Crop Load Management for Best Economic Results

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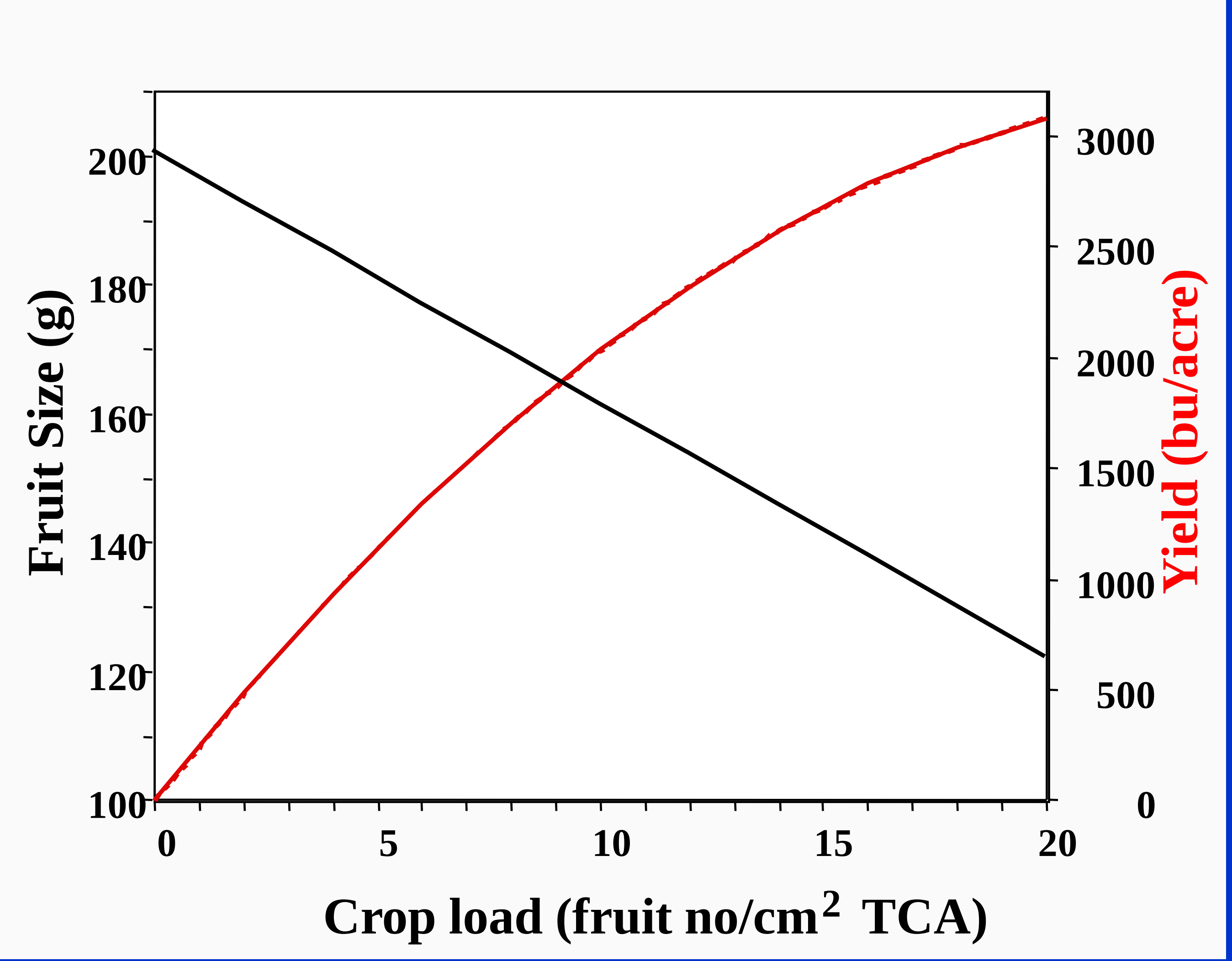
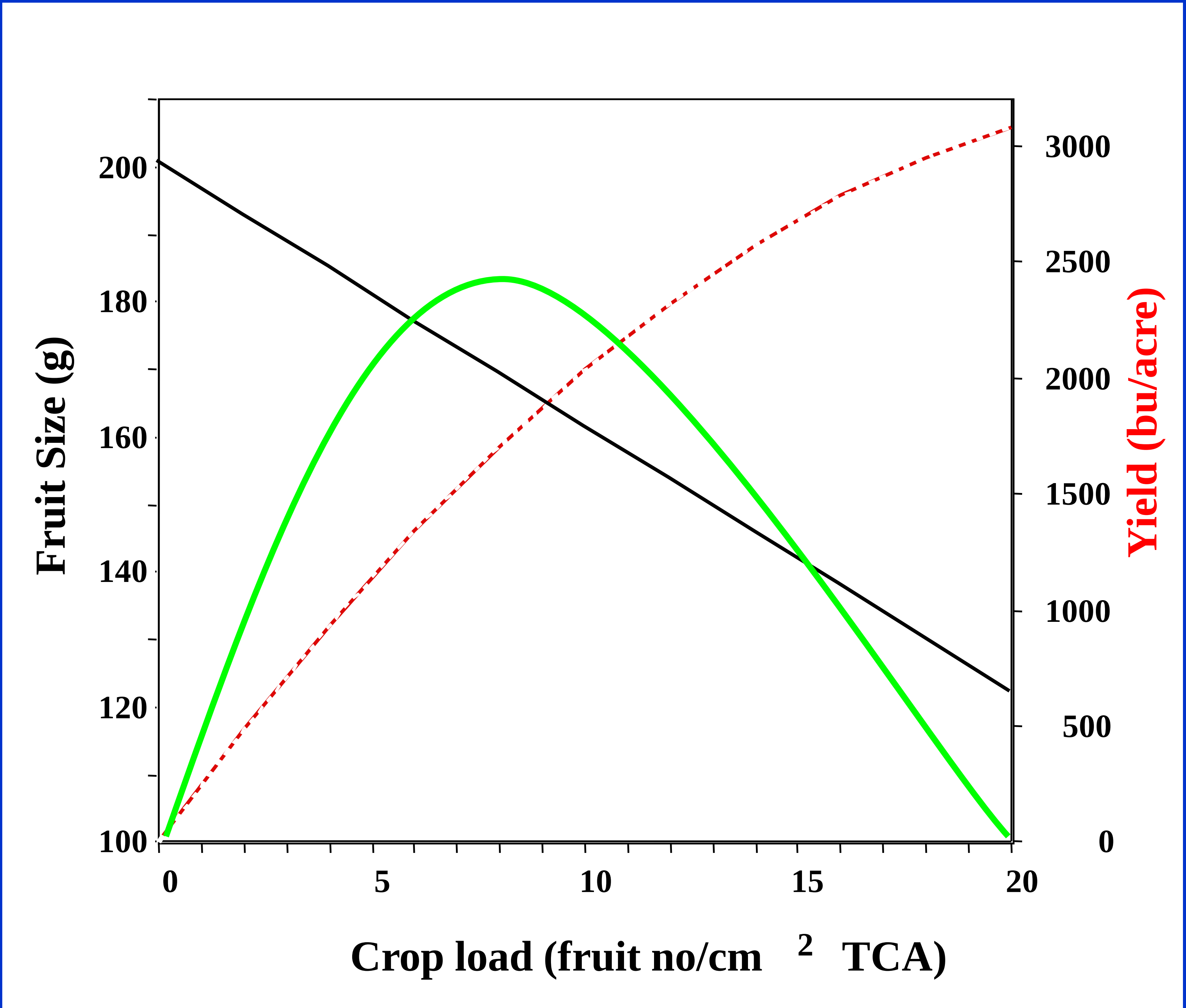
The Counter Balancing Responses to Crop Load Adjustment

