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PATHWAY TO BETTER FRUIT



HOT TIPS FOR CLEAN PICKS:

- Watch for signs of late-season pest damage — even minor injury can show up in the bin.
- Choose product formulations wisely; preharvest intervals, efficacy and residue potential can differ.
- Manage your crop load for better nutrient allocation and better colouring.
- Test fruit and leaves when/if you are unsure of nutrient levels and adjust accordingly.
- Keep sprayers in top shape — nozzle clogs can mean uneven coverage and surprises at harvest.
- Use harvest assessments as a reality check: How well did your IPM strategies hold up?
- Stay audit-ready — preharvest is a good time to double-check food safety and certification details



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Brought to you by the OMAFA Editorial Apple Team:

Erika DeBrouwer
ONcore Editor
Tree Fruit Specialist
(226) 931-4098
erika.debrouwer@ontario.ca

Kristy Grigg-McGuffin
ONcore Editor
Horticulture IPM Specialist
(519) 420-9422
kristy.grigg-mcguffin@ontario.ca

Andrea Vieira
ONcore Art Direction/Design
Publications Officer
andrea.vieira@ontario.ca

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- ✓ Ontario Pest Management Conference
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ORCHARD MANAGEMENT

A Pitfall in the Pipeline – Part 1: Calcium’s One-Way Ticket

Erika DeBrouwer, OMAFA Tree Fruit Specialist

Ca-tch It While You Can

Every success starts from the ground up, and the more researchers delve deeper into apples, the truer it becomes (especially from a nutrient standpoint).

Calcium is present with adequate amounts in the soil in Ontario due to our calcareous parent material (calcium bedrock) and is not often known to be a deficient nutrient in apple trees across Ontario. Localized deficiencies of calcium can be seen in apples, such as bitter pit, but it is debated whether the nutrient deficiency is the cause or a result of the disorder.

Bitter pit is a multifactorial disorder, where calcium deficiency is a risk, but is not the sole reason for the presence of bitter pit.

Calcium is an important secondary nutrient that is critical for cell division, cell elongation and cell structure. **Calcium cannot be stored within the plant – meaning it needs to be readily available throughout the season.**

Thirst Class Transport

Calcium is taken up by actively growing root tips and transported mainly through the xylem pathway. It is known as the long-distance calcium transport pathway due to the nutrient’s movements depending on the xylem. The xylem pathway is a one-way system that moves nutrients from the roots to the desired tissue (leaves and fruit). The pathway relies heavily on water relations to transport nutrients, meaning nutrients only move when transpiration occurs.

Transpiration: the process of releasing water vapour from plant tissues (Figure 1).

Transpiration consists of the following steps:

1. Roots uptake water from the soil
2. Water moves through plant tissues, serving critical metabolic and physiologic functions in the plant
3. Leaves (and other plant tissues) release water vapour into the air through their stomata

Evaporation: when water turns into vapour from any surface.

Diffusion: occurs when molecules move from a place of high concentration to an area of lower concentration.

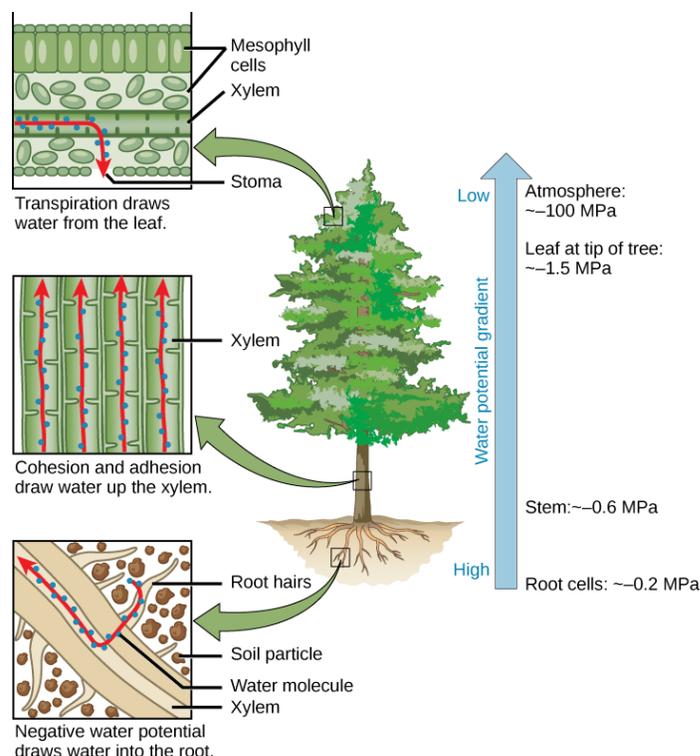


Figure 1. Illustration explaining transpiration and water movement throughout the plant. (Image credit: OpenStax Biology).



Transpiration can be affected by multiple environmental factors including, temperature, relative humidity, air movement (wind), light intensity and soil water. These factors and how they affect transpiration are outlined in [Table 1](#).

In addition to environmental factors, transpiration can also be affected by leaf area and structure, water availability and stomatal regulation.

This means that although calcium may be in demand at the fruit level, there are substantial amounts of barriers and factors that the nutrient must overcome to get to the region of need. And to add more complexity, there may be a complete roadblock that calcium cannot conquer to get to the intended organ.

Season's Feedings

Knowing the seasonal apple tree calcium demand is important to understand how the nutrient fluctuates based on physiological processes and activities. Apple calcium demand throughout the season is outlined below:

Dormant to Green Tip

When trees are just waking up from the winter, there is a minimal demand for calcium. There is not a lot of nutrient movement due to dormancy, but things start to move as the tree awakens.

Green Tip to Full Bloom

A low amount of calcium is needed during this period as buds are initiating growth and limited calcium uptake occurs. Most of the calcium required at this time goes toward green tissue development.

Full Bloom to Fruit Set

Calcium is moderately needed as flowering, pollination and early fruit start to develop. Nutrients are starting to increase in uptake as the main pathway for immobile nutrients (xylem) increases activity.

Fruitlet Sizing

The highest demand of calcium is needed here from a fruit enlargement standpoint. Cell division and expansion are occurring during this time, specifically in the fruit, where both activities require calcium. Calcium is also still needed in leaf tissues, but much of the calcium is allocated to the fruit.

Fruit Maturation

Calcium is still needed, but its required amount is lower, as it is being used for cell are maturation and hardening. Leaf tissues cease growth further slowing calcium requirements.

Harvest to Post Harvest

Required calcium levels are low at this time of year. Calcium is still important from a cell membrane standpoint to ensure peel integrity, especially for long-term stored apples.

As a note, cultivar specific demands from a nutritional standpoint and physiological timings will differ, but generally most apples follow the timeline shared.

Table 1. Environmental Factors that Affect Transpiration

Environmental Factor	Factor Level	Transpiration Rate	Explanation
Temperature	High	↑	Energy of water molecules increases, causing evaporation and diffusion to occur faster
Air Movement (wind)	High	↑	Water vapour moves more quickly with more wind, speeding up
Relative Humidity	High	↓	More moisture in the air causes leaves to slow down as water vapour is already present in the air
Light Intensity	High	↑	More stomata open and/or open wider to allow gas exchange, increasing evaporation
Soil Water	Adequate	↑	Provides water to move through plant, allowing high transpiration rates

Information compiled from the following resources:

¹Organismal Biology. n.d. Water transport in Plants: Xylem.

²Plant & Soil Sciences eLibrary. n.d. Transpiration – Factors Affecting Rates of Transpiration



Lit Up by Calcium

Researchers have studied calcium in apples since the 1930's (holy 🙏!) and over the past century – although many questions are being answered – many more seem to generate.

Multiple findings suggest that calcium is accumulated mostly during the early stages of fruit development when the transport pathway it uses is fully functional and transpiration rates are high. This commonly takes place from bloom through fruitlet sizing (roughly 6 to 8 weeks after bloom). After this time calcium uptake slows drastically and the nutrient cannot be redistributed throughout the tree. Any calcium that was taken up by the fruit is then 'diluted' as the season progresses and enlargement of the fruit occurs.

A study in Spain conducted by Casero et al. 2017 on 'Golden Smoothie' apples looked at the demand and absorption of calcium in fruit and leaves.

The study showed that apple fruit calcium demand was consistently increasing throughout the season (from 10 days after bloom to 164 days after bloom), but the absorption of calcium peaked early in the season (38 days after bloom). This reiterates that **although calcium demand in the fruit is high, the absorption rate may not be able to meet said demand.**

This research also showed that fruit **calcium absorption increased** later in the season (from 94 to 164 days after bloom), which is **presumed to be caused by shoot growth ceasing.**

Similar findings were seen on 'Gala', 'Golden Delicious', and 'Fuji' apples in Brazil (Nachtigall & Dechen, 2006), and in a study performed in China on eight cultivars including 'Gala', 'Fuji', and 'Pink Lady' (Zheng et al., 2006). The former study showed that **leaf calcium accumulation steadily increased throughout the season** up to 30 weeks after full bloom on 'Gala' and 'Fuji', where 'Golden Delicious' apples followed a similar pattern but declined at 25 weeks after full bloom. The latter study showed a wide variation in cultivars calcium absorption and accumulation, which were shown to be strongly affiliated with apple maturity timing and fruitlet growth rates. A similar trend was seen in this study where **calcium levels increased in leaves as shoots developed over the season.**

These findings demonstrate that transpiration and calcium continue to accumulate in the leaves throughout the season and compete with fruit calcium. This is important, especially during critical times of year, in certain cultivars (i.e. Honeycrisp during cell expansion) as more calcium would be directed to the higher transpiring organ.

The Bitter Truth

Bitter pit is a physiological disorder, where dark depressions are usually found on the calyx end of the fruit and is commonly associated with calcium deficiencies (Figure 2).



