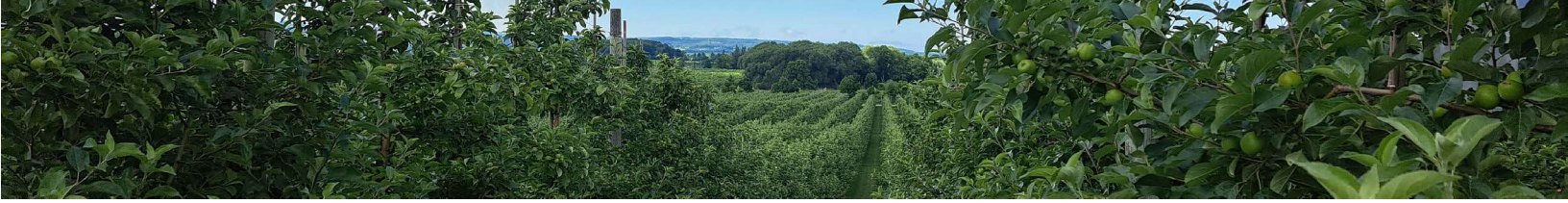


Bitter Pit: Can We See It Coming?

***Erika DeBrouwer**, OMAFA Tree Fruit Specialist*

There are a few options available for growers to get a better idea of bitter pit pressure within their blocks before storage of apples occurs. There are 3 main methods being used:

- Passive Prediction Model
- Fruit Peel Sap Analysis
- Shoot Length

These methodologies are **not precise** (~65% accuracy), have shown to **underestimate** bitter pit across multiple regions and cultivars and have not been thoroughly researched in Ontario.

Recent research indicates that using **multiple prediction methods together** may improve the accuracy of bitter pit predictions. Growers should weigh the costs, time requirements, and management benefits of each method to determine the most practical approach for their orchard.

Passive Bitter Pit Prediction Model

The 'Passive Method' of bitter pit incidence was developed by Dr. Chris Watkin's out of the Cornell University research lab. This method, as described below, looks at a large sample of apples prior to harvest in hopes of estimating the total bitter pit occurrence in storage.

Passive Bitter Pit Prediction Methodology

1. Collect 100 fruit from representative trees in one block three weeks before harvest
   - Harvest fruit from as many trees as possible, with a minimum of 10 trees per block.
   - Blocks that have a variation in crop load, only pick fruit from representative trees AND/OR take separate samples from lower cropping trees.
2. Store fruit at room temperature (20˚C) for three weeks
3. Assess bitter pit (internal and external) of each sample
4. Express data as a percent for bitter pit incidence (shown in highlighted text box).

% of predicted bitter pit =

(amount of fruit with bitter pit ÷ total number of fruit) × 100

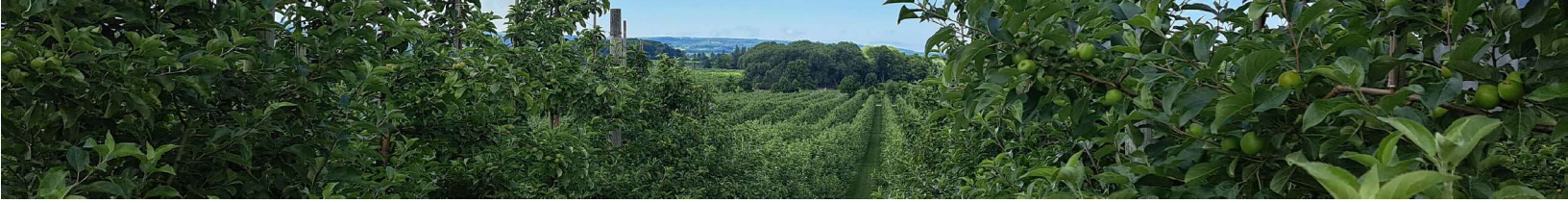
Passive Prediction Model	
Pros	• No lab costs or specialized equipment needed • Block specific information for storage decisions • Can be performed by an array of personnel (grower, consultant, storage operators)
Cons	• Takes 3 weeks • Requires fruit samples (destructive measurement) • Harvest timing is needed in advance • Can underestimate bitter pit • Primarily performed on Honeycrisp

Fruit Peel Sap Analysis

The Peel Sap Analysis is a newer test looking at the differences and ratios of calcium (Ca), magnesium (Mg), potassium (K), and nitrogen (N). This method was developed by Cornell University as well, but by Dr. Lailiang Cheng.

