquaculture, & agriculture
 - Organic approved
 - No residue
- UV Causes thymine-thymine dimers > breaks DNA helix > T-T dimers
- Organisms have: Photolyase-mediated repair of thymine-thymine dimers in DNA
- Enzymes activated by blue/violet light: use at night



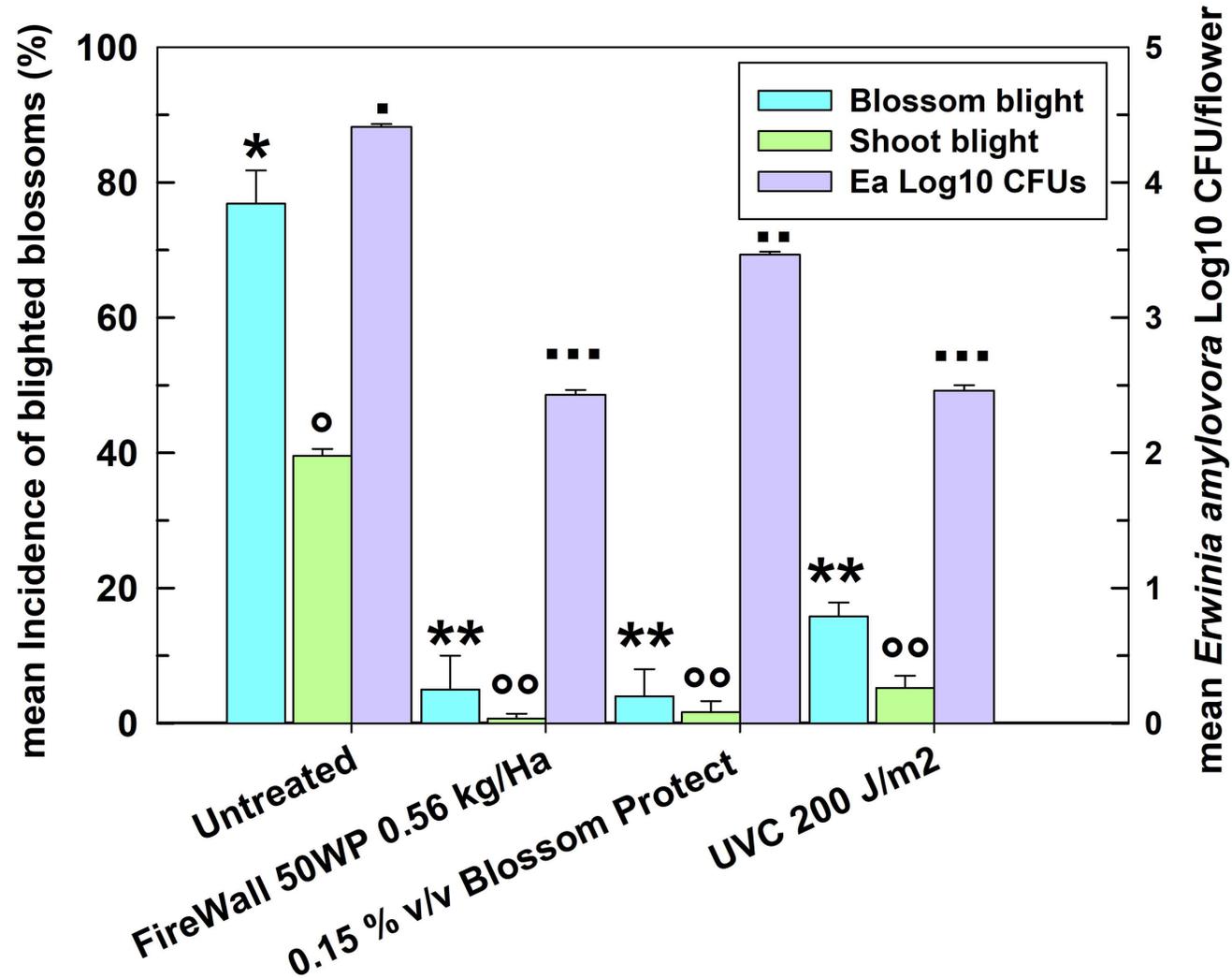
UV-C Fire Blight trials (2021) – ‘Evercrisp’

- Exceptionally cold bloom – low levels of infection on ‘Evercrisp’
- Reduced Ea populations on flowers
- Excellent control of blossom and shoot blight in this cool season



UVC Fire Blight trials (2022) – ‘Evercrisp’

- **Exceptionally warm wet year – high levels of infection on ‘Evercrisp’**
- Reduced Ea populations on flowers, but higher than 2021
- Excellent control of blossom and shoot blight, but still high



UV-C Horticultural impacts Trial at Cornell AgriTech

- At 80% and 100% bloom
 - Streptomycin (Firewall 50 WP 0.56kg/Ha)
 - Aureobasidium pullulans (1.05% buffer protect + 0.15% blossom protect)
- No inoculation with Ea 273
- Weekly and Bi-weekly UVC 200J/m²
- Blossom blight & shoot blight incidence **(none)**
- Ea populations & leaf shape and shoot and tree growth (possible UVC injury)



UV-C Horticultural impacts (2022) – ‘Gala’

No impact of UV applications on growth and development

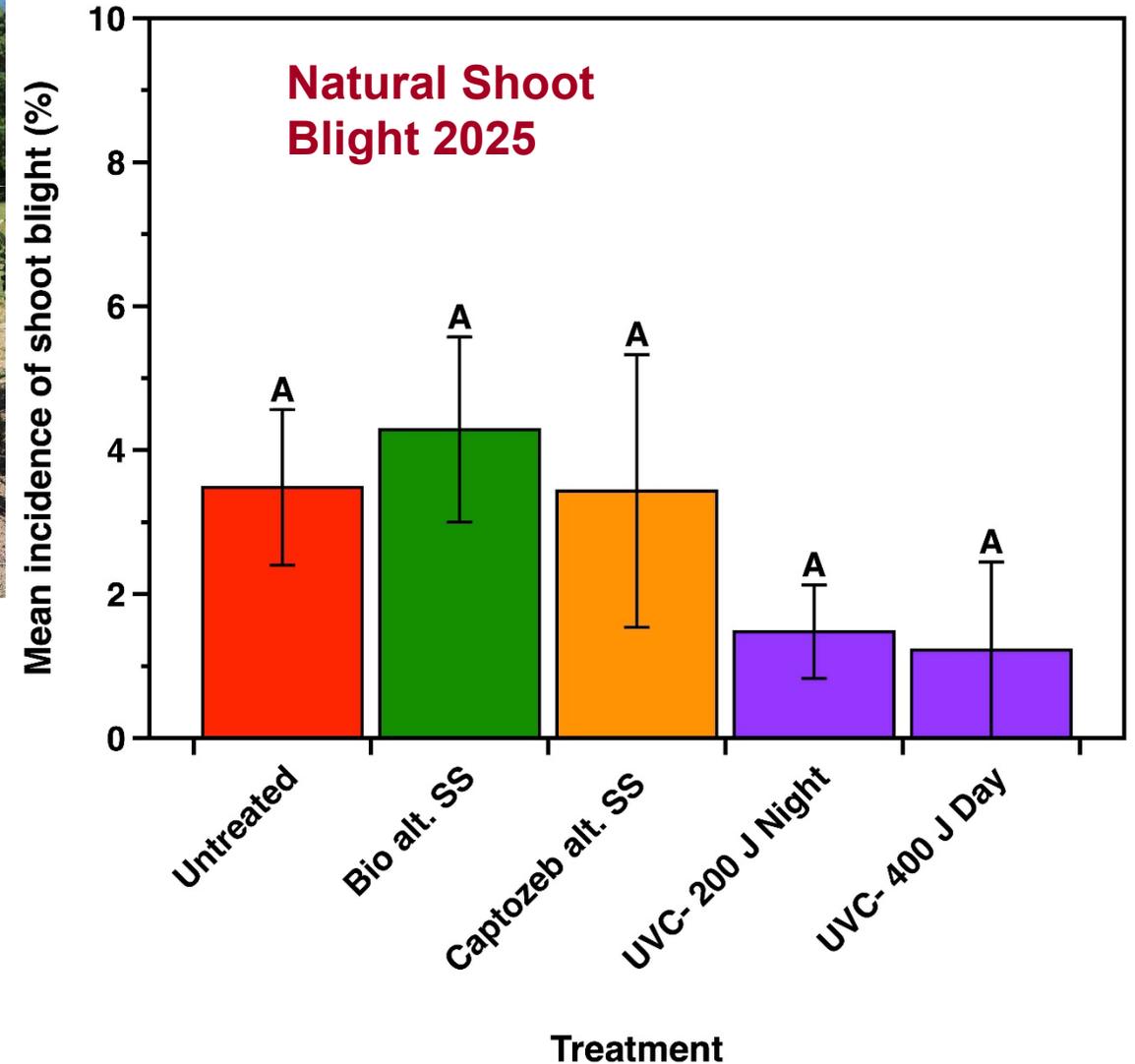
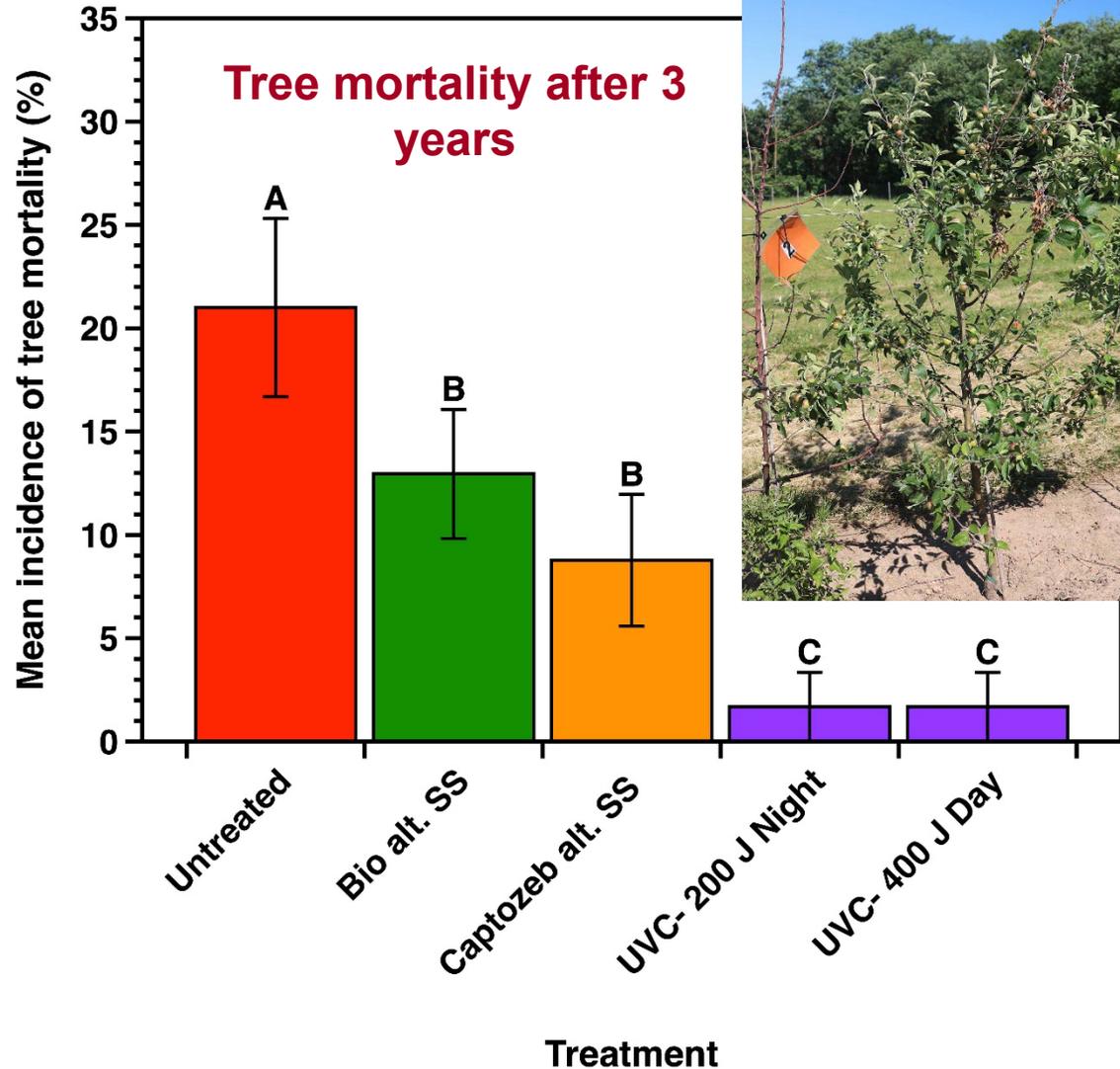
Treatment programs (amt./100 gal)	Log10 CFU/mL	Leaf length (mm)*	Leaf width (mm)*	Internode length on 1st year shoots (%)	1 st year shoot length (cm)	Canopy Height (cm)
Untreated	1.5 ± 0.0 a	91.3 ± 0.3 a	78.7 ± 0.1 a	49.9 ± 0.6 a	22.0 ± 0.3 a	189.6 ± 0.5 a
Streptomycin (Firewall 50 WP 0.56kg/Ha)	0.0 ± 0.0 b	92.2 ± 1.4 a	79.0 ± 1.0 a	47.0 ± 0.9 a	20.3 ± 0.4 a	189.7 ± 1.6 a
Aureobasidium pullulans (1.05% buffer protect + 0.15% blossom protect)	0.0 ± 0.0 b	92.7 ± 0.8 a	77.3 ± 0.2 a	49.1 ± 1.4 a	21.4 ± 0.3 a	189.8 ± 1.4 a
UVC 200 J/m ² 1/week	0.0 ± 0.0 b	93.5 ± 0.4 a	78.4 ± 0.3 a	49.3 ± 0.7 a	21.2 ± 0.5 a	192.4 ± 0.7 a
UVC 200 J/m ² 2/week	0.0 ± 0.0 b	91.2 ± 0.2 a	79.4 ± 0.3 a	49.4 ± 0.7 a	21.9 ± 0.3 a	190.1 ± 0.3 a