Figure 2. Bitter pit on 'Honeycrisp' apples

Bitter pit continues to be a challenge and has been researched heavily over the past three decades. Although extensive knowledge has been gained in the scope of bitter pit the mechanisms that cause bitter pit remain unclear.

Calcium relies on the xylem pathway to travel to the organ in need which is dependent on transpiration levels. This was scientifically proven by Hocking et al., 2016; Montanaro et al., 2015 in tomatoes and kiwi, respectively. These studies also suggested that calcium deficiencies are the result of low calcium levels at the local level. The main reasons why local calcium deficiencies occur in apple fruit are:

- Xylem dysfunction
- High vegetative vigour
- Cultivars, rootstocks, and combinations
- Nutrient imbalances
- Hormonal implications
- Environmental stresses

Many of these factors are mutually influential, where some may hinder or facilitate bitter pit depending on the physiological response and/or cascading response.



Xylem Dysfunction

The association of the xylem pathway slowing throughout the season has been hypothesized to be a contributor of low local calcium levels. And although the xylem loses its function over the season and occurs in every apple cultivar, research has demonstrated that bitter pit prone cultivars display an earlier loss of xylem function (Griffith & Einhorn, 2022; Gomez & Kalcsits, 2020).

Dr. Todd Einhorn and his PhD candidate Chayce Griffith delved deeper into the specifics of the fruit xylem vascular tissue. Griffith has visually demonstrated the decline of xylem function by comparing 'Gala' and 'Honeycrisp' (Figure 3). Xylem dysfunction in the fruit occurs in stages where the outer (towards the peel) vascular bundles lose function first, where the inner bundles progressively lose function over the season (Figure 4). These findings have been further reinforced by Gomez and Kalcsits in 2020 when comparing 'Honeycrisp' to 'WA 38' (Cosmic Crisp®). This study stated that xylem flow was maintained longer in 'WA 38' than 'Honeycrisp', resulting in lower fruit calcium accumulation in 'Honeycrisp'. These studies

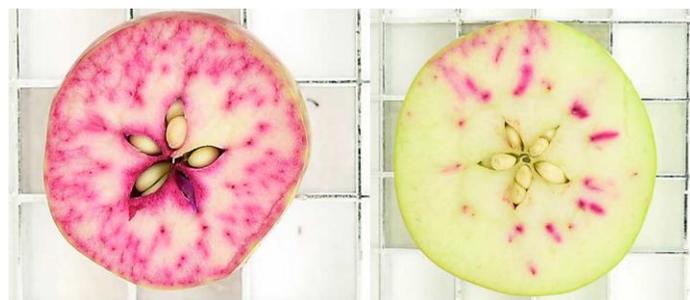


Figure 3. Cross section staining of 'Gala' (left) and 'Honeycrisp' (right) apple showing xylem functionality in apple fruit interior (Photo credit: Chayce Griffith, Michigan State University)

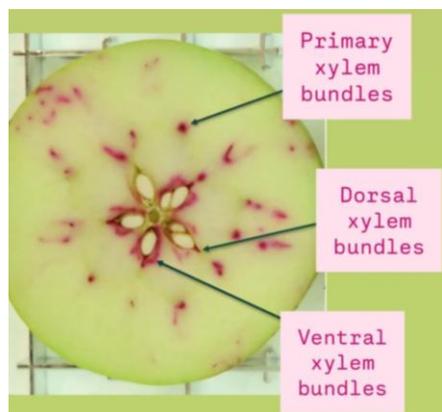


Figure 4. Cross section staining of a 'Honeycrisp' apple showing the different xylem bundles (Photo credit: Chayce Griffith, Michigan State University)

demonstrate that although calcium may be needed in the exterior portions of the apple fruit, the nutrient cannot make it to the area. The cause of the dysfunction is not formally known, and dates of the dysfunction tend to change based on environmental conditions (this can change based on the year and the cultivar).

High Vegetative Vigour

As with any nutrient, division of resources is something that impacts nutrient allocation throughout the plant and should be considered. This is moreso evident regarding calcium in bitter pit prone cultivars.

Generally, fruit doesn't transpire as effectively as leaves, meaning most of the calcium is allocated to leaves (de Freitas et al., 2011; Falchi et al., 2017; Gomez and Kalcsits, 2020). This occurs throughout the season until terminals are set and fruit calcium no longer competes with leaf calcium. Although this late season calcium uptake is beneficial from a fruit cell maturation and hardening standpoint, the calcium accumulated at this time is not enough to mitigate bitter pit and may not be able to enter the fruit given xylem dysfunction.

Adding to the challenge of calcium dispersion is that a large leaf canopy can impair calcium accumulation during critical calcium uptake periods such as fruitlet sizing. It is important to balance vegetative vigour with reproductive vigour to encourage nutrient flow to organs in need at the timing they require.

Nutrient Imbalances

A balance between reproductive and vegetative growth aids with nutrient dispersion throughout the plant, but it is important to consider the changes in uptake throughout the season.

Calcium is in competition with ammonium-based nitrogen (N), potassium (K), magnesium (Mg) and manganese (Mn) at the soil level (Ontario Ministry of Agriculture, Food and Rural Affairs. 2018). As the growing season advances, xylem dysfunction can further impair calcium transport, often resulting in a change of nutrient ratios. This is caused by the phloem continuing to transport and accumulate mobile nutrients, like N, K, Mg, while immobile nutrients slow in uptake.

These nutrient ratios play a significant factor in bitter



pit, as certain ratios can exacerbate the disorder. In Washington (Gomez & Kalcsits), when comparing 'Honeycrisp' to 'WA 38', a greater transpiration rate was seen in leaves of 'Honeycrisp' leading to a higher leaf calcium accumulation and lower leaf potassium and magnesium to calcium ratio (K+Mg/Ca). The opposite was shown in 'WA 38' where fruit calcium accumulation was higher, and the potassium and magnesium to calcium ratio (K+Mg/Ca) was lower. Cheng and Miranda Sazo (2018) shared this sentiment when comparing 'Honeycrisp' to 'Gala' apples. 'Honeycrisp' apple peels had lower calcium concentrations with higher potassium to calcium and magnesium to calcium ratios. In fruit, higher potassium and magnesium levels when compared to calcium often leads to an increase in bitter pit incidence (Cheng & Miranda Sazo, 2018).

Boron (B) is also an important nutrient that should be monitored when addressing bitter pit. B has shown to aid in calcium movement to the fruit through various factors: pollen germination, root and fruit development (Torres et al., 2024). Research has shown inconsistent results, stating that the influence of B on bitter is still unclear, but multiple studies support that a tree deficient in B has led to higher prevalence of bitter pit.

Hormonal Implications

There are many hormonal implications, though most of the research surrounding this topic is regarding external applications to the tree. Therefore, this topic will be expanded further in the next issue of ONcore

Cultivars, Rootstocks and Combinations

Every apple is unique, and although demands of certain cultivars may be similar, there are some that show distinct differences in the nutrient requirements and timings of processes. As mentioned throughout the article there are more sensitive cultivars to bitter pit, where research has demonstrated a relation to early xylem dysfunction (Griffith and Einhorn, 2025). This dysfunction leads to a difference in fruit nutrient uptake, which is why there may be cultivar specific nutrient imbalances.

Further to the cultivar portion, rootstocks have shown to be a major proponent in bitter pit incidence (Cheng, 2024). Much of this is related to the difference in nutrient uptake, where different rootstocks uptake

certain nutrient better than others. Cheng (2024) compared various dwarfing rootstocks looking at bitter pit incidence, along with N, K and calcium uptake over the first 5 years of a 'Honeycrisp' planting.

The following were his findings (Figure 6):

- More efficient K rootstocks: G.41, G. 890 & G.11
- Less efficient K rootstocks: G.214, G.969 & B.10
- Good calcium uptake: G.969
- Bitter pit incidence (least to most, left to right):
 - B.9 < M.9 < G.11 < G.41

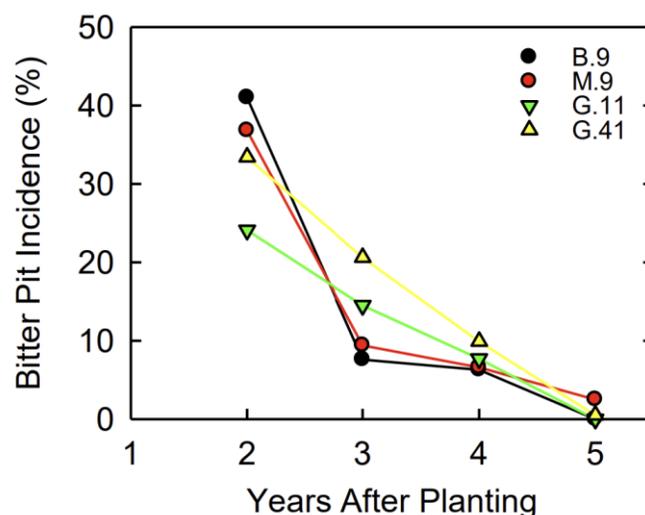


Figure 6. Graph showing the difference in bitter pit incidence in New York on four common apple rootstocks (Cheng, 2024)

Researchers are still identifying why and how rootstocks have an impact on increasing or mitigating bitter pit incidence. A theory that was suggested and continues to be analyzed is the correlation of dwarfing rootstocks and xylem function throughout the tree.

There are 5 main areas of thought for future study on apple rootstocks and their implications:

- Dwarfing rootstock influence nutrient uptake
- Dwarfing rootstock influence on water flow
- Dwarfing rootstock influence on xylem function
- Dwarfing rootstock relationship with cultivars
- Restrictions on/at the graft union



Environmental Stresses

As previously discussed, the environment has a large impact on all immobile nutrients. This is due to their movement being dependent on transpiration, which is environmentally driven.

