Cropload of Honeycrisp Affects Not Only Fruit Size But Many Quality Attributes

Terence L. Robinson[1] and Christopher B. Watkins[2]

[1] Dept. of Horticultural Sciences, NYSAES, Cornell University, Geneva, NY
[2] Dept. of Horticulture, Cornell University, Ithaca, NY

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Honeycrisp can develop extremely high quality fruit if grown optimally, but quality can be greatly reduced if croploads are too high. In addition to the reduction in fruit size and return bloom from excessive croploads, our research has shown that fruit firmness, total acidity, soluble solids, color and starch are all reduced when croploads are above optimum.

The popularity of Honeycrisp in the market and the high fruit prices it commands are largely due to consumer demand based on the unique experience of eating a good apple. Most consumers of Honeycrisp view fruit appearance as secondary to the flavor, crispness and juiciness it delivers when it is grown well. However, optimum fruit quality (taste and eating experience) are not always easy to achieve. The biennial bearing tendency of this variety leads the tree to produce very low crops one year followed by very high crops the second year. In both situations, quality is not optimal. Our objective with this project has been to define appropriate croploads that give adequate repeat bloom and also the best fruit quality.

The 1998 Honeycrisp Trial at Geneva

We planted 150 Honeycrisp/M.9 apple trees in the spring of 1998 to study the influence of cropload on tree growth in the early years and then to study the effects of cropload on fruit quality and repeat bloom as the trees matured. The trees were trained in a vertical axis system and did not have irrigation. The soil was a fertile Honeoye silt loam. In the second year, we allowed the trees to set a modest crop and then imposed a range of croploads on the trees through thinning at 2 weeks after bloom. This procedure was continued in years 3 and 4. Each year we selected the heavy cropping trees and thinned them to various cropload levels to give a range of cropping from none to very heavy. The level of cropload was quantified by counting the number of apples on the tree and then calculating the number of apples per cm^2 of trunk cross-sectional area. The typical range of croploads for many varieties grown in New York State is 5-6 fruits/cm^2 of TCA.

Beginning in the fourth year (2001), we had a sufficiently heavy bloom to impose a wide range of croploads (0-12 fruits/cm^2 of TCA). In the fifth year (2002), we were able to impose croploads up to 15 fruits/ cm^2 of TCA. Near harvest each year we began weekly sampling of the Honeycrisp trees to determine the impact of the different croploads on fruit ripening and flavor development. At each weekly sampling we selected a sub-sample for analysis of fruit maturity and quality factors and divided the remaining fruit into two lots to evaluate the impact of cropload on fruit storage disorders. We stored half of each sample at 38°F and the other half at 33°F for five months in air. After the five month storage period, we evaluated the samples for fruit firmness and storage disorders including bitter pit, senescence breakdown, soggy breakdown, soft scald and superficial scald.

Horticultural Results

The level of cropload carried by Honeycrisp trees affected tree vegetative growth in both the fourth and fifth years. All trees generally grew well with the fertile soils at the Geneva Experiment Station, but trees with a very low or non-existent cropload had greater growth (as measured by the increase in trunk cross-sectional area) than trees with a heavy cropload (Fig. 1). The relationship between cropload and trunk growth was curvilinear indicating that, as cropload on Honeycrisp trees is increased, tree growth declined rapidly up to a cropload of about 5 fruits/cm^2 of TCA. Beyond that, up to a cropload of 12 fruits/cm^2 of TCA, there was similar but slow growth from the trees.

It should be noted that under weaker soils than those at Geneva, it is likely that the heavy croploads would have stopped tree growth almost completely. This point is critical for growers who plant Honeycrisp trees on M.9 rootstock on weak soils. During the developmental years of the orchard, it may be necessary to limit cropload to allow the trees to fill their space.

Fruit size was also reduced by increasing cropload in a curvilinear relationship (Fig. 2) that was very similar to that shown for trunk growth. Fruit size was reduced rapidly as cropload increased from 0 to about 7 fruits/cm^2 of TCA. Even at a cropload of 6-7 fruits/cm^2 of TCA, fruit size was still about 175g (100 count fruit size). Fruit size was 150g at croploads of 10 fruits/cm^2 or greater. Although a 150g Empire or Jonamac apple is still marketable, for Honeycrisp, which is sold as a premium apple, this size is not commercially acceptable. In contrast, at very low croploads, fruit size often approached 300g which is considered excessive by most marketers. In today's market, a Honeycrisp fruit size between 200 and 250g is considered optimal. To obtain that fruit size in our study would have required a cropload of less than 5 fruits/cm² of TCA. This seems suboptimal compared with Empire and Gala and is indicative of the need to sacrifice total yield to obtain the optimum fruit size for the market.

