Crop Load Management for Consistent Production of Honeycrisp Apples

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The popularity and high fruit prices of the Honeycrisp apple in the market are largely due to the unique eating experience from this apple. Most consumers of Honeycrisp are impressed with the flavor, crispness, and juiciness, which Honeycrisp delivers when it is grown properly. However, the biennial bearing tendency of this variety leads the tree to produce very large crops followed by very low crops. With either high or low crop loads fruit quality is not optimal. Based upon the last seven years of field studies with Honeycrisp we currently recommend a multi-spray thinning program (a spray at either bloom or at petal fall followed by a spray at 10-12 mm fruit size), coupled with early hand thinning (when fruit size is 25mm) and a summer NAA program (four sprays beginning in late June) to manage biennial bearing.1

Our previous research has shown that the crop load carried by Honeycrisp trees had a large effect on tree vegetative growth in the 3rd-5th years. As crop load on Honeycrisp trees increased tree growth declined rapidly. In many Honeycrisp orchards excessive crop loads in the early years stopped tree growth preventing young orchards from filling the space allocated to each tree. To ensure proper tree growth we recommend that during the development years of the orchard crop load of Honeycrisp be limited to no more than 4 fruits/cm2 TCA to allow the trees to fill their space (Robinson, 2008). The season following a heavy crop is almost always followed by very little bloom the next year. The trees became non-flowering when crop loads the previous year were greater than 9 fruits/cm2 of TCA. Also surprising was the significant variation about the trend line. There were some trees with relatively low crop loads which we expected to have a high return bloom but produced instead very few flower buds the following year. Many trees had no return bloom following medium crop loads (6-7 fruits/cm2 of TCA), which with other varieties would have resulted in good return bloom. Management strategies to stimulate flowering on 50-60% of the spurs are needed. Our objective with this project has been to define appropriate crop loads and thinning treatments that give adequate repeat bloom and also the best fruit quality.

The extreme biennial bearing tendency of Honeycrisp leads the tree to produce very large crops followed by very low crops. With either high or low crop loads fruit quality is not optimal. Based upon the last seven years of field studies with Honeycrisp we currently recommend a multi-spray thinning program (a spray at either bloom or at petal fall followed by a spray at 10-12 mm fruit size), coupled with early hand thinning (when fruit size is 25mm) and a summer NAA program (four sprays beginning in late June) to manage biennial bearing.1

In this study we hand thinned the trees shortly after petal fall to a broad range of crop loads. Over the three years of the study (2004-2006) there was a consistent negative effect of increasing crop load of 5-6 fruits/cm2 of TCA.

Crop load also has a large impact on fruit quality (Robinson and Watkins, 2003). Fruit soluble solids content was lower in fruit from heavy cropping trees than from light cropping trees. The suppressive effect of high crop loads on fruit soluble solids is probably due to a shortage of carbohydrate supply for the developing fruits on the heavy cropping trees. Fruit red color was poorer on heavy cropping trees than light cropping trees. This was the most striking visual evidence of the crop load effect on fruit ripening. At harvest we observed that fruit from trees, which had in excess of 10 fruits/cm2 of TCA did not develop commercially acceptable fruit color. The curvilinear relationship between crop load and fruit red color showed that red color was reduced slowly as crop load was increased up to about 6 fruits/cm2 of TCA. However the curve became very steep at the higher crop loads. In addition, fruits from heavy cropping trees were softer, had lower acidity, and higher starch ratings. The poorer fruit color and reduced sweetness of the fruit probably from heavy crop loads indicates a lack of adequate resources to develop optimum quality. From a fruit quality perspective it would appear that crop loads around 5-6 fruits/cm2 of TCA are optimum, resulting in good fruit color, good soluble solids and medium acidity. Our previous research also showed a very strong suppressive effect of increasing crop load on return bloom the next year (Robinson and Watkins, 2003). The season following a heavy crop is almost always followed by very little bloom the next year. The trees became non-flowering when crop loads the previous year were greater than 9 fruits/cm2 of TCA. Also surprising was the significant variation about the trend line. There were some trees with relatively low crop loads which we expected to have a high return bloom but produced instead very few flower buds the following year. Many trees had no return bloom following medium crop loads (6-7 fruits/cm2 of TCA), which with other varieties would have resulted in good return bloom. Management strategies to stimulate flowering on 50-60% of the spurs are needed. Our objective with this project has been to define appropriate crop loads and thinning treatments that give adequate repeat bloom and also the best fruit quality.