Remember this when observing local calcium deficiencies in apples:

*"It is not due to lack of **availability**, it is due to lack of **transportability**."*

Ca in a Nutshell (or a pit)

Bottom line, we do not have all of the answers when discussing bitter pit, but there are notes of importance and knowledge that can be used to aid in mitigation.

- Calcium moves through the xylem, and its flow depends on transpiration, which strongly influenced by environmental conditions (Table 1)
- Calcium cannot be easily redistributed within the plant and past a certain point in the season cannot be redistributed at all
- Leaves transpire more than fruit and are commonly in competition with fruit during calcium accumulation
- The xylem pathway degrades over the season and is most dramatically impaired early in fruit in bitter pit prone cultivars like 'Honeycrisp'
- High vegetative vigour and high crop load can increase bitter pit incidence due to dispersion of resources
- High K:Ca and high Mg:Ca ratios may lead to a higher incidence of bitter pit
- Phloem nutrient uptake (N, P, K, Mg) is important to consider when managing bitter pit
- Certain rootstocks are more efficient at accumulating certain nutrients (Figure 6), potentially decreasing or increasing bitter pit incidence

- The environment plays a significant role in calcium uptake and transport

There may not be a silver bullet to mitigating bitter pit, but there are methods and tests that can aid in decreasing its effects.

Resources & References

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Keep a lookout in the next issue of ONcore for

A Pitfall in the Pipeline - Part 2

where I address mitigation strategies, preliminary tests, and outline ongoing research surrounding bitter pit.



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CROP PROTECTION

Borderline Trouble Managing Plum Curculio in Ontario Orchards

Kristy Grigg-McGuffin, OMAFA Horticulture IPM Specialist

Part One: Sneaky Snout

Plum curculio (*Conotrachelus nenuphar*) is a small snout beetle (Figure 1), but its effect on apples is anything but small. For Ontario growers, it's a consistent early-season pest that can also quietly nibble away at fruit quality later in the season. Both adults and larvae have chewing mouthparts and can damage fruits; adults by feeding and laying eggs in newly set fruit and larvae by feeding internally within fruits, causing premature fruit drop in some cases.



Figure 1. Plum curculio is a small, snout beetle

To manage it effectively, it helps to start with a clear understanding of its biology:

When the Weevil Wakes

Plum curculio adults overwinter in leaf litter, hedgerows, and groundcover, often right at the orchard edge or adjacent woodlot. As soon as spring temperatures consistently rise above 10°C, they begin to stir. By late bloom and petal fall (and temperatures 15-16°C, they are on the move into orchards.

Adults can walk or fly, depending on the temperature – warmer days tend to encourage more flight and faster orchard arrival. Activity, however, is primarily at night which is why it's a rare find to spot one in the orchard during the day.

Though we worry about them in apples, plum curculio also attacks **peaches, cherries, pears, plums and wild hosts like hawthorn**, which serve as population reservoirs.

Counting Heat

Degree-days matter! Studies in New York (Reissig et al., 1998) found that adult migration and oviposition closely track degree-day accumulations beginning 100 DD (base 10°C). This makes heat-unit tracking a valuable tool in predicting when management is needed and something that is being validated in Ontario.

Figure 2 summarizes key developmental timings for plum curculio based off existing degree day models used in the US and which we are validating here (NEWA 2025; Reissig et al., 1998). Some of those key timings include: 100 DD (adult migration starts), 275 DD (egg laying begins), 308 DD post petal fall (egg laying stops), 1000 DD (adults emerge). Note, biofix for mentioned timings is March 1st with the exception of when egg laying stops. This value is based on a petal fall biofix which is calculated by 90% petal fall of orchard block.

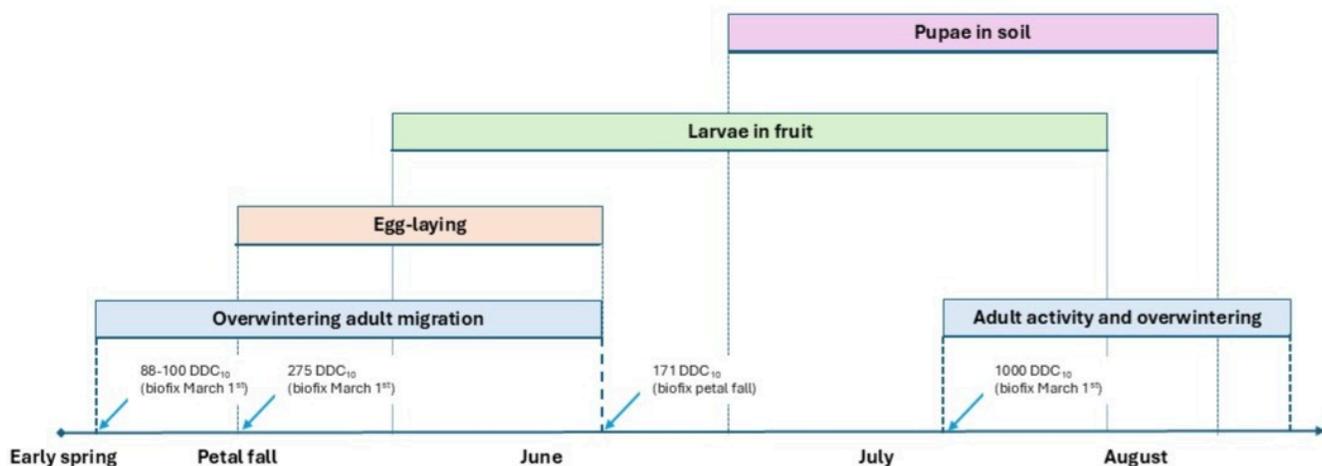


Figure 2. Typical lifecycle timeline of plum curculio in apples.

Signature Moves

Damage by plum curculio includes:

1. **Crescent-shaped wounds, caused by egg laying** - Once in the orchard, females start laying eggs in small developing fruit. They cut crescent-shaped scars into the skin and tuck eggs just beneath the surface (Figure 3). These scars are unique to plum curculio and serve as a telltale sign of activity (Figure 4). Once fruit exceed 25-30 mm, they are unsuitable for oviposition
2. **Premature fruit drop, caused by larvae as they feed within the fruit** - Eggs hatch within 3–12 days depending on temperature. The larvae tunnel inside fruit, feeding on the flesh until the fruitlets abort and drop to the ground.
3. **“Cat-facing” or misshapened fruit, punctures / holes, or corky scars, caused by adult feeding** - Larvae exit the dropped fruit, pupate in the soil, and emerge as new adults later in the summer. In Ontario, plum curculio is generally univoltine (one generation per year), though warm years may see a partial second generation (Racette et al., 1992).

Part Two: Scars Don't Lie

By late June, many growers assume plum curculio pressure has subsided. The most obvious injury — crescent-shaped oviposition scars leading to June drop — has stopped. However, research shows that adult plum curculio remain active well into midsummer, and

their presence can still affect pack-out quality.

Scars Vs Stings

Once fruitlets reach 25–30 mm in size, they are generally no longer suitable for larval development. But that doesn't mean curculio leave the orchard. Adults continue to feed on fruit throughout July and August, creating shallow punctures that result in corky, dimpled scars that expand as the apple grows (Figure 5 & 6).

In fact, studies from the northeastern US (Leskey & Hoggmire, 2005; Racette et al., 1992) demonstrate that late-season injury can account for a significant portion of pack-out losses, especially in years when management tapers off too early. While late oviposition into larger fruit is less likely to succeed, adult feeding punctures persist and expand.

Border Patrol

Activity is rarely uniform across the orchard. Studies in the mid-Atlantic and northeastern U.S. (Leskey & Hoggmire, 2005; Wise et al., 2007) show that plum curculio injury is strongly concentrated in **border rows adjacent to wooded areas or hedgerows**.

Successful monitoring includes:

- **Edge effect scouting** – The best return on scouting is spent inspecting low-hanging fruit in perimeter rows, especially early in the season and again in July.



Figure 3. Early egg-laying injury caused by plum curculio. Crescent-shaped marks indicate where the female curculio laid an egg in the developing fruitlet. (Photo: T. Leskey, USDA)

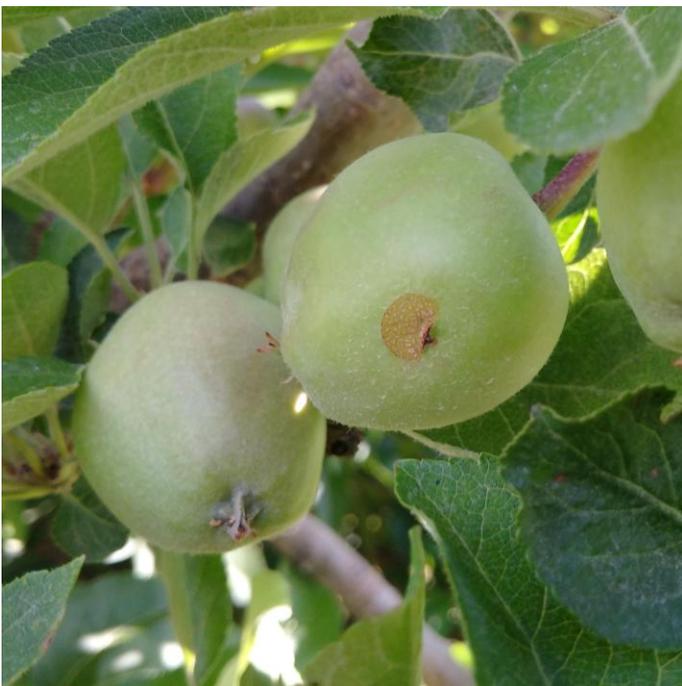


Figure 4. Egg-laying scars from plum curculio on maturing fruit that did not drop prematurely.

