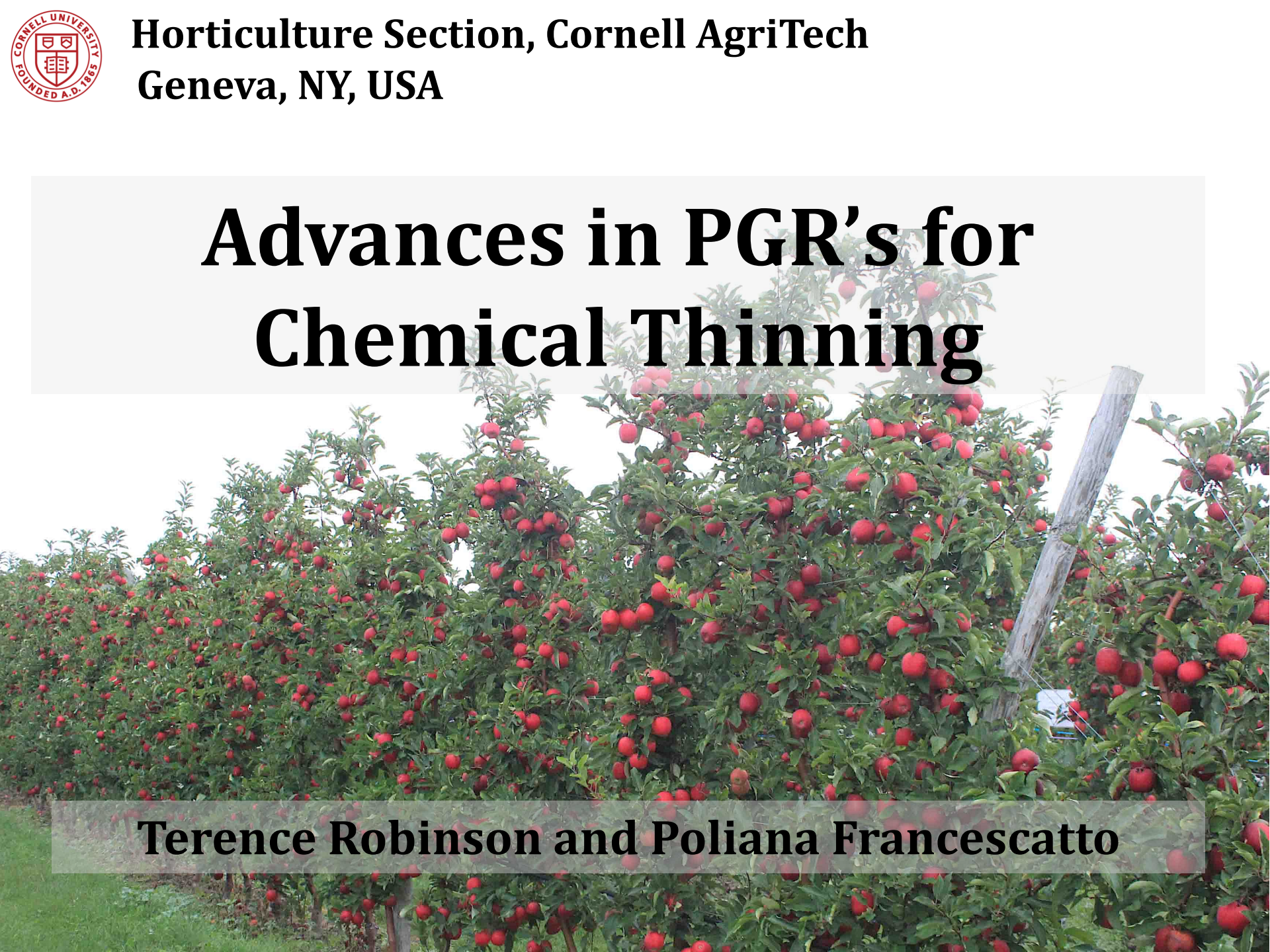




Horticulture Section, Cornell AgriTech
Geneva, NY, USA

Advances in PGR's for Chemical Thinning

Terence Robinson and Poliana Francescatto



Chemical Thinning Options

- Bloom
 - Ammonium Thiosulfate (ATS)
 - Lime Sulfur and Oil
 - Promalin
 - Maxcel
 - NAA
 - Amide-Thin
- Petal Fall (fruits at 5-6mm)
 - Sevin
 - AmideThin
 - Maxcel + Sevin
 - NAA + Sevin
 - Maxcel + NAA
 - Metamitron
- Fruits at 11-13 mm
 - NAA + Sevin
 - Maxcel + Sevin
 - Maxcel + NAA
 - Metamitron
- Fruits at 15-20 mm
 - NAA + Sevin
 - Maxcel + Sevin + Oil
 - Ethrel + Oil
 - ACC+Maxcel
 - Metamitron

Bloom Thinning Options (Caustic Thinners)

- **Ammonium Thiosulfate (ATS)**
 - Burns stigma of pistil
 - Causes mild leaf phytotoxicity but no effect on fruit finish
 - Requires 2-3 applications
 - When used with the PTGM can achieve a substantial portion of thinning job
 - Has a neutral effect on fruit size
 - Not registered as a thinner in NY but can be legally used as a bloom time foliar fertilizer
 - Improves return bloom of Honeycrisp
- **Lime Sulfur and Oil**
 - Burns stigma of pistil and also the style
 - Kills pollen tube growth in the style
 - More “reach back” to kill pollen tubes that are growing than ATS
 - Causes mild leaf phytotoxicity but can also cause some fruit finish problems in some weather conditions
 - Requires 2-3 applications
 - Fish oil or soybean oil or summer spray oils (highly refined) work almost equally well with a slight edge to fish oil
 - When used with the PTGM can achieve the majority of thinning job
 - Has a neutral or negative effect on fruit size
 - Not registered in NY but can be applied as a fungicide. However the Miller Chemical brand of Lime Sulfur prohibits use during bloom

Table 1. Effect of Alternatives of Fish Oil on Thinning Efficacy of Lime Sulfur. (Empire at Geneva NY 2003 Data)

Trt No.	Treatment Description	Fruit No./ Tree	Fruit Size (g)	Cropload Adj. Fruit Size (g)
1	Unthinned Control	288	146	149
2	2.0 gal ATS/100 gal @ 80% FB	156	154	150
3	2.5 gal Lime Sulfur+2.0 gal Fish Oil/100 gal @ 80% FB	181	150	146
LSD P≤0.05		94	11	10
<u>Contrasts</u>				
FOLS @ FB vs ATS @ FB		NS	NS	NS
Fish Oil vs Ultra Fine Oil		NS	**	*
Fish Oil vs Vegetable Oil		NS	**	*
Fish Oil vs Regulaid		NS	NS	NS
Fish Oil vs Silwet		NS	**	*

Table 2. Effect of Organic Thinners on Gala Fruit Size at Geneva NY. (2003 Data)

Trt No.	Treatment Description	Fruit No./ Tree	Fruit Size (g)	Cropload Adj. Fruit Size (g)
1	Unthinned Control	608	139	153
2	2.0 gal ATS/100 gal @ 80% FB	472	143	142
3	2.5 gal Lime Sulfur + 2.0 gal Fish Oil/100 gal @ 80% FB	457	153	156
11	7.5ppm NAA + 1pt Sevin XLR @ 10mm Fruit Size	442	152	154
12	100 ppm BA + 1pt Sevin XLR @ 10mm Fruit Size	426	162	161
LSD P≤0.05		118	14	12
<u>Contrasts</u>				
ATS vs FOLS		NS	NS	*
FOLS vs Unthinned Control		*	*	NS
ATS vs Unthinned Control		*	NS	*
ATS vs BA/Sevin		*	*	*
FOLS vs BA/Sevin		NS	*	*

Bloom Thinning Options (Caustic Thinners)

- Will blossom thinning ever be accepted in the East?
 - The addition of the PTGM is a significant advance
 - Measurement of style length is critical
 - If sepals are removed the visible length of the pistil is longer than shown in this picture
 - If style measurement is too long then chemical application is delayed and too little thinning achieved
- Lime Sulfur and Oil is more effective for thinning than ATS but has greater negative effects on plant metabolism and thus depresses fruit growth rate for several days to a week
- For large fruited varieties, the temporary suppression of fruit growth from caustic thinners causes little consequence but with small fruited varieties the depression of fruit growth is a problem

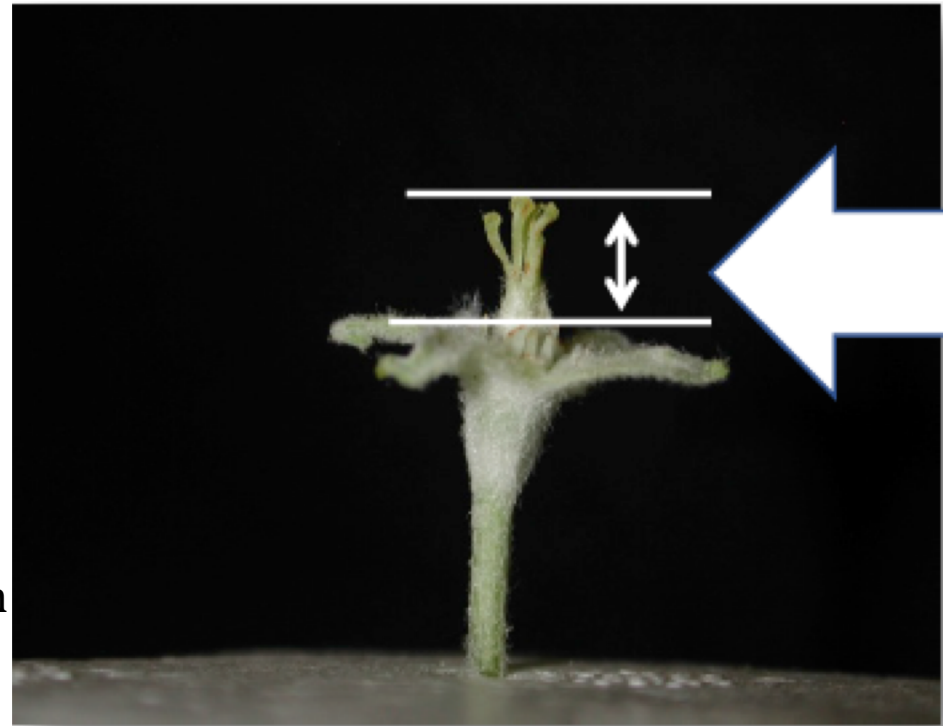
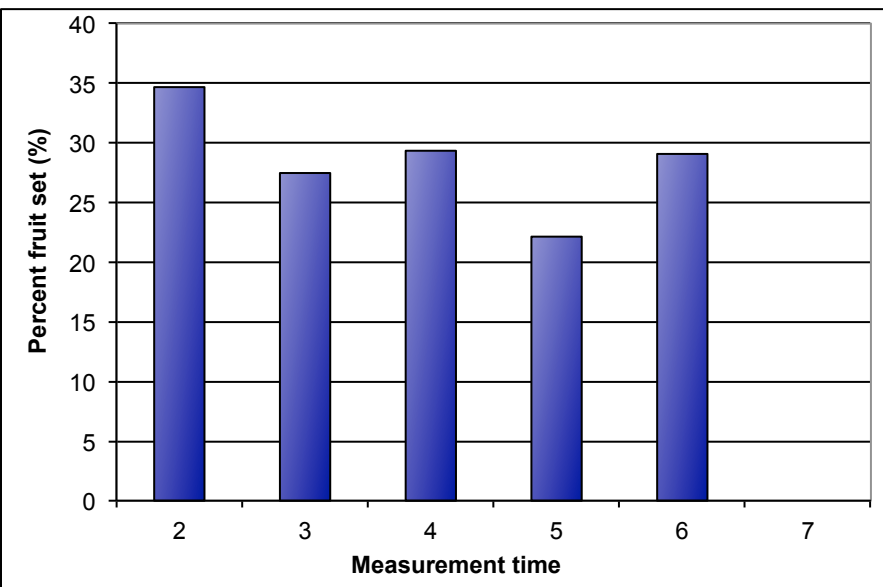


