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Crop Load Management in Apples

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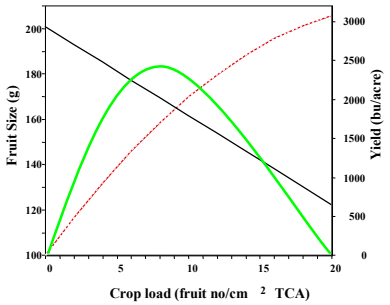
Optimizing Crop Load has a Large Impact on Crop Value

- As crop load is reduced by thinning (or by pruning) fruit size of the remaining fruits increases (black line).
- As crop load is reduced by thinning (or by pruning) yield is also reduced (red line).
- As crop load is reduced total crop value increases until crop load is reduced below the optimum level (green line).



Managing Fruit Load Precisely

1. Precision crop load management is a strategy to determine an optimum crop load and then to use pruning, chemical thinning and hand thinning to consistently obtain that fruit load. (Robinson et al., 2014a)

2. The first step in precision crop load management is to establish a target of final fruit number.
   - Identify a goal for fruit size and yield based on the potential of the orchard and the climate.
   - Example: (1500 bu/ac / 0.180 g/fruit * 1,320 trees/acre = 125 fruits /tree

Precision Pruning

1. Precision pruning is a process of reducing the number of flower buds to a predetermined number through pruning using the rules of Tall Spindle pruning and then spur extinction pruning. (Robinson, et al., 2013).

2. How many flowering spurs to leave?
   - 1 bud per final fruit number. (125)
   - 1.5 buds per final fruit number. (188)
   - 2 buds per final fruit number. (250)
   - 3 buds per final fruit number. (375)
   - 4 buds per final fruit number. (500)

Using Pruning to Pre-thin the Trees

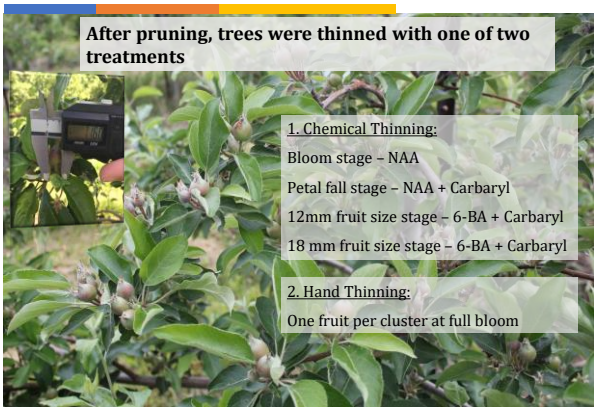
1. Eliminate 1-3 branches larger than ¾" diameter.
2. Columnarize (simplify) the rest of the branches.
3. Count number of bud and then
4. Remove spurs until your reach the target bud number.

Material and Methods

Location:	Experimental orchard at Cornell Station in Geneva, NY, USA
Variety/age:	Brookfield Gala/M. 9T337 planted in 2009
Tree density:	2857 trees · ha^{-1}
Crop load Target:	130 fruit per tree
Years:	2014, 2015, 2016 and 2017
Bud load:	1 bud : 1 final desired fruit per tree 1.5 : 1 2.0 : 1 2.5 : 1 3.0 : 1 3.5 : 1

Material and Methods

Material and Methods



Results

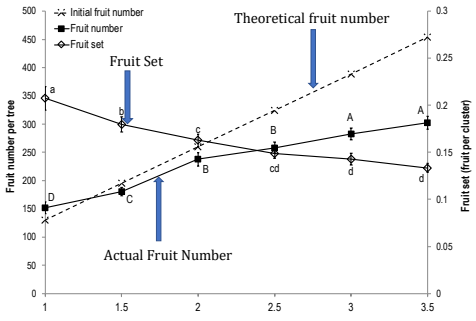
Table 1. Significance of *P* values from the ANOVA of the main effects of years, thinning treatments (hand or chemical thinning) and bud load ratios, and their interactions on yield and crop return of Brookfield Gala apples over 4 years at Geneva NY, USA.

