Apple II

Wednesday afternoon 2:00 pm

Where: Ballroom Room D

Recertification credits: 1 (1C, Comm CORE, Priv CORE)

CCA Credits: PM(1.0) CM(1.0)

Moderator: Scott Swindeman, MSHS Board

2:00 p.m. Effective Use of Apple Blossom Thinners
Steven McArtney, North Carolina State University

2:30 p.m. Update on Managing Fireblight and Other Apple Diseases
George Sundin, Plant Pathology Dept., MSU

3:00 p.m. IPM in the 21st Century
John Wise, MSU Trevor Nichols Research Station

3:20 p.m. Managing Honeycrisp Growth and Crop Load - TRUST REPORT
Jim Flore, Horticulture Dept., MSU

3:40 p.m. Summer-Applied NAA to Enhance Return Bloom
Kyle Coleman, AMVAC Technical Sales Representative
Effective Use of Apple Blossom Thinners

Steven McArtney
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Introduction

Blossom thinners are increasingly being integrated into crop load management strategies in both organic and conventional apple production systems worldwide. They have been more readily accepted in drier regions where there is a low frost risk during the bloom period. Most growers are reluctant to use blossom thinners in regions where the probability of a post-bloom frost event remains high, or where higher humidity and longer drying times increase the potential for fruit russet. However, blossom thinners are currently the only chemical crop load management tools available to organic producers.

There is a long list of materials that can effectively thin apples at bloom, including DNOC (Elgetol), hydrogen cyanamide (Dormex), endothallic acid, sulcarbamide (Within), pelargonic acid (Thinex), ammonium thiosulfate (ATS), lime sulfur (LS) either alone or in combination with an oil emulsion, and various vegetable oil emulsions (VOE’s). However, with the exception of a third party label for lime sulfur in Washington State, none of these materials are currently registered as blossom thinners in the US. Rather, the thinning activity of materials such as ATS or LS just happen to be a useful side effect resulting from their application during the bloom period as a foliar fertilizer or fungicide respectively. This paper describes possible modes of action of some common blossom thinners and considers how to effectively incorporate these materials into a crop load management program in more humid growing environments.

Modes of Action of ATS and LS

Despite the fact that ATS and LS are the most widely used blossom thinning materials in the US, little is known about their precise mode of action. Research by Michael Schroder while he was at the University of Hohenheim in Germany showed that the blossom thinning activity of ATS was related to three distinct mechanisms: (i) a direct effect by desiccating the flowers to prevent fertilization, (ii) a transient reduction in leaf area (and therefore availability of carbohydrates) that indirectly caused drop of very young fruit, and (iii) a secondary thinning effect due to inhibition of auxin transport from young fruit that resulted in a slight increase in June drop. If re-wetting of the leaves occurs soon after ATS application then leaf injury and thinning activity can both be greatly increased.

The thinning activity of LS may be related to either (or both) a transient reduction in the rate of leaf photosynthesis or prevention of ovule fertilization. Sulfur sprays reduce germination of pollen grains and pollen tube growth. Pollen tubes were completely absent from 27% to 48% of flowers that were open on the day of LS application compared with fewer than 4% of flowers having no pollen tubes on unsprayed trees. These data indicate
that 30-50% of flowers that open on the day of LS application are unlikely to set any fruit due to the complete inhibition of ovule fertilization. Sulfur will also reduce the rate of photosynthesis (Pn) in apple leaves. Photosynthetic rates recover much more quickly in some cultivars e.g. ‘Royal Gala’ or ‘Fuji’ compared to “sulfur-sensitive” cultivars e.g. “Braeburn”. The effect of successive LS sprays on spur leaf photosynthesis are additive so that photosynthetic rates may fall by 50% and remain suppressed for several weeks after bloom on sensitive varieties (Figure 1). Fortunately, the rapid development of normally functioning extension shoot leaf area following LS applications during bloom will quickly compensate for reduced photosynthesis by spur leaves.

