Thinning Strategies for 2022

Tools Available for a Precise, Data-Driven Approach to Thinning

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Introduction

Thinning is the most difficult, most important, yet necessary practice a grower must perform each year. Making a mistake will compromise both this year's crop and next year's crop. Over-cropping and under-cropping will reduce income for a block for multiple years. Today, with a more scientific approach to thinning we can achieve successful consistent annual croploads.

A firm understanding of the thinning materials, thinning stages, the natural background sensitivity to thinning sets the foundation for successful thinning. Thinning begins with pruning in the dormant season

to reduce budload. Next, a precise, data-driven approach, including Nibble Thinning and Precision Thinning, can be used to guide thinning decisions. Models including the Fruitset Model and the Carbohydrate Model provide guidance based on block data and environmental conditions to achieve better thinning results. We review each of these concepts, approaches, and tools below.

Pruning to Budload: Early Cropload Management

Cropload management should begin with pruning, well before the traditional thinning window (between petal fall and 30mm fruitlet size. Reducing the number of buds on the tree early in the season will result in stronger buds and better return bloom. With fewer buds on the tree, the nutrients and hormones (cytokinins) provided by the tree are divided among fewer buds. In addition, there are fewer floral buds, and therefore fewer fruits and seeds, producing gibberellins, which inhibit the production of floral buds in the following season.

Begin by determining a target cropload. This should be based on tree age, size, trunk cross sectional area. Large pruning cuts should be made during dormant pruning, typically between January and budbreak. A second, more detailed pruning effort should take place once floral buds are easy to identify (closer to budbreak as buds begin to swell and as late as bloom). Begin by counting the number of buds on a subset of trees. Prune to 1.5x the desired cropload for most varieties. For Honeycrisp, prune to 1.8x the desired crop load, to account for unreliable return bloom.

Thinning Materials

The window for chemical thinning apples begins at bloom and continues up to about 30 DAFB (days after full bloom). The major materials that could be considered include: Lime-Sulfur+Oil, ATS (ammonium thiosulfate), NAD (Naphthaleneaceatimide), NAA, 6-BA, Carbaryl, and Ethrel. Some experimental thinners look promising but are not labeled at this time or have not been tested long enough to offer reliable recommendations. Thinning materials, windows, and timings are reviewed in **Reference Tables 1, 2, and 3**.

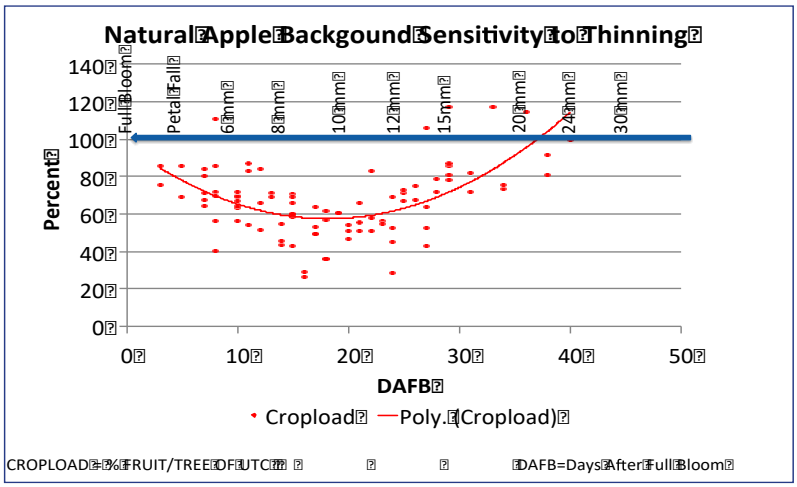
Natural Apple Background Sensitivity to Thinning

Apples vary in their sensitivity to chemical thinners based on their stage of development (**Figure 1**). This natural background sensitivity to thinning was evaluated in a thinning timing trial in a mature Gala block at CRC (Clarksville Research Center) from 2004 to 2011. Every 3.5 days, a treatment of either S+N (Sevin+NAA) or S+M (Sevin+MaxCel) at aggressive rates (NAA @ 15 ppm or MaxCel @ 150 ppm combined with Sevin @ 1 qt/100) was applied. There are four things that can be learned from the results:

1. At the 8 to 12 mm stage, fruitlets are at maximum sensitivity.
2. At PF (Petal Fall), the fruitlets are not very sensitive and over-thinning is a low risk
3. There is a lot of variation in thinning at the early and late timings, and not as much at 10 mm stage.
4. The thinning window closes rather quickly after 15 mm.

Overall, the natural background sensitivity to thinning predicts typical success in thinning. The sensitivity is low at PF, greatest at 10 mm, and then quickly becomes insensitive as 25 mm stage is approached. The thinning response is also driven by the weather at the time of thinning. Hot cloudy conditions at any of these stages will promote thinning and cold sunny weather will decrease thinning.

Figure 1. Natural Background Sensitivity of Gala 2004-2011.



Nibble Thinning

The concept of "Nibble Thinning" is to thin a little of the crop at every opportunity until the cropload has been reduced to the desired target level. This means to thin starting early and planning multiple applications. Start thinning early at FB, then at PF, then again at 6 mm and 10 mm and more if needed (**Figure 2 & 3**). Proceed to nibble the crop down to the perfect cropload.

