2021 DEC HVRL Webinar Session: Conventional Production

Cornell University

Hudson Valley Research Laboratory

Orchard Management in the Extreme Weather: Late Frost, Thinning and Mitigation of Heat Damage

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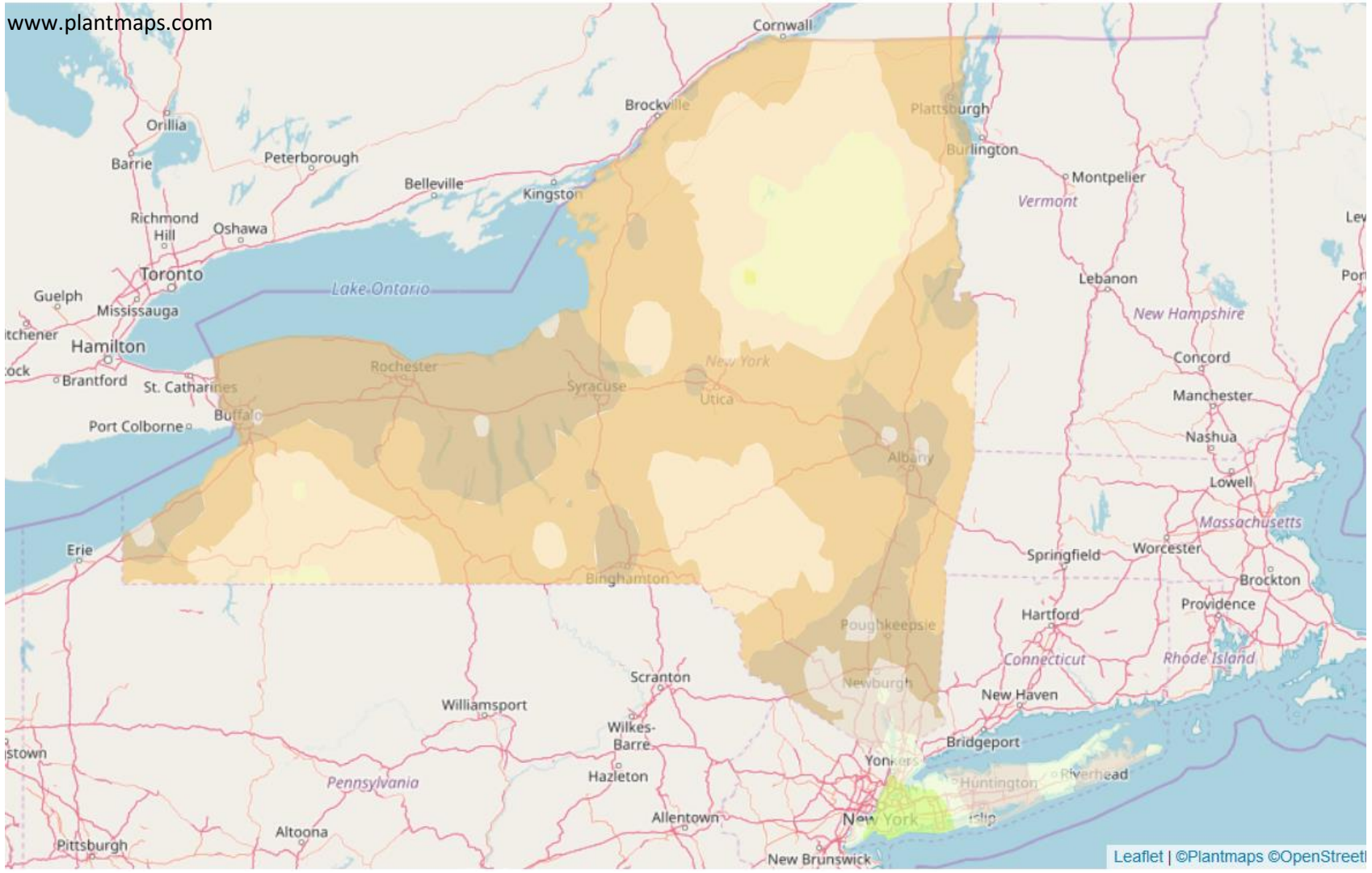
Average Last Frost Date For NYS



Zone 11
Apr. 21 - Apr. 30

Zone 12
May 1 - May 10

Zone 13
May 11 - May 20

Zone 14
May 21 - May 31

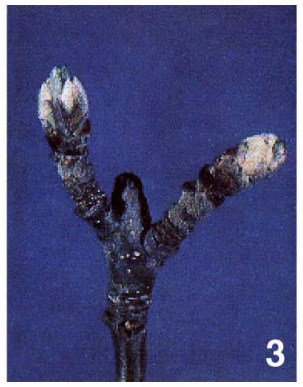
Zone 15
Jun. 1 - Jun. 10

Zone 16
Jun. 11 - Jun. 20

Zone 17
Jun. 21 - Jun. 30

Zone 18
Jul. 1 - Jul. 10

Critical Temp (°F) for Apple Developmental Stages

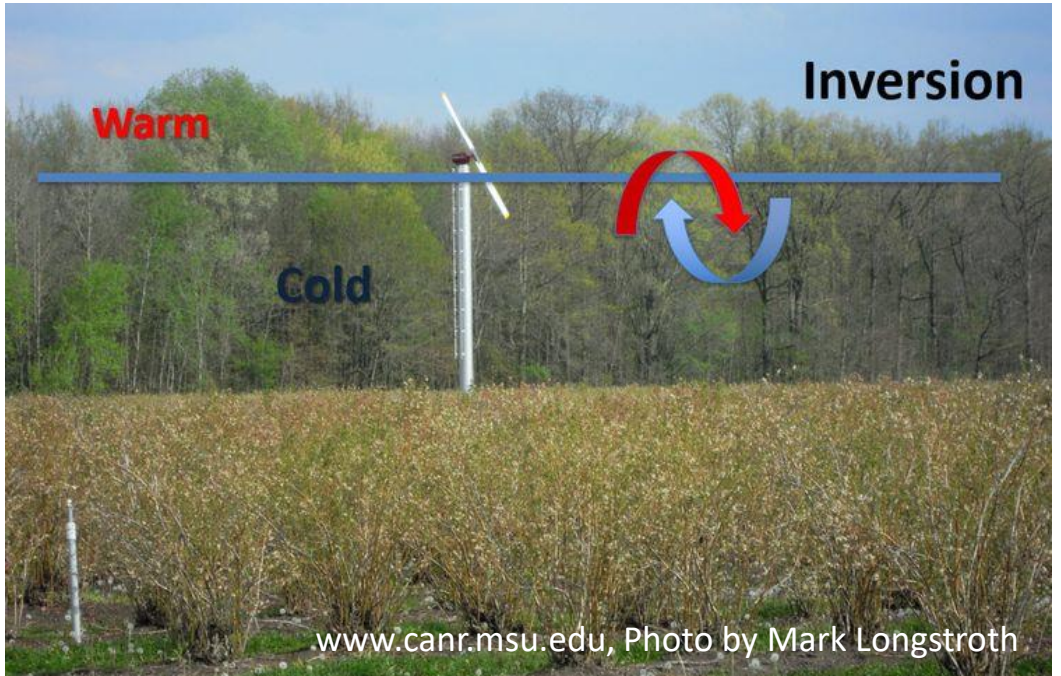


	Green tip	Tight cluster	Pink	Full bloom	Post bloom
Temperature for 10% kill	18	27	27	28	28
Temperature for 90% kill	10	21	25	25	25

D. C. Ferree & I. J. Warrington, *Apples: Botany, Production and Uses*, Cambridge: CABI, 2003. Print.

Preventive Strategies

- **Wind Machines & Helicopters**
- **Overhead Irrigation**
- **Under-the-Tree Irrigation**
- **Orchard Heaters or Fires**



When to Apply a Frost-Rescue Spray?

Year	2012	2016
Growth Stage	Full Bloom	Green Tip/ Tight Cluster
Temperature	High 20s	Low 20s

- Between pink stage to petal fall.
- Promalin: 2 pints/A in 75-150 gallons of water, within 24 hours of the frost event.
- Best results if applied after hard frost (lower than 29°F) when there is significant flower damage.
- 8 to 10% of all flowers to set a good crop.

How Does It Work?

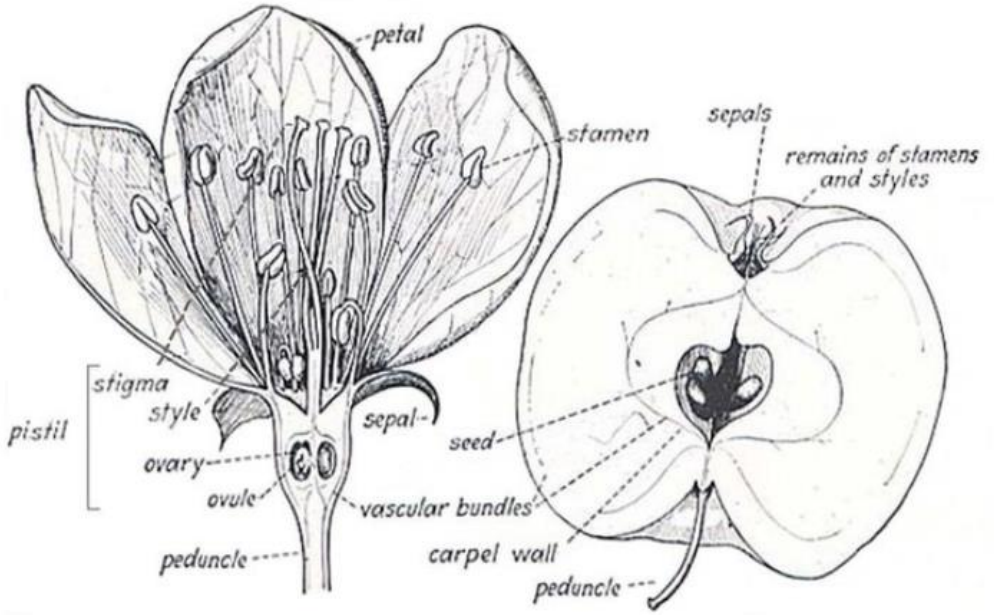
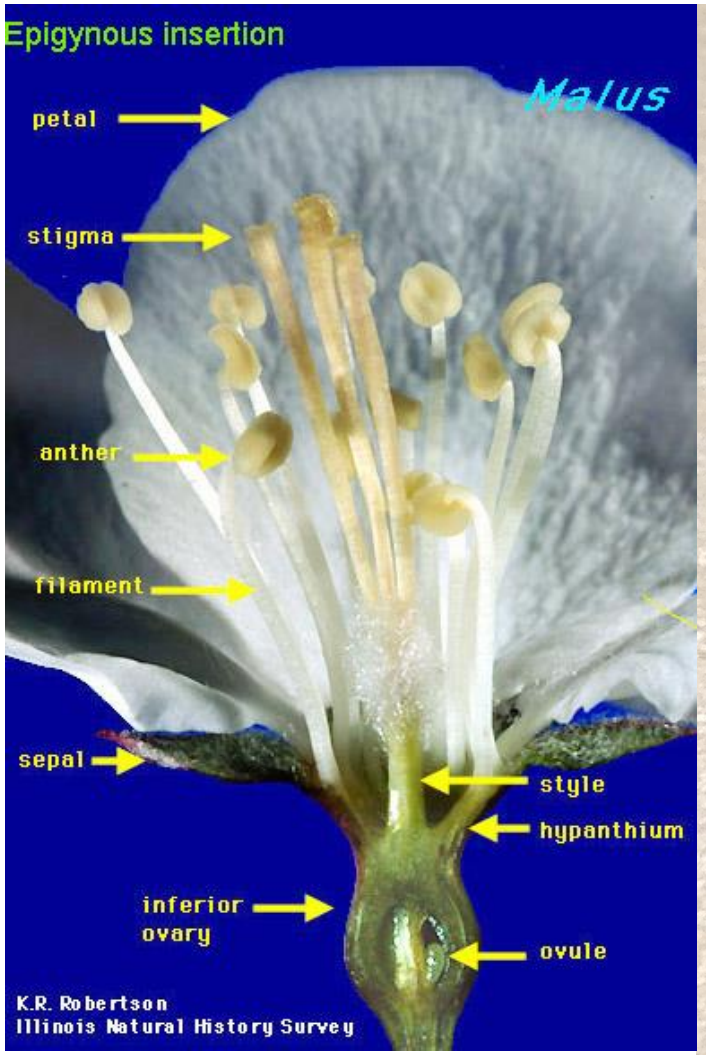


Photo credit: Peter William Edward Kearns

- **Perlan** ® (Fine Agrochemicals Limited) & **Promalin** ® (Valent BioSciencesCorporation)
  - N-(phenylmethyl)-1H-purine 6-amine (1. 8% w/w)
  - Gibberellins A_4A_7 (1. 8% w/w)
- Supplemental label (2EE) in New York for frost damage remediation in apples during the bloom period, within 24 hours after the frost event.
- The gibberellins in Promalin mimic those that would have been produced by the non-existent seeds in the damaged fruitlets. As a result, the seedless fruit remain on the tree.

Frost Injury Assessment



- April 23 - 27.5°F for 4 hrs.
- Tight cluster most cultivars, Empire most advanced with 74% in pink.
- 20 flower buds per cultivar for frost injury estimation.