If a large part of the thinning activity of ATS and LS sprays is related to inhibition of pollen tube growth and prevention of ovule fertilization, then only blooms that are freshly opened on the day of application will be affected by the blossom thinner treatment. If the grower wishes to keep the king bloom, then blossom thinners should not be applied on the day that these blooms open. Application of blossom thinners can be timed to target removal of less desirable fruit such as weaker lateral bloom on spurs or “rat-tail” bloom on one-year wood once the grower is confident that sufficient flowers have been fertilized. If the bloom period is relatively condensed then a single application of either ATS or LS should result in sufficient thinning. However, if bloom continues for a longer period then more frequent applications will be required to achieve a commercially significant level of thinning. Two applications of ATS thinned ‘Fuji’ and ‘Gala’ more effectively than a single spray in a series of thinning trials on commercial orchards in the southeastern U.S. (Figure 2). A third application of ATS did not cause any additional thinning because the bloom period was relatively short, with few new flowers open on the day of application of the third ATS spray. Contrast this result with the increased thinning activity with each additional LS application during the prolonged bloom period of ‘Braeburn’ in New Zealand (Figure 3).

**Fig. 2.** Effects of number of ATS sprays (1.5%) applied at intervals of one or two days during bloom on crop load rating (left) and return bloom (right) of ‘Fuji’ and ‘Gala’ apples in the Southeastern US. MaxCel (100ppm) + Sevin (2 lb/100 gallons) applied as a postbloom thinning spray. Data for each cultivar are averages of six orchards.

**Fig. 3.** Effects of number of LS (3%) applications applied at intervals of three days during bloom on fruit set of ‘Braeburn’ in New Zealand.

**Fruit Size and Return Bloom Advantages from Blossom Thinners**

Blossom thinners will reduce fruit number per tree much earlier than traditional post-bloom thinning materials. According to what we know about the effects of inter-fruit competition during the early part of the season blossom thinners should result in larger fruit size at harvest compared to post-bloom thinning materials. However, a transient reduction in carbohydrate supply to young fruit resulting from injury to primary spur leaves or a reduction in photosynthesis, or a reduction in seed number per fruit may negate the effects of early crop load reduction on fruit growth. Furthermore, experience in the southeast where bloom is relatively short has shown that ATS tends to thin between spurs rather than within a spur,
reducing overall fruit set by completely eliminating fruit set from some spurs while other spurs carry multiple fruit. The net result is that inter-fruit competition for carbohydrates is still present, and the expected gains in fruit size at harvest are less than expected.

Current theories suggest that developing seeds and young fruit are inhibitory to flower bud formation in apple. According to this model, the earlier fruit drop response observed with blossom thinners should result in increased return bloom compared to post-bloom thinners, even when crop loads are reduced to a similar level. However, these responses have not been observed in trials on commercial orchards across the southeast. ATS thinning sprays reduced fruit set of ‘Gala’ and ‘Fuji’, but only ‘Gala’ exhibited an increase in return bloom expressed as the number of flower clusters on a limb cross-sectional area basis, where fewer than five flower clusters per cm² would be considered a limit to achieving a commercial crop load (Figure 2). Furthermore, the increase in return bloom of ‘Gala’ observed with ATS was no better than with a post-bloom thinning spray of MaxCel + Sevin. Blossom thinners can increase return bloom as effectively (or ineffectively) as post-bloom thinning materials; neither category of thinners should be solely relied upon to ensure adequate return bloom of cultivars with a strong biennial bearing tendency.

The Risks: Leaf Damage and Fruit Russet

The potential for fruit and leaf damage is greater with blossom thinners than it is with post-bloom thinners. Not all blossom thinners carry the same risks; the potential for leaf burn is certainly greater with ATS than with LS. Rewetting of leaves after ATS application, even if only resulting from heavy dew the next morning, can greatly increase chemical uptake, leaf damage, and the thinning response. In contrast, the potential for loss of leaf function (photosynthesis) is probably greater with LS than with ATS. In either case, both of these phytotoxic responses may be partly necessary for thinning activity.