Impacts from season-long UV-C application on fire blight

- If apples have repeat applications for fungal disease, any impact on seasonal fire blight development?
- Do UV-C applications have impact on bacterial ooze?
- Are other antibiotics (e.g. kasugamycin impacted).

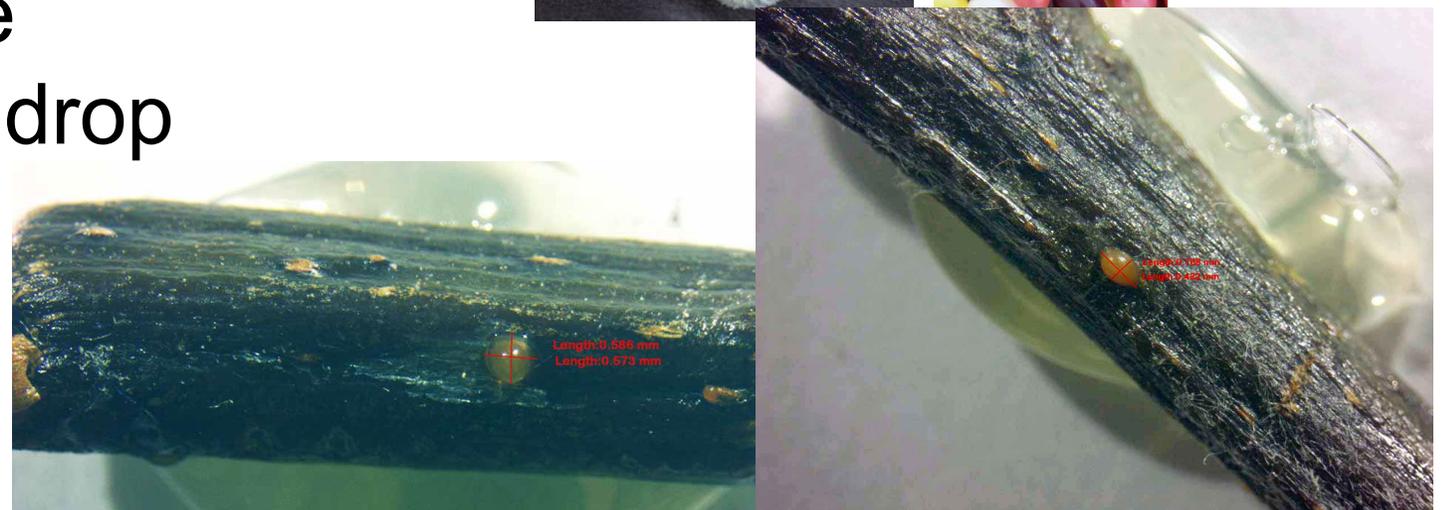


Fire Blight 'Evercrisp' (2025)



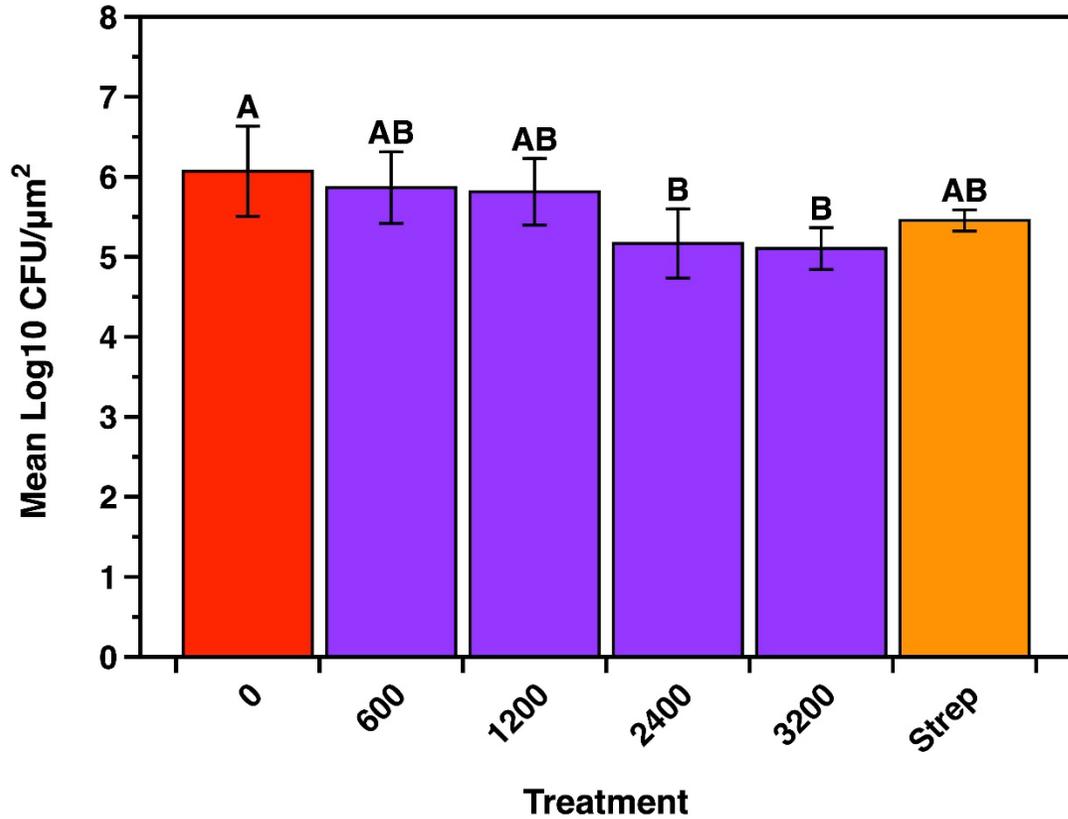
Impacts from UV-C application on Ooze

- Collected newly ooze drops blocked by size and color
- Treated droplets with 0 to 3200J UV-C & Streptomycin
- Dissolved or washed the ooze w/vortex > dilution drop plated
- 6 replicates & repeated

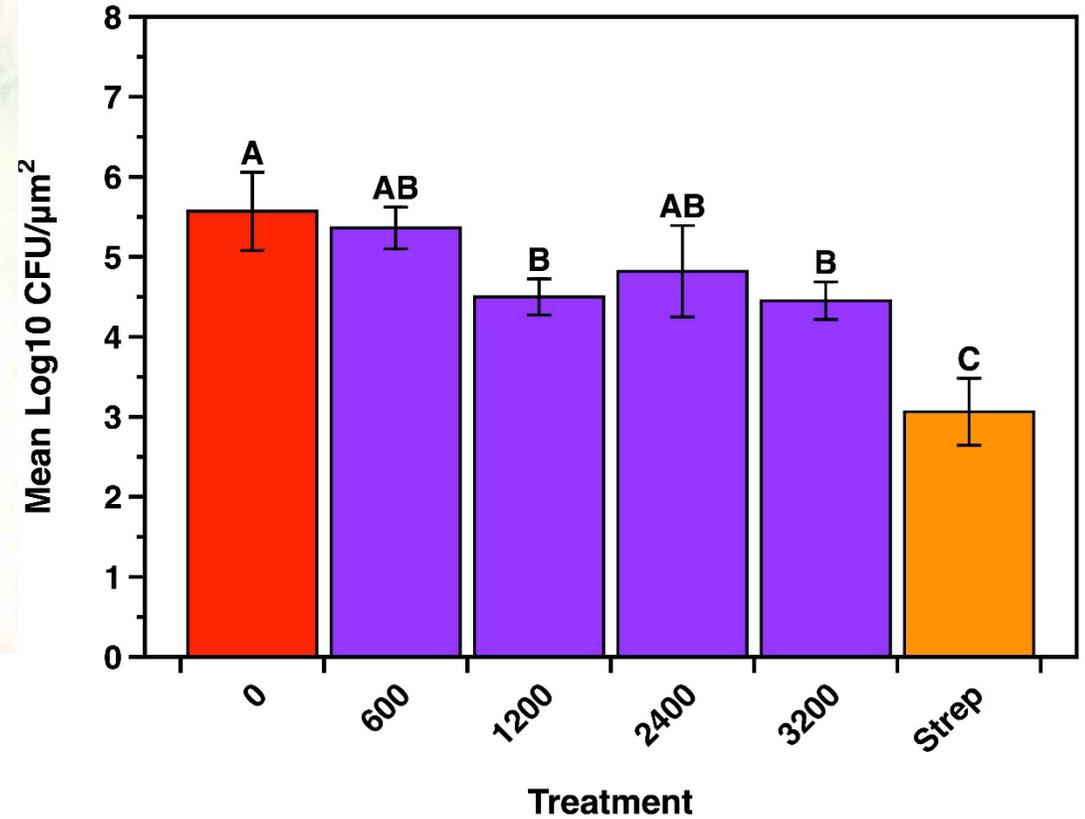


UV-C on Ooze (2025)

Dissolved Ooze



Rinsed Ooze



Impacts from UV-C application on antibiotics

- Flowers treated & culture medium amended 0, 100, and 200ppm streptomycin & kasugamycin
- Exposed to 0 to 3200J UV-C
- Strain Ea110 dilution drop plated at 1×10^6 CFUml⁻¹
- 10 replicates & repeated
- No impact on antibiotics



Seasonal UV-C takeaways

- Season-long use of UV-C at 200 & 400 had impact on tree mortality over three years in orchards receiving only fungicide management
- UV-C application to ooze droplets may harden surface reducing potential for rain space dispersal
- UV-C even at extreme doses doesn't seem to impact antibiotic residues

