THINNERS and GROWTH REGULATORS FOR FRUIT TREES

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GROWTH REGULATORS

Plant growth regulators are defined as organic compounds, other than nutrients, which in small amounts promote, inhibit, or otherwise modify any plant growth processes.

Growth regulators are an integral component of tree fruit production. These regulators can be used to thin or to set crop, to remove the crop or to hold it on until it is ready to harvest, to increase fruit colour and to modify maturity. Growth regulators can also be used to reduce excessive vegetative growth, to modify tree form or to initiate fruiting. Development and evaluation of growth regulators is an ongoing process and this publication looks at the growth regulators that are presently registered December 2009, for use by commercial tree fruit producers in Canada

APPLE POLLINATION AND FERTILIZATION

Fruit will develop following successful pollination of the flower. The apple blossom has five sepals, which persist at the "bloom end" of the fruit; five petals which are soon shed; twenty to twenty-five stamens each with an anther containing pollen surmounting the filament; they surround the five stigmas, which unite in a common style that leads to the ovary, and together constitute the pistil of the flower. The stamens are the male parts and pistils the female parts of the flower (Figure 1).

Figure 1.

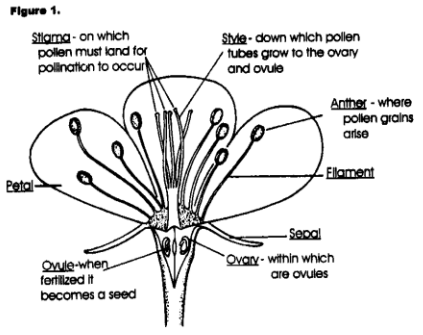
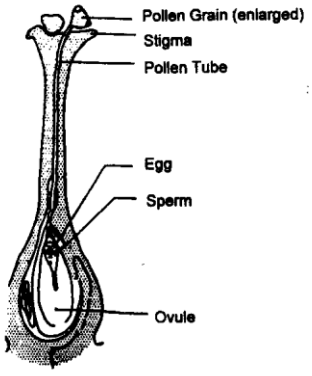


DIAGRAM OF AN APPLE FLOWER

Figure 2.



Pollination is the transfer of pollen from the anther to the stigma and is usually accomplished by the aid of insects. The transfer of pollen from the anther of one flower to the stigma of the **same**

cultivar is known as **self-pollination**. The transfer of pollen to the stigma of the flower to **another cultivar** is **cross pollination**. In some cases, the stigma becomes receptive shortly before the anther dehisces (sheds ripe pollen) and makes it difficult for pollen from the flower to reach the stigma of the same flower. Therefore, this flower would need pollen from another flower on the same tree (self-pollination) which sometimes happens or from another cultivar (cross pollination). Following pollination with pollen of a suitable cultivar, the pollen tube develops, growing down the style through the tissue and finally reaches the ovary, where it releases the sperm which units with the egg cell, thus accomplishing fertilization (figure 2). This process usually results in the formation of seeds. This initiates the growth and development of the fruit and is needed for fruit to set. The ovary ids divided into five compartments each containing two egg cells (three in Golden Delicious, four in Northern Spy). Where the ovules are not fertilized, or where for any reason development is checked, the blossom are soon shed.

It is not necessary for the entire complement of seeds to be produced in order for normal apple development. However, the larger the numbers of seeds that do develop in a fruit, the better chance there is for the fruit to fully develop and remain on the tree to harvest. Apples with one or more compartments devoid of seeds are more likely to be one-sided or otherwise abnormal in shape.

Most apple cultivars are considered to be self-unfruitful, which means that the pollen from one flower will not fertilize an egg of the same cultivar. Thus, in an orchard there is a need for a suitable pollinator or a number of pollinators to be planted.

One of the important factors to be considered in pollination is the weather conditions during the bloom period. Temperature has an important role in fertilization as the rate of growth of the pollen tube is dependent on temperature. Studies have shown that pollen tube growth rate is very slow at temperature below 13°C. Maximum growth rate occurred at temperatures between 13° and 24°C. The fastest growth rates were at temperatures over 27°C. It has been observed that as the number of pollen tubes increase, there is an increased chance of pollination. The average is 30-50 pollen tubes per style but there have been reports of up to 100 pollen tubes per style.

Two vital weather effects are:

1) At lower temperatures bee activity is decreased which leads to reduced pollination.
2) Rain will also stop bee activity and destroy all ripe pollen from anthers, thus rendering it useless for pollination.

During hot bloom periods, the pollen tube can reach the egg before it degenerates while under cooler temperatures the egg can degenerated before it can be fertilized. Excessively hot weather, especially if accompanied by dry winds and cold soil, may also be detrimental to good fruit set.

Orchard nutrition also plays a role in fruit set. Nutrient deficiencies will adversely affect vegetative growth, flowering, fruit set, fruit yield and fruit quality. Trees deficient in nitrogen may have reduced fruit set increased June-drop and be more sensitive to chemical thinners. A phosphorus deficiency could result in reduced flower numbers and flowering may be delayed in the spring. The two micronutrients boron and zinc are also known to play a role in fruit set. A boron deficiency can result in reduced flowering, reduction in pollen tube development and

germination thus severely reduced fruit set. A zinc deficiency can result in a reduction of flowering and fruit set.