The potential for blossom thinners to stimulate fruit russet should always be an important consideration in environments with slow drying conditions. Growers in Washington State have been using LS+oil combinations for several years now without reporting any increases in fruit russet. However, increases in the level of fruit russet at harvest can sometimes be found following blossom thinning sprays that contain LS in more humid environments.

Uniform spray coverage is essential for optimum results with blossom thinners unless the grower is trying to target thinning to different zones within the tree canopy. Uniform coverage may be difficult to achieve in practice with a standard axial fan airblast sprayer, but careful examination of spray coverage and adjustments to the nozzle configuration where necessary will ensure more even coverage and reduce the risk of over- or under-thinning with any blossom thinner.

Incorporating Blossom Thinners into a Crop Load Management Program

There is no doubt that blossom thinners work. Combinations of LS+fish oil have proven to be an effective blossom thinning material in repeated studies and grower experience in Washington State over the past decade. However, there is a lower risk of blossom thinners stimulating fruit russet in Washington State compared to more eastern regions in the U.S. due to lower humidity. Blossom thinners may have a place in more humid regions in the central and eastern U.S., but growers will need to use them with caution. Initial experience and confidence can be gained by using blossom thinners on cultivars with a low susceptibility to developing russet or only using them to target thinning of late bloom on one-year old wood. Blossom thinners are just another tool for the grower to consider when deciding an overall crop load management strategy.
Update on Managing Fire Blight and Other Apple Diseases

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Introduction
Fire blight is the most serious disease currently limiting apple production in Michigan (#3 in U.S. total production), and is such a severe problem on pear in the eastern United States that the production acreage of this crop is quite small. This disease is particularly difficult to manage, and the situation is exacerbated by three major problems: (i) most of the popular apple cultivars selected by growers are either rated as susceptible or highly susceptible to fire blight; (ii) many of the popular dwarfing rootstocks utilized in Michigan are also highly susceptible to fire blight; and (iii) there are few chemical control options registered for fire blight management. Apple scab is a perennial problem in Michigan because infection periods for the pathogen occur each spring and inoculum levels are usually high. The effective management of fire blight and apple scab is impacted by the presence of pathogen strains that are resistant to important chemical controls.

Management of Fire Blight in Michigan
The fire blight pathogen \textit{Erwinia amylovora} is capable of infecting blossoms, fruits, vegetative shoots, woody tissues, and rootstock crowns. There are several distinct phases of the disease including blossom blight, shoot blight, and rootstock blight. The diversity of host tissues, combined with the limited number of management tools available to control the disease, has made it difficult to stop or slow the progress of fire blight epidemics. The continued threat of fire blight to the pome fruit industry is evident from recent epidemics that have occurred worldwide.

The blossom blight phase of fire blight is the only phase where the organism is surface associated and reachable with spray materials. The antibiotic streptomycin is the most effective control compound available for limiting blossom populations of the fire blight bacterium. Reducing blossom populations and thereby reducing fire blight inoculum is critical to the control of the blossom blight phase of the disease and also in reducing disease pressure for the shoot blight phase of the disease. Unfortunately, due to the reliance of the apple industry on streptomycin for fire blight control, streptomycin resistance has developed in populations of the fire blight pathogen \textit{Erwinia amylovora} in Southwest Michigan in the mid-1990’s, and we detected a wide distribution of streptomycin-resistant \textit{E. amylovora} in the Fruit Ridge area north of Grand Rapids in 2004 and in the Hart area in 2006.