- **Indicators of activity** – Fresh scars on border fruit signal that adults are still active, even if interior rows look clean.
- **Visual inspection** – Still the most practical method. Regular scouting from petal fall through July helps track activity trends. When average daily temperatures are above 10°C, plum curculio is active. Focus on low-hanging fruit near orchard edges.
- **Degree-day models** – These can be used to estimate the risk window, but local conditions — like nearby wild hosts — add variability. Models are still being validated in Ontario.
- **Monitoring traps** – Black pyramid traps baited with synthetic lures (benzaldehyde + grandisoic acid) are commercially available (Leskey & Prokopy, 2000). However, catch is not often consistent for low to moderate populations so may not be practical for routine use in Ontario orchards.
- **Tapping trays** – When plum curculio are disturbed,



Figure 5. Late season plum curculio feeding damage.

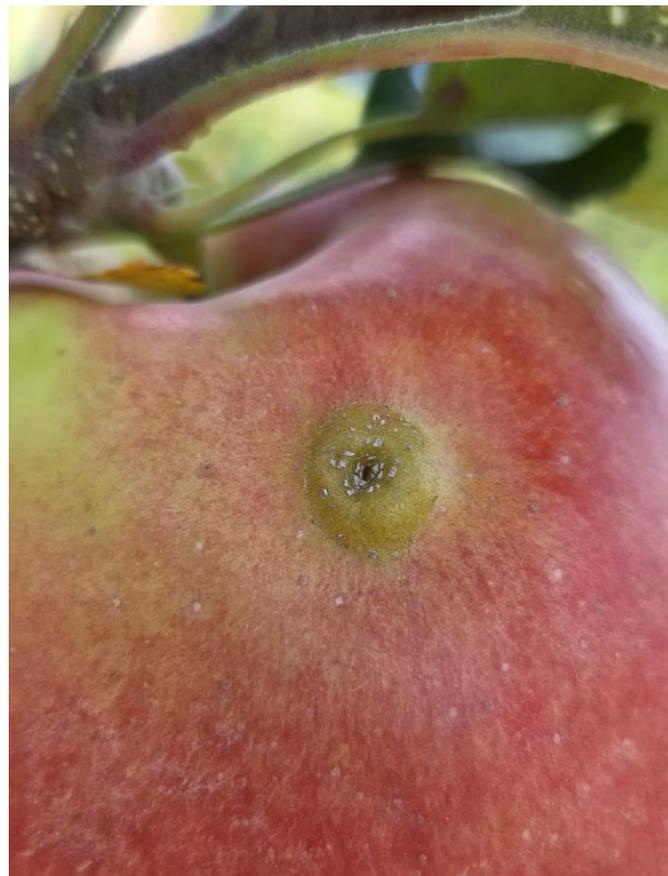


Figure 6. Corky scar left from late season plum curculio feeding damage.

they will “play dead” and fall from the tree. During regular tapping assessments while scouting, key an eye on the tray for any fallen “victims”.

Part Three: From Scars to Strategy

Because plum curculio spans multiple activity windows, growers need both **early season protective measures** and **ongoing monitoring later in the season**.

Prime Time

Petal fall insecticides remain the cornerstone of control. Timing is critical – applications should coincide with early oviposition activity, typically from petal fall until 308 DD (base 10°C) after petal fall (90% petal fall biofix) (NEWA, 2025; Reissig et al., 1998).

For activity, lifestages affected and efficacy of registered insecticides for plum curculio control, see [Table 1](#).

Where plum curculio pressure is high, follow-up application every 10-14 days (or minimum application interval stated on the product label) may be needed to protect fruit until after June drop. This may be particularly important during wet weather when residue has been washed away. Monitoring activity and signs of fresh injury, as well as rainfall amounts will help determine if extended protection is warranted.

Edge of Control

Given the strong edge effect of plum curculio activity, some research supports border-directed sprays with products such as Imidan later in the season to reduce adult feeding damage (Wise et al., 2007). However, effectiveness of border sprays using products from newer groups such as neonicotinoids (Group 4), spinosyns (Group 5) or diamides (Group 28) is unknown.



Table 1. Activity, lifestage affected and efficacy on registered insecticides for plum curculio control

Product (active ingredient)	Group (IRAC Group)	Activity	Lifestage Affected	Efficacy ¹
Imidan WP (<i>phosmet</i>)	Organophosphate (1B)	Lethal via contact	Adults	4
Ship 250 EC / Up-Cyde 2.5 EC (<i>cypermethrin</i>)	Pyrethroid (3)	Lethal, repellent	Adults	3
Perm-Up EC / Pounce 3484 EC (<i>permethrin</i>)	Pyrethroid (3)	Lethal, repellent	Adults	2
Aceta 70 WP / Assail 70 WP (<i>acetamiprid</i>)	Neonicotinoid (4A)	Lethal via contact or ingestion, antifeedant, curative	Adults, eggs	3-4
Theme 480 SC (<i>thiacloprid</i>)	Neonicotinoid (4A)	Lethal via contact or ingestion, antifeedant, curative	Adults, eggs	3-4
Cormoran (<i>acetamiprid</i> + <i>novaluron</i>)	Neonicotinoid (4A) + Insect Growth Regulator (15)	Lethal via contact or ingestion, antifeedant, curative, egg sterilization	Adults, eggs	3-4
Delegate (<i>spinetoram</i>)	Spinosyn (5)	Lethal mainly via ingestion	Adults	2
Exirel (<i>cyantraniliprole</i>)	Diamide (28)	Lethal mainly via ingestion	Adults (possibly eggs)	2-3
Rimon (<i>novaluron</i>) ²	Insect Growth Regulator (15)	Egg sterilization	Eggs	2
Harvanta 50 SL (<i>cyclaniliprole</i>)	Diamide (28)	Lethal mainly via ingestion	Adults (possibly eggs)	2
Vayego 200 SC (<i>tetraniliprole</i>)	Diamide (28)	Lethal mainly via ingestion	Adults (possibly eggs)	2
Surround WP (<i>kaolin clay</i>)	unclassified (UN)	Repellent	Adults	1-2

¹ Efficacy ratings: 1 = reduction in damage, 2 = suppression, 3 = good control, 4 = excellent control

² Targeting codling moth



Orchard Housekeeping

Removing dropped fruit can reduce larval development, though it's rarely practical at a commercial scale. Mulching fruit could be an alternative to help breakdown and decompose fruit.

Keeping orchard edges clear of wild hosts, dense vegetation, or refuges such as bins, wood piles and culls reduces overwintering sites.

Some studies suggest entomopathogenic nematodes can be applied at the base of tree to attack larvae as they drop from the fruit and pupate in the soil. However, effectiveness of this strategy varies. This is a long-term approach and does not provide effective knock-down of high pressures quickly.

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IRRIGATED & NON-IRRIGATED

ONTARIO APPLE ACREAGE SURVEY

3 QUESTIONS

2 MINUTES OF YOUR TIME

1 DROP CLOSER TO A WATER-WISE PICTURE

A GENTLE REMINDER IF YOU HAVEN'T FILLED OUT THE SURVEY

CLICK HERE

OR

SCAN ME



Clearing the Cobwebs on Copper – Part 2: Can You Count on Copper?

Katie Goldenhar, OMAFA Horticulture Plant Pathologist

In the Spring of 2023, I published an ONcore Newsletter article, [Clearing the Cobwebs on Copper](#) about how copper fungicides work. I recommend reading it as a primer for this article where we will look more closely at efficacy on apple diseases.

Are you back? Let's dive deeper into the web of copper fungicides!

There are five copper fungicides registered on apples in Canada ([Table 1](#)). Because copper ions can kill any cells, finding the right rate at the right time to impact the pathogen without impacting tree health is difficult.

In general, low-rate copper products like Cueva work better when applied on regular intervals but do not provide extended control like fixed coppers. The US has low-rate copper fungicides that are not registered here: Master Cop and Instill (5.4% metallic copper as copper sulfate pentahydrate) and Previsto (3.3% metallic copper as copper hydroxide). Lower metallic copper content reduces the risk of phytotoxicity, though there are other factors mentioned in my previous article that contribute to phytotoxicity risk. These low copper

content products are the copper applications available throughout the season with the higher rate, fixed coppers being for after 50% leaf drop and a delayed dormant application (before ¼ to ½ inch green).

Fire Blight

Fire blight, caused by the bacterium *Erwinia amylovora*, is a labelled disease on all copper products. Copper can be a useful tool when properly timed to reduce the number of bacterial cells on the surface of the trees, but its effectiveness is limited. A fixed copper delayed dormant spray can be useful in reducing the fire blight on the bark surface that is present from overwintering cankers.

Studies have shown that most fixed copper will be washed off after 3 inches of rain, and you will **still need to rely on bloom products to control fire blight**.

In Washington State, fire blight pressure is generally lower, but multi-year trials with inoculated experiments, Dupont et al. (2024) compared alternative products ([Figure 1](#)) applied during bloom. Cueva is the only registered copper product they tested that we have available in Canada. In 4 trials, there was suppression of fire blight when Cueva was applied one day before an infection event (at full bloom) and one day after the infection event. The antibiotics, streptomycin and

Table 1. Copper products registered in various crops and their corresponding metallic copper content. Always consult the product label before use.