Fruit Peel Sap Analysis Methodology

1. Collect fruit samples (minimum 20, ideally 100) from representative trees in one block when the fruit is roughly 55 grams in size (golf ball size)
   - Harvest fruit from as many trees as possible, with a minimum of 10 trees per block, and no more than 2–3 apples per tree.
2. Send samples in labelled bags for lab, with the following information:
   - Name, Farm, Cultivar, Block, Date
   - If submitted multiple samples from the same block distinguish between them with identifier (i.e. low crop load, more vigour, rootstock).
3. Place samples in a cooler for transport. If needed, place bags in freezer for future transport to the lab.



4. After analysis occurs, look at K/Ca and N/Ca ratios and compare bitter pit risk as outlined in Table 1.

Table 1. Fruit peel sap analysis nutrient ratios and their risk indicators for bitter pit prediction (Cheng, 2025)

Risk	K/Ca ratio	N/Ca ratio
Low Risk	< 23	< 3
Moderate Risk	23–27	3–5
High Risk	> 27	> 5

Fruit Peel Sap Analysis	
Pros	• Results before harvest • Applicable for multiple cultivars • Useful for long-term management
Cons	• Laboratory costs and standardized sampling required • Cultivar and region may change thresholds • Can be inaccurate if used alone • Can require expertise for interpretation

Average Shoot Length

There is a high correlation of bitter pit incidence with excessive vegetative growth, this is due to competition between leaves and fruit for calcium. As a result, shoot length can serve as a useful indicator of bitter pit risk. Researchers at Penn State University developed a prediction model for Honeycrisp that incorporates both the fruit peel N/Ca ratio and average terminal shoot length, demonstrating that combining measures of tree vigour and fruit nutrient status can improve bitter pit prediction

Average Shoot Length Methodology

1. Three weeks before harvest select 20 representative trees per block
2. Measure the length (inches) of 5 current season terminal shoots from each tree
3. Determine the average length of shoot growth (shown in highlighted box)
4. Collect fruit samples for Fruit Peel Sap Analysis
5. Compare N/Ca ratio and shoot length to Table 2.

Average terminal shoot length =

total lengths (inches) ÷ total number of measurements taken

Table 2. Estimated percent of apples on Honeycrisp trees developing bitter pit after cold storage as affected by shoot length and N/Ca. (Marini, 2023)

N/Ca ratio	Average shoot length (< 5 in.)	Average shoot length (15 in.)	Average shoot length (> 25 in.)
2	0	20	59
6	0	28	67
10	0	36	75
14	5	44	83
18	13	52	91
22	21	60	99

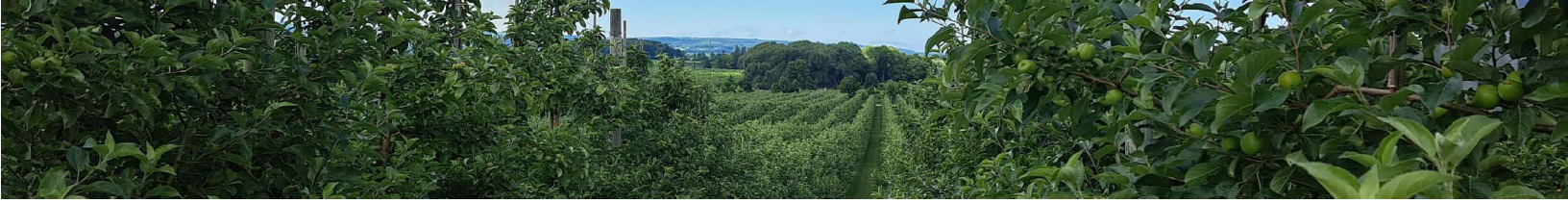
Average Shoot Length & N/Ca ratio	
Pros	• More robust prediction when used in unison
Cons	• Limited research conducted for accuracy across regions • Requires additional test for improved accuracy • Laboratory costs and standardized sampling required • More time consuming than other tests

Bitter Pit Correlations

Across all three approaches, the strongest and most consistent bitter pit associations are: low crop loads, excessive vegetative growth, large fruit size, and calcium imbalance within the fruit. Rootstocks are a contributing factor and can either enhance or suppress bitter pit onset.

For additional information on bitter pit understanding and mitigation please refer to the following articles:

- A Pitfall in the Pipeline – Part I: Calcium's One-Way Ticket
- A Pitfall in the Pipeline – Part 2: Challenging the Pit Problem



Resources & References

Al Shoffe, Y., & Watkins C. Prediction of Bitter Pit In 'Honeycrisp' Using the Passive Method. *Cornell University.*

Basedow, M., Al Shoffe, Y., & Galimberti, A. 2019. Predication of Bitter Pit in 'Honeycrisp' Apples Before Storage. *Northern New York Agricultural Development Program 2019 Project Report.*

Baugher, T.A., Marini, R., Schupp, J.R., & Watkins, C.B. 20157. Prediction of Bitter Pit in 'Honeycrisp' Apples and Best Management Implications. *HortScience,* 52:10. 1368–1374.

Cheng, L. 2025. Diagnosis of Tree & Fruit Nutrient Status via Sap Analysis. *Cornell University.* PowerPoint.

Marini, R. P., Baugher, T. A., Muehlbauer, M., Sherif, S., Crassweller, R., & Schupp, J. R. 2020. Verification and Modification of a Model to Predict Bitter Pit for 'Honeycrisp' Apples, *HortScience*, 55:12. 1882–1887.

Robinson, T., & Cheng, L. n.d. Managing Pruning and Fertilization of Honeycrisp to Balance Growth, Cropping and Fruit Quality. *Cornell Fruit Resources: Tree Fruit.*

Tracton, T., & Farcuh, M. 2024. Controlling Bitter Pit in Apples: Best Practices for Growers. *University of Maryland Extension.* FS-2023-0701.

Wallis, A., Miranda Sazo, M., Sallato, B. 2021. Takeaways From the 2021 Honeycrisp Virtual Meetups. *Michigan State University.*

Watkins, C. Passive Prediction Model for Determining Storage Potential of Honeycrisp. *Cornell University.*

Pearls of Wisdom

Thirty years of *Orchard Network* is really a celebration of the people behind it. Thank you to the authors, editors, contributors, industry partners and growers who have shared their expertise over the years and continue to do so today. Their contributions have helped shape the newsletter into the trusted resource it is today.

John Gardner 1996 to 2008	**Ken Wilson** 1996 to 2001
Bernie Solymar 1996 to 2001	**Pam Fisher** 1996 to 1999
Paul Hagerman 1996 to 1999	**Kevin Schooley** 1996 to 1999
Annette Verhagen 1996 to 1999	**Margaret Appleby** 1996 to 2015
Leslie Huffman 1996 to 2015	**John Cline** 1999 to present
Jennifer DeEll 2002 to present	**Kathryn Carter** 2002 to 2011
John Henderson 2002 to 2011	**Michael Celetti** 2003 to 2018
Hannah Fraser 2003 to 2026	**Denise Beaton** 2006 to present
Christoph Kessel 2004 to 2019	**Anne Verhallen** 2009 to 2023
John Zandstra 2009 to present	**Jason Deveau** 2009 to present
Kristen Obeid 2010 to 2024	**Paul Bailey** 2011 to 2017
Kristy Grigg-McGuffin 2011 to present	**Amanda Green** 2014 to 2020
Katie Goldenhar 2019 to present	**Erika DeBrouwer** 2021 to present
Josh Mosiondz 2022 to present	**Danny Jefferies** 2023 & 2024
Steph Vickers 2024 to present	**Cesar Cappa** 2025 to present

Dates are solely based on articles and mentions within the ONcore (Orchard Network Newsletter).