



Pennsylvania Tree Fruit Production Guide Supplement

GETTING THE MOST FROM STOP-DROPS

ReTain and NAA

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As apples mature they begin to produce large amounts of the ripening hormone, ethylene. One of the ripening processes stimulated by ethylene is stem loosening. Ethylene stimulates the production of enzymes that break down the cell walls in the abscission zone of the stem, leaving the fruit connected to the tree by only the vascular strands, which are easily broken. Once this natural process is complete, susceptible varieties begin to drop. It should also be noted that enzymatic cell wall breakdown is an irreversible process. Once the fruit stems loosen, there is no way to strengthen them up!

Stop drops are plant growth regulators that interfere with the enzymatic breakdown of the cell walls in the abscission zone. Two plant growth regulators are currently registered for control of preharvest drop in apples. Naphthaleneacetic acid (NAA) and aminoethoxyvinylglycine (AVG) are both effective, but are very different compounds with respect to the modes of action, optimal timing, and effect on the fruit. This article is designed to offer a brush up on stop drops--how the two work, and how to optimize control of preharvest drop with each of them.

ReTain

The active ingredient in ReTain is aminoethoxyvinylglycine (AVG), a “look-alike” for one of the chemical precursors to ethylene. When absorbed into plant tissues AVG binds irreversibly with a key enzyme. This prevents the ethylene precursor from binding, thus blocking the production of ethylene. Natural ripening processes are slowed, including stem loosening, fruit flesh softening, starch disappearance, and red color formation.

There are several potential harvest management benefits to slowing the fruit maturation process. Growers can spread the effective harvest window for a given variety, retaining fruit firmness and without excessive drop. Apples on unstressed healthy trees will continue to grow at the normal rate following ReTain treatment (about 1 mm per day). An additional week on the tree can add a quarter inch to fruit diameter. Fruit red color can be increased in cases where a delay in harvesting exposes the fruit to improved weather for coloring (warm sunny days and cool nights). The incidences of fruit disorders associated with ripening, such as water core and stem end cracking can be reduced.

In order for AVG to be effective it must be applied well in advance of the climacteric rise in ethylene production that signals the onset of fruit maturity. The label recommends applying ReTain four weeks before anticipated harvest. This has sometimes caused confusion, as the grower is timing the spray relative to some future, unknown date. A more scientific basis for timing would be to state that ReTain should be applied four

weeks before the natural climacteric rise in fruit ethylene, but this is still a future event with an element of uncertainty. The good news is that there is a fairly wide window when ReTain can be applied with optimal results, and a fairly easy way to determine when to apply it (Figure 1).

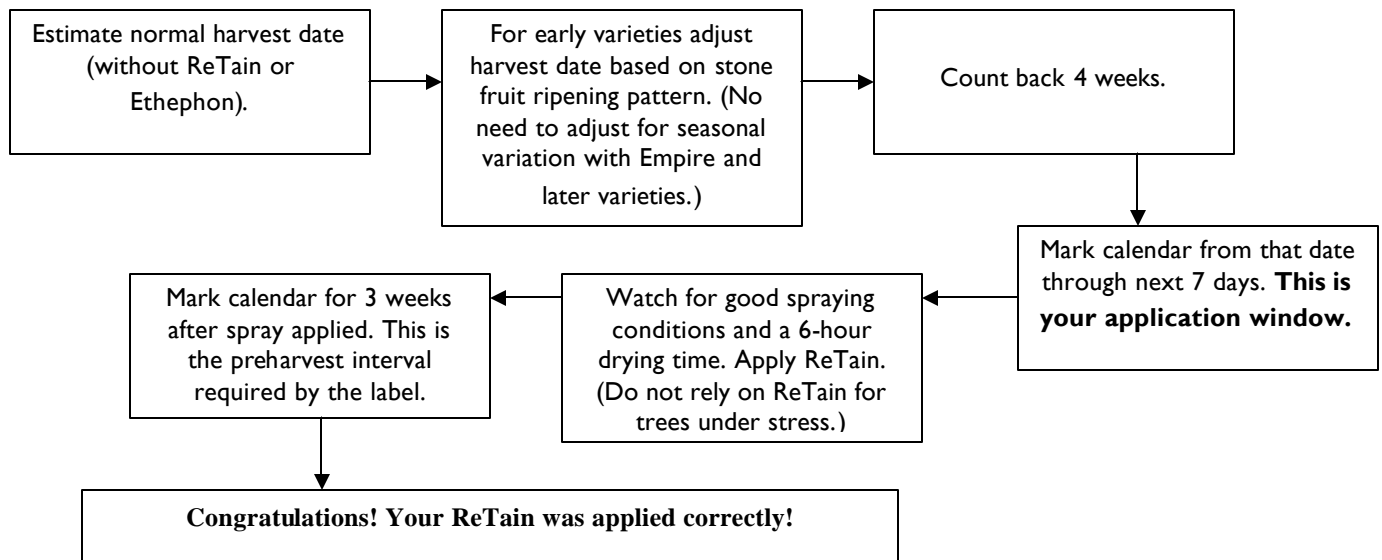


FIGURE 1. *Determining application timing for ReTain to increase effective harvest window, increase fruit firmness, and reduce preharvest drop.*

