

ORCHARD NETWORK

For Commercial Apple Producers

VOLUME #26, ISSUE #3 August 2022 ISSN 2291-5907

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Orchard Management

Field Tools to Determine Apple Maturity

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The importance of proper harvest time for apples is critical to the longevity of storing quality fruit year-round, but also because customers want consistent, tasty, textured and colourful apples that can be eaten every month of the year. To achieve that, harvest timing plays an important role in maintaining that quality apple. Don't let the apple maturity determine where to market your apples, you should be deciding where apples end up and how long they need to be stored to be properly compensated. Knowing your customer plays an important role in determining when to harvest as well. Who is this apple going to? Is this apple going into long-term storage? Is the apple going direct to market? These answers will better assist you with determining best management practices and harvest times. So, what can you look at in the orchard to determine optimal harvest timing for each variety that you grow?

Starch Levels

Starch levels in apples are a great indicator to determine apple fruit maturity. As apples ripen starch is converted to sugar, and one way to determine how much starch is in an apple is to use iodine. Iodine binds to starch molecules giving the apple a blue/black colour. The more stained the apple is, the less mature the fruit (Figure 1).

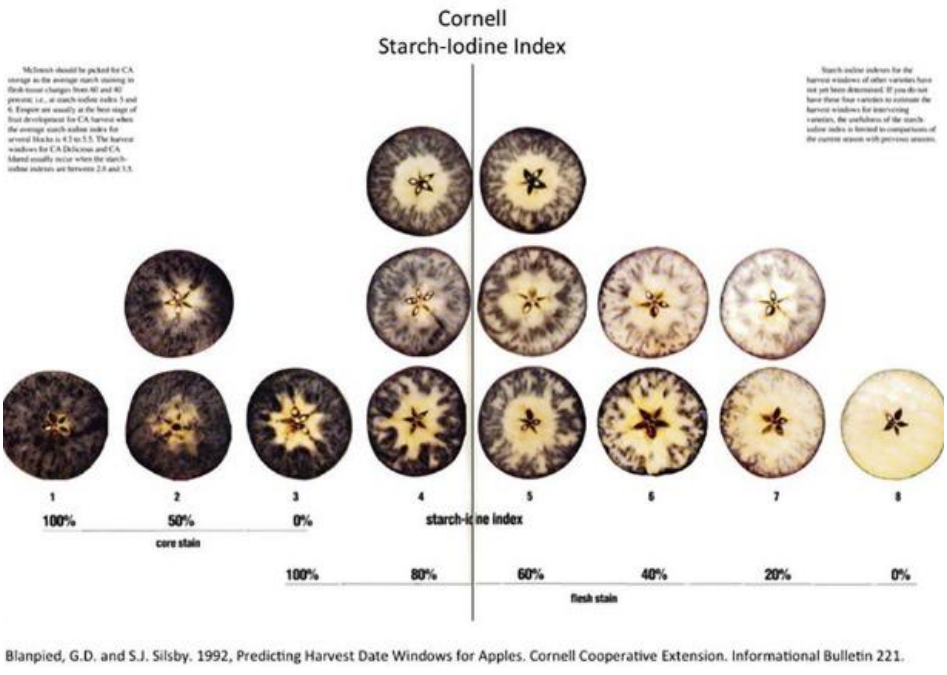

Figure 1. Cornell starch-iodine index. (Photo: Cornell Cooperative Extension).

Tools to Measure Starch Levels

There is one convenient way to measure starch levels in apples, but there are two different recipes that give you the same result. Both advise testing once or twice a week starting 2 or 3 weeks before expected harvest. Trees should be (1) a good representative tree (2) tagged once selected for continual testing (3) not on exterior of rows. Two apples from 5 trees per block should harvest at each assessment, avoiding more mature apples or apples in shaded areas. Testing should be performed right after collection. For a full description of the test please refer to the Predicting Harvest Date Windows for Apples from Cornell (doc_102.pdf (cornell.edu)).

The two recipes used to determine starch/sugar content in apples are below:

Starch-iodine test using potassium iodide

Recipe 1: Add 10 grams of potassium iodide and 2.5 grams of iodine crystals to 1 liter of distilled water. The solution may need to sit overnight before the iodine is fully dissolved but requires a pharmacist or chemist to mix the solution. Once the solution is ready for use, apple can be cross-sectioned (Figure 2) and sprayed or dipped into the solution. Wait roughly 1 minute then evaluate. Pros and cons of recipe 1 are below.

PROS	CONS
• Good representative of sugar accumulation • Can be performed in the field or in a lab setting	• The recipe needs to be prepared by a pharmacist or chemist • Iodine solution needs to be made fresh • Solution is poisonous • Can be difficult to perform in orchard

Starch-iodine test using 2% iodine solution

Recipe 2: Purchase a 2% alcoholic solution of medicinal iodine from your local drug store and mix with an equal amount of water. Once the solution is ready for use, apple can be cross-sectioned (Figure 1) and sprayed or dipped into the solution. Wait roughly 1 minute then evaluate. Pros and cons of recipe 2 are below.

PROS	CONS
• Good representative of sugar accumulation • More convenient regarding supplies than recipe 1 • Can be performed in the field or in a lab setting	• Is more costly than recipe 1 • Iodine must be diluted • Can be difficult to perform in orchard

Starch testing is an effective test to aid in determining apple maturity but should be used in unison with other maturity indicators, such as sugar content and colour. Further information can be found in the article titled “Optimum Apple Maturity at Harvest for Maximum Storage Life” written by Dr. Jennifer DeEll.

Sugar Content

Sugar content, scientifically termed soluble solids concentration (SSC) or total soluble solids (TSS) is also an important maturity indicator. TSS gives you an idea of how mature the apple is and should be taken regularly as variation in sugar content occurs year to year. Sugar content will also be higher in years of reduced moisture, high temperatures and high sunlight – which is why TSS can be influenced by factors such as irrigation, nutrition, weather and the fruit position on the tree. Trees with high crop loads tend to have lower sugar levels. Although useful, it should be used in unison with titratable acidity (TA), as the sugar to acid ratio is directly correlated with consumer quality.

Figure 3. Example of an optical handheld refractometer (Photo: Google images)

Figure 4. Example of a digital handheld refractometer (Photo: Google images)

Tools to Measure Sugar Content

TSS is measured in °brix which can be tested using a refractometer (Figure 3 and 4). There are handheld and tabletop, along with digital and optical refractometers. These can be purchased from various scientific instrument websites such as: Fisher Scientific, Grainger, Ottawa Fastener Supply, amongst others. To determine TSS, it is best to squeeze apples using a garlic press and place a small amount on the refractometer. Areas of the apple that have higher sunlight exposure tend to be higher in TSS, along with apples on the exterior of rows. Using the refractometer changes based on the style that is purchase – handheld optical refractometers require you to hold the instrument up to the light and read the percentage of soluble solids, while digital refractometers display the percentage after a few seconds. Remember to rinse, clean and dry off the instrument between each sample using a soft tissue. To calibrate refractometers, you can zero the instrument with distilled water and at 10% with a solution of 10 grams of sucrose dissolved in 90 grams of distilled water.

PROS	CONS
• Not too expensive (depending on which version) • Can be used in the field • Not too time consuming	• More accurate to be used in unison with acidity testing • Can be difficult to perform in orchard

Acidity

As mentioned above, acidity is important when determining harvest maturity in combination with sugar content. Titratable acidity (TA) is commonly used in cider and wine making, where % (or mg) malic acid is used in apples. TA levels decrease as fruit matures and are most useful when performing consistent measuring on the same tree. It is difficult to determine a range of ideal TA levels as they vary, but it is effective when comparing the rate of change in TA levels for apple maturity. This can be accomplished over time, over multiple years, over multiple harvests.

Tools to Measure Acidity

Acidity can be measured with colourimetric kits (Figure 5). The wine industry uses tartaric acid to measure acidity, while the cider industry uses malic acid. This is because malic acid is the most common acid in apples, while tartaric is the most common in grapes. Wine kits can be used for determining acid content in apples, but the tartaric acid needs to be converted to malic acid. These cider kits are easy to use and give a baseline for acid content in apples.

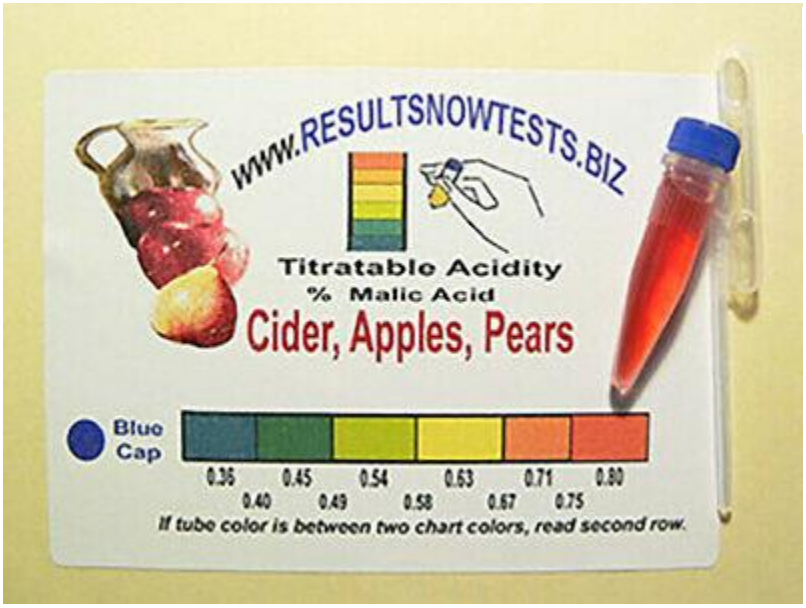

Figure 5. Example of a titratable acidity test kit used for cider, apples and pears (Photo: Google images).

