Honeycrisp: Promising Profit Maker or Just Another Problem Child?

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'Honeycrisp' is a new apple variety that commands high prices in the marketplace, but it is not an easy variety to grow. Honeycrisp's mild flavor, juicy crispness and excellent keeping qualities are offset by problems with bitter pit, soft scald, and color variability. Cornell researchers are working to resolve many of these problems.

'Honeycrisp' is a new apple variety with unique qualities that could eventually propel it into mainstream apple markets. Honeycrisp resulted from a cross of 'Macoun' and 'Honeygold' and was named by the University of Minnesota in 1992. Several years ago, Brown et al. (1999) provided the following description of Honeycrisp:

"The performance and attributes of Honeycrisp are varied and can be grouped under the heading, 'The good, the bad, and the ugly.' The 'good' refers to a great name for marketing and excellent texture, crispness, and juiciness. The 'bad' refers to coloring problems, appearance defects, and susceptibility to an undiagnosed leaf disorder. The 'ugly' refers to bitter pit, scald, soft scald, and a tendency to ferment due to skin permeability problems."

Despite its faults, Honeycrisp is being planted throughout northern fruit producing regions in the United States. Sizable plantings have been made in New England, New York, Michigan, Wisconsin, Minnesota, and Washington State. Growers have been receiving $35 to $50 per packed box for Honeycrisp when prices for other varieties generally ranged from $8 to $15 per box. Prices for Honeycrisp may decline as the volume of Honeycrisp increases. Nevertheless, the unique eating quality, storageability, and shelf life of Honeycrisp should create sustained demand for this variety if producers can produce Honeycrisp of consistently high quality.

The Sales Pitch on Honeycrisp

Honeycrisp has a crisp juicy texture that exists in no other commercially available apple variety. The flavor of Honeycrisp is mild, becoming slightly aromatic in fully matured fruit. However, it is the unique texture of this apple that will generate consumer demand. According to information released by the University of Minnesota, the sensation of juicy crispness in Honeycrisp derives from the fact that, when bitten, this apple shears apart by breaking through cells in the flesh rather than by separating between cells. The breaking of the flesh cells not only releases more juice, it also contributes to a nearly audible sense of crunchiness that contributes to eating pleasure.

Honeycrisp also has excellent keeping quality. Apples held in regular air storage for nine months are indistinguishable from freshly harvested fruit and still have more crispness than most apples available in retail stores during May and June. In casual observations over the past several years, the eating quality of Honeycrisp actually seemed to improve when fruit were held for 7-10 days at room temperature after removal from cold storage. Poststorage ripening allowed development of more varietal flavor without the loss of crispness that would occur with most other varieties. As a result, consumers may well find that the last apple they eat after purchasing Honeycrisp is the best apple in the bag, and that perception should benefit repeat sales.

Problems with Honeycrisp

Honeycrisp is not an easy variety to grow. Some of the major horticultural and storage problems reported for Honeycrisp are listed below in approximate order of severity, with the more severe problems listed first:

1. More than 50% of fruit in some years and locations are unmarketable because of bitter pit.
2. Under certain conditions, virtually 100% of fruit develop soft scald during cold storage.
3. Variability in fruit coloration suggests that multiple strains of Honeycrisp may already exist in commercial plantings. Within the same planting, some trees produce fruit with an attractive pink blush whereas other trees produce fruit that are coarsely-striped, poorly-colored and/or have blotchy coloration.
4. In some plantings and some years, preharvest drop may be similar to what commonly occurs with McIntosh.
5. Production of Honeycrisp with acceptable color may be limited to regions where McIntosh is being grown successfully.
6. Fruit mature unevenly, so multiple harvests may be necessary.
7. Fruit harvested too early never develop varietal flavor and remain almost tasteless. Fruit on over-cropped trees may never mature and therefore are of poor eating quality.
8. Leaves on Honeycrisp trees often develop a disconcerting zonal chlorosis

