ONcore
For Commerical Apple Producers

Volume 29, Issue 4, Fall 2025

SEEDING NEXT YEAR'S SUCCESS!

COOL TIPS FOR DIALING IN 2026:

- Bitter pit management starts with the soil.
- Manage bitter pit by controlling vigour, managing nutrients, controlling crop load and adpating for cultivar/rootstock combos.
- Data driven irrigation scheduling mitigates tree stress, aiding in fruit and tree resiliency.
- Tailor your nitrogen to cultivar, rootstock and soil — plus use postharvest urea to reduce scab pressure (but consider the N input!).
- Get weeds early to minimize competition for water and nutrients, especially with drought-stressed trees.
- Watch your replant — drought can increase herbicide carryover risk and damage to new trees.
- Clean out infected wood, remaining fruit (including mummies) and mulch fallen leaves to minimize pest pressure before buds break.
- Audit your season by reviewing records to spot gaps or trends that affected fruit quality.
- **Read, attend & prep!** Use the off-season to dive into ONcore archives and get inspired at the Ontario Fruit & Vegetable Convention.

ANNOUNCEMENTS

- Ontario Fruit & Vegetable Convention Line-up
- **Register Now** for the Ontario Sweet & Craft Cider Competitions
- **P**recision **A**pple **C**rop Load **Man**agement (PACMAN) Webinar

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Ontario

ORCHARD MANAGEMENT

A Pitfall in the Pipeline – Part 2:
Challenging the Pit Problem

Erika DeBrouwer, *Tree Fruit Specialist, OMAFA*

The Bitter Truth

While this page revisits key points from the previous article, readers are strongly encouraged to first review A Pitfall in the Pipeline – Part 1: Calcium's One-way Ticket from the last issue of ONcore. Doing so will help ensure a clear understanding of calcium transport in apple trees before diving into this article's focus on bitter pit mitigation strategies.

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

As a reminder, here are the key factors contributing to localized calcium deficiencies in apple fruit:

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

Keep in mind that many of these factors interact with one another—some may either promote or suppress bitter pit depending on the tree's physiological response and any resulting cascade of effects.

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

Season's Feedings

As a refresher, understanding the seasonal calcium demand of apple trees is essential for recognizing how calcium levels fluctuate throughout the season. This knowledge supports timely and targeted mitigation strategies. Apple calcium (Ca) 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 Ca. 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 Ca is needed during this period as buds are initiating growth and limited Ca uptake occurs. Most of the Ca required at this time goes toward green tissue development.

Full Bloom to Fruit Set

Ca 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 Ca is needed here. Cell division and expansion are occurring at this time in the fruit, where both activities require Ca. Ca is also needed in leaf tissues, but much of the Ca is allocated to the fruit.

Fruit Maturation

Ca 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 Ca requirements.

Harvest to Post Harvest

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

Match Made in the Orchard

Bitter pit management begins before planting the tree, where focus should be made on soil implications, along with selection of rootstock and cultivar.

Soil Considerations

When planning to plant a bitter pit prone apple cultivar, it is best to consider your soil to decrease the potential occurrence of it happening in your orchard. Soil Ca levels, pH, moisture, texture, structure, nutrient balance and pre-plant testing should all be thought through and considered, especially given that they influence one another.

Soil Ca levels aren't typically an issue in Ontario, although it is a factor that should be considered. If there is a need for soil Ca levels to increase be sure to perform this activity well in advance, as this can take 2 to 3 years before effects are seen.

pH should be between the optimal ranges, typically between 6.5 to 7.0, but certain cultivars may want a more basic or acidic soil. A low pH can result in aluminum and manganese toxicities, reducing Ca availability. Conduct soil testing both prior to and following pH adjustments (if required), ensuring sufficient lead time to allow for additional amendments before planting.

Moisture is important to make sure Ca can move throughout the tree when needed. Fluctuations in soil moisture have shown to increase bitter pit prevalence in some cases. Therefore, consistent moisture is critical when preparing to plant a bitter pit prone cultivar. Consider the following (i) having a good water-source available for irrigation (especially in cases of drought stress) along with (ii) ensuring proper drainage and aeration to counter potential bitter pit issues in the future.