Product (click for label)	Active ingredient	Pests on label	Metallic copper
Copper 53W	basic copper sulphate	<i>Erwinia amylovora</i> (fire blight) <i>Pseudomonas syringae</i> (blister spot / blossom blast)	53%
Copper Spray	copper oxychloride	<i>Erwinia amylovora</i> (fire blight) <i>Venturia inaequalis</i> (apple scab)	50%
Kocide 2000-0	copper hydroxide	<i>Erwinia amylovora</i> (fire blight) <i>Venturia inaequalis</i> (apple scab)	53.8%
Parasol Flowable	copper hydroxide	<i>Erwinia amylovora</i> (fire blight) <i>Pseudomonas syringae</i> (blister spot / blossom blast)	24.4%
Cueva Commercial	copper octanoate	<i>Erwinia amylovora</i> (fire blight) <i>Venturia inaequalis</i> (apple scab)	1.8%

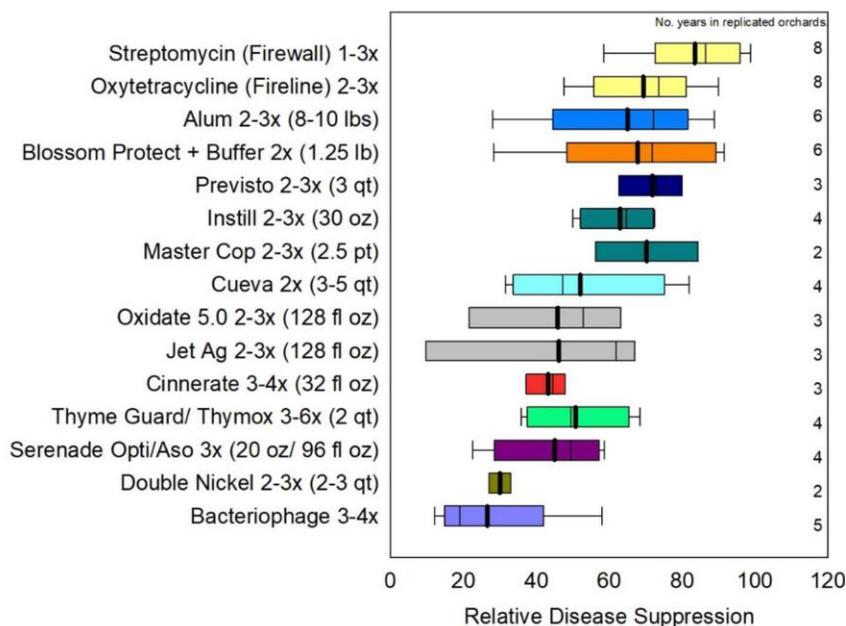


Figure 1. From Dupont et al. 2024. Relative disease suppression of multiple products against fire blight in inoculated trials.

kasugamycin, will provide the highest level of fire blight control and should be used in rotation under high-risk period as identified by a disease prediction model like [Cougar Blight](#) or [Maryblyt](#).

Blister Spot & Blossom Blast

Pseudomonas syringae is the bacterium responsible for blossom blast (Figure 2) and blister spot. This bacterium can survive in the orchard without causing disease, making it tricky to manage. Keeping plants healthy and protecting them from damage during frost events can be effective management for these diseases.

Copper 53W and Parasol Flowable are registered for this bacterium, Copper 53W for blister spot and Parasol for bacterial blight. Both uses, as a delayed dormant application, can help manage these diseases like fire blight, where they may reduce the inoculum load to allow other management to be more efficacious.

Scab & Other Diseases

For management of apple scab (caused by the fungus *Venturia inaequalis*), where there is no tolerance for early season infection, copper should not be relied upon. It typically provides disease suppression in the



Figure 2. Blossom blast in apples



early application when used for fire blight (delayed dormant) but will only last approximately 7 days before another scab fungicide application is needed – less, if there is rapid growth or heavy rain. In a New York study (Frederick et al., 2015) where fixed copper applied at silver tip, they saw increased sensitivity in *Venturia inaequalis* populations towards DMI (group 3) fungicides.

A delayed dormant use of fixed copper is widely recognized as a key part of an apple disease management program and can help reduce fungicide resistance development.

As for the many other apple diseases, they are not labelled on copper products, and I have yet to see convincing data that they should be. In my opinion, you cannot count on copper alone. It can provide suppression when you understand your product and your pest but should only be used in an integrated disease management program.

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IPM Report Card

Harvest Checklist

Why do it?

See how well your pest management program worked (efficacy, timing, gaps)

What's to learn?

Identify hot spots, specific pest issues, susceptible cultivars, or problem blocks

Understanding

what worked & what didn't will...

Save money in input costs for future IPM programs

Better prepare for **early season** action

How to....

- Choose at least 10 (large trees) or 20 (dwarf trees), chosen randomly.
- Inspect 200–400 fruit per block (20–40 fruit per tree), from upper, inner and outer canopy.
- If unable to do field assessment, evaluate 400–500 fruit per cultivar from bins.
- Keep records for reference!

What to look for...

Anything >2–5% damage is of concern.

Chewing or tunnels & frass (e.g. codling moth, OFM, leafroller)

Pits & stings (e.g. plant bug, stink bug, apple maggot)

Lesions & blotches (e.g. scab, rust, fly speck, sooty blotch, fruit rots)

scarring, ribbon-like damage or distortion (e.g. sawfly, aphids)

Raised bumps (e.g. plum curculio, mullein bug)

Branch, leaf or trunk damage (e.g. fire blight, mildew, mites, scale, borers)



CanadaGAP Pollinator Health Addendum

What Growers Can Expect

Kristy Grigg-McGuffin, OMAFA Horticulture IPM Specialist

On April 1, 2025, the [CanadaGAP Addendum for Pollinator Health](#) was released. This addendum is an optional accompaniment alongside the standard CanadaGAP audit (options C and E) to demonstrate adoption of pollinator-protective IPM practices. While CanadaGAP offers the addendum as an optional checklist, it is mandatory for growers who supply to customers like Walmart.

For more information and to download the Pollinator Health checklist, visit the [CanadaGAP website](#) under 'Tools'.

This addition aligns with Walmart's pledge that by the end of 2025, the company will source 100% of its fresh produce from suppliers who adopt IPM practices, verified by third-party programs like CanadaGAP with the Pollinator Health Addendum. This addendum has been benchmarked by the IPM Institute of North America and recognized as meeting Walmart's pollinator-protection requirements.

Growers should **contact their CanadaGAP Certification Body** for information on whether they need the addendum for their sales and for details on the costs involved.

What to Expect in the Audit

Growers will see an extra focus on how pest management decisions are made and documented. This means being able to show auditors **not just what you sprayed, but why you sprayed it**.

Auditors will review how you:

- Monitor pests, and only apply pesticides when economic thresholds are met.
- Keep records of scouting, thresholds, and spray applications.
- Demonstrate strategies that minimize pesticide risk to pollinators.
- Maintain or enhance pollinator habitat on-farm.

They'll also look for whether non-chemical practices are being integrated, and how you mitigate pesticide resistance in your IPM program.

Key Elements of the Pollinator Health Checklist

From the documents included in the [CanadaGAP Addendum for Pollinator Health](#), here's what auditors are likely to verify, and the kinds of justifications or explanations (documents, observations, practices) you'll need to provide. Prior to an audit, be sure to review the checklist in detail.

Prevention / Intervention

What auditor may check: Use of non-chemical strategies to prevent and control a pest, including cultural, mechanical/physical, biological, and/or behavioural.

Examples could include:

Cultural

- Resistant cultivars or rootstocks – for more information on pest susceptibility of common cultivars and rootstocks, see [here](#) and [here](#).
- Irrigation schedule
- Fertility testing and proper nutrient program
- Pruning – including to open canopy, improve air circulation, or remove diseased tissue
- Mulching – to encourage decomposition of leaves, fruit and/or branches

Physical

- Deer fencing
- Mass trapping
- Netting



Biological

- Natural predators and parasitoids – for more information on product toxicity to common beneficial species, refer to the Toxicity to Beneficials section under 'View Details' of a product in the [Ontario Crop Protection Hub](#).
- Granulosis virus or other biological control products

Behavioural

- Mating disruption

Monitoring / Identification

What auditor may check:

- Utilizing appropriate techniques, including regular visual assessments (scouting), traps, weed mapping, forecasting models, and weather monitoring.
- Ability to identify insects, disease, weeds and any other pest which usually requires action (or proof of trained scout or consultant with ability).
- Understanding of key pest biology and life cycle, including how it relates to crop growth stages, crop-damaging life stages, and important behaviours related to IPM (or proof of trained scout or consultant with ability).

Record-Keeping

What auditor may check: Records kept of scouting and monitoring activities, as well as spray records, nutrient/fertilizer applications, and equipment maintenance (e.g. calibration, cleaning).

Implementation

What auditor may check: Management decisions based on scouting reports and action is taken only when pest populations exceed the economic threshold (see the next section, [Thresholds to Watch](#) for more details).

Implementation also includes written pest management plan with training records or staff awareness, if necessary, and evidence of review or changes in plan.

Pollinator Protection

What auditor may check: How pesticides are planned and applied so as to limit pollinator exposure: timing, choice of product, and protective measures.

Examples could include:

- Avoid insecticide use during bloom
- Spray in evening or early morning when bees aren't active
- Assess chemical risk (e.g. toxicity to beneficials) and select low risk options
- On-farm or nearby habitat to support pollinators, including flowering plants, nesting areas and water sources
- Safe buffer zones

For more information on product toxicity to common beneficial species, refer to the Toxicity to Beneficials section under 'View Details' of a product in the [Ontario Crop Protection Hub](#).

Resistance Management

What auditor may check:

- Ability to identify pests at greatest risk for resistance.
- Understanding of chemical groups by modes of action (FRAC/IRAC group).
- Utilizing resistance mitigation strategies to manage risk.

Examples could include:

- Rotate modes of action
- Tank-mix with different groups, where applicable
- Use labelled rate
- Use chemical controls only when needed
- Integrate non-chemical strategies
- Provide untreated refuge

Information to Have Ready

- **Scouting records** – including trap counts, regular visual observations, and thresholds
- **Forecast models** – including degree day calculations, where applicable; this can also come from extension or regional alerts (e.g. fire blight prediction maps, consultant reports, ONfruit blog)
- **Spray records** – including product, rate, timing, and weather conditions at application



- **Pollinator protection notes** – e.g. avoiding insecticide use during bloom, or spraying at night when bees aren't active
- **Habitat management** – documentation of hedgerows, flowering strips, or cover crops that provide forage for beneficials

Thresholds to Watch

Effective IPM relies on knowing when pest levels trigger intervention.