PROS	CONS
• Not too expensive • Can be used in the field • Not too time consuming	• More accurate to be used in unison with sugar content testing • Needs to be tested over time, over multiple years, over multiple harvests

Firmness

Firmness is a common indicator of storage performance and is important for the longevity of apple storage. Apple firmness can be affected by seasonal and orchard variability, tree vigour, fruit size, nitrogen and calcium levels in the fruit and the use of growth regulators. Cultivar specific firmness information based on storage length can be found in the article titled "Optimum Apple Maturity at Harvest for Maximum Storage Life" written by Dr. Jennifer DeEll.

Tools to Measure Firmness

Firmness is measured using either a handheld plunger, termed a penetrometer (Figure 6 and 7), or a tabletop penetrometer (i.e., Guss – Fruit Texture Analyzer). Handheld penetrometers can be used in the field but should be performed with a solid base underneath of the apples. Apples should be peeled (removed of skin) in the area that is being tested for firmness. The penetrometer should also have an 11-mm diameter plunger.

PROS	CONS
Handheld Penetrometers • Not too expensive • Can be used in the field • Not too time consuming Tabletop Penetrometers • Not too time consuming • More accurate than handheld penetrometers	Handheld Penetrometers • Variable readings Tabletop Penetrometers • More expensive than handheld penetrometers • Require space • Fruit must be brought inside to test

Figure 6. Example of a handheld penetrometer used to test firmness in fresh fruits (Photo: Google images).

Figure 7. Example of a tabletop penetrometer used to test firmness in fresh fruits (Photo: QA Supplies).

Colour

Colour is also an indicator of apple maturity, whether that be red, striped red, green or yellow skin. Foreground and background colour are important maturity indices, although over-maturity can be an issue when relying solely on colour indicators.

Blush Colour

Blush colour is commonly used for commercial grading, where red-coloured varieties are normally graded better with redder colouring. Even though this is the case, if apples stay on the tree for too long and are harvested after their peak maturity these apples will have a higher prevalence for postharvest issues, especially if the apples are committed to long-term storage. The apples will not meet the expectations of the consumer or the grower, as there is a higher chance of postharvest issues, including disorders and lower quality of desirable traits (texture, firmness).

Background Colour

Background colour is one of the most important indicators of harvest maturity. This is especially important in Gala, Honeycrisp, Fuji, and Ambrosia. Fruit stored for long periods of time generally should be harvested when the change in background colour starts from green to yellow, while background colours that are more yellow or cream should be targeted for more immediate sale.

Figure 8. British Columbia Ambrosia colour chart

Tools to Measure Colour

Focusing on background colour, British Columbia developed a colour chart for the harvest timing of Ambrosia (Figure 8). This tool should be utilized based on storage timing for your apples and is discussed further in the article titled "'Ambrosia' Harvest Maturity for Storage" written by Dr. Jennifer DeEll.

PROS	CONS
• Easy to use • Can be used in the field	• Not many field-based tools for measuring colour accurately

Additional Tools

There are many other tools that are currently being used in the scientific community to further our knowledge of apple fruit maturity, but most aren't easily accessible, are still being tested or not able to be used easily in the field i.e., internal ethylene content. One of the most important tools that is available to everyone and should be considered, is record keeping.

Records

Recording harvest date, the weather that season, your management practices along with fertilizer applications are all important to look back on annually. Each year is different, but if you have notes of similar situations that occurred in the past you can look back on what you did and whether that worked for you and your orchard. Remember to include:

- calendar date of harvest
- yield and other quality parameters
- length of time stored/when apples were removed from storage (if you have access to this)
- pay out for crop
- and it would be good to check heat unit accumulation and night-time temperatures for reference

Remember that these strategies should be used in collaboration with one another to give you a better idea of when to harvest.

Key Points

Overall, there are many tools that can be used to assist with the success of your apple production and increase the potential of your apples providing you with top market value throughout its stored life. Of all the maturity indicators, background color, starch content, and firmness are the most important factors in guiding harvest timing. Many varieties overlap with harvest timing, making it difficult to decide which apples should be taken off the tree and which should stay on. Knowing your market and recording maturity indicators will benefit you.

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Hexanal Spray Reduces Bitter Pit in 'Honeycrisp' Apples: Results from a Preliminary Study

Karthika Sriskantharajah, J. Alan Sullivan, Gopinadhan Paliyath, Jayasankar Subramanian, Department of Plant Agriculture, University of Guelph

Background Information

'Honeycrisp' (*Malus domestica* Borkh), a premium apple cultivar, is prone to bitter pit (BP) and decline in quality during long-term storage. In many young plantings, more than 50% of 'Honeycrisp' fruit develop BP before harvest or in the early

stages of storage, leaving the apples unmarketable[1]. The symptoms of BP are characterized by small dark depressions most found in the distal end of the fruit. The occurrence of BP is difficult to predict, as the signs can only be seen on the exterior surface of apples by which time it is already late to rectify[1,2]. It is widely believed that the BP is associated with low calcium and high potassium, magnesium and nitrogen content of the fruit[3,4]. It is also aggravated by orchard and climatic factors including excessive tree vigour and fruit size, low soil pH, micronutrient deficiency (specifically boron), and environmental stress such as drought[3,5].

Applying foliar calcium (calcium chloride, $CaCl_2$) during summer is a common practice among growers to mitigate the BP. However, effectiveness of spray regimes is highly variable as the sprays can be phytotoxic to apple foliage, especially when the calcium is applied at high concentrations, or combined with other pesticides. Moreover, the exact physiological cause of BP is not well understood. Hence, management techniques such as applying weekly foliar sprays of calcium from fruit set to maturity to prevent this disorder are often inadequate and also adds to the expenses for the grower. Application of hexanal as a preharvest spray substantially reduced BP in 'Honeycrisp' apples during storage of small-scale studies[6]. However, there is still the question of the effectiveness of hexanal in mitigating BP on a larger scale. Therefore, the objective of this current study was to evaluate the effectiveness of grower-applied (large scale) hexanal spray on mitigating BP during cold storage of 'Honeycrisp' apples.

Materials and Methods

Experimental Location and Treatments

The experiment was conducted in a 'Honeycrisp' orchard located within the Niagara region of Ontario, in the year 2020. Trees at the orchard were 10-year-old, grafted onto M9 rootstocks supported by a trellis system. Hexanal was prepared as a formulation containing hexanal at a concentration of 0.02 % (*v*/*v*) in the final spray. The trees were subjected to two preharvest sprays of hexanal about two weeks (3rd September 2020) and one week (10th September 2020) before the commercial harvest (18th September 2020). A Hol system-CF series sprayer (Trailed sprayer, H.S.S./CG1000, Meteran, Netherlands) was used to spray the hexanal at a rate of approximately 100 L per acre. Trees without spray (control) were also maintained in the same plot for the comparison purpose. Five buffer rows were maintained between hexanal treated and control trees.

Assessment of Bitter Pit During Storage

At harvest, fruit with similar maturity, uniform size and without any visual defects were sampled from treated and control trees and packed into commercial boxes with liners (40 fruit/box and 10 boxes/treatment). The boxes were stored at 2.5 °C for four months. The development of BP was assessed in three different ways at the biweekly intervals.

Incidence of Bitter Pit

Incidence of the BP was assessed visually using a binary scoring system based on the presence (1) or absence (0) of BP symptoms on the outer surface of each fruit.

Progression of Bitter Pit

Progression of the BP was calculated using three different intervals such as 60, 90 and 120 days postharvest based on the difference in the incidence of the BP at 0 days and the postharvest day of measurement.

Progression of BP = incidence of BP (at X days postharvest - 0 days postharvest)

Severity of Bitter Pit

The severity of the BP was assessed using a visual ranking scale from 0 to 5, as previously described by DeBrouwer et al[6]. Figure 1 the visual scaling method used to assess the severity of BP.

Percentage of Marketable Fruit

Fruit that had 0 and 1 severity classes were considered marketable fruit. The percentage of those fruit was calculated at every thirty-day interval based on the total number of fruit in each treatment.