Frost Injury Assessment

- May 9 - 30.1°F
- Full bloom

Flower injuries after the frost on April 23 and May 9, 2020

Variety	% Total Mortality		% King Mortality		% Lateral Mortality	
	3-May	11-May	3-May	11-May	3-May	11-May
Empire	58	80	81	95	51	76
Gala	8	66	15	65	6	67
Honey Crisp	19	28	45	40	12	24
Fuji	36	38	65	70	30	31
NY1	9	67	38	75	3	65
NY2	31	85	64	80	24	87

- Less than 40% king bloom losses as the threshold for bloom thinning
- Over 80% of total flower damage – do not apply thinners

Frost Damages: Conclusions

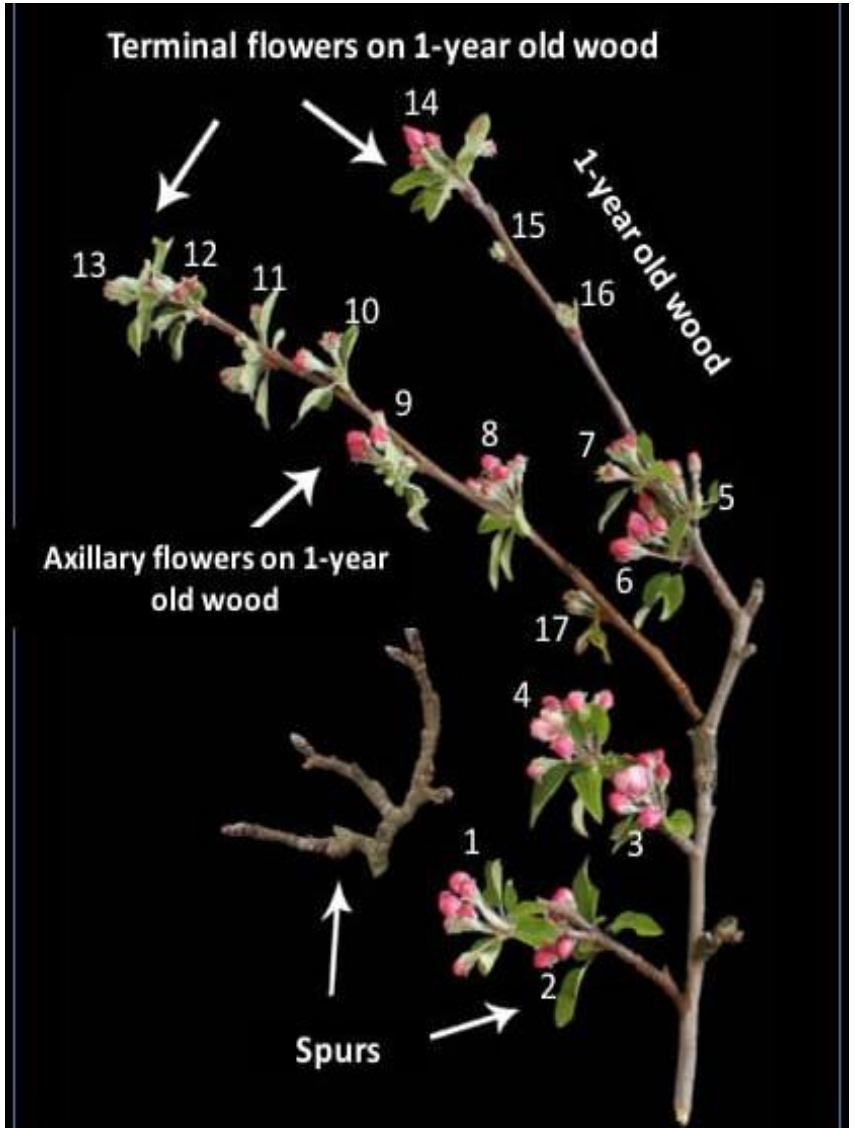
1. Preventive strategies: wind machines, overhead irrigation, heaters.
2. Rescue spray: Promalin. Works only if frost occurs at Pink to PF.
3. 8 to 10% of all flowers to set a good crop
4. No bloom thinning if 40% king bloom is injured
5. No thinning at all if over 80% of total flower is damaged

Set a Stage for the Precision Thinning

1. Select a mature orchard.

2. From pink to bloom, mark 5 representative trees, and count ALL flower clusters/tree

3. Tag 15 spurs (flower clusters)/tree (75 total spurs)



Precision Thinning

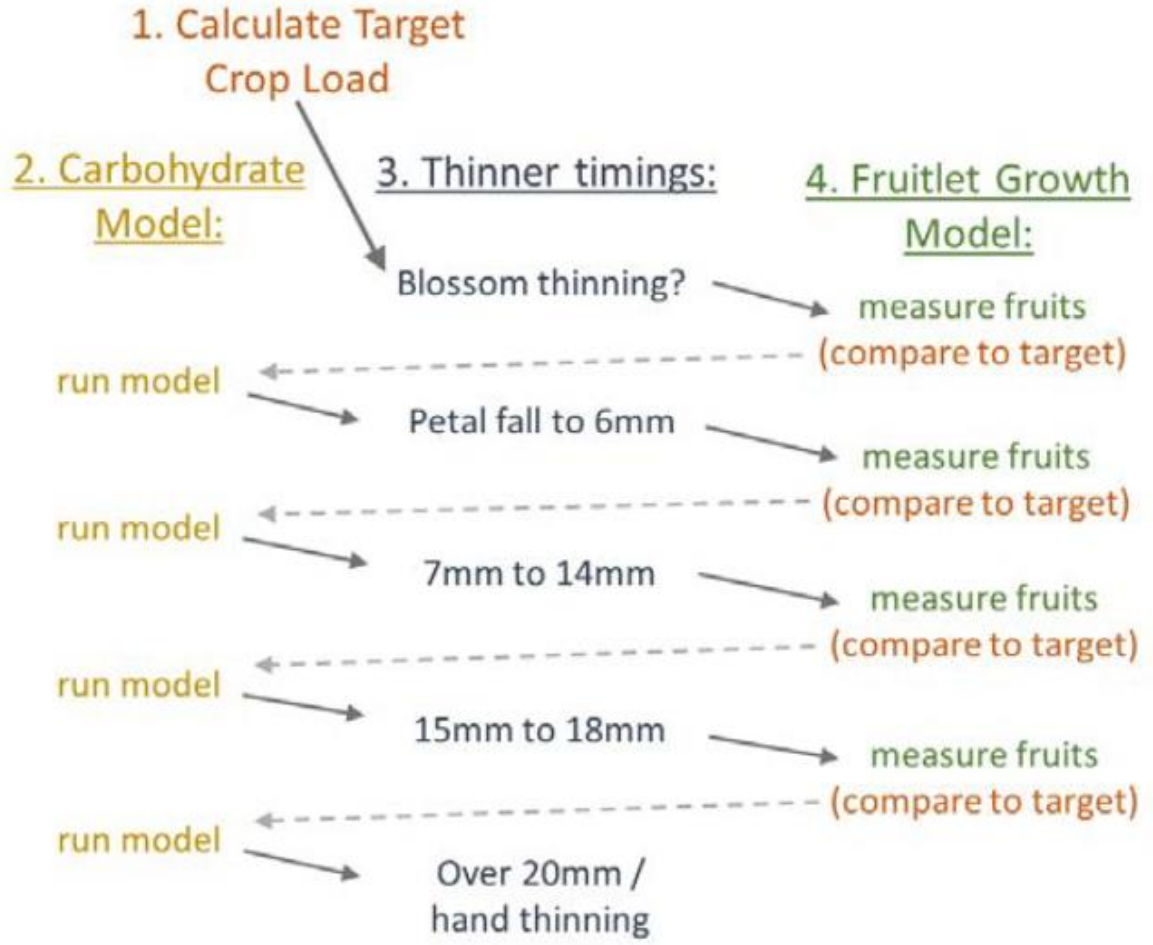
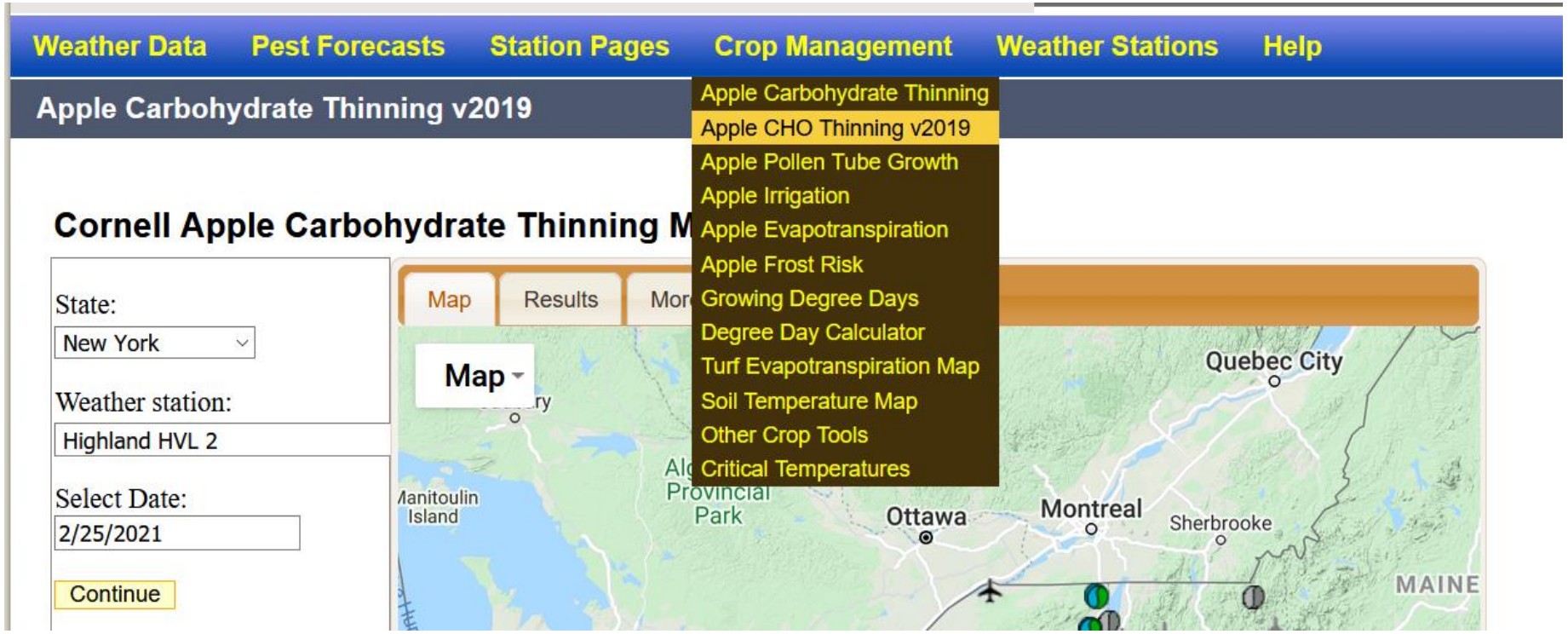


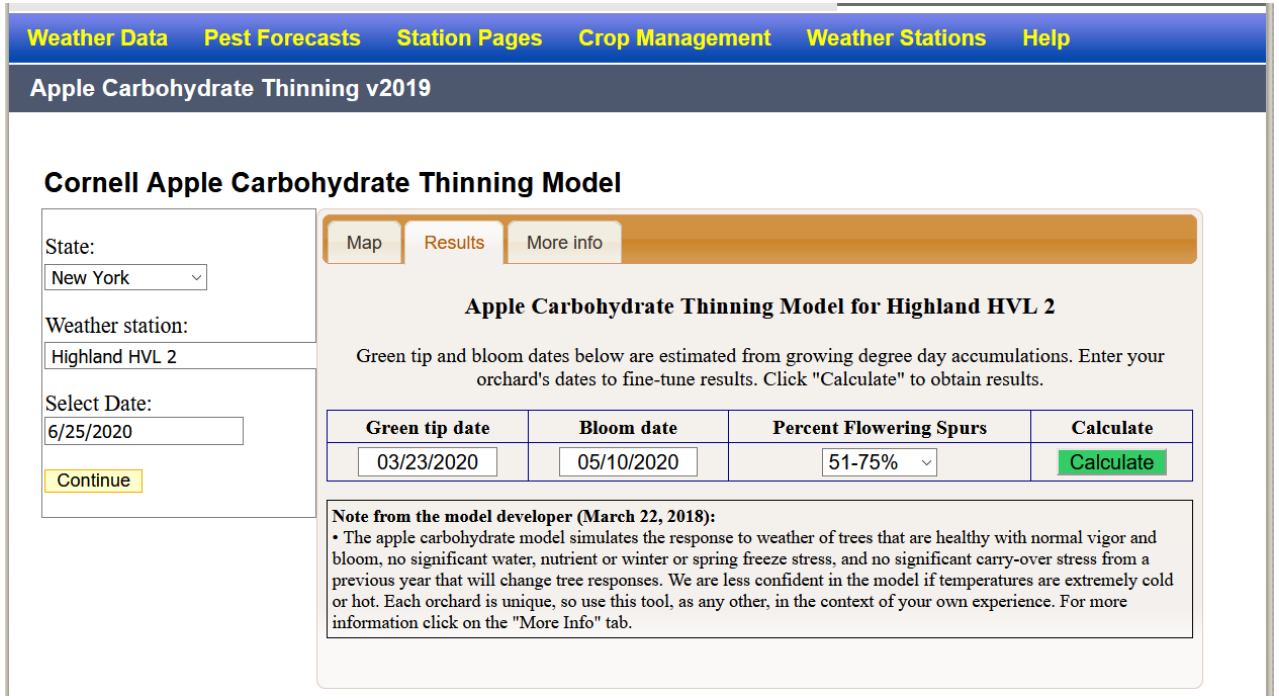
Photo credit: Janet van Zoeren and Amaya Atucha (fruit.wisc.edu)

Carbohydrate Model

- Apply your thinning program and use **the carbohydrate model** to adjust rates based on model recommendations and the amount of thinning to be done (http://newa.cornell.edu)



Carbohydrate Model



Apple Carbohydrate Thinning Model Results

Date	Max Temp (°F)	Min Temp (°F)	Solar Rad (MJ/m2)	Tree Carbohydrate Balance (g/day)		Accum 4°C Degree Days (since bloom)	Thinning Recommendation Red=Danger of overthinning; Yellow=Caution; Green=Low Risk of overthinning)
				Daily	7-Day Ave		
3/23	33	29	2.5	-2.15	-	0.0	-
3/24	45	31	17.8	-3.74	-	0.0	-
3/25	43	32	4.4	-3.72	-5.71	0.0	-
3/26	60	31	20.1	-6.5	-6.41	0.0	-
3/27	60	46	20.7	-10.91	-6.81	0.0	-
3/28	47	37	3.7	-5.74	-7.3	0.0	-
3/29	48	40	2.0	-7.24	-7.67	0.0	-
3/30	47	39	5.2	-7.0	-7.51	0.0	-

Carbohydrate Model

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				Daily	7-Day Ave		
5/8	54	33	10.9	12.57	17.45	0.0	-
5/9	42	30	21.3	34.86	22.44	0.0	-
5/10	62	33	22.5	25.7	21.7	4.6	Increase Chemical Thinning Rate by 30%
5/11	58	39	13.1	7.14	12.67	9.7	Increase Chemical Thinning Rate by 30%
5/12	56	39	27.4	28.31	1.57	14.2	Increase Chemical Thinning Rate by 30%
5/13	60	29	28.7	35.63	-7.8	17.3	Increase Chemical Thinning Rate by 30%
5/14	71	37	23.8	7.74	-16.94	25.4	Increase Chemical Thinning Rate by 30%
5/15	84	53	21.1	-50.7	-23.6	41.6	Apply Standard Chemical Thinning Rate
5/16	73	58	25.0	-42.79	-30.52	56.1	Apply Standard Chemical Thinning Rate
5/17	71	53	20.1	-39.91	-32.61	68.6	Apply Standard Chemical Thinning Rate
5/18	63	55	9.7	-56.84	-32.73	79.5	Apply Standard Chemical Thinning Rate
5/19	69	50	27.5	-18.3	-40.1	90.7	Apply Standard Chemical Thinning Rate
5/20	71	46	28.8	-12.8	-37.65	101.4	Apply Standard Chemical Thinning Rate
5/21	74	41	29.2	-6.9	-34.51	111.7	Apply Standard Chemical Thinning Rate
5/22	79	50	23.0	-51.59	-41.82	125.6	Apply Standard Chemical Thinning Rate
5/23	69	57	7.3	-94.37	-48.94	138.8	Apply Standard Chemical Thinning Rate
5/24	75	50	27.5	-22.72	-61.23	151.6	Decrease Chemical Thinning Rate by 50%