Texture & Structure play a substantial role in how nutrients should be applied and how they move from the soil into the tree. Soil texture cannot be changed, referring to a soil's composition (percent) of clay, loam and sand (Figure 1). Soil texture determines the water drainage, availability, and nutrient holding capacity. Soil structure refers to the arrangement of the sand, loam

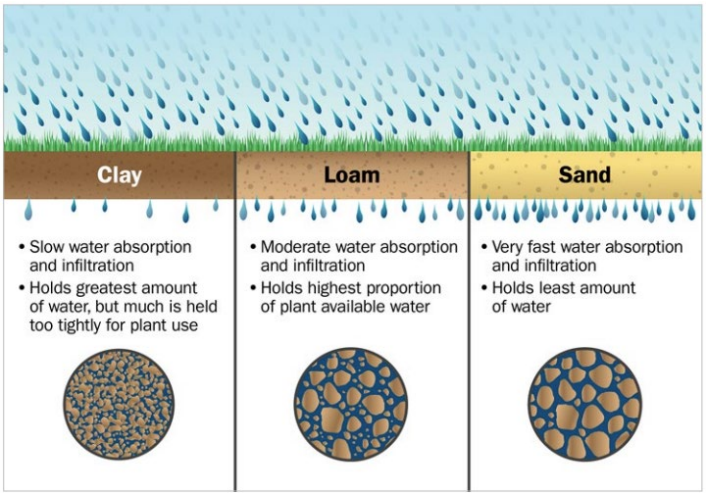

Figure 1. *Drainage and water-holding characteristics of major soil textural classes. (OMAFRA, 2022).*

and clay, in larger aggregates. Words used to describe a soil's structure are granular, platy, or blocky. For more information on soil composition it's role in nutrient cycling/uptake, check out the Ontario Soil Fertility Handbook. Soil texture and structure directly affect tree vigour by influencing nutrient uptake and rootstock establishment. This is why choosing a rootstock that matches your soil, but also allows for balancing your nutrients, is critical for the success of your orchard.

Nutrient Balance specifically in the soil can lead to long-term issues with bitter pit. Too much potassium, magnesium or nitrogen can increase bitter pit occurrence, but also selection of a rootstock that uptakes higher magnesium and potassium levels could further instigate this issue. Nutrient levels can shift with environmental changes but focusing on what you can control makes the biggest difference. Minimizing stressors helps keep nutrients in balance, and selection of an appropriate rootstock further mitigates future headaches.

Soil Testing is crucial before planting and selecting rootstocks for your orchard. Taking soil test(s) prior to planting allows you to (i) act proactively by determining soil needs, (ii) adjust soil conditions based on test results, (iii) and enable you to evaluate the chose rootstock suitability. Soil testing should be conducted at least every 3 years to determine whether adjustments need to be made.

Rootstocks will not behave the same way in different soil environments. Identifying rootstocks that **work well with your soil** will aid in productivity of the tree and quality of the fruit.

Rootstock Selection

Rootstocks influence canopy vigour, fruit size and nutrient uptake, meaning they play a big role in orchard success.

Some rootstocks tend to increase bitter pit, while others have demonstrated consistently lower levels of the disorder. Bitter pit risk increases in rootstocks that have a higher intake of potassium (K) and nitrogen (N). This lowers the K:Ca and the N:Ca ratios and is often associated with more vigorous rootstocks. The theory suggests that more vigorous rootstocks take up more water, leading to more efficient N and K uptake, ultimately resulting in higher bitter pit incidence.

Cornell University performed a multi-year, multi-location trial on Honeycrisp, identifying that G.969, G.214, and B.10 were the top-performing rootstocks when looking at high yields with low bitter pit incidence (Robinson *et al*., 2024). This report summarized multiple studies that looked at many rootstocks, some of which are listed here: B.9, B.10, G.11, G.41, G.202, G. 214, G.814, G.935, G.969, M.9, M.26, V.1, V.5 & V.7. G.41 and G.11 have shown to be used with caution due to their efficient uptake of potassium, while B.9 has a lower bitter pit risk, but also shows low yields due to its weak vigour.