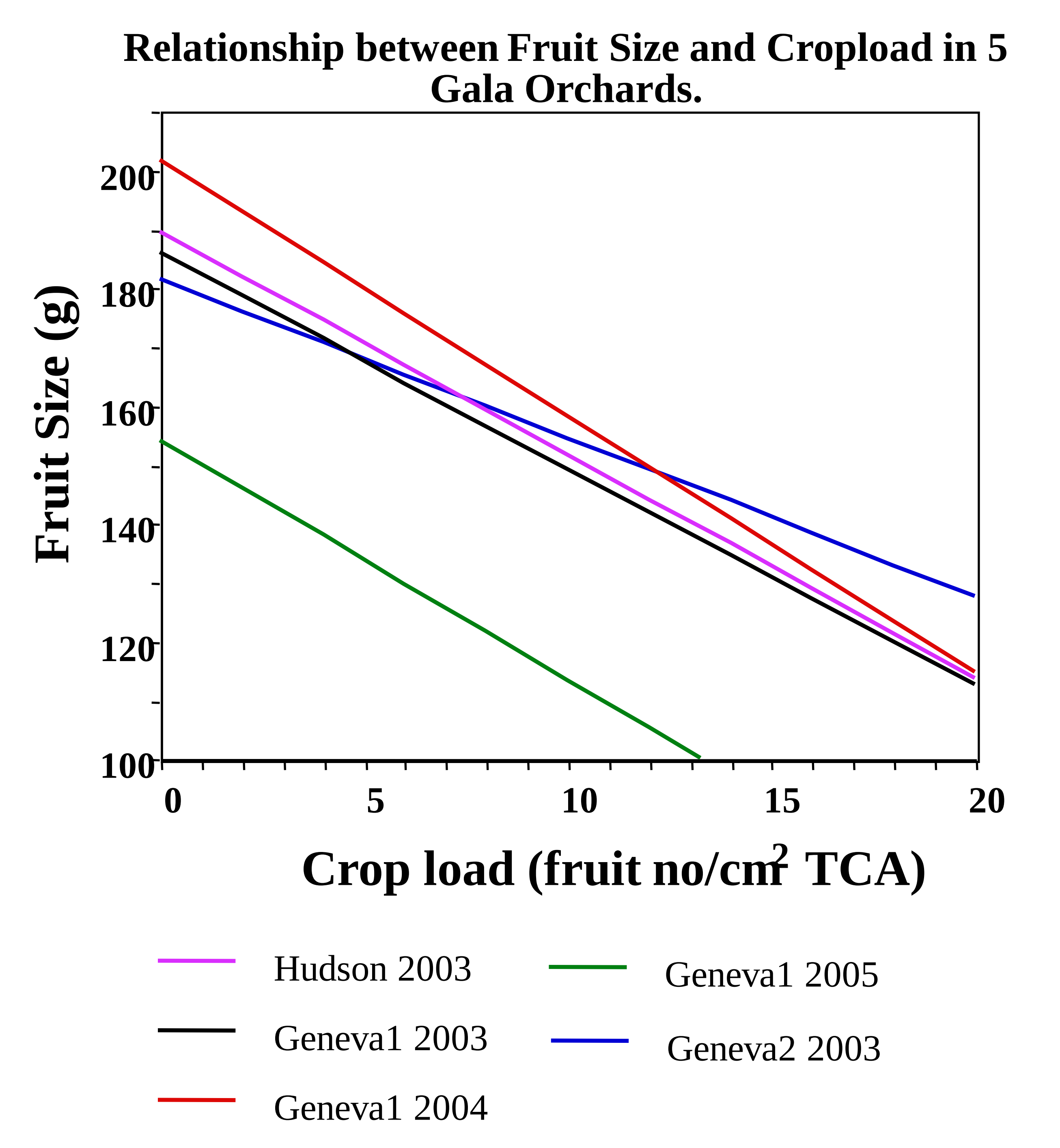
- As crop load is reduced by thinning (or by pruning) fruit size of the remaining fruits increases.
- As crop load is reduced by thinning (or by pruning) yield is also reduced.
- The best way to evaluate the benefits or costs of thinning is to convert yield/acre to crop value/acre taking into consideration fruit size.



The Optimum Crop Load is When Crop Value is Maximized

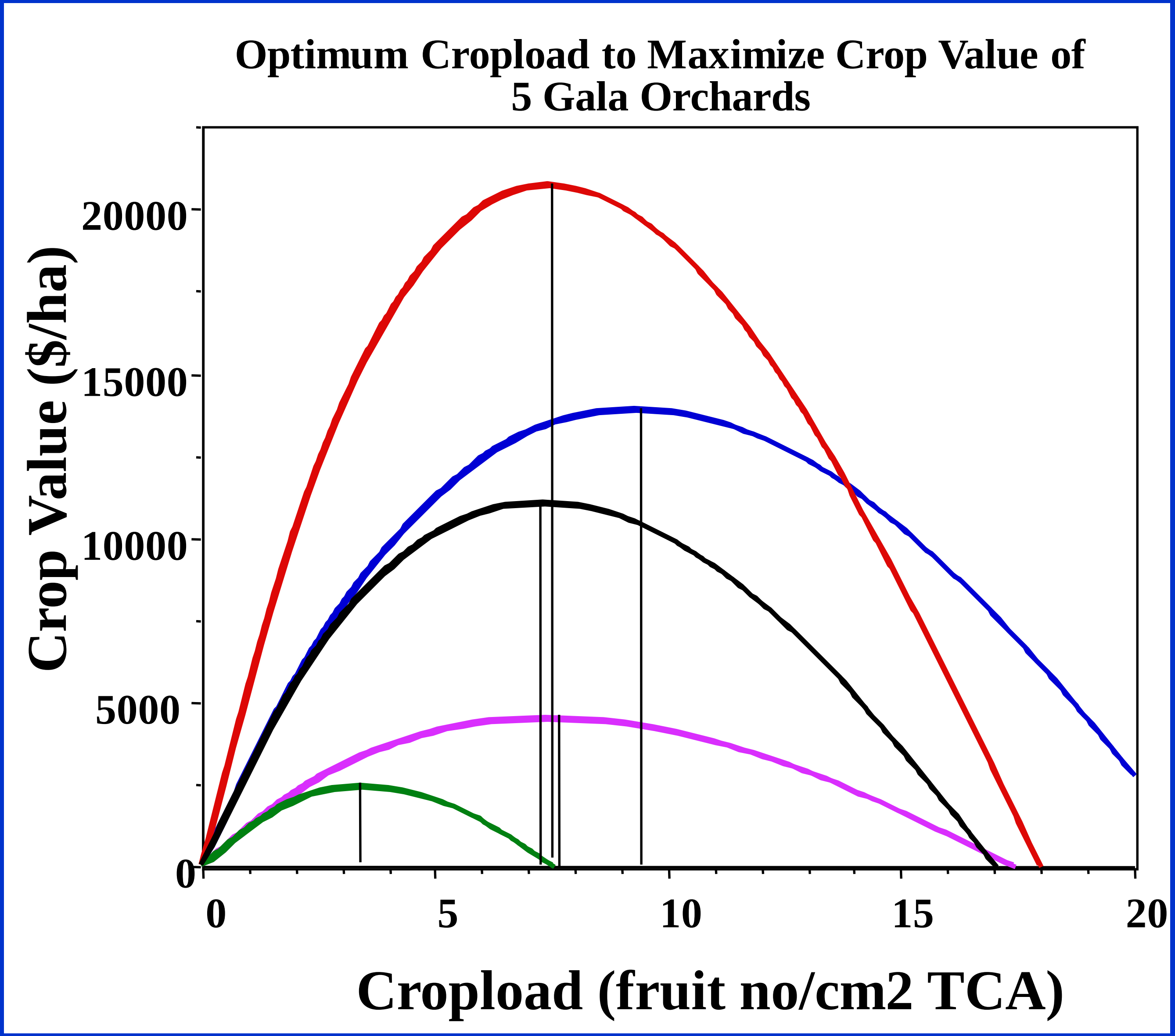


In most years there is a strong relationship between fruit size and crop load.

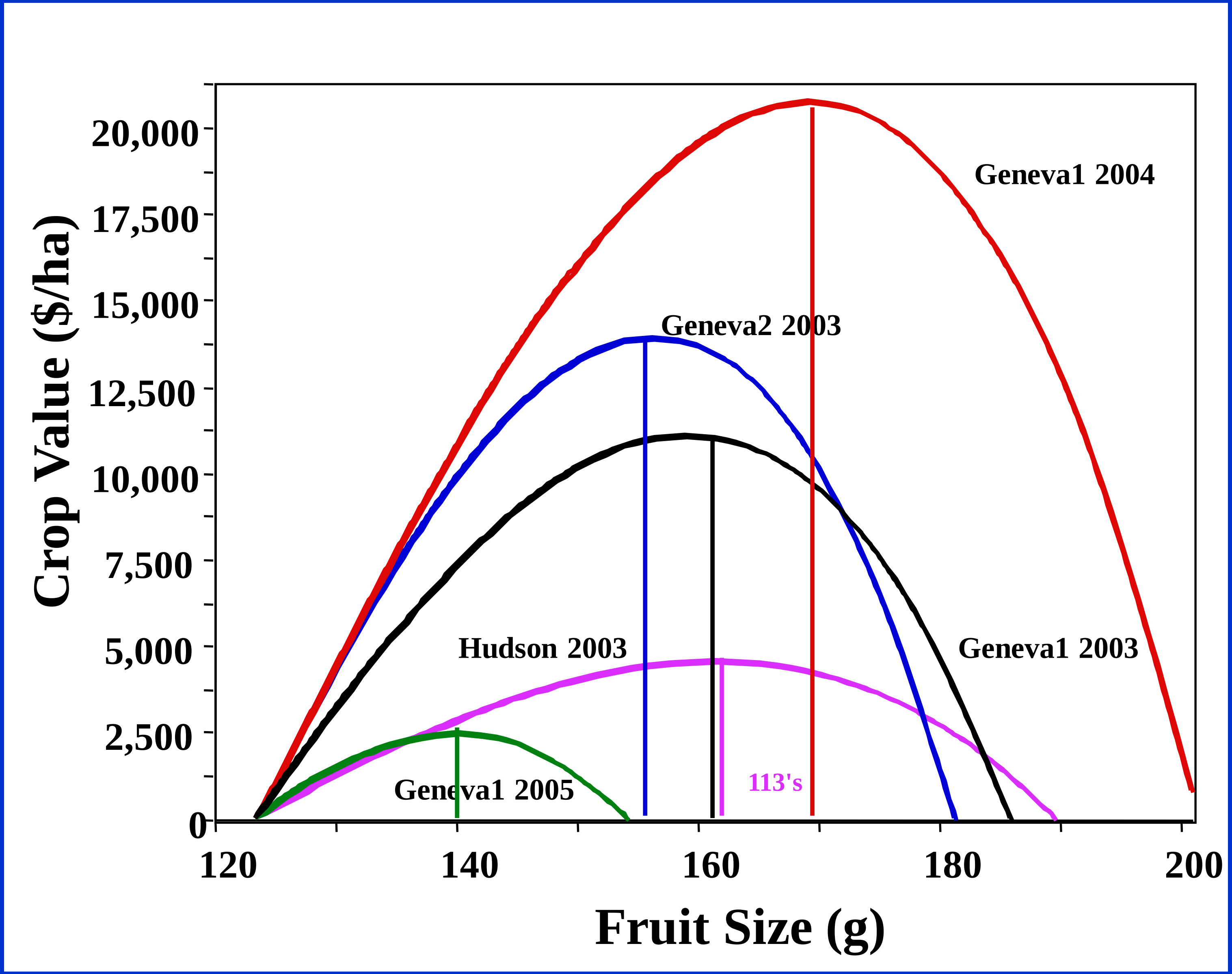


What is the Optimum Crop Load?
What is the Optimum Thinning Level?