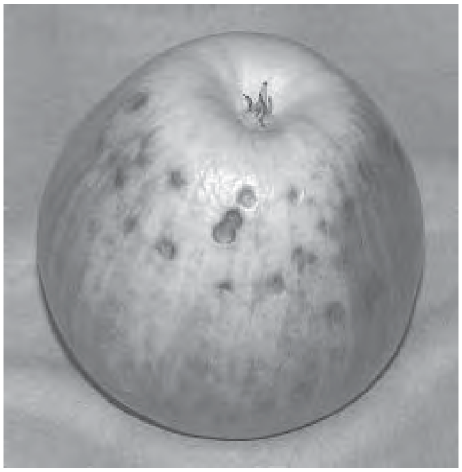

Figure 1. Honeycrisp fruit showing sunken lesions typical of bitter pit.

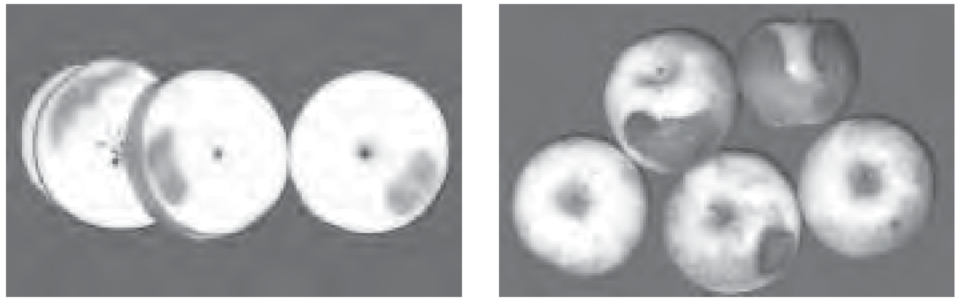

Figure 3. Honeycrisp showing typical symptoms of soft scald.

that resembles the damage caused by potato leafhopper.

Production and storage problems with Honeycrisp are currently being addressed by a group of researchers and cooperative extension specialists at Cornell in cooperation with commercial growers who are pioneering this variety in New York. What follows is a progress report on Honeycrisp research conducted both collaboratively and independently by the contributing authors. Results reported here must be interpreted with caution because many of the results are based on a single year of field trials.

Bitter Pit

Bitter pit is a physiological disorder caused by calcium deficiency in the fruit flesh. Bitter pit is characterized by dark sunken lesions at or beneath the fruit surface (Figure 1). Pits may be present at harvest or, more frequently, become evident after the fruits have been placed in storage. Often the lesions appear first at the surface near the blossom end of the fruit, but symptoms can occur throughout the flesh of the fruit in severe cases.

Conditions that favor excessive fruit size make bitter pit worse. Trees with excessive vegetative growth often produce fruits with low calcium because active vegetative growing points compete strongly with developing fruits for calcium. Bitter pit is worsened by drought, boron deficiency, and excess amounts of soil potassium, magnesium, or nitrogen. Low seed numbers also worsen bitter pit because seeds produce the plant growth substances that direct the movement of calcium into the fruit.

During summer of 2000, Rosenberger, Schupp, Hoying, Cheng, and Watkins cooperated on trials in three 'Honeycrisp' orchards where calcium sprays and Flint fungicide were applied to control bitter pit. Previous reports suggested that Flint fungicide could reduce the incidence of bitter pit in some varieties, although no mechanism for such activity has been elucidated. Trees in test plots were treated during summer with varying rates and/or combinations of calcium and Flint. Fruit were harvested at maturity and evaluated to determine how field treatments affect fruit mineral content and the incidence of bitter pit both at harvest and after cold storage.

Statistically significant reductions in bitter pit could not be detected in two of the three trials because bitter pit incidence varied greatly from tree to tree within treatments. In the third trial, two Flint applications in August reduced the incidence of bitter pit at harvest by 40% compared to control trees. However, the incidence of bitter pit in fruit from Flint treatments increased during cold storage, and there were no significant differences among treatments after 85 days of cold storage at 35 °F. Additional work with Flint is underway to determine its usefulness for reducing bitter pit.