Rootstock influence on bitter pit continues to be researched as rootstocks perform differently based on the environment, meaning the best data is collected regionally. Rootstock research takes decades to collect due to the nature of orchard systems (establishment, collection, analysis).

When selecting a rootstock for your orchard, especially with plants to plant with a cultivar prone to bitter pit, consider **soil suitability, nutrient uptake, and vigour to decrease the potential risk**. No matter the selection be sure to balance growth and nutrient ratios for further mitigation.

The optimal choice in rootstock depends on the planting location.

Cultivar Role

Most of the bitter pit research has been studied on 'Honeycrisp' apples due to its high proclivity of the disorder.

In recent research on Honeycrisp, Dr. Chayce Griffith (under advisement of Dr. Einhorn at Michigan State University), has stated that the cultivar is prone to bitter pit due to its rapid fruit growth rate. Honeycrisp apples expand so quickly that the fruit cells crush the xylem bundles, causing a stop in calcium transport. **Xylem dysfunction can occur as early as 5 weeks after bloom, severely slowing calcium movement to the fruit.** This breakthrough research has resulted in pivoting focus on how to slow the growth rate of this cultivar to allow for extended xylem function.

Although Honeycrisp is the most well-known cultivar to experience bitter pit, there are others that struggle with this disorder as well, such as Cox Orange Pippin, Braeburn, Golden Delicious Cortland, and Fuji.

Rootstock & Cultivar Combinations

Certain combinations would be best to avoid due to the nutrient uptake of the rootstock and/or known compatibility issues between the cultivar and the rootstock. Although most research has been conducted on Honeycrisp, the principles remain the same. Consider soil suitability, nutrient uptake and vigour when choosing a rootstock. Please refer to the Rootstock Selection section for further details.

How to Make a Pit Stop

So, you've got bitter pit – now what? You can't swap rootstocks today, but controlling vegetative growth, moderating crop load, analyzing nutrition, precise irrigation and mid-season testing can meaningfully cut risk.

As mentioned earlier, bitter pit is a complex disorder where many factors can increase its prevalence. This not only means that there are multiple factors to be utilized for mitigation, but there are also some out of