Often, we let the early thinning windows (FB, PF, and 6 mm) pass by because we are unsure of bud health or fruit set. A frost event or some other early trauma makes us want to wait and see what fruitset will be before thinning. We would like to delay thinning until more time has passed and there is more information to judge fruitset and thinning needs, including frost injury, bee activity, pollination, and fertilization.

But apple trees are resilient; they will set crops almost every year even when conditions look bleak. In addition, you may be making it harder on yourself by delaying thinning. Fruitlets are much more resistant to thinning after the 10mm stage. At bloom through PF, thinning is also relatively safe because the flowers are less sensitive to thinning. Delaying first thinning action until late in the thinning window may allow only one chance to thin and then results may be unsatisfactory. Start early when over-thinning risk is low!

Thinning early (at bloom) is especially important for hard to thin varieties, biennial varieties (Honeycrisp and Jonagold), small-fruited varieties (Gala), and in years with a heavy bloom or 'Snowball' bloom. Initial flower load is the best early indicator of cropload. The initial flower numbers on a tree follows with corresponding number of fruit on the tree following fruitset.

Nibble and Precision thinning is to thin at every time there is an opportunity (FB, PF, 6 mm, 10 mm, etc.) until the target cropload is reached. This method achieves success yet reduces risk of over and under thinning. **Figure 2** indicates the typical percent thinning expected if thinning is performed at the corresponding stage with moderate thinning rates. Aggressive rates will have a greater response. Typically about 50% thinning is the target level in the vast majority of years on most blocks.

Figure 2. Nibble or Precision Cropload Flow Chart.

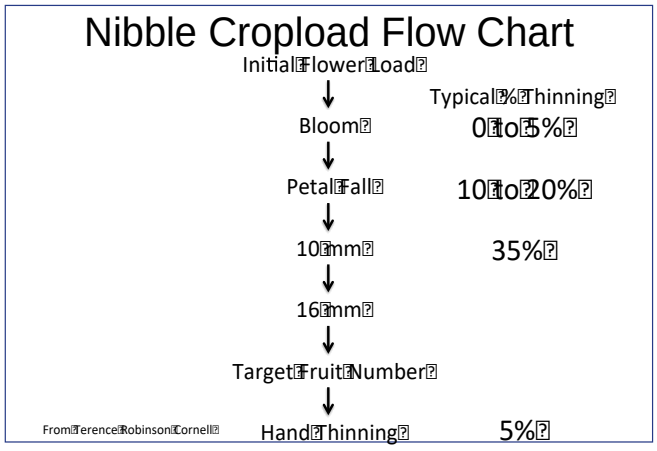
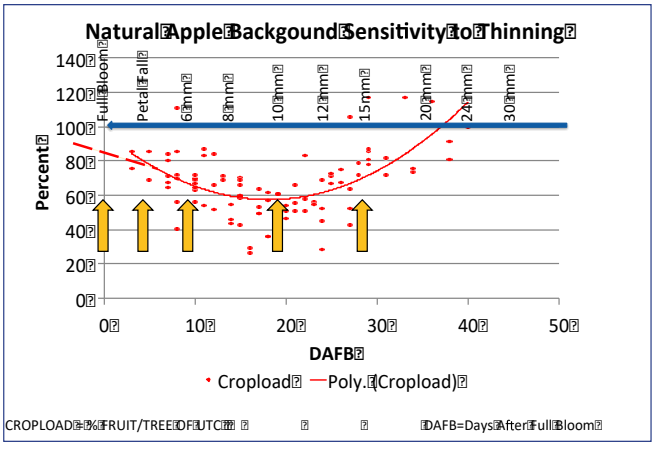


Figure 3. Precision Multiple Thinning Timing.



Precision Thinning

To make accomplish more successful thinning, we can use data to make informed thinning decisions. Over the past 50 years, researchers from Cornell University, Michigan State University, and North Carolina State University have developed models based on data, to inform data-driven thinning.

The Precision Thinning concept uses all information available to achieve a target cropload. The concept of Precision Thinning takes the nibble thinning concept and adds the use of the Carbohydrate Model and the Fruitset Model to help verify or indicate how the thinning process is proceeding. The Carbohydrate Model predicts the stress on the fruitlets, while the Fruitset Model predicts their potential to abscise. Together these are powerful tools for making more informed data-driven thinning decisions.

Theory of Fruitset

Fruitlets are living respiring organs; they need energy (carbohydrates) to grow and set. When fruitlets demand for energy is greater than supply, fruitlets will be shorted energy, and the weakest ones will drop. When energy is abundant, fruitlets set and resist thinning. Fruitlet stress, both environmental and chemical stress, has a big impact on sensitivity and response to thinning actions. Temperature and sunlight affect the supply and demand of energy (carbon) available for the fruit and leaves. Energy is supplied to fruitlets from two sources, 1) last year's overwintering reserves in the wood and 2) this year's photosynthesis. It is thought that photosynthesis is the most important fruitlet energy source. A supply/demand crisis occurs after bloom when reserves are depleted and photosynthesis is picking up. This energy crisis on average occurs at the 10 mm stage, which is why fruit are so responsive to thinning at that time. By quantifying the balance of energy and stress, we can make more informed decisions, leading to more successful thinning.