Hand Thinning Studies to Improve Return Bloom

From 2004-2008 we conducted a series of hand thinning field studies with Honeycrisp to reducing biennial bearing. In a field study planted in 2002 at Geneva, graduate student Sergio Lopez evaluated the impact of different crop loads on return bloom of Honeycrisp. In this study we hand thinned the trees shortly after petal fall to a broad range of crop loads. Over the three years of the study (2004-2006) there was a consistent negative effect of increasing crop load of 5-6 fruits/cm2 of TCA. Crop load also has a large impact on fruit quality (Robinson and Watkins, 2003). Fruit soluble solids content was lower in fruit from heavy cropping trees than from light cropping trees. The suppressive effect of high crop loads on fruit soluble solids is probably due to a shortage of carbohydrate supply for the developing fruits on the heavy cropping trees. Fruit red color was poorer on heavy cropping trees than light cropping trees. This was the most striking visual evidence of the crop load effect on fruit ripening. At harvest we observed that fruit from trees, which had in excess of 10 fruits/cm2 of TCA did not develop commercially acceptable fruit color. The curvilinear relationship between crop load and fruit red color showed that red color was reduced slowly as crop load was increased up to about 6 fruits/cm2 of TCA. However the curve became very steep at the higher crop loads. In addition, fruits from heavy cropping trees were softer, had lower acidity, and higher starch ratings. The poorer fruit color and reduced sweetness of the fruit probably from heavy crop loads indicates a lack of adequate resources to develop optimum quality. From a fruit quality perspective it would appear that crop loads around 5-6 fruits/cm2 of TCA are optimum, resulting in good fruit color, good soluble solids and medium acidity.

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Pheromone blends into the orchard. Puffer cabinets were suspended in the upper one-third of the tree canopies at a rate of 1 per acre, starting along the inside of the windward border edge and spaced approximately 132 ft apart, with the remaining cabinets deployed in a regular grid pattern in the orchard interior. The Isomate and Duel plots were all approximately 5 acres in size, and the Puffer plots were 7.3–10 acres in size. Because the puffers are recommended for use in plantings of 40 acres or more, these plots were additionally ringed with Checkmate CM membrane dispensers applied one per tree in every tree of the first two border rows (and row ends) of each plot, to compensate for any potential edge effects of the smaller-size plots.

The amount of time required for application of each type of pheromone dispenser was: Isomate CM/OFM, 40 min/A/person; Duel CM-OFM, 43 min/A/person; Puffer, 5 min/A (although plot measurement and setup for the Puffers took 2-3 hours).

Pheromone treatment efficacy in depressing male moth catches in the traps was monitored by using nine large Delta-style traps per plot (three each for CM, OFM, and LAW, located at either end plus the center of a middle row), each baited with a standard 1x1 rubber septum lure, and checked weekly from 7 May to 28 August. A similar group of nine traps in a non-disrupted check plot nearby was monitored at each farm as well to maintain information on background levels of each of these species and for purposes of fruit injury comparison at harvest. Lures in all traps were changed at the end of June, and again for CM during the last week of July.

A fruit sampling protocol, consisting of weekly on-tree fruit inspections, was conducted from 9 July to 13 August, comprising 300 fruits per plot (20 on each of 15 trees) during the first week and 100 fruits per plot (10 on each of 10 trees) on subsequent weeks, to detect the initial occurrence of any larval fruit damage in time to curtail further infestation. An evaluation of larval fruit feeding damage at harvest was made by taking random samples of 500 fruits from each plot (20 from each of five trees along each plot edge, and 20 from each of five trees distributed throughout the plot interior) and examining them for internal and surface injury. Pre-harvest samples were taken between 12–18 Sept.