- In 2003-2004 four Gala orchard of the same age but with different tree sizes had optimum crop loads of 7-10.5 fruits/cm^2 TCA.
- In 2005 which was a dry year the optimum was significantly lower.

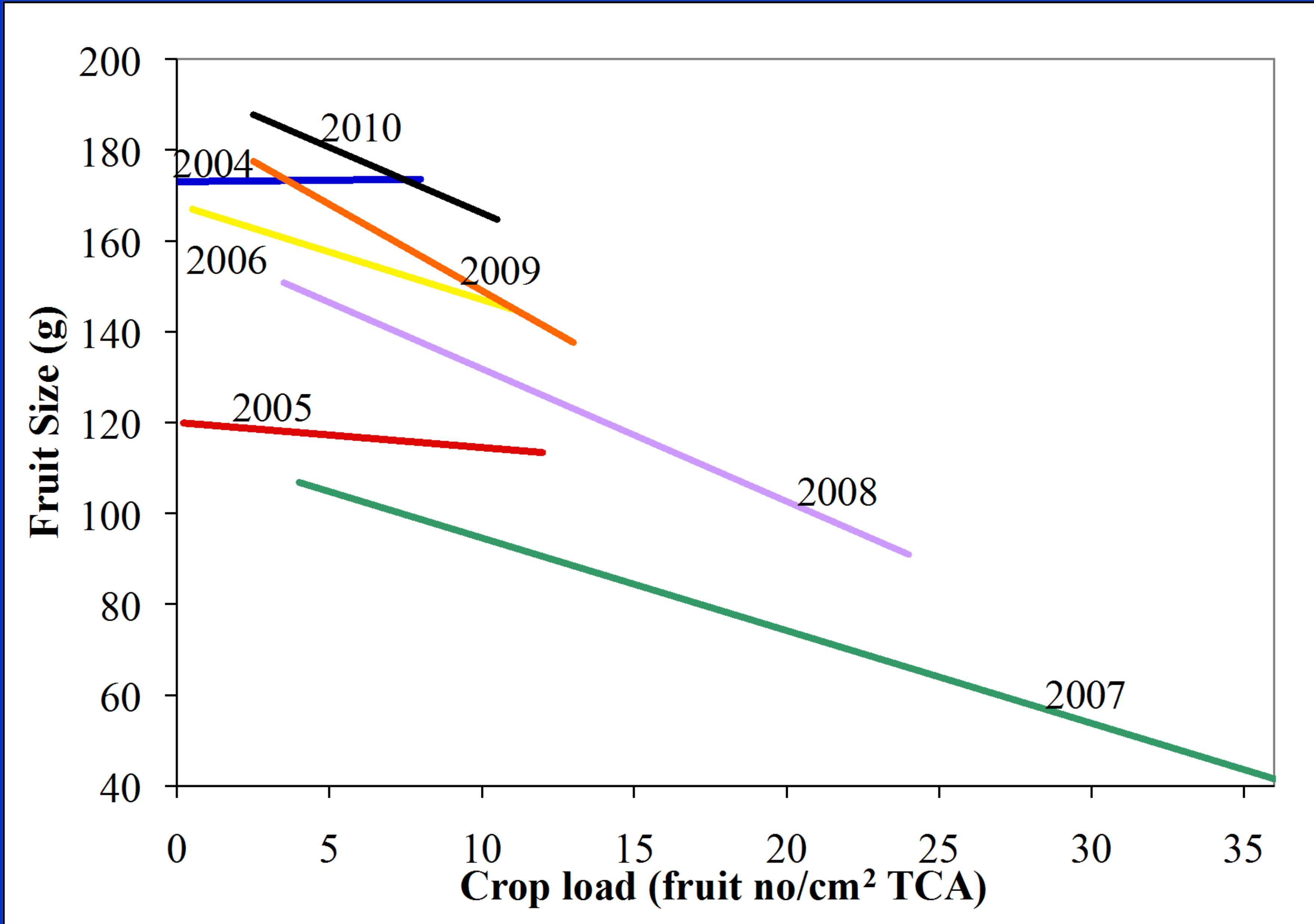


What Fruit Size will Give the Greatest Returns?



The optimum fruit size for Gala appears to be 100 count fruit (~170g) except in dry years.

Variability in Fruit Size Between the Years



Fruit size of Gala in 2007 was 70g less than in 2010

Variability in Thinning Efficacy is Caused by:

1. The chemical thinner concentration
2. Fruit Size
3. The application process
   - -sprayer setup- water volume, air speed, droplet size
4. The chemical uptake process
   - -cuticle thickness
   - -environment during and after applying the chemical (temperature, humidity, application coverage, drying conditions)
5. The sensitivity of the tree
   - -bloom density (bud load)
   - -initial set
   - -temperature
   - -sunlight
   - -tree vigor

Can we manage crop load more precisely?

Precision Crop Load Management

1. Adjust bud load by pruning to a specific flower bud number
2. Use multiple applications of chemical thinners to achieve to a specific fruit number
3. Hand thin to a specific fruit number

Calculation of Desired Fruit Number

1. Determine desired yield/ha (75 t/ha) and desired fruit size (200 g)=375,000 fruits/ha

   (375,000 fruits per ha / 3,000 trees/ha = 125 fruits/tree

2. Count flowering spurs on 5 representative trees at pink.

   (In this example I counted 200 flowering spurs/tree X 5 flowers per spur = 1,000 potential fruits/tree)

3. Calculate % fruits needed (thinning task) (125 fruits per tree/1000 potential fruits per tree = 12.5%

4. Calculate the optimum bud load per tree (125 fruits/tree X 1.5 = 188 buds per tree)

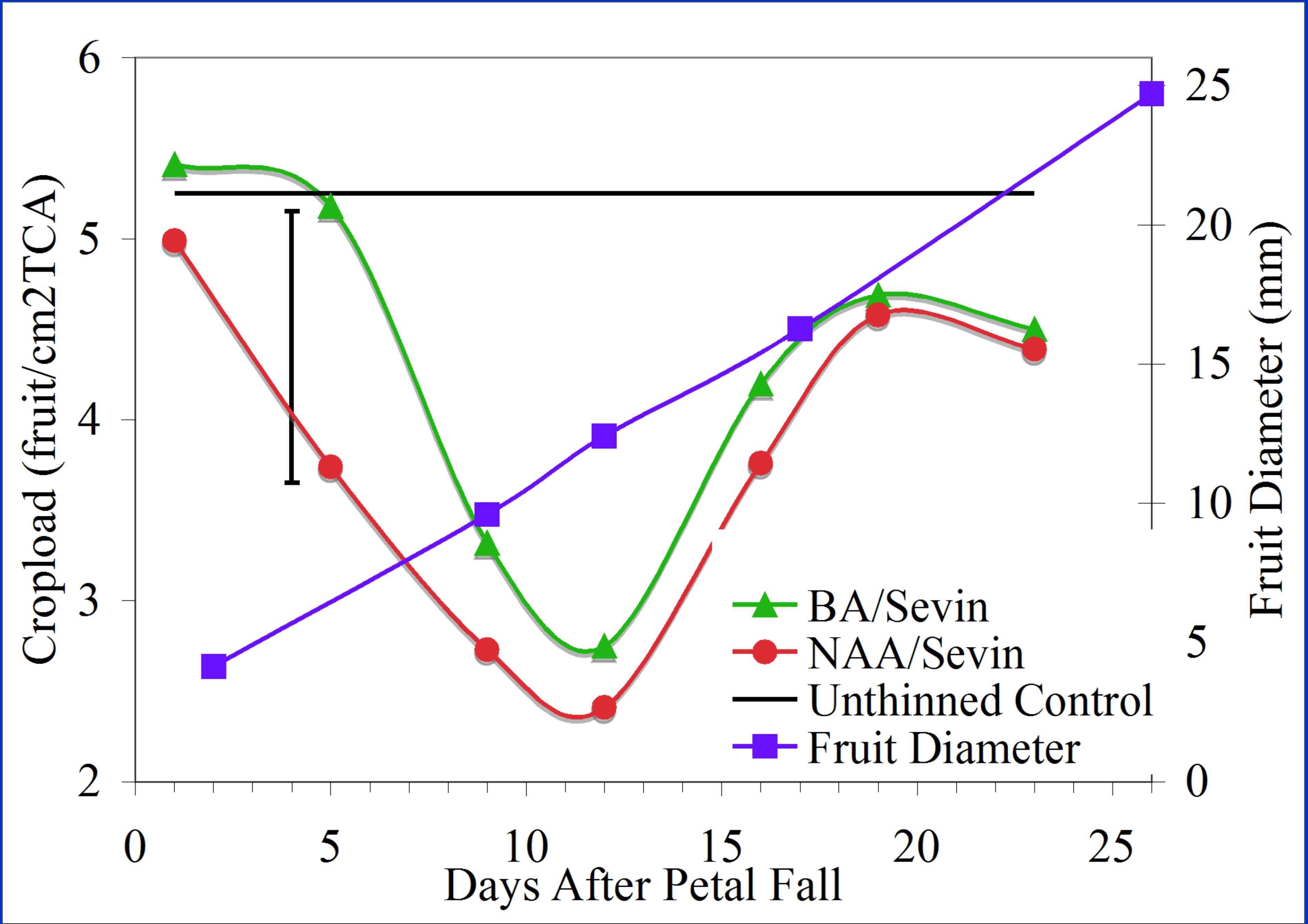
Using the Pruning Shears to Thin (Reducing Bud Load)
Target 1.5 flower buds : 1 final fruit