Carbohydrate Model and MaluSim App

Dr. Alan Lakso and Dr. Terence Robinson of Cornell University developed the Apple Carbohydrate Model in 2019 to predict in current real time the energy levels. The original model was based on a fully bearing mature moderately cropped Empire tree, and decision rules were determined based on subsequent experiments on field and controlled greenhouse conditions. This model is useful to assist thinning decisions. In 2019, the Malusim app was developed as a more user-friendly interface to access this and other models for apple orchard management.

The Carbohydrate Model can be accessed several ways. In Michigan, we typically use the MSU Enviroweather website, which houses our Michigan-specific weather data and models. Clicking on the model in the Enviroweather website takes you to the Network for Environmental and Weather Applications (NEWA) Website to run the model. In 2019, researchers at Cornell also created an app called MaluSim, which houses the Carbohydrate Model along with others in a visually pleasing, easy-to-use format designed for smartphones.

- The MSU Enviroweather https://enviroweather.msu.edu/
- The Network for Environmental and Weather Applications (NEWA) http://newa.cornell.edu/
- The Malusim application https://malusim.org/

Simply, the model predicts the daily carbohydrate balance of a tree (photosynthesis producing energy vs. tree use of energy), and the resulting daily stress small, young, setting fruitlets might be experiencing. This information helps growers adjust their chemical thinning applications.

The carbohydrate balance predicts fruitlets' sensitivity to drop, set, and thinning. A surplus of energy at thinning time will set fruitlets and growers will need to thin more aggressively. A serious energy deficit will drop fruitlets and growers may want to delay thinning or reduce rates. The model starts at green tip and will predict the tree daily supply and demand of carbon (energy) based on three daily inputs, 1) daily max, 2) min temperature and 3) daily solar radiation. It also adjusts predictions for the earth latitude of the weather station to estimate day length. Sparta is at latitude 43°, Benton Harbor 42°, and Suttons Bay 45°. The four days following a thinning application are the most important carb model stress prediction to estimate thinning results. A four-day average carb balance of the predicted carb levels is used to help make a thinning decision. In real time this four-day average is using the results of the weather forecast to predict the future. This is risky, in that rarely are the forecast predictions correct, but it is the best information in real time during the thinning time. A decision guide has been developed by Cornell and adjusted for Michigan conditions (**Figure 4 & 5**), which include a suggested rate at various stress levels for difficult to thin varieties (**Table 4 & 5**).

Figure 4. Michigan Carb Balance Predicted Thinning.

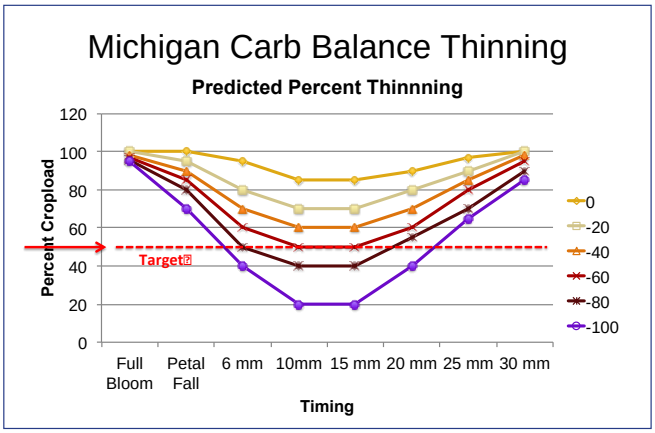


Figure 5. Michigan Predicted Percent Thinning.

Michigan Predicted % Thinning

Target

4 Day Ave Carb. Balance						
	0	-20	-40	-60	-80	-100
Full Bloom	0	0	2	3	4	5
Petal Fall	0	5	10	20	30	40
6 mm	5	20	30	40	50	60
10 mm	15	30	40	50	60	80
15 mm	15	30	40	50	60	80
20 mm	10	20	30	40	45	60
25 mm	3	10	15	20	30	35
30 mm	0	0	2	5	10	15

Table 4. Carb Model Thinning Decision Guide.

Stress Level	4 Day Avg Carb Balance	Thinning Rate Recommendation
No	> 0	Increase Rate by 30%
Slight	-20 to 0	Use Standard Rate
Mild	-40 to -20	Reduce Rate by 15%
Moderate	-60 to -40	Reduce Rate by 30%
Severe	-80 to -60	Reduce Rate by 50%
Extreme	<-80	Do not thin, many fruits will fall off

Table 5. Thinning Combination Rates Levels

Level	Sevin + MaxCel (1 qt + ppm)	Sevin + NAA (1 qt + ppm)
30% Increase	1 + 150 + 1 qt Oil	1 + 15 + 1 qt Oil
Aggressive	1 + 150	1 + 15
Standard	1 + 100	1 + 10
10% Reduction	1 + 75	1 + 7
20% Reduction	1 + 50	1 + 5
30% Reduction	1 qt Sevin	1 qt Sevin
Sevin rate = 1 qt/100 = 1 qt/acre.		