STEPS IN SUCESSFUL THINNING

The first step in a successful thinning program is do all you can to achieve good pollination conditions. It is important for growers to be able to predict a heavy set. There are a number of essential that can contribute to a good set. These are:

1) Adequate bloom of good vigour
2) Adequate fresh, ripe pollen from other diploid cultivars such as McIntosh, Cortland, Gala, Golden Delicious Honeycrisp and Idared.
3) Honey bee and other pollinating inset activity to carry pollen to the stigma of flowers.
4) Warm 18°C plus weather, bright light conditions, and relatively calm conditions all encourage pollen maturity and bee activity. How these conditions are accessed often determine the success or failure of the thinning program.

CHEMICAL THINNING

There is a strong market for large and high quality apples and pears. Export markets primarily exist for high quality fruit in large count size. Chemical thinning helps to reduce the crop load which in turn promotes increased fruit size. It also is also well that excessive crop leads to biannual bearing. This can result in economic losses both the on year when excessive cropping reduces fruit size and the off year when yields can be light or non-existent. Reducing the crop load by means of chemical thinning, hand thinning or the combination of both will help to reduce these problems. The draw back with hand thinning only is that it is slow and costly and may not have any impact on reducing biannual bearing. Therefore growers should be interested in maximizing the potential of chemical thinners.

Advantages of chemical thinners are:

1) Increased fruit size and quality
2) Reduced biennial bearing
3) Increased fruit yield

Growers may be reluctant to make full use of thinners because of variable results that have occurred from the use of a thinner or the fear of over thinning. The variability of results obtained from the use of thinners may be related to a number of factors which a grower needs to take into consideration prior to the use of thinners. Some of these are:

1) **Weather conditions**
   a) Cool, wet weather preceding application may precondition leaves, causing more thinning than usual.
   b) Trees subjected to frost or low temperatures at “pink” or “bloom” are easier to thin.
   c) Slow drying conditions following spray applications increase the thinning effect of hormone type thinners.
   d) A low temperature, eg 10°C, during spray application decreases the thinning effect.
   e) Low humidity causes rapid drying of the spray and decreased absorption occurs after

spraying and decreased thinning effect.

f) Prolonged cloudy periods reduce photosynthesis before or after application and will increase the thinning effect.
g) Fruit that is set under good pollination conditions is harder to thin.

2) Tree Conditions

a) Any stress on the tree makes it easier to thin.
b) Trees with a heavy crop bloom and/or fruit set are thinned more readily than those with a light bloom and/or fruit set.
c) Trees that bore a heavy crop load or were under stress in the previous growing season are somewhat easier to thin.
d) Trees that are weak, suffering from lack of nutrition, have root damage or have been mouse girdled will be easily over thinned.
e) Young trees are easier to thin then are mature trees.
f) Fruit set on spurs in well light areas of a tree (tops and outer periphery) are more difficult to thin while fruit set on spurs on the lower, shaded inside branches are easier to thin. This is not as big a factor for apples grown on dwarf rootstock.

3) Varietal Response

a) Cultivars respond differently to chemical thinners

Easy to thin:
Idared
Cortland
Non-spur Red Delicious
Jonagold

Moderately difficult:
Ambrosia
Empire
Gala
Honeycrisp
McIntosh
Northern Spy
Spartan
Spur-type Red Delicious

Difficult to thin:
Golden Delicious
Gravenstein
Fuji
Paulared

b) Spur–bound or over-spurred trees which are common for certain rootstock

combinations are also hard to thin. They need special attention with regards to pruning and nutrition to encourage a balanced ratio between vegetative and fruit wood before thinning will be fully effective. Spur-type cultivars are particularly prone to this condition which if not thinned leads to small fruit and biennial bearing.

4) Other

a) Fruit size plays a role in the effectiveness of thinners. Most chemical thinners work best when applied to fruit between 4 and 14 mm in diameter.
b) If not included in the product the addition of a wetting agent (surfactant) will enhance the effectiveness of the thinning agent.
c) Trees treated with the growth regulator Promalin during bloom period are easier to thin.
d) The application of Apogee to control shoot growth may increase fruit set and a more aggressive thinning program may be required for these trees.

When these factors are taken into consideration growers have been very successful and have seldom had variable results.

With good pollination, 3-4 or more fruit set in each flower cluster (Figure 3). The king blossom (first blossom to open in a healthy flower cluster), if it sets, will produce the largest fruit with in the cluster. Chemical thinning will remove two or more of the weaker fruitlets in the cluster leaving only the strongest. This is the ideal in a well-balanced tree. The aim of chemical thinning is to remove 75% of the excess fruit with the remainder being removed by hand thinning. However, in an over-spurred tree, the fruit may still be too small and close together at harvest following chemical thinning. This problem can only be corrected by proper pruning techniques.

CLASSIFICATION OF CHEMICAL THINNERS

Thinning can be accomplished at bloom time and during the early post-bloom period. Since the discontinued production of Elgetol there have been no new product registered as blossom thinners. The Atlantic Food and Horticultural Research Centre continue to evaluate product as possible blossom thinner. The liquid foliar fertilizer ATS (Ammonium-Thiosulphate) when applied during the bloom period as a foliar fertilizer is caustic to the flower parts and prevents pollination. Timing of application for a blossom thinner is very critical, being dependent upon temperature and the stage of bloom.

The post bloom thinners are mainly hormone types that temporarily upset the natural balance of the tree. The time of application of these chemicals is determined by fruit size or days after full bloom.