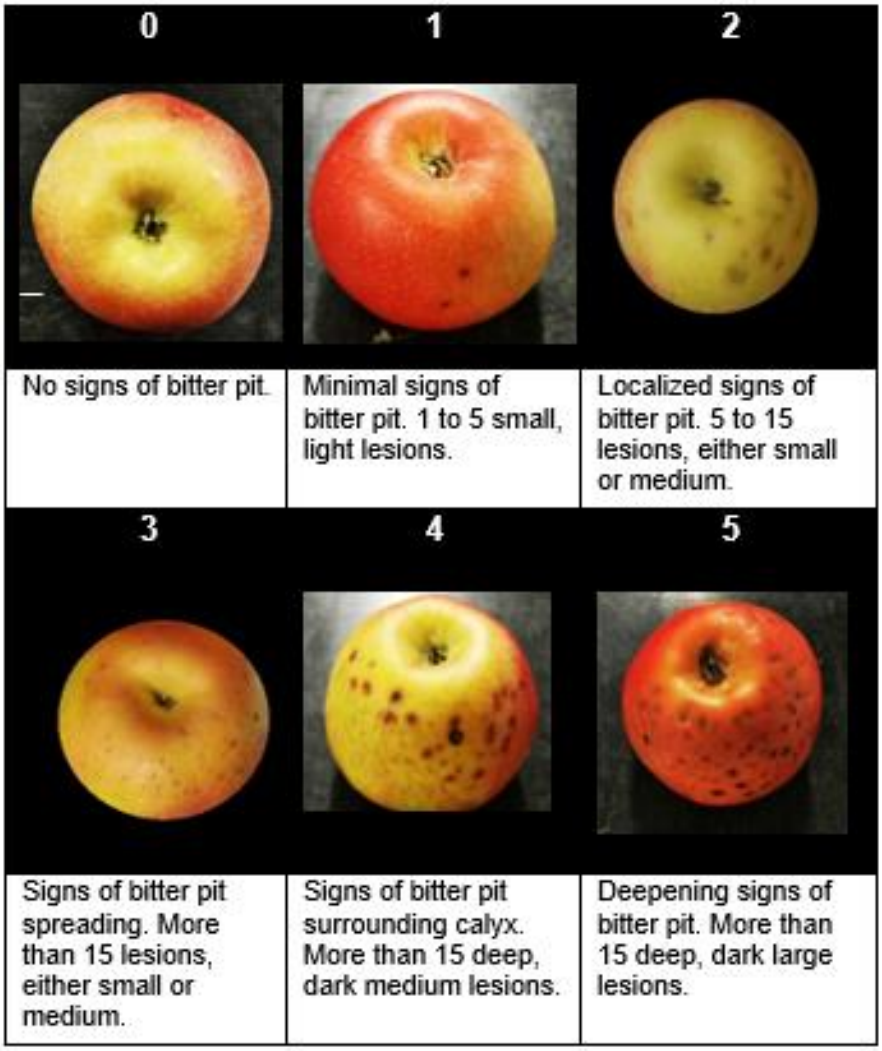

Figure 1. A representation of six severity categories in BP. The image on the top left displaying no BP symptoms (rank of 0), image on the bottom right displaying severe BP (rank of 5). The white line represents a scale of 1 cm.

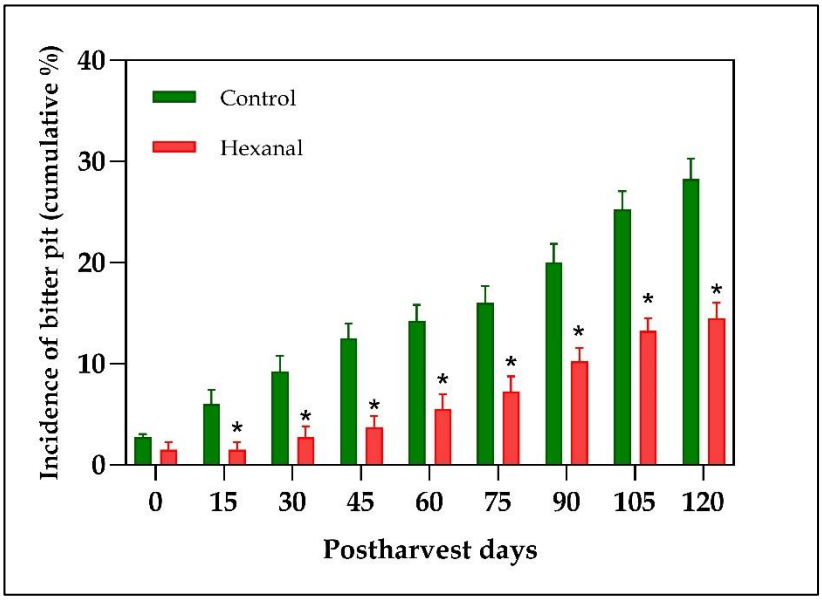

Figure 2. Effects of a preharvest spray hexanal on the incidence of BP in 'Honeycrisp' apples during 120 days of storage. Each value represents the average of 400 fruit. Means with an asterisk at the same storage time indicate a significant difference between control and hexanal ($p<0.05$).

Results

Effect of Hexanal on Incidence of BP

The cumulative percentage of incidence of BP increased throughout the storage in both hexanal treated and control fruit (Figure 2). However, on average, hexanal spray showed a lower incidence of BP compared to that of control. In the early stages of storage period (for example, up to 45 days postharvest), hexanal sprayed fruit developed almost four times lower (3.75%) symptoms of BP compared to control group (12.5%). The progression of BP was slow in the hexanal sprayed (slope = 1.76) fruit compared to control (slope = 3.08). Overall, hexanal sprayed fruit showed a significantly lower incidence of BP throughout the storage.

Effect of Hexanal on Progression of BP

Progression of BP increased in both hexanal sprayed and control fruit throughout the storage. However, the progression of BP in hexanal-treated fruit was consistently lower compared to control (Figure 3), throughout the postharvest storage period of 120 days.

Effect of Hexanal on Severity of Bitter Pit

At harvest, only a small amount (<3%) of the fruit had BP in both control and hexanal sprayed fruit. However, as the time in storage increased, more fruit from the control group showed progression of BP with more spots in the affected fruit. For example, at the end of 60 days postharvest, fruit with all six BP ratings were observed in the control group. However, in the hexanal sprayed fruit, the highest severity rating was only 3. Likewise, the percentage of fruit classified in the severity groups 1-5 substantially increased in the control as the

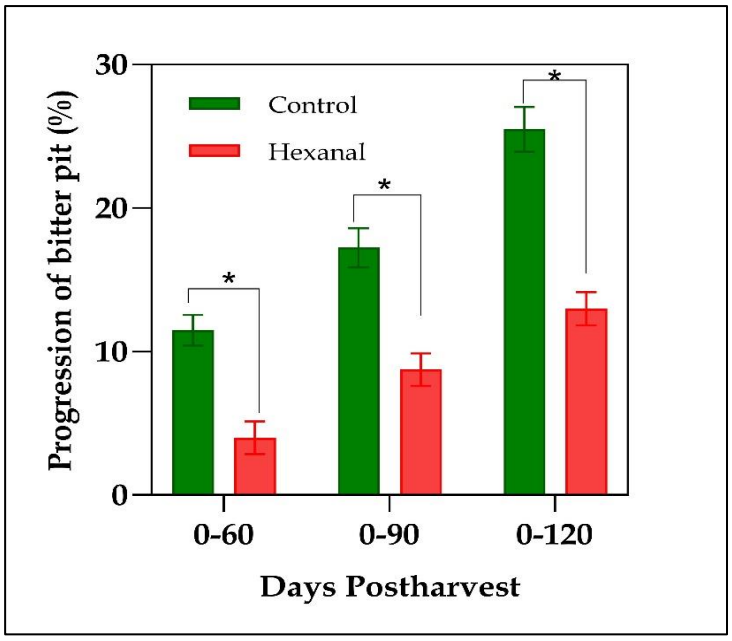

Figure 3. Effects of hexanal on the progression of BP in 'Honeycrisp' apples during 120 days of storage. The progression of BP has calculated as the percentage difference between the incidence of BP on day X and day 0. Means with an asterisk at the same storage time interval indicate a significant difference between control and hexanal at $p<0.05$.

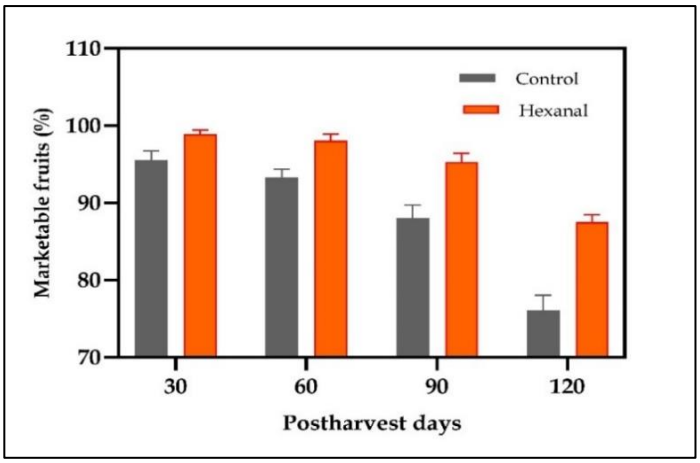

Figure 4. Effects of preharvest spray of hexanal on percentage of marketable fruit in 'Honeycrisp' apples. Marketable fruit were defined as those fruit with a bitter pit rating of 0 or 1 on a 0 to 5 rating scale.

time in storage increased. However, in hexanal sprayed fruit, the severity was significantly lower even at the end of 120 days storage.

Effect of Hexanal on Marketable Fruit

The percentage of marketable fruit was significantly higher after spraying with hexanal even after 120 days of storage (Figure 4). Further, a greater percentage of fruit from hexanal group were marketable at each time point. For example, after three months of storage, more than 95% of the hexanal sprayed fruit were considered marketable. While 88% of the control fruit were marketable at this storage time. Approximately 76% of the fruit from the control group remained marketable at the end of four months of storage, whereas around 87% of the fruit from the hexanal group were considered marketable.

Conclusions

- Applications of hexanal spray twice before the expected harvest substantially decreased the incidence of bitter pit at harvest and during postharvest storage.
- Hexanal spray also reduced the progression and severity of bitter pit during cold storage.
- The hexanal treated fruit were firmer and crispier compared to control fruit throughout the storage.
- The hexanal formulation also enhanced marketable fruit which can increase grower income by about $1300-1,500/Ac by considering the current marketable price of this premium fruit.

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The ups and downs of penetrometry and a new way to screen apple texture quality

Dr. Alexandra Grygorczyk, Research Scientist, Vineland Research and Innovation Centre

What can and can't a penetrometer do?