2007 Results

Traps catches of adults were generally suppressed to low levels in all pheromone treatment plots during the mid- and late summer, although some breakthrough captures did occur, particularly for codling moth. Therefore, trap shutdown was not absolute in all cases (Figures 5-7). Two sites with notable CM catches were Ridgeway and Newfield, where large numbers of moths were caught in the nondisrupted Grower Standard plots during the last week of June. At Ridgeway, CM catch was effectively suppressed in all the pheromone treatments for the entire season; at Newfield there was a slight breakthrough in the Isomate and Puffer plots during this June peak. CM pressure was not as severe at Eagle Harbor, and minor breakthrough catches occurred in all pheromone treatments during the last half of June. For these trials, all CM traps were attached to bamboo poles and hung in the upper third of the tree canopies. Inasmuch as flight activity in this species tends to be concentrated near the tree tops, trap placement could have been a major factor contributing to the number of moths caught in the pheromone-disrupted plots. Oriental fruit moth pressure was considerable at Eagle Harbor, but all treatments showed low trap numbers at all three sites throughout the season. Lesser appleworm was very numerous at Newfield, but the respective OFM pheromone treatments effectively depressed these trap numbers at all three sites as well.

The fruit sampling procedure was simple and convenient to implement, requiring 10–15 min per plot, and appeared to effectively allow detection of low-level infestations at a very early stage, so that the growers could be notified of any extra needed control measures in a timely fashion. Incidence of fruit injury was extremely low all season in all blocks until August, when damage on return bloom the following year; it appeared however that with increasing age of the tree the relationship was not quite so negative (Figure 3). In 2005 following the first cropping year (2004) a return bloom of 50% of the spurs flowering required relatively low crop loads of 4 fruits/cm² TCA. In 2006, 50% return bloom was achieved following a crop load of 5 the previous year and in 2007 a 50% return bloom was achieved following a crop load of 10 fruits/cm² TCA. Thus, it appears that with more mature trees it is possible to carry heavier crops and achieve a moderate return bloom. With most varieties it is desirable to have more than 50% return bloom but with Honeycrisp having 40-50% of the spurs flowering is probably preferable to having every spur on the tree flowering (snowball bloom indicated by points in the upper left hand side of Figure 1) because such high flowering is almost always followed by no flowers the following year.

We also evaluated return set (second year crop load) as a function of different levels of return bloom (Figure 2). As return bloom increased return set also increased. However, the relationship indicated that to achieve a return set of 10 fruits/cm² TCA (sufficient for a good commercial crop) required only a return bloom of 30% in 2005 and 40% in 2006. Thus, with relatively low return bloom, Honeycrisp can still have a good commercial crop load because of high return set.

Lastly we evaluated the effect of crop load on the variation in yield from one year to the next (bienniality). Following low crop loads in year one there was a large positive variation in second year yield (strong bienniality) while with very high crop loads in year one there was a strong negative variation in second year yield (strong bienniality). With intermediate crop loads of 8-10 there was little variation in yield between the two years (Figure 3). Thus for growers to achieve the same yield every year, crop load should be kept at ~8 fruits/cm² TCA. In our study this crop load resulted in significant variation in return bloom from one year to the next, but the return yield varied little since even with a low return bloom, Honeycrisp can set a good commercial crop load because of high return set.
Mechanically Applied Pheromone Products for Mating Disruption of Codling Moth and Oriental Fruit Moth in Apples

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The codling moth (CM), Cydia pomonella, and the oriental fruit moth (OFM), Grapholita molesta, are two internal-feeding lepidopteran (“worm”) pests that in the past 7-8 years have developed into the most serious pests of eastern tree fruits, including those in New York. Since 2001, numerous loads of apples have been rejected at NY processing plants because of unacceptable infestations by larvae of OFM and CM, as well as lesser appleworm (LAW), Grapholita platura. A species related to OFM that is also capable of incurring fruit damage (Reissig 2003). Because there is a “zero tolerance” on apples with these pests, growers are conducting trials during 2007-08 to assess the effect on CM and OFM management programs of incorporating the use of two different mechanically applied products.

