Thinning for Best Results in the Orchard
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Thinning is an essential practice for apples to ensure optimum fruit size, soluble solids, and quality, and to prevent biennial bearing. There are three ways to thin fruit 1) manually, 2) mechanically and 3) chemically.

**Hand thinning** can be very precise but is time consuming and consequently expensive. Hand thinning can also cause damage to the remaining crop by careless disposal of waste fruit, by physical damage similar to limb rub caused by ladders and people operating carelessly. Hand thinning should be done before fruit buds differentiate to ensure return bloom although later hand thinning can be used to grade fruit on the tree. The earlier it is done, the better response for fruit size. Hand thinning dwarf trees is much easier and cheaper than standard trees since almost all can be done from the ground without the need to move and reposition ladders. Also crop loads can be adjusted more accurately and easily on dwarf trees since there are fewer fruit to count on dwarf trees and estimation is easier and more accurate.

**Mechanical** - Pruning to reduce flower numbers and potential crop is the primary mechanical method. This method is 100% effective but risks reducing fruit buds to less than the number desired if fruit buds are killed after pruning through a later catastrophic event such as frost or freeze. Apple trees should be pruned annually with crop load reduction always a consideration. The amount and type of pruning depends on the variety, potential crop, vigor considerations, and timing of pruning. Typical pruning for crop load management includes spur pruning, renewal pruning, branch simplification (columnarization), and branch shortening (Gala).

Mechanical thinning with a machine has not been used much with apples since a narrow canopied structured tree with accessible fruit or blossoms is needed to achieve good even thinning throughout the tree. Recent research on apples and peaches in Quebec Ontario by Ken Slingerland and John Cline and in Pennsylvania by Steve Miller, Tara Baugher and Jim Schupp (Miller et al., 2011, Oster, 2008) both show mixed results for apple. Currently mechanical thinning has resulted in uneven distribution of fruit left within the canopy. Entire spurs are typically removed which thins the absolute number of fruit on the tree and fruit that remain are clustered which results in smaller under-colored fruit which are difficult to protect from direct pests. There is also the risk of spreading fireblight through the orchard where the inevitably leaf and shoot damage caused by this method of thinning provides entry points for the disease. There is potential for mechanical thinning of apples so research and commercialization continues. More work needs to be done with tractor speed and drum rotation speed for optimum thinning but until thinnable tree canopies are developed mechanical thinning will remain a curiosity. On that note there has been progress toward structured canopies where mechanical thinning will be practical. Much of the work has been done with the “Darwin” string thinner (distributed by N.M. Bartlett in Beamsville, Ontario, Canada) which is now more appropriate for peaches than for apples.

**Chemical thinning** - The bulk of thinning done today in orchards is with chemical sprays. And the workhorses have been carbaryl and naphthalene acetic acid. More recently 6-benzyl adenine
has been added to the mix. Chemical thinning is very cost effective and through the years has become fairly predictable as our knowledge has increased on the effects of external variables on the response of apple trees to chemical applications. Since, the risk of over-thinning is always present, growers typically do not take the risk of completely losing their crop in any one season.

**Strategies for thinning** - Since chemical thinning currently is the most cost effective and practical, it is the most used method for thinning the crop. Hand thinning often needs to be used as a follow-up since the growers need to be conservative to preserve crop. Although over-thinning can be costly, under thinning is also very costly. Therefore, research continues to refine chemical thinning programs to remove as much fruit as needed to maximize profitability by eliminating the need for hand thinning. This requires a good understanding of all factors that contribute to thinning. Hennerty and Forshey (1972) outlined tree physiological conditions as a source of variation in chemical thinning and Williams and Edgerton (1981), Forshey (1986), and Schwallier (1996) all produced simplified tables that listed conditions that affected the ease of chemical thinning. From these tables we learn that trees are easier to thin when they are shaded, have inadequate nitrogen or moisture supply, heavy bloom, excess vigor, poor pollination (no pollinators or poor weather for pollinator flight), heavy fruit set, easy to thin cultivars, high temperatures and humidity, frost injury, prolonged cool periods and associated soft foliage, reduced photosynthesis with prolonged cloudiness. And that trees are harder to thin at the top and outside of the tree because of better exposure to sunlight and healthier buds, moderately vigorous, have balanced nutrition, mature bearing, light bloom and set with high leaf to fruit ratio, good pollination weather conditions, good insect activity, single fruit rather than clusters, moderate temperatures and low humidity, cool periods following thinning. Growers and advisors have been integrating these factors in their heads for years to adjust thinning rates.

**Varietal Categories for thinning** - Perhaps the single most important factor is the response of different varieties to chemical fruit thinners. We have grouped varieties into categories based on how difficult they are to thin. These categories are “Easy to Thin” (IdaRed, McIntosh, Jersey Mac, and Northern Spy), Moderately difficult to thin (Jonagold, Crispin, Paula Red, Spartan), Hard to thin (Empire Gala, Fuji, Honeycrisp) and Impossible to thin (Jonamac, Macoun). Different thinning materials, rates, and application timings are all used to adjust thinning for these groups.