Suppression of fungal diseases of apple w/UV light



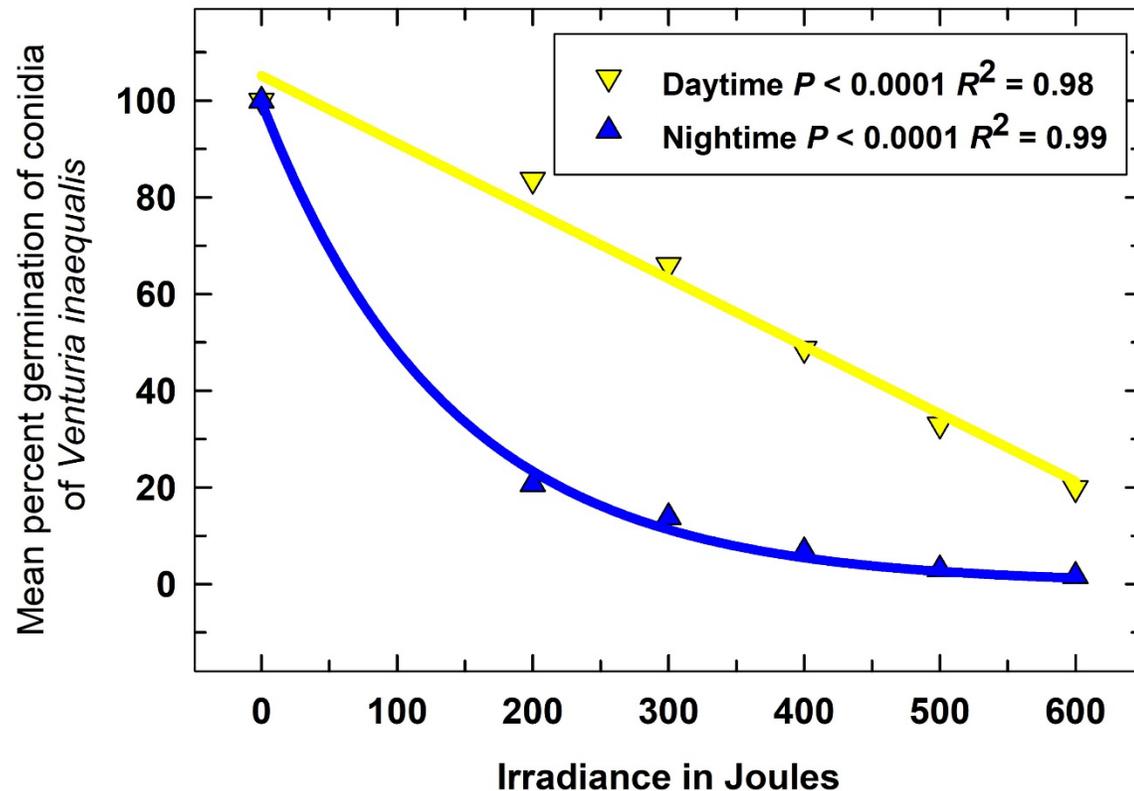
Suppression of apple scab using UV light

- UV-C could be effective at manage fire blight of apple, a bacterial disease
- Apple Trees can tolerate season long weekly applications 2 weeks/harvest w/no impacts
- Impacts on other apple diseases such as apple scab?
- *Venturia inaequalis* is darkly pigmented & photolyase-mediated repair enzymes: needs higher doses

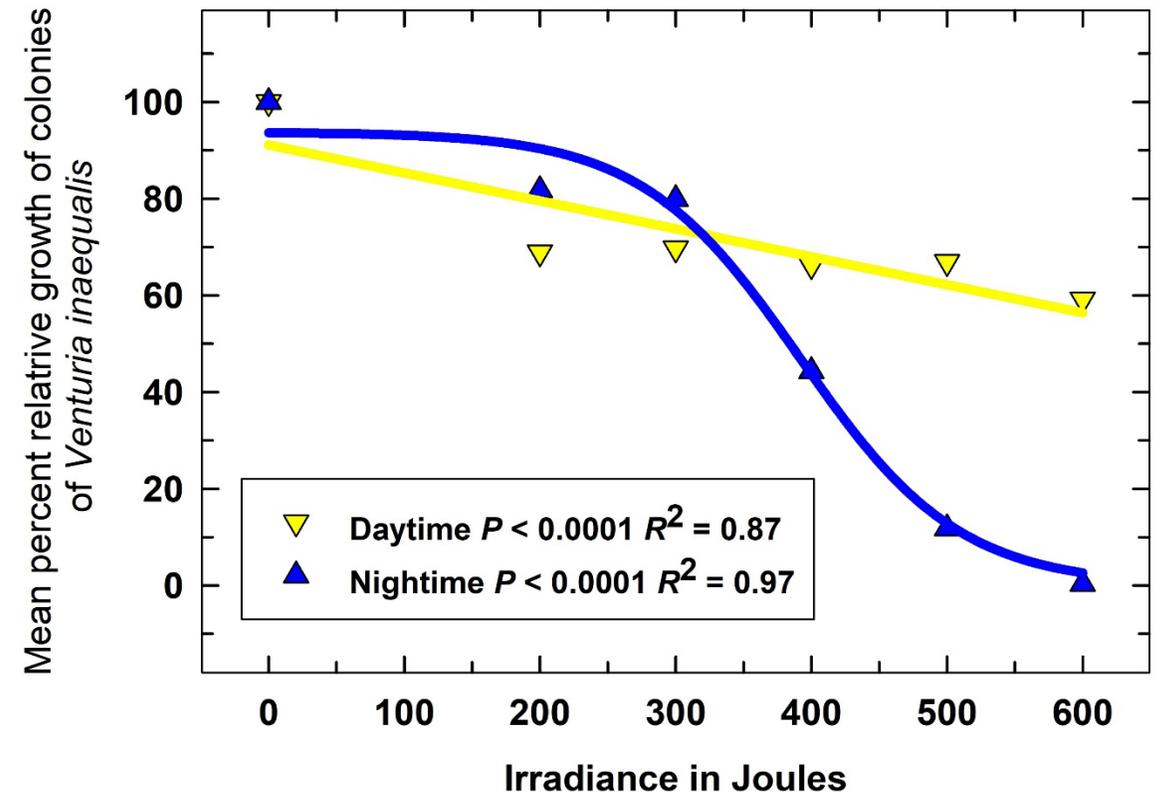


Suppression of apple scab using UV light

Spore germination



Colony growth after 72 hrs



Field Trials at Cornell AgriTech 2023-2025

- High Density Super Spindle planting
- 'Evercrisp' on G.41 planted in Aug 2022
- Reduced trellis (96") to accommodate UV-C unit for grapes
- Replicated plot panels (RCB): 4 reps w/ ten trees each



Field Trials at Cornell AgriTech 2023-2025

Treatment	Program
1	Untreated Control (no fungicides)
2	Manzate Max + Captec rotated biweekly with Aprovia, Flint Extra or Cevya
3	Double Nickel rotated biweekly with Aprovia, Flint Extra or Cevya
4	UV-C 200 J/m² at Night
5	UV-C 400 J/m² During the Day

Simplified conventional standard program

Experimental Biopesticide programs

Forecast timing NEWA & rimpro germination timing (16 applications)

Field Trial at Cornell AgriTech

Forecast timing NEWA
& rimpro germination
timing

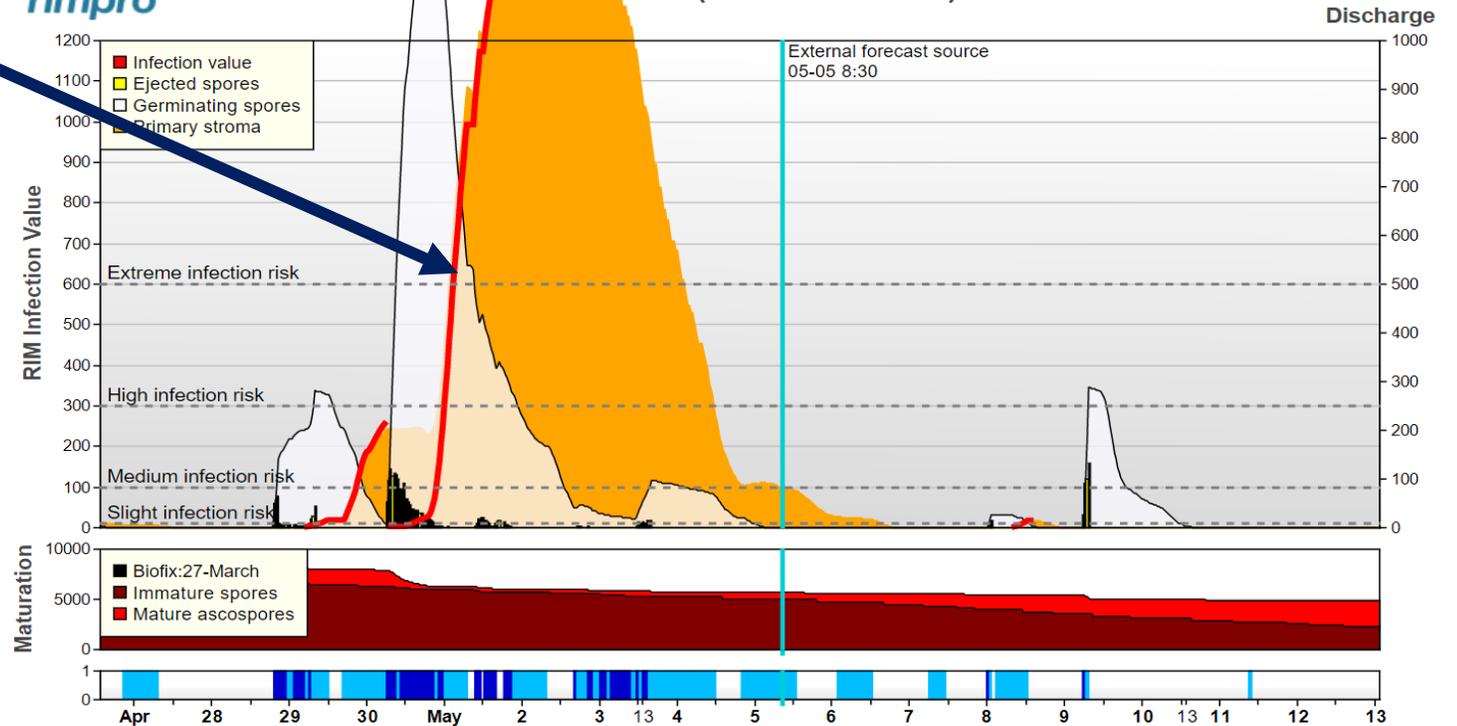
Infection Events Summary

Date (2023)	Infection Events
Apr 26	no
Apr 27	no
Apr 28 Forecast	combined
Apr 29 Forecast	combined
Apr 30 Forecast	combined
May 1 Forecast	yes
May 2 Forecast	no
May 3 Forecast	no

Scab Primary Scab Secondary Spots Weather Data Breakpoints Spray Plan Weather forecast

