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Atlantic Canada - 'Honeycrisp'

Maintaining Tree Growth and Cropping Balance

Apple production conditions in Atlantic Canada are proving to be ideal for growing 'Honeycrisp'. However, with optimum growing conditions and good management, mature 'Honeycrisp' orchards have exhibited an extreme tendency for over-cropping resulting in an alternate bearing cycle called biennial bearing. This is the tendency for a cultivar to cycle between a full ("on") crop year and a minimal ("off") crop year. In the "on" year, if left unmanaged, fruit are too small and have poor colour. In the "off" year there are only a few fruit and they may be too large. So apple growers in this region are making a concerted effort to learn how to more efficiently manage this cultivar. The challenging production question is: What combination of management practices will promote optimum yield of high quality fruit annually?

In 2003 the Kentville field production research team began to study the impact of reducing blossom levels and subsequent crop density on fruit size and colour and on the biennial nature of 'Honeycrisp'. It was found that even very effective fruitlet thinners which significantly reduced the crop-load had little impact on return bloom. The greatest improvement in return bloom occurred when there was a significant reduction in blossom levels through blossom removal by hand (Figure 1) or through detailed spur pruning. When fruitlet thinning was conducted using bioregulators in addition to blossom thinners and spur pruning, test trees developed an optimum crop-load which in turn gave good fruit size and colour, better tree growth and annual cropping.

Figure 1. 'Honeycrisp' tree with heavy bloom

In summary, the research showed that the following management factors have a direct impact on yield, size, colour, annual flowering and tree growth of 'Honeycrisp': a) spur-wood pruning, b) blossom thinning, c) fruitlet thinning and d) hand thinning.

Spur-wood Pruning

As noted above, it was found that blossom removal increased tree growth and annual bearing. While it is not practical to remove blossoms by hand, it is possible through detailed spur wood removal. In observational experiments, all visible spur wood was removed from 'Honeycrisp' trees and there was a "flush" of vegetative lateral limb growth during the summer. It was surprising to observe a smattering of flowers and subsequent fruit set on vegetative laterals the following season. This prolific response is not common in other commercial cultivars.

A number of experiments were designed to measure the degree to which spur pruning would influence annual flowering. The three sites selected had heavy, medium or light spuriness within the

tree canopy. Following dormant spur pruning, initial observation on new growth indicated that the number of new shoots and the total length of new shoots were directly correlated with the amount of spur-wood removed (Figure 2). Average shoot length was not significantly affected by the degree of spur removal. Trees that were spur pruned the most severely had the lowest blossom density.

Figure 2. Response to dormant spur pruning after one season. Left: un-pruned. Right: dormant spur pruned.

While this type of pruning is labor intensive for fruit-spur laden 'Honeycrisp' trees it has resulted in a positive vegetative response. Our research shows that the removal of greater than 50% of the fruit buds is necessary to achieve a balance between new shoot growth and flowering. The annual removal of some of the fruit-spur-laden secondary limbs is also part of a good spur reduction management program for 'Honeycrisp'. The goal in pruning mature 'Honeycrisp' is to promote a better balance between fruitwood and vegetative-wood. There is also a high tendency for multiple fruit set of each blossom cluster in this cultivar (Figure 3). This heavy set seems to be especially strong when trees are in balance so pruning does not eliminate the need for a 'Honeycrisp' crop-load management program through blossom and/or fruitlet thinning.

Figure 3. Multiple set 'Honeycrisp' after ''July drop'' such as this illustrates the need for hand thinning.

Considerations prior to spur wood pruning for balanced growth

- The fruiting habit of 'apple' is principally on spurs that arise from lateral limbs or buds on the previous season's extension growth. For example new laterals that grow in 2007 will have lateral buds forming flower initials in late summer of 2008 which will bloom in 2009.
- These buds usually bloom the following spring and generally remain in production for 2 or 3 years or longer depending on exposure to light.
- Since new flower buds can only arise from lateral buds on those new shoots formed the previous year, the pruning system must leave a sufficient number of two year old shoots each year to insure the continued production of new spurs and flowers.

A renewal pruning system for 'Honeycrisp' should:

- Provide for the continuous renewal of the spur system.
- Ensure that the maximum number of spurs are exposed to sunlight at least half of the time.
- Permit selected terminals to grow 3 to 4 years before renewal.