For early season varieties, such as Gala and McIntosh, start by estimating when you would normally expect to begin harvesting the variety if no ReTain or ethephon were used. Now take into consideration the season. For instance, if the bloom date and the ripening pattern of cherries, peaches, and summer apple varieties suggest that the season is about 10 days earlier than normal, the anticipated harvest date can be adjusted accordingly. Then count back four weeks on the calendar. Now mark the calendar from that date through the next seven days. This is your application window for that early season variety. Watch for good spray conditions and a six-hour drying time within that week and apply the material at the first opportunity. Congratulations! Your ReTain is on at the right time. Now mark your calendar for three weeks after the spray was applied. This is the preharvest interval, as required by the label. You can not legally harvest before this date. Repeat the same thought process for later varieties, but keep in mind that later varieties are usually less affected by seasonal variation in maturity than stone fruit or early apple varieties. It is usually unnecessary to account for seasonal variation in fruit maturity for Empire and later varieties.

ReTain is an expensive chemical to produce, and the maximum rate of AVG allowed by the label is at the low end of the effective range. For most applications every molecule we apply needs to be absorbed and do its duty. One exception to this rule is application to low ethylene varieties.

Varieties differ in the production of ethylene and consequently differ in their response to ReTain. Low ethylene producers such as Gala are strongly influenced, while ethylene production is much harder to control for high ethylene varieties such as McIntosh. Fruit maturity of Gala on dwarfing rootstocks can be slowed with 7.5 oz (two thirds of the full label rate) of ReTain if timing and application recommendations are followed closely. Most varieties, however, require the full labeled rate of ReTain (1 pouch or 333 grams per acre) in order to obtain satisfactory results.

Growers who are planning to use ethephon (Ethrel, Ethephon II) to color Macs should apply the full rate of ReTain at the usual time. There is some limited research that suggests ReTain can offset the deleterious effects of ethephon on fruit maturity and fruit softening.

Use a 100% organosilicone surfactant, such as Silwet L-77 or Sylgard 309 at 12 oz per 100 gallons. For optimum results, apply ReTain with 100 gallons of water per acre and spray each row from both sides. Split applications do not enhance the performance of ReTain. A single well-timed spray will give the best delay in maturity and best control of preharvest drop.

ReTain requires a considerable time to act, and its effects persist for a considerable period of time, so the effect of weather is little understood. It is known that trees under stress (mites, drought, etc.) are less responsive to ReTain and are poor candidates for its use. Much of what is known centers on the need to maximize coverage and absorption.

Ideally no rain should fall for at least six hours after ReTain is applied; however if the coverage was good, the ReTain spray was applied with a full rate of Silwet, and the residue dried before it rained, you probably got most of the benefit of the spray. Just keep a close eye on drop and fruit maturity.

Application of ReTain under slow drying conditions is thought to be beneficial. Conversely, spraying ReTain on wet foliage can result in a loss of performance due to the material dripping off before it can be absorbed. Wait until the foliage dries. If you must apply ReTain to damp foliage, reduce the rate of Silwet to 6 fluid oz instead of 12 to reduce the sheeting action and possible runoff. Another tactic that can work on a limited scale if time is running out is to drive slowly through the block to be sprayed with just the fan on before applying the spray.

NAA

Shortly after synthetic auxins (NAA, 2,4-D, 2,4,5-TP) were discovered it was learned that these materials had activity as stop drops. Auxins interfere directly with the enzymes that create the abscission zone. Today the one remaining auxin that is registered for this use is NAA (Fruitone N).

Unlike ReTain, fruit maturity of apples treated with NAA is not delayed, and in some cases may be accelerated. For this reason, the use of NAA for control of preharvest drop has been overshadowed in recent years by that of ReTain. However, ReTain use must be planned weeks prior to harvest. Since the optimal application time for NAA is just before the onset of drop, NAA offers a "rescue" treatment, should the threat of preharvest drop be increased due to unforeseen circumstances. Examples of such situations include unavoidable delays in harvest due to bad weather or labor issues, slow red color development, and overlapping harvest schedules of varieties with similar maturity windows, such as that of Empire and Delicious.