Petal Fall

Apple Carbohydrate Thinning Model Results

Date	Max Temp (°F)	Min Temp (°F)	Solar Rad (MJ/m2)	Tree Carbohydrate Balance (g/day)		Accum 4°C Degree Days (since bloom)	Thinning Recommendation (Red=Danger of overthinning; Yellow=Caution; Green=Low Risk of overthinning)
				Daily	7-Day Ave		
5/25	75	51	22.2	-34.87	-66.67	164.7	Decrease Chemical Thinning Rate by 50%
5/26	85	57	26.2	-69.49	-56.15	182.5	Decrease Chemical Thinning Rate by 30%
5/27	82	60	25.0	-62.6	-45.61	200.2	Decrease Chemical Thinning Rate by 30%
5/28	77	63	11.3	-92.93	-33.54	217.2	Decrease Chemical Thinning Rate by 15%
5/29	83	66	15.4	-89.7	-24.99	236.8	Decrease Chemical Thinning Rate by 15%
5/30	79	63	25.9	-20.74	-19.61	254.5	Increase Chemical Thinning Rate by 30%
5/31	65	48	26.4	51.04	-5.91	264.0	Increase Chemical Thinning Rate by 30%
6/1	67	42	22.4	49.64	3.74	272.6	Increase Chemical Thinning Rate by 30%
6/2	70	49	10.9	-9.66	4.4	283.7	Increase Chemical Thinning Rate by 30%
6/3	81	56	13.6	-24.92	2.11	299.8	Increase Chemical Thinning Rate by 30%
6/4	85	60	26.2	2.96	1.98	318.4	Increase Chemical Thinning Rate by 30%
6/5	84	65	19.3	-22.12	4.68	338.0	Increase Chemical Thinning Rate by 30%
6/6	87	67	24.7	-16.16	7.42	358.9	Increase Chemical Thinning Rate by 30% and/or add oil as a surfactant
6/7	71	58	24.5	35.04	0.79	373.0	Increase Chemical Thinning Rate by 30% and/or add oil as a surfactant
6/8	78	51	28.7	48.68	7.95	387.0	Increase Chemical Thinning Rate by 30% and/or add oil as a surfactant

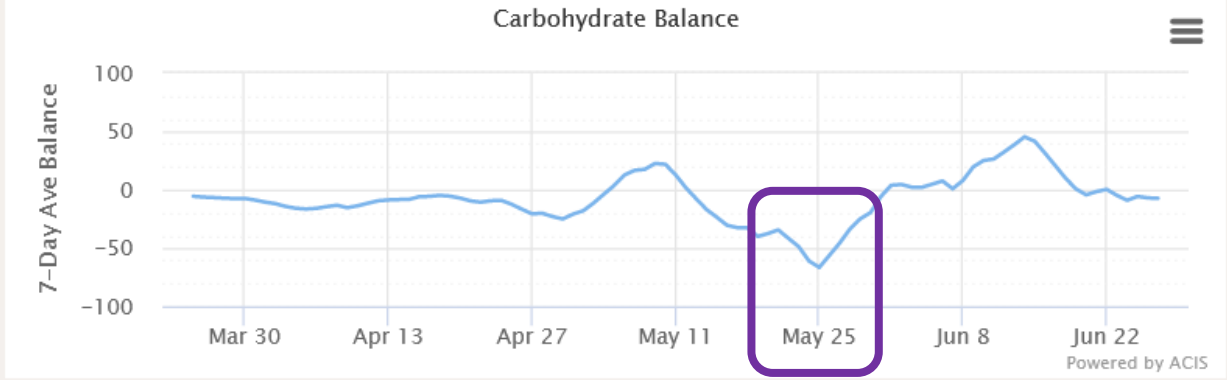
Fruit Size 8-12 mm

Fruit Size 15-20 mm

Carbohydrate Model

- Don’t spray when the carbohydrate deficits are -50 or less

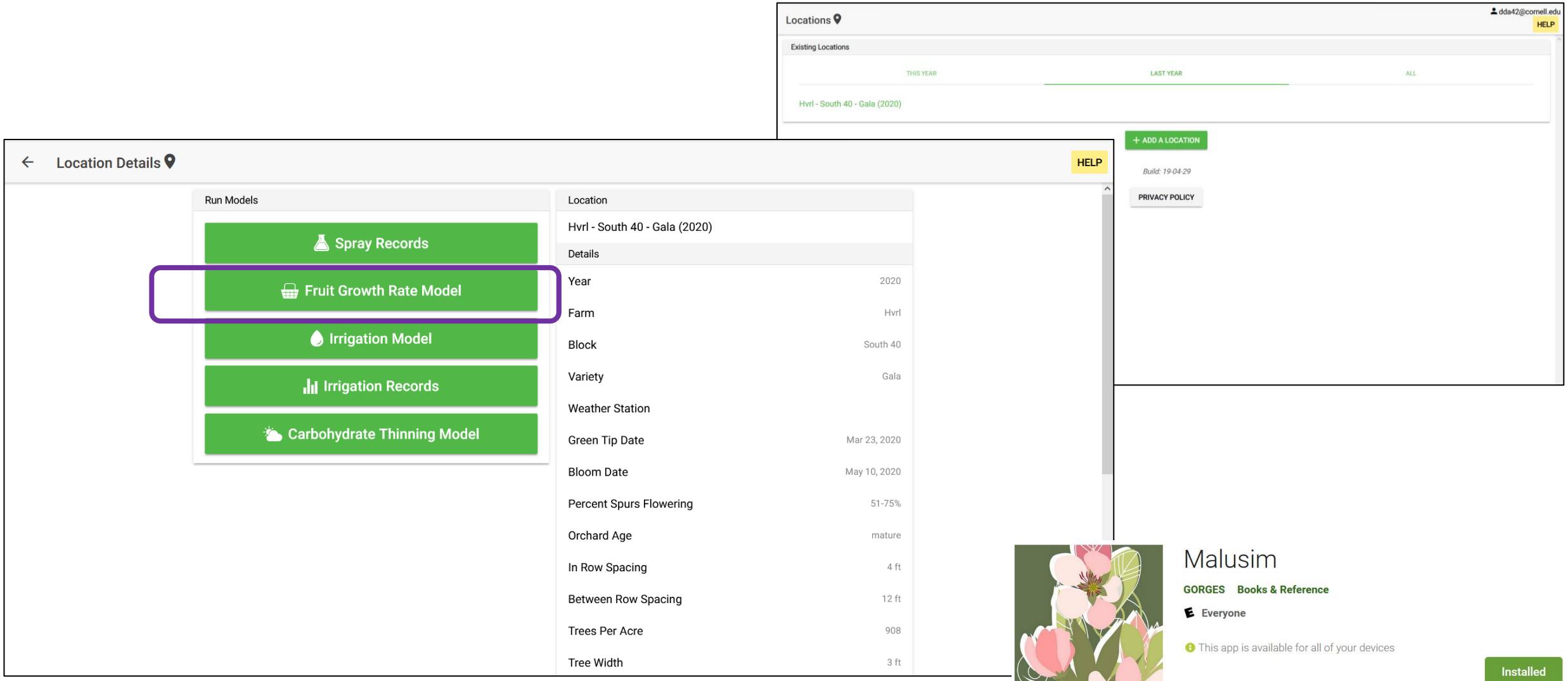
6/22	92	67	23.0	-17.07	0.19	630.5	-
6/23	85	69	21.5	-12.6	-4.94	651.4	-
6/24	84	67	25.2	2.39	-9.13	671.6	-
6/25	84	58	26.2	23.2	-5.83	689.2	-
6/26	83	61	24.1	14.02	-7.05	707.4	-
6/27	73	60	7.3	-42.99	-7.49	722.4	-
6/28	83	61	12.9	-30.86	-	740.9	-
6/29	81	62	21.5	5.99	-	758.9	-
6/30	78	63	13.3	-21.13	-	776.1	-
7/1	82	62	20.1	-0.7	-	794.4	-
	Text color represents expected thinning efficacy: Blue=Mild; Green=Good; Orange=Very good; Red=Excessive						Recommendations only provided for 35 days following bloom.