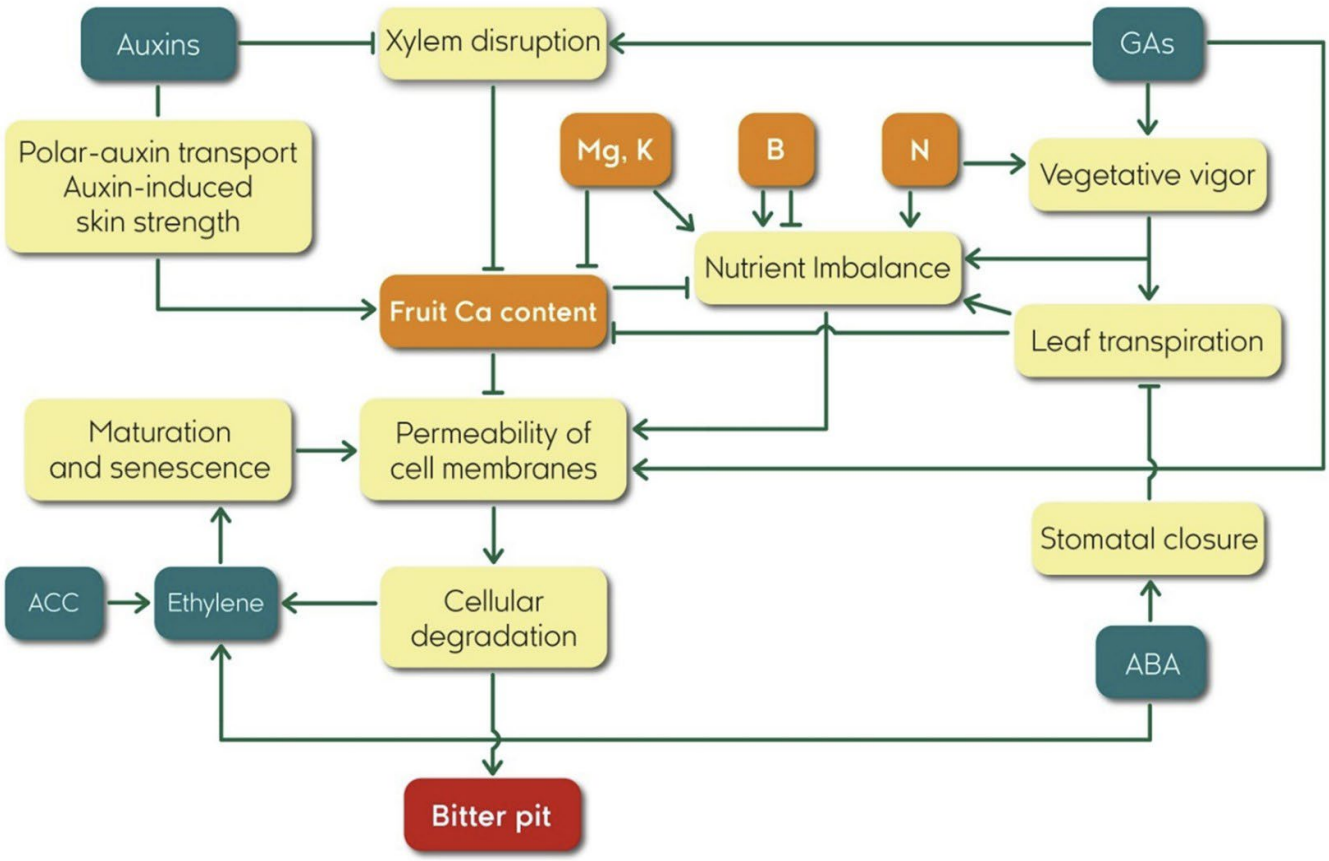

Figure 2. *Flowchart of relationships among plant growth regulators, Ca content, and bitter pit in apple fruits (Torres et al., 2024). ACC: 1-aminocyclopropane-1-carboxylic acid, ABA: abscisic acid, Ca: calcium, Mg: magnesium, B: boron, N: nitrogen, GAs: Gibberellins*

your control. Figure 2 shows the various influences that lead to bitter pit, including nutrient imbalances, vegetative vigour, transpiration, xylem disruption, and more. Understanding that this is a complex issue that may need many approaches to address, is the first step.

University of Wisconsin suggests that weather and irrigation have a large impact on bitter pit, followed by crop load. Weather is not something you can control, irrigation you can (to an extent), and crop load you can also manage. Below is a compilation of points from various resources outlining bitter pit management strategies:

Manage crop load

- Dormant prune to leave 150% of target fruit before the growing season begins (insurance buds).
- Utilize various chemical thinners and adjust as needed to meet target crop load.
- Keep in mind biennial bearing nature of cultivar, if this is of concern.
  - Precision apple crop load management may outweigh the possibility of bitter pit, but to be sure look at your orchard economics and compare.
  - Excessive fruit thinning and/or light crops (not much bloom, biennial) results in larger fruit, leading to more potential bitter pit. Consistent annual cropping should be promoted.
- A moderate crop load is 6 – 8 fruit per cm^2 TCSA (trunk cross sectional area).

Test soils, leaves and fruit

- Honeycrisp may like a higher soil pH (~7.2) compared to other apple cultivars (*initial research in New York).*
- Honeycrisp leaf Ca levels should target 2%.
- Limit K and N applications to maintain low leaf concentrations.

- Ensure boron (B) is at adequate levels.

Regulate orchard floor

- Herbicide strips should not extend past tree limbs.
  - Excess N and leaching can lead to further bitter pit problems.
- Mulch can aid in moisture fluctuations.
  - Do not use high N sources (i.e. legume hay).