Return bloom the following season was also reduced by increasing croploads (Fig. 3). The statistical relationship was linear and steeper indicating that the higher the cropload that is allowed to persist on a Honeycrisp tree, the greater the inhibition of flowering the following year. The trees became non-flowering at croploads greater than 9 fruits/cm² of TCA. Also surprising was the significant variation about the trend line. There were some trees which had relatively low croploads and produced very few flower buds the following year (points in the lower left hand corner of Fig. 3). There were very few trees that had a heavy cropload the previous year that came back with significant flowering (points in the top right hand corner of the figure. The suppressive effect of high croploads on next year's flowering was slightly greater in 2002 than in 2001 as indicated by the dashed line in Fig. 3 that dips below the solid line at the high croploads. It is disturbing to see that many trees had no flowers following what we typically have called medium croploads (6-7 fruits/cm² of TCA).

For adequate cropping, most growers prefer to have a minimum of 40-50 percent of the spurs flowering each year. To achieve that level of flowering would have required relatively low croploads of 3-4 fruits/cm² of TCA the previous year. An undesirable situation is to have every spur on the tree flowering (snowball bloom indicated by points in the upper left-hand side of the figure) because this is almost always followed by no flowering the following year. Management strategies to stimulate a 50-60 percent of the spurs to flower are needed.

Many Honeycrisp growers have observed leaves with a blotchy or mottled appearance that is first evident in mid-July. We related this disorder to cropload (Fig. 4). Trees with light or no crop always had more serious leaf mottling than heavy cropping trees. The severity of the disorder increased rapidly as cropload dropped below 5 fruits/cm² of TCA. It is not known if this disorder causes any deleterious effects on the tree or its longevity.

Fruit Maturation

Internal fruit ethylene concentration (IEC) measurements over the harvest period showed that ethylene in the fruit gradually rose as the fruits matured but that Honeycrisp does not produce high amounts of ethylene like McIntosh. At each harvest date in 2002, there was a consistent trend of higher ethylene associated with the higher cropload trees (Fig. 5). However, this relationship was quite weak and, in 2001, there was no statistical relationship between cropload and IEC. The higher IEC in fruit from heavy cropping trees indicates that they are slightly more mature than those from light cropping trees. This view was supported by the other harvest indices: a negative relationship between fruit firmness and cropload (Fig. 6), increased starch ratings associated with higher croploads (Fig. 7), and lower total acidity in the heavy cropping trees (Fig. 8).

In contrast, soluble solids content was lower in fruit from heavy cropping trees than that from light cropping trees (Fig. 9). Typically soluble solids increase during fruit ripening. However, the effect of high croploads depressing fruit soluble solids is probably not related to delayed ripening but rather to a shortage of carbohydrate supply for the developing fruits on the heavy cropping trees. In this case, soluble solids content is not a good indicator of fruit ripening.

Similarly, measurements of fruit red color indicated that the heavy cropping trees had poorer fruit color than light cropping trees (Fig. 10). This was the most striking visual evidence of the cropload effect on fruit ripening. At harvest we observed that fruit from trees which had in excess of 10 fruits/cm² of TCA just did not develop commercially acceptable fruit color. The curvilinear relationship in Figure 10 indicates that fruit color is reduced slowly as cropload is increased up to about 6 fruits/cm² of TCA. However, the curve becomes very steep at the higher croploads. The lack of characteristic fruit color development at high croploads is probably indicative of a shortage of resources rather than delayed maturity of the fruit.

In summary, fruit from heavy cropping trees appeared to be more

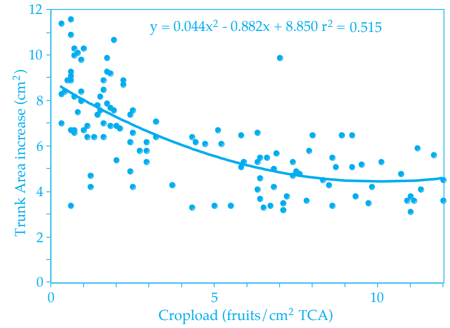

Figure 1. Effect of cropload on trunk cross sectional area increase of Honeycrisp/M.9 in the fourth year (2001).