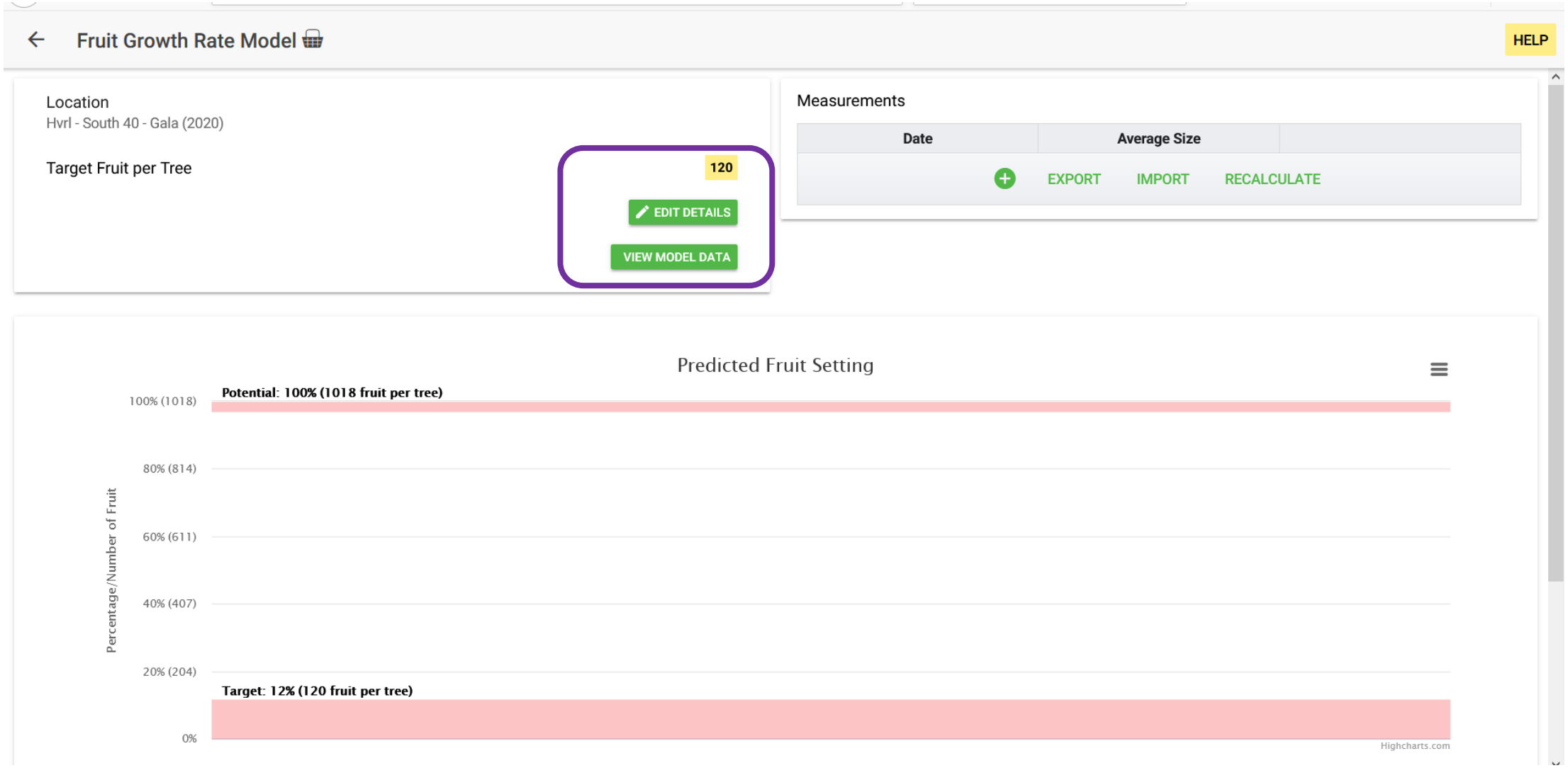
NEWA

Powered by ACIS Northeast Regional Climate Center

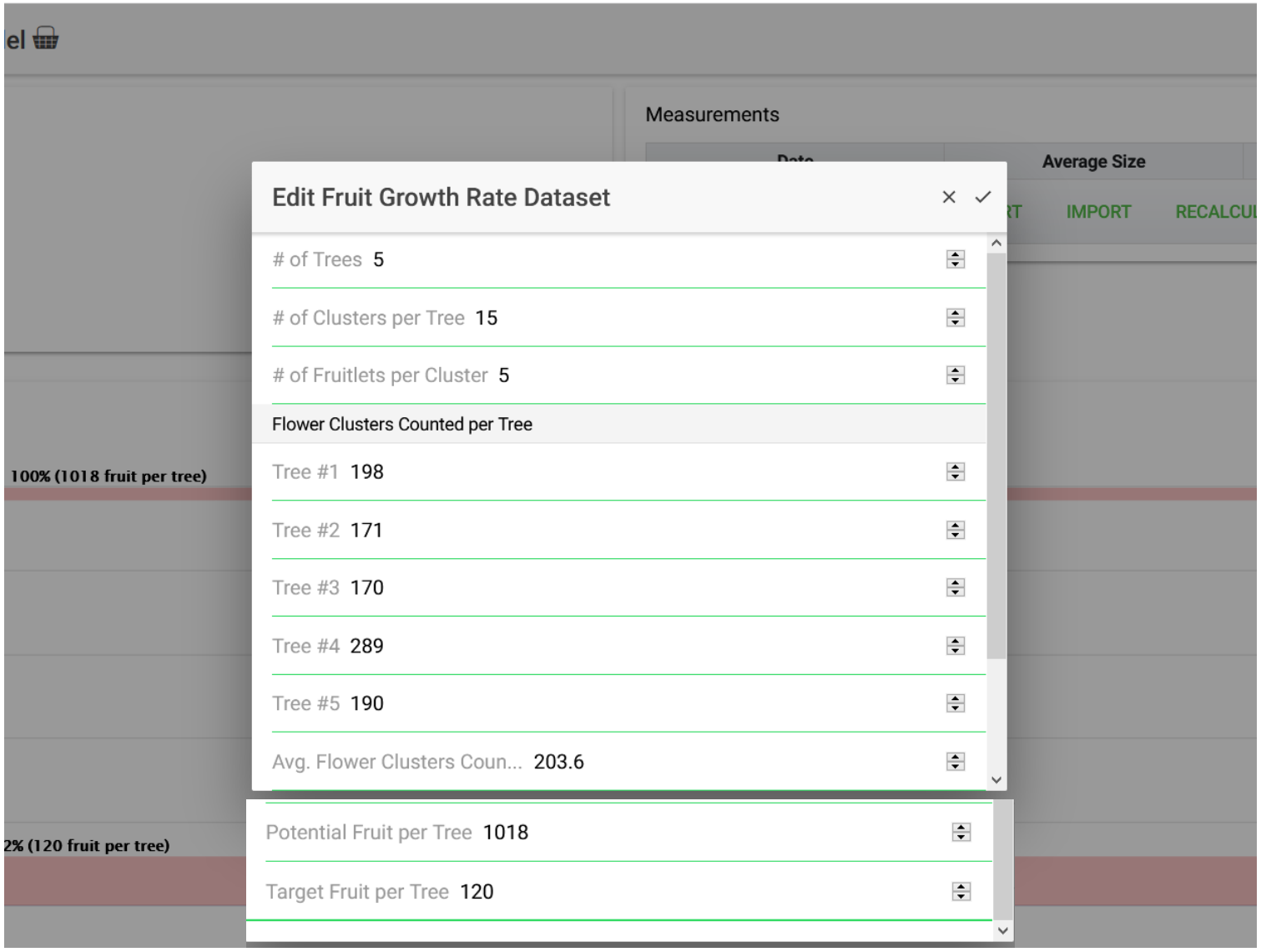
Fruit Growth Rate Model



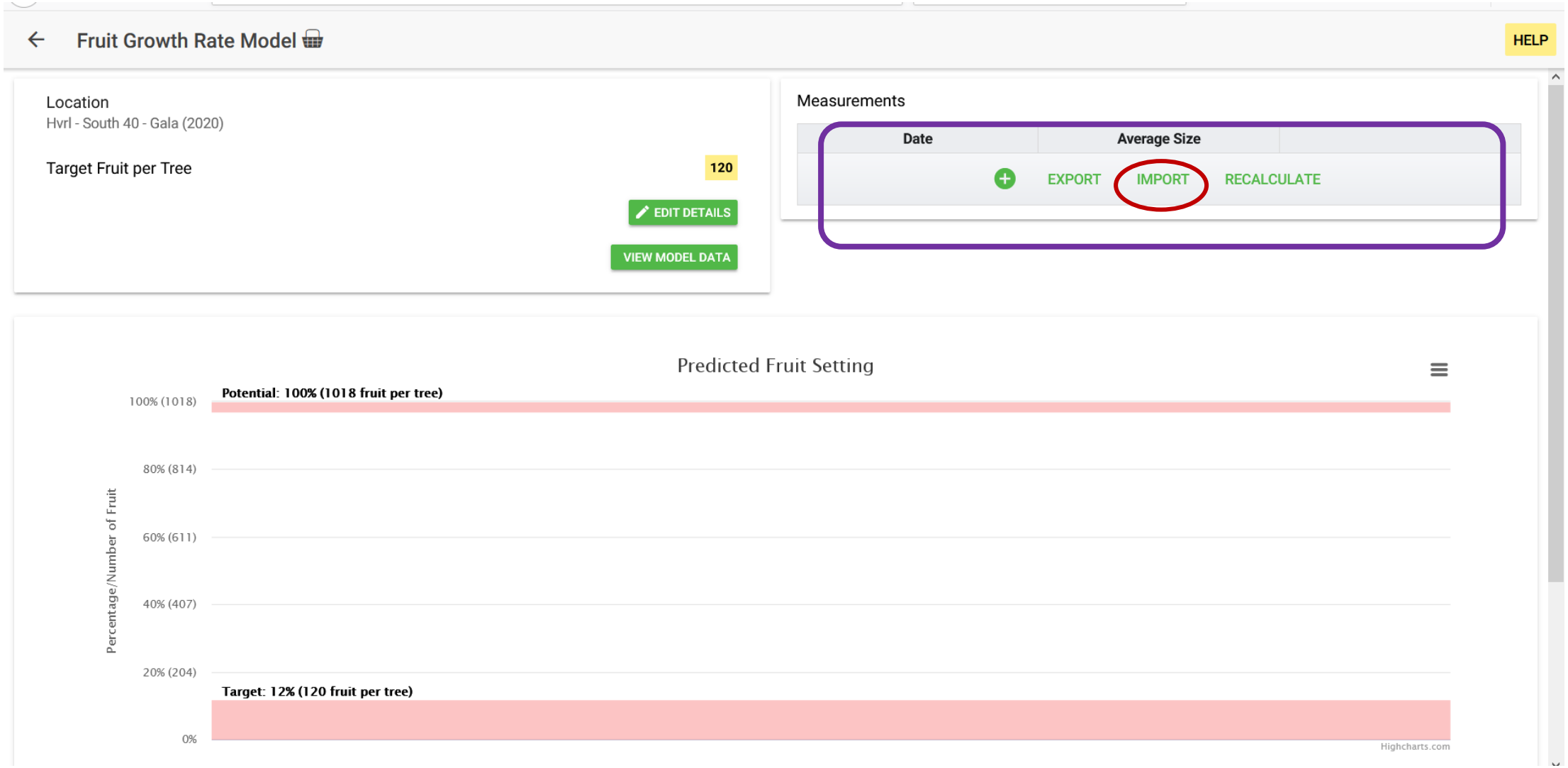
Fruit Growth Rate Model



Fruit Growth Rate Model



Fruit Growth Rate Model



Fruit Growth Rate Model

← Import Measurement Data

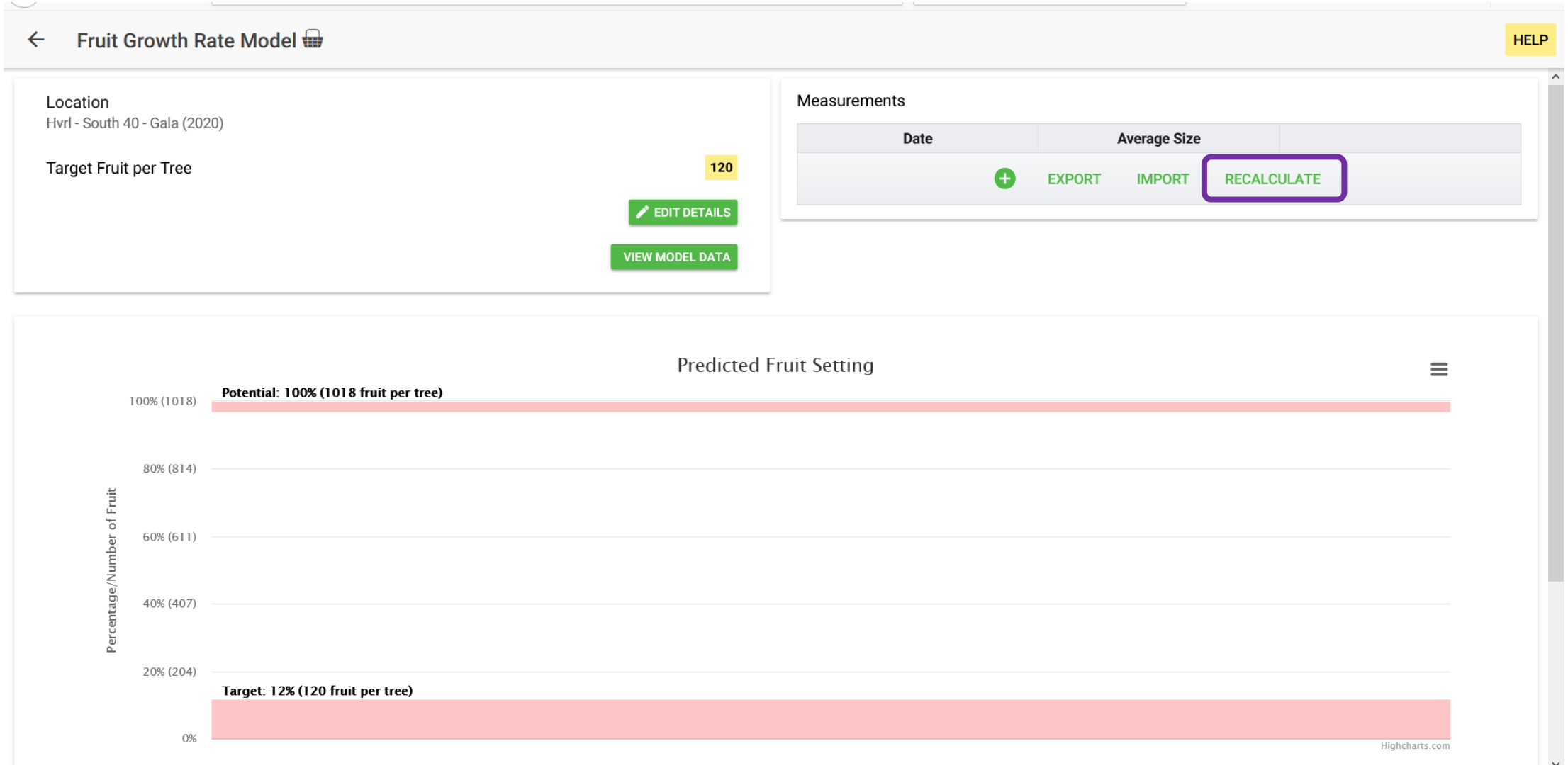
To import measurement data, paste the tab-separated values into the field below, and select Import. The data should be in the same format that is generated by the Export function - for example:

```
Tree  Cluster  Fruitlet  05/27/2017  05/31/2017
1     1        1         8.48        12.11
1     1        2         8.42        11.55
```

IMPORT

Tree	Cluster	Fruitlet	05/24/2020	05/28/2020	06/02/2020	06/0
1	1	1	8.85	12.98	19.69	23.54
1	1	2	6.94	7.19	17.52	21.4
1	1	3	10	8.33	17.1	17.2
1	1	4	9.46	15.01	8.06	
1	1	5	7.6	14.65		
1	2	1	6.01	14.18	18.4	21.18
1	2	2	9.12	14.58	18.01	22.3
1	2	3	9.3	7.59		
1	2	4	7.67	6.18		
1	2	5	0.1			
1	3	1	5.78	6.06	17.22	22.57
1	3	2	7.12	6.17	6.81	
1	3	3	8.28	6.51	5.94	
1	3	4	5.28	11.84	5.9	
1	3	5	5.77	7.03		
1	4	1	8.79	13.59	18.47	21.94
1	4	2	8.61	7.69	16.67	22.36
1	4	3	6.63	14.14	18.6	16.36
1	4	4	9.02	12.89	7.04	

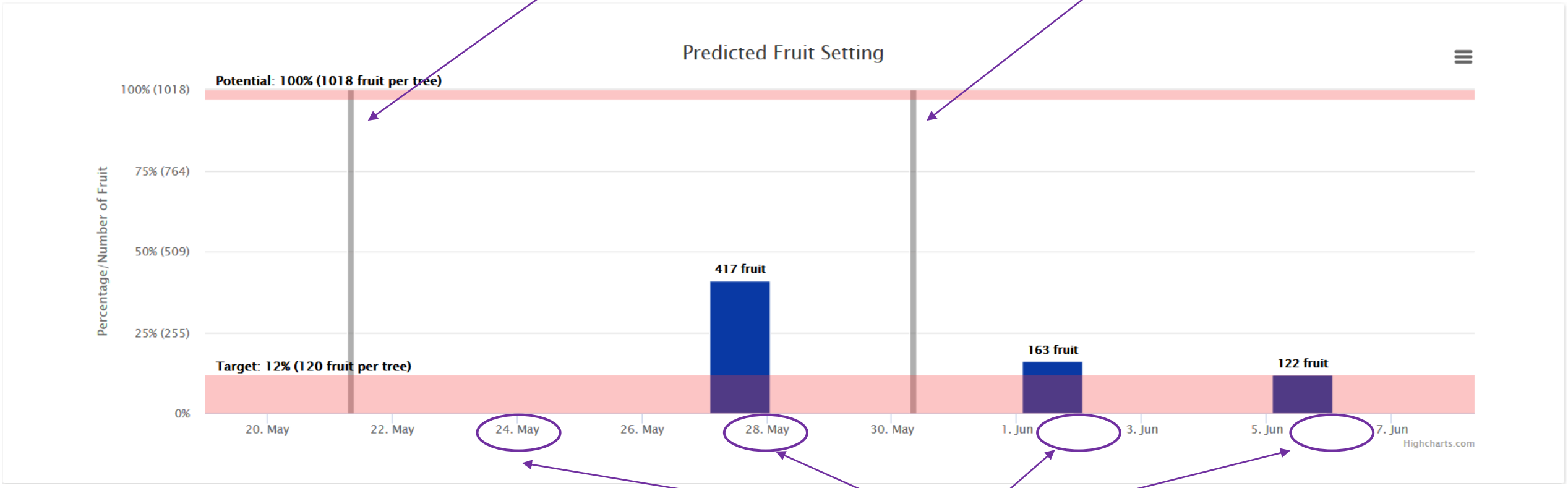
Fruit Growth Rate Model



Fruit Growth Rate Model

Petal Fall Spray (21. May)

11-14 mm Spray (31. May)



Fruitlet's measurement
(24. May, 28. May, 2. June, 6. June)

Precision Chemical Thinning

- Measure fruit diameters:

  2x after **petal fall spray** (3 days and 7 days after the spray)

  2x after **10-12mm spray** (3 days and 7 days after the spray)

  2x after **18 mm spray** (3 days and 7 days after the spray)

The number of times to measure will depend on when you reach the target number.