***100 gal/acre for difficult to thin varieties.**

Updates to the Carbohydrate Model for 2019

(adapted from an email from Terence Robinson, May 1, 2019)

In 2019, several updates were made to the carbohydrate model's look and information, as follows:

- The NEWA apple carbohydrate thinning model will has an updated look.
- The input page requires users to input the % of spurs that are flowering in one of 4 ranges (0-25, 26-50, 51-75 and 76-100%.).
- The output data table has a column of DD base 4°C and will have colors highlighting when we are in the sweet spot for thinning (200-250DD from bloom).
- The new version gives a Thinning Index composed of the average carb balance of 2 days before, the day of thinning and the next 4 days= 7 day running average.
- The thinning recommendations are based on a 3-dimensional lookup table taking into account, DD from bloom, % of spurs that are flowering, and carb balance over 7 days. The thinning recommendation cells in the table are also color-coded to indicate red=high risk of overthinning, blue= mild thinning expected, yellow= caution possible aggressive thinning efficacy and green=good thinning efficacy.

Updates to NEWA for 2021

In 2021, the NEWA website underwent many updates and improvements. The newest version, NEWA 3.0, is available at https://dev.newa.cornell.edu. Note this website address has dev in the front indicating it is a 'development' website, meaning there could be some occasional bugs or issues. If you discover a glitch, have a problem, or want to ask questions, contact the NEWA Help Desk right away by sending an email message to support@newa.zendesk.com.

There are three important steps to complete before using NEWA 3.0 models. Quickstart video tutorials are available for each at the NEWA Help Desk https://newa.zendesk.com/hc/en-us.

- How to start using NEWA https://newa.zendesk.com/hc/en-us/articles/360054268454
- Customize your NEWA dashboard https://newa.zendesk.com/hc/en-us/articles/360054268354
- How to use your NEWA dashboard https://newa.zendesk.com/hc/en-us/articles/360057357553

Fruitset Model

The Fruitset Model was developed by Duane Green and others at the University of Massachusetts. The model is based on the concept that fruitlets whose growth is slowing (growing at less than 50% of the fastest growth rates) will abscise, while others will set and remain on the tree. To determine which/how many fruitlets are actively growing and which will abscise, measurements are taken at 3 and 8 days after thinning applications are made. Originally, this was conducted by tagging clusters and using calipers to measure pre-marked fruitlets, but new technologies using computer vision are being developed to make this process easier.

This model is available as an Excel Spreadsheet downloadable on the MSU Extension Apple website: https://www.canr.msu.edu/news/updated-apple-cropload-management-models-are-available

This model keeps track of measurements of fruitlet growth and predicts set. We suggested that between 20 to 100 (40 is probably adequate) representative flower clusters should be marked and diameter measured every three to four days. The diameter growth will be used to predict fruitlet abscission. All fruit that slow to a growth rate of 50% or less of the growth rate of the fastest growing fruit, will ultimately stop growth and abscise.

Table 6. Fruitset Model Growth Prediction.

Fruitlet Fate	Prediction
Persist	A fruit is predicted to persist if the growth rate over the measurement period was at least 50% or greater of the fastest growing fruit.
Abscise	A fruit is predicted to abscise if the growth rate of the fruit slowed to 50% or less of the growth rate of the fastest growing fruit.

Environmental Factors

Effect of Environmental Conditions on Thinners

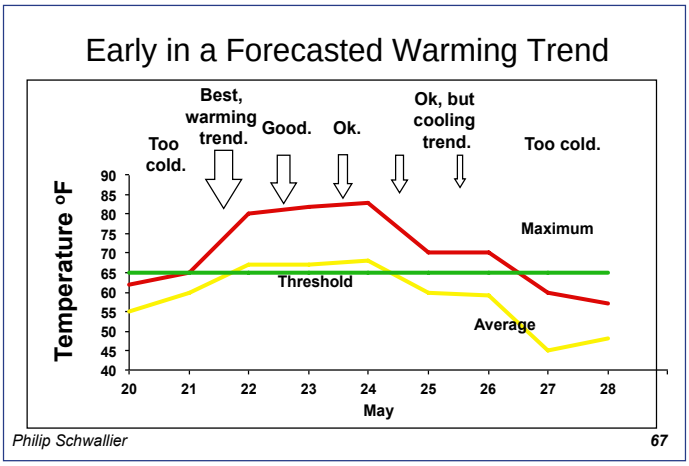
Thinners work best when temperatures are warm especially for four days following the thinning application. Slow drying conditions when the thinners are applied will increase uptake and response. Cloudy, hot conditions will increase stress and thus, increase thinning. Young trees (under 4 or 5) will thin easier. Nighttime temperatures are important, warm nights increase respiration thus stress.

Table 7. Summary of Thinner Effectiveness and Climate Conditions (adapted from Cornell information).

Climate Condition	Prediction
Warm Conditions >65°F.	All thinners work best.
Dark Cloudy Weather.	Greater stress, greater thinning response, greater drop.
High night temperatures (>65°F).	Greater stress, high demand and use of energy for night respiration, greater drop.
Very High day-time temperatures (>85°F).	Greater stress, high energy demand, greater drop.
Very cool temperatures (<65°F), greater set.	Reduced stress, reduced energy demand, greater set.
High light.	**Increased supply: harder to thin.**
Low light.	**Reduced supply: easier to thin.**
Low temps.	**Low demand: harder to thin.**
High temps.	**High demand: easy to thin.**
Worst.	**Low light and warm temps.**

Thinning Timing

For best thinning response, pick climate conditions that favor a response. Apply thinners early in a forecasted warming trend when maximum temperature reaches 80 to 85°F (>65°F). If temperatures are cool, either increase the rate or delay treatment until warm conditions return. Avoid applying thinners during a cooling trend where maximum temperatures will drop <65°F. Cloudy warm conditions will increase drop and may cause mild thinning. Cut back on rates.