Photo from Greg Peck presentation

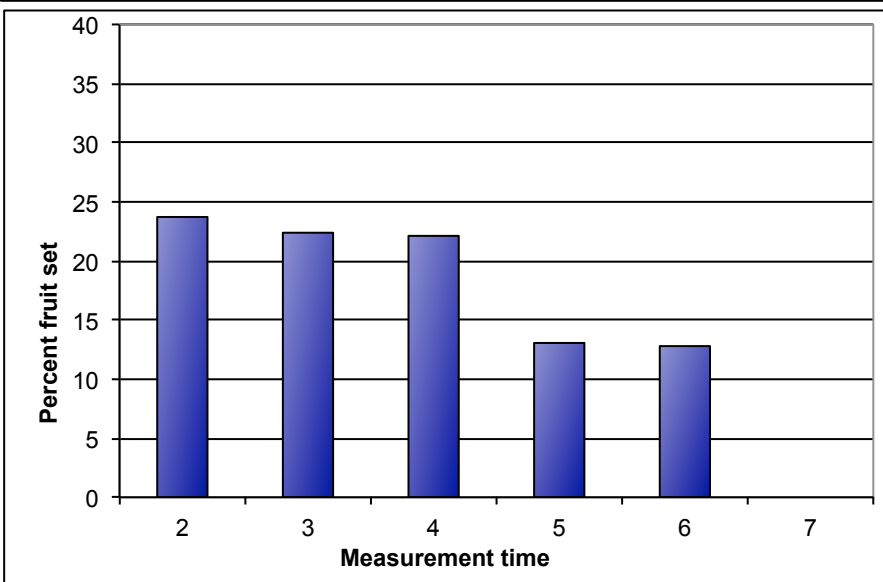
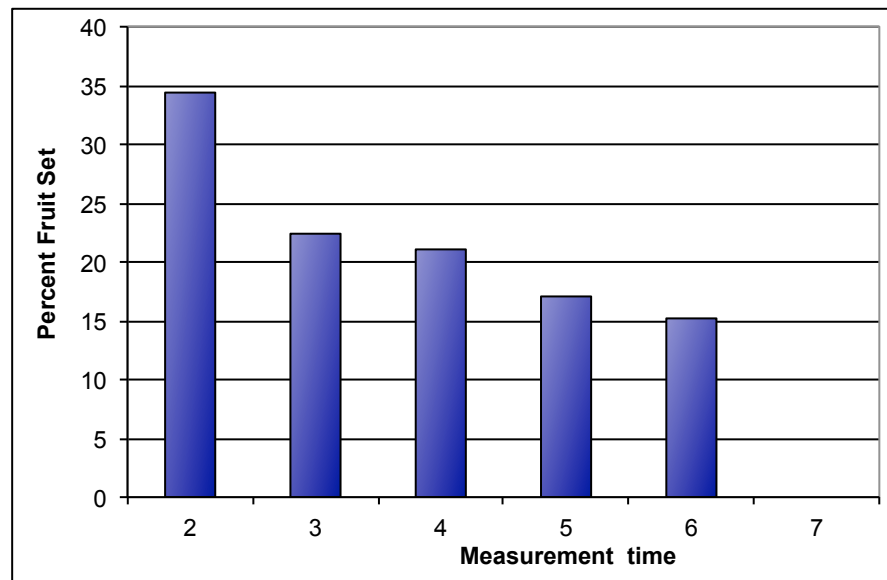
Bloom Thinning Options (Hormone Thinners)

- BA+GA4+7 (Promalin, Perlan, Typy)
 - Causes more typey fruit for Delicious, Gala and other varieties
 - In some years can cause some thinning
 - When temperatures are warm it has a good effect.
 - Timing is at early king bloom and well before full bloom
 - Use rate of 2pt/acre gives a low amount of BA compared to Maxcel use rates
- BA (Maxcel, Exilis, Riteway)
 - Causes more blocky fruit (not elongated)
 - Is a very mild thinner at bloom but can increase fruit size
 - Increases cell division to create a potentially larger fruit
 - Works well in warm conditions during bloom but poorly in cool conditions (1 year out of 2-3 there is a great response).
 - Use rate of 8pt/acre gives a high amount of BA compared to Promalin use rates
- NAA (Fruitone, Pomaxa, Refine)
 - A mild thinner (safe) when used at bloom
 - Can be sprayed safely at high rate of 10ppm
 - Has a neutral effect on fruit size
 - Little or no depression of photosynthesis at bloom
 - Can help improve return bloom on Honeycrisp
- NAD (Amide-Thin W)
 - A mild thinner (safe) when used at bloom
 - Can be sprayed safely at high rate of 8 oz/100
 - Has a neutral effect on fruit size
 - Little or no depression of photosynthesis at bloom
 - Can help improve return bloom on Honeycrisp

Untreated Control



Promalin then 3 Maxcel/Sevin



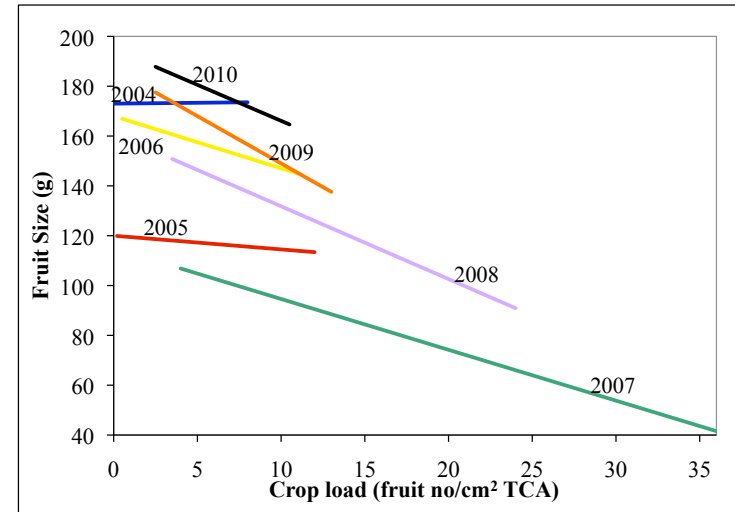
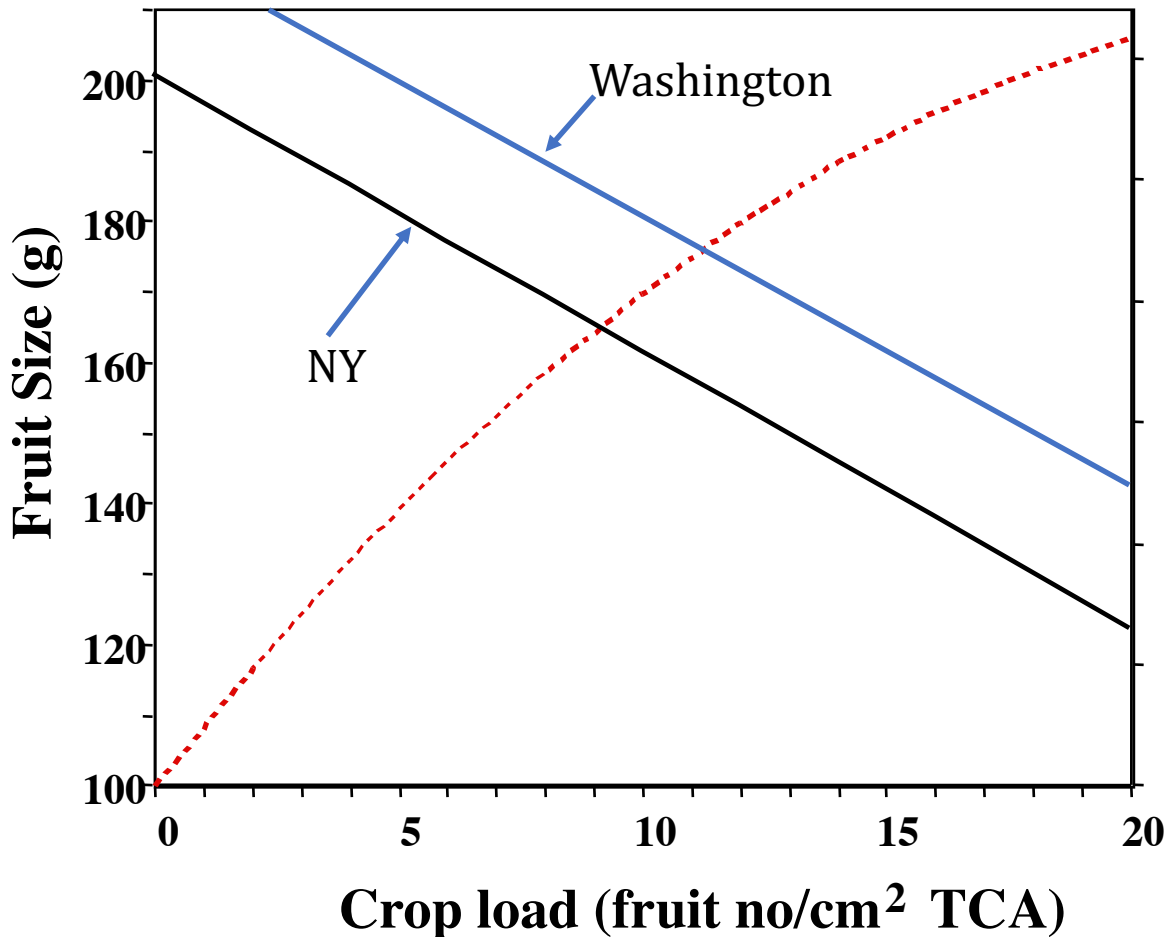
Maxcel then 3 Maxcel/Sevin