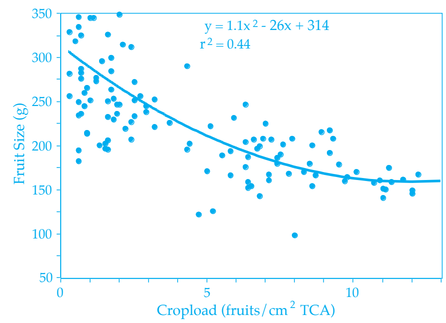

Figure 2. Effect of cropload on fruit size of Honeycrisp/M.9 in the fourth year (2001).

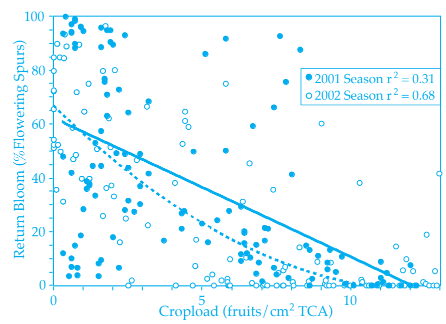

Figure 3. Effect of cropload on return bloom of Honeycrisp/M.9 in the fourth and fifth years (2001 and 2002).

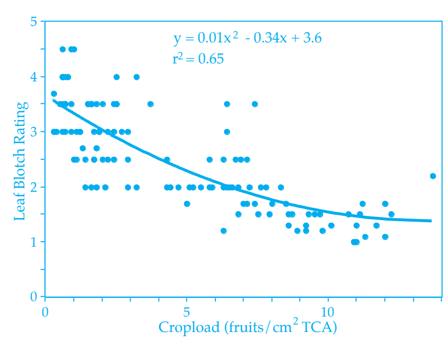

Figure 4. Effect of cropload on leaf blotch symptoms of Honeycrisp/M.9 in the fourth year (2001). Rating scale: 1=no symptoms, 2=25% of shoots show symptoms, 3=50% of shoots show symptoms, 4=75% of shoots show symptoms, 5=100% of shoots show symptoms.

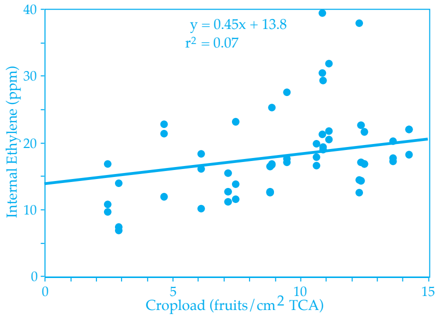

Figure 5. Effect of cropload on internal fruit ethylene concentration of Honeycrisp/M.9 in the fifth year (2002).

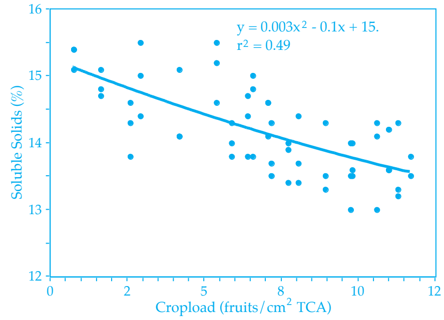

Figure 9. Effect of cropload on soluble solids content of Honeycrisp/M.9 in the fourth year (2001).

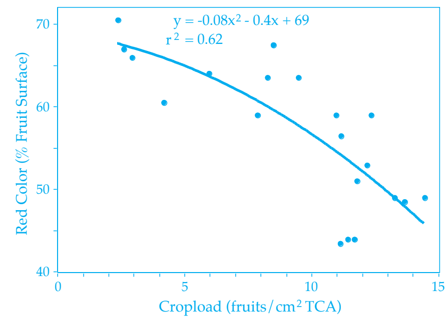

Figure 10. Effect of cropload on fruit red color of Honeycrisp/M.9 in the fifth year (2002).

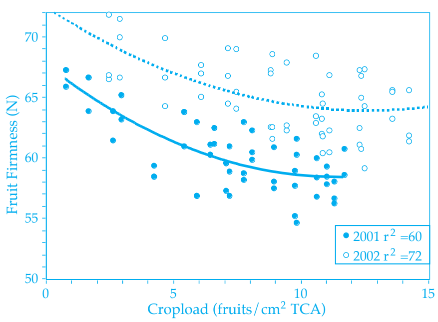

Figure 6. Effect of cropload on fruit firmness of Honeycrisp/M.9 in the fourth and fifth years (2001 and 2002).

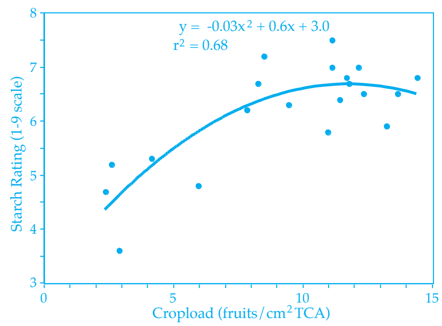

Figure 7. Effect of cropload on starch rating of Honeycrisp/M.9 in the fifth year (2002).