Significance (*p*)	Fruit set (fruit cluster^{-1})	Fruit No. per tree	Yield (kg tree^{-1})	Yield (t ha^{-1})	Fruit Size (g)	Crop Value ($/ha)
Year (Y)	**†	**	**	**	**	**
Thinning treatment (T)	**	**	*ns*	*ns*	**	*
Bud load treatment (BL)	**	**	**	**	**	**
Y * T	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Y * BL	**	*ns*	**	**	*	**
T * BL	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Y * T * BL	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

†*, ** or NS indicate treatment had a significant effect at P≤0.05 or P≤0.01 levels, or had a non-significant effect, respectively.

Results

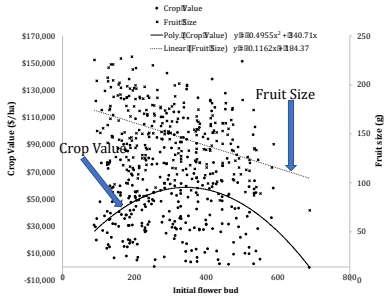
Final fruit number per tree and fruit set of Brookfield Gala after trees had been pruned to 6 different bud load and hand or chemically thinned over 4 years at Geneva, NY, USA.



Fruit Set

Results

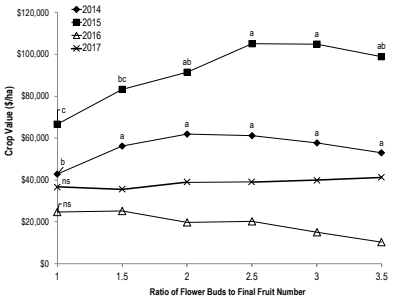
Fruit size and crop value responses of Gala apples to initial flower bud over 4 years



The combined data shows that crop value was maximized when the optimum level of pruning severity for Gala was about 2.0 :1. This resulted in an optimum of 250 buds per tree (200 fruits/tree) which is double the target bud number we had assumed before the experiment.

Results

Crop value response after trees had been pruned to 6 different bud loads in each of the four years studied. Geneva, NY, USA.



Under dry weather conditions, severe pruning would be favorable.

Other Results

Return bloom and fruit quality

- There was no significant effect of pruning level or bud load ratio on return bloom.
- In some years, fruit color and sugar content were increased when crop load was reduced and weather conditions were favorable.
- The effect of year on fruit quality was related to the weather conditions.
- Severe pruned trees, with lower bud load ratios had firmer fruit at harvest.

Conclusions

- Leaving too many flowering buds results in too many fruits after chemical thinning and a large hand thinning job.
- Our results indicate that maximum crop value for a 'Gala' Tall Spindle orchard in New York State was achieved when fruit size was about 160 g and fruit number per tree was 200 fruits/tree
- We recommend pruning to a bud load ratio of 1.5-2.0 flower buds per final fruit number.

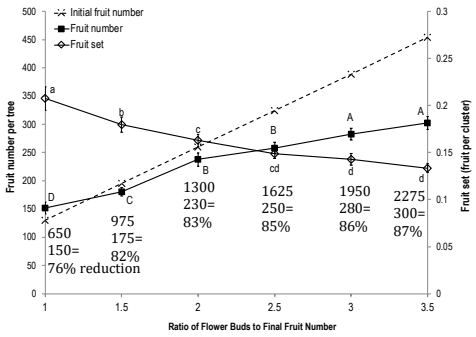
What is precision chemical thinning?

It is a strategy to reduce crop load by sequential applications of chemical thinners to achieve a pre-determined crop load.

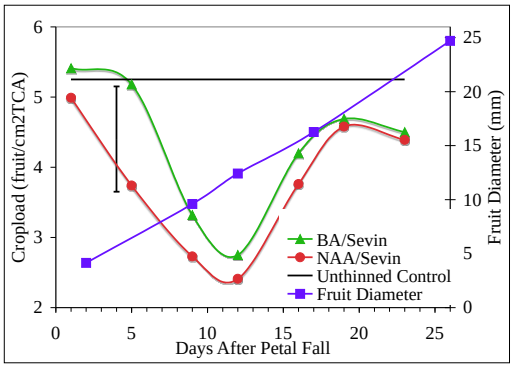
- It is done by using the carbohydrate model to guide the timing and rate of chemical application and
- by using the fruit growth rate model to assess the effect of each application

The Problem

When flower bud number is high, chemical thinning is more effective but the final result is too many fruits which requires significant hand thinning



There is a variation in the effect of chemical thinners with timing after bloom



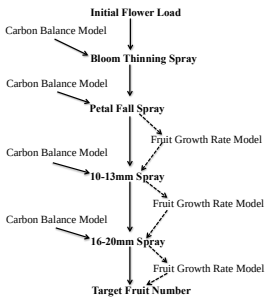
The effect of chemical thinners is maximized at 200-25 degree days (base 4°C) after full bloom.