Results of Precision Thinning of Gala at Geneva in 2013

Treatment	Initial Fruit Number Number	After Bloom Spray	After PF Spray	After 10mm Spray	After 18mm Spray	Target Fruit
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

Bloom Thinning Issues

- Why is blossom thinning more successful in the West?
 - More consistent weather at bloom
 - Less russeting
 - Better relationship of crop load and fruit size, thus if LS and Oil depress fruit growth for a few days they still can achieve 80-88 count Gala



Bloom Thinning Options

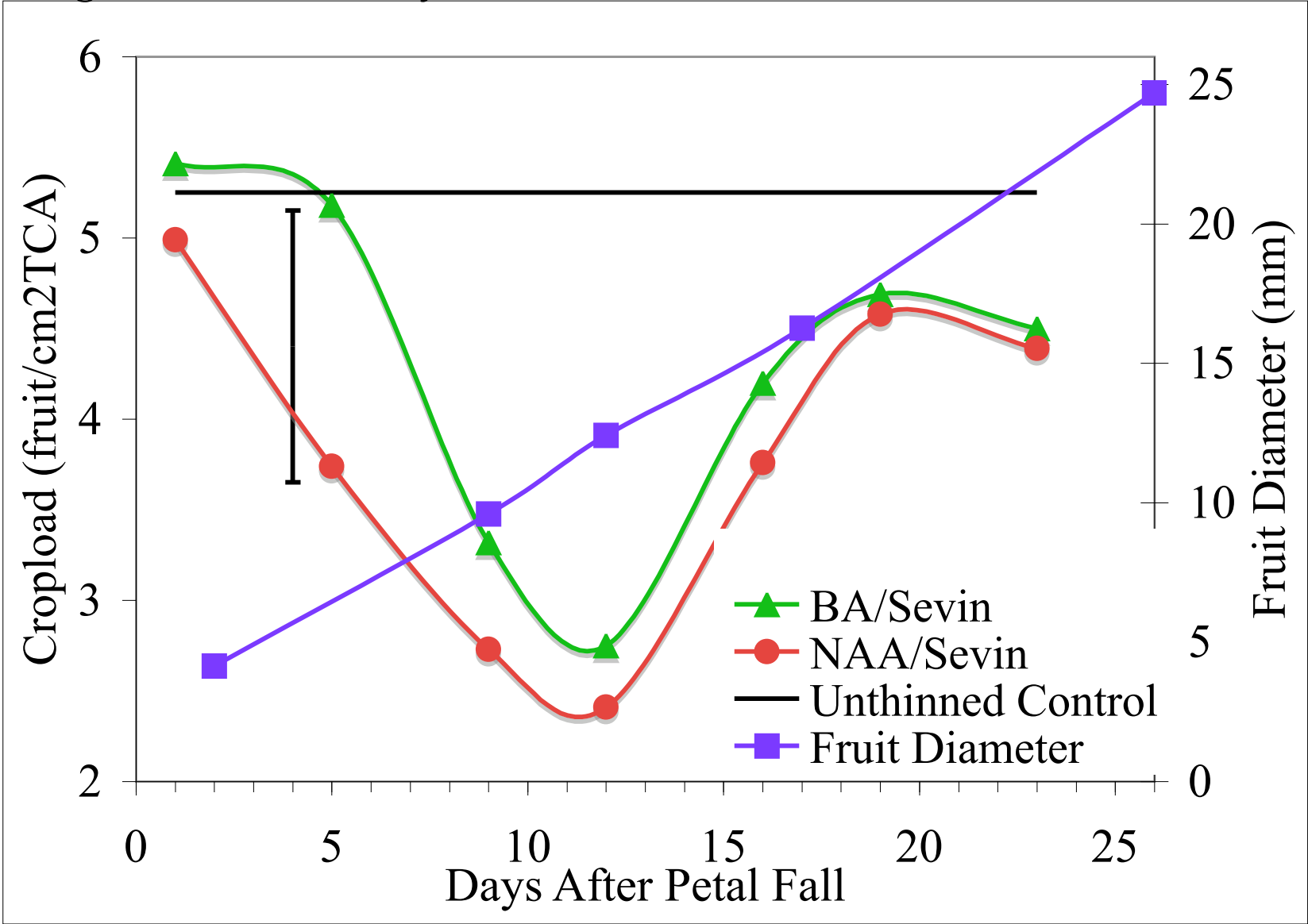
- Conclusions and Recommendations

- Use the PTGM and spray ATS or Lime Sulfur and oil (if legal) 2 or 3 times during bloom for large fruited varieties:
 - Honeycrisp
 - Fuji
 - Evercrisp
 - McIntosh
 - Delicious
 - Cortland
 - Rome
 - Jonagold
 - NY2
 - Other large fruited varieties
- Use a hormone type thinner for small fruited varieties during bloom
 - Gala
 - NY 1
 - Jazz
 - Empire
 - Macoun
 - Pink Lady
- Do not spray caustic thinners under slow drying and wet conditions or if there is frost
 - Frost causes damage to fruit skin and caustic thinners then cause russetting

Chemical Thinning Options

- Bloom
 - Ammonium Thiosulfate (ATS)
 - Lime Sulfur and Oil
 - Promalin
 - Maxcel
 - NAA
 - Amide-Thin
- Petal Fall (fruits at 5-6mm)
 - Sevin
 - AmideThin
 - Maxcel + Sevin
 - NAA + Sevin
 - Maxcel + NAA
 - Metamitron
- Fruits at 11-13 mm
 - NAA + Sevin
 - Maxcel + Sevin
 - Maxcel + NAA
 - Metamitron
- Fruits at 15-20 mm
 - NAA + Sevin
 - Maxcel + Sevin + Oil
 - Ethrel + Oil
 - ACC+Maxcel
 - Metamitron

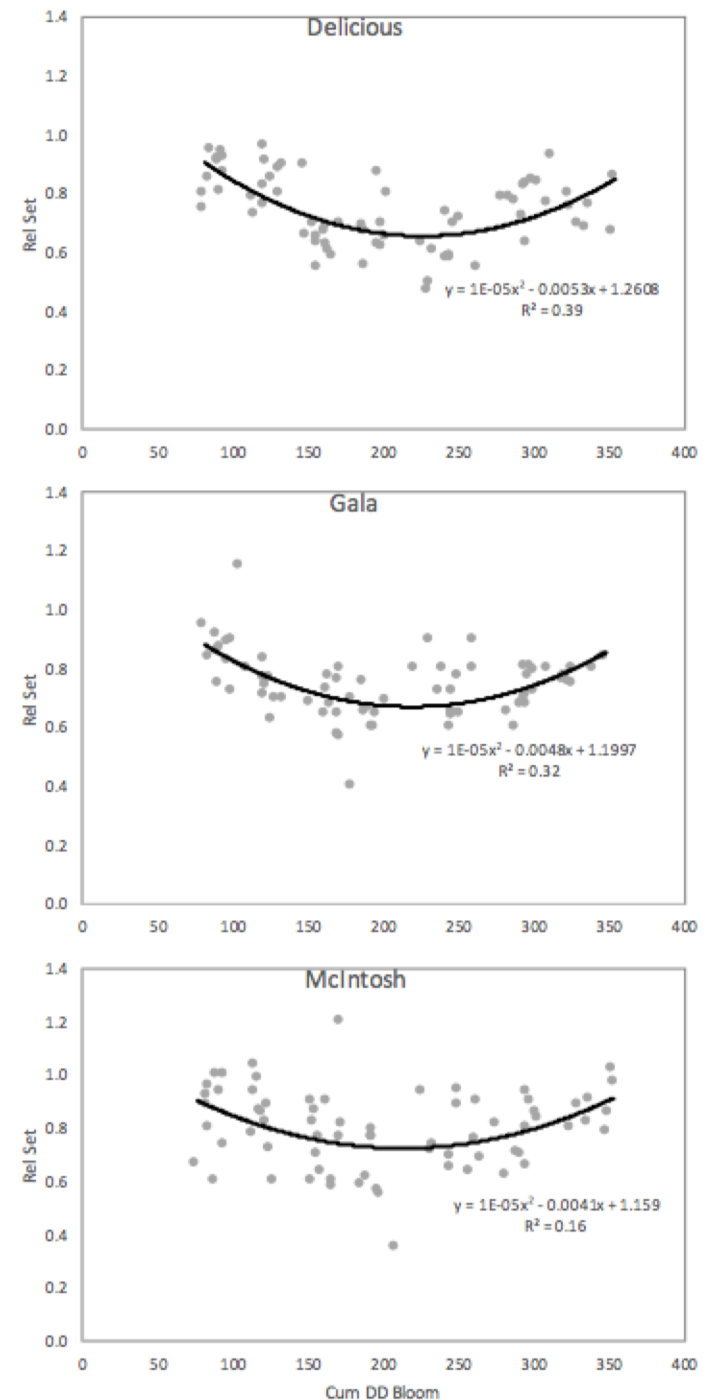
At Petal Fall the effect of NAA/Sevin or BA/Sevin is mild. A few days after petal fall the effect is greater but still very safe