- If you decide not to apply a bloom and/or a petal fall thinning spray, measure fruit diameters :

  when fruitlets reach 5-6mm (usually the king fruitlet)

  3-4 days after the first measurement

Bloom Thinning

- The full bloom 80% flowers open on the north side of the tree
- Essential for return bloom of Honey Crisp and Fuji, benefits hard-to-thin varieties (Gala)
- Less than 40% king bloom losses due to frost as the threshold for bloom thinning

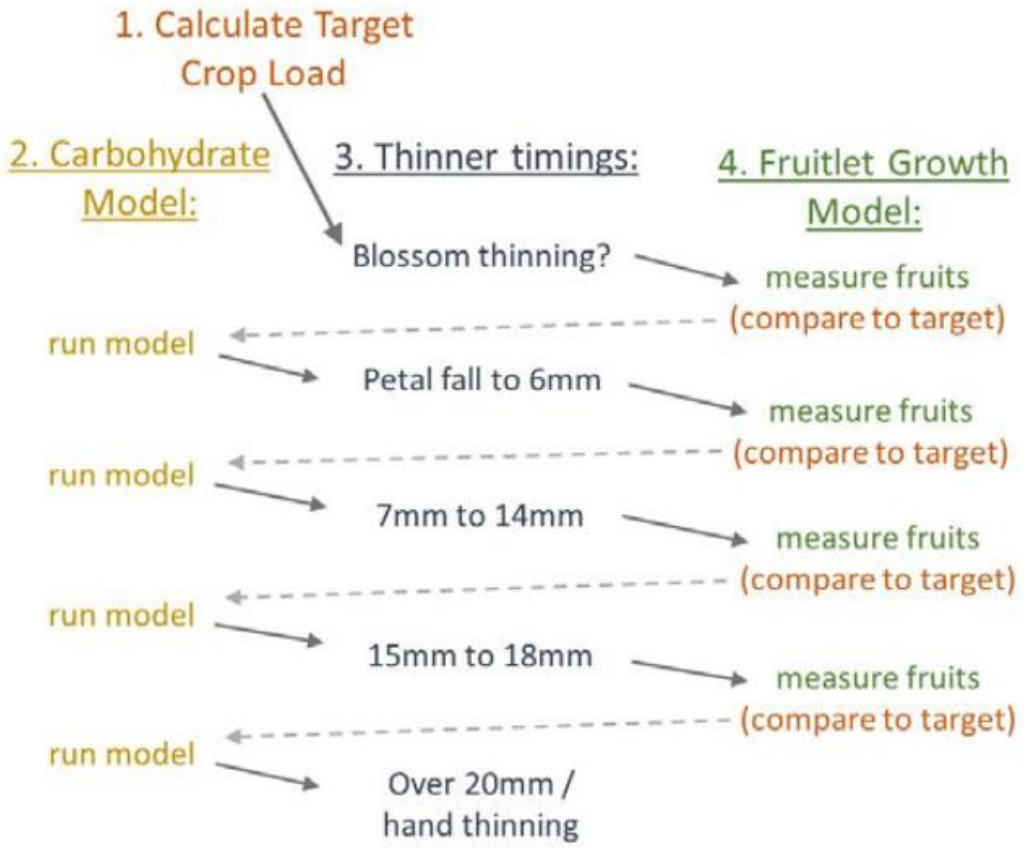


Photo credit: Janet van Zoeren and Amaya Atucha (fruit.wisc.edu)

Bloom Thinning

- Materials:
  - Ammonium thiosulfate (ATS)
  - Lime Sulfur and Oil
  - BA + GA (Promalin)
  - 6-benzyladenine/ 6-BA (MaxCel)
  - Napthaleneacetic acide/ NAA (Fruitone L or Pomaxa)
  - 1- Naphthaleneacetamide (Amide-Thin)
  - Regalia (a knot-weed extract)

- PTGM info: Implementing the Pollen Tube Growth Model on NEWA by G. Peck and D. Olmstead

Petal Fall or 5-6 mm Thinning

Apple Carbohydrate Thinning Model Results

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5/9	42	30	21.3	34.86	22.44	0.0	-
5/10	62	33	22.5	25.7	21.7	4.6	Increase Chemical Thinning Rate by 30%
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5/17	71	53	20.1	-39.91	-32.61	68.6	Apply Standard Chemical Thinning Rate
5/18	63	55	9.7	-56.84	-32.73	79.5	Apply Standard Chemical Thinning Rate
5/19	69	50	27.5	-18.3	-40.1	90.7	Apply Standard Chemical Thinning Rate
5/20	71	46	28.8	-12.8	-37.65	101.4	Apply Standard Chemical Thinning Rate
5/21	74	41	29.2	-6.9	-34.51	111.7	Apply Standard Chemical Thinning Rate
5/22	79	50	23.0	-51.59	-41.82	125.6	Apply Standard Chemical Thinning Rate
5/23	69	57	7.3	-94.37	-48.94	138.8	Apply Standard Chemical Thinning Rate
5/24	75	50	27.5	-22.72	-61.23	151.6	Decrease Chemical Thinning Rate by 50%

- 100-125 DD post full bloom base 4°C (39°F)
- Materials:
  - NAA + Sevin
  - AmideThin
  - Maxcel + Sevin
  - Maxcel + NAA

Fruit Size 8-12 mm Thinning

- 200-250 DD post full bloom base 4°C (39°F)
- Materials:
  - 6-BA + Carbaryl
  - NAA + Carbaryl
  - 6-BA + NAA

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6/8	78	51	28.7	48.68	7.95	387.0	Increase Chemical Thinning Rate by 30% and/or add oil as a surfactant

Thinning Recommendations for the 8-12 mm spray

- **Varieties where BA + Carbaryl works well**

Gala 

Jonamac 

Fuji 

Empire 

Macoun 

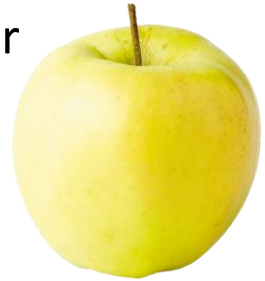
Red Delicious 

www.applesfromny.com

Thinning Recommendations for the 8-12 mm spray

- **Varieties where NAA + Carbaryl works well**

Mc Intosh 

Ginger Gold 

Rome Beauty 

Jonagold 

www.applesfromny.com

Honeycrisp 

NY1 

NY2 

Pink Lady 

nyas.yesapples.com

Cortland 

Golden Delicious 

Idared 

www.applesfromny.com

Thinning Without Carbaryl

- 7.5ppm NAA can replace 1pt carbaryl:

  Gala – 100ppm 6-BA6 + 7.5ppm NAA /100 gal TRV dilute.

  Empire & Macoun – 75ppm 6-BA+ 7.5ppm NAA /100 gal TRV dilute.

- This does not apply for Fuji and Red Delicious as pygmy fruit may result

  Red Delicious & Fuji – Bloom: 8oz Amid Thin/100 gal TRV dilute;
  PF: 75ppm 6-BA /100 gal TRV dilute;
  8-12mm: 100ppm 6-BA6 /100 gal TRV dilute

  - **Jonagold & Honeycrisp** – 7.5ppm NAA +50ppm 6-BA/100 gal TRV dilute.
  - **Golden Delicious** – 7.5ppm NAA+ 75ppm 6-BA /100 gal TRV dilute,
  - **NY1 & NY2** – 7.5ppm NAA + 100ppm 6-BA6 /100 gal TRV dilute.

Fruit Size 15-20 mm Thinning

- 300-350 DD post full bloom base 4°C (39°F)
- Materials:
  - 6-BA + Carbaryl + Oil
  - NAA + Carbaryl
  - Ethrel + Oil

Apple Carbohydrate Thinning Model Results

Date	Max Temp (°F)	Min Temp (°F)	Solar Rad (MJ/m2)	Tree Carbohydrate Balance (g/day)		Accum 4°C Degree Days (since bloom)	Thinning Recommendation Red=Danger of overthinning; Yellow=Caution; Green=Low Risk of overthinning)
				Daily	7-Day Ave		
5/25	75	51	22.2	-34.87	-66.67	164.7	Decrease Chemical Thinning Rate by 50%
5/26	85	57	26.2	-69.49	-56.15	182.5	Decrease Chemical Thinning Rate by 30%
5/27	82	60	25.0	-62.6	-45.61	200.2	Decrease Chemical Thinning Rate by 30%
5/28	77	63	11.3	-92.93	-33.54	217.2	Decrease Chemical Thinning Rate by 15%
5/29	83	66	15.4	-89.7	-24.99	236.8	Decrease Chemical Thinning Rate by 15%
5/30	79	63	25.9	-20.74	-19.61	254.5	Increase Chemical Thinning Rate by 30%
5/31	65	48	26.4	51.04	-5.91	264.0	Increase Chemical Thinning Rate by 30%
6/1	67	42	22.4	49.64	3.74	272.6	Increase Chemical Thinning Rate by 30%
6/2	70	49	10.9	-9.66	4.4	283.7	Increase Chemical Thinning Rate by 30%
6/3	81	56	13.6	-24.92	2.11	299.8	Increase Chemical Thinning Rate by 30%
6/4	85	60	26.2	2.96	1.98	318.4	Increase Chemical Thinning Rate by 30%
6/5	84	65	19.3	-22.12	4.68	338.0	Increase Chemical Thinning Rate by 30%
6/6	87	67	24.7	-16.16	7.42	358.9	Increase Chemical Thinning Rate by 30% and/or add oil as a surfactant
6/7	71	58	24.5	35.04	0.79	373.0	Increase Chemical Thinning Rate by 30% and/or add oil as a surfactant
6/8	78	51	28.7	48.68	7.95	387.0	Increase Chemical Thinning Rate by 30% and/or add oil as a surfactant

Fruit Thinning: Conclusions

1. Use the protocol for Precision Thinning to achieve targeted number of fruit/tree.

2. NEWA's Carbohydrate Model and Malusim are free and easy to use.

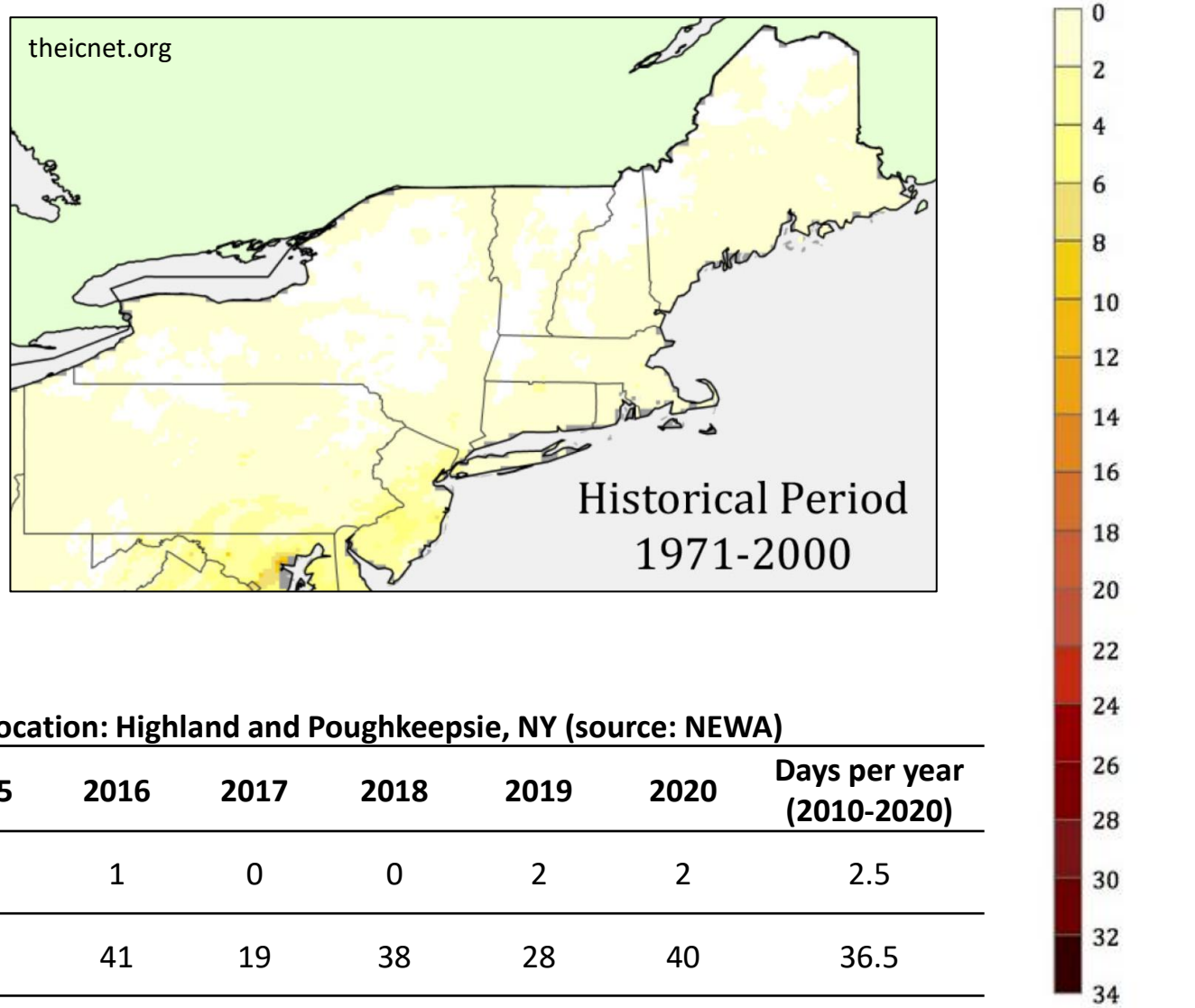
3. 6-BA: Gala, Empire, Jonamac, Macoun, Fuji, Red Delicious

4. NAA: McIntosh, Honeycrisp, Cortland, Ginger Gold, NY1, NY2, Golden Delicious, Rome Beauty, Northern Spy, Idared, Jonagold, Pink Lady.

Get Ready For 2050s

By the year 2055, according to NESDIS – NOAA, the Hudson Valley region will likely experience an **additional 6-12 days with a maximum temperature exceeding 95°F** (scenar-ios.globalchange.gov).

This trend would likely cause an increase of the occurrence of temperature dependent types of sunburn.