Economic threshold is the pest density at which action should be taken to prevent an increasing pest population from reaching economic injury level.

Determining a threshold may be based on visual observations of pest or damage, trap counts, degree day timings, specific weather conditions favourable to disease development, and/or cultivar value and costs of control measures.

When to Respond

For insects, thresholds are usually **reactive** and based on the presence of the pest at certain levels. For example,

- Codling moth sprays are recommended when trap counts exceed 5+ moths per week, timed with degree day models to target egg hatch.
- Apple maggot control is triggered 7-10 days following catch on a yellow sticky card or immediately following catch on a red sphere.
- Mullein bug exceed threshold when 7-9 nymphs are caught per 25 taps in a block.

Thresholds for direct pests, which feed on fruit and have an immediate effect on fruit quality, are generally lower than thresholds for indirect pests that feed on leaves, branches or roots.

For general monitoring and threshold guidelines for common insect pests, see [Table 1](#).

For disease, management guidelines tend to be more **preventative** and may be based on the pest's damage potential. Because diseases like apple scab or fire

blight can spread rapidly under the right conditions, sprays are often applied before infection events. This is estimated using weather models, crop tolerance, stage of crop development and field observations.

For general monitoring and threshold guidelines for common disease pests, see [Table 2](#).

Benchmarks

General economic thresholds in apples are often cited at 2-5% damage before control is warranted. However, this number can vary:

- For **high-value cultivars** (e.g. Honeycrisp, Ambrosia), thresholds may be as low as 1-2% damage since even small blemishes can downgrade fruit to processing grade.
- For **processing-oriented orchards**, a higher tolerance may be acceptable.
- For **young or high-density orchards**, trees may not be able to tolerate high pest pressures before economic injury occurs.
- For **standard established orchards**, a higher tolerance may be acceptable, especially later season as the canopy fills out.

This means growers must weigh orchard age and system, market destination and cultivar value when deciding if a spray is economically and agronomically justified.

Outdated Thresholds?

It's worth noting, thresholds have not been developed or validated for all pests in Ontario. **Even established thresholds require continuous adjustments for different cultivars, markets and crop vigour.** Many of the thresholds used were originally developed on large, standard-sized trees with different canopy architecture, spray coverage patterns and pest dynamics.

With today's high-density, dwarf rootstock orchards, several questions arise:

- Are thresholds still valid, or do more susceptible cultivars or smaller trees require tighter intervention levels?
- Does increased canopy uniformity mean pests establish and spread differently?
- Should we be lowering thresholds for pests like



mites, where even low populations can cause visible bronzing or stress on high-density trees with higher yields per acre?

Until new research adjusts these benchmarks, growers are encouraged to use **professional discretion**: combining monitoring data, cultivar value, orchard system, non-target species impact, and market requirements when making control decisions.

Actions to Improve Pollinator Health

To not just pass the audit but to move toward sustainable farm practices that support pollinator health:

- Establish or enhance flowering strips or hedgerows in or adjacent to orchards with different bloom times (early, mid, late season) for continuous forage.
- Create or preserve nesting sites: patches of bare ground, brush, undisturbed edges.
- Provide water sources for bees – shallow dishes, water troughs, or natural sources with easy access.
- Reduce unnecessary mowing during bloom
- Choose pesticides with lower non-target toxicity, avoid insecticide applications during bloom or when pollinators are actively foraging, and apply at times when bees are less active (late evening, etc.)
- Use alternative strategies, where possible: cultural (pruning, thinning, nutrition), biological, etc.
- Scout regularly and use forecast models to better time interventions – fewer sprays, better timing.
- Train staff to identify pollinators, understand pollinator risk and proper application.
- Keep good records!

Bottom Line for Growers

While the pollinator addendum could be seen as adding red tape – it formalizes many practices that growers are already using through IPM. Being prepared with good records of your already existing IPM-based decisions and pollinator-friendly practices will make the audit smoother while demonstrating to buyers and consumers that Ontario apples are grown responsibly.

Information to Help

CanadaGAP

[Addendum for Pollinator Health](#)

[Pollinator Health Addendum Checklist](#)

[Component 6 – CanadaGAP Program Management Manual](#)

Bee Health

[Practices to Reduce Bee Poisoning from Agricultural Pesticides in Canada](#)

[Protecting Pollinators](#) – training module for certified pesticide applicators, pesticide and crop advisors, and agricultural producers

[Protecting Pollinators from Pesticides in Apples](#)

[Using Pesticides in Ontario](#)

Ontario Crop Protection Hub

[Apple Search](#) – product rates, efficacy, toxicity

[Product Search](#) – quick find for a specific product

[Supporting Information](#) – supplemental resources for apple growers

Pest Management

[Ontario Crop IPM - Apples](#)

[Apple IPM Workshop Series](#) – YouTube

[Guidelines for Using Insect Pheromone and Visual Traps in Orchards](#)

[Disease Susceptibility Ratings of Common Apple Cultivars](#)

[Insect and Disease Susceptibility Ratings of Common Apple Rootstocks](#)

[Managing Pesticide Resistance](#)



Table 1. Monitoring and Threshold Guidelines for Common Apple Insect Pests

Pest	When to Look	Monitoring	Threshold
Apple maggot	July to harvest	Use yellow sticky cards and/or red sticky spheres. Check weekly.	Apply 7-10 days after first catch on yellow card or immediately after first catch on red sphere
Codling moth	Bloom to harvest	Use pheromone traps. Check weekly. Accumulate degree days starting first sustained moth catch and base 10°C.	1 st generation (eggs) – 50-100 DDC 1 st generation (larva) – 111-138 DDC 2 nd generation – 639-694 DDC *timing varies depending on product
Dogwood borer	June to harvest	Use pheromone traps. Check weekly.	Apply 7-14 days after peak flight *timing varies depending on product
European apple sawfly	Pink to early summer	Use white sticky card or 3D trap. Check weekly.	Apply prebloom if monitoring indicates early activity. Apply postbloom if 6 sawflies (prebloom insecticide applied) or 3 sawflies (no prebloom insecticide applied) per trap
Green apple aphid	Green tip to harvest	Examine 100 terminals weekly.	10% infested terminals *20%, if predators present
Japanese beetle	July to August	Monitor for adults and feeding damage.	No threshold available.
Leafcurling midge	Tight cluster to harvest	Accumulate degree days starting March 1 st and base 9°C. Alternatively, examine terminals for eggs weekly.	1st generation – 76-132 DDC 2nd generation – 430-556 DDC 3rd generation – 942-1160 DDC OR If eggs observed
Mites	Dormant	Look for overwintering eggs on spurs.	If eggs observed
	Tight cluster to harvest	Examine 2 leaves from 25 trees weekly.	Early season – 5-7 mites/leaf Mid season – 7-10 mites/leaf Late season – 10-15 mites/leaf *timing varies depending on product – some should be applied earlier, as populations are building
Mullein bug	Petal fall to 2-3 weeks later (10-12mm)	Make 25 taps on randomly selected trees weekly.	7-9 nymphs per 25 taps
Obliquebanded leafroller	Tight cluster to June	Examine 50 terminals and 50 buds/blossoms weekly.	1-2% infested terminals or buds
	June to August	Use pheromone trap. Check weekly. Accumulate degree days starting first sustained moth catch and base 6.1°C.	240-280C



Table 1. Monitoring and Threshold Guidelines for Common Apple Insect Pests (cont.)

Pest	When to Look	Monitoring	Threshold
Oriental fruit moth	Late April to harvest	Use pheromone traps. Check weekly. Accumulate degree days starting first sustained moth catch and base 7.2°C.	If >10 moths per trap per week. Apply 6-10 days after upswing in trap counts. OR 1 st generation – 194-208 DDC 2 nd generation – 805-833 DDC 3 rd generation – 1361-1389 DDC *timing varies depending on product
Plum curculio	Bloom to early summer	Look for perimeter damage weekly.	At first sign of injury
Potato leafhopper	June to harvest	Examine 100 leaves weekly.	No threshold available. 1-2 nymphs per leaf can cause leaf curling.
Rosy apple aphid	Tight cluster to mid season	Examine 100 clusters weekly.	5% infested terminals
Scale	Dormant	Examine bark for 'black caps' (nymphs). Use a knife to peel back wood to look for discoloration of underlying tissue.	If harvest assessments from previous year indicate pressure.
	Pink to harvest	Accumulate degree days starting March 1 st biofix and base 10°C. Alternatively, wrap electrical tape on infested trees to monitor for crawlers.	1 st generation – 278 DDC 2 nd generation – 806 DDC OR At first sign of crawlers
Spring-feeding caterpillar	Half inch green to July	Examine 50 terminals and 50 buds/blossoms weekly.	12-15% infested terminals or buds
Tarnished plant bug	Pink to petal fall	Monitor for adults and feeding damage.	No threshold available
White apple leafhopper	Pink to harvest	Examine 100 leaves weekly.	2-5 nymphs per leaf
Woolly apple aphid	Tight cluster to harvest	Monitor for waxy covering around pruning cuts, limbs, and water sprouts weekly.	No threshold available