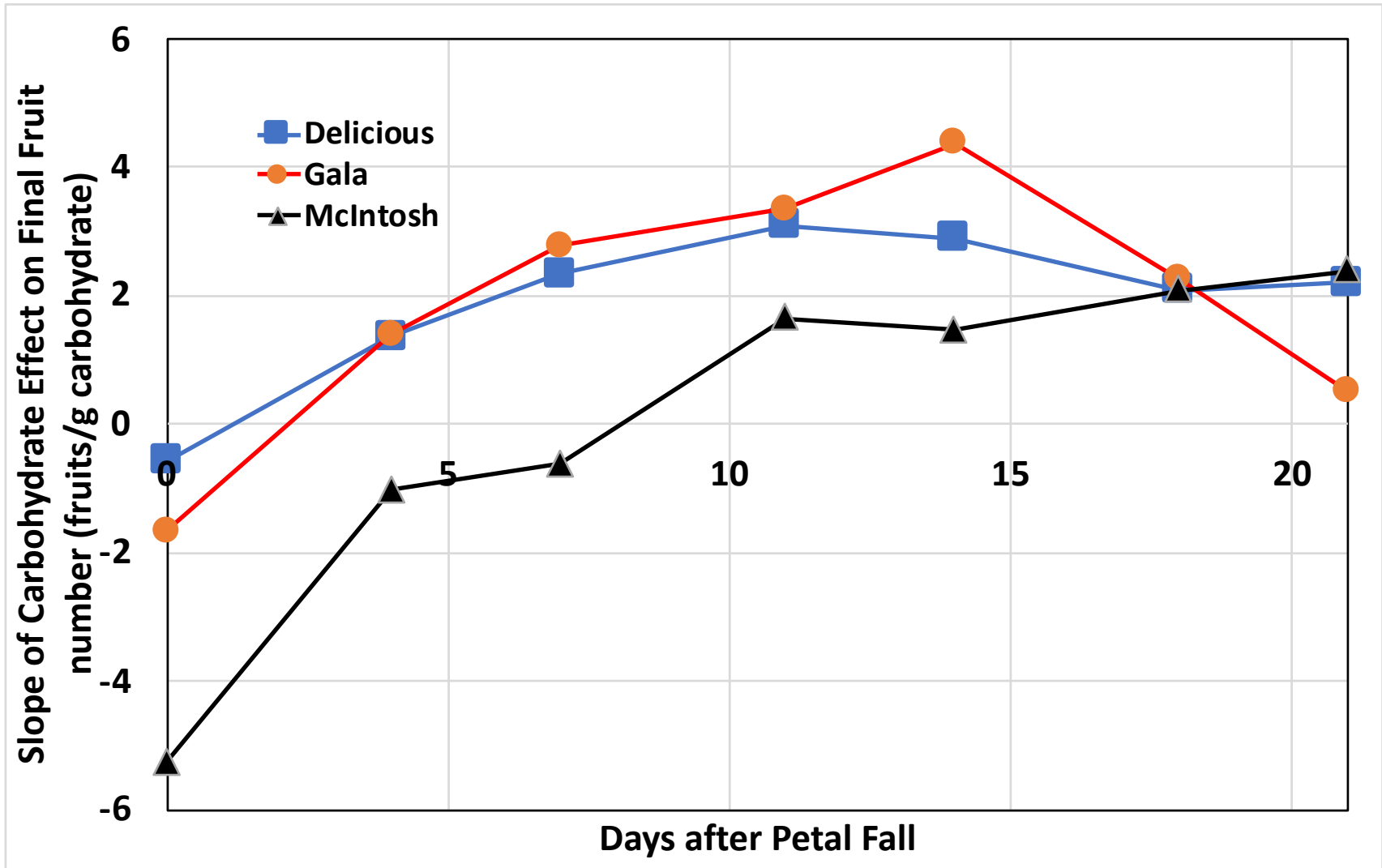
Results – Chemical Thinning

Fruit set of Delicious, Gala and McIntosh was lowest when chemical thinners were applied at 200-250 degree days after full bloom

Bottom Line: Apply thinners for maximum effect at 200-250 DD after bloom



Results – Chemical Thinning



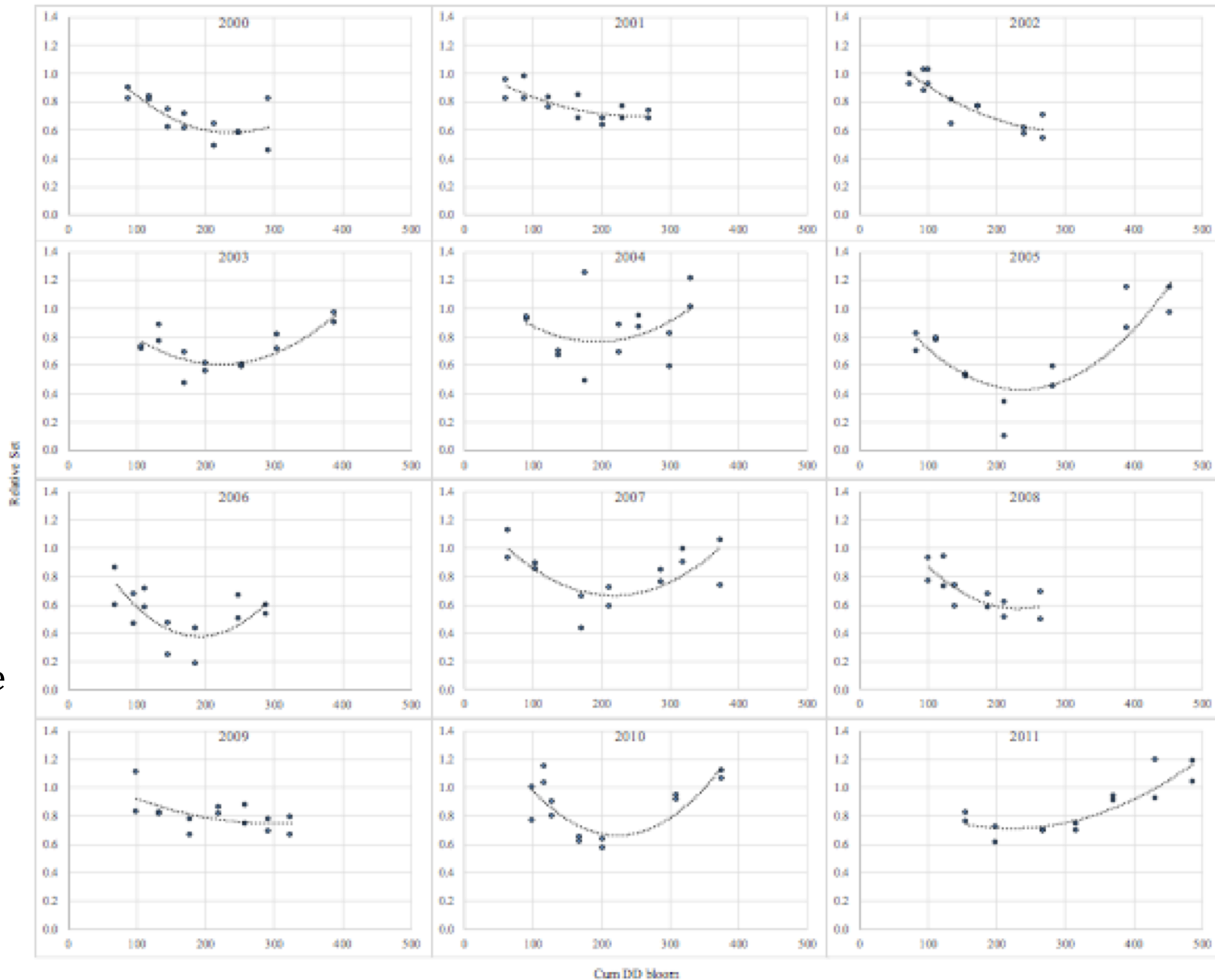
At petal fall there is a very small effect of carbohydrate balance on thinning results
At later times the effect varied from 1 fruit to 4 fruits per g of carbon

Results – by year

Year to Year
Variability in
results at
petal fall and
18 mm

Best
thinning was
always
between
200-250 DD

Take home
message: Time
thinning
sprays by DD
and target
200-250DD



Petal Fall Thinning Options

- Carbaryl (Sevin)
 - A mild thinner at Petal Fall (very safe)
 - Limited solubility in water (Rates above 1 pt/100 are not soluble but in suspension)
 - If applied at 2pt/100 rate then it can be re-wetted and give additional thinning
 - Has some insect control benefits if applied at 2pt/100 rate
- BA+ Carbaryl (Maxcel, Exilis, Riteway)
 - BA alone is a very mild thinner (safe) but can increase fruit size
 - Increases cell division to create a potentially larger fruit (Use on small fruited varieties)
 - When combined with Carbaryl the efficacy is much better.
 - The combination of BA/Sevin works well in warm conditions during bloom but poorly in cool conditions (1 year out of 3 there is a great response).
 - Use high rate of BA (4-8pt/acre)
 - Use only 1pt Carbaryl per 100 so that there is little chance of re-wetting and excessive thinning.
- NAA+Carbaryl (Fruitone, Pomaxa, Refine)
 - Avoid rates above 3 oz/100 since it depresses photosynthesis at high rates.
 - Has a neutral effect on fruit size
 - When combined with Carbaryl the efficacy is much better.
 - Can help improve return bloom on Honeycrisp
 - Avoid with Fuji and Delicious (causes pygmy fruit if BA used later)
 - Avoid surfactants (Regulaid) since they dramatically increase the uptake of NAA
- NAD (Amide-Thin W)
 - A mild thinner (safe) when used at petal fall
 - Can be sprayed safely at high rate of 8 oz/100
 - Has a neutral effect on fruit size
 - Little or no depression of photosynthesis at petal fall
 - Can help improve return bloom on Honeycrisp

New Petal Fall Thinning Options without Carbaryl

- BA+ NAA
 - The combination of BA with NAA (3oz/100) thins similarly to BA+Sevin.
 - Vary rate of BA (4-8pt/acre) depending on the variety
- BA+NAD
 - The combination of BA with NAA (8 oz/100) thins similarly to BA+Sevin.
 - Vary rate of BA (4-8pt/acre) depending on the variety
- Metamitron (not yet registered)
 - A photosynthesis inhibitor
 - If there is a carbon deficit it will thin but generally mild at PF
 - Can be sprayed safely at high rate of 200-400ppm
 - Has a neutral effect on fruit size
 - A 40% depression of photosynthesis