Penetrometry is the most widely used instrumental method for judging apple texture quality. Hand-held penetrometers are inexpensive, data collection is fast and can be completed in-field. It is well established that penetrometer readings generally correlate well with human perceptions of apple firmness and crispness. However, one of the major limitations of penetrometry is that these perceptions are only one dimension of apple texture quality and penetrometry cannot account for mouthfeel attributes such as mealiness or juiciness.

Depending on the season and on the apple cultivar, firmness, mealiness and juiciness may sometimes coincide by chance. In these times, the use of penetrometry can be quite beneficial. However, when these attributes diverge, penetrometry may accurately indicate that an apple has acceptable firmness without revealing that it, in fact, is also exhibiting unacceptable dryness or mealiness. Hence, the penetrometer reading may lead to inappropriate conclusions about overall apple texture quality. The trouble is, without further testing (e.g. sensory), it's impossible to know whether the penetrometer reading is an accurate reflection of the overall apple texture quality or not and sensory testing may not always be practical.

So when is penetrometry most useful? Any time you only need to rely on apple firmness. For example, when you're looking for indications that an apple is ready to harvest by detecting a softening in apple hardness. Another situation where penetrometers are useful is in the earliest stages of apple selection in a breeding program to screen thousands of apples in the orchard.

When should other methods be considered? Any time you'd like to draw conclusions about the overall apple flesh texture quality.

A complimentary method

Recently, our group at Vineland Research and Innovation Centre (Vineland) published two research papers showing that the friction coefficient of apple flesh is strongly correlated with perception of apple crispness, mealiness and juiciness. The measurements can be completed on either high-end equipment such as a dedicated tribometer (a friction measuring instrument) or the more affordable option of a friction rig attachment on a texture analyzer. Data was collected over three harvest seasons and friction consistently produced strong correlations with these texture attributes. Data collection has to be completed in a laboratory setting however the time to complete the measurements was comparable to the time needed to collect data with an in-laboratory penetrometer.

The single value of friction is influenced by the combined effect of crispness, juiciness and mealiness. Therefore, if an apple has an unacceptable level of any one of these attributes, this will negatively impact the friction coefficient. This makes interpretation fairly simple as one can set a cut-off limit and screen out any apples that do not meet the friction cut-off.

The method was developed as part of a project aimed at investigating instrumental methods that can help streamline screening of apples for consumer-desired traits in Vineland's apple breeding program. The 2021 harvest season was our fourth year collecting friction measurements on apples. After three years of strong correlations between friction and apple texture attributes, this year Vineland's apple breeding team made the leap and successfully replaced one stage of sensory testing with friction measurement in the apple screening process.

Vineland's consumer insights group will also make friction measurements part of their fee-for-service offerings for interested parties who would like to index these apple texture attributes in a single measurement for their screening or marketing needs.

Take away

Penetrometers have many practical advantages and their use is beneficial in situations that depend on evaluations of apple firmness. However, in situations where other texture properties (such as mealiness) are important, alternative methods of analysis should be considered such as this newly investigated method using friction.

Friction measurement has been found to correlate strongly with textures related to apple flesh such as crispness, mealiness and juiciness. However, friction measurement must be carried out in a laboratory setting and requires access to a texture analyzer. The method has successfully been applied within Vineland's apple breeding program to replace a portion of sensory testing and is available for screening apples from external sources.

Funding acknowledgements

The research was funded by the Ontario Agri-Food Innovation Alliance, Agriculture and Agri-Food Canada, the Canadian Agricultural Partnership and the Ontario Apple Growers.

Crop Protection

What's Your Apple IPM Report Card?

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Do you know how effective your pest management program was this year? With only a small time commitment required, a harvest assessment can provide information on what part of your management program went well (or not so well).

Advantages to doing a harvest assessment

- Knowledge of this year's problems will help you **better prepare** your IPM program next year.
- Provides an accurate read of not only the **type** of damage but also the **extent** of damage in a block or orchard.
- Preparedness for **early season** pest management needs such as sprayer calibration, urea and/or leaf shredding for scab control, dormant oil for San Jose scale or early season copper and other fungicides for fire blight, scab and powdery mildew.
- Understanding what practices worked and what didn't will **save money** in input costs for future management programs.
- Improves **fruit quality** for any late season pest issues that may be observed and can be managed prior to harvest. This is particularly helpful if your scout has finished.
- Highlights any **susceptible varieties** or **hot spots** in a block or orchard, which allows targeted monitoring and potential spot treatments in future years.
- Provides a **historical record** for reference and increased awareness of potential challenges.

How should you do it?

In the field:

- Choose at least 10 (large trees) to 20 (dwarf trees) healthy trees randomly throughout the block.

- Select 200-400 apples (20-40 apples per tree), turning each to see all sides of the fruit without removing it.
- Randomly choose fruit from different positions on the trees: upper, inner and outer part of the canopy.
- Keep records for reference.

If a field assessment is just not feasible prior to harvest, a post-harvest evaluation of fruit can be done. However, this type of assessment will only provide information on severity of damage and not the location in the block this damage occurred. Examine 400-500 randomly selected fruit for each variety from harvest containers. If damage is found, you may want to increase the sample size in order to thoroughly assess the damage.

What should you look for?

Anything causing **2–5% damage** is of concern. For higher value cultivars, consider 1-2% damage for pests causing direct injury to the fruit. Look for presence of:

- Larvae or larval feeding from oriental fruit moth, codling moth or other caterpillars
    - Oriental fruit moth: tunnel from calyx or stem end; tunnel in flesh of fruit
    - Codling moth: piles of frass at hole which can be side or bottom of fruit; tunnel to seed cavity of fruit
    - European apple sawfly: ribbon-like scar spiralling from calyx
    - Obliquebanded leafroller: surface feeding; scarred and misshapened fruit; leaves often webbed to fruit
- Black caps of San Jose scale and/or halos on fruit surface
- Distorted fruit caused by spring feeding caterpillar or rosy apple aphid
- Pits or stings caused by tarnished plant bug, stink bug or apple maggot
- Raised bumps by mullein bug, plum curculio or other plant bug
- Blotches/lesions caused by scab, sooty blotch/fly speck, rust or calyx end rot
- Lace-like russetting caused by powdery mildew
- Fruit rot
    - Black rot: firm lesion; black fruiting bodies
    - Bitter rot: sunken lesion; orange to salmon-coloured spores
- Vertebrate feeding such as deer, turkey or other birds

As you walk through the orchard, also make note of damage to leaves, branches and graft unions caused by pests such as fire blight, scab, powdery mildew, leafroller, tentiform leafminer, leafcurling midge, mites and borer.

Go to Ontario AppleIPM for more information on these pests including descriptions and pictures of typical damage.

Which block should you do?

To get the best idea of what's happening in your orchard, assess all blocks. If time is limited, give yourself half an hour to one hour per block and select representative areas of the orchard. If you assess the same block every year, you can compare your results and notice trends over time.

Remember, simply determining this year's IPM report card will put you ahead of the game for next year's management program.

SERENE® Herbicide label expanded via Minor Use Program to help manage labelled weeds in various fruit crop groups

Josh Mosiondz, Minor Use Coordinator, OMAFRA

The Pest Management Regulatory Agency (PMRA) recently announced the approval of a minor use label expansion registration for SERENE® Herbicide for control or suppression of labelled weeds in various fruit crop groups in Canada. SERENE® Herbicide was already labeled for management of weeds crops in Canada. These minor use proposals were

submitted by The Ontario Ministry of Agriculture, Food, and Rural Affairs as a result of minor use priorities established by growers and extension personnel.

The following is provided as an abbreviated, general outline only. Users should be making weed management decisions within a robust integrated weed management program and should consult the complete label before SERENE® Herbicide.

Crop / Crop Group	Target	Rate (L product/ha)	Application Information
Crop Group 13-07 (Berries and Small Fruits) (greenhouse or field)	Suppression or Control of Labelled Weeds	179 – 717.5	Apply Serene as a uniform band or spot application directed at weeds on the ground between the crop. Apply using hooded or shielded application equipment. Ensure spray drift will not come in contact with foliage. Do not spray the crop directly. Do not apply when plants are under stress. Retreatment is required for regrowth of weeds.
Crop Group 11-09 (Pome Fruit) (Excluding apples*) Crop Group 12-09 (Stone Fruit)	Suppression or Control of Labelled Weeds	179 – 717.5	Apply Serene as a uniform band or spot application directed at weeds on the ground between the trunks or plants. Ensure spray drift will not come in contact with foliage. Do not spray the crop directly. Apply only to weeds around healthy established trees. Do not apply after budbreak unless using hooded or shielded application equipment and applicator can ensure spray drift will not come into contact with fruit or foliage. Do not apply when plants are under stress. Retreatment is required for regrowth of weeds. * - Apples already labelled with separate use instructions

Toxic to aquatic organisms and non-target terrestrial plants. Observe buffer zones specified under DIRECTIONS FOR USE. To reduce runoff from treated areas into aquatic habitats avoid application to areas with a moderate to steep slope, compacted soil, or clay. Avoid application when heavy rain is forecast. Contamination of aquatic areas as a result of runoff may be reduced by including a vegetative strip between the treated area and the edge of the water body.

Follow all other precautions, restrictions, and directions for use on the SERENE® Herbicide label carefully.