There are few alternative control materials available for blossom blight control, and none are as effective as streptomycin. For the past 17 years, the Michigan Department of Agriculture working in conjunction with MSU Extension has successfully applied for a Section 18 emergency exemption for the use of oxytetracycline (Mycoshield) for blossom blight control. This material is the first choice in orchards where streptomycin resistant \textit{E. amylovora} are present. It is important to remember that oxytetracycline is less effective than streptomycin because its activity is bacteriostatic and not bactericidal, meaning that oxytetracycline inhibits growth of the pathogen, but does not kill the pathogen. In addition, oxytetracycline must be applied prior to rain events. The biological control material Serenade MAX
appears to work like an antibiotic and has shown some ability to reduce blossom blight in trials conducted in Michigan. Serenade MAX is best used in conjunction with antibiotics and growers should not rely on this material solely for control. BlightBan A506 is a biological control bacterium that inhibits blossom blight through early colonization of blossoms. BlightBan A506 must be applied early, usually with a first spray at 10% bloom and another at about 70% bloom. Unfortunately, we have not observed effective control of blossom blight as yet in trials incorporating BlightBan A506. There are more promising bacterial biological control agents in the pipeline, BlightBan C9-1 and Bloomtime, but these materials will not be registered in 2007.

Copper compounds are excellent materials for fire blight control because the pathogen is highly susceptible to copper. The difficulty with copper, of course, is the effect of copper on fruit russeting. A dormant copper application, or one put on at about 1/4 inch green tip, is effective in reducing fire blight inoculum emerging from cankers. Copper can also be used for control in nonbearing trees.

**Shoot Blight Management with Prohexadione-calcium**

Shoot blight is an important phase of fire blight in Michigan and can occur even in years such as 2005 and 2006 where little blossom blight occurred. This is because of late-appearing inoculum emerging from fire blight cankers. Trauma conditions, caused by high winds and hail, also play an important role in the occurrence of shoot blight. Prohexadione-calcium, marketed as Apogee, is a growth inhibitor that has excellent activity in reducing shoot blight infection. This is an important material in a grower's toolbox for shoot blight control. The activity of prohexadione-calcium as a shoot blight inhibitor seems to be directly related to its activity in limiting growth. Actively-growing apple shoots are highly susceptible to fire blight infection, whereas shoots that are inhibited in growth by prohexadione-calcium can be infected, but become highly resistant to spread of the pathogen. The optimal timing for a prohexadione-calcium application is petal fall of the king bloom, as it takes 10-14 days for the material to exert its effects. The other important aspect of this control material is that it is not affected by the streptomycin resistance status of the pathogen.

**Management of Apple Scab in Michigan**

Control of apple scab must begin early as emerging apple tissue is susceptible to infection if environmental conditions are conducive. Primary apple scab spores are present in leaf litter from the previous season. Primary scab infection periods are based on temperature and duration of leaf wetness considerations and basically track the time needed for scab spores to be disseminated to leaves, germinate, and infect leaves. Control of apple scab is mainly through the use of fungicides targeting primary scab infection, but also requires diligent cover spray fungicide applications throughout the rest of the season.

There are several fungicide modes of action available currently for apple scab management. These include multi-site fungicides such as Captan and the EBDC's and single-site fungicides such as the strobilurins, anilinopyrimidines (APs), and sterol inhibitors. The multi-site fungicides are protectants and must be applied prior to infection. The strategy of use of these materials is as a blanket, covering all susceptible foliage and developing fruit tissue and therefore providing protection. While some of the other fungicides do possess some degree of post-infection activity, in order to prevent the occurrence of fungicide resistance, these materials should also be used with a protectant strategy. The reasoning behind this recommendation is that anytime growth of the apple scab fungus is allowed, there is the potential for the development of fungicide resistance. Fungicide resistance of the apple scab fungus to the SI class of fungicides has been reported previously in Michigan, and control effectiveness of the APs and strobilurins is apparently weakening in New York. Thus, we need to utilize these fungicide classes wisely to prevent the development of resistance. In emergency situations where an infection period has been missed, the use of dodine (Syllit) as a rescue material is warranted; however, resistance to dodine has been reported previously.
Management of Crop Load and Vegetative Growth an Honeycrisp to Optimize Fruit Size, Fruit Quality, Return Bloom and Fruit Set

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Michigan State University
East Lansing, MI. 48824