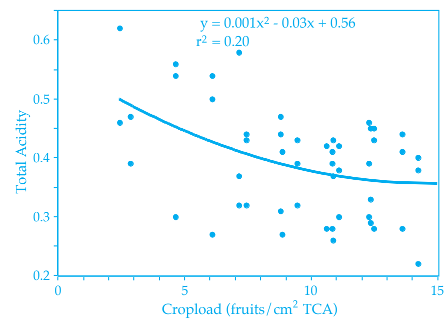

Figure 8. Effect of cropload on total acidity of Honeycrisp/M.9 in the fifth year (2002).

mature because they produced more ethylene, were softer, had lower acidity, and higher starch ratings. Additionally, the poorer fruit color and reduced sweetness of the fruit probably indicates lack of adequate resources to develop optimum quality. We did not objectively measure taste and juiciness, but subjective judgements indicate that the fruit from trees with croploads greater than 9-10 fruits/cm² of TCA were of very poor quality and would be less acceptable in the marketplace. From a fruit quality perspective, it would appear that croploads around 5 fruits/cm² of TCA are optimum, resulting in good fruit color and soluble solids and medium acidity.

Fruit Storage Disorders

Cropload also greatly affected storage quality of Honeycrisp apples. After storage for five months, fruit from trees with higher croploads were softer, but had lower incidences of bitterpit, senescent breakdown, rot and superficial scald (Table 1). Fruit from trees with higher croploads had greater soggy breakdown, but not soft scald. The poorer fruit firmness and quality from the high cropload tress at harvest resulted in poorer firmness after storage but lower susceptibility to fruit storage disorders.

Harvest date influenced fruit firmness and many of the storage disorders (Table 1). Firmness was greatest with the earliest harvest date, however, bitter pit

TABLE 1

Effect of cropload, storage temperature and harvest date on fruit quality after 5 months of air storage at 33°F or 38°F of Honeycrisp apples from four-year-old Honeycrisp/M.9 (2001).

		Firmness (lb)	Bitter pit	Senescent Breakdown	Rot	Soggy breakdown	Soft Scald	Superficial Scald
Regressions with Cropload		Negative**	Negative**	Negative*	Negative *	Positive *	NS	Negative *
Harvest Date								
	Sept. 11	13.7	5	1	1	4	6	7
	Sept. 18	13.3	3	4	2	9	16	2
	Sept. 25	12.9	1	2	12	7	14	2
Statistical significance of harvest date		**	**	NS	**	**	**	**
Storage Temperature (°F)	33	13.2	1	1	4	12	17.0	8
	38	13.3	5	4	6	0.4	7.2	0
Statistical Significance of storage temperature		NS	**	**	**	**	**	**

NS=Means were not significantly different, *=Means were significantly different, **= Means were highly significantly different.

was also greater at the earlier harvest date. Fruit rot, soggy breakdown, and soft scald were increased by the later harvest.

Storage temperature did not have a significant influence on fruit firmness but did influence storage disorders (Table 1). The warmer storage atmosphere resulted in more bitterpit, more senescent breakdown, and more rot but lower incidences of soggy breakdown, soft scald and superficial scald.

Conclusions

The major effects of excessive cropload with Honeycrisp are reduced flowering the following year and reduced fruit size. In addition, tree growth is sensitive to excessive croploads. Of particular importance for this variety may also be the negative impact of excessive croploads on fruit quality maturation and storage. Croploads above 10 fruits/cm^2 of TCA resulted in poor size, poor color and poor flavor which did not improve in storage, although they tended to have the least storage disorders. Even moderate croploads of 7-8 fruits/cm^2 of TCA resulted in disappointing return bloom and mediocre fruit quality. It appears that for optimum quality and annual cropping, relatively low croploads of 4-5 fruits/cm^2 of TCA will be necessary. This will require precise chemical thinning followed by accurate hand thinning.

Precise management of Honeycrips is a necessity from the production standpoint to avoid biennial bearing, and from the marketing perspective to continue to provide the consumer with an extremely high quality apple that will result in an outstanding eating experience.

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Terence Robinson is a research and extension professor in the Dept. of Horticultural Sciences who specializes in canopy and cropload management strategies. Christopher Watkins is a research and extension professor who leads Cornell's postharvest research and extension program in fruit crops.