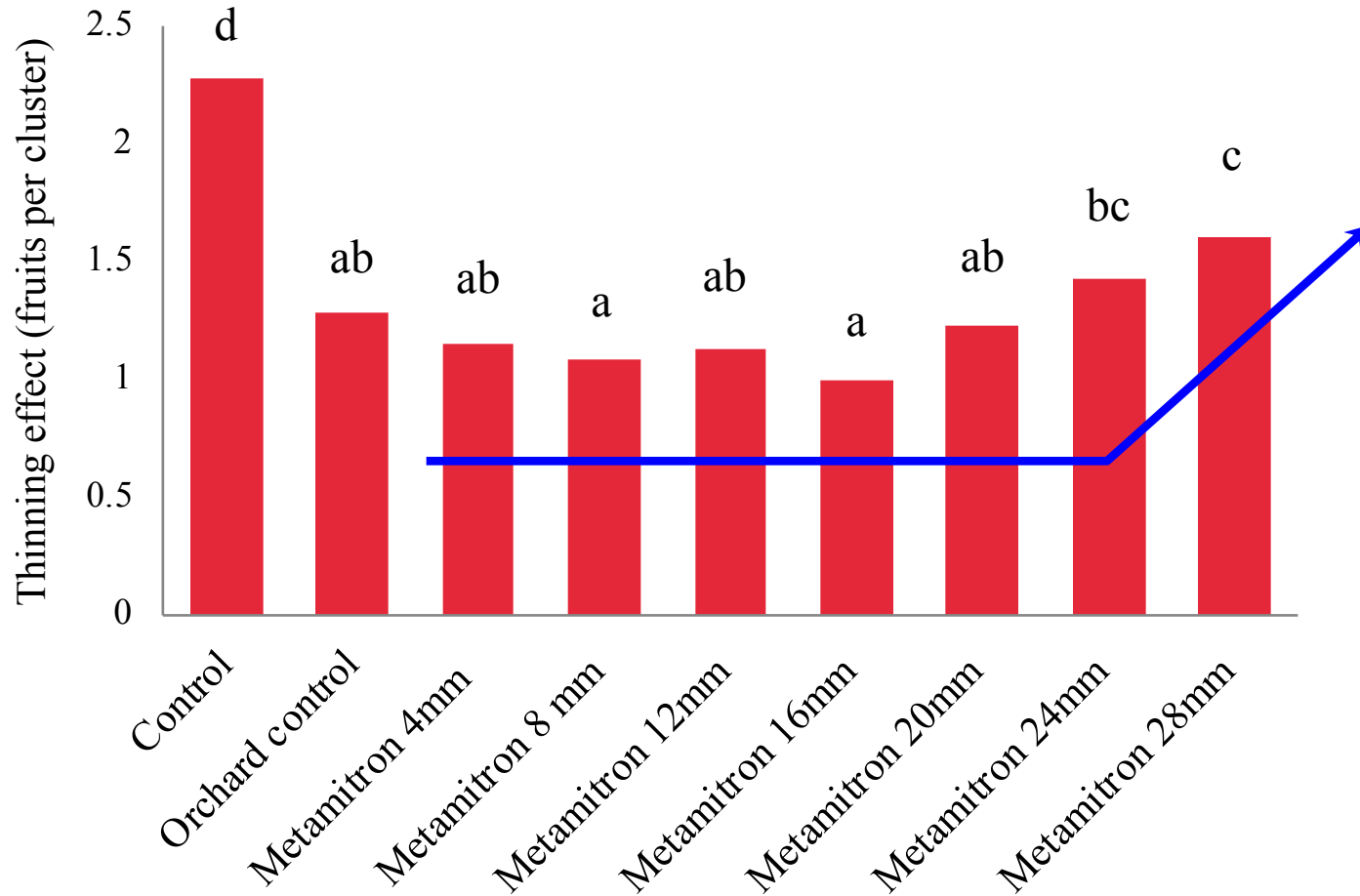
Metamitron as an apple thinner

- It is not a PGR -a photosynthesis inhibitor (Used as a sugar beet herbicide)
- Can be applied at normal thinning window (petal fall to 18mm)
- Works best when there is a carbohydrate deficit
- Can cause phytotoxicity at very high rates (leaf damage)
- Registered in EU, to be registered in the US in the near future.



Metamitron

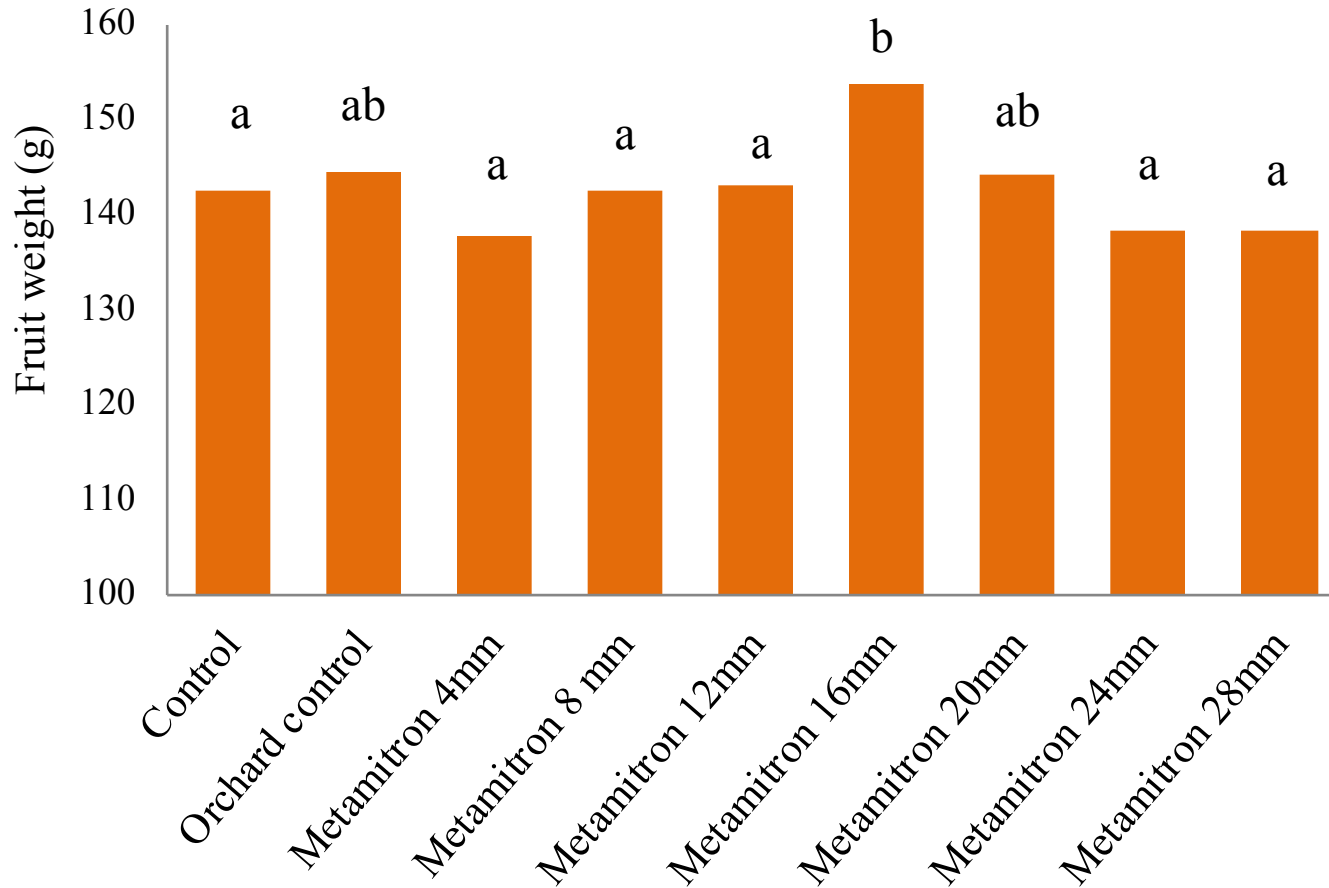
Thinning effect



Metamitron had a wide window for thinning

Metamitron

Fruit weight adjusted by crop load



**No differences were found in crop load
adjusted fruit weight**

In NY our trials show Metamitron is a mild thinner at Petal Fall and a much better thinner at 10-18mm

Mild thinning at Petal Fall.



Petal Fall

The thinning effect was greatest when metamitron was applied at 12mm fruit size.



12 mm fruit size

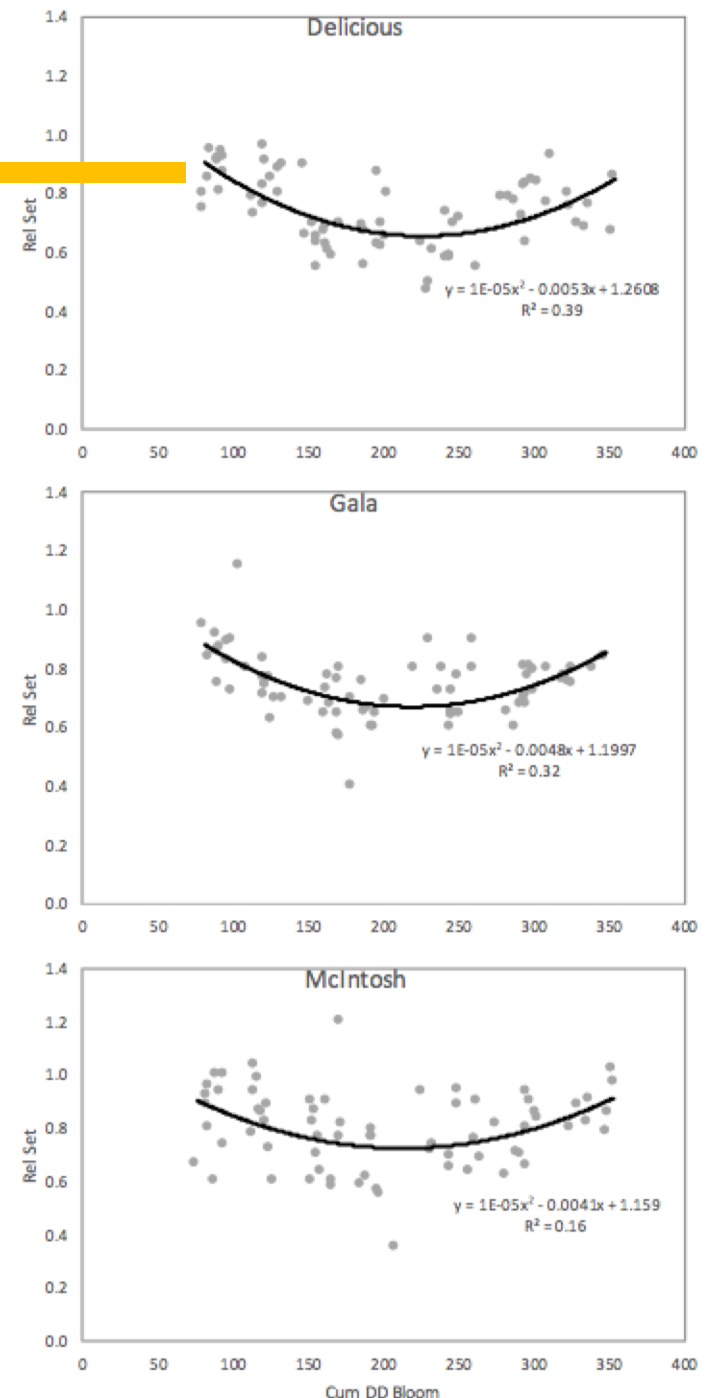
Chemical Thinning Options

- Bloom
 - Ammonium Thiosulfate (ATS)
 - Lime Sulfur and Oil
 - Promalin
 - Maxcel
 - NAA
 - Amide-Thin
- Petal Fall (fruits at 5-6mm)
 - Sevin
 - AmideThin
 - Maxcel + Sevin
 - NAA + Sevin
 - Maxcel + NAA
 - Metamitron
- Fruits at 11-13 mm
 - NAA + Sevin
 - Maxcel + Sevin
 - Maxcel + NAA
 - **Metamitron**
- Fruits at 15-20 mm
 - NAA + Sevin
 - Maxcel + Sevin + Oil
 - Ethrel + Oil
 - ACC+Maxcel
 - Metamitron