Introduction: The variety Honeycrisp is being widely planted by Michigan growers. It has outstanding flavor, crispness, and market demand. It currently is the most profitable variety in the industry. However, uniformity and regulation of fruit size and return bloom can greatly be influenced by crop load and tree vigor. This variety tends to be strongly biennial, which leads to very low crops one year and high crops the next. Data from CHES indicate that many trees will not flower at all following a high crop year (more than 7 fruit per trunk sectional area (TCA), Bukovac and Schwallier unpublished data 2003, 2004). We propose to (1) conduct a detailed study on the effect of crop load on return bloom in relation to tree and seasonal variability, and (2) on crop quality (fruit firmness, total acidity, soluble solids, color and starch). These results will help us development management strategies related to crop load adjustment that will assure optimum fruit size (200-225 grams/fruit) and quality.

Hypothesis. “Uniformity of fruit quality, yield and return bloom are affected by crop load and seem to be related to the supply and demand for carbon by the vegetative and reproductive parts of the tree, and are modified by soil type, water, and tree management”.

Objectives. We proposed to determine the optimum balance of fruit to vegetative growth for Honeycrisp under Michigan conditions that will optimize return bloom and fruit quality characteristics, by:

A. Developing response relationships between crop load and fruit size and return bloom by manipulating crop load (chemical and hand thinning), and vegetative growth (degree and timing of pruning).

B. Characterize the relationship between carbon supply and demand by measuring whole tree photosynthesis, starch content of the leaves during the season, and associating it with fruit size and return bloom the following year.

Goal: Determine if current season fruit size and next years return bloom can be predicted by fruit to leaf ratio, and or leaf carbohydrate contents.

2006 Research and Results: The relationship between various fruit loads, established by hand thinning after the June drop, were studied at two different farms, in the Belding and Grand Rapids areas. Forty three-year-old Honeycrisp trees on M9 and 60 four and nine-year-old Honeycrisp trees on M9 were selected at the Belding site and Grand Rapids orchards, respectively.
Trees were trained to a central leader and winter pruned to maintain comparable canopies. Irrigation was provided during the season. After June drop crop load was adjusted to different fruit to spur ratios (from 4-5 (natural bearing) to 1 fruit per every 2 spurs) to achieve various numbers of fruit per tree (NFT), number of fruit per trunk sectional area (NF/TCSA) and leaf to fruit ratios (L/F).

At the Belding site, four different levels of crop load were imposed:

- Un-thinned control or high crop load (NFT 111.1, NF/TCSA 18.1 and L/F 8.6),
- Medium-high crop load (NFT 89.3, NF/TCSA 14.3 and L/F 12.9),
- Medium crop load (NFT 67.0, NF/TCSA 8.4 and L/F 26.6) and
- Low crop load (NFT 30.3, NF/TCSA 4.3 and L/F 35).

At the Grand Rapids plot, five levels were imposed on four-year-old trees, and nine-year-old trees by including an additional Medium crop load treatment of approximately 6 NF/TCSA. Shoot extension (n=15 per tree) and fruit growth (n=20 per tree) were measured weekly during the season, and photosynthetic performance of the trees was monitored. At the end of the season fruit were harvested and counted to calculate the fruit drop during the season. The diameter of each fruit was measured on a weight per tree basis.

**RESULTS**

Yield and fruit quality were related to crop load. As crop load increased, yield per tree and % drops increased; while color, fruit weight, fruit diameter and bitter pit decreased. Results were similar at both sites (Grand Rapids and Belding). Yield was affected by tree age. Tables 1 and 2, and figure 1.