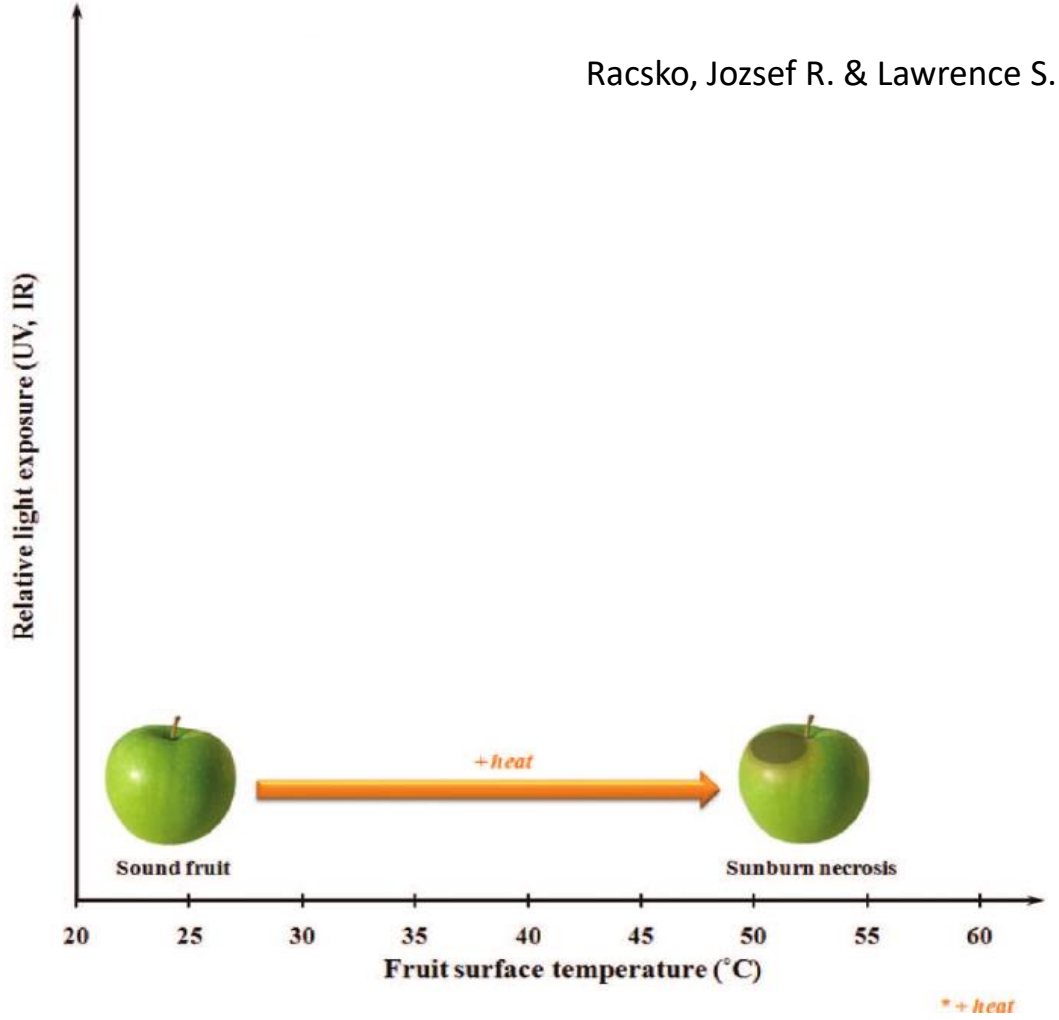


Growing Season (1-Mar to 31-Oct), Location: Highland and Poughkeepsie, NY (source: NEWA)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Days per year (2010-2020)
Days per year over 35°C/95°F	6	5	6	2	0	3	1	0	0	2	2	2.5
Days per year over 30°C/86°F	54	30	43	28	27	54	41	19	38	28	40	36.5

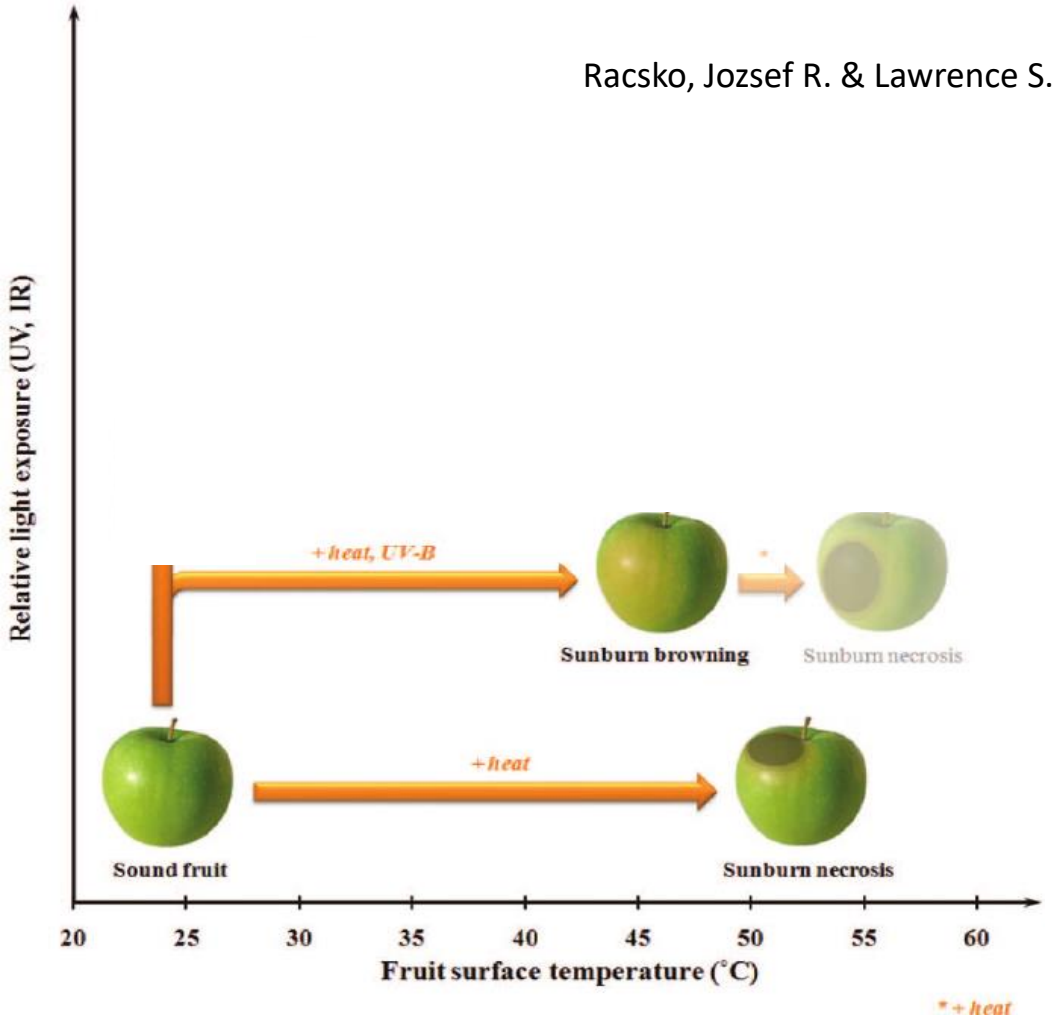
Temperature Dependent Sunburn Type: Necrosis

Racsko, Jozsef R. & Lawrence S. (2012)



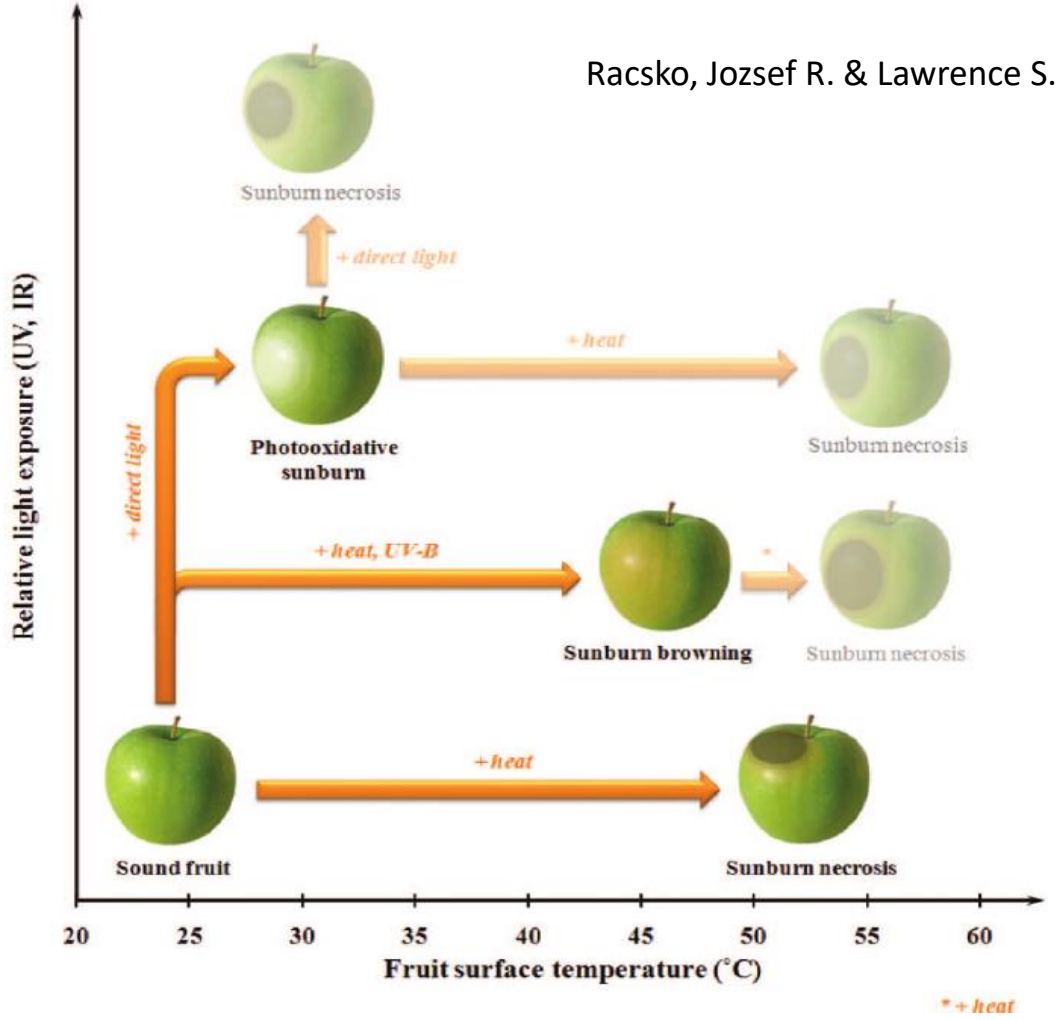
Temperature Dependent Sunburn Type: Browning

Racsko, Jozsef R. & Lawrence S. (2012)



Temperature Independent Sunburn Type: Photooxidative

Racsko, Jozsef R. & Lawrence S. (2012)

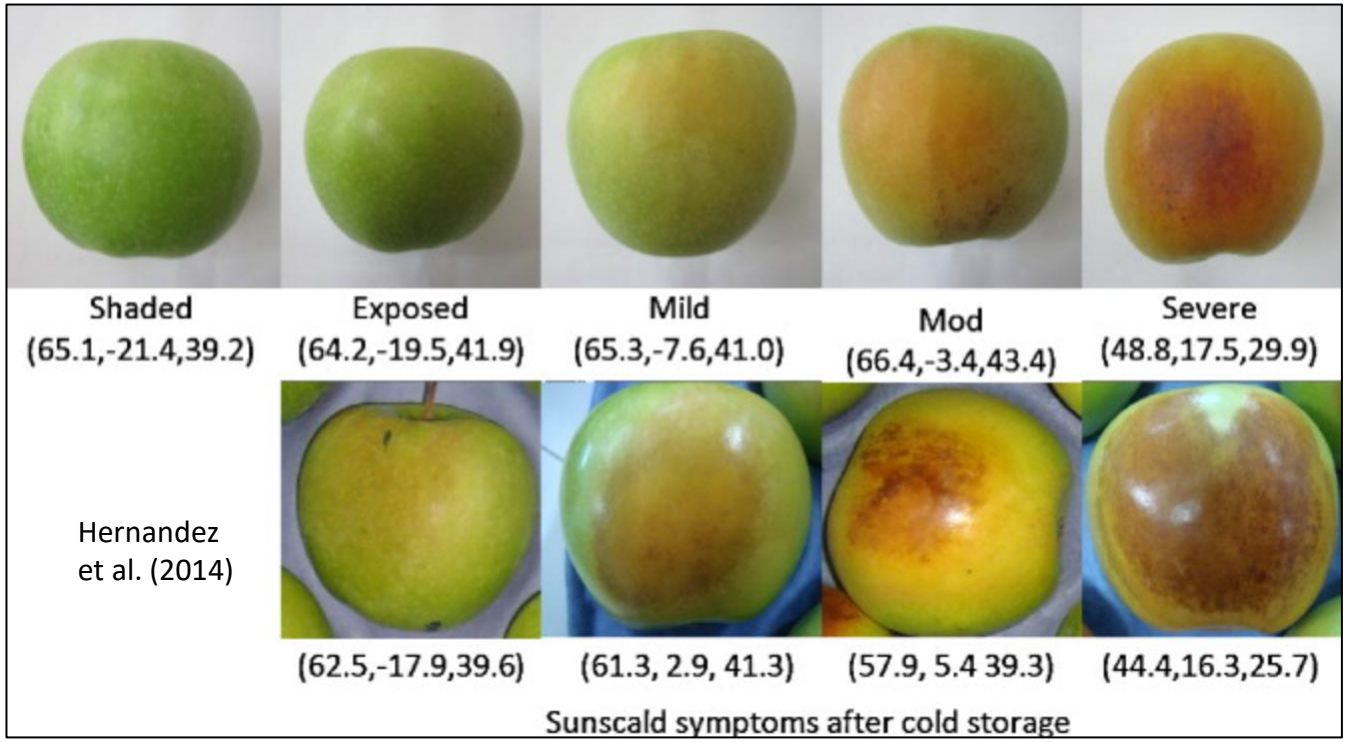


Undetected Sunburn Turns Into A Financial Loss: Sunscald

Delayed sunburn or sunscald: fruit surface browning that appears after storage.

$100 million in losses every year in Washington State.

Sunscald models predict the likelihood of sunscald development after a cold storage so fruit that's likely to develop damage in storage can be sold quickly.



Predicting Factors: Fruit Surface Temperature (FST) vs. Air Temperature

Air temperature provides the most convenient indicator of risk.

Air Temperature	Risk Level
≥ 40°C / 104°F	High Risk of Sunburn Necrosis
≥ 35°C / 95°F	High Risk of Sunburn Browning
30 to 35° C / 86 to 95°F	Variable Risk, Depending on Other Risk Factors

Other Factors That Increase The Risk of Sunburn

Calm days - hot, sunny, and calm days increase the risk.

Cool, cloudy weather followed by clear-sky days greater than 30°C.

Air humidity and drought - water stress on hot days.

Bare fallow between the tree rows - reflecting additional heat into the tree canopy.