Season-specific Recommendations

2021 Review

In 2021, there were multiple frost events early in the spring, resulting in a lighter crop across the region. Many Honeycrisp blocks across Michigan, the Northeast, and the Upper Midwest experienced a significantly lighter crop. This was most likely due to climactic conditions, due to the broad area affected. Stressful conditions in May-June 2020, corresponding to floral induction and initiation, including high temperatures and/or dry conditions may have led to the light bloom in 2021. In addition, bloom conditions were less than ideal, including a prolonged bloom lasting 7-10 days, with high temperatures mostly in the 50-60's F. As a result, there was a lighter than normal crop and uneven maturity at harvest in many locations. However, even with the frost damage and light crop, production was very good, only down approximately 30% from the 2020 crop.

2022 Outlook

A very heavy bloom and potential crop is expected in most varieties across the region. This is especially true of Honeycrisp and other biennial varieties that were light in 2021. We are recommending early thinning, beginning with bloom thinning, to promote a good crop for 2022 and return bloom in 2023. A summary of Honeycrisp thinning recommendations for 2022 is available in this article.

Some king damage is apparent in the region. This varies considerably from location to location, ranging from 20-90% king mortality. Most damage has been observed in Honeycrisp and gala. However, very little damage has been observed in laterals and there is still a very large potential crop, even in blocks with frost damage.

2022 Thinning Plan – Phil Schwallier

Assuming no frost/freeze injury, favorable pollination conditions, favorable application time weather and moderate/high budload.
Assuming Carb Model will be favorable at the thinner application time.
Apply 2/3 mixtures to the top ½ of tree except bloom applications.
Start early and plan on repeat applications.
*Oil applications need to be 4-5 day before or after Captan applications.

Variety	Timing	Timing and material	Comment
Easy to Thin			
Gingergold, Jonathan, Macs, Idared, Zestar, NovaSpy, Cortland, Etc	Full Bloom 6 mm 12 mm	MaxCel 100 ppm NAA 10 ppm S+N, 1 pt + 10 ppm NAA 10 ppm	Small fruited varieties Other varieties
Special Varieties			
Red Delicious, Fuji	Full Bloom 6 mm 12 mm 18 mm	MaxCel 100 ppm S+M, 1 pt + 100 ppm S+M, 1 pt + 100 ppm S+M + *Oil, 1 pt + 100 ppm	 If needed If needed, tops only.
Difficult to Thin			
Goldens, Romes, etc	Full Bloom 6 mm 12 mm 18 mm	MaxCel 100 ppm Or NAA 10 ppm S+N, 1 pt + 20 ppm S+N, 1 pt + 20 ppm S+M + *Oil, 1 pt + 20 ppm	 If needed If needed, tops only.
Gala	Full Bloom 6 mm 12 mm 18 mm	MaxCel 100 ppm Or NAA 10 ppm S+N, 1 pt + 10 ppm S+N, 1 pt + 10 ppm S+N + *Oil, 1 pt + 20 ppm	 If needed If needed, tops only.
LSO or ATS	Bloom	LSO 2% + 2%, *Oil Or ATS 2%	Experimental area

2022 Thinning Recommendations – Poliana Francescatto

Poliana Francescatto, Valent Biosciences

General Thinning Recommendations

- We recommend an intensive block-by-block scouting to make good thinning decisions, and be aggressive when heavy bloom and good set are evident.
- A reminder that old trees on more vigorous rootstocks thin easier (MM.111, MM.106, M.7), lower rates may be more appropriate in these orchards. Trees on M.9 clones, Bud.9 and G-series rootstocks set more fruit and thin harder. Young trees thin very easy, see the guidance for young trees in the "Thinning Suggestions" described below.
- Spray pattern – 1/3 to the bottom and 2/3 to the top (bloom and Petal fall). Shutting off bottom nozzles and adjust the chemical according to your tree.
- Temperatures at application (>85F do not thin);

Tree-Row-Volume (TRV) Considerations: https://lof.cce.cornell.edu/submission.php?id=452

Options for the Bloom Spray

- **Amid-Thin**- This is a mild thinner that can be used at bloom and petal fall. It should be used at the highest label rate suggested, 8 oz/100 gal TRV dilute.
- **NAA**- During bloom and petal fall it can generally be safely used at a rate of 10 ppm without over thinning
- **Caustic products:** such as ATS (2-2.5%); Lime Sulphur (2%) + Oil (2%), Regalia (1%) + Oil (1%) at 40% and 80% bloom. Some varieties can be more sensitive to others, so know your variety before applying.