**ZONAL CHLOROSIS**

A common problem in Honeycrisp is a leaf disorder that develops early in the season (June/July). It first appears as a chlorosis towards the outer edge of the leaf and then gradually spreads to in interior of the leaf. Literature reports (Cheng and Robinson, 2006) indicate that the chlorosis is related to the accumulation of sugar and starch in slow growing shoots and is more evident in low cropping trees, but no information is available on the impact of the chlorosis on floral bud differentiation and consequently on return bloom. During the summer we selected seven different farms with Honeycrisp trees of different ages (from 1 to 11) on different rootstocks (dwarfing and vigorous) to evaluate the level of the chlorosis in relation to environmental factors and crop load. Chlorosis and crop load for each tree were visually rated by 3 horticulturists based on an estimate of percentage of heavy crop (5) to low crop (1) and complete tree canopy chlorosis (10) to no evidence of chlorosis (0). Data will be evaluated using correlation analysis. Furthermore, digital image photographs of every tree at each farm will be analyzed to calculate a percentage of chlorosis in the leaf population. The same technique will be utilized during the spring for the evaluation of the return bloom.

**Observations to date:**

Chlorosis decreases with crop load. Photosynthetic rates of Honeycrisp leaves are greater that other varieties, in nonchlorotic leaves. In addition we did not see a strong decline in photosynthesis during the afternoon on low cropped trees as seen in other varieties. More vigorous rootstocks seem to have less chlorosis than weaker trees on M-9 or Geneva 30 which is greater in sandy soils.
Table 1. The effect of crop load adjustment on Honeycrisp at Belding (Wittenbach’s) in 2006.

<table>
<thead>
<tr>
<th>CROP LOAD ADJUSTMENT</th>
<th>Treatment</th>
<th>HCL</th>
<th>M-HCL</th>
<th>MCL</th>
<th>LCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fruit per tree</td>
<td>111.1</td>
<td>89.3</td>
<td>67.0</td>
<td>30.3</td>
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<tr>
<td>Number of Fruit/TCSA</td>
<td>18.1</td>
<td>14.3</td>
<td>8.4</td>
<td>4.7</td>
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<tr>
<td>Leaf/Fruit Ratio</td>
<td>8.6</td>
<td>12.9</td>
<td>26.6</td>
<td>35.0</td>
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<table>
<thead>
<tr>
<th>HARVEST DATA</th>
<th>Treatment</th>
<th>HCL</th>
<th>M-HCL</th>
<th>MCL</th>
<th>LCL</th>
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<tbody>
<tr>
<td>Yield (kg/tree)</td>
<td>17.7a</td>
<td>16.6a</td>
<td>12.7b</td>
<td>8.3c</td>
<td></td>
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<tr>
<td>Color pick (%)</td>
<td>55.4a</td>
<td>65a</td>
<td>78.7b</td>
<td>95.2b</td>
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<tr>
<td>Drop (%)</td>
<td>13.1a</td>
<td>8.1a</td>
<td>7.9a</td>
<td>0.9b</td>
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<td>Fruit weight (g)</td>
<td>170.5a</td>
<td>189.0a</td>
<td>229.2b</td>
<td>252.9c</td>
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<td>Fruit diameter (mm)</td>
<td>74.2a</td>
<td>76.0a</td>
<td>80.1b</td>
<td>83.8c</td>
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<td>Yellow (1 to 5)</td>
<td>2.5a</td>
<td>3.5a</td>
<td>3.8a</td>
<td>4.0a</td>
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<tr>
<td>Bitterpit (%)</td>
<td>1.6a</td>
<td>2.6a</td>
<td>1.6a</td>
<td>3.3a</td>
<td></td>
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</table>

Figure 1. The effect of crop load adjustment on fruit size at Belding (Wittenbach) and Grand Rapids, in 2006.
Table 2. The effect of crop load adjustment on Honeycrisps in Grand Rapids (Schwallier’s) 2006

