ReTain is a plant growth regulator that stops the production of ethylene in the apple fruit and thus, delays maturity, stops drop and lengthens shelf life. It is very useful in controlling pre-harvest fruit drop but is also useful as a harvest management tool. There are many other benefits that ReTain can offer apple producers. The ReTain effect will improve storage quality, a major objective of shippers and processors. ReTain also reduces watercore, greasiness, cracking and improves fruit size.

The major benefit of ReTain is its impact on pre-harvest fruit drop on apples. ReTain stops ethylene production, which stops the ethylene ripening effect and thus, dropping fruit (a ripening effect). NAA also reduces pre-harvest drop as well, but by a different mode of action. It delays the formation of the fruit abscission zone. Unfortunately, NAA alone also turns on ethylene, which in turn, will ripen fruit; and after the NAA abscission zone effect wears off, fruit drop will be enhanced by the increased ethylene. ReTain, however will eliminate the NAA induced ethylene. Thus using the combination of ReTain + NAA provides the best of both worlds, improved stop drop from both materials and ReTain’s control of the NAA induced ethylene ripening.

Our best ReTain recommendation is to apply a full rate, split into 2 sprays at 30 and 14 days before harvest. This “Full Rate Split Application” of ReTain will annually give reliable and successful results. Add NAA at 10 ppm with the 14 day before harvest spray for the best stop drop management.

More research on lower rates of ReTain + NAA needs to be done. Overall ReTain + NAA has performed well in the past 4 years of trials on all varieties and the details in this article will explain further.

ReTain Features
The effects of ReTain on the plant are dose dependent, time dependent and variety dependent. ReTain is very effective at controlling ethylene production in apples. Even low rates can eliminate ethylene production for some time. The standard full rate of 333 g/acre (1 pouch/acre) applied at 30 DBH (Days Before Harvest) gives excellent control of ethylene production and a delay in maturation. The delay in fruit maturity caused by ReTain allows the fruit to continue growing for 7-10 more days resulting in larger fruit size. A full rate and even low rates provide improvements of other fruit problems such as cracking, greasi-ness and watercore. However, a full rate of Retain not only delays fruit maturation but also delays the development of red color. To minimize the negative effect on red color development, ReTain can be applied in split applications. For maximum maturity delay, apply up to 2 full rate applications of ReTain. Additional stop drop control will occur when ReTain is combined with NAA at 14 DBH.

Variety Nuances
Gala, Jonagold and Honeycrisp The efficacy of ReTain is variety dependent. Gala and Jonagold are noted for their high degree of sensitivity to ReTain. Honeycrisp has intermediate sensitivity to ReTain. Because these varieties have an elevated sensitivity to ReTain, the normal recommended rate for Gala, Jonagold and Honeycrisp is ½ rate (165 g/acre). This rate will have the same impact on these 3 varieties as the full rate (333 g/acre) does on all other varieties. These 3 varieties respond to even lower rates of Retain (1/4 and 1/3 rate) but not all low rates have been thoroughly tested and thus, ¼ rate may not perform well some years.

McIntosh is a special case because it is a high producer of internal ethylene and has considerable variation in ripening. McIntosh is notorious for a mix of maturity on the tree and is prone to heavy fruit drop. Some apples on the same tree mature early and produce significant ethylene while many others are still green. McIntosh starts producing ethylene up to 3 weeks before harvest in some fruits and thus, drop in some years can start early. This makes it important to spray ReTain early (30 DBH) in McIntosh to be sure to successfully manage for the early ethylene production tendency. This is particularly important during those years when summer heat/drought stress is above normal. High summer stress tends to elevate ethylene early and runaway fruit drop may occur.