For a copy of the new minor use label contact Josh Mosiondz, Provincial Minor Use Coordinator OMAFRA, Guelph (226) 971-3407, your regional supply outlet, or visit the PMRA label site http://www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

Note: This article is not intended to be an endorsement or recommendation for this particular product, but rather a notice of registration activity

PURESPRAY GREEN® spray oil label expanded via Minor Use Program to help manage insects on numerous fruit crops in Canada

Josh Mosiondz, Minor Use Coordinator, OMAFRA

The Pest Management Regulatory Agency (PMRA) recently announced the approval of a minor use label expansion registration for PURESPRAY GREEN® spray oil for management of numerous insects on various crops and crop groups in Canada. PURESPRAY GREEN® spray oil was already labeled for management of insects and powdery mildew on a wide range of crops in Canada. These minor use proposals were submitted by the British Columbia Ministry of Agriculture, Food and Fisheries (BCMAFF), and Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) as a result of minor use priorities established by growers and extension personnel.

The following is provided as an abbreviated, general outline only. Users should be making insect and disease management decisions within a robust integrated pest management program and should consult the complete label before using PURESPRAY GREEN® spray oil.

Crop(s)	Target	Rate (L product / 1000 L of water)	Application Information
Crop Group 13-07 (Small fruit and berries) *	Control of Scale	20	Dormant to Green tip up to 1 cm green or first leaf. Foliar spray using ground application equipment only. For Lecanium Scale in highbush blueberry, apply one application as dormant spray in late winter. Use 1000L/ha for small bushes –1500L/ha for large bushes. Maximum of two dormant applications per year if summer spray applications are expected during the growing season. Apply at 7 – 14 day intervals.
Apples Pears **	Control of Codling Moth	10	For codling moth overwintering, 1st summer and 2nd summer generations: apply at or just prior to first egg hatch and during egg laying. Apply every 7-14 days depending upon level of pest pressure. Do not exceed more than 10 L oil per ha per application for summer treatments. For apples and pears do not use oil within 14 days before or after captan fungicide. Do not apply as dormant spray.
Grapes **	Suppression of Leafhopper Nymphs	10	Eight (8) summer spray applications with a 10-14 day interval. Begin applications when eggs or small nymphs are present. Thorough coverage is essential. PHI is 14 days for table grapes as oil will remove bloom on grapes. On grapes, do not tank mix oil and copper more than once per season. Do not use copper and oil together with fruit present. Do not use oil within 14 days before or after captan fungicide.

* - submitted by MAPAQ, ** - submitted by BCMAFF

TOXIC to aquatic organisms. Observe BUFFER ZONES specified under DIRECTIONS FOR USE. To reduce runoff from treated areas into aquatic habitats avoid application to areas with a moderate to steep slope, compacted soil, or clay. Avoid application when heavy rain is forecast. Contamination of aquatic areas as a result of runoff may be reduced by including a vegetative strip between the treated area and the edge of the water body. For terrestrial uses: Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high-water mark. Do not contaminate water when disposing of equipment washwater or rinsate. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas.
Follow all other precautions, restrictions, and directions for use on the PURESPRAY GREEN® spray oil label carefully.

For a copy of the new minor use label contact Erica Pate, Berry Crop Specialist OMAFRA (CG 13-07), Simcoe (519) 410-0624 Kristy Grigg-McGuffin, Horticulture IPM Specialist (Apples) OMAFRA, Simcoe (519) 420-9422, Wendy McFadden-Smith (Pears, Grapes), Horticulture IPM Specialist, OMAFRA, Vineland (905) 932-8965, your regional supply outlet, or visit the PMRA label site http://www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

Note: This article is not intended to be an endorsement or recommendation for this particular product, but rather a notice of registration activity

Benefits of Monitoring and Using Degree Days

Alyssa Speiran, Horticulture Research Assistant, OMAFRA

Did you know that insects can't regulate their own body temperature? For an insect to grow and thrive, it must be under its own favourable conditions. That is where degree day modeling comes in. A *degree day* is a period of 24 hours where the temperature remains within a lower and upper threshold for development (Figure 1). Individual insect species have varying thresholds, which is why insects will emerge and grow at different times. A common lower threshold for an insect is 10°C, while the common upper threshold is 35°C.

Consider bees: they emerge in spring and summer when it's warm, meaning they have a higher threshold. On the other hand, mosquitos typically come out during summer nights when it cools down, which means they have a lower threshold.

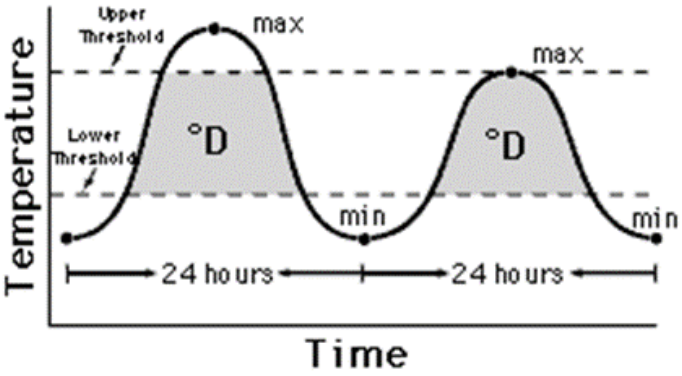

Figure 1. Insects develop within particular temperature ranges over a 24-hour period, above (upper threshold) and below (lower threshold) which growth does not occur.

Why Use Degree Day Models?

Degree day models depend on an insect's growth being closely related to the temperature of where it's found. These models are created to establish key timings in an insect's development and predict important events such as egg hatch, crawler emergence or first flight. It can be extremely difficult to observe some of these life stages in the field due to the size of these insects as well as labour it would take to monitor. For that reason, degree day models are key as they can be used as a tool for scouting or management. Critical life stages can also be very short lived, so timing is crucial. For instance, codling moth larvae can enter developing fruit within 24 hours after hatch. Timing needs to be precise to target these critical life stages, especially with the movement toward reduced-risk insecticides with a limited application window. In summary, degree day models are a very useful tool in monitoring the life stages of an insect.

Benefits of Using Degree Day Models

The benefit of using degree day models is that they are useful in predicting and monitoring insect development to precisely time critical life events. The number of degree days for each pest with vary in different areas depending on temperature, moisture, and climate. Therefore, it's important to look at weather data in each area annually to determine pest activity.

A biological fix point, or more commonly known as a *biofix*, is an event that is easily observed. An example of this is the first capture of a moth in a delta trap. The information gathered from these models can then be used to determine spray timings for targeted life stages.

Degree Day Models for Hard to Monitor Pests

Two examples of degree day models OMAFRA used this season for pest prediction were the Max/Min Method for both San Jose scale (SJS) and apple leafcurling midge (ALCM). The Max/Min Method uses the following formula for calculating degree day Celsius (DDC).

DDC = [(daily min. temperature + daily max. temperature) / 2] – min. base temperature

As pictured in Figure 2, double sided tape can be used to monitor for SJS crawlers. Degree day models signify when the double-sided tape can be applied to the trees. However, this method can be difficult to observe due to the very small size of the crawlers. Using a degree day model instead with a biofix of March 1st or based off first adult flight can help predict this critical crawler emergence period.

Delta traps with a pheromone lure can be used for a number of orchard pests, including ALCM. Each week, OMAFRA summer students would collect these liners from two orchards in Simcoe. As a result of high ALCM pressure, the liners tended to be consistently full of ALCM (Figure 3) and difficult to accurately predict trends. ALCM eggs are found tucked into the newest unfurled leaves of a growing terminal and can be difficult to detect with the untrained (or unmagnified) eye. However, targeting management for larvae once leaf curling has actually been observed often provides ineffective control. Degree day models are useful in this instance because they provide the predicted date for when egg laying and larval emergence occurs.

Figure 3. Electrical tape used to monitor San Jose scale crawler emergence. Note the small yellow crawlers on the black tape.

Figure 3. Delta trap with pheromone lure used to monitor adult apple leafcurling midge flight.

Predicted 2022 Emergence Dates for San Jose Scale and Apple Leafcurling Midge

The starting date (biofix) for each model was March 1st, 2022. These models used minimum base temperatures of 9°C and 10°C for ALCM and SJS, respectively. Degree days were accumulated in all 5 growing districts in the province, including stations in Harrow, London, Delhi, Grimsby, Clarksburg, and Oshawa (Table 1 and 2).

In addition, three apple orchards local to Simcoe used first generation SJS flight as a biofix, meaning that degree day accumulation began the first day the pest was caught using a pheromone trap. Past weather data for each location was used, along with 14-day forecasts that were updated regularly.

Table 1. Predicted dates of San Jose Scale crawler emergence in different regions across Ontario (March 1st, base 10°C)

Region	1st Generation (278 DDC)	2nd Generation (806 DDC)
Harrow	June 7	July 22
London	June 16	August 6
Simcoe	June 13	August 1
Grimsby	June 13	July 27
Clarksburg	June 19	August 6
Newcastle	June 19	August 7

Table 2. Predicted dates of Apple Leafcurling Midge adult emergence in different regions across Ontario (March 1st, base 9°C)

Region	1st Generation (132 DDC)[1]	2nd Generation (556 DDC)	3rd Generation (1160 DDC)
Harrow	May 19	June 26	August 8
London	May 23	July 6	August 21
Simcoe	May 21	July 1	August 20
Grimsby	May 22	July 2	August 15
Clarksburg	May 26	July 13	Late August[2]
Newcastle	May 26	July 11	Late August[2]

[1] Predicted dates are based off 50% emergence for the generation

[2] Timing 14+ days as of writing this article (Aug 11, 2022)

Insect species can have distinct generations, meaning that once the accumulated number reaches a certain point, it signifies a new generation. For SJS, the 1st generation key DDC timing is 278, while the 2nd generation key DDC timing is 806. The way that degree day models can identify spray timings are using these accumulated numbers.