A. BLOSSOM THINNERS

Chemical Name	**Trade Name**
Ammonium-Thiosulphate	ATS

B. POST BLOOM

Chemical Name	Trade Name
Naphthaleneacetatamide	Amid-Thin
Naphthalene Acetic Acid	Frutone-N
Carbaryl	Sevin XLR
6-benzyladenine	MaxCel
6-benzyaminepurine	Cilis Plus

BLOSSOM THINNERS

Ammonium-Thiosulphate-ATS

Results of experiment conducted by the Atlantic Food and Horticultural Research Centre and by North American researchers indicate that the liquid fertilizer ATS can provide effective blossom thinning. The rates used in Nova Scotia trials varied between 0.6 and 1.0 % active with the solution being applied just after full bloom when it is estimated that that adequate pollination had occurred. To date growers have been successful thinning Honeycrisp, Gravenstien, Red Delicious and Northern Spy with ATS. This product is phytotoxic and cause foliar burn and if not properly applied can cause considerable damage to the foliage especially when applied during warm temperatures to sensitive cultivars such as McIntosh. Even spray distribution is import to reduce the amount of foliar burn.

POST BLOOM THINNERS

1. **Naphthaleneacetamide(NAAmide)NAAmide-Amid-Thin**
   This hormone type material is absorbed into the system of the plant where it directly induces formation of the abscission layer between spur and fruit. Amid-Thin can be applied at petal fall and up to two and half weeks after bloom. The petal fall application timing is recommended for apple and pears in the Atlantic Canada Region. The thinning effect of Amid-Thin is not as rapid or dramatic as some of the other chemical thinners and there is less of a risk of over thinning with this product. On the other hand Amid-thin may take enough fruit off. Repeat bloom is also encouraged by both Amid-Thin and Fruitone-N.

2. **Naphthalene acetic acid (NAA)-Fruitone-N.**
   This material is absorbed into the plant system where it influences auxin activity so that the mechanisms that cause normal fruit drop development are altered. Fruitone N causes flagging of the foliage following application which temporarily stops vegetative and fruit growth. Fruit development of the youngest and weakest is reduced by NAA and drop occurs about two weeks after the application of NAA. Fruitone-N is applied from petal fall to 21 days after bloom (12.5 mm fruitlet stage).

3. **Carbaryl-Sevin XLR.**
   Sevin XLR was registered as a broad-spectrum insecticide. It was later found to have apple thinning properties and is currently the most commonly used thinner in Nova Scotia. Sevin XLR is absorbed primarily through the fruit, not the foliage. The presence of carbaryl in the vascular system of the fruit disrupts the movement of vital chemicals. Certain important fruit growth processes cease, and the fruit drops. It is a consistent thinner that does not have a phytotoxic effect and it appears that the weaker fruit drop heavily at the June drop period. The data shows that while most of the drop occurs at the time there is a reduction of fruit numbers at harvest indicating weaker fruit continue to fall after June drop period.

   Thinning with Sevin XLR increases with concentration up to 0.75 kg (active ingredient/1,000 liters with rates above this having little or no increase in thinning effect. Sevin XLR is relatively insoluble so low concentrations produce a saturated solution. Sevin XLR provides very fine particle which are easy tomix and have less potential for contact with bees which are very sensitive to carbaryl. Fruit surface residue of Sevin can be further absorbed if re-wetting occurs.

4. **6-BA-MaxCel & Cilis Plus**
   MaxCel and Cilis are both cytokinins which have the ability to thin fruit and enhance cell division. The enhanced cell division can lead to larger fruit at harvest. The active ingredient for these two thinners are slightly different with 6-benzyladenine as the active in MaxCel and 6-benzylaminopurine for Cilis Plus. The BA thinners are considered to be mild thinners and should be used in combination with Sevin XLR to obtain the desired thinning effect.

5. **Ethephon-Ethrel**
   Ethrel which induces ripening and flower bud formation on apples can also thin fruit. It can thin apples when applied 10 to 20 days after bloom and remove fruitlets that are greater than 12.7 mm in diameter. In the United States it has been of value when other thinners have been used and insufficient thinning has occurred. The product is used alone or in combination with other thinners. The risk of over thinning is much higher with this product. Trail work by the Atlantic Food and Horticultural Research Centre was less than satisfactory because of the variability in thinning results. At this time Ehtrel is not registered as a thinner in Canada.

METHOD OF APPLICATION

The method is less important than is the delivery of the accurate amount of chemical with uniform coverage of each flowering spur throughout the tree. The hormonal thinners need to be dissolved or uniformly suspended in water in order to be absorbed by the foliage. Almost all NAA and NAAmide is absorbed from the original solution. With carbaryl, however, there may be sufficient additional absorption from rewetting. Using large volumes of water under slow drying conditions would be recommended when applying NAA or NAAmide but this does not appear as important with carbaryl.

Applying chemical thinners as a concentrated spray has been used by growers in Nova Scotia. Because there is no run-off, concentrated sprays have a tendency to apply more material on the lower limbs. These limbs which can be partially shaded are easier to thin than the tops of the trees where growth is stronger and thinning, therefore more difficult. For this reason, when applying thinners the spray pattern should be adjusted to place more spray into the top portions of the tree. The addition of a spreader sticker should give more uniform result due to the better cover of the fruit and leaves. Growers have reported good results with carbaryl even when applied at a 10X concentration (330 litres of water per hectare). The majority of the hormonal type thinners are applied with water volume of at least 550-1,120 litres per hectare. ATS on the other hand should be applied with a high volume of water. Contact with the flower parts is critical as the thinner need to destroy the flower parts to be effective. Good results have been obtained when ATS is applied in a water volume of 2,200 litres per hectare.