rimpro

Venturia 3.0 - Geneva (Research North) - 2023

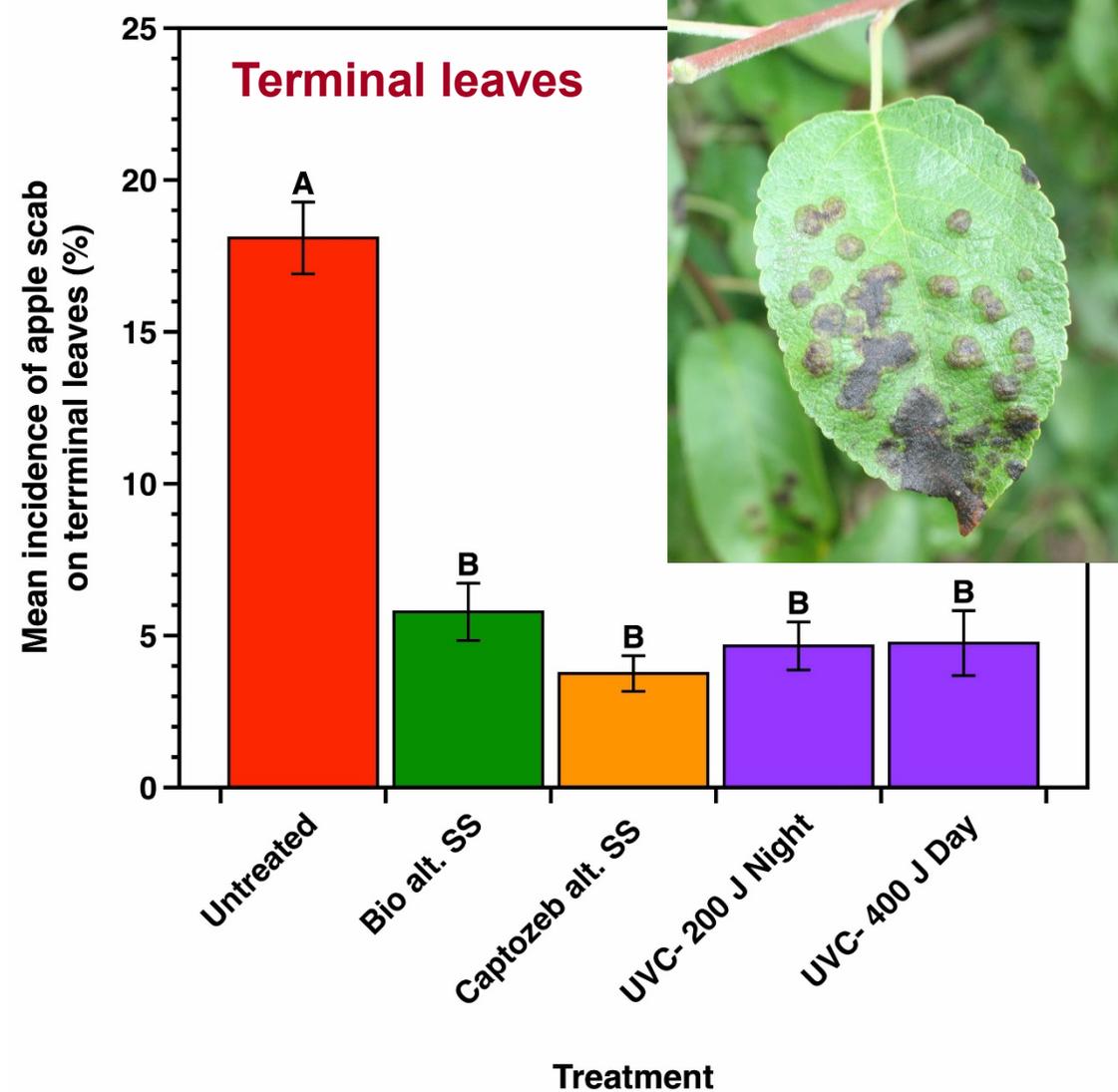
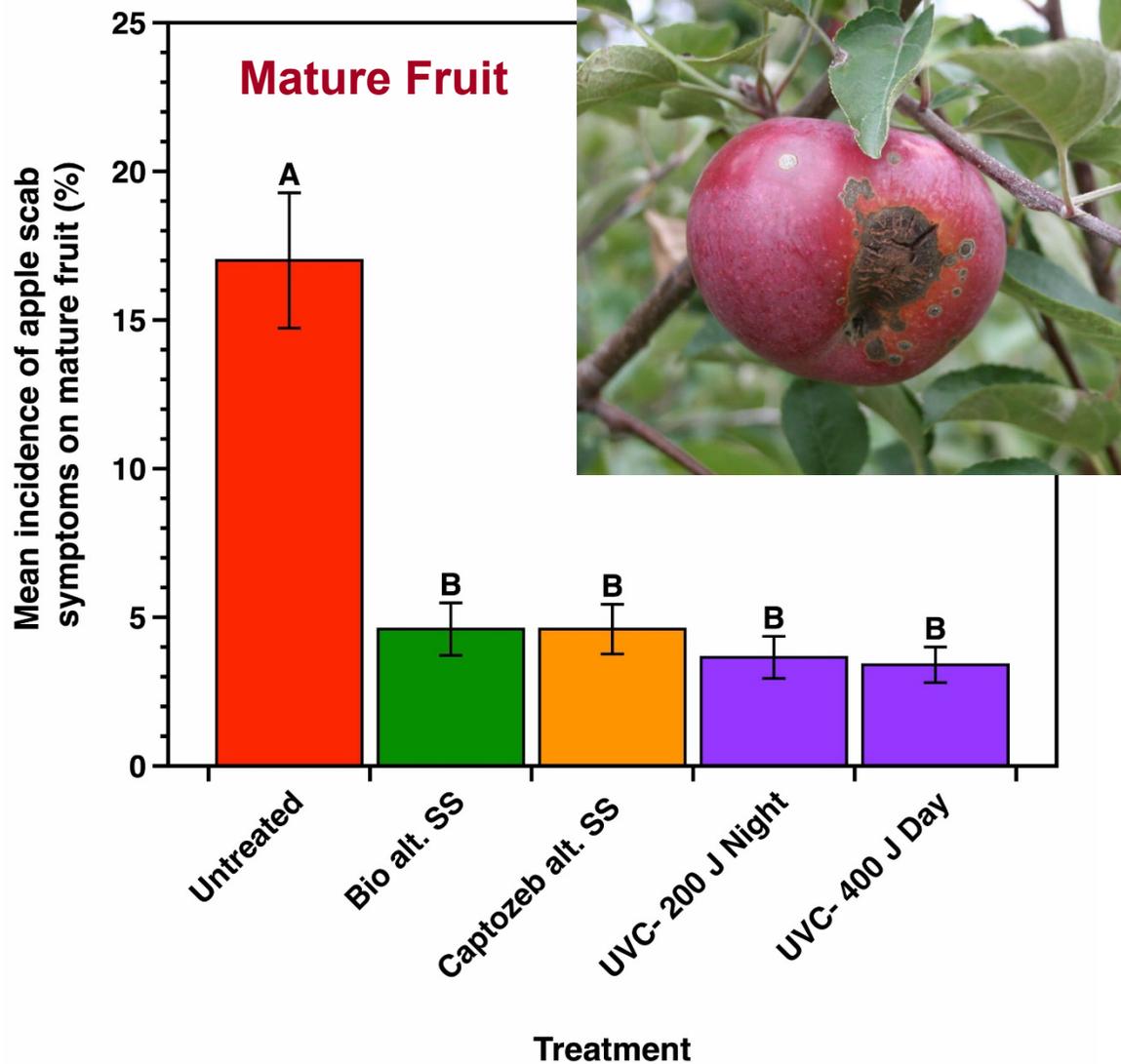


Mouse action: Drag graph with mouse to Scroll Click in graph to Zoom In Click in graph to Zoom Out

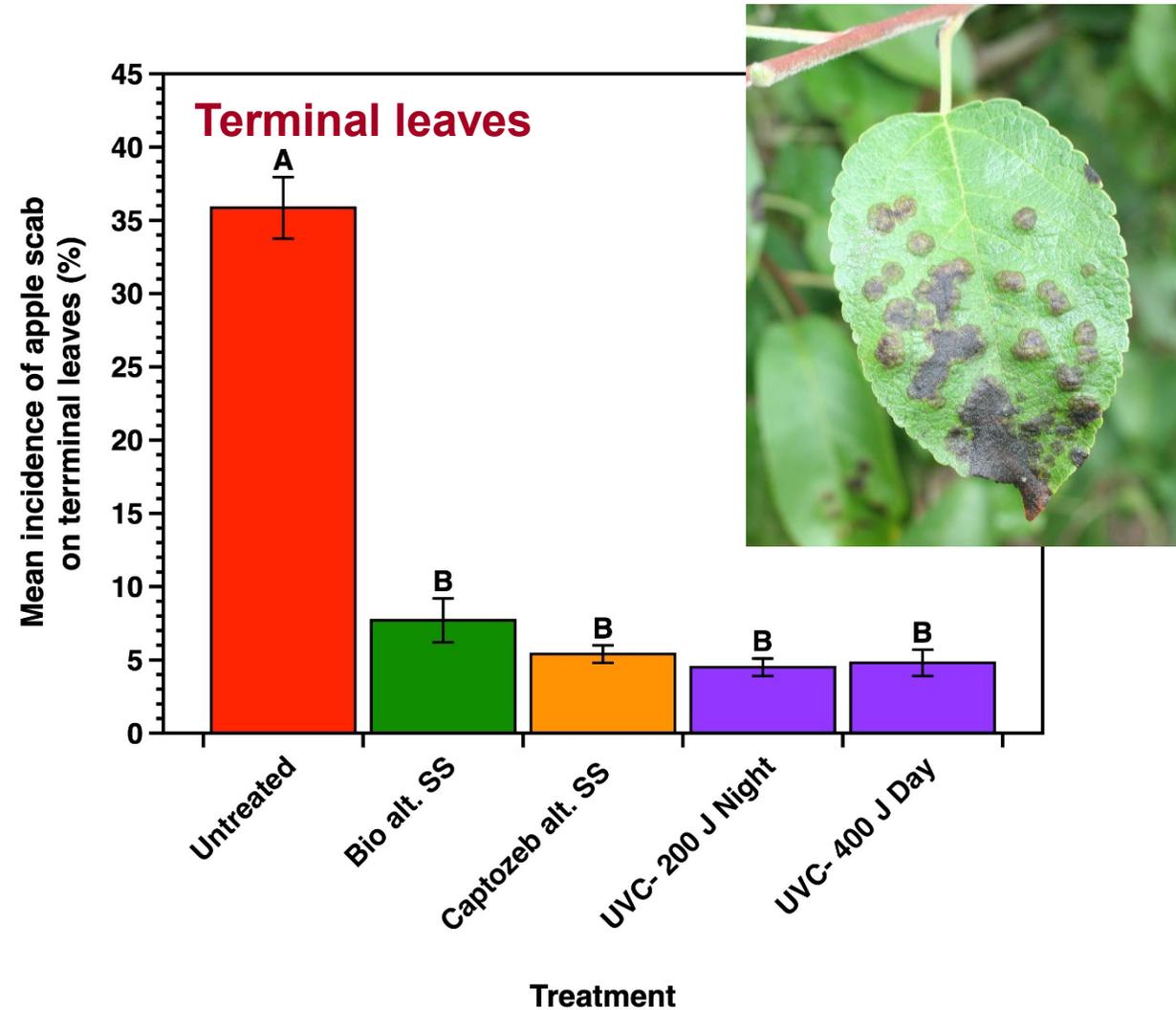
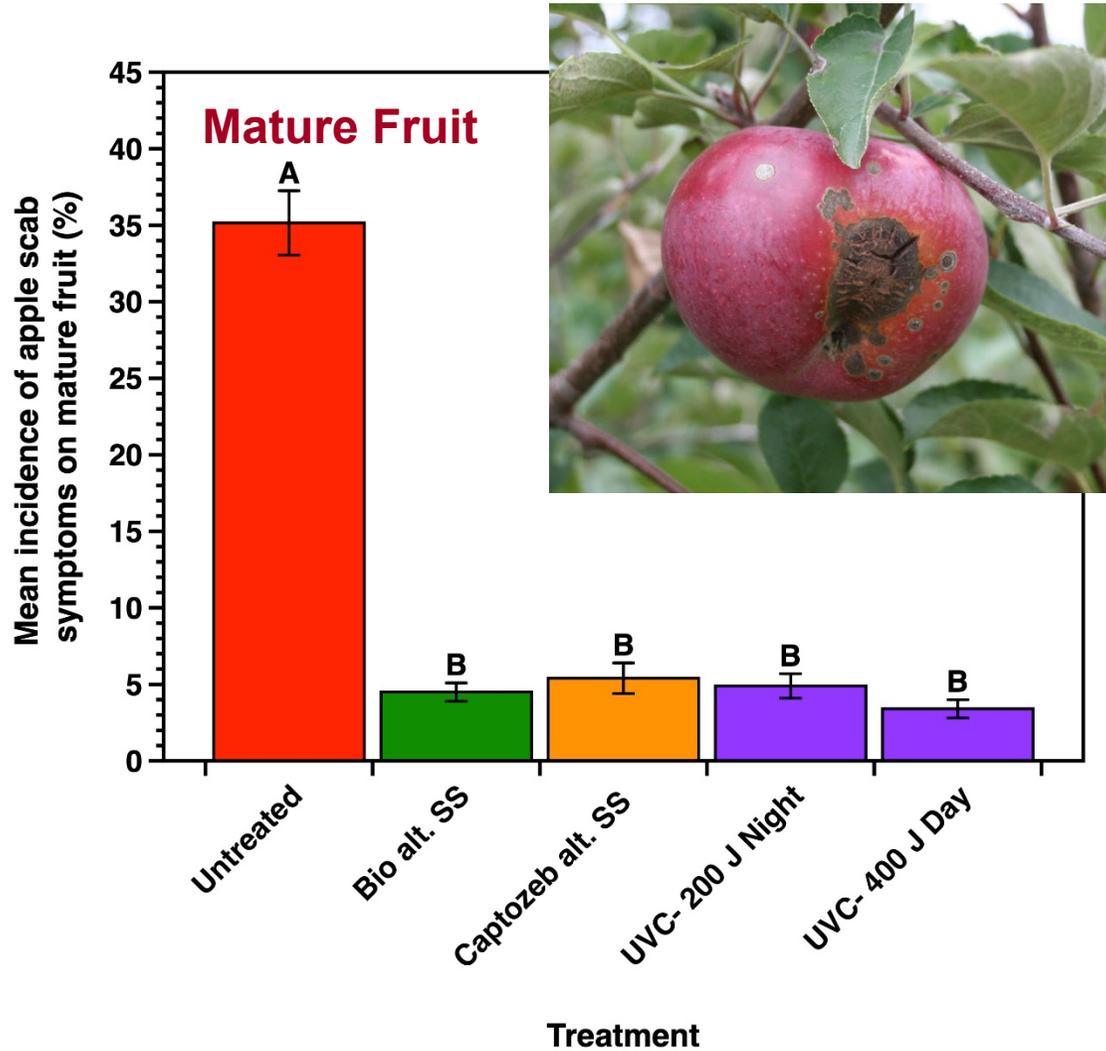
Entire year Period: 01-01-2023 - 31-12-2023