Range of Pruning Severities for Gala in 2013

Orchard	Ratio of F. Buds : Final Fruit Number
1	1.13
2	1.31
3	1.47
4	1.64
5	1.74
6	1.82
7	1.83
8	1.85
9	1.94
10	2.05
11	2.11
12	2.64
13	2.70
14	2.88
15	3.26

Orchard	Ratio
16	3.48
17	4.38
18	5.80
Average	2.39

Variability in Chemical Thinning Efficacy Within a Season



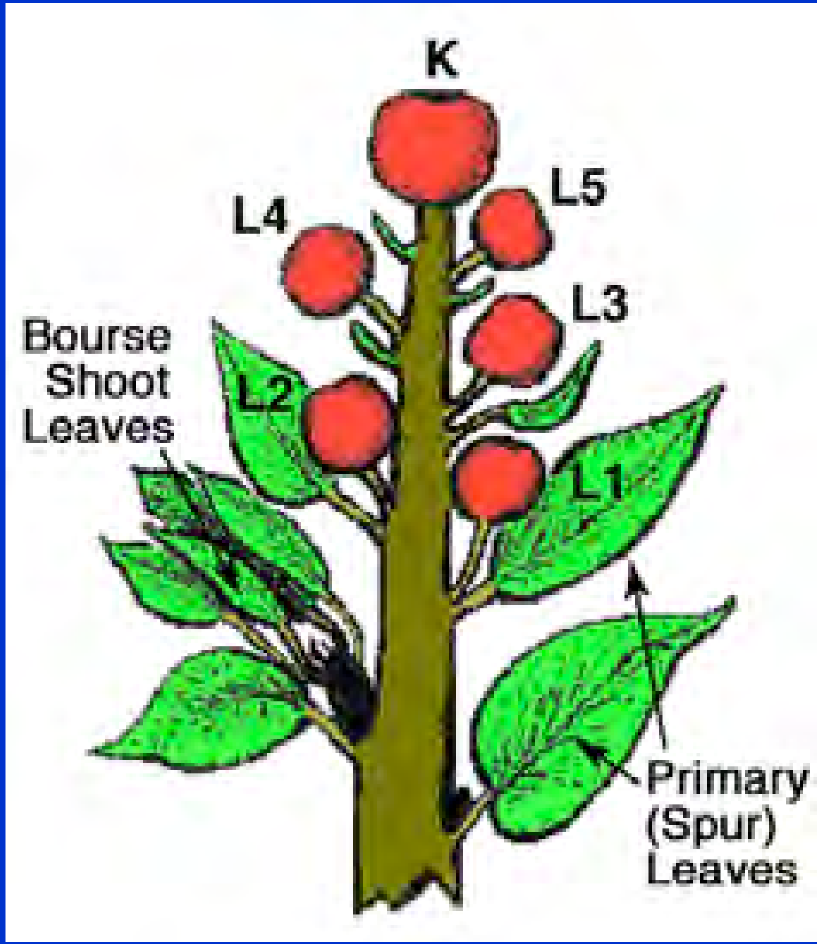
During the chemical thinning window there is competition for resources between sinks :

1. Between fruits in the cluster
2. Between adjacent clusters
3. Between fruits and shoots
4. Between shoots and roots

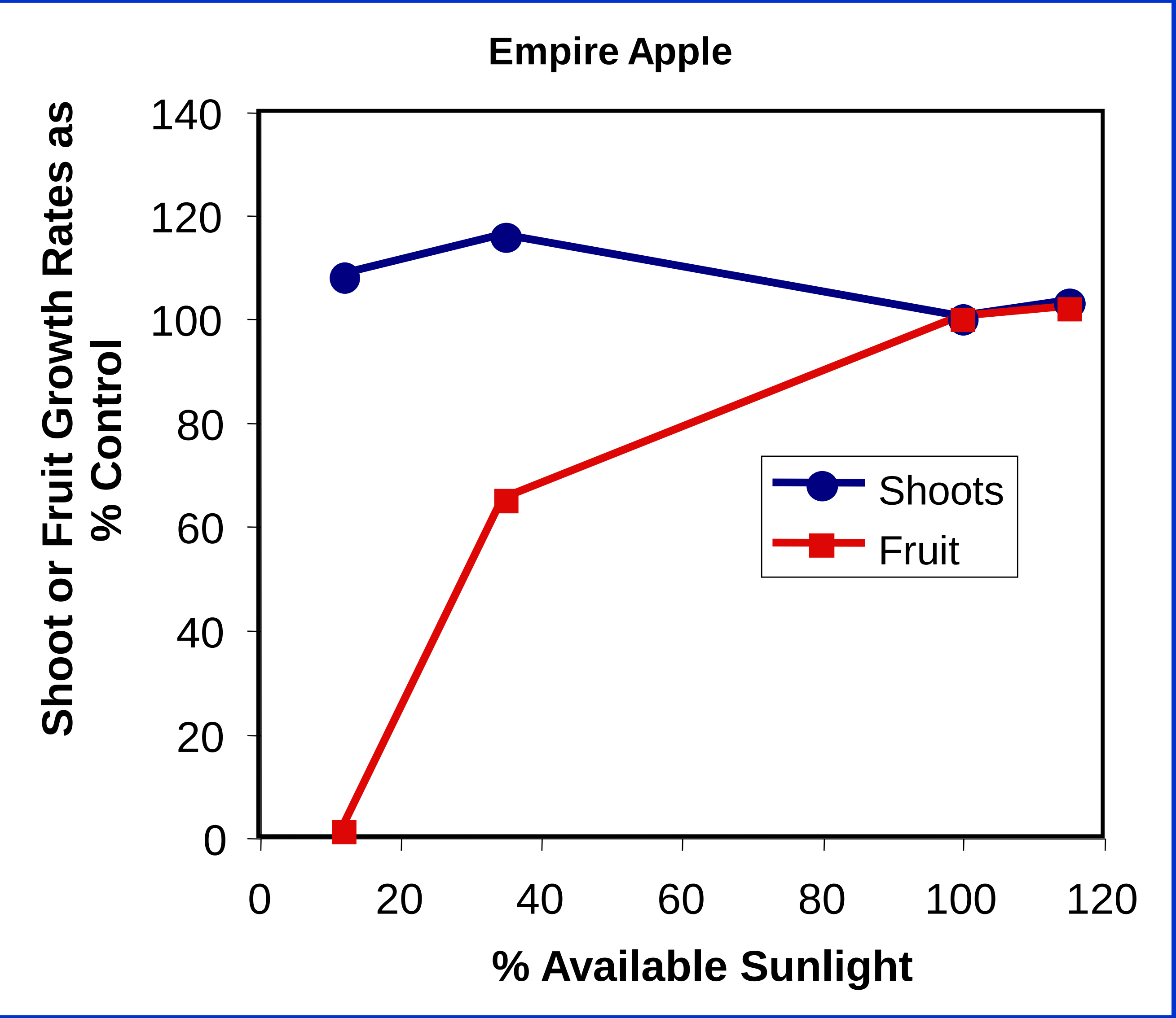
A Carbon Based Hypothesis of Fruit Growth and Abscission

Fruitlet sensitivity to chemical thinners is primarily a function of carbon supply available for fruit growth from current production.

- Temperature and sunlight influence the trees carbon production.
- Temperature affects demand from competing sinks and demand from fruits.
- When demand for fruit growth exceeds supply from current production the least competitive fruits abscise.
- Trees are more susceptible to chemical thinners when carbon supply is limiting and less susceptible when carbon is ample.



Competition between shoot growth and fruit growth in Empire apple trees at the time of thinning.



Shoot growth was not affected by the reduction in carbohydrates caused by shade, but fruit growth was severely reduced at lower light, defruiting the trees at the lowest light.