Timing and weather conditions are very important to the use of chemical thinners. Weather has the following effects: **First** it influences both the degree and nature of the fruit set; **Second** it influences the rate of absorption of the thinner application.

Weather that promotes soft, succulent and rapid growth leads to increased absorption. Likewise adsorption of these hormone type materials under warm temperatures and slow drying conditions (high humidity and minimum sunshine). Avoid applying these products under windy, cool (below 15°C) and fast drying conditions. Temperatures at 21-24°C are considered to be optimum. Rates of these products should be adjusted for weather conditions preceding and during bloom.

ATS application timing is critical and it should be applied when trees are at90% full bloom. Some foliage burn can occur from the application and the extent of the burn will depend upon rate and uniformity of coverage. Burning also appears to be more extensive on shaded spur which have a tendency to be weaker. Rewetting of the foliage following application does not appear to cause additional burn.

Amid-Thin application timing is relatively critical for the cultivar Red Delicious; if sprayed after most of the petals are off, there is the risk of pygmy fruit. Early maturing cultivars should be sprayed within seven days of fruit bloom especially if weather has been warm since later applications may result in premature ripening. With the above exception, while Amid-Thin is most effective and satisfactory when applied at petal fall (90-95% of petals off), it can be useful up to two weeks after bloom.

NAA (Fruitone N) application timing can be based upon either days after petal fall or fruitlet size. When used as a post bloom thinner the timing of application can vary from 7-8 days after petal fall. Earlier applications may result in some permanent stunting or disorders of the foliage. However, effective thinning without distortion can be achieved by applying low rates (eg. 3 ppm on Gravenstein) as near as possible but, never earlier than 75-95% petal fall stage.

When fruit size is used as the guide for timing of application a random sample of 10-20 fruitlets from each of 10 trees should be measured. For reliable results use the same type of fruit, either the “king bloom” or “side bloom” each year. The optimum average fruit size for applying the

chemical is between 7 and 12 mm.

Carbaryl (Sevin XLR) – Timing of application is not as critical as first thought. Research has demonstrated that good thinning results can be obtained with applications from petal fall to 12-14 mm stage of fruitlet development. Once the fruitlet stage has passed the 14 mm size Sevin XLR has no thinning effect. Following fruit set assessment Sevin XLR treatments can be applied if weather conditions are favourable. Warm temperatures during and following application will enhance the impact on thinning response rather than fruit size up until the fruit reaches the 14mm diameter size.

MaxCel® & Cilis Plus® - Best results are obtained when these products are applied between the 7 and 12 mm fruit size. Apply during periods of slow drying conditions (early morning) and warm temperatures. The best results are obtained when it is applied at temperature greater than 20°C during and following its application. Uniform spray coverage is important and it is recommended that the volume of water should range from 500 to 2,000 litres per hectare. Do not apply in concentrations greater than 2X. Do not apply in combinations with NAA or NAAmide (either tank mix or separate sprays) to Red Delicious or Fuji as it may result in the formation of pygmy fruit. MaxCel® and Cilis Plus® are considered to be mild thinners therefore consider tank mixing with Sevin XLR where more aggressive thinning is desired.

SPRAY ADDITIVES – Surfactants (wetting agents) greatly enhance foliage absorption of hormone type chemicals under unfavourable absorption conditions. A surfactant may reduce the amount thinning variability due to environmental conditions. The type and amount of surfactant used can affect the amount of chemical absorbed. A lower concentration of a hormone-type thinner plus a surfactant may be as effective as a high concentration of a chemical without the surfactant. Check the products label with regards to the need for and type of surfactant.

COMPATIBILITY – In most cases, combining chemical thinners with insecticides and fungicides is not recommended. The delivery spray pattern used for thinning sprays should differ from that used for pesticide application. When thinning, more spray should be placed in the upper portion of the tree where the fruit is more difficult to thin. When thinning, the whole block may not be treated because of the cultivar mix and possible variations in fruit set.

1) Do not use NAA or NAAmide with Bordeaux or lime sulphur.
2) Urea probably decreases the effectiveness of hormone type thinners

LEAVE A REPRESNTATIVE CHECK- Remember in order to access results, one needs a comparison. If growers are going to master the technique of chemical thinning, they need to know their results. Always leave representative unsprayed "check" trees. Also keep accurate records of factors such as cultivar, weather, dates, concentrations and level of fruit set.

In experimental work it is not uncommon to increase fruit size at harvest as much as 20 percent by actual measurement and yet the difference cannot be seen in the orchard at any time. It will not take long to measure a sample of fruit in comparing sprayed and unsprayed trees and it is the only way to determine the true results.

CHEMICAL THINNING RECOMMENDATIONS

APPLES

See tables 1 and 2 products, timing and rates.

PEARS

Pears like apples benefit from fruit thinning, however, research on fruit has shown that the increase in fruit size is generally small compared considering the earliness of thinning and the amount of fruit removed. The response of pears to chemical thinners can be more inconsistent from year to year than that of apples and therefore growers may wish to start off on a small scale until they have evaluated response in relation to tree vigour, cultivar and fruit desired and that obtained.