Venturia Table

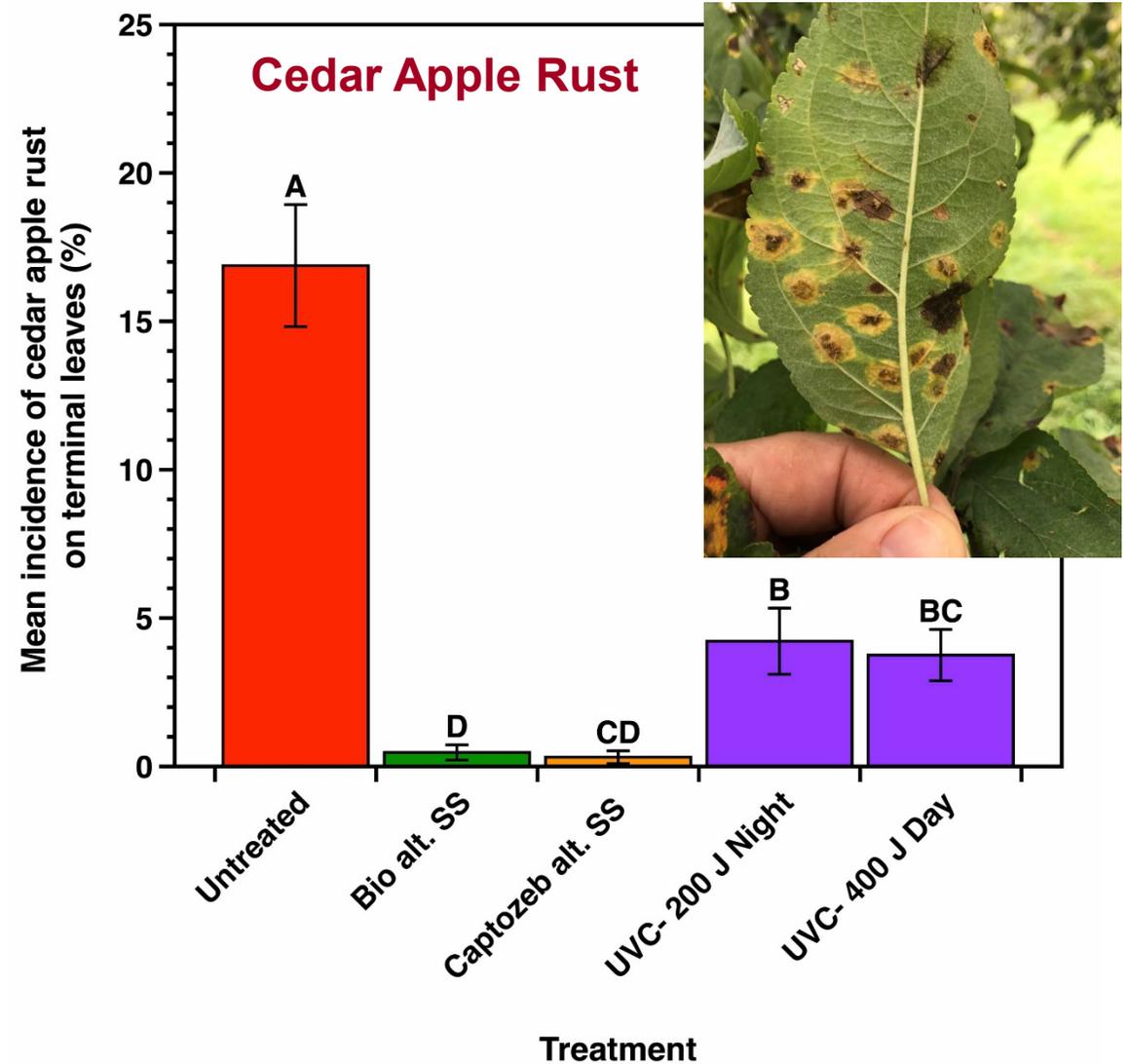
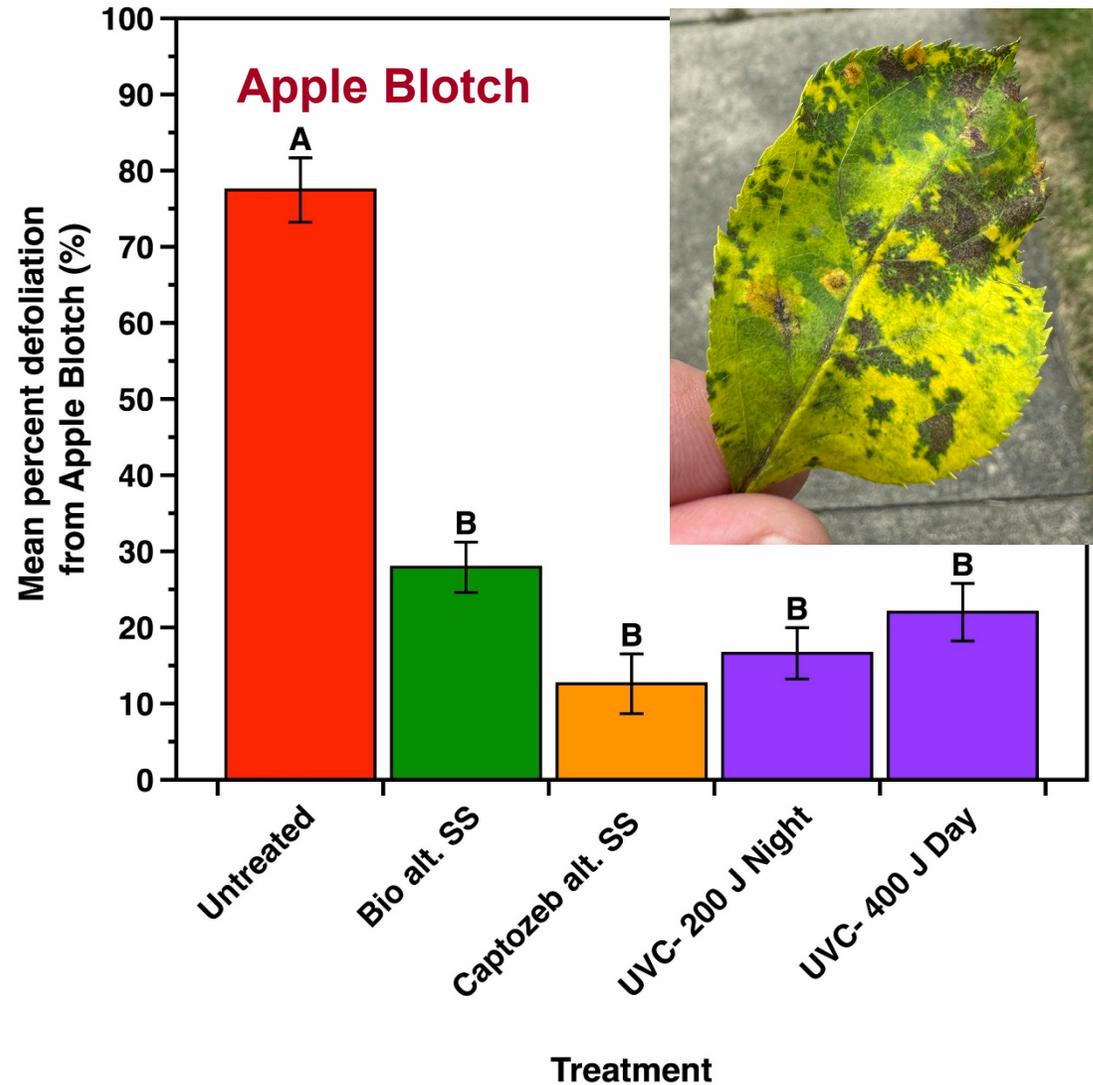
Apple Scab 'Evercrisp' (2024)



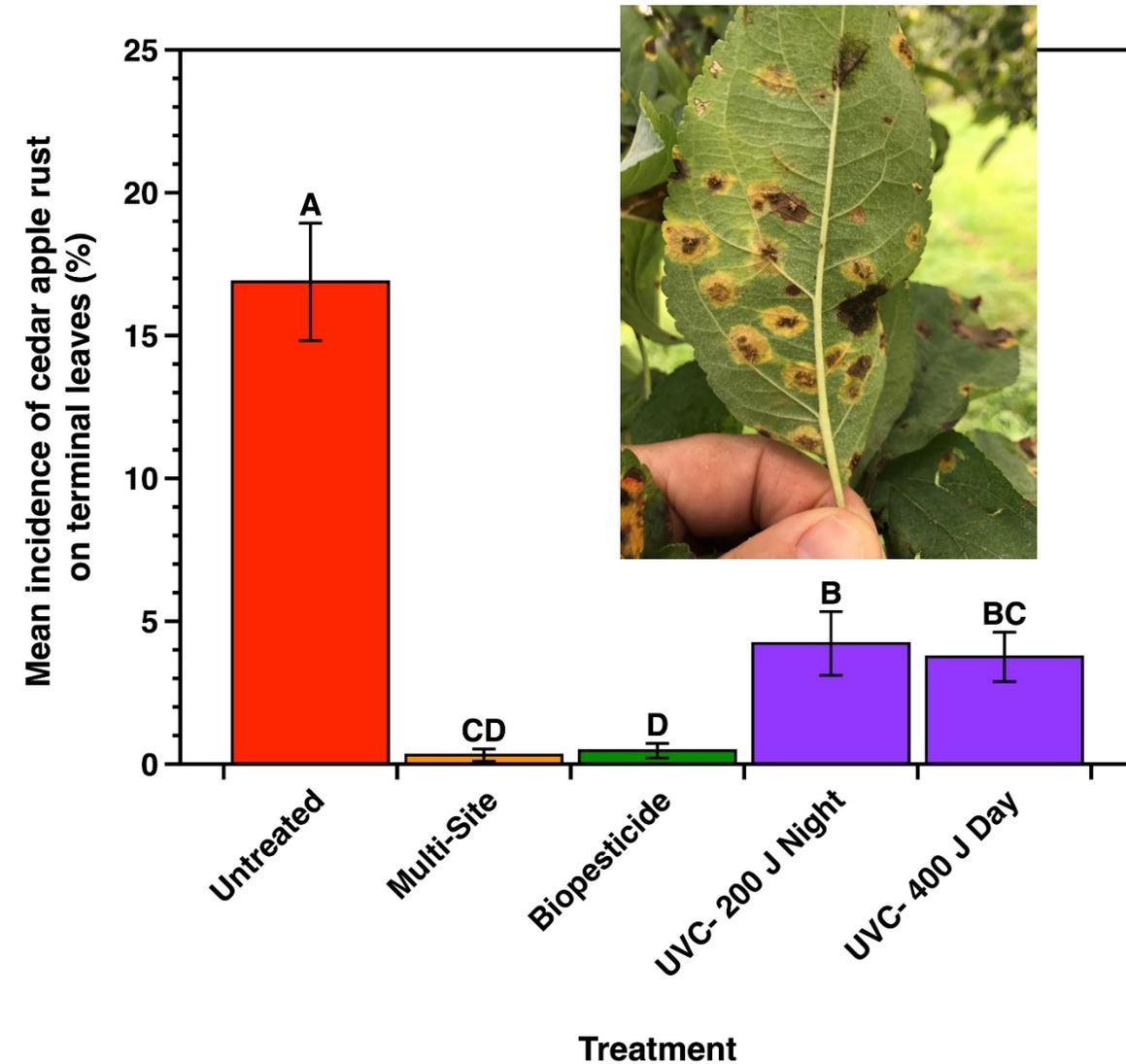
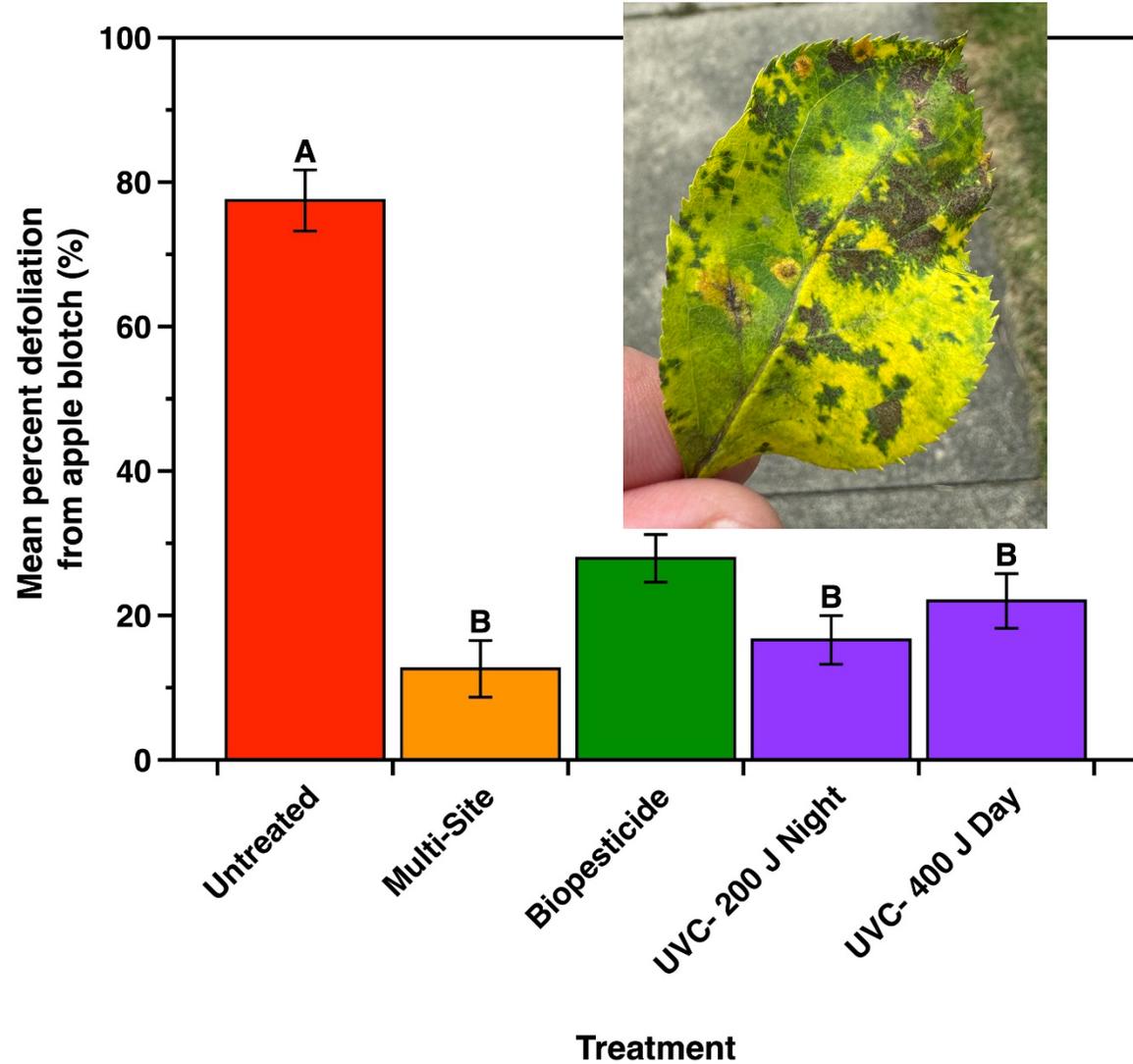
Apple Scab 'Evercrisp' (2025)