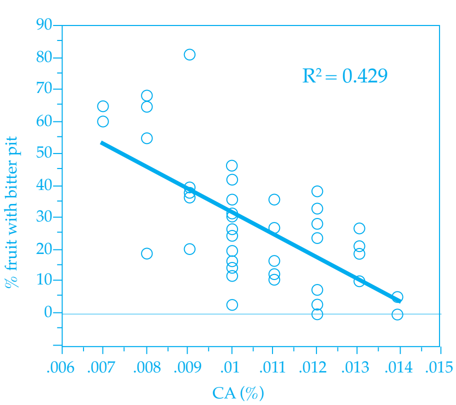

Figure 2. Effect of calcium level on incidence of bitter pit noted on Honeycrisp after storage for 85 days at 35 °F.

There was a highly significant relationship between incidence of bitter pit and calcium content of Honeycrisp fruit from the 45 individual trees in the Hudson Valley trial even though the low rates foliar calcium applied during summer did not reduce bitter pit significantly in statistical comparisons of the treatments themselves. Differences in calcium content accounted for 42.9% of the variability in incidence of bitter pit evident after cold storage (Fig. 2). The positive correlation between calcium content of fruit and reduction in bitter pit suggests that bitter pit problems in Honeycrisp can be resolved with calcium sprays. Additional research is needed to find the best way to get enough calcium into the fruit.

Soft Scald

Soft scald, also called ribbon scald or deep scald, is a low temperature disorder of apples that can be induced in some varieties by storing them at temperatures of 36-37°F or lower. Soft scald has caused extensive losses in some lots of Honeycrisp that have been held in cold storage (Fig. 3).

During the 2000 harvest season, Watkins and Iungerman cooperated on a study of preharvest factors that might affect susceptibility of Honeycrisp to soft scald. Fruit samples were collected from four orchards in the Champlain Valley planted in 1995, 1996 and 1997 on M.26 and B.9. Fruit were harvested from a minimum of 10 trees in each block on September 14, 21 and 28, 2000. The most mature fruit were selected on each occasion, except for orchard #2, where high-blush fruit from some trees was kept separate from lowblush fruit from other trees. Two bushels of fruit were harvested from each block for storage for 12 weeks at either 33 or 37°F.

TABLE 1

Incidence of soft scald and bitter pit in Honeycrisp harvested in the Champlain Valley on 14, 21 and 28 Sept. 2000 and stored at 33 or 37 ºF for 12 weeks followed by 7 days at 68ºF.

Orchard block	% fruit with soft scald						% fruit with bitter pit[1]			
	14 Sept.		21 Sept.		28 Sept.		14 Sept.		21 Sept.	
	33ºF	37ºF	33ºF	37ºF	33ºF	37ºF	33ºF	37ºF	33ºF	37ºF
1	21	3	52	0	97	42	15	42	33	54
2 (high blush)	17	0	52	0	-	-	28	40	4	11
2 (low blush)	2	0	16	2	-[2]	-	9	16	5	5
3	3	0	33	0	78	48	0	14	9	13
4	0	0	64	3	70	28	6	51	8	8
Mean for all samples	**9**	**1**	**43**	**1**	**82**	**39**	**12**	**33**	**12**	**18**

[1]Data on bitter pit was not collected for fruit harvested 28 Sept. because the severe soft scald obscured bitter pit.
[2]No samples were available from Orchard 2 on 28 Sept.

Fruit quality was assessed according to standard procedures.

A sub-population of 20 fruit was examined after six weeks of storage. Soft scald had already developed by this time, but the incidence was affected by harvest date, orchard and storage temperature (Figure 4). Informal tasting of fruit also indicated that presence of alcoholic off-flavors was affected by these same factors. In general, adverse affects on fruit metabolism as evidenced by off-flavors and soft scald were greatest in fruit stored at 33 compared with 37ºF, and in fruit from later harvests. Soft scald incidence was extremely high in fruit harvested on September 28 and stored at 33ºF. However, soft scald occurred in this fruit even at 37ºF, and off-flavor development was apparent in all fruit harvested on that date.