Control tree vigour

- Nitrogen: test levels, adjust applications and timings.
  - If applying N, apply early. Applications after mid-April increase the incidence of bitter pit.
  - Read N-tuition for the Orchard – Part 1: Budgeting for Success for more details on N demand.
- Pruning: reduce shoot competition for calcium.
  - If excessive pruning is to occur, reduce N applications.
- Irrigation: ensure adequate but not excess irrigation between May and July.
  - Reduce irrigation before harvest.

Monitor fruit size & slow growth rate

- Encourage good pollination
- Leave fruitlets in doubles
  - Remember to consider the biennial bearing nature of certain cultivars.
  - Consistent annual cropping should be promoted.

Foliar applications

- Calcium applications: apply early and regularly if utilizing this approach
  - Keep in mind that less than 10% of the calcium applied ends up in the fruit

Sprayed Solutions?

As alluded to earlier, recent research suggests that bitter pit is influenced by hormonal balance and vascular function. A review conduct by Torres et al., in 2024, highlighted the implications of plant growth regulators and their potential role in mitigating bitter pit by improving calcium transport, reducing shoot vigor, and maintaining xylem functionality. Below is a breakdown of each hormone with further referencing in Table 1.

Auxins (IAA, NAA)

- **Role:** Auxins regulate cell expansion, influencing calcium movement into fruit.
- **Findings:** Low auxin levels in fruit have been linked to poor calcium uptake and higher bitter pit risk. Successive sprays of auxins could reduce bitter pit in Honeycrisp apples.
- **Caution:** Synthetic auxin (NAA) has shown mixed results — some trials increased bitter pit when applied late or at high frequency. Timing is critical for application and still being researched. Phytotoxicity should also be considered.

Abscisic Acid (ABA)

- **Role:** ABA regulates stomatal closure and stress responses, influencing transpiration and calcium distribution.
- **Findings:** Foliar ABA sprays improved calcium allocation to fruit and lowered bitter pit in trials. ABA may activate calcium transporters and related genes.
- **Caution:** Trials conducted were with products not currently registered for commercial use in Ontario.

Gibberellins (GA)

- **Role:** Gibberellins stimulate shoot and fruit growth, which can dilute calcium and accelerate xylem dysfunction.
- **Findings:** High GA levels correlate with increased bitter pit risk. Conversely, GA inhibitors reduced bitter pit and increased fruit calcium in several studies by limiting vegetative vigor and slowing fruit expansion.

Ethylene (Ethephon)

- **Role:** Used for maturity management; its effect on bitter pit is inconsistent
- **Findings:** Some trials report reduced bitter pit with ethephon, while others show no change or even increased risk when over-applied.
- **Caution:** ethephon is only for use on non-bearing apple trees in Ontario.

Pit Patrol

In summary, best management begins before planting, but mitigation strategies can help with problematic blocks.

Before Planting consider soil information, rootstock selection and cultivars, to generate a better picture for potential future issues. Steer away from rootstocks that are too vigorous for your soil type and/or from problematic cultivar and rootstock combinations.

In Young Orchards be sure to balance nutrition to avoid excessive vigour. Manage crop load early to prevent oversized fruit.

Table 1. Effect of external hormonal applications on calcium content in fruit and bitter pit incidence.