Table 2. Monitoring and Threshold Guidelines for Common Apple Diseases

Pest	When to Look	Monitoring	Threshold
Apple scab	Green tip to harvest	Monitor leaves and fruit for lesions. Monitor weather conditions and leaf wetness. Accumulate degree days starting 50% green tip and base 0°C.	Apply when conditions are conducive to infection. Between 125-418 DDC, risk of infection is highest.
Bitter rot	Petal fall to harvest	Monitor fruit for lesions weekly.	No threshold available. Apply when conditions are conducive to infection (warm and wet).
Black rot	Tight cluster to harvest	Monitor leaves, limbs and fruit for lesions weekly.	No threshold available. Apply when conditions are conducive to infection (warm and wet).
Fire blight	Dormant	Note presence of overwintering cankers.	Prune out if observed
	Bloom	Monitor weather conditions and blossom development. Use forecast models such as Cougar Blight, Maryblyt or follow the Ontario Fire Blight Prediction Maps.	Apply during bloom when conditions are conducive to infection (>18°C, humid and wet). OR When epiphytic infection potential reaches 100 or risk is high/extreme (moderate risk for biological products).
	Active shoot growth	Note symptom development on shoots, fruit, canker or rootstock.	Prune out if observed. Apply when conditions are conducive to infection (>18°C, humid and wet).
Fly speck	Mid summer to harvest	Monitor fruit for lesions weekly.	No threshold available. Apply when conditions are conducive to infection (moderate temperatures and high humidity)
Powdery mildew	Green tip to terminal set	Monitor terminals weekly.	Apply when conditions are conducive to infection (warm and humidity, no rain).
Rust	Pink to harvest	Monitor cedar prebloom for presence of overwintering galls. Monitor leaves and fruit for lesions weekly.	No threshold available. Control if previous season had pressure.
Sooty blotch	Mid summer to harvest	Monitor fruit for lesions weekly.	No threshold available. Apply when conditions are conducive to infection (moderate temperatures and high humidity)

Why Are My Airblast Nozzles Plugging?

Possible Causes & Solutions

Dr. Jason Deveau, OMAFA Application Technology Specialist

This article was inspired by the following email and [Figures 1 & 2](#):

"I'm an organic apple grower with constant nozzle-clogging problems. These problems occur when we use wettable powders such as micronized sulfur and Surround WP. We always premix before adding to the tank through its strainer.

Our airblast sprayers have towers and employ mechanical agitation. The nozzle/filter combo is TeeJet TXR8001K Ceramic Conejet Visiflow Hollow Cone spray tips with TeeJet 4514NY10 50-mesh nylon slotted strainers. The nozzle strainers rarely make it through a full tank without having problems. Do I need to add an additional level of filtration or is there something that I'm missing?"

You can almost feel the frustration. When I receive grower enquiries, I first turn to the library of articles on Sprayers101 as well as the [Airblast101 textbook](#). I was surprised to discover that we didn't have anything that addressed this issue directly. So, I checked through university extension and industrial resources. Ultimately I couldn't find what I was looking for, so let's correct this oversight.



Figure 1. A clogged slotted strainer inside the nozzle body. Note that the inners of the check valve seem clear (a good thing).

Possible Causes

There may not be a single reason for why nozzles plug. It might be a combination of the following factors:

Product choice

While any tank mix can create clogs if they prove to be *physically incompatible*, there are two formulations that have a reputation for clogging nozzles.

- **Wettable powder (WP)** formulations such as micronized sulfur and diatomaceous earth are notorious for clogging nozzles. WPs consist of a finely ground solid active ingredient often combined with wetting and bulking agents to help hold them in a dilute suspension. They tend to be dry products rather than liquids.
- In a similar vein, **suspension concentrate (SC)** formulations also consist of a finely ground solid active ingredient, but this time they are suspended in a liquid and kept dispersed in the sprayer tank by wetting agents, dispersants, and thickeners. These formulations are known as "flowables" or "suspensions".

Mixing practices

Pre-slurries are sometimes prescribed for SCs. I personally feel that pre-slurries create exposure risks and more things to clean, but this opinion is moot in the case of WPs: Micronized sulfur and diatomaceous earth are not soluble. They're particles that are held in



Figure 2. A clogged slotted strainer.



suspension by fluid flow or agitation, so there's no point in a pre-slurry.

For those readers that cook, consider the corn starch metaphor. You're making a sauce, and you choose to thicken it with a pre-slurry of corn starch and water. The particles disperse, but do not dissolve, so if you fail to use it immediately they settle to the bottom of the container. They must be forcibly scraped up and resuspended.

Agitation

Best practice is to fill the tank at least ½ full of water and engage agitation before you add anything. To extend the cooking metaphor, you want a simmer but not a rolling boil. Once filled, *never stop agitating* or WPs and SCs will settle and may not resuspend uniformly, if at all.

Your sprayer design may affect matters. Some hydraulic agitation systems flag if they have undersized pumps. If your pump is busy sending flow to the nozzles, it may not have sufficient capacity to run the agitation. When your sprayer is "empty", is there a thick accumulation at the bottom? You may have insufficient hydraulic agitation. Mechanical (paddle) agitation does not suffer this issue because it is direct-driven off the PTO. Read more [here](#).

Clean-out practices

Perhaps plugs are occurring because of the previous tank, not the current tank. WPs can leave a buildup of settled pesticide in the tank, suction strainer and nozzle strainers. If you aren't diligent about *rinsing at the end of each day*, products will settle and harden. Micro sulfur particles, for example, are less than 10 µm in diameter and harden into a flakey shell that can break loose and cause plugs.

Flow restriction

Several things can restrict flow. Elbows, bends and fittings can increase friction, reducing flow. The greater the distance a fluid needs to travel, the more flow is reduced. The greater the head (a pump's head is the maximum height that the pump can achieve pumping against gravity), the more flow is reduced. There is an excellent description of this relationship [here](#).

So, if an operator is using nozzles with a particularly small orifice, plus nozzle strainers, on a vertical boom,

liquid flow will be reduced. This allows particles to fall out of suspension and settle, forming further restriction to flow and eventually, plugs.

Possible Solutions

Now, armed with these potential causes, let's return to the grower. After some back-and-forth, he clarified that the clogs were a problem, but restricted flow was worse. An operator will stop to *clean or replace* a plugged nozzle, but may not notice reduced flow. This has the potential to affect several rows as well as leave unsprayed product in the tank.

My first proposal was to increase nozzle size. An '01 tip is very, very small and even with slotted strainers (as opposed to mesh), that's a lot of restriction. I suggested recalibrating for larger tip orifices. This is a rather *involved process*, but options included using every second nozzle (as long as there were no gaps in coverage), and/or dropping pressure, and/or increasing *travel speed* (as long as the spray still reached the tree top and canopy centre). I shared this [Excel output calculator](#) to help with the process.

Failing that, we discussed a plumbing project. Section 5.2.1 of [Airblast101](#) describes a way to create a self-cleaning line filter that replaces nozzle strainers. That means instead of climbing a ladder to pull tips off a tower to reach the strainers, all filtration is conveniently located at ground level for easier (and more frequent) *cleaning*.

The Outcome

The grower felt the numbers worked best running orange 02 TXR's in every second position. He ordered new 50 mesh slotted nozzle strainers. His new operating parameters would be 5 nozzles/side, at 8.2 bar (120 psi) and 5.1 km/h (3.2 mph) for a total 51.5 L/ha (55 gpa). He noted some incompatibility issues running Braglia nozzle bodies (spec on his Rears sprayer), TeeJet TXR's, TeeJet slotted strainers and TeeJet CP20230 caps. That was an important observation, and you can learn more about it [here](#).

We felt good about this, but while there was an improvement, it didn't solve the problem. There was still strainer clogging after the first tankload. So, he added inline filters and removed the tip strainers ([Figures 3-5](#)). The result:



"Yesterday I sprayed over 350 pounds (over 1000 gal) of Surround WP and had no issues. I'm really excited about this new setup - it looks very promising. I've attached more pics if you're interested (I don't spend a lot of time scrubbing sprayers until after Surround season). Thanks again for all your help in this matter." - Joe Fahey, Peck & Bushel Fruit Company

Fantastic. Thanks to Joe for letting me share this story. Hopefully his experience will help you diagnose and solve any flow or nozzle plugging issues in your own operation.

Happy Spraying.

You Might Also Like

1. [Remove and Scrub Your Filters - Even When You Use Down](#)
2. [Strainers \(aka Filters\)](#)
3. [The Agitation Over Agitation](#)
4. [Measuring Pressure Drop](#)



Figure 3. A 50 mesh inline filter assembly with a 1/4 turn ball valve for quick flushes.



Figure 4. New filter plumbed and secured. Note the anti-rub wrap on the line - always a good idea.



Figure 5. The new loadout. O2's in every second position, with no tip strainers, and a new inline filter on each side of the sprayer.



POSTHARVEST

Controlled Atmosphere (CA) Storage for Apples

Dr. Jennifer DeEll, OMAFA Horticulture Fresh Market Quality Specialist

Optimum harvest maturity is essential. Apples must be harvested when physiologically mature but not ripe for successful controlled atmosphere (CA) storage. Each cultivar must be harvested at the proper maturity in order to achieve maximum storage life and marketing season.

If apples are harvested too early, they are of poor colour, small size and have little flavour. They also may fail to ripen or 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 flavour development. Immature apples are also more likely to develop superficial scald 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 disease infection and various storage disorders, including soft scald, soggy breakdown, flesh browning, and senescent breakdown. Over-mature apples can also develop poor eating quality and off-flavours.

For the above reasons, the determination of optimum apple maturity for harvest is essential for maximum storage life and quality, while minimizing postharvest losses. 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 generally fairly constant but can vary in any one year. 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, starch-iodine staining, color changes (including delta absorbance readings), flesh firmness, soluble solids content (sugars), and acidity. It is important to note that not all apples mature and ripen in the same manner each year. Furthermore, there will sometimes be a need to compromise between correct maturity and the required firmness and sugar levels for market.