- For example, insecticides effective against SJS such as Sivanto Prime or Closer should be applied at or around predicted crawler emergence (278 DDC and 806 DDC) whereas Movento should be applied just ahead of activity.
- Appropriate timings for ALCM are still being determined as this model was only recently developed. Currently, applying effective insecticides at peak adult emergence and egg laying per generation look to be the most efficacious.

Degree day timings have been determined for a number of other orchard pests such as oriental fruit moth. Similar to SJS and ALCM, it is important to consider control product when determining appropriate spray timing. For instance, Group 5 and 28 insecticides have an ideal timing of 805-833 DDC for the 2nd generation, and 1361-1389 DDC for the 3rd generation, whereas products belonging to Group 4 are best applied slightly earlier as 750-778 DDC and 1205-1333 for 2nd and 3rd generation, respectively.

It's important to continue monitoring for pests using degree day models, where developed and visual observations. This is because the information gathered is crucial in determining and implementing appropriate timing for control strategies, making for more precise management and potential reduction in pesticide use.

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Beetle Invasion

Alida Malloy, Horticultural Research Assistant, OMAFRA

Right now, up in the tops of the canopy, leaves are being reduced to the lace-like skeletons of their veins. This skeletonization is the result of the appetite of one insect: the Japanese beetle. So, what do these insects look like? Where do they come from? And how do they impact Ontario apples?

Description

Adult Japanese beetles are easily identifiable with their metallic green abdomen and thorax (Figure 1). The adult insects also have copper-coloured wing coverings and tufts of white hair down the sides and back of their abdomen.

At the larval stage, they are white C-shaped grubs with brown heads and a distinctive V pattern of spines on their final segment.

Figure 4. Adult Japanese beetles

Origin

As the name implies, the Japanese beetle is an invasive species native to the main islands of Japan. The first sighting in North America was in southern New Jersey in 1916. It was identified in Canada only in 1939, arriving from a Maine ferry on a tourist's car in Yarmouth, Nova Scotia. Since its arrival to Canada, beetle populations have been established in southern Ontario and isolated pockets of Quebec. However, its range continues to expand yearly. The climate in these regions seem to be ideal for the beetles, who enjoy a summer soil temperature between 17.5 °C and 27.5 °C, precipitation of 25 cm, and a winter soil temperature of -9.4 °C. Careful monitoring and scouting have tracked the infestations, though it has been impossible to eliminate the insect from Canada.

Life Cycle

These insects have only a single generation per year (Figure 2). In summer, the adults emerge in late June and their activity peaks in late July through ear August. Beetle flight peaks on clear sunny days at 21°C and at 60% humidity, though it is mostly confined to short distances. Flight is often in response to either a feeding-induced volatile emitted from a damaged plant or a highly attractive sex pheromone. This is because adults spend their days eating and mating before returning to the soil for the night.

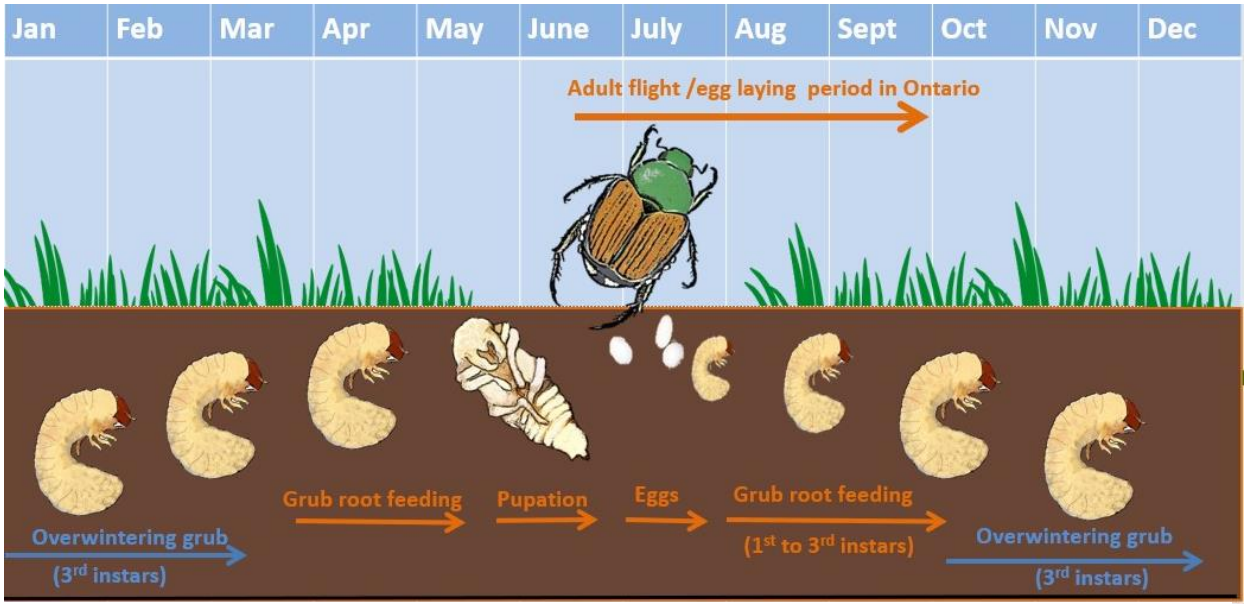

Figure 5. Depiction of the life cycle of a Japanese beetle (Image: OMAFRA ONfloriculture)

Adult females live only 30-45 days but will lay up to 60 eggs approximately 8cm deep in moist, loamy soil covered in short grass cover or reduced-tillage crop fields, like soybean. After approximately two weeks, the eggs hatch and the small larvae feed off grass roots until cold weather hits. Then, the larva overwinter 5 to 31cm below the surface. In spring, they emerge and begin feeding again.

When fully grown, the larva pupate before resting for two weeks. After this period, adult beetles emerge to begin the cycle anew.

Figure 7. Adult Japanese beetles skeletonizing apple leaves.

Figure 7. Wild grape growing in hedgerow adjacent to an orchard.

Feeding

During both its adult and larval stage, the beetle is considered a pest in Ontario to different crops. Adults feed heavily, munching on the vegetation of over 250 plants and severely injuring elm, maple, hazelnut, grape, peach, apple and more. Beginning at the top of the canopy where the plants are completely exposed to the sun, the beetles work their way down. The insects consume the green tissue between the veins, leaving behind the distinctive, lacy skeleton (Figure 3). In apples, newly planted or nursery trees are particularly susceptible to Japanese beetle damage, especially Honeycrisp.

Directly following emergence, adult Japanese beetles focus on low-growing plants and after 7-10 days move onto fruit and shade trees. Severely injured leaves turn brown and drop. As the leaves become less and less attractive, the beetles move on to flowers and field crops.

In its larval state, the Japanese beetle feeds on the fibrous roots of turf, ornamentals, and vegetables. Typically, this activity peaks in August and September as damaged turf initially wilts and yellows before dying. Larval feeding is so devastating, it can mimic signs of drought.

Cultural Management

Having non-grass cover in row middles and maintaining clean cultivating soils can discourage Japanese beetles from laying eggs in orchard systems. Clean cultivation may also expose eggs and grubs to the sun, wind, and predators by bringing them close to the surface. However, these practices do not prevent adult Japanese beetles from moving into the orchard from the adjacent landscape.

Orchards that are surrounded by naturalized landscape with wild bramble (raspberry/blackberry), Virginia creeper, or wild grape tend to have more feeding damage (Figure 4). Additionally, having these weeds nearby allows adults to move in and out of the crop, increasing the number of insecticide applications required to control for the pest. Removing these weeds can help reduce beetle populations on both accounts.

Overall, these beetles are an invasive pest of Ontario crops and can cause extensive damage depending on the cultivar, climate, and soil conditions.

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(Common) Uncommon Orchard Issues

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

For the most part, these articles focus on annual pests and regional or provincial issues. Makes sense – everyone deals with these things. But what about those not so common issues; those sporadic pests that only some orchards experience depending on the year or cultivar or landscape. Here are a few fairly common uncommon pest issues that have come up this year:

Calyx End Rot

Just as the name implies, calyx end rot describes lesions on the calyx end of developing fruitlets. This can be caused by any one of three different fungi: *Sclerotinia sclerotiorum, Botrytis cinerea* (grey mould in storage) or *Botryosphaeria obtusa* (black rot). The symptoms caused by these pathogens can be so similar, confirmation by a diagnostic lab is sometimes needed if damage is extensive enough. In all cases, calyx end rot is common in years with extended wetting periods (2-3 day duration) during bloom to early fruit set though symptoms often don't become visible until weeks following petal fall.

Figure 9. Calyx end rot on developing apple caused by *Sclerotinia sclerotiorum*.

Figure 9. Calyx end rot caused by *Botrysphaeria obtusa*, or black rot

In recent years, several growers and consultants have noticed developing fruitlet with petals remaining attached, particularly on Ambrosia and Gala. These delicate petals can be an avenue for infection causing calyx end rot. Fungal spores from pathogens causing this type of rot cannot infect fruit directly. However, the senescent flower petals can be colonized and provide entry for infection to spread into the developing fruit.

Calyx end rot caused by Sclerotinia sclerotiorum

Sclerotinia sclerotiorum overwinters as a persistent structure called a 'sclerotia' just under the soil surface usually around the base of infected weeds such as dandelion. During cool, wet springtime conditions, sclerotia sporulate and invade the calyx end of fruit.