Apply NAAmide (Amid-Thin) at 10-50 ppm or NAA (Frutone N) at 15-20 ppm just after petal fall. The rate of these materials varies by cultivar and time of application. Best results are obtained with a through spray coverage. In Nova Scotia NAAmide has been the thinner of choice for thinning Clapp's Favourite and Bartlett pears. A rate of 10-12 ppm generally provides satisfactory results for Clapp's Favourite and 15-20 ppm for Bartlett when applied at petal fall.

PEACHES AND PLUMS

Presently there are no chemical thinners registered for peaches or plums in Canada. Hand thinning prior to the pit hardening stage is the main method for thinning. Trails are ongoing in search for a suitable chemical thinner for peaches and plums. In some countries ATS and lime sulphur have provided some thinning activity. An alternative method to chemical is mechanical thinning. The Darwin string thinner is being evaluated in Nova Scotia and other growing areas as a mechanical blossom thinner for peaches.

DEFRUITING YOUNG TREES

Certain cultivars and rootstock combinations may come into production and bear fruit too heavily before the tree structure can support the crop. Vegetative growth and tree structure can be lost due to this cropping and therefore it may become necessary to remove some or all of the fruit from young developing trees especially in high density plantings. Close attention should be given to the central leader as the weight of the fruit can bend it over resulting in poor vegetative growth and subsequent loss of the leader.

The defruiting of young trees can be done by hand, with chemical thinners or the combination of the two. A dilute spray of 15 ppm of NAA plus Sevein XLR 1.5-2 L per hectare within a week of petal fall should remove a high percentage of the fruit. The addition of 70 sec Superior oil at 0.5 L per 1000 L of water would increase the thinning effect. Some hand thinning still may be required to fully defruit young trees.

PRE-HARVEST DROP CONTROL OF APPLES

Pre-harvest drop control is a useful harvest management tool for growers to consider each year. Each cultivar differs in its tendency toward pre-harvest drop with McIntosh causing the greatest concern. Climatic conditions, nutrition, soil type and tree health are factors that will influence pre-harvest drop.

Trees with excessive nitrogen content late in the growing season and a heavy crop load have the greatest tendency to drop fruit. Trees with a magnesium or boron deficiency are also more prone to pre-harvest drop. A growth regulator spray to prevent pre-harvest drop will not overcome a dropping problem caused by a nutrient deficiency such as magnesium. Trees that are under stress be it lack of soil moisture or insect damage to the foliage, such as heavy populations of leaf minor or mites, have a greater tendency for pre-harvest drop. Abnormally hot days and warm nights just before and during the harvest period will enhance fruit drop.

In controlling pre-harvest drop the formation of the abscission layer (where the fruit stem joins the fruit spur) has to be slowed. This can be done by applying either ReTain or Fruitone-N. While the main objective is to control fruit drop these products may increase fruit colour and size due to the extended period the fruit is left on the tree.

Fruitone-N (Napthaleneacetic acid - NAA)

Fruitone-N (NAA) which is used in the spring for fruit thinning can be applied in the autumn for drop control. Apply at a rate of 10-20 ppm when the first sound apples begin to fall. Growers should note that the drop of apples due to those being pushed off or dropping as a result of insect damage, disease or nutritional deficiency are not to be considered as drop of normal sound apples The single strength rate of 10 ppm has less of an impact on storage life and should be used when conditions permit instead of the 20 ppm rate. Application timing varies with the growing season and cultivar to be treated. This product will provide drop control for 7-12 days after application depending upon the rate used. Longer drop control may be obtained with repeated applications every 7 days. High rates and repeated applications of NAA, however, do have a negative side in that the maturity of the fruit can be advanced and storage life of the apple reduced.

NAA is a hormone-type chemical and should be applied under conditions that favour good leaf absorption. Best results are obtained when it is applied as a dilute spray which provides a more uniform coverage of the foliage and fruit which is important as the product is only locally systemic. The greater volume of water also slows the drying time which allows for increased absorption. Air temperature also influences the absorption rate and the optimum temperature range is 21-24°C with high humidity. The absorption rate is adversely affected where the foliage has been damaged by insects, disease or frost and temperatures below 16°C. The addition of a non-ionic type spreader sticker will improve the absorption of NAA and should be used when weather conditions are less than ideal for good absorption. The timing of application for NAA can present some problems for producers in that it may be difficult to move a tractor and sprayer down orchard rows due to crop load. If applied before any harvest has taken place, it takes 1-2 days for the product to have an effect. It may take even longer after spot picking has taken place. The pre-harvest interval for NAA is 5 days.

ReTain (Aminoethoxyvinylgycine hydrochloride - AVG)

ReTain is a plant growth regulator that provides preharvest drop control of apples. ReTain supress ethylene production thus reducing preharvest drop. ReTain may also improve fruit quality as a result of firmer apples, reduced water core, improved fruit colour and increased storage life. With the delay in ethylene production the ripening process is delayed thereby allowing the fruit to remain on the tree longer without adverse affect. Fruit colour is often increased resulting for the increased duration the fruit is left on the tree. ReTain treated fruit tend to maintain fruit firmness which allows more fruit to be placed in storage at the optimum maturity. ReTain is applied four weeks prior to the normal anticipated harvest date. This date would be the period when non treated fruit would be harvested for long term storage. Timing should be based upon the current seasons growing condition and the cultivar to be treated. The recommended rate of Retain is one 333 gram water soluble pouch per acre (2.5 pouches per hectare). The addition of the surfactant Sylgard 309 may improve spray coverage and enhance absorption. The surfactant concentration of 0.05 to 0.1 % (v/v) (i.e. 500 to 1,000 ml per 1,000 litres of water) is recommended. The lower concentration is recommended when high temperature (in excess of 32°C) conditions prevail or are anticipated. Apply ReTain with a sufficient volume of water to ensure thorough wetting of the fruit and leaves while avoiding spray run-off. In modern orchard systems 1,000 litres of water per hectare should provide adequate coverage. The water volume should be adjusted according tree size and spacing. Best results are obtained when ReTain is applied during periods of slow drying conditions to ensure adequate absorption. For best results the water pH should range between 6 and 8.