Apple Blotch & Cedar Apple Rust 'Evercrisp' (2024)



Apple Blotch & Cedar Apple Rust 'Evercrisp' (2025)



More Trials at Cornell AgriTech 2024-2025

- High Density Super Spindle planting
- ‘Gibson Golden’ and ‘Cortland’ on G.11 planted in Aug 2023
- Reduced trellis (96”) to accommodate UV-C unit for grapes
- Replicated plot panels (RCB): 4 reps w/ ten trees each



More Trials at Cornell AgriTech 2024-2025

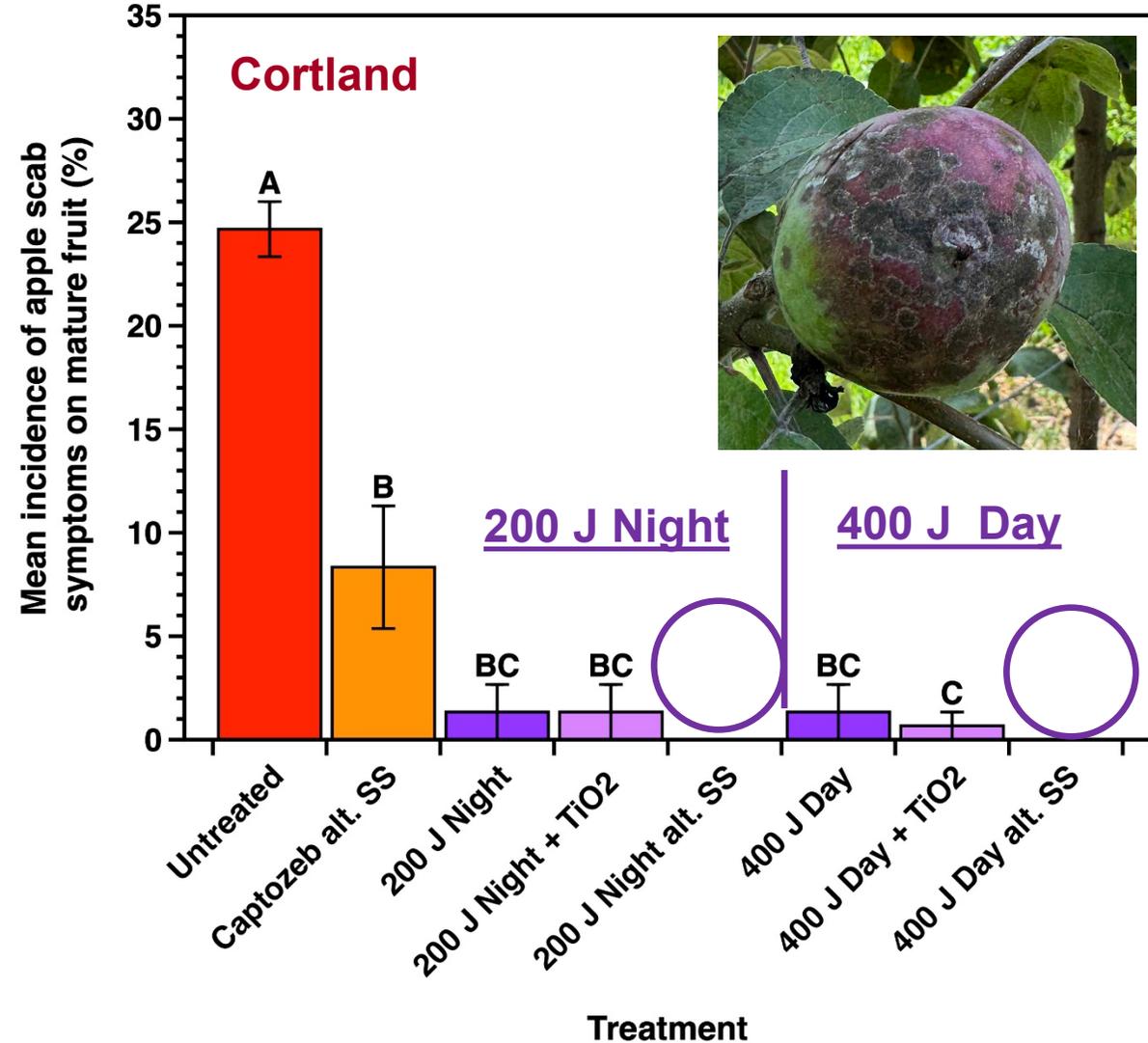
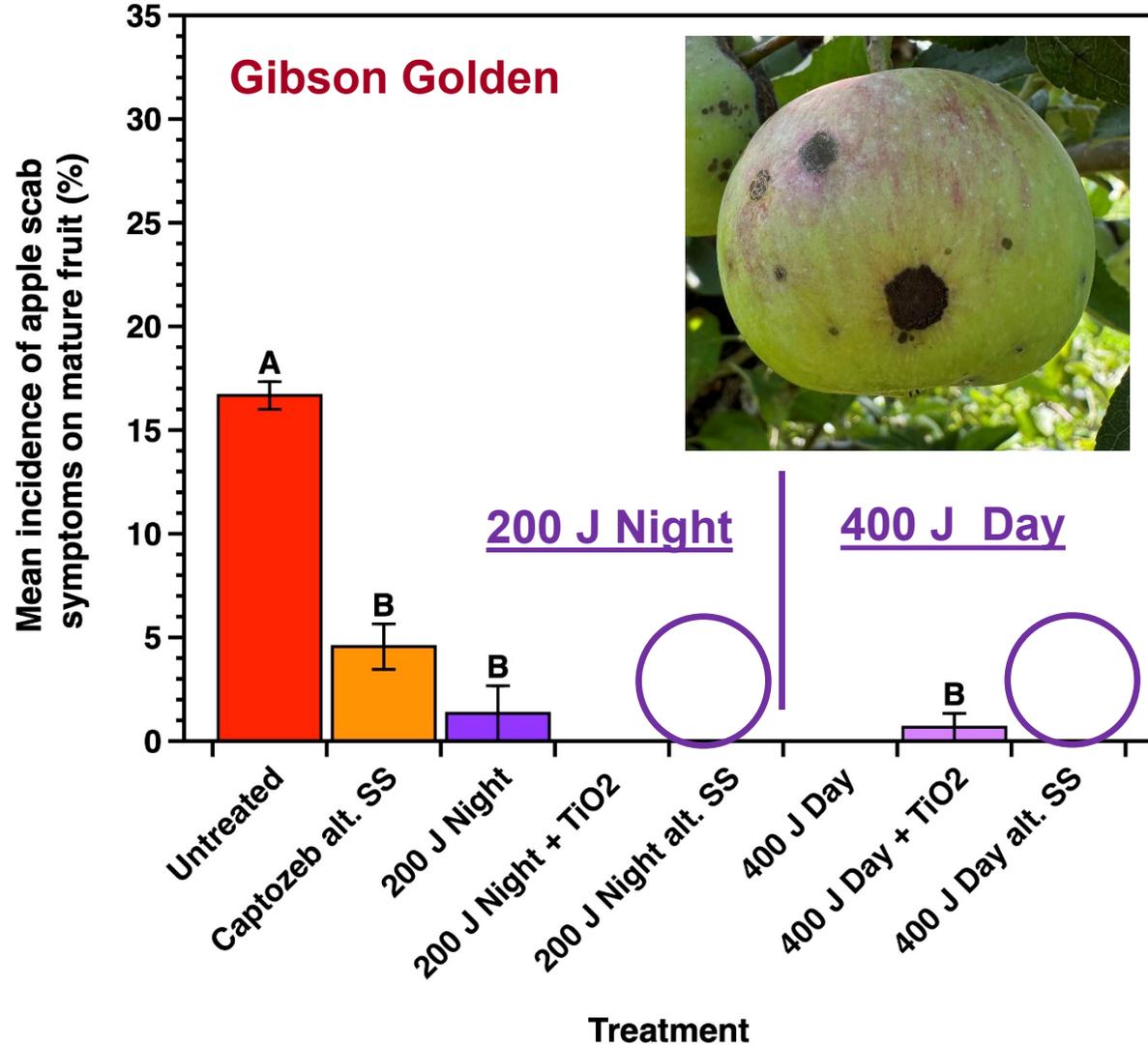
Treatment	Program
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2	Manzate Max + Captec rotated biweekly with single-sites (Aprovia, Flint Extra or Cevya)
3	UV-C 200 J/m ² at Night
4	UV-C 200 J/m ² at Night + 750 ppm TiO ₂
5	UV-C 200 J/m ² at Night rotated biweekly with single-sites
5	UV-C 400 J/m ² During the Day
5	UV-C 400 J/m ² During the Day + 750 ppm TiO ₂
5	UV-C 400 J/m ² During the Day rotated biweekly with single-sites