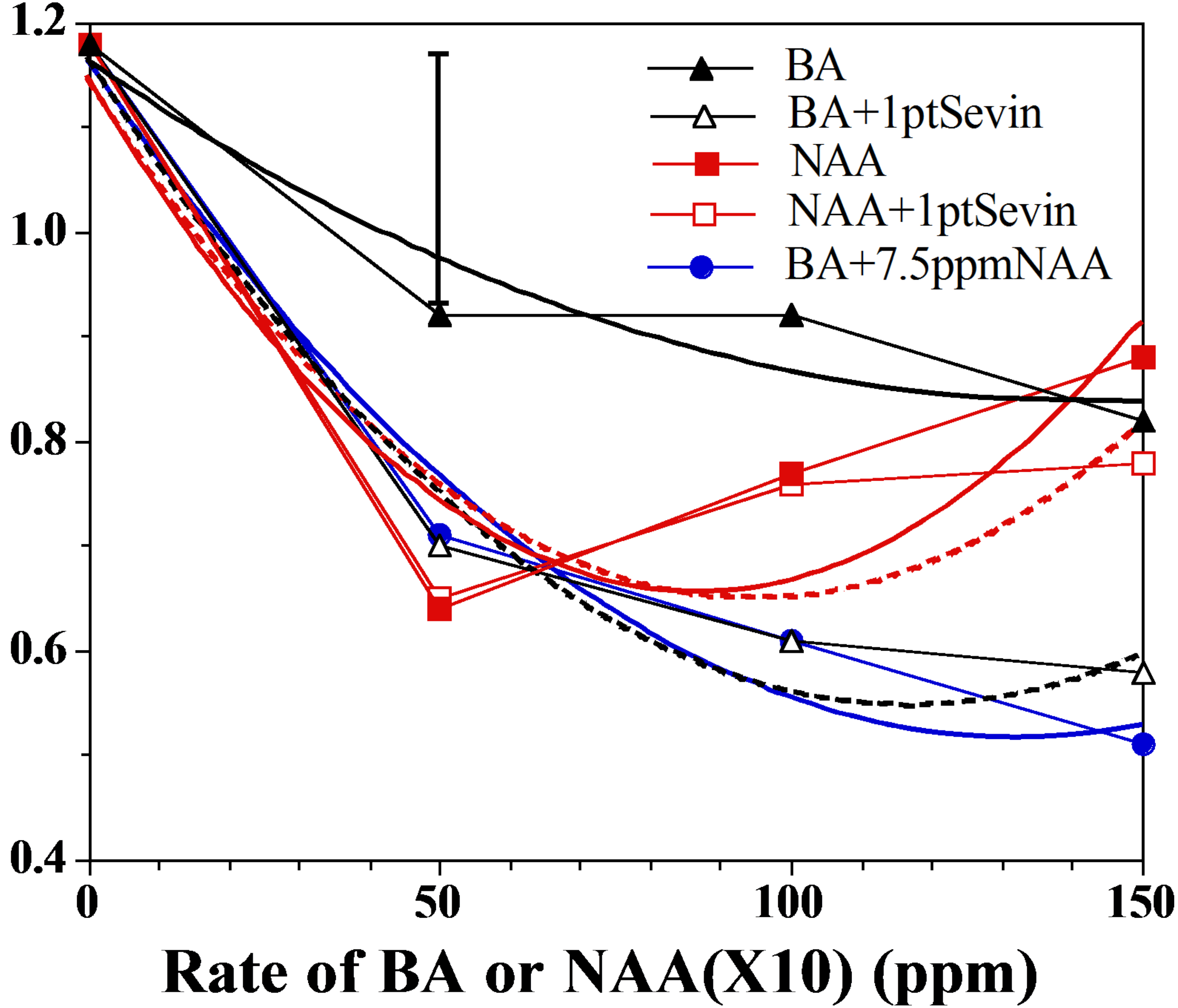
Chemical Thinning Windows

- Bloom
  - Ammonium Thiosulfate (ATS)
  - Lime Sulfur and Fish Oil
  - Promalin
  - Maxcel
  - NAA
- Petal Fall (fruits at 5-6mm)
  - Sevin
  - Maxcel + Sevin
  - NAA + Sevin
  - Maxcel + NAA
- Fruits at 10-13 mm
  - NAA + Sevin
  - Maxcel + Sevin
  - Maxcel + NAA
- Fruits at 15-20 mm
  - NAA + Sevin
  - Maxcel + Sevin + Oil
  - Ethrel + Oil

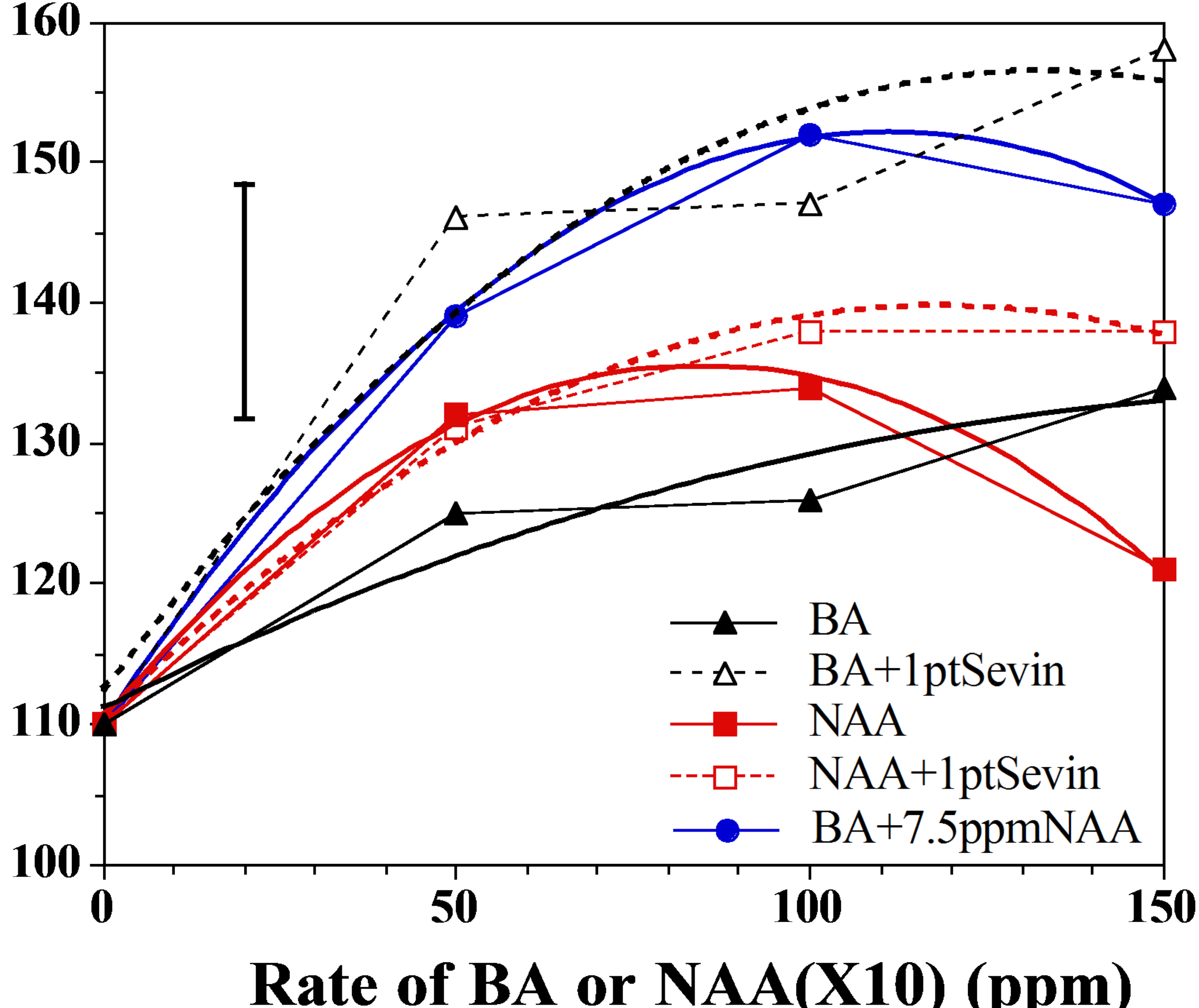
Rate of Chemical

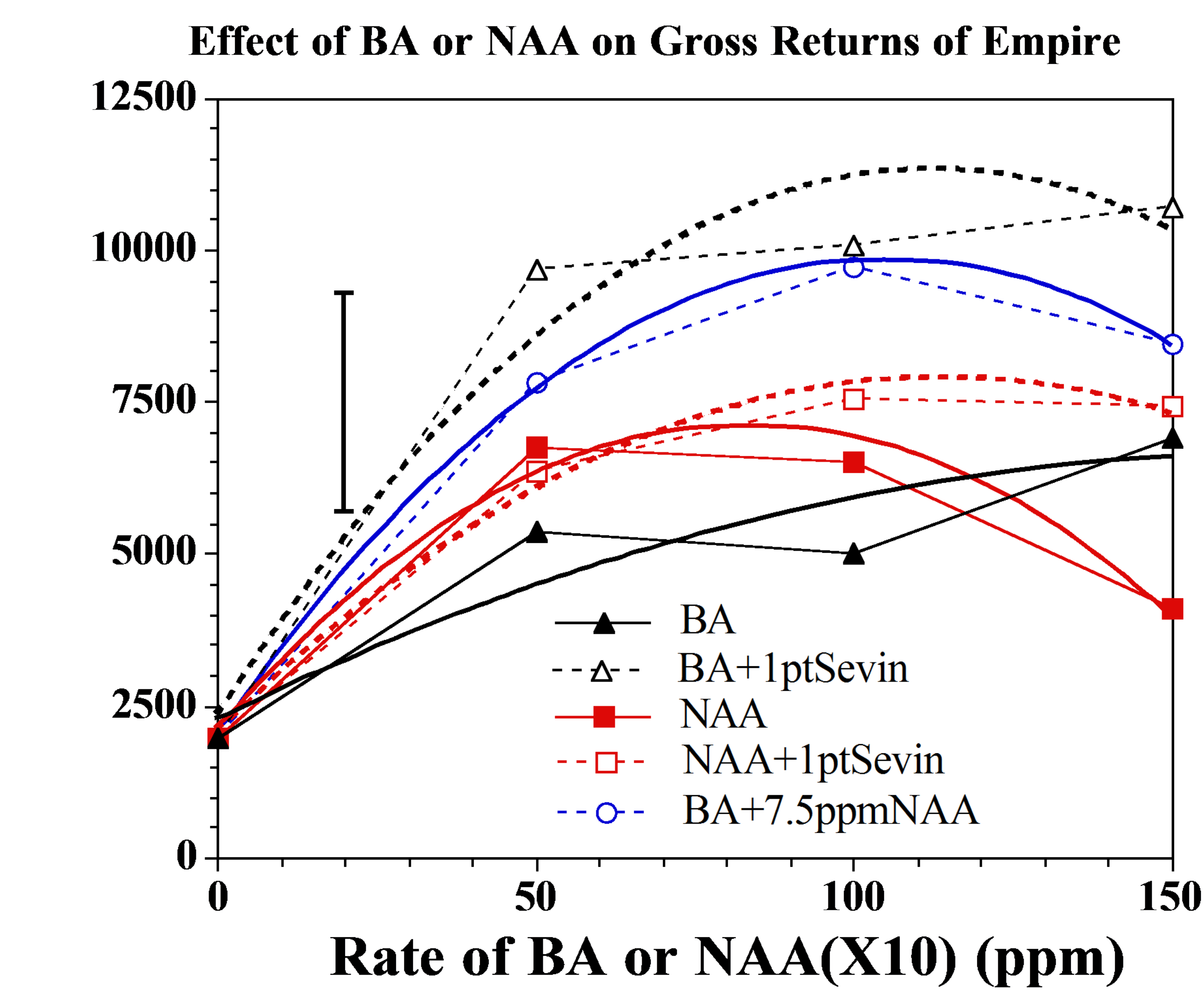
- NAA – rates from 2.5ppm-15ppm
  - good rate response in some years, but in many years there is no rate response between 5-10ppm.
  - above 15ppm suppresses fruit growth rate too much
- Maxcel – rates from 50-150ppm
  - good rate response up to 150 ppm
  - Above 200ppm causes branching
- Carbaryl – rates from 600-1200ppm
  - not rate responsive above 600ppm
- Caustic Blossom Thinners - small rate effect but at high rates can cause phytotoxicity (burning of leaves).