Options for the Petal Fall Spray

- **Carbaryl** - it is a mild thinner and it will hardly over-thin (except Cortland). Be sure you have all bees out before spraying Carbaryl.
- **Amid-Thin (naphthalene acetamide)**- is the amide salt of NAA and is a relatively mild thinner. It can be used at bloom and petal fall. It should be used at the highest label rate suggested, 8 oz/100 gal TRV dilute. A surfactant could be included in the tank.
- **NAA**- 8-12ppm. When more aggressive thinning is required, NAA is frequently the thinner selected. It is not so aggressive at petal fall as compared with when it is applied at the 7 to 14 mm fruit size stage. Add 1 pt Sevin (TRV dilute) for harder to thin cultivars.
- **Maxcel** at 100ppm (64oz/100gal TRV dilute) + 1 pt Sevin (TRV dilute) is a good option for Gala to get some sizing.

When temps are warm, use Maxcel instead of NAA for petal fall (size benefit)

When fruit-set is clear, and if heavy on hard-to-thin varieties such as Gala or on biennial bearing varieties such as Honeycrisp, Macoun and Golden Delicious we are recommending to use 7.5 to 10 ppm NAA plus 1pt Carbaryl /100 gallons TRV dilute at **petal fall**.

Thinning Recommendations for the Petal fall and 8-12 mm spray (when indicated):

Varieties where we like Maxcel + Sevin

- **Gala** – Promalin at Pink to Full Bloom of the King flower, 64 oz Maxcel (100ppm BA) /100 gallons TRV dilute + 1pt Sevin/100 gal TRV dilute at Petal and again 8-12mm size. You can also use 7.5ppm NAA + 1pt Sevin/100 gal TRV dilute at petal fall and come back at 8-12mm size with the Maxcel option.
- **Empire** – 48 oz Maxcel (75 ppm BA) /100 gallons TRV dilute + 1pt Sevin/100 gal TRV dilute (petal fall and 8-12mm size).
- **Jonamac** – 48 oz Maxcel (75 ppm BA) /100 gallons TRV dilute + 1pt Sevin/100 gal TRV dilute
- **Macoun** – It has to have a petal fall spray to stimulate return bloom (7.5ppm NAA plus 1 pint Sevin/100 gallons TRV dilute). At 8-12mm use 48 oz Maxcel (75 ppm BA) /100 gallons TRV dilute + 1pt Sevin/100 gal TRV dilute
- **Fuji** – Bloom 4 ounces NAA (10ppm) /100 Gallons TRV Dilute, then 48-64 oz Maxcel (75-100 ppm BA) /100 gallons TRV dilute + 1pt Sevin/100 gal TRV dilute (petal fall and 8-10mm)
- **Red Delicious** - 48 oz Maxcel (75 ppm BA) /100 gallons TRV dilute + 1pt Sevin/100 gal TRV dilute. Do not use NAA because of pygmy fruit formation. A dose of 1pt Sevin/100 gal TRV dilute would work if fruit set is low and you want to break clusters. We like the 1-1.5 pint of Promalin from first bloom to full bloom, you get some fruit typiness but furthermore you get some thinning.

Varieties where NAA works well

- **McIntosh** – respond well to both Maxcel and NAA. So, 2oz Fruitone L or Pomaxa (5ppm NAA)/100 gal TRV dilute + 1pt Sevin/100 gal TRV dilute will work great. AceyMac thins harder than the true Macs – 7.5ppm NAA + 1pt Sevin.
- **Honeycrisp** – mature Honeycrisps are hard to thin because of the vigor level of the tree - less competition. Use 3oz Fruitone L or Pomaxa (7.5ppm NAA)/100 gal TRV dilute + 1pt Sevin/100 gal TRV dilute. Hopefully you have started with 10ppm NAA at bloom. Come back at PF with 7.5ppm NAA + carbaryl and again (5-7.5ppm) at 8-12mm when needed. It will help flower initiation.
- **Cortland** – It doesn't like carbaryl and it thins very easy, so use 2oz Fruitone L or Pomaxa (5ppm NAA)/100 gal TRV dilute at 8-12 mm size.
- **Gingergold** – 1oz Fruitone L or Pomaxa (2.5ppm NAA)/100 gal TRV dilute + 1pt Sevin/100 gal TRV dilute at 8-12 mm size
- **NY1 and NY2**– according to our 3rd year trial both varieties are hard to thin varieties and responding well to either BA or NAA (Maxcel is preferable due fruit size): 64 oz Maxcel /100 gallons TRV dilute + 1pt Sevin/100 gal TRV dilute OR 3oz Fruitone L or Pomaxa/100 gal TRV dilute + 1pt Sevin/100 gal TRV dilute (petal fall and 8-10mm). NY2 can be biennial if over-cropped.
- **Golden Delicious** - If you use Provide to control russeting at petal fall, then Golden thins easier and 10ppm of NAA (4oz Fruitone L or Pomaxa /100 gal TRV dilute) + 1pt Sevin/100 gal TRV dilute is ok, otherwise put 15ppm NAA on. Maxcel works OK on golden, but it is the toughest variety for Maxcel to thin well – 64oz.
- **Rome Beauty** –5ppm NAA (2oz Fruitone L or Pomaxa /100 gal TRV dilute) + 1pt Sevin/100 gal TRV dilute (spur type use 7.5ppm NAA) – 8-12mm.
- **Northern Spy** – it is a biennial, and it needs a bloom or petal fall with 2oz Fruitone L or Pomaxa (5ppm)/100 gal TRV dilute + 1pt Sevin/100 gal TRV dilute.