Lesions first appear as slightly sunken circular tan brown to grey. They are dry for most of the season unless secondary pathogens such as bacteria enter through the wound. As the lesions expand (though no more than 15 cm in diameter), they tend to grow in one direction, appearing slightly off centre from the calyx and may be surrounded by a dark border and/or a red halo (Figure 1). Fruit ripens prematurely and typically drops before harvest. While the fungus infects weeds it directly contacts on the orchard floor, infection does not spread from one fruit to another.

Calyx end rot caused by Botrytis cinerea

Botrytis cinerea also overwinters as sclerotia, though usually in infected apples left on the orchard floor from the previous season. Infection is often latent so symptoms do not become visible until late summer as fruit matures. Lesions caused by *B. cinerea* are often light brown and completely surround the calyx.

Calyx end rot caused by Botrysphaeria obtusa

The calyx end rot that I have had the most reports from in the last few years has been that caused by *Botrysphaeria obtusa*, or black rot. This fungus overwinters in cankers, dead wood and mummified fruit. Ascospores released early in the season are wind blown.

Sepals of fruit can become infected just after bud scales become loose. As the fruit matures, the fungus penetrates the fruit from the calyx causing calyx end rot (Figure 2). Eventually, concentric dark and light rings expand over the fruit surface along with tiny pimple-like black pycnidia, resulting in premature fruit drop.

Calyx end rot management

Successful disease management for all three pathogens really starts with orchard sanitation. Remove cankers, mummified fruit, dead or dying limbs and dropped fruit on the orchard floor. Keeping grass and ground cover, particularly dandelions cut short will allow the soil to dry quickly and prevent sclerotia from germinating. However, be mindful of mowing during bloom and petal fall if early season insect pests such as tarnished plant bug have been an issue in the past as this can encourage movement into the trees. Since dandelions and other broad leaf weeds can be hosts for calyx end rot pathogens, good broadleaf weed control in the orchard will also prevent the build up of sclerotia population in the orchard.

While there are a number of fungicides registered in Ontario for black rot management, there are no fungicides registered for the other fungal causes of calyx end rot on apples. However, powdery mildew and scab fungicides applied over bloom and petal fall belonging to Group 1, 7 and 11 may also protect petals from infection. As with any fungicide, application must occur prior to infection for best results. Infected fruit should be hand thinned and removed from the orchard since throwing infected fruit onto the orchard floor will result in more inoculum for future years.

Bull's Eye Rot

Bull's-eye rot (BER) is a less familiar rot in the province that has recently started to become a sporadic issue in certain regions and catching some growers and packers by surprise coming out of storage. More common in the Pacific Northwest (PNW), BER is caused by *Neofabraea* spp., including the species causing perennial canker. In the PNW, cultivars such as Golden Delicious, Fuji, Spartan and Gala have been found to be highly susceptible, whereas in Ontario, Ambrosia seems to be the common cultivar affected.

Lesions caused by BER can look similar to other fruit rots common in Ontario that may develop during storage. They are brown, slightly sunken, circular spots with alternating light and dark concentric rings, giving an appearance of a target (Figure 3). As the rot progresses, cream-coloured spore masses may appear at the center of the lesion while dense rot progresses towards the core.

Figure 10. Bull's-eye rot on apples from storage. Multiple brown spots can appear on a single fruit, eventually forming cream-coloured masses on the surface. A dark rot can extend towards the core as the lesion progresses. (Photos: Washington State University)

The fungus overwinters as acervuli in perennial cankers and releases spores to maturing fruit and young limbs. In addition to cankers, *Neofabraea* spp. can also overwinter in mummified fruits, dead or decaying wood, leaf litter and alternative hosts such as crabapple, hawthorn and mountain ash.

Infections are more frequent in rainy seasons, only infecting fruit preharvest. However, infections remain latent so symptoms typically don't become obvious until after 3-4 months of storage. Once in storage, BER does not spread to other fruit inside the bin.

Research in the PNW found risk of fruit infection that develops postharvest increases 8 weeks before harvest. That said, studies have shown that fungicides applied 18 weeks before harvest were more effective in controlling BER than those applied two weeks before harvest. Group 1 fungicides such as Senator seem to provide the best efficacy against BER with Group 7/11 fungicides such as Pristine having fair to good control. There are currently no products registered in Canada for BER.

Necrotic Leaf Blotch

Necrotic leaf blotch is a relatively common but minor issue of Golden Delicious and cultivars with Golden Delicious as a parent (e.g. Aurora Golden Gala, Gala, Mutsu/Crispin, Sunrise, Silken, etc.).

It is caused by a physiological disorder that usually starts to appear in apple orchards in late June or early July. Generally, symptoms appear on mature leaves on the base of upright, succulent, rapidly growing shoots. Affected leaves initially have necrotic yellow blotches on them (Figure 4). These blotches are usually contained by the larger leaf veins. Within a few days, leaves turn yellow, then brown prior to defoliating. In severe cases, up to 50% of leaves fall off over several days.

Figure 11. Necrotic leaf blotch on Golden Delicious.

This disorder usually appears in two to four (or more) waves of symptoms during periods throughout the later half of the growing season. All sports of Golden Delicious on any root stock appear to be equally susceptible.

The exact cause of necrotic leaf blotch is unknown. There does not appear to be any biotic factors, including fungi or bacteria involved in necrotic leaf blotch (though symptoms can look similar to Glomerella leaf blotch and Alternaria leaf blotch). Instead, it seems to involve rapid synthesis of gibberellins and perhaps a hormonal imbalance triggered by environmental factors. At the same time, efficacy trials in Northeastern US have found a reduction in necrotic leaf blotch symptoms when zinc-containing fungicides or foliar nutrients such as zinc oxide where applied, suggesting this disorder may be associated with zinc deficiency.

Nonetheless, necrotic leaf blotch typically occurs when a cool rainy period of four to five days precedes several hot, sunny days. Trees with an annual moderate crop of fruit have less necrotic leaf blotch than trees with a biennial bearing habit or a light fruit crop.

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Reduce Apple Scab with Orchard Sanitation

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

When pest outbreaks occur, it is often presumed that pest control products are the most important and effective management tools available. However, a good sanitation program can help eliminate or reduce sources of infestation and disease inoculum from the orchard, potentially improving the effectiveness of other management practices.

Over the two years, the Pest Management Regulatory Agency (PMRA) has released a number of re-evaluation decisions for numerous Group M fungicides that are a critical part to apple scab management. The following table is a summary of these decisions:

Table 1. Re-evaluation decisions for Group M fungicides registered for apples

Active ingredient	Orchard system	New rate	Max. apps per year	Restricted entry interval	Preharvest interval
mancozeb*	all	4.5 kg a.i./ha	4	12 hour (general) 35 days (thinning)	77 days
captan	canopy width, less 2 m	2.4 kg a.i./ha	10	2 days (general) 6 days (pruning/training) 15 days (thinning)	15 days
	canopy width, greater 2 m	2.4 kg a.i./ha	2	2 days (general) 4 days (pruning/training) 24 days (thinning)	19 days
metiram	All uses cancelled				
thiram	All uses cancelled				
ferbam	All uses cancelled				

* previously approved label is valid until Nov 19, 2022

With a limited arsenal of available fungicides effective against scab on the horizon, integrating inoculum-reducing strategies will be an important component of effective management practices. Practical and inexpensive, these methods can contribute to the reduction of overwintering ascospores that will infect green tissue the following season.

Table 2 summarizes research from New Hampshire that looked at the impact of inoculum pressure on primary scab infection the following spring. An orchard with 20% overwintering leaf scab has the potential to produce ***7,000 times*** more ascospores than an orchard with less than 1% overwintering leaf scab (Gadoury and MacHardy, 1986).

Table 2. Primary scab infection activity based on overwintering inoculum levels, New Hampshire[1]

	Ascospore production the following spring		
Leaf scab in fall (%)	**Total ascospores produced/acre ('000)**	**Ascospores/acre released at green tip ('000)[2]**	**Potential lesions/acre from green tip infection period[3]**
<0.5	888	18	0.18
1-3	9,262	185	1.85
4-10	242,559	4,851	48.5
20	6,090,000	121,812	1,218

[1] Adapted from Gadoury and MacHardy (1986)

[2] Assuming 2% of ascospores released.

[3] Assuming 1% of released spores cause infection. Actual infection will vary depending on climate and spraying conditions.

You can save time and money usually invested in fungicide applications by reducing the initial scab inoculum load going into the season:

- In a typical year, only a small proportion of ascospores are actually mature early season. Therefore, reducing (or eliminating) the risk of infection, and potential need for chemical control, at green tip.

- Scab spores do not travel far and most infections start from within the orchard. Again, getting the inoculum out greatly reduces the risk of infection.
- Most fungicides tend to work better in low-inoculum orchards, particularly when dealing with our Ontario spring weather.
- The trend in new product registrations is towards single-site fungicides which have high resistance potential. Reducing scab inoculum means less selection pressure placed on these products (ie., longer life of these products).

Apply 45 kg of agricultural urea per 1,000 L of water/ha to the orchard floor after 95% leaf drop (November) or in the spring (April) before bud break. Urea works in a number of ways:

1) It directly inhibits the development of ascospores.
2) It stimulates the growth of naturally occurring organisms that are antagonistic against the scab fungus.
3) It facilitates the breakdown of the leaves.

Since the early 2000's, research has shown this practice to be effective in reducing over-wintering spores. Research from the University of New Hampshire showed a 97% reduction in ascospore productivity in leaves sprayed with 5% urea just before leaf-fall, 50% reduction when urea was applied to the leaf litter when approximately 95% of the leaves had fallen, and 70% reduction when urea was applied to the leaf litter in spring (Sutton et al., 2000).