ReTain should not be applied to trees under stress (e.g., water, disease, insect). Unsatisfactory results with ReTain have been reported in orchard blocks with heavy mite and or leaf miner populations. Injured or stressed fruit (due to heat, sunburn, disease, insect or poor nutrient content) may not respond to Retain.

The introduction of SmartFresh to block ethylene production once the fruit has been placed into storage has reduced the need to apply ReTain pre harvest toe block ethylene production and increase storage life. ReTain is now seen as more has a harvest management tool to prolong the harvest season without losing fruit quality.

EARLY COLOUR AND EARLY RIPENING OF APPLES

Ethrel (Ethephon) has a number of uses of which fruit ripening is one. When Ethrel is applied as a foliar spray, it stimulates the natural ripening processes which includes advanced and more uniform maturity, accelerated fruit abscission (detachment of the stem from the spur) and increased fruit colour. Temperature has a great influence on the response to Ethrel. It is rather ineffective when applied at temperatures below 18°C. For fruit colour, the best results are obtained with warm, sunny days, and cool nights. In cool weather the response is slowed down and in warm it is accelerated. Ethrel will not substitute for light in poorly pruned trees and poorly coloured fruit in shady areas will merely become yellow and of poor colour after treatment. The rates of application will depend upon the cultivar, tree vigour, temperature, weather conditions and degree of response required.

Since the maturity is advanced by Ethrel applications fruit drop can occur 7 to 9 days post treatment. The application of NAA (Fruitone N) in a tank mix with Ethrel is advisable to reduce fruit drop until harvest. Spray coverage is important as Ehtrel is not very mobile within the tree; therefore to obtain the desired results it is essential for the material reach the fruit. Best results therefore will be obtained with dilute sprays.

NAA at 10 ppm, tank mixed with Ethrel, has held Gravenstien apples on tree in Nova Scotia for up to 9 days. However, unusual weather conditions such as an extended warm period could hasten ripening. Under these conditions a second application of NAA at 5 to 6 days after treatment may be required.

Ethrel should only be applied to the number of trees that can be harvested in a 2 to 3 day period. The maturity of fruit should be checked on a daily bases following treatment with harvesting usually completed 5 to 10 days after treatment. No attempt should be made to spot pick treated trees with the intention of returning a week later to finish the harvest. This late harvested fruit more often than not will be over mature and of poor eating quality.

Harvesting Ethrel treated fruit at the proper maturity and placing the fruit in cold storage immediately following harvest are crucial for maintaining the shelf life of the apple. Fruit treated with Ethrel should not be kept in cold storage for more than one to two month.

RECOMMENDED RATES OF ETHREL

Cultivar	**Rate per hectare**
Early Season Cultivars	1.3 - 2.1 L
Gravenstein	1.3 - 2.1 L
McIntosh	3.0 - 4.2 L

FLOWER BUD INITATION AND GROWTH CONTROL

Slow returns from new orchards make apple production less profitable and any method to improve early production is important. The use of dwarfing rootstocks which are precious has reduced the incidents of orchard that are slow to come into bloom and production. There can still be incidents when new orchards are slow to come into production which more often than not is related to cultivar rootstock combinations such as Northern Spy on semi vigorous rootstocks.

Ethrel is the only plant growth regulator that is presently available that when applied to non-bearing apple trees will increase flower bud formation and decrease vegetative shoot growth. Timing is quite important to achieve the desired effect. On non-bearing trees that have that have a frame work which will support apples Ethrel should be applied as a dilute spray one to two weeks after peak bloom. Peak bloom is determined by the bloom in surrounding orchards. On young trees that are just coming into bearing or are bearing a light crop load the application

should be delayed to three to five weeks after bloom to avoid problems with over thinning and misshapened fruit. The application of Ethrel at this time of the growing season will result in a chemical pinch where the terminal growth is suppressed and two to three weeks often elapse before terminal growth occurs.

RECOMMENDED RATES OF EHTREL FOR FLOWER BUD FORMATION

	Dilute	Comments
Spur-type Cultivars	2.0 L/1000 L	Apply 1-2 wks after full bloom on non-bearing trees. Apply 3-5 wks after full bloom on bearing trees or those just coming into bearing.
Non spur-type Cultivars	4.25 L/1000 L	

APOGEE-(Prohexadione-calcium) when applied to apple trees reduces vegetative shoot growth. The biosynthesis of gibberellins which regulated cell elongation is inhibited by this product. The reduction in shoot growth can result in reduce pruning time, improved fruit colour, improved disease and insect control and reduce the severity of fire blight shoot infections.

Timing of Apogee application is critical to obtain the desired results. The first application should go on when the average shoot growth is approximately 5 cm in length. The first application generally has to be applied around late bloom or early petal fall. Delaying the application can result in poor vegetative growth control. Depending upon the amount a vigour control required a second application can be made 14 to 21 days following the initial application.