The remaining fruit (n = 30-60) were tested 12 weeks after harvest

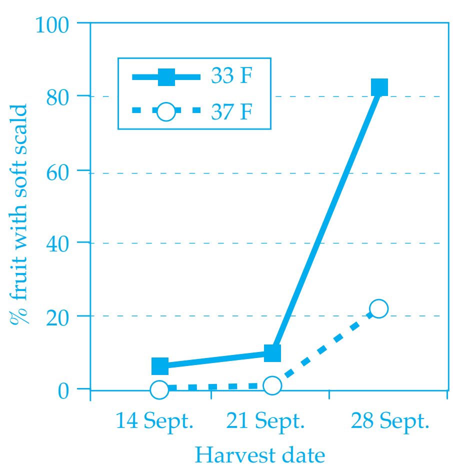

Figure 4. Effects of harvest date and storage temperature on incidence of soft scald in Honeycrisp apples after 6 weeks of storage. Apples were harvested from four orchards in the Champlain Valley during September of 2000.

(Table 1). By this time, soft scald was present even in the earliest harvested fruit stored at 33ºF. Incidence of the disorder at this temperature increased rapidly with advancing harvest date. By the September 28 harvest date, incidence of soft scald was high irrespective of harvest date. Bitter pit was present in fruit from most orchard blocks, but incidence of the disorder tended to be higher at 37ºF than at 33ºF.

Watkins also evaluated three postharvest factors for their effect on soft scald development. These factors were: (i) storage temperature, because soft scald in other varieties can be controlled by raising the storage temperature; (ii) postharvest application of diphenylamine (DPA), because this antioxidant compound has controlled soft scald in other varieties; and (iii) a postharvest cooling delay.

In 1999, 'Honeycrisp' apples were harvested from a Western New York orchard on September 17, and randomized into 24 lots of 40 fruit. In addition three 10-fruit samples were taken for analysis of maturity. Fruit were then transported to the Cornell University Orchard laboratory in Ithaca. Internal ethylene concentration (IEC) was measured on each fruit of the maturity samples. The fruit lots were divided to provide three replicates for treatments involving factorial comparisons of 33ºF versus 36ºF, DPA treatment versus no DPA, and a one-week holding period at 50ºF prior to cold storage versus cold storage immediately after harvest. For DPA treatment, fruit were dipped in 1000ppm for 1 minute, allowed to drain for 2 hours, and placed into cold storage at the same time as non-treated fruit. After storage for 12 weeks, fruit were transferred to an evaluation room maintained at 68ºF. After 1 d, IEC and firmness were measured on 50 fruit samples per replicate. On day 7, the firmness of 50-fruit replicates was again measured, and all fruit assessed for presence of disorders. A similar experiment was completed using fruit harvested in 2000.

Fruit were climacteric at harvest in both years with average internal ethylene concentrations of 50 ppm and 30 ppm in 1999 and 2000, respectively. For fruit moved to cold storage immediately after harvest, the lowest soft scald incidence occurred in fruit treated with DPA and held at 36ºF. Holding fruit for one week at 50ºF resulted in a significant reduction in soft scald. Fruit with delayed cooling averaging less than 1% soft scald, irrespective of prior DPA treatment or subsequent storage temperature. No interactions between the main factors were detected.

Bitter pit incidence was not affected by DPA treatment, but bitter pit incidence averaged 25% in fruit with delayed cooling compared with only 14%

TABLE 2

Incidence of soft scald and bitter pit in 'Honeycrisp' apples grown in 1999 as affected by storage temperature, DPA treatment, and cooling to the indicated temperatures immediately after harvest or only after holding fruit for one week at 50 ºF.

Treatment	% fruit affected by	
	Soft scald	Bitter pit (%)
33ºF	28	14
36ºF	19	11
33ºF + DPA	19	11
36ºF + DPA	8	18
33ºF + delay	2	20
36ºF + delay	0	34
33ºF + DPA + delay	0	17
36ºF + DPA + delay	0	27
$LSD_{0.05}$	**5.3**	**7.6**

in fruit cooled immediately after harvest (Table 2). No other significant fruit quality effects were detected. Results were similar in the trial conducted with fruit grown in 2000.

This research clearly shows that severity of soft scald is affected by storage temperature and harvest dates. Soft scald was consistently severe on fruit moved directly to storage at 33 F. Severity of soft scald at 36-37°F increased as harvest was delayed into late September. A one-week holding period at 50°F also markedly reduced soft scald development. Informal tasting of fruit indicated that Honeycrisp quality was not deleteriously affected by this treatment, and at least two growers have applied this method with good results.

The major recommendations from this work are that fruit should be harvested as soon as appropriate color and flavor have been obtained. Of the maturity indicators available, starch may be useful as a guide to over-maturity, and we tentatively suggest a starch-iodine index of 6 as a cut-off for harvest. A storage temperature of 38 °F is tentatively recommended. Storage operators need to find a way to ensure a dedicated room is available to hold fruit at the appropriate temperature, especially as crop volume increases.

Delayed cooling and/or warmer storage temperatures significantly reduced losses to soft scald, but both of those strategies resulted in increased losses to bitter pit. Thus, storage temperature adjustments will need to be combined with a rigorous calcium nutrition program to produce fruit that can withstand the warmer storage temperatures without undue losses to bitter pit. Postharvest drenches with calcium chloride may be essential for minimizing bitter pit at warmer storage temperatures.

Strain Variations

Many Honeycrisp growers are finding that consistent production of fruit with attractive red color is more difficult than with most other apple varieties. The amount of fruit color and fruit appearance of Honeycrisp is highly variable from tree-to-tree (see Fig.5). Highly colored strains of some other apple cultivars vary in their genetic stability and their frequency of reversions to less-desirable fruit color. Genetic instability in Honeycrisp could explain the large tree-to-tree variation in the intensity and pattern of red color that is found in many orchards. Careful selection of propagation wood from trees with the preferred red-blush color development will be of limited value if blush-type Honeycrisp do not stay true-to-type.

Figure 5. Variations in fruit color of Honeycrisp from various New York orchard blocks.

Fifty Honeycrisp selections with the potential for improved red color have been identified by researchers at the University of Minnesota and were propagated on Bud.9 rootstocks. Two plantings were made in 2001, one in Minnesota and another at Cornell's Hudson Valley Lab where Jim Schupp will be evaluating the selections for horticultural characteristics and fruit quality. It is hoped that one or more of these selections may have improved color while maintaining the texture and flavor that has made Honeycrisp so desirable. Observations in these plantings, combined with those from commercial orchards, should provide good information on genetic stability and strain variations.

Enhancing Color

Red color formation in Honeycrisp fruit may be temperature sensitive in the same way as observed for McIntosh and other cool climate cultivars. Whether Honeycrisp of marketable color can be consistently produced in regions such as the Hudson Valley is yet to be determined.

Particle film sprays such as Surround have been recommended for improving red fruit color in situations where temperatures are supra optimal. Jim Schupp conducted a study in Milton, NY, during the 2000 growing season to determine the effect of Surround on fruit color and fruit maturity of Honeycrisp apples. Surround applied in the weeks following petal fall had no effect on fruit color of Honeycrisp apples, and Surround applied later in the season actually reduced red fruit color. Furthermore, Surround applications resulted in undesirable residues in the calyx basins and stem cavities on fruit. The residues were not removed by brushes on a commercial packing line and were so disgusting as to preclude repetition of the experiment. Thus, Surround is not the answer for improving fruit color of Honeycrisp.

Schupp and Watkins also evaluated the effects of Retain used alone or in combination with Ethrel to determine effects of these plant growth regulators on fruit color and quality. ReTain was applied to Honeycrisp/M.26 trees four weeks prior to anticipated harvest. Ethrel was applied at one pint/100 gallons seven days prior to the first harvest. Fruit samples were harvested on 5 Sept. and on 11 Sept. for evaluation of fruit maturity and quality at harvest and after storage.

Ethrel treatment did not increase Honeycrisp fruit color when applied either with or without ReTain, but ReTain blocked the expected effects of Ethrel on maturity indices. Harvest evaluations showed that ReTain reduced internal ethylene concentration, starch index rating and red fruit coloration while increasing fruit firmness. Ethrel had little or no effect on any measurable fruit maturity or fruit quality parameter, but it did cause increased fruit drop. Application of ReTain prior to Ethrel resulted in preharvest fruit drop similar to that of the untreated controls. Schupp and Watkins are continuing studies to determine how ReTain and Ethrel affect fruit maturity, fruit color, fruit quality, and storage potential of Honeycrisp fruit.

Zonal Chlorosis on Leaves

Honeycrisp leaves often develop a zonal chlorosis that resembles the damage caused by potato leafhopper (Fig. 6). To determine if potato leafhoppers (PLH) caused the symptoms on Honeycrisp, Rosenberger and Straub used whole-tree cages to exclude leafhoppers from four Honeycrisp/M.9 trees during summer of 1999. The caged trees were paired with similar non-caged trees. The trees were monitored throughout the summer for the presence of PLH on the leaves and for chlorotic symptoms.

For both caged and uncaged trees, three out of four trees developed leaf chlorosis symptoms by 17 June. One uncaged tree remained free of symptoms throughout the entire monitoring period whereas all of the caged trees eventually developed symptoms in the absence of PLH. Only low levels of PLH infestation occurred in the uncaged trees. This experiment verified that the chlorotic leaf symptoms on Honeycrisp are not due to PLH. Schupp hypothesized that the zonal chlorosis of Honeycrisp leaves may have a physiological cause and might be related to the buildup of starch grains in the chloroplasts. Impaired phloem loading or phloem transport in Honeycrisp could cause toxic accumulations of carbohydrate in leaves under certain conditions. This hypothesis is supported by the fact that zonal chlorosis occurs earlier in the season on non-bearing or lightly-cropping trees than on heavily cropping trees where the fruit provide a large carbohydrate sink. Schupp and Cheng are cooperating on research to test the hypothesis that zonal chlorosis results from carbohydrate build-up in leaves.

Figure 6. Zonal chlorosis of Honeycrisp leaves.

Conclusions

The consensus of those contributing to this paper is that most of the horticultural problems that have surfaced with Honeycrisp can be and are being resolved. We believe that bitter pit in Honeycrisp can be managed by maintaining reasonable crop loads, applying foliar calcium sprays during summer, and using a postharvest calcium chloride drench. Soft scald and the fermented flavors that are a precursor to soft scald can be avoided by adjusting storage temperature and harvest dates. The multi-strain plantings in the Hudson Valley and in Minnesota should improve our understanding of strain differences and/or variability and stability of the germplasm. We may not be able to eliminate zonal necrosis on Honeycrisp leaves, but there is no evidence that this phenomenon affects productivity or fruit quality.

Unless stable, high-coloring strains of Honeycrisp can be selected, acceptable fruit color development could remain as a significant problem for southern production areas in New York and other states. Poorly colored fruit from southern production regions will not compete well against the best fruit from western NY and the Champlain Valley. However, marketing Honeycrisp based on color may prove a faulty strategy for all concerned because no production area is immune to production of poorly-colored fruit given the variability that currently exists in established plantings and variability that has been observed from one season to the next.

More important to the success of Honeycrisp than fruit color will be the quality of the product that is sent to consumers during the early years of Honeycrisp marketing. High prices for Honeycrisp increase the temptation to sell fruit of sub-optimal quality (i.e., immature fruit that lack flavor, or fruit with bitter pit, soft scald, or fermented off-flavors). Marketing poor quality fruit will quickly cement Honeycrisp's reputation as a problem child among apple varieties. If Honeycrisp growers and packers commit themselves to producing and marketing only high-quality fruit, then Honeycrisp might contribute significantly to improved profitability of the apple industry over the next decade.

Acknowledgments

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