Mechanically Applied Pheromone Products for Mating Disruption of Codling Moth and Oriental Fruit Moth in Apples

The use of pheromones for mating disruption is one tactic that has generated substantial interest and shown some promise, but recommendations on their use have been hampered by the lack of experience with this approach in NY. Over the past seven years, we have conducted a number of assessments of different pheromone dispensing technologies available, to determine their potential usefulness as supplements to control internal-feeding worms in NY apple orchards. We have generally found that hand-applied dispensers such as polyethylene ties or controlled release membranes are very effective in suppressing moth catches and lowering fruit damage, but the economics of implementing these approaches are not favorable on an individual block scale (Agnello et al. 2006).

The improved efficacy of mating disruption when applied on an area-wide basis against these pests has been demonstrated in the Northwestern US, as well as in Michigan and Pennsylvania (Brunner et al. 2001; Calkins & Faust 2003; Epstein et al. 2007; Hull et al. 2008). The unique landscape of eastern orchards, in which a mosaic of tree fruits is planted in small blocks interspersed among a diversity of managed and un Managed plantings, provides the opportunity to test the use of pheromone products in NY apple orchards. In 2007 we evaluated a broad range of pheromone treatments at Chazy Orchards in the Champlain Valley with the help of Eric Green and Gary Moore. In 2007, three spray combinations of pheromones at full bloom, Sevin at Petal Fall and either NAA plus Sevin or Maxcel plus Sevin at 10 mm fruit size sig significantly improved return bloom compared to the unthinned controls.

In 2008 we evaluated the effect of pheromone treatments on return bloom of Honeycrisp apples in 2007 at Geneva, NY. (Vertical arrow indicates least significant difference)

2007 Trials

In 2007, three pheromone dispensing technologies were tested in three “low” to “high risk” commercial orchards. The pheromone treatments, all applied between 9-11 May, were: 1. Iso mate CM/OFM Twin Tube tie dispensers, 2. Checkmate CM-OFM Duol membranes (Suiterra et al., LCD, OR; Figure 2), and 3. Suiterra CM/OFM Puffers (Suiterra, Figure 3), each applied against all seasonal generations of CM and OFM. The OFM pheromones were directed additionally against LAW, as these species have similar pheromone blends. In all cases, growers used their normal pesticide programs against major insect pests in these blocks, and the pheromone treatments were applied as supplements to help in the management of internal-feeding caterpillars.

The Checkmate Puffer pheromone dispenser consists of a plastic tube enclosing an aerosol canister containing CM and OFM pheromone blends (Figure 4). Every 15 min between 5:00 pm and 5:00 am each day, a battery-powered timer activated the dispenser, releasing a 40-ppm puff of the combined pheromone.
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Figure 9. Effect of various chemical thinning treatments applied in 2007 on return bloom of Honeycrisp apples in 2008 in the Champlain Valley at Cherry Orchards.

Figure 10. Effect of summer NAA or Ethrel sprays applied in 2004 on return bloom of Honeycrisp apples in 2005 at Geneva, NY. (Vertical arrow indicates least significant difference)

thinning treatment alone significantly improved return bloom although Maxcel plus Sevin treatment had a higher numerical return bloom (Figure 9). The addition of a single summer NAA or a single summer Ethrel spray significantly improved return bloom compared to the untreated control. However, increasing the number of sprays to three of either NAA or Ethrel did not further improve return bloom.

In 2003 we again evaluated summer NAA sprays following a sequential thinning treatment of 5ppm NAA plus Carbaril or 50ppm Maxcel plus Carbaril at the 10mm fruit stage. In contrast to the year before, both the chemical thinning treatments at the 10mm stage improved return bloom but the summer NAA sprays did not further improve return bloom (Figure 10). In 2007 we applied a series of three summer NAA (5ppm) sprays on Honeycrisp trees with a wide range of natural crop loads to determine if the summer NAA sprays would improve return bloom better if crop load was normal or low compared to excessively cropped trees. In 2008 there was no difference in return bloom at any crop load between trees receiving three sprays of NAA during the summer compared to those which did not (Figure 11). Thus, the results from the use of summer NAA or Ethrel sprays to improve return bloom have been in