Rate
ReTain response is dose dependent (Figure 1). The greater the rate of ReTain, the greater the delay in maturity and the longer the ReTain will have effect. The gold standard (standard recommendation) use of ReTain is to apply it 30 DBH (Days Before Harvest) at full rate, 333 g/acre (1 pouch/acre). This early application will provide maximum ethylene control, maximum maturity delay and maximum stop drop protection and will delay harvest 7 to 10 days. However, this 30 DBH application will also wear off earlier than later applications of the same rate. Using a reduced rate, 30 DBH (Figure 1) will provide similar benefits but wear off earlier, that is, ½ rate will provide only 4 to 7 days delay in maturity instead of the 7 to 10 day delay of the full rate. A 30 DBH full rate of ReTain will also have maximum impact on red color development. Because of high sensitivity to ReTain, Gala and Jonagold maturity will be delayed much longer than most other varieties (Figure 1).
ReTain Rate Impact on Apple Maturity

<table>
<thead>
<tr>
<th>DBH</th>
<th>30</th>
<th>21</th>
<th>14</th>
<th>7</th>
<th>0</th>
<th>-7</th>
<th>-14</th>
<th>-21</th>
<th>-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate/Acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No ReTain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4 Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/3 Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>½ Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/3 Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>¼ Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1. ReTain Rate and Variety Maturity Chart.

ReTain Timing Impact on Apple Maturity

<table>
<thead>
<tr>
<th>DBH</th>
<th>30</th>
<th>21</th>
<th>14</th>
<th>7</th>
<th>0</th>
<th>-7</th>
<th>-14</th>
<th>-21</th>
<th>-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate/Acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No ReTain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Days Before Harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 Days Before Harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Days Before Harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Days Before Harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Split Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. ReTain Timing Maturity Chart.

**Timing**

ReTain is time dependent. Early applications (30 DBH) will have a greater impact on the fruit than later applications (Figure 2). Applying ReTain closer to harvest will have less impact on reduced fruit color and will extend the days to harvest. Also, fruit may start dropping before a late application of ReTain can gain control of internal ethylene. Varieties highly prone to drop should receive a ReTain application no later than 14 DBH but 21 DBH would be a better timing. If the first ReTain application is made as late as 7 DBH the risk of drop will increase but there is a lesser impact on fruit quality (red color) and a lesser delay in harvest maturity.

**Split Treatments**

ReTain can be applied as a split treatment for example, 1/2 rate 30 DBH plus 1/2 rate 14 DBH (Figure 2). This treatment is always one of the best treatments for controlling drop, managing harvest and achieving excellent fruit quality. Split applications of ReTain are always as good or better than a single application.

**Maturity**

ReTain is dose dependent and higher rates have greater impact on delaying maturity. Some varieties are very sensitive to ReTain and high rates will delay maturity 20 to 30 days. To have maximum impact on delaying maturity use the full rate and apply 2 applications. Gala and Jonagold are highly sensitive (Figure 1). Blocks with a heavy crop load will mature even later with ReTain applications (Figure 3).

**Fruit Quality**

ReTain will improve fruit quality (Figures 4 & 5) and is a very effective material even at low rates. Fruit cracking is a bothersome problem with some varieties. Lower rates such as ¼ to 1/3 rate will control cracking plus provide other fruit quality control such as watercore and greasiness.

**Red Color**

ReTain will delay the development of red color especially if applied early (30 DBH). Delaying a ReTain application until fruit are closer to harvest (10 to 7 DBH) will reduce the negative impact on red color but may also have less impact on stop drop. Fruit treated with ReTain will recover the red color levels of untreated trees but growers need to be patient and wait for fruit to achieve full maturity. Fruit harvested in a premature condition will have lesser red color.

**Fruit Size**

Apple fruit growth will slow when ReTain is applied. ReTain however, will hold fruit on the trees and can increase fruit size in some years. Usually ReTain treated fruit size is larger or not different than untreated trees when harvested at proper maturity.