Due to the inherent low vigor of 'Honeycrisp', only small amounts of new growth will occur if steps are not taken to adjust crop load in mature trees. Research has shown that removal of adequate amounts of spur wood and/or blossoms will enhance vegetative growth within the tree canopy (Figure 4). This in turn enables the initiation and development of new fruit spurs. Producers that annually practice adequate spur wood removal can develop a balanced ratio of vegetative growth and flower buds (Figure 5).

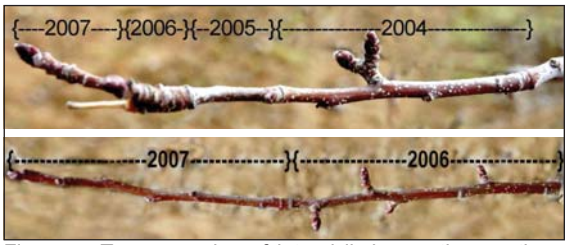

Figure 4. Two examples of lateral limb growth over time. Top limb has short annual growth and needs to be spur pruned or removed. Bottom limb has good annual growth and should be maintained for at least two more seasons.

Figure 5. Spur pruned 'Honeycrisp' tree with good balance between vegetative growth and fruit production. Crop density was 67 apples m^{-3} and canopy volume of 3.43 m^3 with average fruit size of 234.3 g and a total of 230 fruit.

Blossom Thinning

Blossom thinning provides an opportunity to reduce "overset" when excessive bloom is present. Risk of over thinning, leaf phytotoxicity and a narrow window for application has discouraged many producers from considering this method of thinning. The alternate bearing nature of 'Honeycrisp' has inspired our research team to design experiments to evaluate the effect of blossom intensity and crop-load on fruit quality and return bloom. In an eight year old 'Honeycrisp' orchard on M.26 rootstock, blossom clusters were counted then divided by the TCSA to determine the blossom intensity of each tree. At 80% full bloom the blossom intensity was manually adjusted to 150, 100 or 50 blossom clusters $tree^{-1}$. Following fruit set the crop-load was further manually adjusted to 9, 6 and 3 fruit cm^{-2} TCSA respectively and one treatment remained unadjusted to serve as a control.

In this four year study the un-thinned control trees displayed extreme biennialism. The trees with 150 blossom clusters $tree^{-1}$, which were subsequently thinned to 9 fruit cm^{-2} TCSA, showed some biennialism.The trees with blossom levels reduced to 100 or 50 blossom clusters $tree^{-1}$ followed by manually adjusted crop-loads of 6 and 3 fruit cm^{-2} TCSA had much more uniform annual production (Embree *et al*., 2007).

The number of blossoms to be removed depends on the size of the tree which is closely related to the TCSA. The TCSA change and thus tree growth was observed after four seasons of study. The results show that any amount of thinning below 9 fruit cm^{-2} TCSA did increase tree vigor and enlarge the canopy volume. Canopy volume is determined by measuring the tree width within the row, the width between the row and the height of the tree from the bottom scaffold and then applying this information to the formula CV = [(¼) π a b h) / (m(x) + m(y) + 1] (Wright *et al.*, 2006). For ease of visualizing this, one cubic meter of apple tree is about the size of one bulk bin (Figure 6).

These results have renewed interest in managing the blossom density and researching effective blossom thinners. Blossom development for 'Honeycrisp' follows a similar pattern each season. First the king blossom opens, followed by the lateral blossoms in the cluster. Thus producers should consider a spray applica-

Figure 6. Diagram using apple bulk bins to illustrate a method to estimate the canopy volume (1 bulk bin = 1 m^3 of CV) when determining the crop for an individual tree.

tion targeted after the majority of the king bloom have been open and there was sufficient pollination for good set. Fertilization usually occurs within 24 hours after pollination and is temperature dependant. The recommendation at the present time is to apply ammonium thio-sulphate (ATS), a liquid fertilizer, to coincide with this timing of adequate king flower fertilization. This usually occurs when the orchard is in full bloom or full bloom plus one half or one day. Precise timing is critical but varies with the temperature during flower development. Rates and weather will also influence the degree of foliage burn. The extent of blossom thinning is best assessed as the fruit reach 10mm in size. If thinning was inadequate or there is evidence of multiple set per cluster (even with a low number of clusters per tree) fruitlet thinners need to be applied.