**Materials** – Different combinations of chemicals are appropriate for different varieties. The mildest thinning material is carbaryl and is commonly used alone when only mild thinning is necessary. The addition of NAA or 6-BA to carbaryl is the next more potent step. The rates of NAA and 6-BA can be increased to provide yet stronger thinning. When the maximum level of NAA and 6-BA are reached, multiple applications of thinner are needed.

**Multiple Applications** - Many of the harder to thin varieties need multiple applications and we continue to strongly recommend this approach to NY growers. Multiple thinning also is useful when we need to improve fruit size, or spread the risk. We use it routinely for Empire, Fuji, Gala, Golden Delicious, Honeycrisp, Jonamac, Liberty, Macoun, Paula Red, and Spartan (Agnello et al. 2011). We vary the number of sprays and the rate depending not only on sensitivity of the variety but the current weather and tree sensitivity factors.
Typically for the most difficult to thin varieties, the first application is at full bloom to reduce flower numbers, the second is at petalfall which reduces a portion of setting fruitlets, and the third spray when fruit are between 8-16 mm depending on weather and tree conditions and the need for additional thinning. For hard to thin varieties where a bloom application is not needed, a petalfall spray is almost always warranted. We have never over-thinned with a single petal-fall spray. This spray simply reduces the number of fruitlets making subsequent sprays more effective. Reducing the competition among fruitlets early also improves ultimate fruit size. Carbaryl is the base material with additional amounts of NAA when needed.

The Carbohydrate Model - Recently, the development and refinement of “The Carbohydrate Model” developed by Alan Lakso (Lakso et al., 2001) and Terence Robinson has given us new tools to use when adjusting thinning rates. The model tracks carbohydrate supply and demand within the apple tree based on the theory that fruitlet sensitivity to chemical thinners is primarily a function of carbon supply available for fruit growth. This carbon comes both from current production through photosynthesis and stored reserves within the tree. The supply of carbon available for use by the tree is influenced by temperature and sunlight and affects the demand from competing sinks and fruits. The role of carbon reserve within the tree is still not clear. When carbon demand for fruit growth exceeds the supply from current production the least competitive fruits abscise. Trees appear to be more sensitive to chemical thinners when new carbon supply is limiting and less susceptible when carbon is ample. This hypothesis explains why many of the factors that were identified by earlier tree fruit physiologists are important (Forshey and Hoffman, 1966, Williams and Edgerton, 1981, Schwaller, 1996).

Our approach has been to use the model to estimate relative thinning rates compared to a “normal” season. Suitable thinning windows which combine a fruit size between 8-16mm fruit diameter, temperatures above 65°F (18°C), and dry conditions are selected and the model consulted for carbohydrate status of the tree just before and after the anticipated spray. This model calculates a “thinning index” based on grams of carbohydrate accumulation predicted and averaged over a 3 day period. Index levels range from 40g to -40g per day with deficits indicating that chemical thinner will work better than expected and positive values indicating that thinners will not work as well as expected giving the grower information how to adjust thinning rates.

This model has been refined and used by cooperating growers since 2008 in NY (Robinson and Lakso, 2011). Growers report that it has provided them with more consistency in thinning and reduced hand thinning. We believe in that in some areas of NY in 2011 prevented widespread over-thinning. Robinson received funding in 2011 to put up a simplified model on the web for use by growers so the model should become available in the near future. This model will use local weather conditions to make Carbohydrate Index Predictions.

This model still is not perfect. It is only as good as the weather predictions, interpreting solar radiation is difficult based on information available, temperature differences among orchard blocks can differ significantly causing different results among orchards, many weather stations do not have a solar radiation capability, and we do not know exactly how to interpret small differences in the Index in terms of sensitivity of fruitlets to thinning.
What we have learned of practical significance about thinning

1. Fruit size at time of application is less important than originally thought – rather temperature and sunlight have a larger affect. Growers should time thinning sprays to conditions rather than to fruit size as long as they are within the fruit size window of 8-16mm diameter.
2. Multiple thinner applications reduce the risk of over or under-thinning.
3. High initial fruit set results in greater final fruit set despite the application of thinners therefore growers should use a more aggressive thinning program when fruit set appears to be high.
4. Avoid high rates of NAA on small fruited varieties such as Jonamac, Empire, and Gala.
5. Temperature at time of application is not important as long as temperature reaches 18°C during the day.
6. Two days of dark cloudy weather either before or after application increase thinning response (this is integrated as the solar radiation part of the carbohydrate model).
7. High night temperatures increase thinning response after application especially when combined with cloudy day time weather. Future forecasts are important predicting thinning response.
8. Adjust thinning rates to the predicted carbohydrate levels which are based on immediate past and predicted sunlight and temperature. Use the Thinning Index as a guide to within tree carbohydrate levels.

References: