Integrative Management of Bitter Pit in 'Honeycrisp' Apples from the Extension Perspective

By Daniel J. Donahue

Introduction

This article is a "meat and potatoes" summary of an American Society of Horticultural Science (ASHS) Postharvest Group webinar I presented on January 18, 2022. The webinar audience was a mix of research, extension, and commercial industry fruit workers from North America and Europe. As such, it was necessary to introduce the NYS apple industry, the Hudson Valley in particular, the Honeycrisp (HC) apple, and an overview of the 6-years of results from a Honeycrisp bitter pit (BP) research project for the most part conducted in the Hudson and Champlain valleys. Since our CCE-ENYCHP Produce Pages readers have seen much of this data presented at fruit schools and in previous articles, I'm going to focus on specific recommendations that you can implement for the 2022 growing season. If you would like to review the research in more detail, a list of links to relevant articles will be provided at the end. A recording of the full webinar is available to ASHS members by following this link https://ashs.org/page/ArchivedWebinars .

Bitter Pit and Honeycrisp: General Observations & Recommendations

It's a "bitter" pill to swallow, but after 6 seasons of research in the Hudson Valley, and much more by others in Honeycrisp regions, it's clear to me that our current level of mitigation technology and understanding of the causal mechanism for BP will not lead to the commercially satisfactory control of bitter pit in Honeycrisp. By this I mean "control" at the levels we expect from our currently available pest management technologies (Figure 1). Our strategy is little different from that of the great coach Vince Lombardi and his "4 yards and a cloud of dust" football playbook. Commercial producers must implement a series of tactics that individually may not work from year to year, but as an integrated program will serve to significantly reduce losses.

Figure 1. We expect our management technologies to produce clear, consistent results. Unfortunately, this is not the case with bitter pit.

The three most significant BP variables under the control of the commercial producer and marketer are first, the region where you decide to grow Honeycrisp and second, the rootstock you choose to produce it on, and third, how well you manage annual crop load. Cool geographic regions such the Champlain Valley of New York State reliably produce Honeycrisp with much less BP than warmer regions such as the Hudson Valley of New York State. This realization is of cold comfort to the Hudson Valley producer and marketer, but it is reality. In the future if we continue to move towards an oversupply situation, lower FOB's will inevitably make HC from warmer regions less financially attractive attributably to BP and color challenges. The second variable, rootstock, is a management choice which is under producer control independent of the growing region. The third variable, crop load, is completely under the control of the orchard manager. We really can't "reduce" BP through good crop load management, we can only balance crop load, BP incidence, and fruit quality in such a way to maximize profitability over the economic life of the orchard.

Finally, HC orchard profitability over the long term is essentially a decision matrix in that all of your management decisions have consequences, usually effecting more than one variable. For example, not investing in the hand thinning of a heavy crop not only impacts fruit size, but it will reduce return bloom in the next year, reduce fruit color and Brix at harvest, delay maturity, and perhaps result in an off flavor. Yes, BP will be reduced, but at a very heavy cost. The light crop produced with next year will be characterized by excessively large fruit ravaged by BP. I think it's unlikely you can successfully implement any practices that will mitigate the BP under those circumstances. Bottom line, HC is a variety that requires hands-on management and close attention to detail, nothing like the other varieties we grow.

General Recommendations for Eastern New York State:

- Condition Honeycrisp for 7 days post-harvest at 50^{o}F, then store at 38^{o}F in both the Hudson and Champlain Valleys. The objective is to reduce chilling injuries such as soft scald and soggy breakdown. Yes, conditioning, and warmer storage temperatures increase BP somewhat. However, losses to chilling injury in the Hudson Valley appear to be increasing and when they happen, soft scald losses make BP look like a poser.

- The Hudson Valley is a world of many varieties generally stored on-farm. With Gala, McIntosh, and Honeycrisp harvest timings colliding with each other and closely following Paula Red and Jonamac, producers rarely have a free storage room to devote to 50^{o}F conditioning or even dedicated HC storage. Consider how to best balance your storage risk in high BP situations by mixing varieties in rooms of limited storage duration where the warm HC temperature will have only a minimal impact on those varieties which are best when stored at 33^{o}F. Short on HC conditioning space? At least in lower volume situations, a reefer body running at 50^{o}F can handle 50 bins, although in that case removing the initial field heat is best accomplished in a standard cooler. Not as

efficient as a dedicated storage room, but it can work when space is tight on smaller farms.

- Consider the customer satisfaction consequences of putting high BP risk fruit, say over 30%, into the marketplace. A tough decision but balance the cost of an unhappy buyer and load rejections (Figure 2). As quality standards tighten, those high BP M.26 blocks may be more of a liability than they are worth.

Figure 2. Honeycrisp bitter pit in the wholesale supply chain. For your eyes only, not your customers!

- Avoid excessive irrigation in the second half of the season. I included a link below to ta Good Fruit grower article which discusses the research of Dr. Lee Kalcsits (WSU) on the deficit irrigation of HC.

- The early, physical removal of fruit buds (precision pruning), flowers (pollen tube model thinning) and aggressive early thinning strategies (precision thinning) can aggravate bitter pit. The effect may not be noticeable in low BP orchards like those on B.9, but can be significant if BP exceeds 20% as many Hudson Valley orchards do. I've not observed the same effect from bloom thinning with NAA. Again, every management decision with HC is a tradeoff. In this case the balance between crop load and return bloom. Since early HC thinning doesn't seem to reliably enhance return bloom, its best to pick your battles on this one.

- Avoid the combination of G.41 and HC. Terrible bitter pit in most situations coupled with a reduced fruit set issue, not to mention the potential for graft union breakage.

Recommendations for new 'Honeycrisp' plantings in bitter bit prone regions of NYS:

- Plant high-color strains

- Plant B.9 (for now) and choose a planting density compatible with your site and local experience. I prefer 2.5' x 10' for the B.9/Honeycrisp combination in ENY.

- Avoid replant sites or at least implement a multi-year remediation plan on replant ground. Sorghum/Sudan is a nice cover crop mix prior to planting apples. The fallow period also provides a window to gain control over difficult perennial weeds.

- Adjust soil to a pH of 7.0 and incorporate amendments to correct mineral deficiencies.

- Take all necessary steps to maximize vegetative growth during the first few years.

- Avoid cropping in the second leaf, HC tends to settle down quickly once it's allowed to crop. Unfilled canopy space = low yields for the life of the planting.

Recommendations for an established orchard planted on B.9:

- Maintain pH and a balanced program of soil fertility. Follow Dr. Lailiang Cheng's and Mario Miranda-Sazo's recommendation to moderate potassium fertilization. Muriate of Potash can become quickly available to the tree if water is applied. Less K is required in an off year.

- Avoid the use of Prohexadione calcium (commercially formulated and sold as Apogee and Kudos) at any timing, as you already have a low-BP rootstock with low-vigor characteristics.

- Maintain a consistent annual cropping program based on NAA at bloom, followed by NAA & carbaryl as needed according to the carbohydrate thinning model.

- If needed, hand-thin early to touch-up or correct thinning mistakes and apply 4 summer NAA sprays at 5 ppm to encourage return bloom.

- Set the kings, avoid doubles. Lower BP in king fruit, at least under low-BP conditions.

- Start a foliar calcium program at petal fall, 5-weekly applications, continue every two weeks into mid-August.

- No need to spend time or money on bitter pit prediction. BP will be reliably low, fruit from B.9 orchards will be your go-to for longer-term storage.

- Allocate your 2nd and 3rd picks into longer-term storage (90d+).

- Allocate your 1st pick into 60-90d storage, maximize the economic potential of your low-BP orchards by prioritizing them for storage and later sale at higher FOB's.

If an established orchard is planted on M.9, M.26 or others, then:

- Maintain pH and a balanced program of soil fertility. Follow Dr. Lailiang Cheng's and Mario Miranda-Sazo's recommendation to moderate potassium fertilization. Muriate of Potash can become quickly available to the tree if water is applied. Less K is required in an off year.

- Apply a single application of Prohexadione calcium (Apogee or Kudos) at pink stage. Adjust the timing slightly to catch a 60^{o}F application window.

- Do Not Apply Prohex after bloom. Research has demonstrated that there is a significant risk of aggravating BP with post-PF applications and research has also shown that whatever competition occurs between shoots and fruits, especially in the summer, it does not reliably aggravate BP.

- Maintain a consistent annual cropping program based on NAA at bloom, followed by NAA & carbaryl as needed according to the carbohydrate thinning model.

- If needed, hand-thin to touch-up or correct thinning mistakes and apply 4 summer NAA sprays at 5 ppm to encourage return bloom.

- Set the kings, avoid doubles. Lower BP in king fruit, at least under low-BP conditions.