Apples should 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 internal browning / breakdown or bitter pit development:

- Large fruit from lightly cropped trees
- Fruit from excessively vigorous trees
- Fruit from young trees just coming into bearing
- Fruit from interior parts of trees that are heavily shaded
- Early harvested fruit high in starch
- Fruit with a low number of seeds.

Fruit off the tree mature much faster and begin to ripen sooner with warmer temperatures.

Some apple cultivars require cooling as quickly as possible after harvest, while others prefer slow stepwise cooling or conditioning prior to setting the final storage temperature ([Table 1](#)). Cooling to some degree is needed before establishing CA. Oxygen (O₂) and carbon dioxide (CO₂) levels are also specific to individual cultivars.

CA storage will not improve fruit quality, so place only the best fruit into CA storage. If over- or under-mature or poor quality apples are put into CA, the result will be poor quality apples upon removal. Successful CA storage begins by harvesting apples at the proper maturity, followed by adequate cooling and establishment of CA conditions, with proper maintenance of the desired temperature and atmosphere thereafter.



Table 1. Controlled atmosphere (CA) storage guidelines for apples.

Cultivar	O ₂ (%)	CO ₂ (%)	Temp (°C)	Important Notes
Ambrosia	1.2 – 1.7	1 – 1.5%	0.5 – 1	Slow cooling or conditioning necessary with 1-MCP; <1% O ₂ possible with fruit monitoring (SafePod, etc.)
Cortland	1.5 – 2.5	1.5 – 2	0.5 – 2	Higher temp with 1-MCP; Sensitive to CO ₂
Crispin/ Mutsu	1.5 – 2.5	1.5 – 2.5	0 – 0.5	—
Delicious (Red)	1 – 2	1 – 2	0 – 0.5	<1% O ₂ possible with fruit monitoring (SafePod, etc.)
Empire	1.5 – 2	1 – 1.5	2	Extremely sensitive to CO ₂ ; Keep CO ₂ <0.5% for 1 st month if not treated with DPA
Fuji	1.5 – 2	0.5 – 1	0 – 1	Sensitive to CO ₂ ; Delay CA with 1-MCP
Gala	1 – 2	0.5 – 1.5	0.5 – 2	Higher temp with 1-MCP; <1% O ₂ possible with fruit monitoring (SafePod, etc.)
Golden Delicious	1 – 2	1 – 2	0 – 1	Slow stepwise cooling with 1-MCP; <1% O ₂ possible with fruit monitoring (SafePod, etc.)
Granny Smith	1.5 – 2	0.5 – 2	0 – 1	<1% O ₂ possible with fruit monitoring (SafePod, etc.)
Honeycrisp	2 – 3	1 – 3	3 (after conditioning at 10°C for 5–7 days)	Delay CA for 1 st month if not treated with DPA
Idared	1.5 – 2.5	1.5 – 2.5	0 – 1	—
Jonagold	1.5 – 2.5	1.5 – 2	0 – 1	Higher temp with 1-MCP
McIntosh	2.5	2 for 1 st month, then 4.5	3	Sensitive to CO ₂ with 1-MCP
Northern Spy	1.5 – 2.5	1.5 – 2	0 – 0.5	Sensitive to CO ₂
Spartan	2 – 3	2 – 2.5	0.5 – 1	—

Adapted in part from DeEll, J.R. 2020. *Pome fruits: Apple quality and storage*, p. 293-298. In: M.I. Gil and R. Beaudry (eds). *Controlled and Modified Atmosphere for Fresh and Fresh-cut Produce*. Elsevier Academic Press, United Kingdom.



ANNOUNCEMENTS

Ontario Pest Management Conference October 24, 2025

Get ready for the 2025 Ontario Pest Management Conference (OPMC)! This conference offers an exciting opportunity to learn about the latest strategies and technologies shaping integrated pest management (IPM).

With registration now open until **Friday, October 10**, it's the ideal time to secure your spot. Don't miss the chance to connect with leaders in the industry!

To register, visit the OPMC website at
www.ontariopmc.ca

Event Details

This year's conference takes place on **Friday, October 24**, at the picturesque **Royal Botanical Gardens (Rock Garden)** in Hamilton, Ontario. The theme will be taking pest management to new heights, focusing on:

"Drones & Pests: Aerial Strategies for IPM"

The event will run from **8:30 AM to 4:30 PM** with an afternoon symposium on biological control. Attendees can expect a full day packed with informative presentations, engaging discussions, and networking opportunities.

We are pleased to be holding this year's conference in conjunction with the [162nd Annual General Meeting of Entomology Society of Ontario \(ESO\)](#). In addition to the joint biological control symposium and evening mixer, attendees can register for the ESO program on October

25-26. See <https://www.entsocont.ca/> for more information.

Plus, everyone will have complimentary access to the beautiful trials at the Royal Botanical Gardens, which provides a stimulating setting for both learning and some relaxation.

Featured Speakers

This year's lineup features remarkable experts who will offer valuable insights:

- **Dr. Michael Reinke**, a Viticulture Specialist from Michigan State University Extension, will explore **'Application drones: A new tool for modern pest management strategies'** including the challenges and successes of coverage and efficacy for both insect and disease management.
- **Dr. Rebecca Schmidt-Jeffris**, a Research Entomologist with the U.S. Department of Agriculture – Agriculture Research Service, will focus on **'It's raining bugs! Benefits and challenges of deploying pest predators by drone'** in agricultural settings.
- **Angela Fawcett**, a Registration Product Manager with Corteva Agriscience, will discuss the Canadian registration journey for **Garlone XRT – Canada's first herbicide with drone application** and the future of drone-applied registrations.

Student Competitions

Students will have the chance to showcase their research through competitions, making this a highlight of the conference. Graduate students can participate in the **CropLife Canada - Ontario Region poster and paper competition**, while undergraduate students are invited to engage in the **Dr. C.R. Harris undergraduate student poster competition**.

These competitions are not just platforms for showcasing research; they also create connections with industry professionals. This networking can be a game-changer for students as they prepare to enter the workforce.



Biological Control Symposium

In the afternoon, the conference will feature a **Biological Control Symposium**. Participants will learn about the latest advancements in biological pest control methods in Ontario. The session will discuss strategies that have shown up to a 40% reduction in chemical pesticide use, focusing on sustainable practices that can be applied in real-world settings.

Speakers during this symposium include:

- **Dr. Sarah Jandricic**, Ontario Ministry of Agriculture, Food & Agribusiness
- **Dr. Rose Labbe**, Agriculture & Agri-Food Canada
- **Dr. Sandy Smith**, University of Toronto
- **Dr. Rob Bouchier**, University of Toronto / Agriculture & Agri-Food Canada
- **Dr. Andrew C. Wylie**, Vineland Research & Innovation Centre

Industry Updates

The OPMC will also host presentations and posters that focus on the most recent trends and technologies in crop protection. Attendees will learn about innovative solutions that could impact their work. Staying informed about these developments is vital in today's fast-changing agricultural landscape.

Registration Options

Registering for the conference is easy and offers several options to meet different needs. Participants can select from OPMC events only, ESO events only, or both.

Pricing Tiers

- **Regular:** \$150.00
- **Student:** \$60.00

This tiered pricing encourages both students and experienced professionals to attend, creating a rich and diverse learning environment.

Don't Miss Out

The 2025 Ontario Pest Management Conference promises to be an outstanding event for anyone in the field. With a focus on the latest research, new

technologies, and collaboration, this conference is designed to foster knowledge-sharing and professional networking among attendees.

Whether you are a seasoned expert or a student eager to learn, the OPMC has something valuable for you.

We look forward to seeing you there!

For more information about speakers and registration, please visit the OPMC website at <https://www.ontariopmc.ca/>

AgRobotics Working Group Research Funding Available

Background

In 2021, the Ontario-based AgRobotics Working Group was formed to bring together a cross-functional group of members to reduce barrier to robotics / automation adoption.

Funding for on-farm research is guided by items outlined in the Sustainable Canadian Agricultural Partnership (Sustainable CAP). Under the Building Sector Capacity, Grown and Competitiveness Priority Area and Productive Designed Program, which will contribute to intermediate and/or crosscutting outcomes such as:

- The sector has modernized its systems, equipment, and facilities and implemented new practices, processes, and technologies.
- The sector has increased capacity through new technologies, equipment, practices or processes
- The sector has increased capacity and growth across the entire agri-food value chain.

Key Goals

The key goals of the funding Ontario-based agrobotics research is to de-risk adoption by:

- Undertaking applied research to test and



demonstrate robotics and technologies at the commercial field scale level to ensure they meet producer needs

- Sharing this knowledge at knowledge translation and transfer events

Focus

The Western Fair Association, through the AgRobotics Working Group, is seeking interested producers, or commercial robotics companies, to test and demonstrate technology at the commercial field scale level.

Funds are still available for projects between September 26th, 2025 and March 31st, 2026.

This could be modifications to a robotic unit for a 2026 growing season project, or a Fall 2025 project. Please see [application information](#) for how to apply.

Timelines for 2026 Projects

- October 1, 2025 – December 31, 2025: Application period for proposals
- January 1, 2026 – January 30th, 2026: Proposal review and selection
- February 15, 2026: Notification to successful applicants

- February 25, 2026: Notification to unsuccessful applicants
- March 1, 2026: Presentation of Summer Projects to AgRobotics Working Group
- May 1, 2026: Projects commence (unless start date otherwise changed)
- July 1-31, 2026: Presentation to ARWG on status of project
- Oct 30, 2026: Project end
- November 1-30, 2026: Presentation to ARWG on status of project
- December 29, 2026: Final report due to ARWG for review before adding to Annual Report
- In the event that there is funding remaining, Western Fair District will direct the research sub-committee to provide further information on timelines to accept proposals on a rolling basis.

For a program guide, budget worksheet and application form, visit the AgRobotics Working Group website at

<https://www.agroboticswg.com/research-1>

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