Effect of Rate of BA or NAA on Fruit Set of Empire



Effect of BA or NAA on Fruit Size of Empire

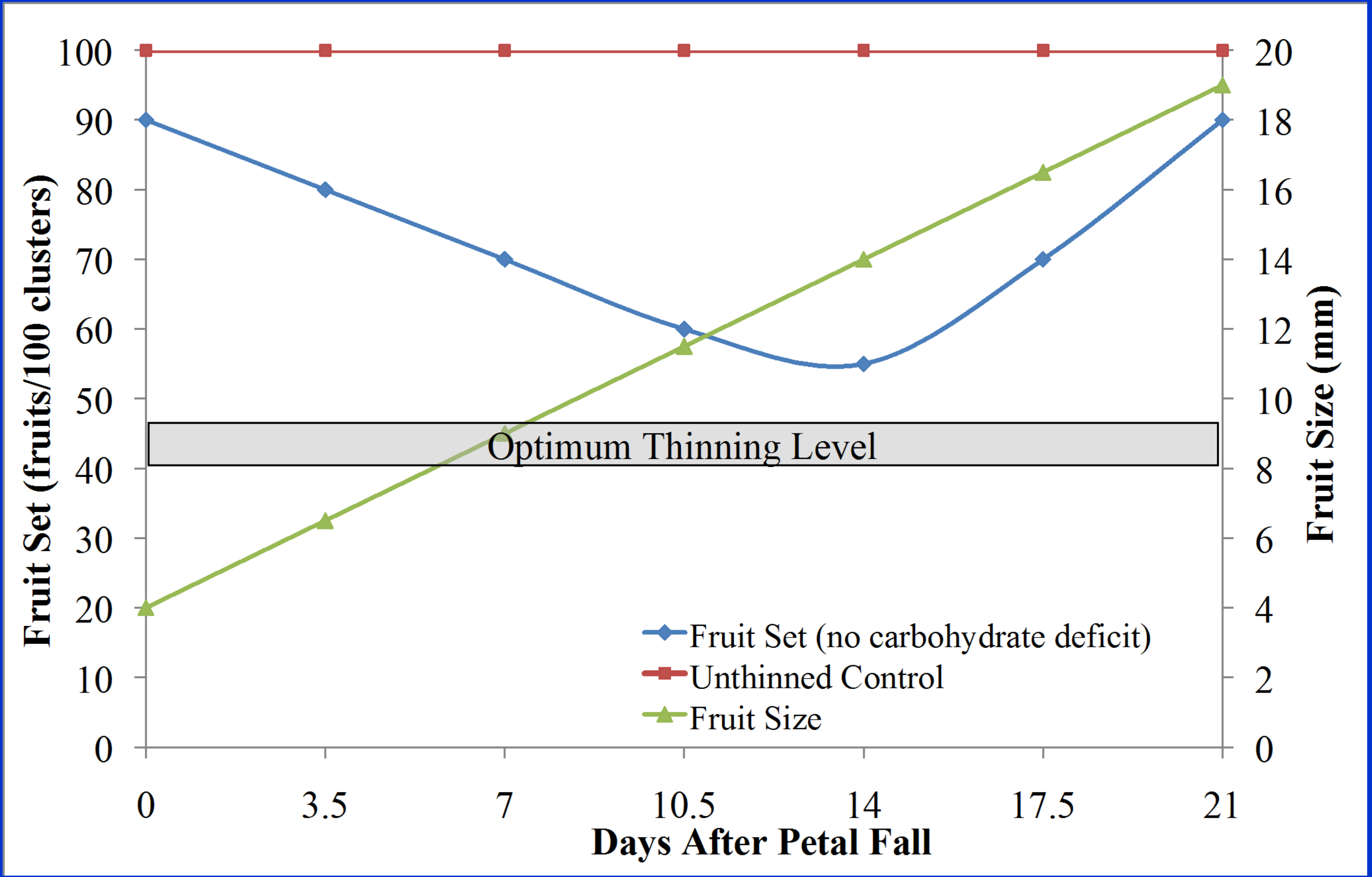



Effect of BA or NAA on Gross Returns of Empire
12500
10000
7500
5000
2500
0
0
50
100
150
Rate of BA or NAA(X10) (ppm)
BA
BA+1ptSevin
NAA
NAA+1ptSevin
BA+7.5ppmNAA

Fruit Size at Time of Application

- The greatest sensitivity to NAA is when fruit size is 10mm.
- The greatest sensitivity to BA is when fruit size is 12mm
- Recent Results: Combining 15 years of thinning trials in VA there was no significant effect of fruit size at time of application on thinning results.
- Conclusion: Weather (carbohydrate balance) is probably more important than fruit size in determining response.

Thinning Efficacy During the Thinning Window



Weather Effects:

- Dark, cloudy weather of more than 1-2 day duration reduces carbohydrate supply and results in greater natural drop and greater chemical thinning.
- High night temperatures (>60° F, 15.5° C) increase carbohydrate demand and increase natural drop and chemical thinning response.
- Very high day-time temperatures (>85° F, 29.5° C) increase carbohydrate demand and causes excessive thinning.
- Very cool temperatures (<65° F, 17° C) reduce fruit demand and results in poor thinning response.

Apple Carbohydrate Thinning

Cornell Apple Carbohydrate Thinning Model

Weather Station: Williamson (Demarree)

Select Date: 06/08/2013

Continue

Map | Results | More info

Apple Carbohydrate Thinning Model for Williamson (Demarree)

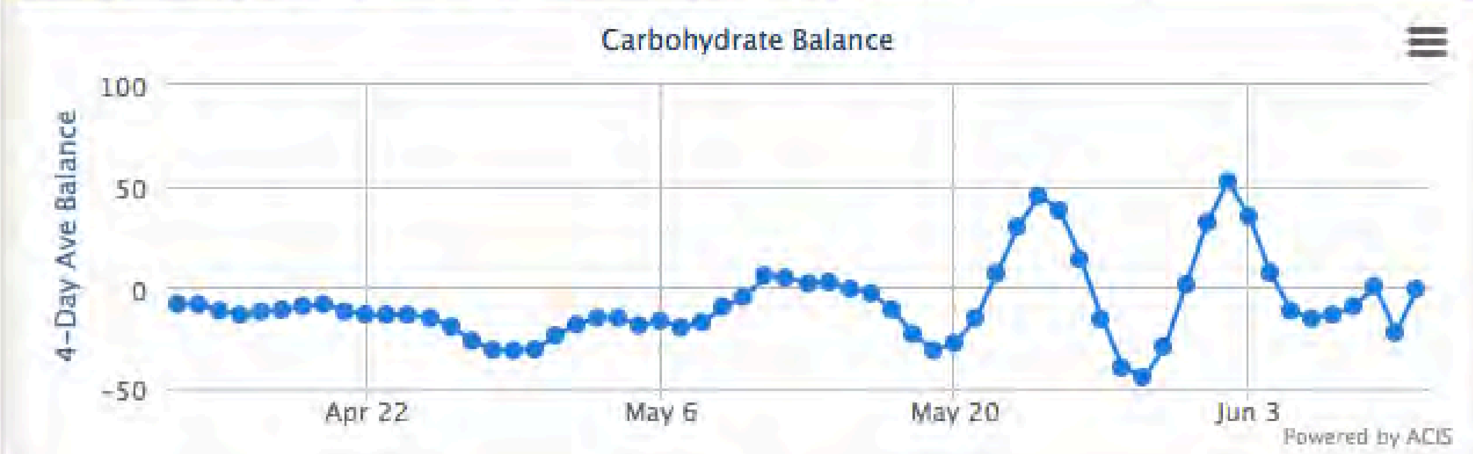
Change green tip and/or bloom date and click "Calculate" to recalculate results.