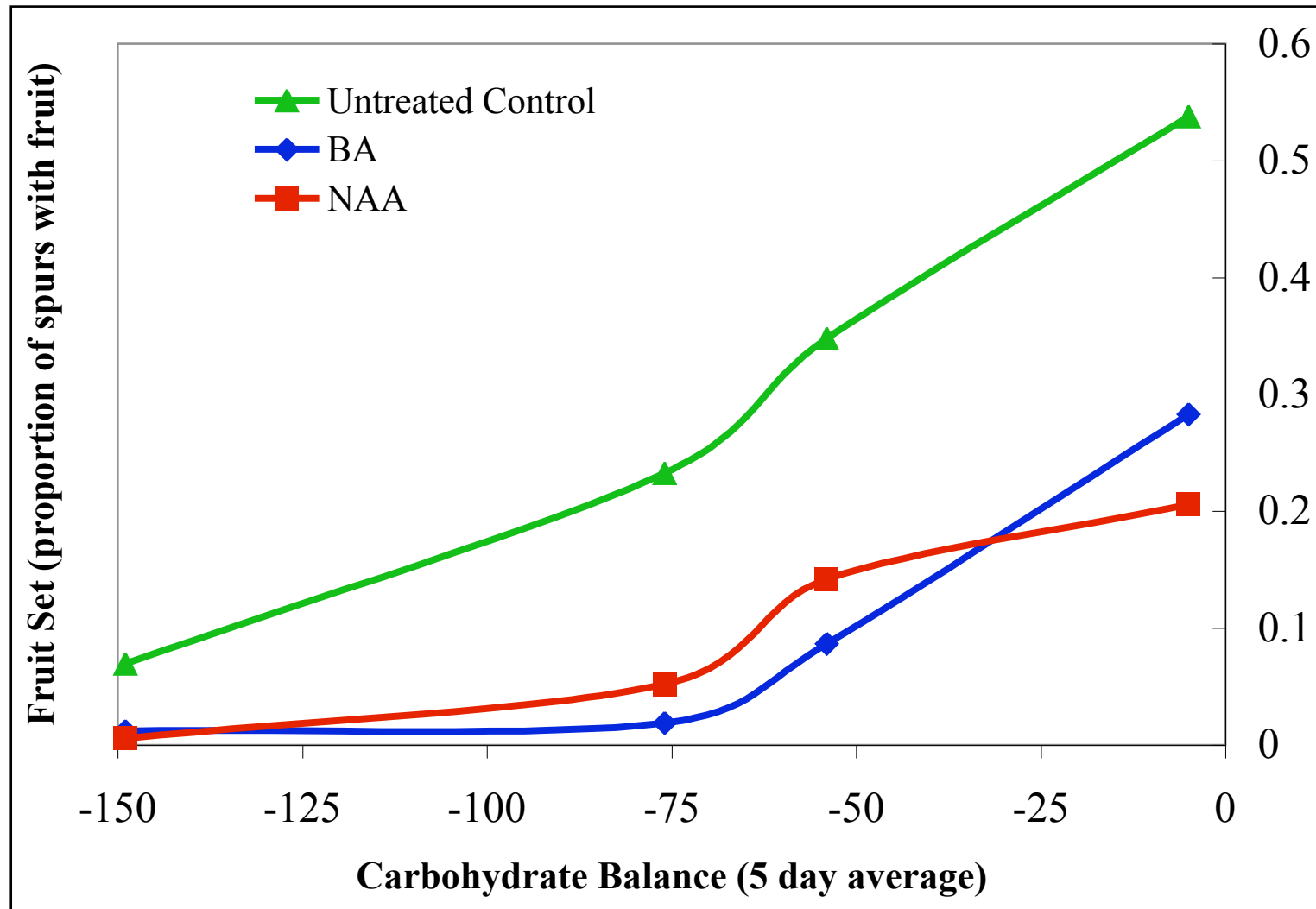
Results – Chemical Thinning

Fruit set of Delicious, Gala and McIntosh was lowest when chemical thinners were applied at 200-250 degree days after full bloom

Bottom Line: Apply thinners for maximum effect at 200-250 DD after bloom



Relationship between carbohydrate balance for 5 days after application of thinners and fruit set of Empire/M.9 apple trees.

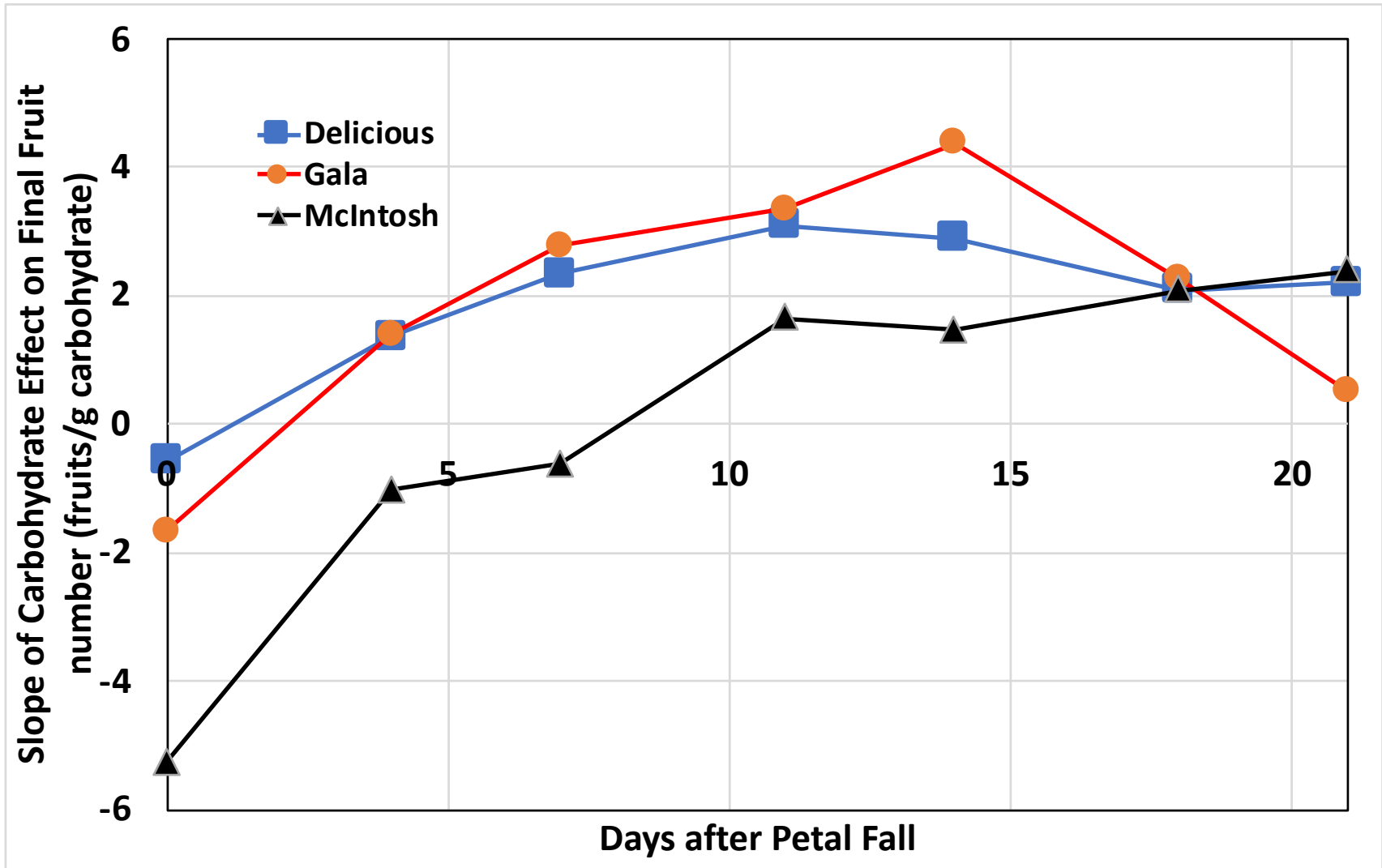


Decision Rules We Use to Make Recommendations



4-Day Av. Carb. Balance	Thinning Recommendation
+20g/day to +40g/day	Increase Chemical Thinning Rate by 30%
+20g/day to 0g/day	Increase Chemical Thinning Rate by 15%
0g/day to -20g/day	Apply Standard Chemical Thinning Rate
-20g/day to -40g/day	Decrease Chemical Thinning Rate by 10%
-40g/day to -60 g/day	Decrease Chemical Thinning Rate by 20%
-60g/day to -80 g/day	Decrease Chemical Thinning Rate by 30%
< than -80g/day naturally)	Do not thin (many fruits will fall off