**Stop Drop**

In those years of stressful summer conditions (hot and dry), fruit will start ripening early and fruit can drop early. In these hot and dry years, apply ReTain earlier and use higher rates. ReTain is very effective at stopping drop if applied early enough to provide control before ethylene production begins and drop commences. ReTain+NAA will provide even better stop drop. Many years all ReTain rates provide excellent stop drop control but the best
Table 1. ReTain and NAA Recommendations 2014.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Objective</th>
<th>30 DBH</th>
<th>21 DBH</th>
<th>14 DBH</th>
<th>7 DBH</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Use</td>
<td>Full maturity delay.</td>
<td>Full rate</td>
<td>Full rate + NAA</td>
<td>Provides early stop drop and maturity delay and best for stressful years.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stressful Years</td>
<td>Stop drop</td>
<td>Apply 1st ReTain early and add NAA</td>
<td>Apply 2nd ReTain add NAA</td>
<td>Stressful years will hasten drop, early control is required.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Variety Specific Recommendations

- **McIntosh (Drop prone)**
  - Maturity delay and stop drop.
    - Full rate + NAA
    - Half rate + NAA
  - Some maturity delay and stop drop.
    - 1/3 rate + NAA
    - 1/2 rate + NAA
  - Reduced maturity delay, stop drop, less color impact.
    - 1/2 rate + NAA
  - Least maturity delay, but still stop drop, less color impact.
    - 1/2 rate + NAA

- **Gala, Jonagold, Honeycrisp (ReTain sensitive)**
  - Maturity delay and stop drop.
    - 1/4 rate + NAA
  - Maturity delay, stop drop, less color impact.
    - 1/4 rate + NAA
  - Especially for Honeycrisp
    - 1/4 rate + NAA

- **All Other Varieties**
  - Maturity delay and stop drop.
    - 1/4 rate + NAA

--

* NAA@10 ppm. Will not stop push-offs.
treatments are split applications and NAA combinations (Figures 6 & 7).

ReTain and NAA Recommendations 2014

Table 1 lists 2014 general variety recommendations for the use of ReTain and NAA as well as for certain sensitive varieties. Generally, to delay maturity, use early applications and multiple full rates. When summers are stressful (hot and dry) use early applications and add NAA. On McIntosh, which are prone to drop, use half rate ReTain + NAA twice at 30 DBH and 14 DBH. Gala and Jonagold are very sensitive to ReTain, thus half rate will work well. Two ¼ rates will work well and add NAA as needed. Honeycrisp responds nicely to ¼ rate ReTain + NAA 14 to 21 DBH. All other varieties respond well to ⅛ to ⅙ rate ReTain + NAA 14 to 21 DBH. Full rates will work well also.

Philip Schwallier and Amy Irish-Brown, are Regional Michigan State University Extension Educators located in Sparta, MI.

Recommendations to Assist Spreading the Harvest Window 2014

This year it may become difficult to harvest all varieties on time due to many reasons. Shortages of labor or condensed ripening of multiple varieties, strains and variations in blocks and farms may delay timely harvest. This is a list of a few treatments that can help harvest management and the successful maximum capture of prime maturity fruit.

ReTain, NAA and Harvista are excellent maturity delay and stop drop materials. If the blocks are already treated with any of these materials, rest assured they will keep the fruit in prime condition and on the trees until harvest can be performed except if NAA is the only pre-harvest material you have on the fruit.

If the block is ripening and it appears harvest will be too late and no harvest materials have been applied, consider the following choices:

1. NAA @ 10 ppm will provide stop drop for up to 10 days. If harvest is delayed longer than 10 days, apply a second NAA treatment on day 7. NAA will hasten ripening and drop after 10 days if no second spray is applied. NAA is good for a short-term stop drop control.

2. ReTain @ ¼ rate plus NAA @ 10 ppm is a better choice if harvest will be more than 10 days late. The ReTain will control the ethylene NAA promotes and a second treatment will not be necessary. ReTain has a 7 day PHI. Gala, Jonagold and Honeycrisp only should get a ¼ rate of ReTain. Other varieties could be treated with higher rates such as 1/3 to ½ rate ReTain. The best for short to medium stop drop control and maturity delay.

3. Harvista would also provide the same stop drop and maturity delay as ReTain + NAA. Excellent for stop drop and maturity delay.

These late pre-harvest treatments will provide a reprieve from excessive loss of fruit due to the inability to harvest fruit on time. Use 1) NAA for short-term fruit control and 2) ReTain + NAA or 3) Harvista for longer control.