Fruitlet thinning

AFHRC Crop-Load Regulation Research Reports and the Product and Rate Recommendations for Blossom & Fruitlet Thinning tables are good references in addition to technical advisors for product rates and timing.

The fruitlet thinners Fruitone N™, Amid Thin®, Sevin® XLR and MaxCel® can be applied as early as petal fall and are effective until the fruit is 12-14 mm in diameter. Initial fruit set can be determined as soon as the flowers drop. The effectiveness of fruitlet thinners, like blossom thinners, is influenced by many factors. These include: a) the ease of thinning for the specific cultivar, b) the product rate applied, c) weather conditions before, during and after application, d) techniques of application, e) tree and foliage health and overall tree health, f) yield history (on year, off year), and g) seasonal trends for the region.

Hand thinning

Even though the initial fruit set is measurable when the flowers drop the second natural drop occurs about 50 days after full bloom and is called “June or July” drop (Figure 7). This is the time to assess the efficiency of the blossom and fruitlet thinning program and determine the need for hand thinning. Adjusting the crop-load to approximately 6 fruit cm^{-2} TCSA or 60 fruit m^{-3} of canopy volume should ensure a crop of high quality apples. The over cropped tree on the left had fruit of small size and poor colour. The hand thinned tree on the right had large fruit size and a greater portion of fruit with >50% orange-red colour (Figure 8).

Figure 8. Tree on right, hand thinned in August, shows improvement in fruit size and color at harvest.

Fruit size and colour

‘Honeycrisp’ can produce large, well coloured apples if grown optimally, especially on young trees that have not yet filled their space. Excessive crop-loads will reduce not only size and colour of apples, but also fruit firmness, total acidity and soluble solids (please refer to factsheet entitled: ‘Honeycrisp’: Management for a unique cultivar in Nova Scotia, Table 1). Effective crop-load adjustment is reached when fruit numbers are sufficiently reduced to cause the desired increase in fruit size. Fruit size is determined by cell division which takes place during the 50 days following flower fertilization. Cell enlargement continues from time of fertilization until harvest. Cell division and enlargement are both influenced by carbohydrates and water availability (Figure 7). During the later phase of growth, in September, ‘Honeycrisp’ fruit size increases very rapidly, provided crop levels are optimum.

Fruit bud formation and biennial bearing

Fruit bud initiation begins in mid summer and may be influenced by any seasonal variation in temperature, water or sunlight. All of these environmental factors can have a direct influence on fruit bud formation (Figure 7). The current year’s crop-load, when excessive, reduces the potential for the tree to develop strong healthy flower buds. By balancing the annual crop-load there is a better supply of nutrients and natural growth regulators promoting the development of strong fruit buds thus reducing biennial bearing.