- Start a foliar calcium program at petal fall, even as early as pink (but not tank-mixed with your Prohex application) 5-weekly applications, continue every two weeks into mid-August.

- Implement the bitter pit prediction protocol of your choice. The EMR prediction model and the "Passive" prediction protocol were developed in NYS and were properly validated. Identifying potential BP storage disasters is worth the cost of $70 for HC orchards up to 5 acres in size. BP prediction is not only for the large wholesale producers. Smaller retail operations that want to continue in operation supplying quality HC through the winter and spring need low BP fruit as well.

- Allocate your 3rd picks into longer-term storage (90d+) if you must to marketing conditions.

- Allocate your 2nd pick into 60-90d storage.

- Allocate your 1st pick for immediate sale if your prediction model suggests BP in the 10-20% range. As mentioned earlier, predicted BP over 30% (reality check: 50% of HV orchards experienced BP over 30% in 2021) presents a rejection risk in the retail supply chain.

Future Direction: What do we need?

Follow all the steps above, and unfortunately you'll often continue to be disappointed with the BP observed in many orchards:

- We need to identify a low-BP rootstock for 'Honeycrisp' that is a little more vigorous than B.9 for replant situations and sites with weak soils.

- Continue work with plant growth regulators to find materials or combinations that improve the delivery and distribution of calcium ions within the fruit.

- Identify the gene(s) which influence the delivery and distribution of calcium within the fruit and deal with them through conventional plant breeding techniques, genetic engineering, or even using plant growth regulators to influence gene expression.

- We need production economics studies of established Honeycrisp orchards that are producing too much lower quality fruit. At what point do we fire up the dozer?

To conclude, the goal of this article was to suggest action items that you can implement to reduce losses to bitter pit. The causation question is another matter entirely. What we see expressed on the fruit's surface visually is the death of individual cells through desiccation following the structural failure of the cell membrane. However, this result is clearly not a random event attributable to the "global" status of calcium content in the fruit. We see variability of symptom expression at the fruit, tree, orchard, and storage level. I say "symptom expression" because we only know what we can see. Are there other groupings of weakened cells in a particular fruit that might have expressed visual symptoms of cell membrane failure if only they experienced a differing set of conditions during development and/or storage? Colleagues and I describe BP as a "calcium-related disorder", which is different than saying it's a straight-up global calcium deficiency. What exactly constitutes "related" is the open question, we have several hypotheses, but no consensus. The topic of causation is its own discussion, work continues…….

Resources if you're interested in a deeper dive into the data

Donahue, D.J.; Reig Córdoba, G.; Elone, S.E.; Wallis, A.E.; Basedow, M.R. 'Honeycrisp' Bitter Pit Response to Rootstock and Region under Eastern New York Climatic Conditions. Plants 2021, 10, 983. https://doi.org/10.3390/plants10050983

D.J. Donahue, G. Reig M. Rutzke, A. Wallis, M. Basedow and S.E. Elone. A predictive model for Malus × pumila Borkh. 'Honeycrisp' to reduce storage risk in eastern New York State, USA. Acta Hortic. 1314. ISHS 2021. DOI 10.17660/ActaHortic.2021.1314.51 Proc. International Symposium on Precision Management of Orchards and Vineyards. Eds.: R. Lo Bianco et al.

Daniel Donahue. 2017. Bitter Pit in Honeycrisp on G-41 vs M9-337: Observations from an Orchard Visit 2017. Fruit Quarterly. Volume 25, number 1, Spring pp. 13-17.

Daniel J. Donahue, Gemma Reig, Anna E. Wallis, and Sarah E. Elone. Bitter Pit Mitigation and the 'Honeycrisp' Apple: Prohexadione-calcium and Bourse Pinching Effects on Bitter Pit, Shoot Extension, and Fruit Size. 2018. Fruit Quarterly. Volume 26, number 3, Fall, pp. 23-28.

Daniel J. Donahue, Gemma Reig Córdoba, Sarah E. Elone, Anna E. Wallis and Michael R. Basedow. Rootstock, Region and Pick Timing are Factors to Consider When Choosing 'Honeycrisp' Blocks to Minimize Bitter Pit in Storage. Fruit Quarterly. Volume 29, number 3, Fall pp. 14-19.

Prengaman, Kate. 2020. Stress for success with Honeycrisp. Good Fruit Grower. April 9, 2020. https://www.goodfruit.com/stress-for-success-with-honeycrisp/ .