<table>
<thead>
<tr>
<th>Treatment</th>
<th>4 - yr- old</th>
<th>9 - yr- old</th>
<th>Honeycrisp - OLD TREES</th>
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<tbody>
<tr>
<td></td>
<td>HCL</td>
<td>M-HCL</td>
<td>MCL</td>
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<tr>
<td>Fruit/TCSA</td>
<td>15.7</td>
<td>8.1</td>
<td>6.2</td>
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<td>Leaf/Fruit Ratio</td>
<td>6.6</td>
<td>10.4</td>
<td>16.1</td>
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<tr>
<td>YIELD (kg/tree)</td>
<td>11.1a</td>
<td>7.8b</td>
<td>7.6b</td>
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<tr>
<td>Average of MFW (g)</td>
<td>197.2a</td>
<td>211.5b</td>
<td>225.3b</td>
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<tr>
<td>Fruit diameter (mm)</td>
<td>79.6a</td>
<td>82.5b</td>
<td>84.8b</td>
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<tr>
<td>Bitterpit (%)</td>
<td>4.6a</td>
<td>3.6a</td>
<td>9.6a</td>
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<tr>
<td>Paramater</td>
<td>HCL</td>
<td>M-HCL</td>
<td>MCL</td>
</tr>
<tr>
<td>Yield (kg/tree)</td>
<td>20.8a</td>
<td>20.0a</td>
<td>19.4a</td>
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<tr>
<td>Color pick (%)</td>
<td>30.0a</td>
<td>25.0a</td>
<td>27.0a</td>
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<tr>
<td>Drop (%)</td>
<td>37.2a</td>
<td>36.8a</td>
<td>20.2a</td>
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<tr>
<td>Fruit weight (g)</td>
<td>132.2a</td>
<td>151.2a</td>
<td>175.8b</td>
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<tr>
<td>Fruit diameter (mm)</td>
<td>72.0a</td>
<td>73.4a</td>
<td>74.5a</td>
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<tr>
<td>Bitterpit (%)</td>
<td>3.2a</td>
<td>7.8a</td>
<td>5.8a</td>
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REFERENCES:


Biennial fruit production has many negative consequences for commercial growers. During heavy production years, growers face higher chemical and hand thinning costs, and competing fruit tends to be smaller. When crop loads are light, production capacity is lost, unit costs for inputs rise, freezing weather has an even larger impact on already low yields and on some varieties, larger fruit that results from low yielding trees can become more susceptible to internal disorders, such as bitter pit. Biennial production may also lead to labor management concerns and other production and supply issues.

In 1999, Dr. Dick Unrath (NC State, Fletcher) initiated trials using NAA in the summer months to enhance return bloom the following year. Unrath treated Red Delicious apples 1-8 times with 5 ppm of Fruitone, or 4 ounces per acre, delivered in 200 gallons (see Table 1). Results showed that a statistically significant improvement in return bloom was achieved when at least four applications were made.

### Table 1: RED DELICIOUS (Oregon spur II)

<table>
<thead>
<tr>
<th>Treatment</th>
<th># Apps/Application date(s)</th>
<th>Percent of non-flowering Spurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruitone N @ 5 ppm</td>
<td>1 (6/1/99)</td>
<td>66% a *</td>
</tr>
<tr>
<td>Fruitone N @ 5 ppm</td>
<td>2 (6/1, 6/21/99)</td>
<td>75% a</td>
</tr>
<tr>
<td>Fruitone N @ 5 ppm</td>
<td>3 (6/1, 6/21,7/5/99)</td>
<td>71% a</td>
</tr>
<tr>
<td>Fruitone N @ 5 ppm</td>
<td>4 (6/1, 6/21, 7/5,7/19/99)</td>
<td>25% b</td>
</tr>
<tr>
<td>Fruitone N @ 5 ppm +PL</td>
<td>8 (6/1, 6/21,7/5 , 7/19/99)</td>
<td>15% b</td>
</tr>
<tr>
<td>Preload stop-drop (PL)</td>
<td>4 (8/9, 8/16, 8/23, 8/30/99)</td>
<td>20% b</td>
</tr>
<tr>
<td>Untreated Check</td>
<td></td>
<td>79% a</td>
</tr>
<tr>
<td>LSD .05</td>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

* MRT significant at \( P =0.05 \)
Since this trial, many more observations have been documented. Among them, Schwallier (Michigan State University) treated numerous varieties with three applications at 5 ppm (approx. 6 ounces per acre in 300 gallons) over a five year period (Fig. 1). He reported on average a positive numerical response in four of the five years, with a combined average improvement of more than 30% over the untreated comparisons. The Washington State Tree Fruit Research Commission tested various varieties with programs similar to Unrath and Schwallier in 2005, but found no improvements in return bloom.