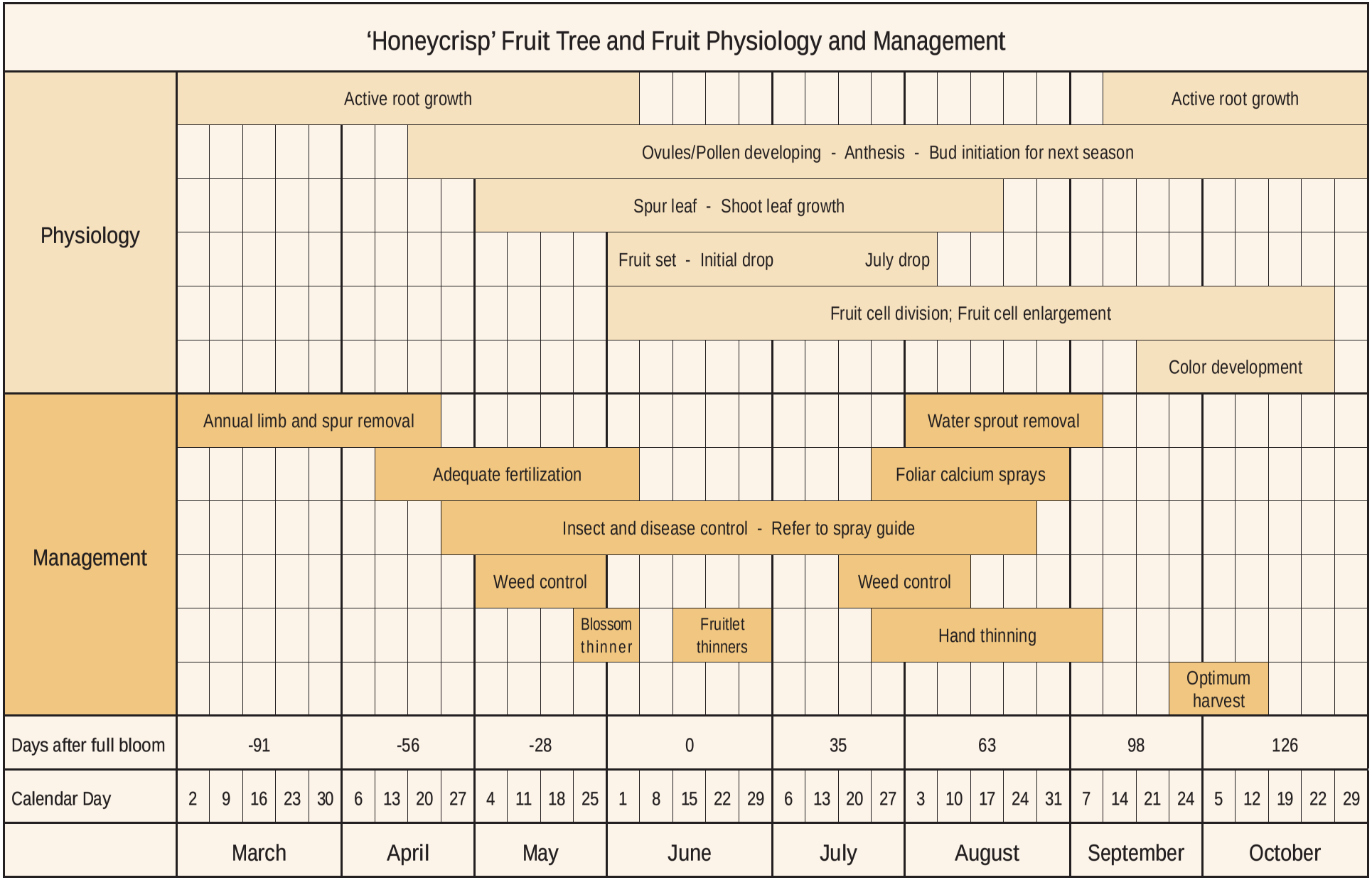

Figure 7. Time line of physiological processes and timing of orchard management decisions to maximize the physiological impact of tree and fruit development within the ‘Honeycrisp’ apple tree.

Nonetheless, our studies clearly show the current year response of adequate thinning on fruit size. In the “on” years, adequate blossom numbers were present for all treatments. In the “off” year however, a significant increase in blossom number did occur for lowest crop-load treatments (Embree *et al*., 2007). The blossom number on these trees, although low, did provide an opportunity for some fruit set in the off year, thus, reducing the impact of the biennial bearing cycle on ‘Honeycrisp’ production.

Summary

The highest priced ‘Honeycrisp’ apples on the fresh fruit market are large and highly coloured. Detailed pruning coupled with adequate flower and fruitlet thinning improves size, colour and annual bearing. Hand-thinning to adjust blossom numbers and crop-load is very time consuming and costly for commercial enterprises. Spur pruning, blossom and fruitlet thinning are undoubtedly three of the most important tools that producers have for dealing with biennial bearing and poor fruit quality consequences. At the present time there are a limited number of approved blossom thinning products. Research into more environmentally friendly blossom thinning agents is under way in many locations. The challenge is to find optimal rates for existing products and to test new and novel products and combinations. These optimal rates and new products must also have low phytotoxicity.

In order to optimize the quality and annual bearing in ‘Honeycrisp’ orchards blossom and fruitlet levels need to be managed. For example, trees with a canopy volume of 2.5 m^3 or a TCSA of 30 cm^2 should have only 200 blossom clusters per tree. Following fruit set and initial drop, the crop-load should be reduced to 180 fruit $tree^{-1}$. In the commercial orchard this can be achieved through detailed annual pruning followed by the application of blossom and/or fruitlet thinners. Fruitlet thinners and follow-up hand thinning should be employed following assessment of fruit set at 5-10 mm fruit size and again after June or July drop respectively (Figure 5).

Managing the best time, materials and rates for ‘Honeycrisp’ blossom and fruitlet thinning is a critical challenge for apple growers in the Annapolis Valley. The current research goal for the Production Team at AFHRC is to develop reliable techniques for managing bloom and crop-load levels for high quality annual crops.

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