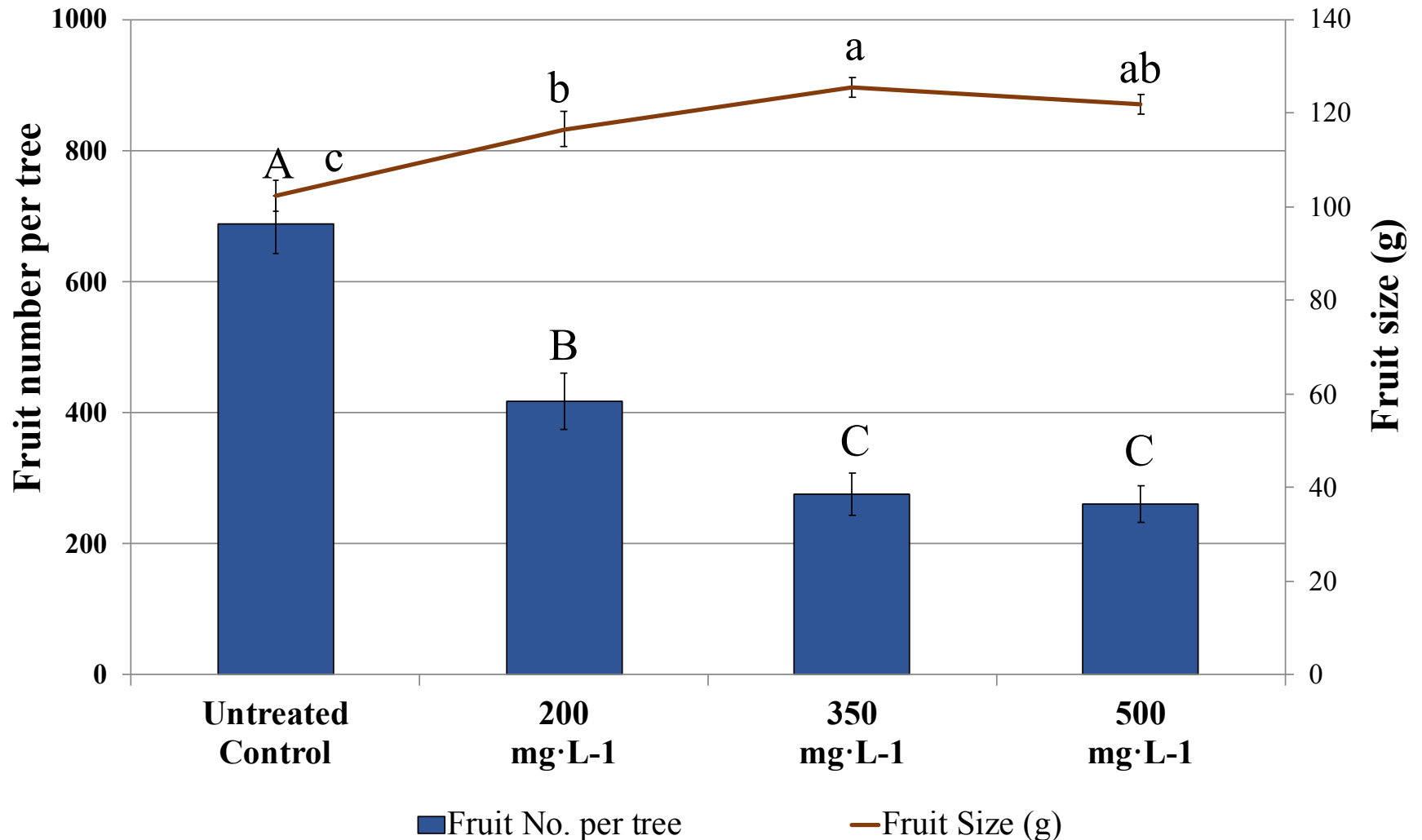
Results – Chemical Thinning



At petal fall there is a very small effect of carbohydrate balance on thinning results
At later times the effect varied from 1 fruit to 4 fruits per g of carbon

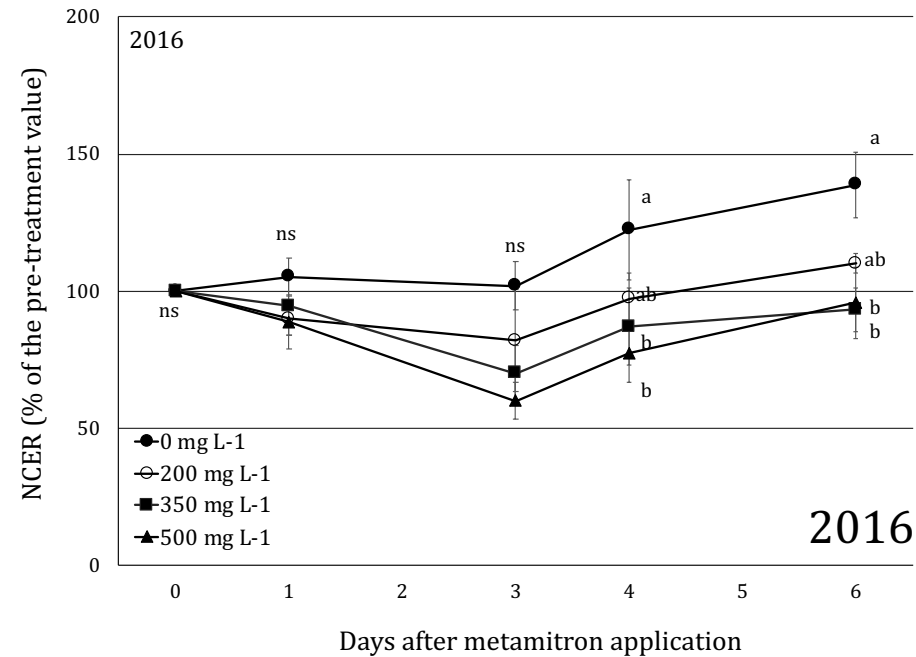
Results

Effects of metamitron on yield and size of Gala apples



Results

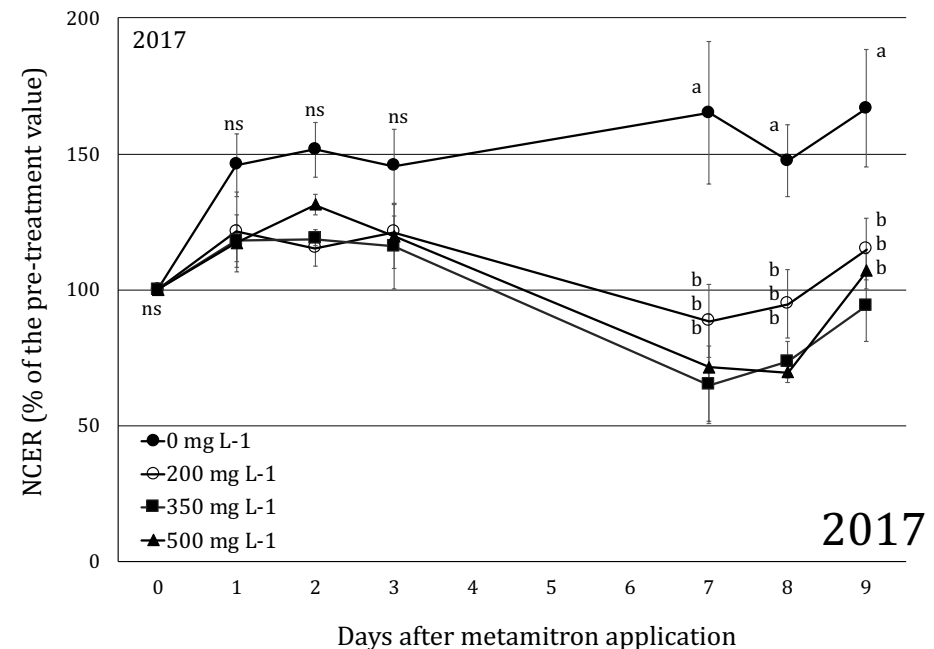
Whole-tree net C exchange rate



In 2016, with warm temperatures, there was a significant response to rate of metamitron and the maximum reduction in whole-tree photosynthesis occurred three days after application.

In 2017 with cooler temperatures, there was not rate response and photosynthesis reached its lowest level around 7-8 days after application.

The maximum reduction in photosynthesis due to metamitron was around 40% in both years

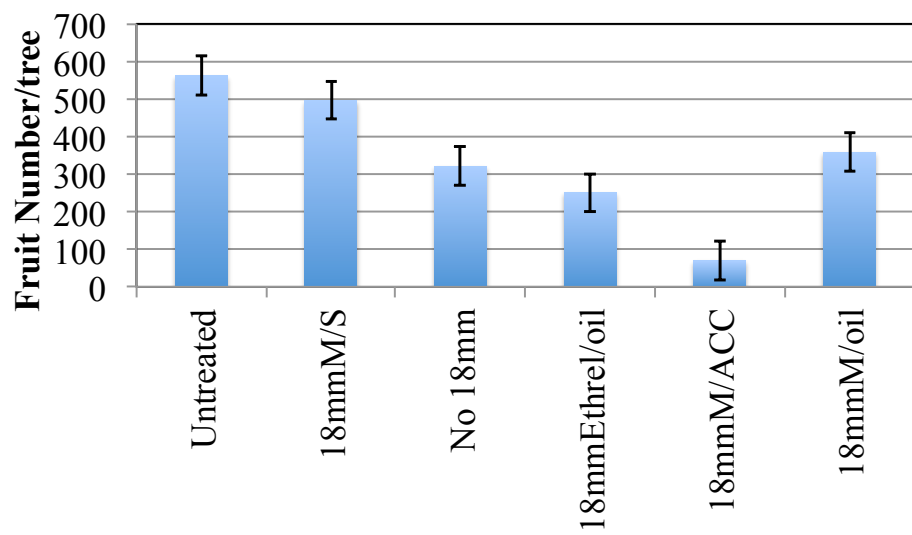


Chemical Thinning Options

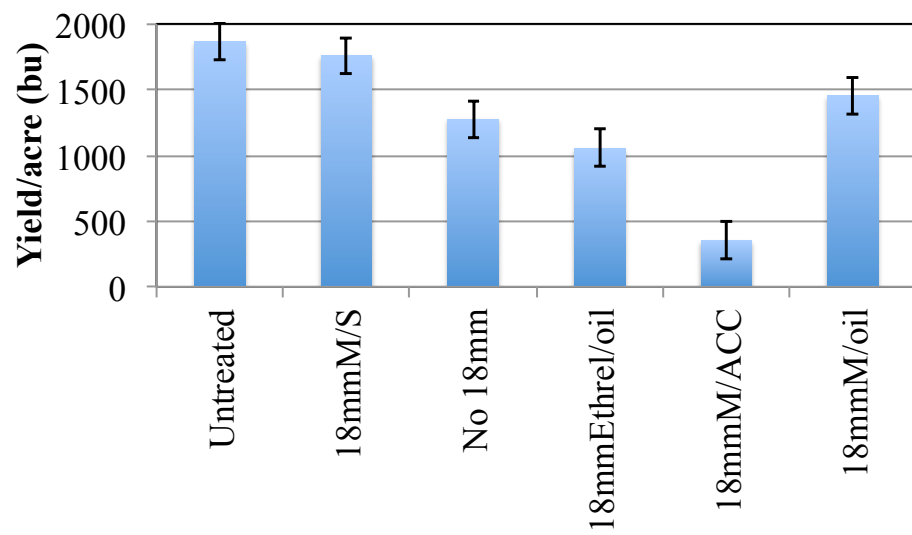
- Bloom
 - Ammonium Thiosulfate (ATS)
 - Lime Sulfur and Oil
 - Promalin
 - Maxcel
 - NAA
 - Amide-Thin
- Petal Fall (fruits at 5-6mm)
 - Sevin
 - AmideThin
 - Maxcel + Sevin
 - NAA + Sevin
 - Maxcel + NAA
 - Metamitron
- Fruits at 11-13 mm
 - NAA + Sevin
 - Maxcel + Sevin
 - Maxcel + NAA
 - Metamitron
- Fruits at 15-20 mm
 - NAA + Sevin
 - Maxcel + Sevin + Oil
 - Ethrel + Oil
 - ACC+Maxcel
 - Metamitron