Beyond obvious reasons such as a lack of resting spurs on the year of treatment, Amvac’s goal over the years has been to identify variables that can be considered which may lead to more consistent, positive results. Rates, timing, the number of applications, varietal type, and other factors may all play a role in improving return bloom with NAA. For example, some growers have reported that Fuji is among the least cooperative varieties. Others have complained that the labeled rate of 5 ppm is impractical for low volume spray equipment because it limits the amount of active ingredient that is applied per acre. Data backs that observation. In 2005, Stopar and Simončič (Ag Institute of Slovenia) demonstrated that NAA, used at a constant rate of 10 ppm, became less effective at thinning fruit as the amount of water per acre used to apply the product declined. In other words, there came a point when 10 ppm was delivered in such low rates of water, the amount of active ingredient was inconsequential. In contrast, these same researchers also showed that if the dose per hectare of active ingredient was held constant, the thinning results were more consistent, even as the amount of water used to carry the product declined dramatically.

As a result of feedback on varieties and rates, AMVAC recently received a Special Local Needs (SLN) label for Fruitone in Washington State which allowed for more aggressive rates (See http://amvacchemical.com/fruitone_labels.html).

2006-07 TRIALS

A commercial grower in Wenatchee, Washington set out to determine what rates might be most effective for promoting return bloom, and if a more aggressive program would have an impact on fruit quality. 30 individual sites of various varieties were tested (some are planned to come out of production in 2007) by rate and/or number of applications. Each site was a non-replicated, side-by-side comparison of 10-20 trees. Fruitone applications were made on an ounce per acre basis with commercial spray equipment. A Washington State Experimental Use Permit was obtained for plots where rates and timing went beyond the bounds of the current Fruitone SLN label.
While the return bloom data is not due until spring of 2007, numerous observations were made throughout the year regarding fruit quality: Among them, applications made in June had a tendency to drop leaves on some varieties, and some the fruit treated with higher rates in July/August tended to weigh more, and mature faster than the untreated fruit. The latter observation may be of commercial importance.

Phil Schwallier (MSU) and Jim Shupe (Penn State) have noted occasional advanced maturity when NAA is used, particularly at higher rates, in warm temperatures, or on high ethylene producing varieties, such as some older Red varieties. Historically, this has generally been viewed as a negative for many apple producers, as advanced ripening has the tendency to reduce storability. However, current conditions in Washington State have forced some growers into thinking things anew, and someday growers may actually seek to advance fruit ripening with NAA if permitted by label. Here’s why:

1. **Labor shortage**: Labor was extremely tight for some growers in Washington in 2006. One grower in Mattawa, WA reported losing one-third of his crew when it was announced there would be a 36 hour gap between finishing one variety and starting the next. Wages and management costs were up in some areas as a result of the labor shortage. An early harvest management tool would help accommodate small picking crews by protracting the harvest window.

2. **Early market potential**: One grower in Brewster, WA reported a $150/bin premium on fruit sold September 5, versus September 22 of this year. While lucrative early pools are never guaranteed, growers may appreciate the option.

3. **Early harvest to avoid freezing weather**: Varieties such as Fuji and Pink Lady may lost due to severe, cold weather prior to harvest. Orchards prone to freezing may benefit from an earlier harvest versus no harvest at all.

4. **Size**: The Wenatchee grower was surprised to report a slight numerical increase in fruit weight on several varieties treated with NAA at certain times, with certain rates.

5. **Manageable loss in firmness**: Fruit was generally less firm at harvest than the untreated comparisons, but not so much to cause concern for this particular grower.

Labor management, early markets, timely harvest, larger fruit size and storability are things that our Wenatchee grower feels are commercially important to him at this time.

Our discussion will specifically identify trends and ideas worthy of further study.

**Literature Cited**