Ventanas de Raleo

- Raleo en Flor
  - Tiosulfato de amonio (ATS)
  - Polisulfuro de Calcio y aceite
  - Promalin
  - BA
  - ANA
- Raleo a caída de pétalos (frutos a 5-6mm)
  - Carbaril
  - BA+Carbaril
  - ANA+Carbaril
  - BA+ANA
  - Metamitron
- Raleo a fruto de 12-13 mm
  - ANA+Carbaril
  - BA+Carbaril
  - BA+ANA
  - Metamitron
- Raleo a fruto de 18-20 mm
  - ANA+Carbaril+Aceite
  - BA+Carbaril+Aceite
  - BA+ANA+Aceite
  - ACC

Protocol for Precision Chemical Thinning

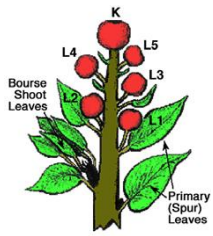
1. Use the carbohydrate model before applying chemical thinners to assess the effect of weather on the thinning response.
2. Adjust the rate of chemical thinner based on the results of the model.
3. Apply a bloom and petal fall spray.
4. Evaluate the effect of the thinning spray using the fruit growth rate model.
5. Re-apply a third spray if needed.
6. Re-evaluate the effect of the third spray using the fruit growth rate model.



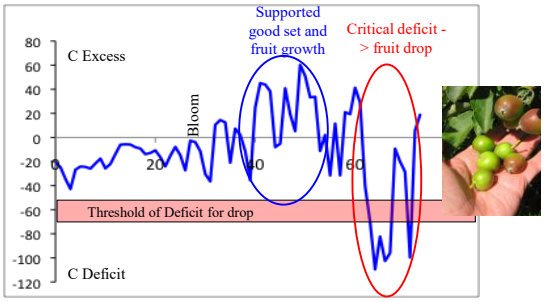
The Hypothesis of Carbohydrates and Chemical Thinning

The sensitivity of the fruitlets to a chemical thinning spray is a function of the carbohydrate supply to support growth of the fruitlet.

- Temperature y solar radiation solar influence the supply of carbohydrates through their effects on photosynthesis.
- Temperature affects the demand for carbohydrates of both fruits and shoots.
- When the demand for carbohydrates is greater then the supply the least competitive fruits begin to abscise.
- Trees are more susceptible to chemical thinners when carbohydrates are limited and trees are less susceptible to chemical thinners when carbohydrates are in excess of demand.

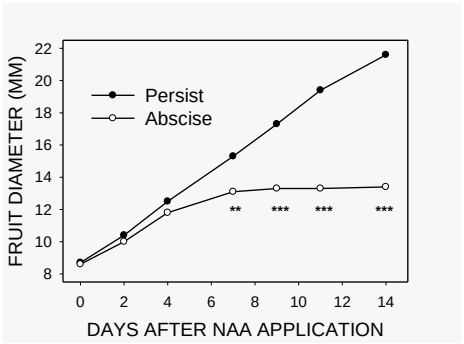


Weather effects on natural drop are consistent with carbohydrate supply/demand balance