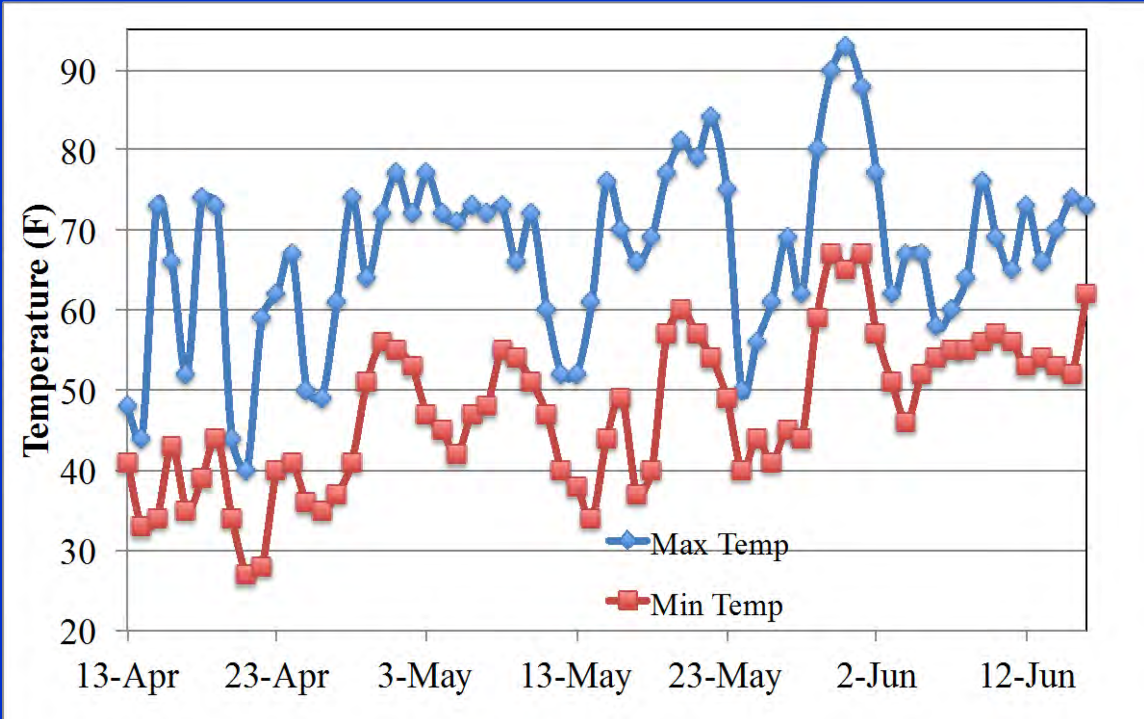
Green tip date	Bloom date	Calculate
4/13/2013	5/6/2013	

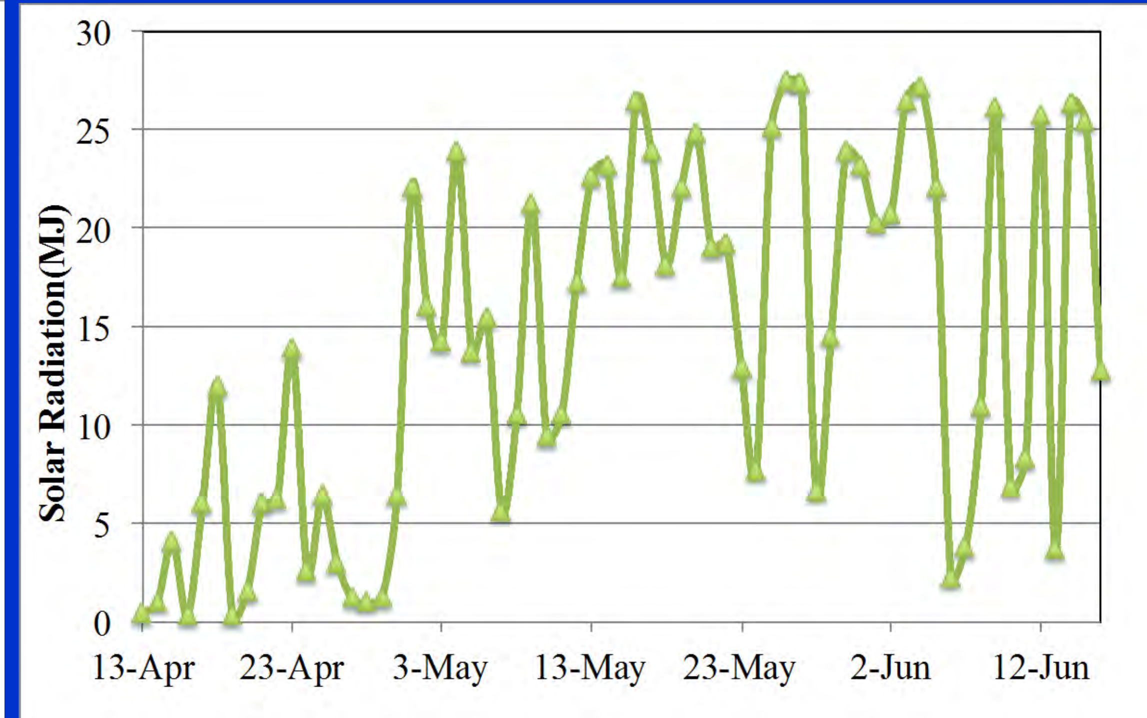
Apple Carbohydrate Thinning Model Results

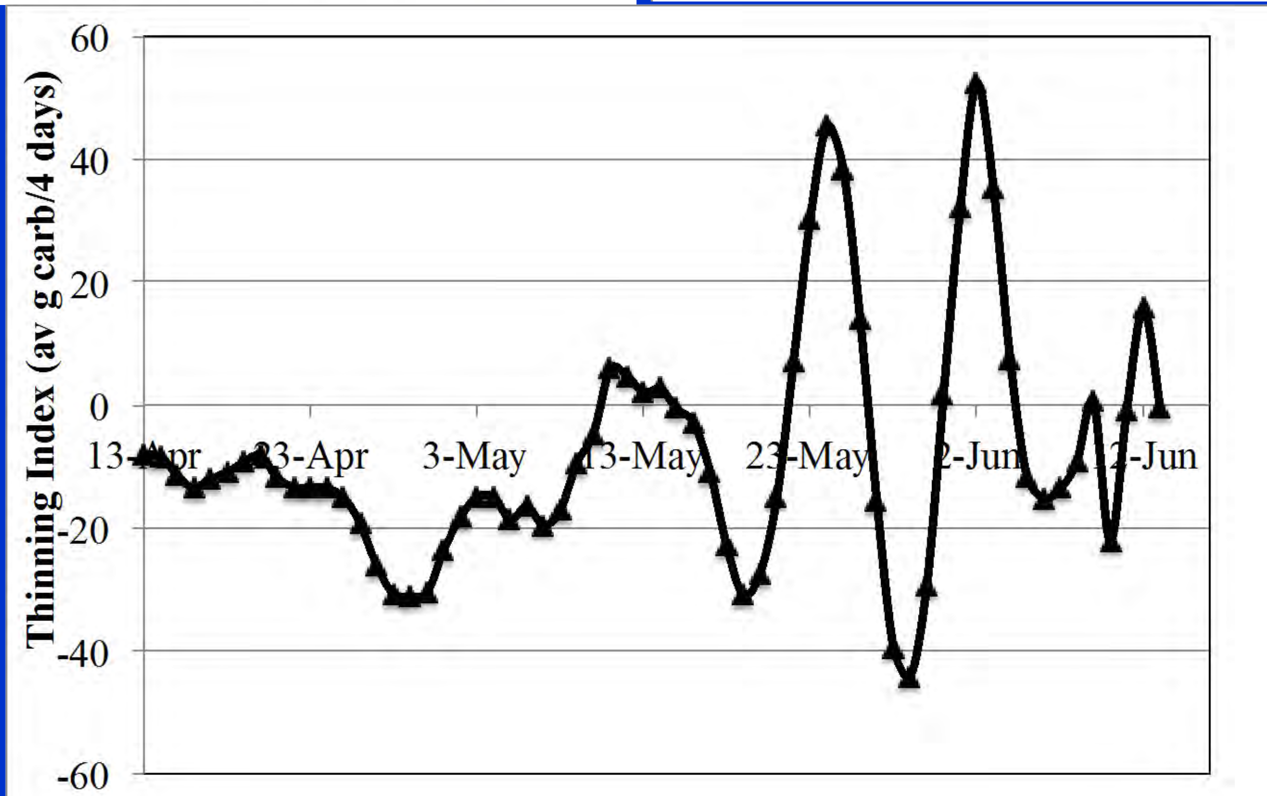
Date	Max Temp (°F)	Min Temp (°F)	Solar Rad (MJ/m2)	Tree Carbohydrate Status (g/day)				Thinning Recommendation
				Production	Demand	Balance	4-Day Ave Balance	
4/13	48	41	0.4	0.00	5.76	-5.76	-8.09	-
4/14	44	33	1.0	0.00	3.93	-3.93	-8.35	-
4/15	73	34	4.1	0.00	10.23	-10.23	-11.36	-
4/16	66	43	0.3	0.00	12.42	-12.42	-13.54	-
4/17	52	35	6.0	0.00	6.84	-6.84	-11.89	-
4/18	74	39	12.0	0.00	15.95	-15.95	-11	-
4/19	73	44	0.3	0.00	18.95	-18.95	-9.21	-
4/20	44	34	1.5	0.00	5.82	-5.82	-8.23	-
4/21	40	27	6.0	0.00	3.29	-3.29	-11.82	-
4/22	59	28	6.2	0.00	8.77	-8.77	-13.37	-
4/23	62	40	13.9	0.39	15.41	-15.03	-13.43	-
4/24	67	41	2.6	0.00	20.18	-20.18	-13.54	-

6/2	77	57	20.7	89.58	69.55	20.03	52.36	thinner rate by 30%
6/3	62	51	26.5	114.67	46.25	68.42	35.26	Increase chemical thinner rate by 30%
6/4	67	46	27.2	119.81	46.45	73.36	7.33	Increase chemical thinner rate by 30%
6/5	67	52	22.1	103.28	55.65	47.62	-11.56	Apply standard chemical thinner rate
6/6	58	54	2.3	0.46	48.83	-48.37	-15.26	Apply standard chemical thinner rate
6/7	60	55	3.8	12.01	55.31	-43.30	-13.56	Apply standard chemical thinner rate
6/8	64	55	10.9	58.45	60.63	-2.18	-9.33	Apply standard chemical thinner rate
6/9	76	56	26.2	112.14	79.34	32.80	0.57	Increase chemical thinner rate by 30%
6/10	69	57	6.9	32.78	74.34	-41.56	-22.25	Decrease chemical thinner rate by 15%
6/11	65	56	8.3	43.76	70.13	-26.37	-0.73	-
6/12	73	53	25.8	116.44	79.03	37.42		-
6/13	66	54	3.7	11.99	70.49	-58.50		-
6/14	70	53	26.4	120.09	75.55	44.54		-




Temperature (F)
90
80
70
60
50
40
30
20
13-Apr
23-Apr
3-May
13-May
23-May
2-Jun
12-Jun
Max Temp
Min Temp


Solar Radiation(MJ)
30
25
20
15
10
5
0
13-Apr
23-Apr
3-May
13-May
23-May
2-Jun
12-Jun


Thinning Index (av g carb/4 days)
60
40
20
0
-20
-40
-60
13-Apr
23-Apr
3-May
13-May
23-May
2-Jun
12-Jun

Precision Thinning

1. Calculate the desired fruit number per tree (This defines the target).
2. Use the carbohydrate model to assess tree sensitivity to a chemical thinning spray <u>before</u> application.
3. Apply a chemical thinner spray.
4. Use the fruit growth rate model to assess the effect of the chemical thinning spray <u>after</u> application.
5. Use the carbohydrate model to assess tree sensitivity before re-application of a second chemical thinning spray.
6. Use the fruit growth rate model to re-assess the effect of the second thinner.