A single spray of NAA can provide about seven days of drop control. Since it is less expensive than ReTain, it may be more cost effective to use NAA when only a few days of drop control are needed to conduct an orderly harvest. For example, when using ethephon (Ethrel, Ethephon II) to promote fruit coloring, growers should also use NAA to prevent excessive fruit drop resulting from accelerated fruit maturation. When NAA is used to control drop on ethephon-treated trees, the two may be tank-mixed if the fruit are to be harvested within seven days. If the fruit are to be left on the tree longer than seven days after the ethephon, then NAA should be applied two to three days after the ethephon.

Other than when applying NAA with ethephon, timing an NAA stop-drop spray is a little like a game of chicken, requiring both steely nerves and a good understanding of your opponent (Figure 2). The label says to apply NAA when the first sound fruit begin to drop. Based on research with McIntosh, a variety that is very prone to drop, a single spray of 10 to 20 ppm NAA can control drop for about seven days from the date of application, but it takes two or three days to "kick in." If NAA is applied too early, then effective drop control

may wear off when it is needed most. On the other hand, if NAA is applied just a few days too late, a significant portion of the crop may be on the ground before it takes effect. Predictive degree-day models and the pattern of starch disappearance, as gauged by the starch index test can provide a general indication of whether the potential for drop is earlier or later than normal, but more direct monitoring is required for the actual timing of the sprays.

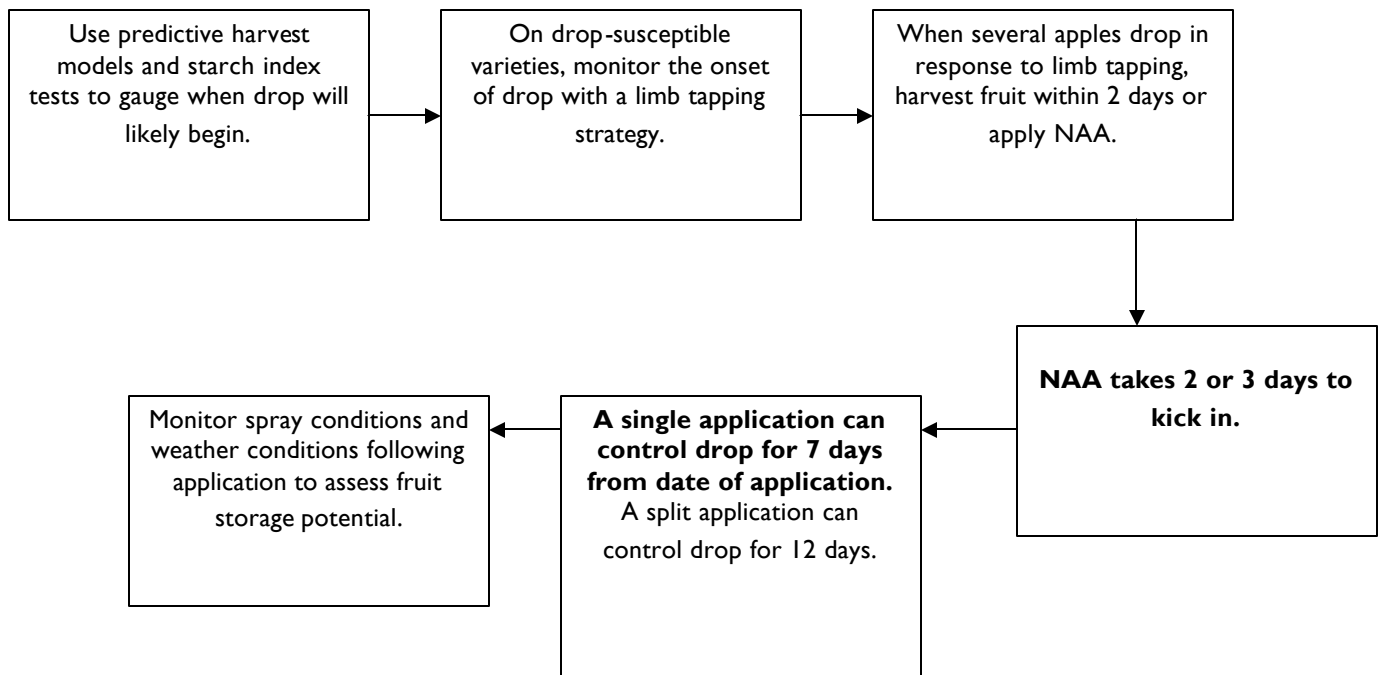


FIGURE 2. *Determining application timing for NAA to extend harvest window and reduce preharvest drop.*

Varieties that are susceptible to preharvest drop should be monitored to determine when fruit drop is beginning. Limb tapping is one method that can be used to determine the onset of drop as fruit near maturity. Bump several scaffold limbs of three or four inches in diameter throughout the block on a daily basis. Use the palm of your hand with a short firm stroke, striking the limb at its mid-point (just like golf, this skill improves with practice and experience). If zero to one apple per limb drops on average, it is too soon to apply NAA. If the average is about two, check again later the same day or the next morning. When several apples drop in response to limb bumping, it is time to harvest within two days or apply NAA.