- **Idared**: It thins very easily. Use 2.5ppm NAA (1oz Fruitone L or Pomaxa /100 gal TRV dilute) + 1pt Sevin/100 gal TRV dilute at 8-12mm.
- **Jonagold**: use moderate rates 7.5ppm NAA (3oz Fruitone L or Pomaxa /100 gal TRV dilute + 1pt Sevin/100 gal TRV dilute) at 12-14mm - one time.
- **Pink Lady**: it thins very easy. Use 2.5 to 5ppm NAA (1oz to 2oz Fruitone L or Pomaxa /100 gal TRV dilute) + 1pt Sevin/100 gal TRV dilute at 8-12mm.

Thinning Without Carbaryl (blocks were carbaryl are not permitted or you still have bees)

- **Use the same rates at petal fall and 10-12mm**
- As a rule of thumb 7.5ppm NAA can replace 1pt carbaryl in moderate to hard-to-thin varieties. However, this does not apply for varieties such as Fuji and Red Delicious as pygmy fruit may result.
- **HC** – 32oz Maxcel + 3oz Fruitone L/100 gal TRV dilute
- **Gala** – 64oz Maxcel + 3oz Fruitone L /100 gal TRV dilute
- **Empire** – 48oz Maxcel + 3oz Fruitone L/100 gal TRV dilute
- **Macoun** – 3 oz Fruitone L (7.5ppm NAA) + 48oz Maxcel /100 gal TRV dilute
- **Golden Delicious** – 3 oz Fruitone L (7.5ppm NAA) + 48oz Maxcel /100 gal TRV dilute, or a long time program used in NJ for Goldens is at 8-12MM use ½ pint of Ethephon /100 gal TRV dilute plus 4 ounces of NAA (10PPM NAA) /100 gal TRV dilute
- **Jonagold** – 3oz fruitone + 32 oz Maxcel/100 gal TRV dilute
- **NY1 and NY2** = 64oz Maxcel + 3oz Fruitone L /100 gal TRV dilute
- **Red Delicious and Fuji –** start with a petal fall spray using 8oz Amid Thin//100 gal TRV dilute. Then two shots of 48-64oz Maxcel alone – one at petal fall and another one right after at 8-10mm for Red Delicious and Fuji.

- It might be good to use 10ppm NAA/100 gal TRV dilute at bloom on Fuji, but we do not have any data to support.
- Amid Thin at 8oz/100 TRV dilute is a good option for bloom and petal fall for all varieties, including Fuji and Red Delicious.
- Amid-Thin 8oz plus Maxcel

<u>Chemical thinning program for Young Trees:</u>

- For **newly planted trees** where you desire to totally eliminate the crop try a high rate of Maxcel (64 ounces) + Sevin (2pts) + Oil (1pt) /100 gallon TRV dilute when fruit size is 8-10mm.Or , as soon as the bees are out, begin repeated heavy doses of carbaryl (2 pints/100 gallons) tank-mixed with Regulaid (1 pint/100 gallons).
- For **2nd year trees** where we want a small crop use only hand thinning and the Cornell young tree thinning guide to adjust crop load.
- For **3rd year trees** use Sevin alone + follow-up hand-thinning.
- For **4th year trees** use 1/2 of our suggested full rate of NAA + Sevin or Maxce l+ Sevin
- For **5th year trees** use 75% of a full rate of NAA + Sevin or Maxcel + Sevin.
- For **6th year trees** use a full rate of NAA + Sevin or Maxcel + Sevin.

Cautions

- We suggest that Captan **not** be added to or near thinning sprays.

Use of Provide for russeting control

- 2-3oz ProVide per 100 TRV dilute
- Minneiska: Promalin (1/4 pint); Retain (1/2 pouch at 30% and ½ pouch at 80%), 2-3 oz Provide (2 for easy to thin and 3 for hard to thin blocks) – 4x weekly

Take-home messages

- You have to know the thinning history of your orchard/block;
- Weather plays a very important role on thinning (cold vs warm)
  - DO NOT thin when temperatures are above 85F;
  - Under long cold conditions, do not skip any spray in your program.
- Tree status is as important as weather conditions on defining/adjusting rates;
- Either to improve size or return bloom thinning HAS to start at bloom.
- Make sure to adjust the rate according your tree size;
- Make sure to adjust your sprayer nozzles!

Reference Tables

Table 1. Chemical Apple Thinning Materials and Comments.