Example of Precision Thinning of Gala

- Bloom
  - ATS (2.%)
- Petal Fall (5-6mm)
  - NAA (7.5ppm) + Sevin (1pt/100gal)
- 10-13 mm fruit size
  - Maxcel (100ppm) + Sevin (600ppm) (directed to the upper part of the tree)
- 18-20 mm fruit size (desperation spray)
  - Maxcel (125ppm) + Sevin (600ppm) + Oil (0.125%) (directed to the upper part of the tree)

Results of Precision Thinning of Gala at Geneva in 2013

Treatment	Initial Fruit Number	After Bloom Spray	After PF Spray	After 10mm Spray	After 18mm Spray	Target Fruit Number
Untreated Control	4430	1536	1217	1299	1288	335
Promalin, 3 Maxcel/S	4430	1524	992	933	673	335
Maxcel, 3Maxcel/S	4430	1051	992	981	567	335

Precision Crop Load Management and Follow-up Hand Thinning

Use the Target Fruit Number to precisely hand thin

1. Count representative trees before and after hand thinning
2. Review the results with hand thinning crew
3. Simple trees are easier to manage precisely.
4. Tall Spindle/Fruiting Wall with 4 wires= ~30 fruits between each wire

Return Bloom

Flower initiation is inhibited in the bourse shoot by gibberellins produced in the seeds and shoots and transported down the fruit stem and the shoot stem

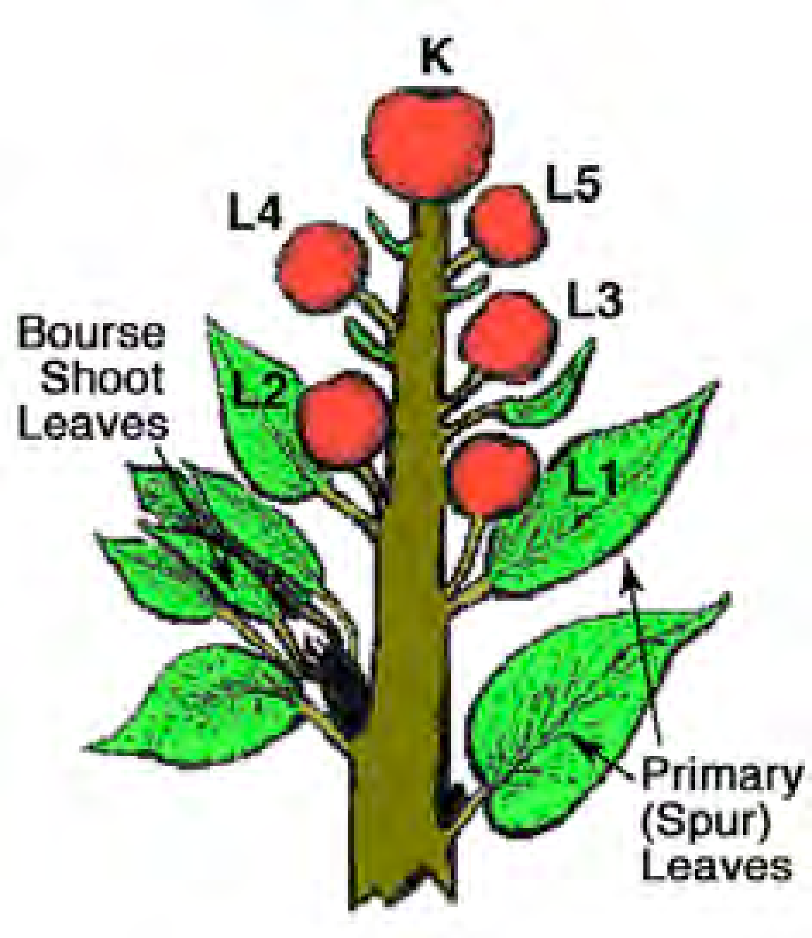
Total Seed number per tree is related to return bloom. More seeds=less return bloom.

NAA and/Ethrel applied in summer counter act the effect of seed produced GA's and shoot produced GA and stimulate more flower bud initiation

The mechanism is thought to be a temporary reduction in shoot growth rate

Spray 4 weekly sprays of a low dose of NAA (5-7ppm)
Spray 4 weekly sprays of a low dose of Ethrel 150ppm

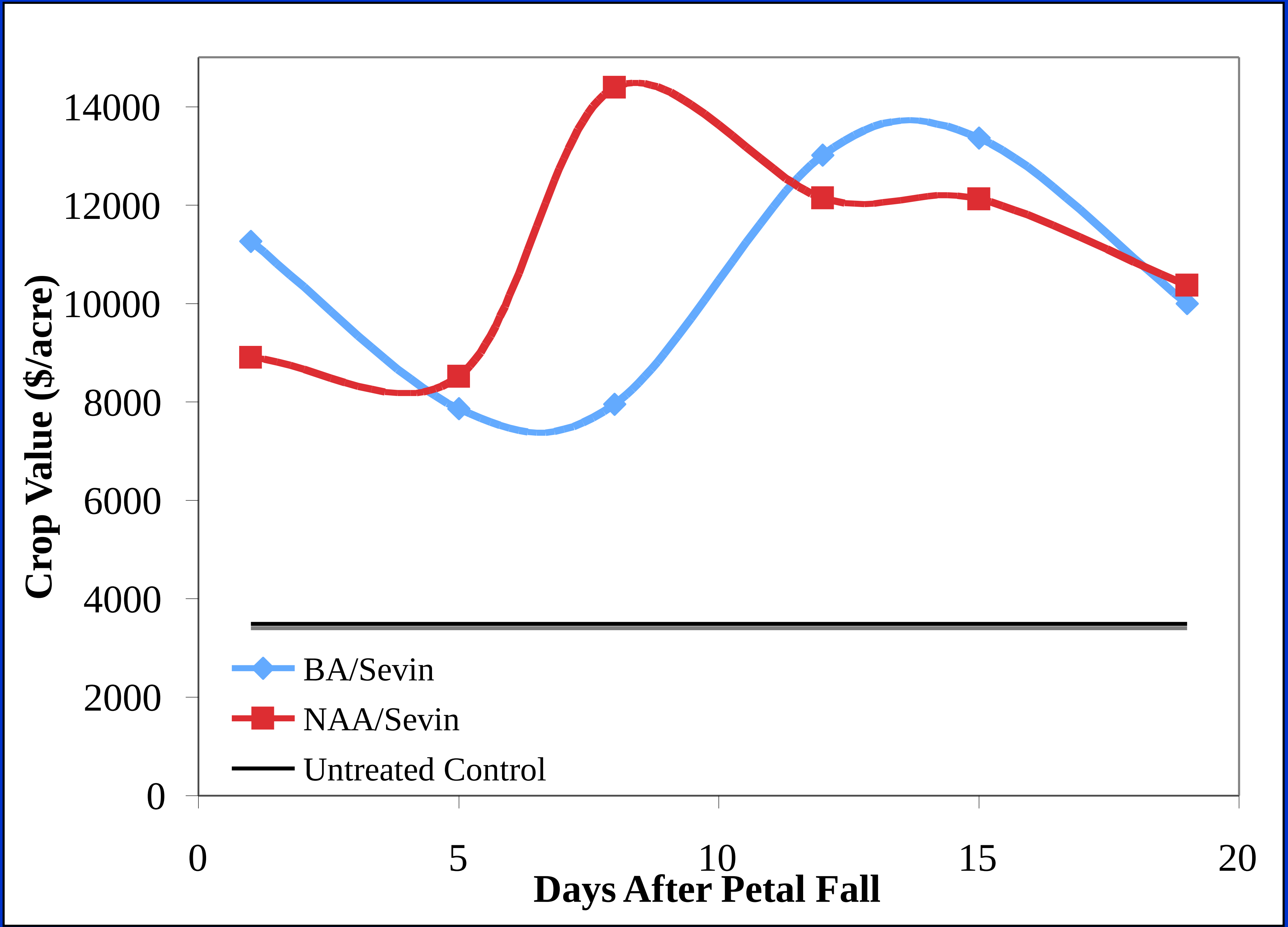
Begin sprays on June 21



Recommendations for Managing Biennial Bearing

1) Manage bud load by pruning (precision pruning)
2) Use 2 % ATS at 80% Bloom or
3) Use Aggressive Petal Fall Thinning (10ppm NAA + Carbaryl).
4) Use 7.5ppm NAA+ Carbaryl at 10mm fruit size as a second spray).
5) Hand thin early to 5 fruits/cm^2 TCA on young trees and 8 fruits/cm^2 TCA on mature trees.
6) Apply 4 sprays of summer NAA (10ppm) at 10 day intervals beginning in mid-late June (in some years NAA helps).

Is it Worth the Effort to Precisely Manage Crop Load?



Thank You for Your Attention

Questions?