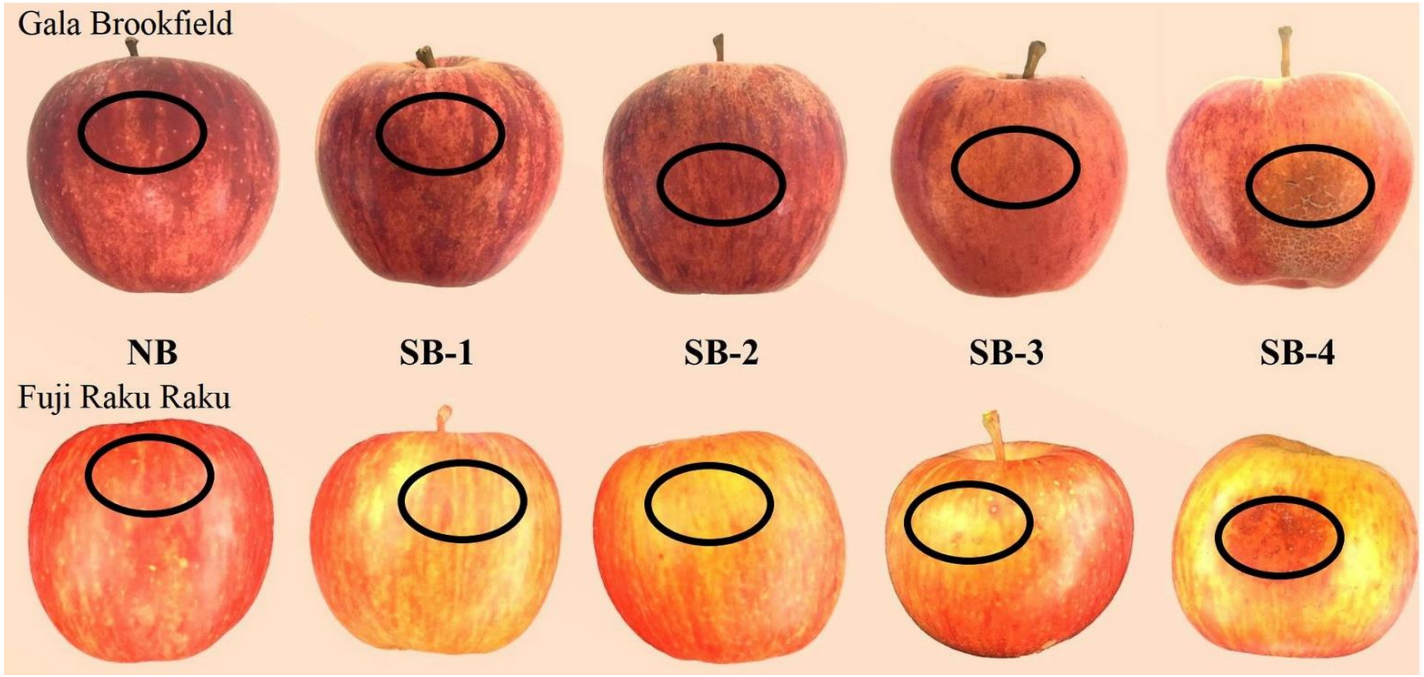
Sudden exposure to the direct sunlight - summer pruning, picked apples in bins.

Production style - high density orchard, dwarfing rootstocks, training system with a good light penetration.

www.beaulieutechnicaltextiles.com

Other Factors That Increase The Risk of Sunburn

Olivares-Soto et al. (2020)



Lotze, Daiber & Midgley (2017)

Figure 1. Sunburn classification for GD adapted by Daiber [3]

Sensitive Varieties:

Granny Smith

Royal Gala

Jonagold

Braeburn

Golden Supreme

Ginger Gold

Golden Delicious

Fuji

Cameo

Honeycrisp

Snow Sweet

Products Used In 2020 Season Trial

Materials	Description & Ingredients	Mode of Action	Company
RAYNOX Plus®	- carnauba wax, organically modified clay, and emulsifiers	- particle film reduces the amount of UV and visible light that reaches the fruit surface	Valent
Parka™ POWERED BY SureSeal	- blend of phospholipids	- a supplement for cuticle development of the growing fruit and foliage	Cultiva
VAPOR GARD® ANTI-TRANSPIRANT CONCENTRATE	- pine resin emulsion composed of 96% di-1-p-Menthene	- a physical barrier to water vapor loss from plant tissues	Miller Chemical
DrapeNet® cost effective crop protection	- complete exclusion protective netting system, white color	- shading effect	Drape Net North America

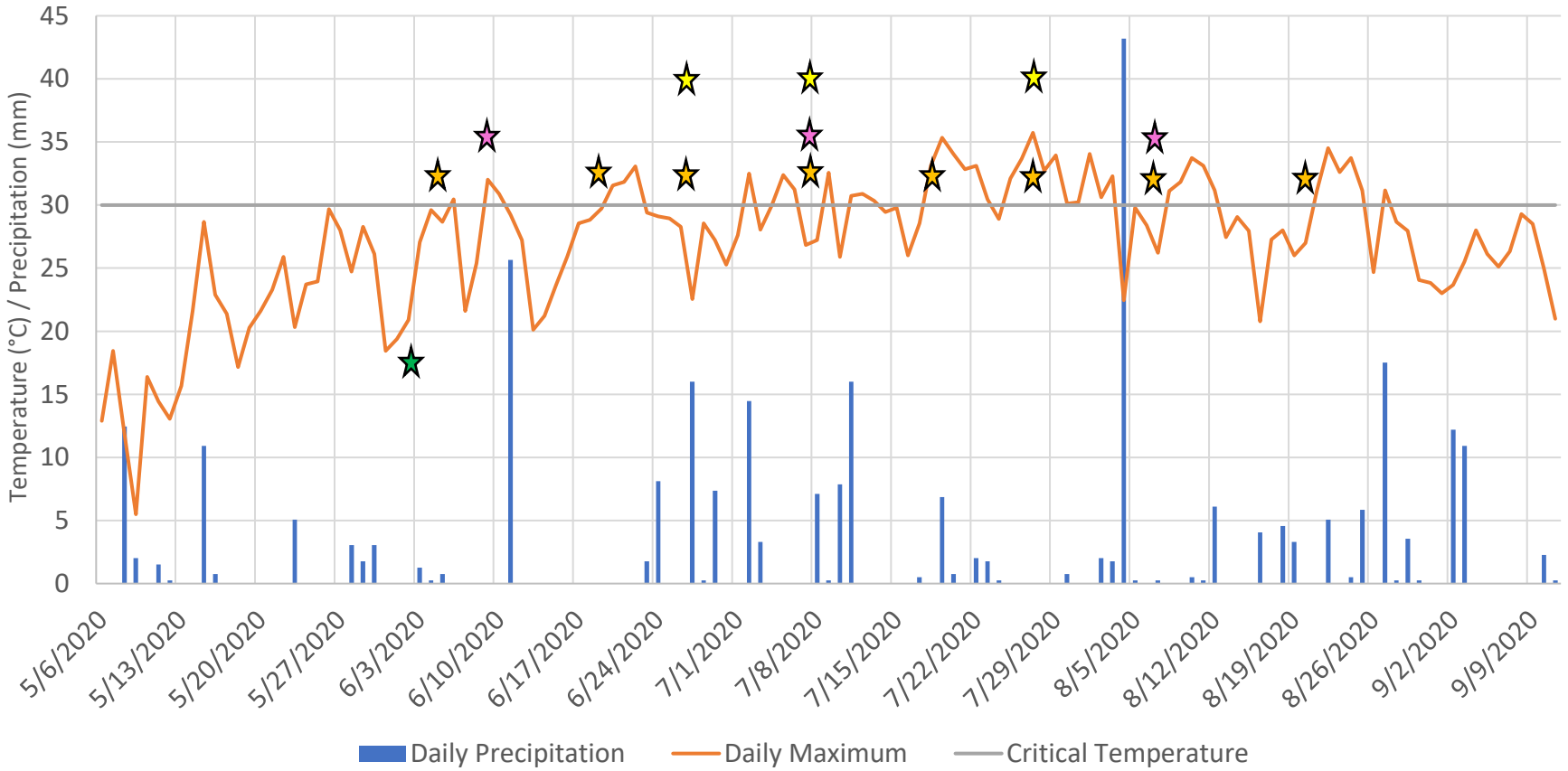
List Of Treatments

Treatment	Rate	Spray/Installation Date
1. Raynox Plus	1 Gal/A	26-June; 7-July; and 27-July
2. Parka	1 Gal/A	8-June; 7-July; and 6-August
3. Vapor Gard	1 Gal/A	4-, 18-, 26-June; 7-, 18-, 27-July; and 6-, 20-August
4. White Drape Net		2-June, and removed on 11-Sep (Honeycrisp) and 25-Sep (Snow Sweet)
5. White Drape Net + 1 WAH*		2-June, and removed on 18-Sep (Honeycrisp) and 1 Oct (Snow Sweet)
6. White Drape Net + 2 WAH		2-June, and removed on 22-Sep (Honeycrisp) and 6 Oct (Snow Sweet)

*WAH – Week after Harvest

Daily Maximum And Precipitation From Bloom To Harvest

2020 Season: 2,600 GDD (base 50°F) by Sep 1st (like 2015, the warmest year on record since 1950)



- Tall Spindle, 3 ft x 14 ft
- Honeycrisp (Nic.29.) & Snow Sweet (M.9T337, B.9.)
- CRBD: 9 blocks Honeycrisp & 3 blocks Snow Sweet

Colored stars indicate treatment applications: Raynox Plus – Yellow, Parka – Pink, Vapor Gard – Orange, and Drape Net – Green.

The Treatment Effect On Harvest Parameters

Treatment	Honeycrisp			
	Number of Fruit	Yield per Tree (kg)	Fruit Drop per Tree	Fruit Weight (g)
UTC	124.3 ab	19.1 ab	19.1 d	177.9 c
Raynox Plus	125.6 a	22.7 a	20.7 cd	202.9 a
Parka	92.6 bc	16.2 bc	24.9 bcd	188.4 b
Vapor Gard	104.3 ab	19.4 ab	24.3 bc	192.3 ab
White Drape Net	102.6 abc	17.4 bc	31.4 b	188.4 bc
White Drape Net +1WAH	95.0 abc	15.8 bc	56.3 a	199.5 ab
White Drape Net +2WAH	76.3 c	13.1 c	65.6 a	192.8 ab
p† or ChiSq‡ -statistics	0.0177†	0.0082†	<.0001†	<.0001‡

UTC – Untreated Control
WAH – Week after Harvest

The Treatment Effect On Harvest Parameters

Treatment	Snow Sweet				
	Number of Fruit	**Yield per Tree (kg)**	**Fruit Drop per Tree**	**Fruit Weight (g)**	
UTC	58.0	10.2	1.3	168.4	e
Raynox Plus	88.7	15.4	1.3	186.4	d
Parka	77.7	14.3	1.0	194.2	cd
Vapor Gard	97.7	17.4	3.7	209.6	ab
White Drape Net	86.7	15.2	5.0	186.2	d
White Drape Net +1WAH	87.3	15.2	3.0	197.3	bc
White Drape Net +2WAH	66.0	13.1	9.0	214.2	a
p-statistics	0.1056	0.1333	0.1014	<.0001	

UTC – Untreated Control
WAH – Week after Harvest

The Treatment Effect On Fruit Chemistry

Treatment	Honeycrisp					
	Fruit Firmness (kg)		Soluble Solids Concentration		TA (g/100mL as malic acid)	
	(B-side)	(NB-side)	(B-side)	(NB-side)	(B-side)	(NB-side)
UTC	7.5 ab	7.4 a	14.0	13.2	0.51	0.50
Raynox Plus	7.3 ab	7.1 ab	14.5	13.4	0.52	0.53
Parka	7.5 a	7.3 ab	14.2	13.6	0.53	0.53
Vapor Gard	7.5 ab	7.2 ab	14.1	13.0	0.51	0.51
White Drape Net	7.4 ab	7.4 a	13.8	13.0	0.52	0.54
White Drape Net +1WAH	7.3 b	7.1 b	14.5	13.3	0.50	0.50
White Drape Net +2WAH	7.2 b	7.2 ab	13.4	12.7	0.50	0.50
ChiSq -statistics	0.0005	0.0004	0.4348	0.999	0.9449	0.8256

B – Sun exposed side.
NB – Shade side.
UTC – Untreated Control.
WAH – Week after Harvest.

The Treatment Effect On Fruit Chemistry

Treatment	Snow Sweet					
	Fruit Firmness (kg)		Soluble Solids Concentration		TA (g/100mL as malic acid)	
	(B-side)	(NB-side)	(B-side)	(NB-side)	(B-side)	(NB-side)
UTC	7.9 abc	7.6 ab	14.1	13.0	0.46	0.47
Raynox Plus	7.9 bc	7.4 bc	13.4	12.0	0.39	0.38
Parka	8.2 ab	7.7 ab	13.5	12.3	0.39	0.39
Vapor Gard	7.8 c	7.2 c	13.0	12.4	0.39	0.44
White Drape Net	8.4 a	8.1 a	13.0	12.0	0.39	0.39
White Drape Net +1WAH	8.0 abc	7.9 a	13.0	12.2	0.39	0.39
White Drape Net +2WAH	7.9 bc	7.9 a	13.5	12.8	0.40	0.40
p-statistics	<.0001	<.0001	0.8035	0.2666	0.6819	0.1227

B – Sun exposed side.
NB – Shade side.
UTC – Untreated Control.
WAH – Week after Harvest.

The Treatment Effect On Fruit Color

Treatment	Honeycrisp				
	Hue (B-side)	a*/b* (B-side)	Hue (NB-side)	a*/b* (NB-side)	Blush (%)
UTC	-42.9 a	0.9 c	-33.3 b	0.2 b	48.3 b
Raynox Plus	-45.6 bc	1.2 b	-34.6 b	0.4 b	51.7 b
Parka	-43.6 a	1.0 c	-33.8 b	0.3 b	48.8 b
Vapor Gard	-46.7 c	1.3 ab	-31.8 a	0.2 b	49.8 b
White Drape Net	-44.4 ab	1.0 c	-33.2 ab	0.2 b	48.4 b
White Drape Net +1WAH	-46.9 c	1.4 a	-36.2 c	0.5 a	62.7 a
White Drape Net +2WAH	-46.7 c	1.5 a	-37.6 c	0.7 a	58.8 a
ChiSq-statistics	<.0001‡	<.0001‡	<.0001‡	<.0001‡	<.0001‡

B – Sun exposed side.
NB – Shade side.
UTC – Untreated Control.
WAH – Week after Harvest.

The Treatment Effect On Fruit Color

Treatment	Snow Sweet								Blush (%)	
	Hue		a*/b*		Hue		a*/b*			
	B-side				NB-side					
UTC	-50.2	ab	2.4	a	-42.7	b	1.4	a	77.2	a
Raynox Plus	-49.3	ab	2.1	ab	-39.0	a	0.8	c	69.4	c
Parka	-51.0	b	2.4	a	-39.1	ab	0.8	bc	70.4	bc
Vapor Gard	-48.3	a	1.8	b	-40.6	ab	1.0	abc	68.2	c
White Drape Net	-49.1	ab	2.3	a	-41.0	ab	1.1	ab	75.1	ab
White Drape Net +1WAH	-49.6	ab	2.3	a	-41.6	ab	1.1	ab	74.2	abc
White Drape Net +2WAH	-50.6	ab	2.3	a	-41.7	ab	1.2	a	71.9	abc
ChiSq-statistics	0.0088		<.0001		0.0117		<.0001		<.0001	

B – Sun exposed side.
NB – Shade side.
UTC – Untreated Control.
WAH – Week after Harvest.