Material	Description	Comment
Lime Sulfur & Oil	Depresses Photosynthesis. Burns Pistils. Reduces Fertilization. Prevents Pollen Germination Good for Organic Growers.	Use LS @ 2.5 gal/100 + Oil @ 2 gal/100. Apply @ 100/acre. Target 80% FB (just after KB). Follow every 3 to 4 days as needed.
ATS (Ammonium Thiosulfate) Fertilizer	Burns Pistils. Nitrogen and Sulfur fertilizer.	Use ATS @ 2 to 3 gal/100. Apply @ 100/acre. Target 80% FB (just after KB). Follow 2 days later if needed.
NAD (Naphthaleneaceatimide) Amid-Thin	Mild to little thinning. Use only at Petal Fall. NAD treated trees should be more difficult to thin at the 10 mm stage.	Use @ 50 ppm. Mostly on early summer varieties (Spy, Mac, Empire).
NAA (Naphthaleneacetic Acid) Fruitone N Fruitone L PoMaxa	Workhorse thinner. Moderate harsh thinner. Dose dependent. Use throughout thinning window. Can be damaging (defoliation). Promotes return bloom. Stunts fruit growth temporarily, but fewer fruits then grow larger. Aggressive with Sevin.	Use @ 5 to 20 ppm. Red Delicious and Fuji are sensitive to NAA. Stunted leaves and pygmy fruits can result if applied with or close to Promalin or 6-BA applications.
6-BA (6 Benzyadenine) MaxCel Exilis	Mild to moderate, gentle, thinning. Dose dependent. Improves fruit size, increases cell division. Not compatible with NAA. (needs more research) Aggressive with Sevin.	Use @ 50 to 150 ppm. Standard rate = 100 ppm (64 oz/100 or /acre). Labeled up to 200 ppm.
Carbaryl Sevin	Workhorse thinner. Mild to moderate thinning. Relatively safe gentle thinner. Tends to promote large fruit size. Not dose dependent. Use throughout window, but generally used late. Can be damaging (russet). Selective, thins weak laterals, leaving one fruit/cluster (singulates fruit). Will also thin out whole clusters. Can be used from PF to 30 mm. Harsh on beneficials and bees.	Use at 1# to 2#/acre (1 pt to 1 qt/100 or /acre). Combinations with NAA or 6-BA are aggressive thinners.
Ethrel	Mild to excessive thinning. Dose dependent. Will thin very late (20mm +). Generally used late for emergency thinning. Somewhat unpredictable. Can over-thin.	
Other Thinners	ACC ABA Metamitron	

Table 2. Apple Thinning Windows Considerations.

Stage	Description	Choices and Comments
Bloom	Set unknown. Early timing, start of "Nibble" or "Precision" thinning. Generally, too early for growers to feel comfortable. Helps difficult to thin varieties. Helps small fruited varieties. Fruits drop early. Maximizes fruit size & return bloom. Allows additional steps in reducing a heavy crop. Generally, weather is not best.	Lime Sulfur & Oil (maybe not preferred). ATS (possible with experience). **MaxCel (preferred choice).** NAA (good choice).
Petal Fall	Generally early time to thin. Best 1st thinning for return bloom. 1st thinning which allows 2nd and 3rd chance. Fruitset is unknown, generally under-thins. Bloom climate and bee activity is known.	NAD on early summer varieties. **Sevin alone on all varieties across the board**. NAA alone. Sevin+NAA or Sevin+MaxCel for more aggressive thinning.
6 mm	Get started early. Can get some thinning, but generally under-thins. Moderate risk thinning. Excellent return bloom. Still will have more chances to thin. Good for "Nibble" or "Precision" thinning.	Dose/rate dependent for thinners, choose rates to get target thinning: 6-BA or NAA or combinations of: Sevin+NAA or Sevin+6-BA.
10 mm	8 mm to 12 mm diameter fruit. **Traditional best timing and results for one-time application thinning.** Choose thinning level. Fruitset somewhat unknown, but fruitlets showing strength. Good return bloom. Still will have a last chance in 7 days.	Dose/rate dependent for thinners, choose rates to get target thinning: 6-BA or NAA or combinations of: Sevin+NAA or Sevin+6-BA.
15 mm	12 mm to 18 mm diameter fruit. Still receptive to thinning. Should use full or higher rates. Combinations best. **Last chance thinning.** Thinning window closing fast.	Dose/rate dependent for thinners, choose rates to get target thinning: Probably need combinations of: Sevin+NAA or Sevin+6-BA.
25+	Very late, probably no or low response. "Rescue thinning" Use aggressive combinations. Perhaps **Ethrel** is only good choice. Dangerous and unpredictable. Ethrel at 300 to 600 ppm (1 pt-1 qt). Can use Ethrel + other thinners and oil.	Use: Ethrel +Sevin +Oil All @ 1 qt/100 or /acre. ACC and metamitron may have some utility here.

Table 3. Precision Thinning, Timing, Materials and Predicted Percent Thinning Most Years.

Stage	Material Choices (red = preferred choice)	Predicted % Thinning (red = expected)			
Bloom	Lime & Sulfur Oil	0 to 20%			
	ATS (2 to 3 gal/100)	0 to 20%			
	MaxCel (100 ppm, 64 oz/100)	5 to 10%			
	NAA (10 to 15 ppm, 8 to 16 oz/acre)	5 to 10%			
Petal Fall	Sevin (1 qt/100 or /acre)	10 to 20%			
	NAA (10-15 ppm, 8-16 oz/acre)	10 to 20%			
6 to 20 mm		**6 mm**	**10 mm**	**15 mm**	**20 mm**
	Sevin (1# to 2#, 1 pt to 1 qt /acre)	10 to 25%	15 to 30%	15 to 30%	10 to 25%
	NAA (10-20 ppm, 8-20 oz/acre)	**15%**	**20%**	**20%**	**15%**
	Sevin+NAA (standard rates)	15 to 35%	25 to 50%	25 to 50%	15 to 35%
	Sevin+MaxCel (standard rates)	**30%**	**40%**	**40%**	**25%**

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