Rates of 10 to 20 ppm NAA are usually needed to be an effective stop-drop. To obtain the maximum drop control, use a split application of 10 ppm in the first spray, followed by a second spray of 10 ppm five days after the first. Split applications can provide some drop control for about 12 days from the date of the first application.

NAA must be taken up by the spur leaves in order to be effective and does not translocate very far within the tree, so it must be applied with good coverage and plenty of water. Concentrating beyond 4X (less than 75 gallons of water per acre for 300 gallon TRV trees) may diminish the effectiveness. The use of alternate row spraying is discouraged. Use of a non-ionic or organosilicone surfactant is recommended to enhance uptake.

Calcium in the spray water is detrimental to NAA efficacy. This includes both tank mixed calcium for bitter pit control as well as calcium present because of hard water. If your water source provides hard water, use of a water conditioner is advisable.

Weather conditions following the application also impact efficacy. Rewetting within two or three days of the spray application and spraying under slow drying conditions (high humidity) will both increase the uptake of NAA. Temperatures in the mid-70s produce a better response than cooler temperatures, while excessively hot weather immediately following an NAA spray may result in accelerated ripening.

When used as a stop-drop, NAA may advance ripening, especially at the maximum label rate of 20 ppm. The primary impact of this advance in maturity is reduced storage potential of the fruit, particularly in the loss of firmness. This effect is not consistent from year to year, and may be attributed to high temperatures, as mentioned previously.

Research by Rich Marini and Ross Byers in Virginia showed that the deleterious effects of NAA sprays on fruit maturity and fruit softening were minimized in Delicious by making repeated applications of 5 ppm NAA at four weekly intervals prior to harvest. This "pre-loading" technique has recently been included as an application option on the Fruitone N label. I repeated this research on Delicious in 2004, and NAA pre-loading accelerated ethylene and fruit softening. Also, using NAA pre-loading on McIntosh resulted in more advanced ripening, accelerated drop, and fruit softening, not less! I do not recommend NAA pre-loading for McIntosh and other early season, high-ethylene varieties. I suggest that growers use caution when trying pre-loading on high ethylene-producing varieties until more is known about how different varieties will respond.

The question then arises whether NAA-treated fruit have potential for CA storage or treatment with SmartFresh (1-MCP). Perhaps the simplest way to answer the question with regard to CA is to remember the adage "garbage in, garbage out." If the fruit were left on the tree to the bitter end of the drop control, are measurably softer than previously harvested fruit, and have elevated starch index values, then they should be marketed in the short term. On the other hand, if the fruit were harvested within a week after treatment and have appropriate firmness and starch values for CA storage for the variety, there is little reason to expect performance different than similar fruit that received no NAA.

The question of whether NAA stop-drop sprays have advanced fruit maturity may be most critical when using SmartFresh on McIntosh, where the maturity of the fruit is an overwhelming influence on whether the fruit will respond to 1-MCP. Quoting Dr. Chris Watkins in the *Proceedings of the 2003 Cornell Apple Storage Workshop*, "We do not have any data yet, but we assume that induced ethylene production that results from use of NAA will deleteriously affect fruit responses to 1-MCP. If you use stickers [NAA stop-drop], your storage operator should be informed."

Finally, a comment about use of NAA on trees previously treated with ReTain. The use of both stop-drops at the respective correct times results in drop control that is superior to that obtained by using either one alone. Fruit treated in this manner, then left for an extended time on the tree, often have limited storage potential (see above). This combination, however, can be an effective way of getting the ultimate in drop control. This drop control comes at a high price and should therefore only be used on high value fruit with little or no storage period, such as for a few rows of trees held for late picking in pick-your-own blocks.

Table I summarizes the attributes of ReTain and NAA. Both stop drops are useful compounds, although quite different with respect to activity and timing. A table on growth regulators for apples and pears can be found in the *Pennsylvania Tree Fruit Production Guide* (also on the Web at <http://tfpg.cas.psu.edu>).

TABLE I. A quick comparison of the two compounds registered as stop-drops.

Parameter	ReTain	Fruitone N
Active ingredient	AVG	NAA
What is blocked	Ethylene production	Stem loosening
Drop delay (approximate)	14 days	5-7 days
Fruit ripening	Slowed	Advanced
Fruit color	Delayed	No effect
Fruit softening	Delayed	Advanced
Applied (relative to drop)	4 weeks before	Just prior to
Rescue option?	No	Yes
Days to "take effect"	>7	~2
Split sprays helpful?	No	Yes
REI	12 hours	48 hours
PHI	21 days	2 days

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