Apogee rates are based upon tree vigour and size of tree. The rate for medium vigour trees is 450 grams per 1000 litres of water per hectare applied twice. The number of application can be increased to 3 if tree vigour is excessive. The 450 gram rate is based upon TRV water volume of 1,000 L/ha as dilute (point at which water will begin to drip off the leaves). The application rate per hectare for an orchard block with full tree canopy can require water volumes of up to 3,000 litres as a dilute spray and the Apogee rate would be 3 X 450 or 1,350 grams per 300 litres per hectare applied twice. The rate of Apogee as based upon tree vigour and tree canopy volume can be applied as a dilute or concentrated spray provided good coverage is obtained. Do not thank mix with calcium sprays. If the water that is used for spraying contains high levels of calcium or magnesium the addition of green house grade AMS (ammonium sulphate) at a ratio of 1:1 to Apogee is recommended.

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The application of Apogee can result in more difficult thinning conditions thus product rates may

need to be increased were Apogee has been applied.

PROMALIN- This product is a mixture of GA_{4+7} and 6-benzyladenine (6-BA) and is used on Red Delicious to promote fruit elongation. Promalin was developed to help overcome the problem of squat Red Delicious which lack the desired elongated shape and five pronounced lobes in cooler climates.

Timing of the application influences the effectiveness of Promalin. It should be applied between the king bloom stage and full bloom. Best results are obtained when the spray is applied under warm temperatures and slow drying conditions. It should not be applied at temperatures below 5° C or above 26° C. Rain fall within six hours after application will reduce the activity of Promalin. Apply with a water volume rate of 1,700 to 2,250 L/ha. The recommended rate is 1.4 to 2.8 L/ha.

Promalin can also have a thinning effect on blossom, particularly weak or frost injured flowers. It can also increase the amount of thinning achieved with a subsequent thinner such as Amid-Thin or Sevin XLR. Do not apply Promalin with NAA to delicious in the same year as this may result in the development of pigmy fruit

Table 1. Thinners and Rates for Apple

Stage FB-Full Bloom PF-Petal Fall mm-fruitlet size	Products	Rate	Product Required per		
			Litre of Water	Hectare	Acre
100% F B	ATS 0.6% v/v	Medium	10 mL	33.7 L	13.7 L
100% F B	ATS 0.75 % v/v	High	12.5 mL	42.1 L	17.1 L
P F	Amid-Thin	Low	0.24 g	809 g	327 g
P F	Amid-Thin	High	0.48 g	1,620 g	660 g
P F/7-14 mm	Seven XLR Plus	Low	0.87 mL	2.9 L	1.2 L
7-14 mm	Seven XLR Plus	High	1.25 mL	4.2 L	1.7 L
P F	Fruitone-N	Low-2.5 ppm	0.08 g	270 g	109 g
P F 7-12 mm	Fruitone-N	Medium-5 ppm	0.16 g	539 g	218 g
7-12 mm	Fruitone-N	High-7.5 ppm	0.24 g	809 g	327 g
7-12 mm 7-14 mm	Fruitone-N Sevin XLR Plus & Fruitone-N	Very High-10 ppm Low Low-Medium 2.5-5 ppm	0.32 g 0.87 mL 0.08-0.16 g	1,087 g 2.9 L 270-539 g	436 g 1.2 L 109-218 g
7-14	Sevin XLR Plus & Fruitone-N	High High 7.5 ppm	1.25 mL 0.24 g	4.2 L 809 g	1.7 L 327 g
PF-14 mm	MaxCell	Low-50 ppm	2.5 mL	8.4 L	3.4 L
7-14 mm	MaxCell	Medium Low 75 ppm	3.75 mL	12.6 L	5.1 L
7-14 mm	MaxCell	Medium High 100 ppm	5.0 mL	16.8 L	6.8 L
7-14 mm	MaxCell	High 125 ppm	6.25 mL	21.0 L	8.5 L
7-14 mm	MaxCell	Very High 150 ppm	7.5 mL	25.2 L	10.2 L
7-14 mm	Seven XLR Plus & MaxCel	High Medium High 100 ppm	1.25 mL 5.0 mL	4.2 L 16.8 L	1.7 L 6.8 L

Note: The product requirement is based on full tree-row canopy that would require water delivery of 3370 L/hectare, or 1363 L/acre or 300 imp gal/acre.

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Table 2. Cultivars and Thinning Options