A fall application of urea does not have a negative impact on winter hardiness or the fruitfulness for subsequent years. If snow cover remains until bud break, this may reduce the time for a spring urea application to work and reduce the effectiveness of the treatment. In orchards requiring lower rates of nitrogen, a fall application may also be preferred to reduce the impact of the nitrogen.

In addition to a urea application, scab inoculum can be reduced 80-90% by shredding overwintering leaves in November or April (Sutton et al., 2000; Vincent et al., 2004). Rake or blow leaves from under trees and shred them using a flail mower. This helps encourage leaf decay and may re-orient the leaves to prevent spores from discharging up into the trees.

References

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Post Harvest

'Ambrosia' Harvest Maturity for Storage

Dr. Jennifer DeEll, Fresh Market Quality Specialist – Horticulture Crops, OMAFRA

It is **very important NOT to wait until the background color is yellow to start harvesting** 'Ambrosia' that will go into storage. When the background color is yellow, the fruit will be over-mature and more prone to internal browning and splitting. 'Ambrosia' background color should show more green than yellow at harvest time for good storability.

The starch index can be an overall useful indicator of 'Ambrosia' fruit maturity. **Starch values of 2.5 to 4.0 at harvest time are optimal** for fruit storage. 'Ambrosia' with starch values above 4 should not be stored for long periods of time, as these will be prone to internal browning and splitting.

'Ambrosia' produces very little ethylene during maturation on the tree. As starch is degraded and color changes, there continues to be only trace amounts of internal ethylene present (<1 ppm). This makes **internal ethylene a poor indicator of fruit maturity for 'Ambrosia'**.

I_{AD} readings from a delta absorbance (DA) meter can be useful for accessing fruit maturity in 'Ambrosia'. It has been suggested that **'Ambrosia' should be harvested when I_{AD} readings average 0.7 to 0.6** for storage. Fruit with values near 0.5 and below should not be stored for extended periods, while those with less than 0.3 should be marketed as soon as possible. Be sure to take DA meter readings on the margin between the blush and non-blush areas, and not directly on the blush or shade sides of the fruit.

Optimum harvest of 'Ambrosia' for storage tends to be **around the same time as 'Empire'**. 'Ambrosia' in Norfolk County (ON) at optimum maturity have measured <1 ppm internal ethylene concentration, fruit firmness ~18-20 lb, starch index ~2 to 4, and background color yellow 2 to 3 on the BC color chart (Figures 1 and 2). Apples harvested later tended to become mealy and soften more rapidly, as well as develop more disorders and greasiness during storage.

Figure 1. 'Ambrosia' ready for harvest.

Figure 2. British Columbia color chart for 'Ambrosia' apples.
(Available from OAG for members)

Acknowledgements: Thanks to the Ontario Apple Growers, Norfolk Fruit Growers' Association, Apple Marketers' Association of Ontario, AgroFresh Inc., Storage Control Systems Inc., Pommes Philip Cassidy Inc., GRB Ag. Technologies Inc., Decco US Post-Harvest Inc., and the Canadian Horticultural Council (BC, ON, QC, and NB apple growers) for their continuous support, as well as Sky Lesage, Geoff Lum, and Younes Mostofi for their technical assistance. Recent work was funded in part through the Canadian Horticultural Council's Canadian Agri-Science Cluster for Horticulture 3.

Optimum Apple Maturity at Harvest for Maximum Storage Life

Dr. Jennifer DeEll, Fresh Market Quality Specialist – Horticulture Crops, OMAFRA

For successful long-term storage, apples must be harvested when they are physiologically mature but not fully ripe. Each cultivar must be harvested at the proper maturity to achieve maximum storage life and marketing season, while minimizing postharvest losses.

If apples are harvested too early, they are of poor color, small size and have little flavor. They will usually fail to ripen or may ripen abnormally, and the overall quality will be poor. High water loss, low sugar content, high acidity, low aroma volatile production, and high starch content are characteristics of immature apples that contribute to inadequate flavor development. Immature apples are also more likely to develop storage disorders like superficial scald, external CO_2 injury and bitter pit.

Harvesting apples too late can result in a short storage life. Such apples are too soft for long-term CA storage and are more susceptible to mechanical injury and disease infection. Over-mature apples may develop poor eating quality, mealiness, and off-flavors. They are more susceptible to internal browning, watercore and breakdown, as well as soft scald and soggy breakdown in a cultivar like 'Honeycrisp'.

Numerous methods have been suggested for determining harvest date, but no single test is completely satisfactory, and some are too unpredictable, complicated, or expensive. Days after full bloom is overall somewhat constant but can vary in a year with weather extremes. Therefore, days after full bloom should be used as a general reference to indicate the approximate date when apples might reach harvest maturity, which is then confirmed using tests such as internal ethylene concentration (IEC), starch-iodine staining, flesh firmness, and soluble solids content (sugars).

In general, and especially for older cultivars, IEC of 1 ppm is considered to be the ultimate threshold above which fruit ripening and flesh softening are initiated and progress rapidly. Harvest for long-term storage should be completed before 20% of the apples have an IEC higher than 0.2 ppm. More recent cultivars, such as 'Honeycrisp', do not always follow that rule.

Using the starch-iodine test, most apples destined for long-term storage should have 100% of the core tissue starch degraded (no stain) with greater than 60% of the flesh tissue still having starch present (stain). Again, recent cultivars do not always follow that rule, such as 'Honeycrisp'. It is also important to note that not all apples mature and ripen in the same manner each year, and often there will be a need to compromise between correct maturity and the required firmness and sugar levels for market.

The following chart represents harvest guidelines for apples destined for long-term CA storage (Table 1). Extreme weather during the growing season can influence fruit maturity, so actual values may vary during such seasons. Of course, you also need proper color to market the fruit.

Table 1. Suggested starch index values and firmness at harvest for apples going into long-term storage.

Cultivar	Starch Index (1-8)*	Firmness (lb)
Ambrosia	2.5 - 4	>17
Cortland	2.5 - 3.5	>15
Crispin	3.5 - 4.5	>17
Delicious (Red)	2.5 - 3.5	>17
Empire	2.5 - 3.5	>17
Gala	2.5 - 3	>18
Golden Delicious	3 - 4	>16
Honeycrisp	~ 5	>15
Idared	3 - 4	>15
McIntosh	2.5 - 3.5	>15
Northern Spy	2.5 - 3.5	>18
Spartan	**2.5 - 3.5**	>15

* Cornell Starch Iodine Index Chart (1-8)

The delta absorbance (DA) meter has been recently added into the toolbox for evaluating fruit maturity. It provides a measure of chlorophyll content (green color) of the fruit. In comparing our Ontario data through collaborations with colleagues in Minnesota and Maine, we found no consistent effect of DA values among apple cultivars, growing location, orchard blocks, and harvest times. However, the DA meter could be a useful tool if one takes the time to develop standardized readings during the harvest period for a given cultivar and orchard block.

Apples can be segregated into lots at harvest by their storage potential. The following types of apples should not be designated for long-term storage because of their potential for problems: 1) large fruit from lightly cropped trees, 2) fruit from excessively vigorous trees, 3) fruit from young trees just coming into bearing, 4) fruit from interior portions of trees that are heavily shaded, 5) early-picked fruit high in starch, 6) late picked fruit with advanced maturity, and 7) fruit with low seed count (< 5 per fruit).

Announcements

Ontario Pest Management Conference

Tuesday November 1, 2022

The Ontario Pest Management Conference (OPMC) will be back **in-person** at the Victoria Park East Golf Club in Guelph, ON on **November 1, 2022**. The OPMC features research on all aspects of pest management associated with plant, animal and human health.

This year's theme is 'Building Resiliency into Pest Management' and features the following plenary speakers:

- **Dr Kerik Cox, Cornell University** – *Best practices for implementing biopesticides for fungal and bacterial diseases of fruit*
- **Dr Jocelyn Smith, University of Guelph** – *Battling the billion dollar bug*
- **Ryan Brewster, Brewster Consulting Services and Aaron Oppenlaender, Huebel Grape Estates** – *Soft chemistries to manage hard problems in Niagara vineyards*

Stay tuned to the new conference website **www.ontariopmc.ca** for more details on the event.

For the 2022 conference, OPMC will be soliciting abstracts for

1) **Student Competition - Graduate Oral Presentation** (sponsored by CropLife Ontario Council) – 6 spots total, one $500 award and plaque for the winning entry
2) **Student Competition - Graduate Poster Presentation** (sponsored by CropLife Ontario Council) – 6 spots total, one $500 award and plaque for the winning entry
3) **Student Competition - Undergraduate Poster Presentation** (sponsored by OPMC) – 4 spots total, one $250 award and plaque for the winning undergraduate (or diploma) student
4) **General Posters –** non-competitive

Refer to the Call for Posters/Oral Presentations section on the OPMC website for details and instructions on submissions (https://www.ontariopmc.ca/submission). **The submission period ends on Friday September 16th.** For questions on the submissions, please email sean.westerveld@ontario.ca

OFVC 2022: Save the Date

Wednesday & Thursday February 22 & 23, 2023

The Ontario Fruit and Vegetable Convention (OFVC), Canada's premier horticultural event, is returning to the Niagara Falls Convention Centre, Ontario on **February 22-23, 2023**.

The Apple Program will be adding an additional half-day session, taking place Wednesday afternoon, Thursday morning & Thursday afternoon.

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