The Treatment Effect On Honeycrisp Sunburn Incidence

Treatment	'Honey Crisp'		
	Total Sunburn (%)	**PS (%)**	**SB (%)**
UTC	9.6	0.7	8.9
Raynox Plus	11.5	2.6	8.5
Parka	8.9	1.5	7.4
Vapor Gard	12.6	2.6	10.0
White Drape Net	11.5	1.1	10.7
White Drape Net +1WAH	13.8	0.6	13.2
White Drape Net +2WAH	10.8	1.5	9.4
ChiSq -statistics	0.4702	0.1627	0.3198

UTC – Untreated Control.
WAH – Week after Harvest.
SB – Sunburn Browning
PS – Photooxidative Sunburn.

UTC

Raynox Plus

Parka

Vapor Gard

White Drape Net

White Drape Net +1WAH

White Drape Net +2WAH

The Treatment Effect On Snow Sweet Sunburn Incidence

Treatment	'Snow Sweet'		
	Total Sunburn (%)	**PS (%)**	**SB (%)**
UTC	32.2	1.1	31.1
Raynox Plus	30.0	0.0	30.0
Parka	31.1	1.1	30.0
Vapor Gard	26.7	0.0	26.7
White Drape Net	30.0	0.0	30.0
White Drape Net +1WAH	34.4	1.1	33.3
White Drape Net +2WAH	33.3	0.0	33.3
p-statistics	0.8549	0.6785	0.9298

Factor	**Fruit Surface Temperature (°C)**	
Treatment	**Aug 11th AAT 31.2°C**	**Aug 31st AAT 22.1°C**
UTC	29.9 a	19.3 a
Raynox Plus	30.6 a	19.5 a
Parka	30.1 a	19.4 a
Vapor Gard	29.7 a	18.9 b
White Drape Net	30.8 a	19.5 a
ANOVA (*p*-value)	0.8468	0.0246

UTC

Raynox Plus

Parka

Vapor Gard

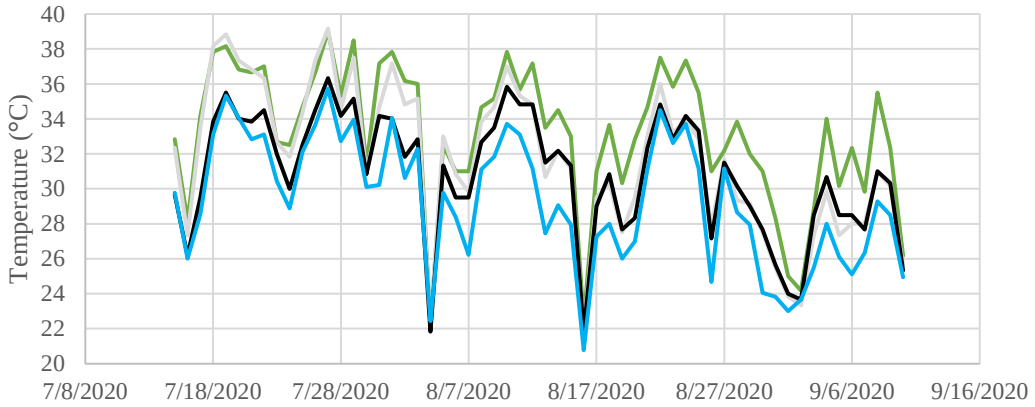
White Drape Net

White Drape Net +1WAH

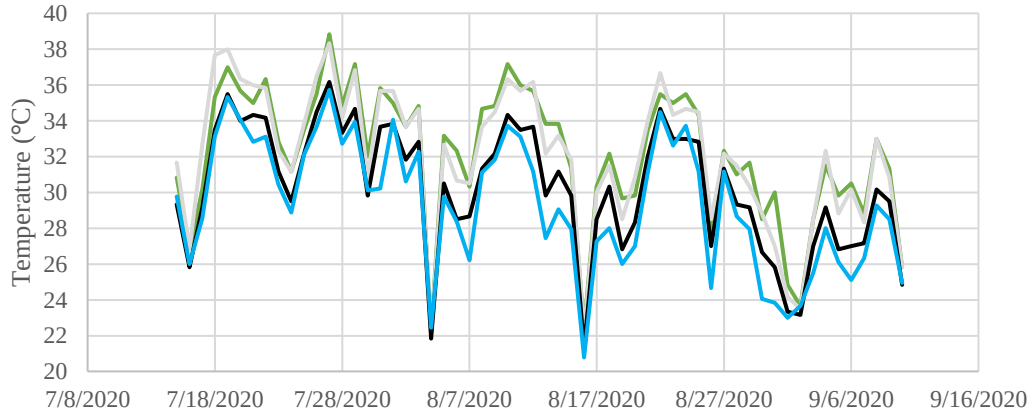
White Drape Net +2WAH

Maximum Daily Temperature of the Tall Spindle Canopy Recorded from 7/15 to 9/ 10/2020

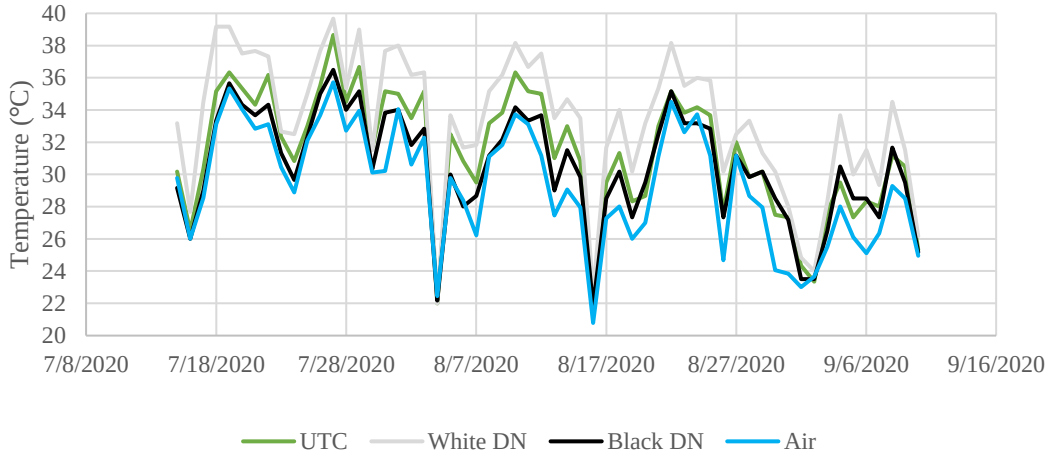
Upper Canopy



Medium Canopy



Lower Canopy



Honeycrisp's Fruit Surface Temperature Measured on August 11 and 31, 2020.

Factor	Fruit Surface Temperature (°C)	
Treatment	**Aug 11**	**Aug 31**
UTC	28.5 a	19.8 a
White Drape Net	28.6 a	20.5 a
Black Drape Net	27.0 b	18.1 b
ANOVA (*p*-value)	<.0001	<.0001
Canopy Position		
Upper Canopy	28.6 a	20.1 a
Middle Canopy	28.0 ab	19.3 b
Lower Canopy	27.6 b	19.0 b
ANOVA (*p*-value)	0.0142	0.0117
Row Side		
East	29.9 a	21.7 a
West	26.1 b	17.2 b
ANOVA (*p*-value)	<.0001	<.0001

Means followed by the same letter are not significantly different at α=0.05 according to Student's t-test.
UTC – Untreated Control.
Average air temperature on Aug 11, during period the FST measurements took place, from 9am to 2.30pm, was 30.4°C.
Average air temperature on Aug 31, during period the FST measurements took place, from 11am to 13pm was 20.5°C.

Intercepted Light in Honeycrisp Trees Covered with Drape Net, Measured on August 1 and 14, 2020.

Factor Treatment	Share of PAR intercepted by the canopy (%)
UTC	24.3 ab
White Drape Net	29.3 a
Black Drape Net	18.1 b
ANOVA (*p*-value)	0.0159
Canopy Position	
Upper Canopy	52.4 a
Middle Canopy	12.7 b
Lower Canopy	6.6 c
ANOVA (*p*-value)	<.0001

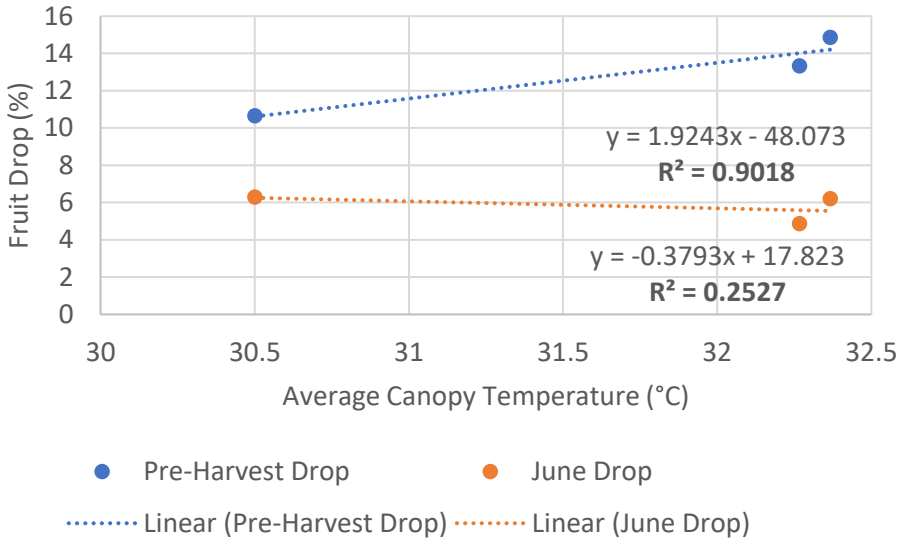
Means followed by the same letter are not significantly different at α=0.05 according to Student's t-test.
UTC – Untreated Control.
Level of the photosynthetic active radiation (PAR) was measured on August 1 and 14, 2020

Drape Net Effect on Honeycrisp's Per-Harvest Fruit Drop

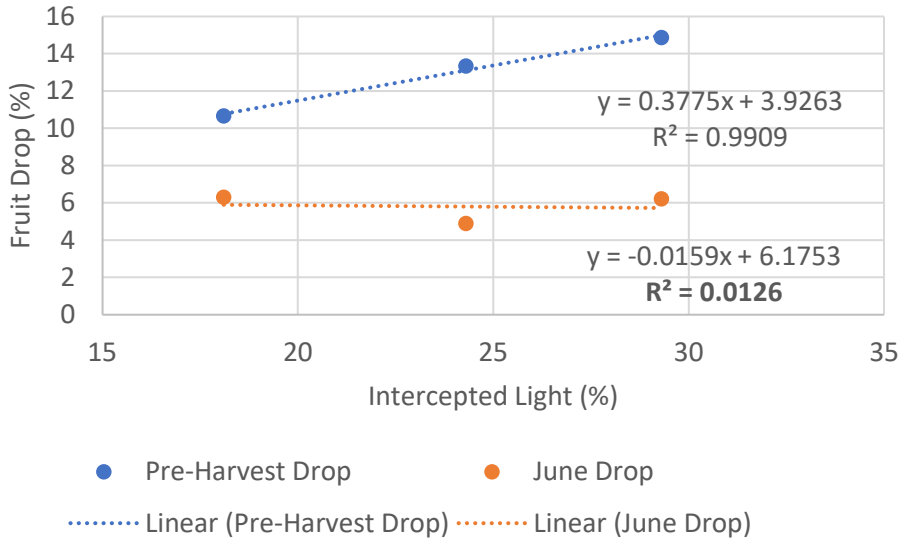
Treatment	Fruit Set (%)	June Drop (%)	Number of Fruits at Harvest (Sep. 9)	Yield per tree (kg)	Pre-Harvest Drop (%)
UTC	15.3	4.9	95.1	19.1	13.3
White Drape Net	17.4	6.2	109.7	20.1	14.9
Black Drape Net	14.8	6.3	99.0	16.8	10.7
ANOVA (*p*-value)	0.1729	0.5725	0.3867	0.1495	0.3808

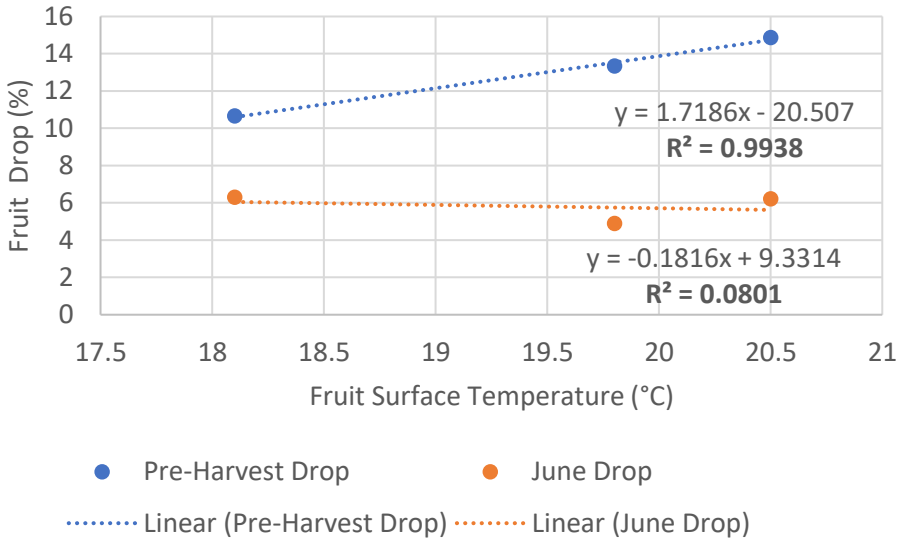
Means followed by the same letter are not significantly different at α=0.05 according to Student's t-test.
UTC – Untreated Control.

Do Canopy Temperature And FST Affect Fruit Drop?



Does the Intercepted Light Affect Fruit Drop?





Sunburn Damage: Conclusions

1. The postponed harvest of Drape Net covered Honeycrisp can improve fruit color development.

2. Spray products (Raynox Plus®, Parka™, and Vapor Gard®) and Drape Net White did not control sunburn incidence in Honeycrisp and Snow Sweet in 2020.

3. Additional shading and altered canopy temperature caused by Drape Net does not affect June drop. However, more light penetration into the canopy and higher FST promote pre-harvest drop.

Thank You For Your Attention

- Financial Support:

  Apple Research and Development Program.

  Toward Sustainability Foundation

  Cultiva

  Drape Net North America

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  Meaghan McElroy