Cultivar	Material	Timing	Rate per hectarer	Rate per acre
Early Cultivars	**Amid-Thin**	**25% petal fall**	**40 ppm**	**40 ppm**
	NAA + Sevin XLR	**Petal fall to 13 mm**	**5 ppm + 4.2 L**	**5 ppm + 1.7 L**
Gravenstein	**Amid-Thin**	**Less than 25% petal fall**	**40 ppm**	**40 ppm**
	NAA	**7 to 10 days after petal fall or 8-10 mm**	**5-10 ppm**	**5-10 ppm**
	Sevin XLR	**Petal fall to 12.5 mm**	**4.2 L**	**1.7 L**
	NAA + Sevin XLR	**Petal fall to 12.5 mm**	**7.5 ppm + 4.2 L**	**7.5 ppm + 1.7 L**
	MaxCel + Sevin XLR	**7 to 14 mm**	**16.8 L + 4.2 L**	**6.8 L + 1.7**
Paulared	**NAA + Sevin XLR**	**Petal fall to 12.5 mm**	**7.5 ppm + 4.2 L**	**7.5 ppm + 1.7 L**
McIntosh & Spartan	**Amid-Thin**	**petal fall**	**40-50 ppm**	**40-50 ppm**
	NAA	**7 to 10 days after petal fall or 8-10 mm**	**10-15 ppm**	**10-15 ppm**
	NAA + Sevin XLR	**Petal fall to 12.5 mm**	**3-5 ppm + 4.2 L**	**3-5 ppm + 1.7 L**
	Sevin XLR	**Petal fall to 12.5 mm**	**3 to 4.2 L**	**1.2 to 1.7 L**
	MaxCel + Sevin XLR	**7 to 14 mm**	**12.6 L + 4.2 L**	**5.1 L + 1.7**
Cortland	**Sevin XLR**	**Petal fall to 12.5 mm**	**3 L**	**1.2 to 1.7 L**
	MaxCel + Sevin XLR	**7 to 14 mm**	**12.6 L + 4.2 L**	**5.1 L + 1.7**
Honey Crisp	**Sevin XLR**	**Petal fall to 12.5 mm**	**4.2 L**	**1.7 L**
	NAA + Sevin XLR	**Petal fall to 12.5 mm**	**3-4 ppm + 4.2 L**	**3-4 ppm + 1.7 L**
Red Delicious	**Amid-Thin**	**50-75% petal fall**	**50 ppm (Do not use after petal fall)**	**50 ppm (Do not use after petal fall)**
	Sevin XLR	**Petal fall to 12.5 mm**	**4.2 L**	**1.7 L**
Spy	**NAA**	**75-90% petal fall**	**12 ppm**	**12 ppm**
	Sevin XLR	**Petal fall to 12.5 mm**	**4.2 L**	**1.7 L**
	MaxCel	**10-12 mm**	**16.8 L**	**6.8 L**
	MaxCel + Sevin XLR	**7 to 14 mm**	**16.8 L + 4.2 L**	**6.8 L + 1.7**

Table 3. Grams of Fruitone N (3.1 ai) required to prepare a dilute solution

PPM	Grams required at various water volume						
	100	500	1,000	1,500	2,000	3,000	3,300
1	3.2 g	16.1 g	32.3 g	48.5 g	64.6 g	96.6 g	105.6 g
2	6.4 g	32.2 g	64.6 g	97.0 g	129.2 g	193.2 g	211.2 g
4	12.8 g	64.4 g	129.2 g	194.0 g	258.4 g	386.4 g	422.4 g
6	19.2 g	96.6 g	193.8 g	291.0 g	387.6 g	579.6 g	633.6 g
8	25.6 g	128.8 g	258.4 g	388.0 g	516.8 g	772.8 g	844.8 g
10	32.0 g	161.0 g	323.0 g	485.0 g	646.0 g	966.0 g	1,046.0 g
12	38.4 g	193.2 g	387.6 g	582.0 g	775.2 g	1,159.2 g	1,267.2 g
14	44.8 g	225.4 g	452.2 g	679.0 g	904.4 g	1,352.4 g	1,478.4 g
16	51.2 g	257.6 g	516.8 g	776.0 g	1,033.6 g	1,545.6 g	1,689.6 g
18	57.6 g	289.8 g	581.4 g	873.0 g	1,162.8 g	1,738.8 g	1,900.8 g
20	64.0 g	322.0 g	646.0 g	970.0 g	1,292.0 g	1,932.0 g	2,112.0 g

Table 4. Grams of Amid-Thin (8.3 ai) required to prepare a dilute solution

PPM	Grams required at various water volume						
	100 L	500 L	1,000 L	1,500 L	2,000 L	3,000 L	3,300 L
1	1.2 g	6.0 g	12.0 g	18.0 g	24.0 g	36.0 g	39.6 g
10	12.0 g	60.0 g	120.0 g	180.0 g	240.0 g	360.0 g	396.0 g
15	18.0 g	90.0 g	180.0 g	270.0 g	360.0 g	540.0 g	594.0 g
20	24.0 g	120.0 g	240.0 g	360.0 g	480.0 g	720.0 g	792.0 g
25	30.0 g	150.0 g	300.0 g	450.0 g	600.0 g	900.0 g	990.0 g
30	36.0 g	180.0 g	360.0 g	540.0 g	720.0 g	1,080.0 g	1,188.0 g
35	42.0 g	210.0 g	420.0 g	630.0 g	840.0 g	1,260.0 g	1,386.0 g
40	48.0 g	240.0 g	480.0 g	720.0 g	960.0 g	1,440.0 g	1,584.0 g
45	54.0 g	270.0 g	540.0 g	810.0 g	1,080.0 g	1,620.0 g	1,782.0 g
50	60.0 g	300.0 g	600.0 g	900.0 g	1,200.0 g	1,800.0 g	1,980.0 g

Table 5. Volume of MaxCel per volume of water required to obtain a given ppm concentration

Water Volume Litres	**Concentration of MaxCel**								
	10 ppm	25 ppm	50 ppm	75 ppm	100 ppm	125 ppm	150 ppm	175 ppm	200 ppm
380	90 ml	475 ml	950 ml	1.42 L	1.9 L*	2.38 L	2.85 L	3.33 L	3.8 L
1,000	470 ml	1.25 L	2.5 L	3.75 L	5.00 L	6.25 L	7.50 L	8.75 L	10

*For a 100 ppm solution applied to 0.4 HA (1 ac)