Hormone	Expected Physiological Response	Effect	Cultivar	Location	Reference
Abscisic acid	Transpiration reduction in leaves	↓ bitter pit and ↑ calcium	'Super Chief'	• *Wenatchee, Washington, USA* • *Ludhiana, Punjab, India*	• Gomez and Kalcsits (2020) • Angmo et al. (2022)
Auxins	Improvement of fruit boron content	↓ bitter pit (IAA) ↑ bitter pit (NAA)	'Notaris'	• *Unknown* • *Unknown*	• Van Stuivenberg and Pouwer (1950) • Mulder, 1951 cited by Griffith and Einhorn (2023)
	Vascular function stimulation	↓ bitter pit and ↑ calcium	'Honeycrisp'	• *East Lansing, Michigan, USA*	• Griffith et al. (2022)
	Flower-promoting	↓ bitter pit and = bitter pit	'Honeycrisp'	• *Simcoe, Ontario, Canada*	• Cline (2019)*
Ethylene (ethephon)	Advancement of fruit maturity	↓ bitter pit and = calcium	'Bramley's Seedling'	• *Maidstone, Kent, United Kingdom*	• Prinja (1990)
	Flower-promoting	↓ bitter pit and ↑ bitter pit	'Honeycrisp'	• *Simcoe, Ontario, Canada*	• Cline (2019)*
Gibberellins	Fruit and vegetative growth stimulation	↓ bitter pit and ↑ calcium	'Catarina' and 'Fuji' 'Braeburn'	• *Lages, Santa Catarina, Brazil* • *Elk Grove, California, USA*	• Silveira et al (2012) • do Amarante et al. (2020)
		= bitter pit and = calcium	'Honeycrisp'	• *Quincy, Washington, USA*	• Serban and Kalcsits (2018)
Prohexadione-Calcium	Reducing extension shoot growth	↓ bitter pit and ↑ calcium	Catarina' and 'Fuji' 'Braeburn'	• *Lages, Santa Catarina, Brazil* • *Elk Grove, California, USA*	• Silveira et al (2012) • do Amarante et al. (2020)
		↓ bitter pit and ↑ bitter pit = bitter pit and = calcium	'Honeycrisp' 'Honeycrisp'	• *Highland, New York, USA* • *Quincy, Washington, USA*	• Donahue et al. (2018)** • Serban and Kalcsits (2018)
Paclobutrazol	Reducing extension shoot growth	↓ bitter pit and ↑ calcium	'Gardiner Delicious'	• *Amherst, Massachusetts, USA*	• Greene (1991)
Triiodobenzoic Acid	Effect on calcium movement and accumulation in plant tissues	↑ bitter pit and ↓ calcium	'Golden Delicious' 'Northern Spy'	• *Wenatchee, Washington USA* • *Ithaca, New York, USA*	• Stahly and Benson (1970) • Oberly (1973)

Table adapted from Torres, E., Kalcsits, L., & Nieto, L.G. 2024
IAA, indole-3-acetic acid; NAA, 1-naphthaleneacetic acid.
* Three sprays of NAA or ethephon reduced BP incidence, while six sprays increased it.
** Prohexadione-Ca applications at pink button stage reduced BP incidence, while petal fall increased it.

For Established Orchards rely on in-season strategies to maintain a moderate crop load, monitor leaf, soil and fruit nutrient levels, and be sure to control vigour through pruning and limiting N applications.

> "**Bitter pit is a complex disorder** as its incidence is related not just to **mineral status** but also to **hormonal balances, cellular functions**, and **horticultural techniques**."
>
> Griffith & Einhorn, 2022

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Soak It In: Key Takeaways from the Ontario Apple Irrigation Survey

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

Earlier this summer a survey was released to better understand the Ontario apple industry regarding irrigation access and use.

A total of **57 responses** were collected, representing **roughly 27%** of OAG membership (216 members total – 2024 OAG Annual Report). These responses represent **roughly 41%** of Ontario's total apple acreage (15,850 acres – 2024 OAG Annual Report).

Moisture Metrics

Refer to Table 1, along with Figures 1, 2 and 3 for further insights and numerical values.

- All districts were represented within the survey, where an average of 10 respondents per district was achieved
- Of the apple acreage represented in survey, 61% of apple acreage in Ontario is irrigated, where 39% is not irrigated
- District 1 had highest amount of participation (23%) with 2nd highest of irrigation adaption (72%), showing the 2nd lowest unreported acreage (58%) within that district
- District 2 had the 2nd highest acreage representation (1216), showing the provincial average of irrigated (61%) and non-irrigated (39%) acreage
- District 3 had the highest irrigated percentage (78%) with the 2nd highest unreported acreage (73%) within that district
- District 4 had the lowest acreage representation (336) with the highest unreported acreage (83%), showing comparable averages to the province (63% irrigated, 37% non-irrigated)
- District 5 shows the highest % non-irrigated acreage (61%), the highest number of acre representation (1838) and the lowest unreported acreage (45%) within that district