Chemical Thinning past the optimum time

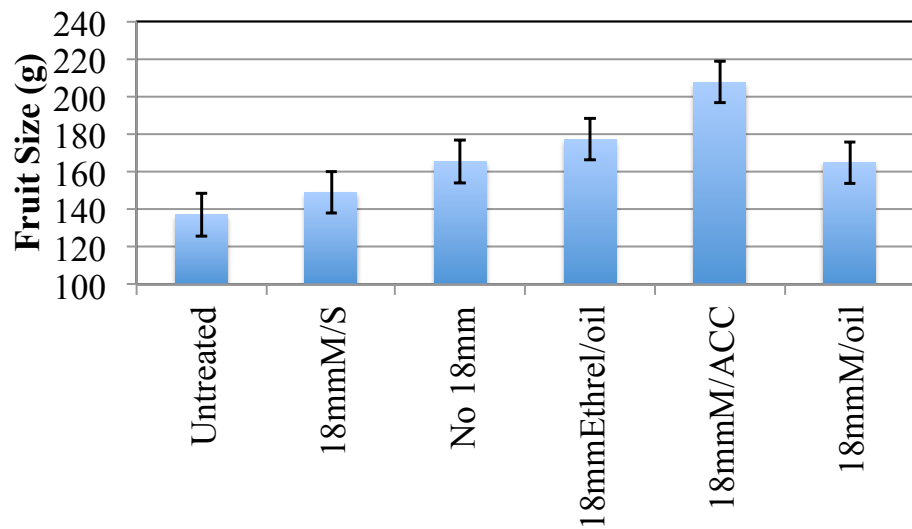
- Fruits at 15-20 mm
 - NAA + Sevin + Oil (1pt/100)
 - Marginally effective without oil
 - Maxcel + Sevin + Oil (1pt/100)
 - Without the oil, BA/Sevin is marginally effective
 - With oil we have had very good success with Gala
 - Ethrel + Oil
 - Ethrel generates ethylene in the plant
 - Powerful thinning combination if temperatures are hot
 - ACC+Maxcel
 - ACC is a precursor of ethylene and probably works by generating ethylene in the fruit
 - We have had good success with ACC only if combined with Maxcel
 - We are evaluating ACC with regulaid or oil
 - Metamitron
 - Very effective at 15-18mm fruit size if there is a carbon deficit
 - Can be sprayed safely at rate of 200-400ppm depending on carbon balance
 - Has a neutral effect on fruit size
 - Causes a 40% depression of photosynthesis



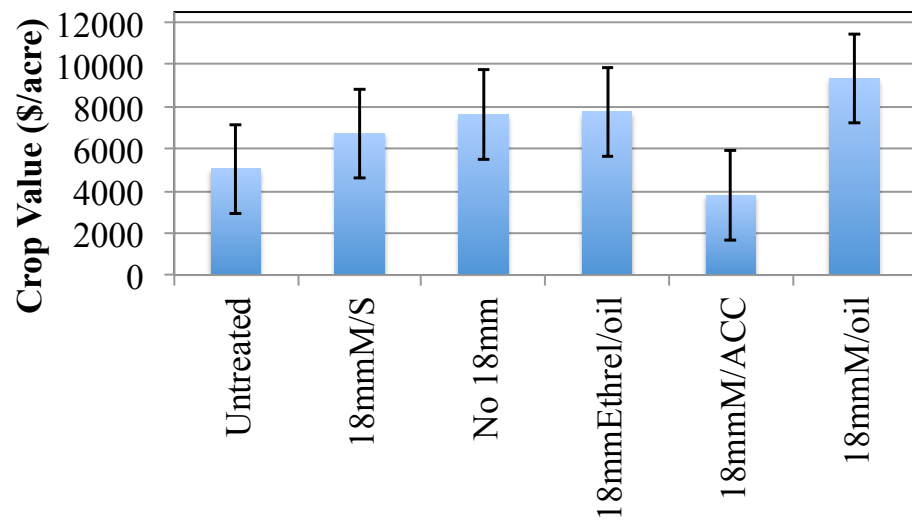
Effect of 18mm Treatments



Effect of 18mm Treatments



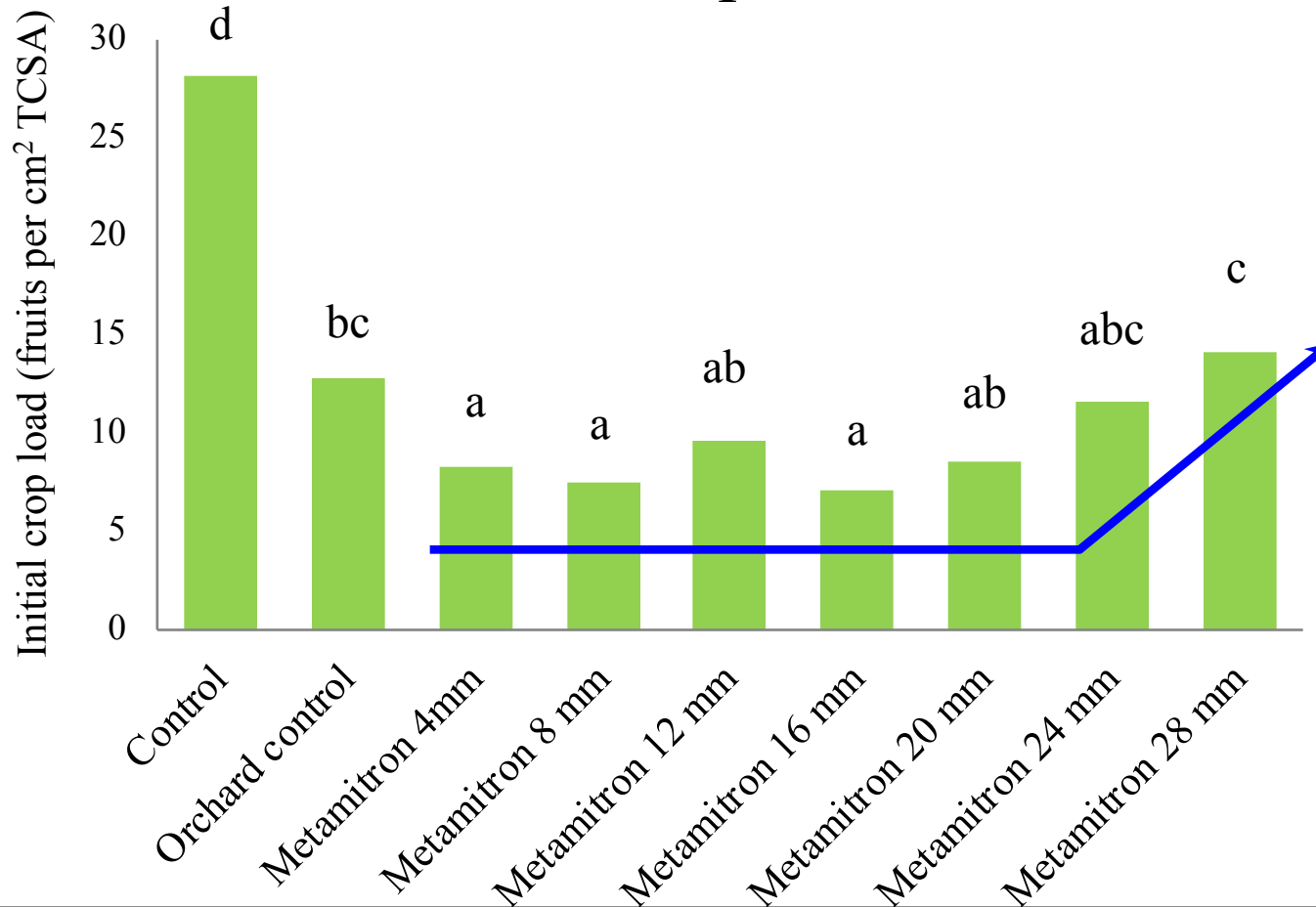
Effect of 18mm Treatments



Effect of 18mm Treatments

Metamitron

Initial crop load



A Lesson on Tree Row Volume and Thinning

- We suggest calculating of amount of thinning chemicals per acre based for the size of the tree canopy using TRV
- All of our rates in the Cornell Recommends are rates per 100 gallons of dilute spray
- Most modern orchard have a TRV of 100-220 gallons of spray to fully wet the tree
 - Example: Tall Spindle trees planted 3X11 and 12 feet tall and 6 feet wide ($43560/11=3960$ linear feet of row per acre $*6*12*0.7/1000=200$ gallons dilute TRV)
 - Example: Super Spindle trees planted 2X11 and 10 feet tall and 4 feet wide ($43560/11=3960$ linear feet of row per acre $*4*10*0.7/1000=111$ gallons dilute TRV)
- To calculate the rate per acre multiply the rate per 100 by the fraction of TRV/100 base rate
 - Example: Tall Spindle trees with TRV=200 (concentration factor or 2.0) and a Maxcel rate of 64 oz/100 gal=128 oz Maxcel per acre
 - Example: Super Spindle trees with a TRV=111 (concentration factor of 1.11 and a Maxcel rate of 64 oz/100 gal=71 oz Maxcel per acre)
- **The amount of chemical put in the tank is the per acre amount regardless of the volume of water**

A Lesson on Tree Row Volume and Thinning (cont.)

- The volume of water per acre can be varied from full dilute (1X) to 1/3 the full dilute volume (3X) without differences in thinning response
 - Example: Tall Spindle trees with TRV=200 can be sprayed at 200 gallons per acre (full dilute) or with half the water volume (100 gallons/acre) or at 1/3 water volume (67 gallons per acre)
 - Example: Super Spindle trees with a TRV=111 can be sprayed at 111 gallons per acre (full dilute) or with half the water volume (56 gallons/acre) or at 1/3 water volume (37 gallons per acre)
- Mixing protocol
 - Example: Tall Spindle trees with TRV=200 but sprayed at 100 gallons per acre with half the water volume (64oz Maxcel/100 gal dilute *2=128 oz Maxcel/acre * 5 acres sprayed per tank=540 oz/tank=5 gallons Maxcel/tank)
 - Example: Super Spindle trees with TRV=111 but sprayed at 50 gallons per acre with half the water volume (64oz Maxcel/100 gal dilute *1.11=71 oz Maxcel/acre * 5 acres sprayed per tank=355 oz/tank=2.77 gallons Maxcel/tank)

Best Spray Pattern for Thinning

- The problem: The bottom half of the tree is usually overthinned and the tops of trees are underthinned
 - This is due to more light and thus more carbohydrates available for fruitlets in the tops of trees than in the bottoms of trees.
- Traditional recommendation
 - Nozzle the sprayer so the top half of the tree receives $\frac{2}{3}$ of the spray volume and the bottom half of the tree receives $\frac{1}{3}$
 - This spray pattern continues to overthin the bottom of the tree and underthin the top of the tree
- We have done 4 separate trials with higher percentages directed to the top of the tree and the best results are when 80-100% of the spray is directed to the top of the tree
 - We suggest that for the bloom and petal fall sprays the traditional spray pattern of $\frac{2}{3}$ and $\frac{1}{3}$ is best
 - For the 12 mm sprays we suggest the pattern be changed to 80% in the top and 20% in the bottom
 - For the 18mm spray we suggest the pattern be changed to 100% in the top



Questions?

Irrigation.