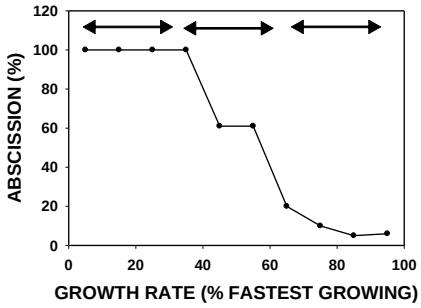


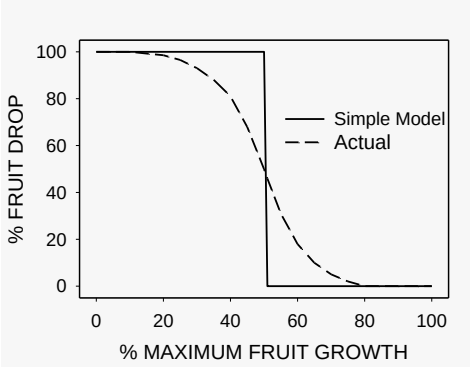
Web version of the Carbohydrate Model

The Fruit Growth Rate Model

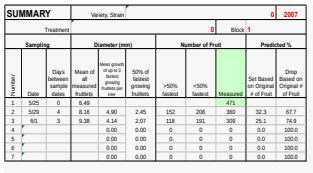


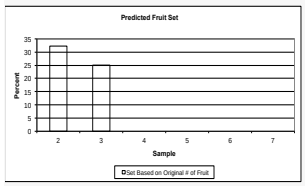
GROWTH RATE INFLUENCES ABSCISSION

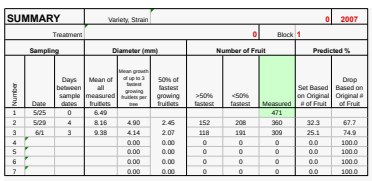


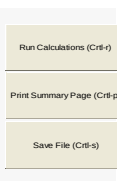


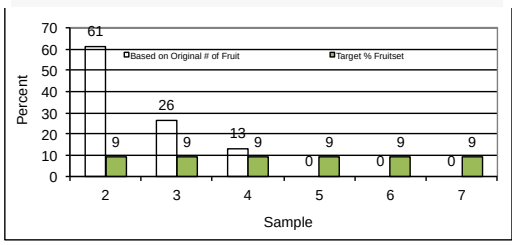
The Fruit Growth Rate Model (Greene, Lakso and Robinson)

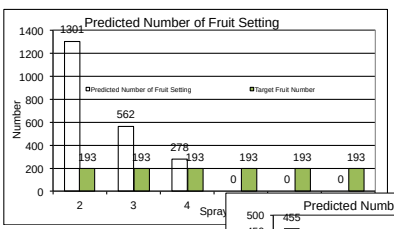


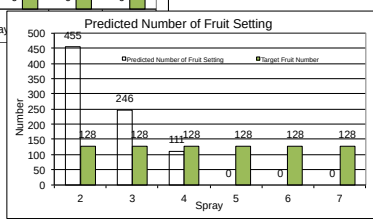








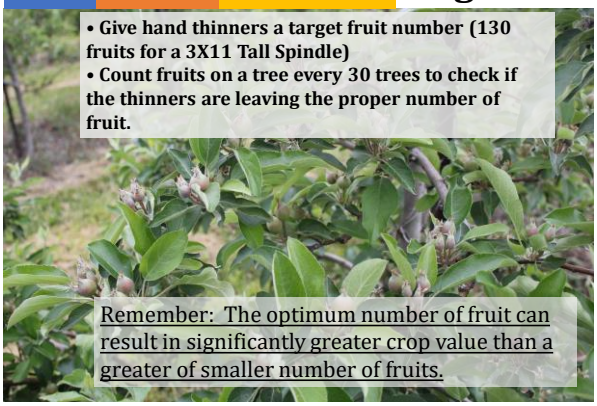




Example of Precision Thinning with Gala

- Bloom
  - ATS (2.0 %) (1-3 applications guided by polen tube growth model
- Petal Fall (5-6mm)
  - NAA (7.5ppm) + carbaryl (600ppm)
- 12mm
  - BA (100ppm) + carbaryl (600ppm) (directed at only the upper part of the tree)
- 15-18 mm
  - BA (100ppm) + carbaryl (600ppm) + oil (0.1%) (directed at only the upper part of the tree)

Precision Hand Thinning



Conclusions

- Crop load has very large impact of total crop value.
- To manage crop load more precisely requires information to guide pruning, chemical thinning and hand thinning severity.
- An effort to count flower buds and then prune to a flower bud load target has a large impact on the success of chemical thinning and has large economic impacts.
- Using sequential chemical thinning sprays guided by the carbohydrate balance and by the fruit growth rate model leads to a step-wise reduction in crop load and a small hand thinning job.
- An effort to hand thin exactly to the target final fruit number results in the optimum crop value each year

Where do we go from here:

- Develop computer vision counting of buds, flowers and 25 mm fruits to give more precision to pruning and hand thinning.
- Robotic pruning.


Thank you for your attention
Questions?