Simplified conventional standard program

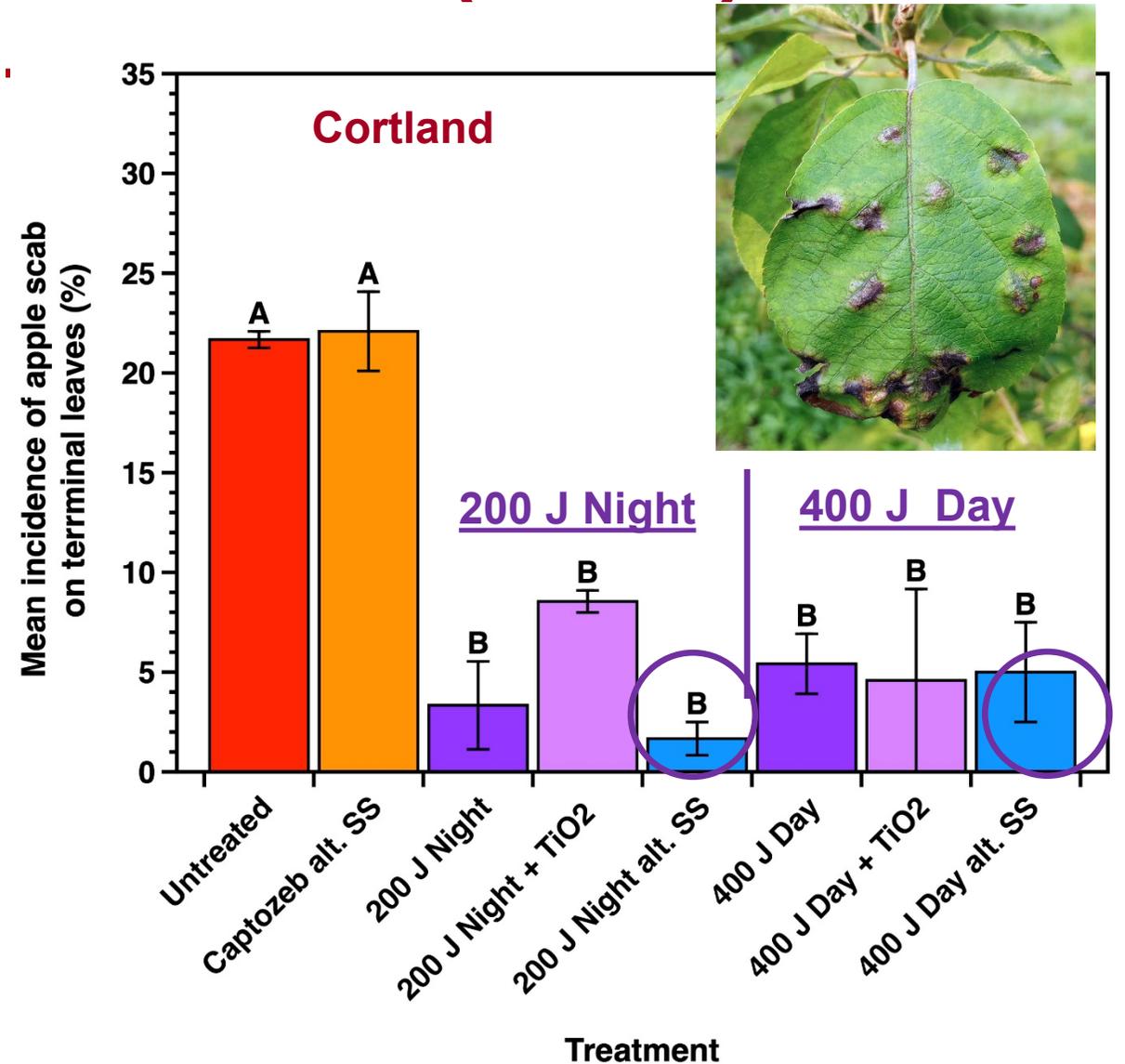
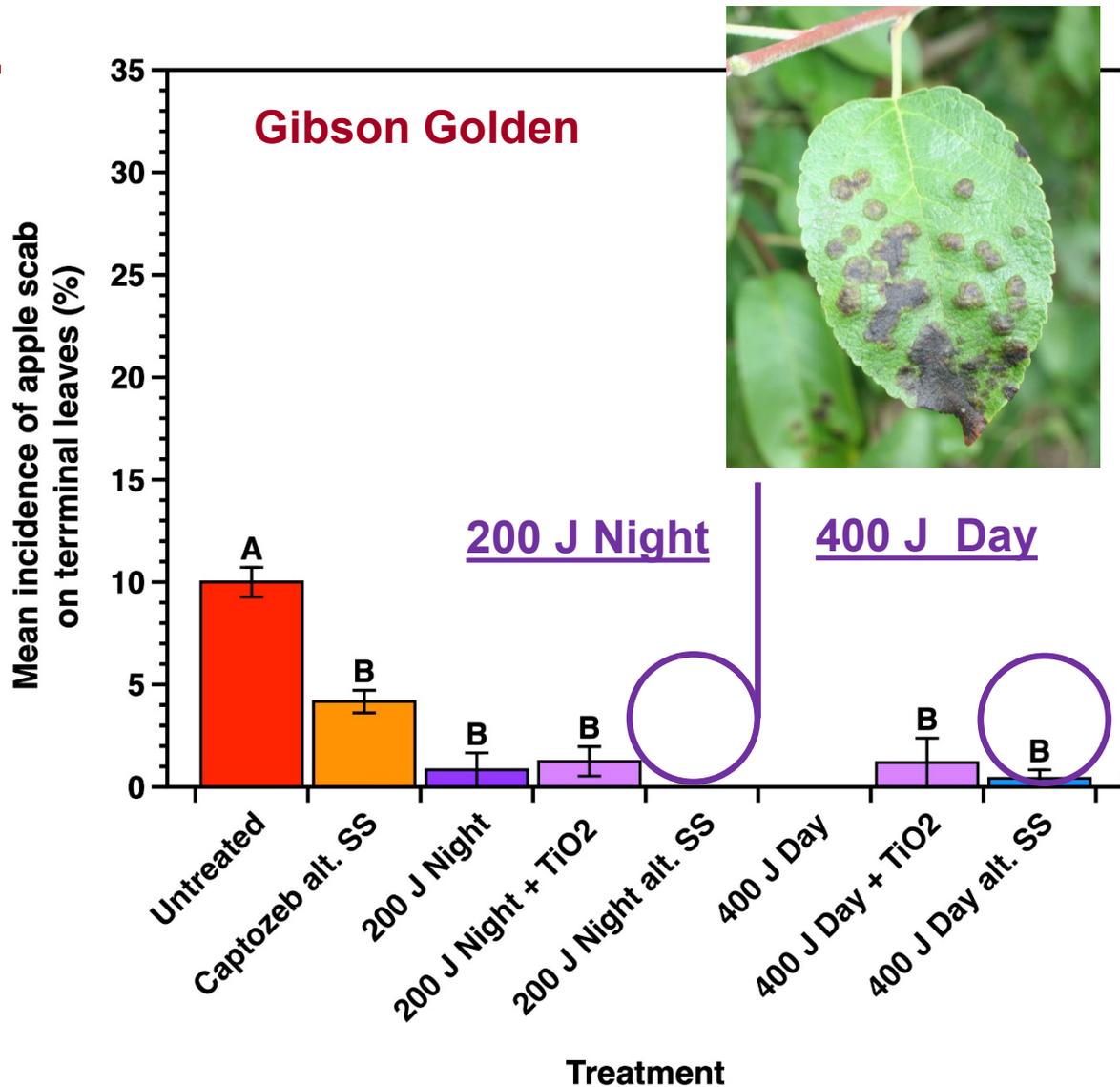
Experimental programs

Calendar timing (16 applications)

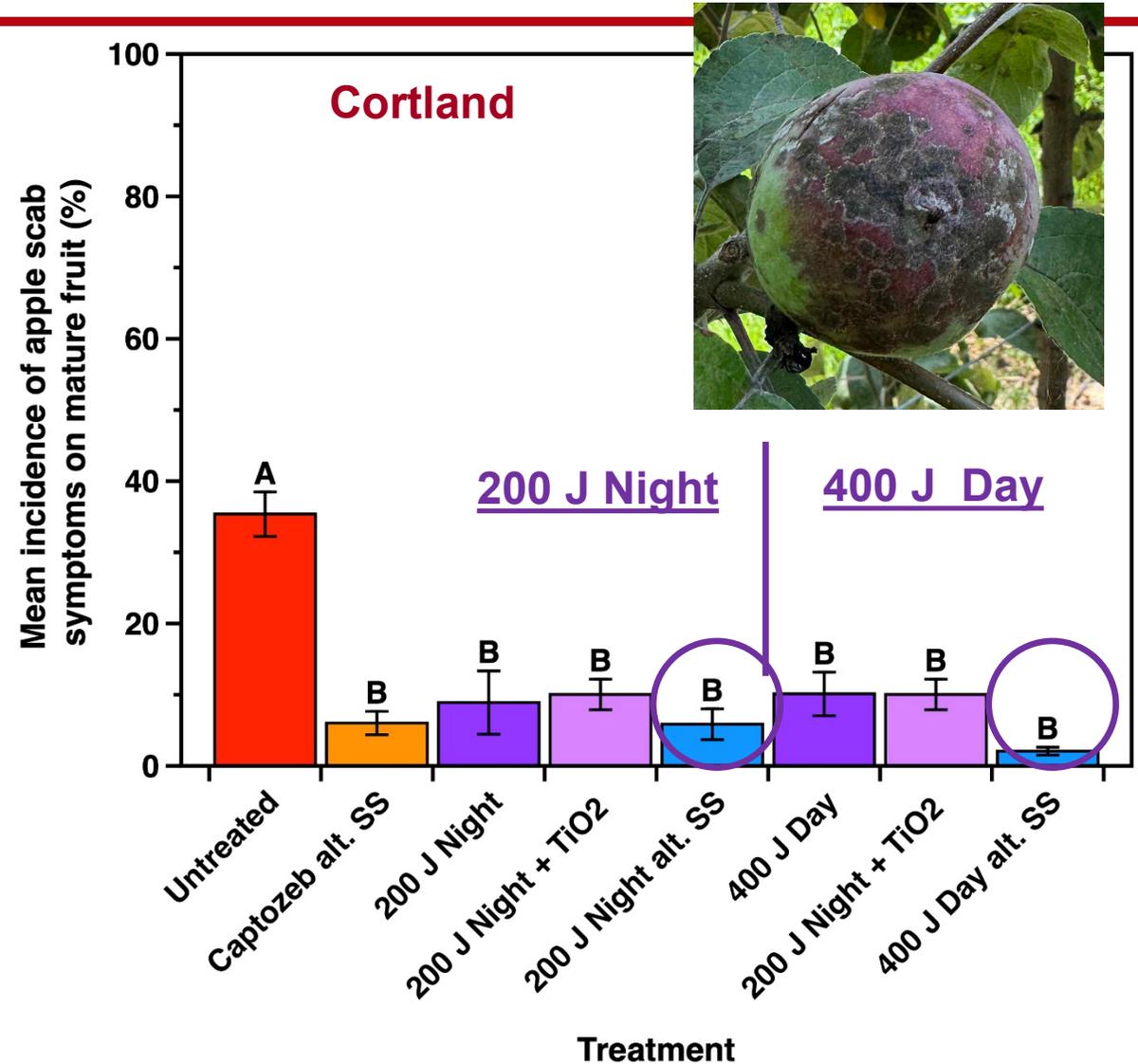
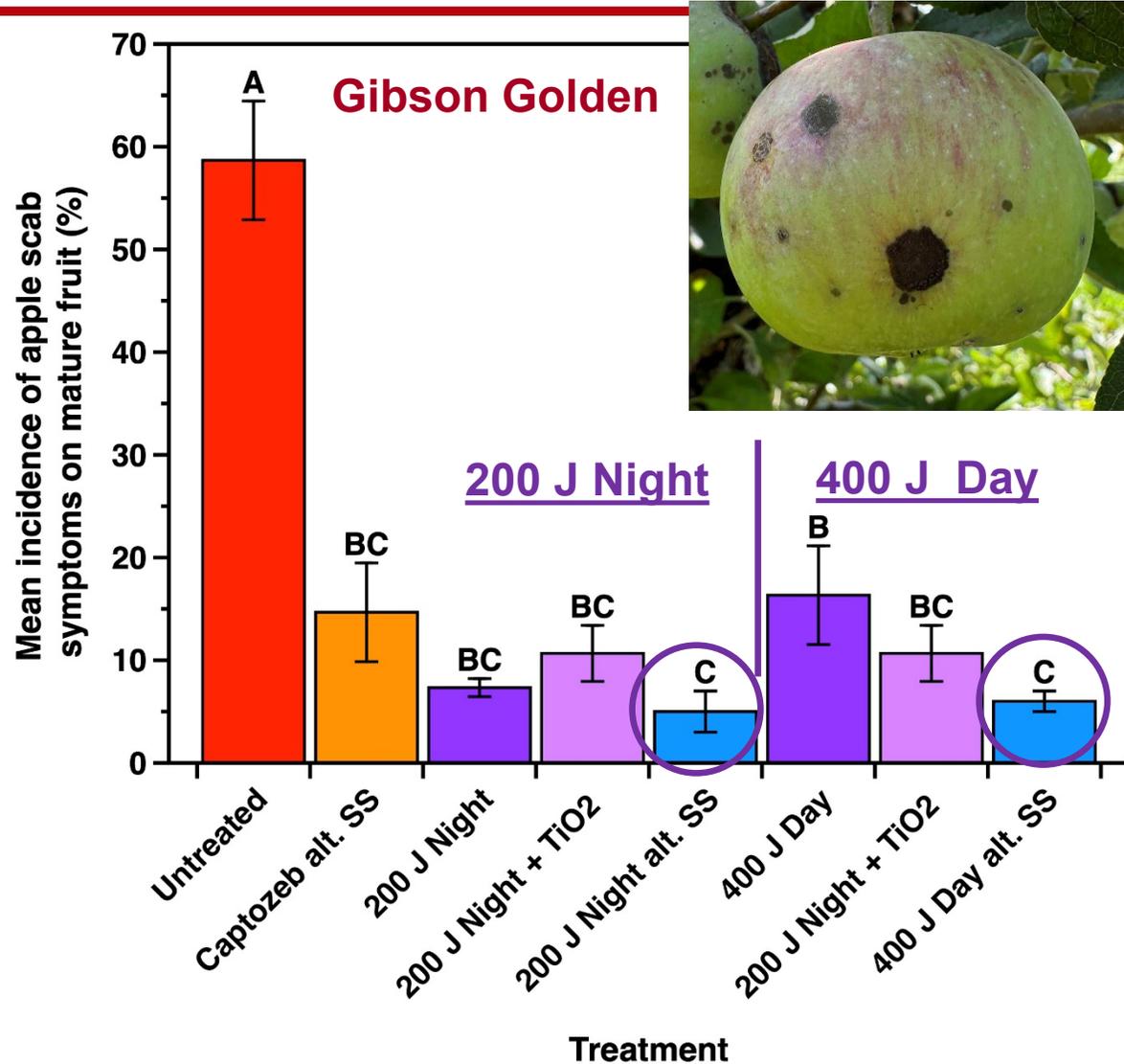
Apple Scab on Fruit (2024)