consistent. In 2004 there was a clear benefit of these sprays but in 2005 and 2007 there was no improvement in return bloom from summer NAA sprays.
Conclusions
Over the past five years our studies with Honeycrisp have shown that biennial flowering is strongly related to crop load the previous year. Relatively low crop loads are required to ensure a strong return bloom each year with young trees requiring a low crop load of 4 fruits/cm² TCA while with older trees higher crop loads of 6 fruits/cm² TCA give good return bloom. Our studies have shown that Honeycrisp has a very high return set each year. Relatively low crop loads are required to ensure a strong return bloom each year with young trees requiring a low crop load of 4 fruits/cm² TCA. This initial spray should be followed by a spray of 2-3oz NAA/100 gallons + 1pt Sevin XLR/100 gallons at 10-12 mm fruit size if needed. About 14 days after the last thinning spray is applied all Honeycrisp trees should be hand thinned to 8 fruits/cm² TCA. This will require growers to measure trunk circumference and calculate the total fruit number per tree to achieve 8 fruits/cm² TCA. The chemical and hand-thinning program should be coupled with a summer NAA spray program of four sprays of 3oz NAA/100 gallons every 10 days beginning on June 21. This program is especially important during the heavy blooming year to ensure at least 40% return bloom. In the light blooming year, a less aggressive thinning program can be performed but early hand thinning should be done to ensure that crop load does not exceed 8 fruits/cm² TCA.

Our chemical thinning studies have shown that very early (bloom or petal fall) aggressive chemical thinning is essential for good repeat bloom of Honeycrisp. Trials in 2007 showed that aggressive petal fall thinning (10ppm NAA+Sevin) gave the best return bloom of 14 treatments. Later thinning sprays at the 10-12mm stage or hand thinning later in June or July have been less effective at improving return bloom than either bloom or petal fall sprays. However, if Honeycrisp trees are to be hand thinned, the earlier in the season it can be completed, the greater the improvement in return bloom. The best time to hand thin Honeycrisp is as soon as fruits reach 25mm which is about three weeks after petal fall. Some trials have shown benefits of using summer NAA or Ethrel treatments to stimulate better return bloom but in other trials there has been no benefit. The use of Ethrel in July has led to increased pre-harvest drop and advanced maturity. The inconsistency of summer NAA or Ethrel sprays indicates that they are only part of the answer and must be combined with aggressive bloom or petal fall thinning to achieve annual bearing. Based upon the last seven years of trials with Honeycrisp we currently recommend a multi-spray thinning program coupled with early hand thinning and a summer NAA program to manage biennial bearing. The first thinning spray should be applied at either bloom with an application of 2 gal ATS/100 gal at petal fall with an application of 8oz NAA + 1pt Sevin XLR. This initial spray should be followed by a spray of 2-3oz NAA/100 gallons + 1pt Sevin XLR/100 gallons at 10-12 mm fruit size if needed. About 14 days after the last thinning spray is applied all Honeycrisp trees should be hand thinned to 8 fruits/cm² TCA. This will require growers to measure trunk circumference and calculate the total fruit number per tree to achieve 8 fruits/cm² TCA. The chemical and hand-thinning program should be coupled with a summer NAA spray program of four sprays of 3oz NAA/100 gallons every 10 days beginning on June 21. This program is especially important during the heavy blooming year to ensure at least 40% return bloom. In the light blooming year, a less aggressive thinning program can be performed but early hand thinning should be done to ensure that crop load does not exceed 8 fruits/cm² TCA.

References

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Contents
3 Mechanically Applied Pheromone Products for Mating Disruption of Codling Moth and Oriental Fruit Moth in Apples
Arthur M. Apel and Harvey Reissig
11 The New Face of New York Berry Growers: Insights From the 2007 NYS Berry Growers Survey
Deborah Horbin, Cathy Heidenreich, Laura McDermott and Marvin Pritts
17 Fire Blight and Streptomyces: The Reality of Resistance
Nicole L. Russo and Herb Adkins
20 Antioxidant Capacity and Phenolic Phytochemicals in Black Raspberries
Hayedee Marquez, Courtesy A. Weber and Chan Y. Lee
24 Crop Load Management for Consistent Production of Honeycrisp Apples
Teresa Robinson, Sergio Lopez, Kevin Fingerman and Gabino Reginato

Covers: High density Tall Spindle Honeycrisp orchard, with pheromone dispenser inset.