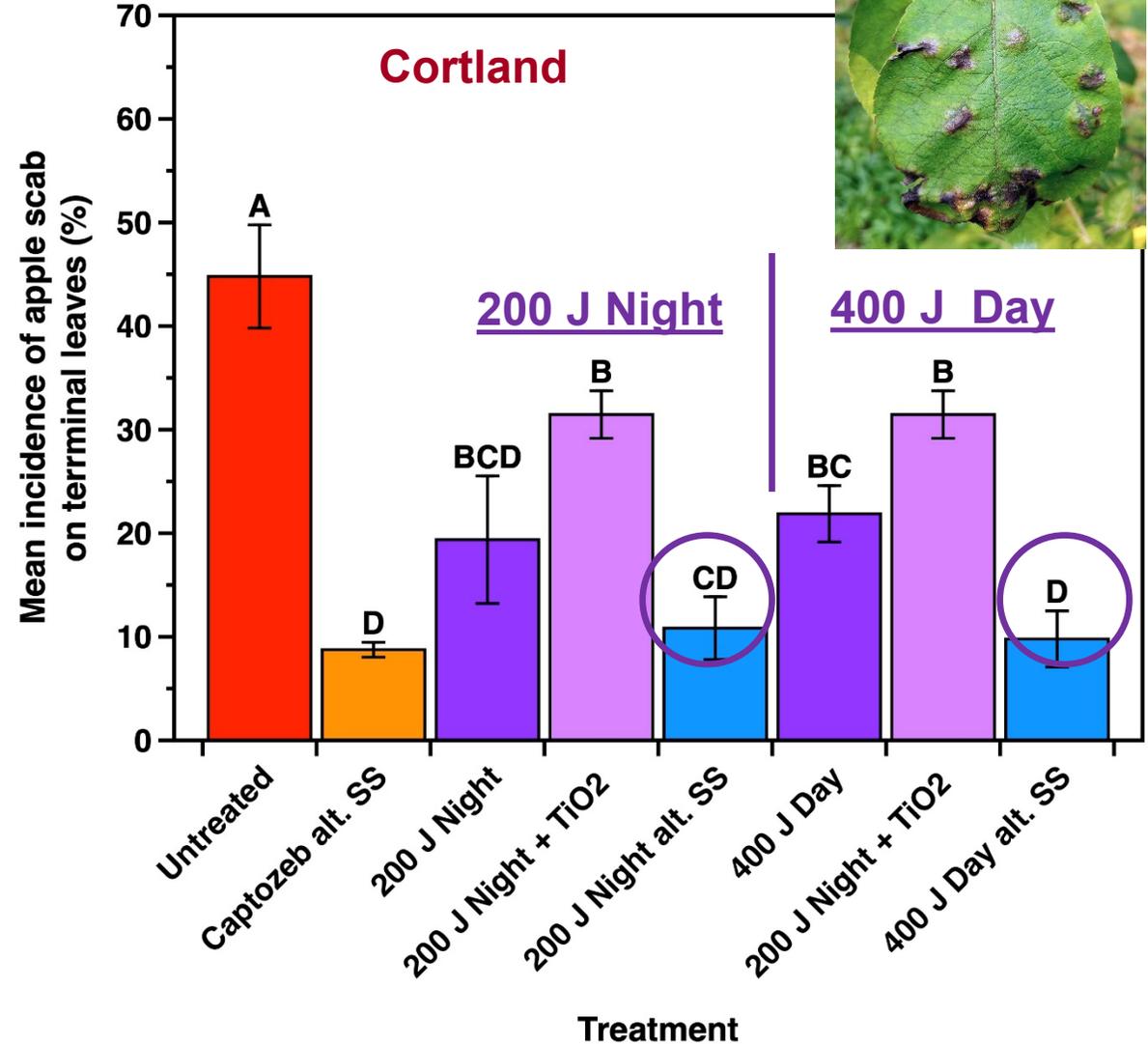
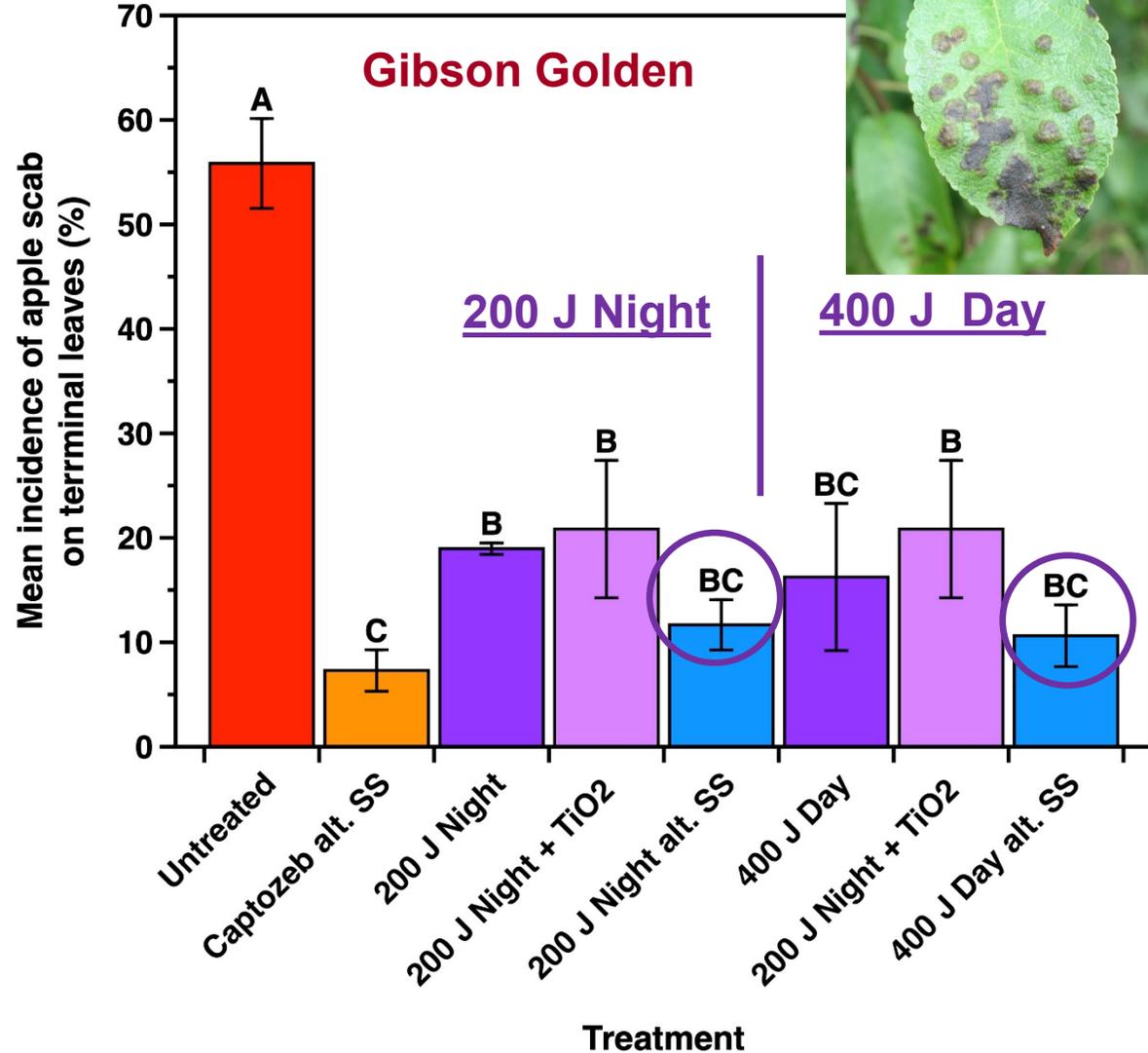
Apple Scab on Leaves (2024)



Apple Scab on Fruit (2025)



Apple Scab on Leaves (2025)



Summary: Fungal Disease

- 2023: Exceptionally cold dry early spring 2nd leaf 'Evercrisp' (establishment)
- 2024-2025: Exceptionally cold wet spring and early summer (high pressure)
- **Nightly time UV-C (200 J/m²) was effective at for apple scab: low inoculum, dry season, establishment years**
- **400 or higher J/m² may allow for daytime applications**
- UV-C impact powdery mildew, cedar apple rust, and apple blotch

Summary: Fungal Disease

- 'Gibson Golden' & 'Cortland' more higher levels of apple scab > seemingly less effective especially on leaves
- Reduced effectiveness in 'Gibson Golden' & 'Cortland' due to application DSS timing calendar timing
- Single-site alternation – sometimes better
- TiO_2 not helpful & acts as sunscreen and not catalyst?
- Ability and need to apply in the rain to be effective

How do we move forward?

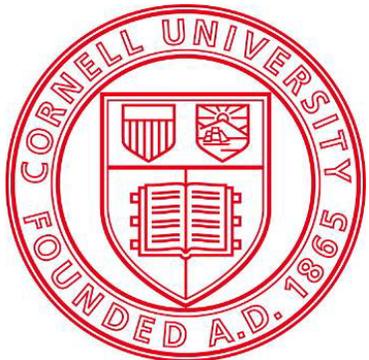
- Consistent performance from a design apple growers can use
- We may need a covered system, but best w/ fruiting wall or nursery
- At least 3 years of data, on orchards > 3rd leaf, warmer production regions



Acknowledgments

Program research
funded by

**Apple Research and
Development
Program**



**Cornell
AgriTech**

New York State Agricultural
Experiment Station

Cox Lab Members

Olivia Hullihen
Morgan Caraballo
Ingrid Miller
Riley Harding
McKenzie Schessl