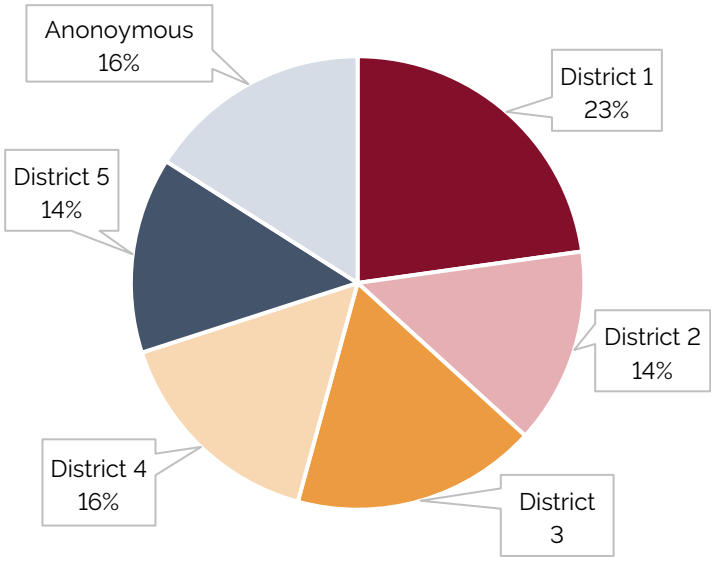

***Figure 1.** Distribution of survey responses across Ontario apple districts*

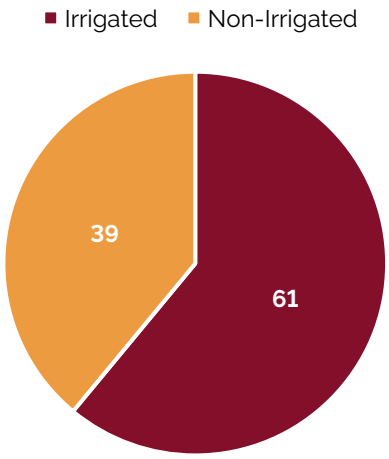

***Figure 2.** Percent irrigated and non-irrigated apple acreage based on survey responses*

Although we can glean a substantial amount of information for this survey, it is important to note that the data collected was voluntarily given and may not reflect the full scope of practices across the province. These numbers also don't reflect consistent access to water, especially during drought conditions. Additionally, some growers may depend on municipal water sources which can be restrictive, along with variability within municipalities regarding access to water sourcing.

Irrigation Resources

A list of Ontario resources related to irrigation, along with brief descriptors are below.

Determining Irrigation Rates & Timings

- Insights to irrigation during water shortages
- Strategies for better water dispersion during drought
- Mitigating the risk of insufficient moisture
- Best management practices for irrigation management (Irrigation Manual)

Essential Irrigation Guidelines

- Permits to take water
- Food safety through good irrigation practices

Determining Irrigation Rates & Timings

- Calculating evapotranspiration to make irrigation decisions
- Scheduling irrigation for fruit crops
- Important timings for irrigation in fruit trees
- Drip Irrigation for high density orchards

A special thank you to all who took the time to participate in the survey, your input really quenched our thirst for knowledge—thank you

Table 1. Ontario Apple Irrigation Survey Results by District

	Acreage	Irrigated Acreage	Non-Irrigated Acreage	% Irrigated	% Non-Irrigated
District 1	1146	827.80	318.20	72.23	27.77
District 2	1216	747.20	468.80	61.45	38.55
District 3	1062	826.94	235.07	77.87	22.13
District 4	336	210.40	125.80	62.58	37.42
District 5	1838	726.75	1111.25	39.54	60.46
Anonymous	910	624.50	285.50	68.63	31.37
Total	**6508**	**3963.59**	**2544.62**		

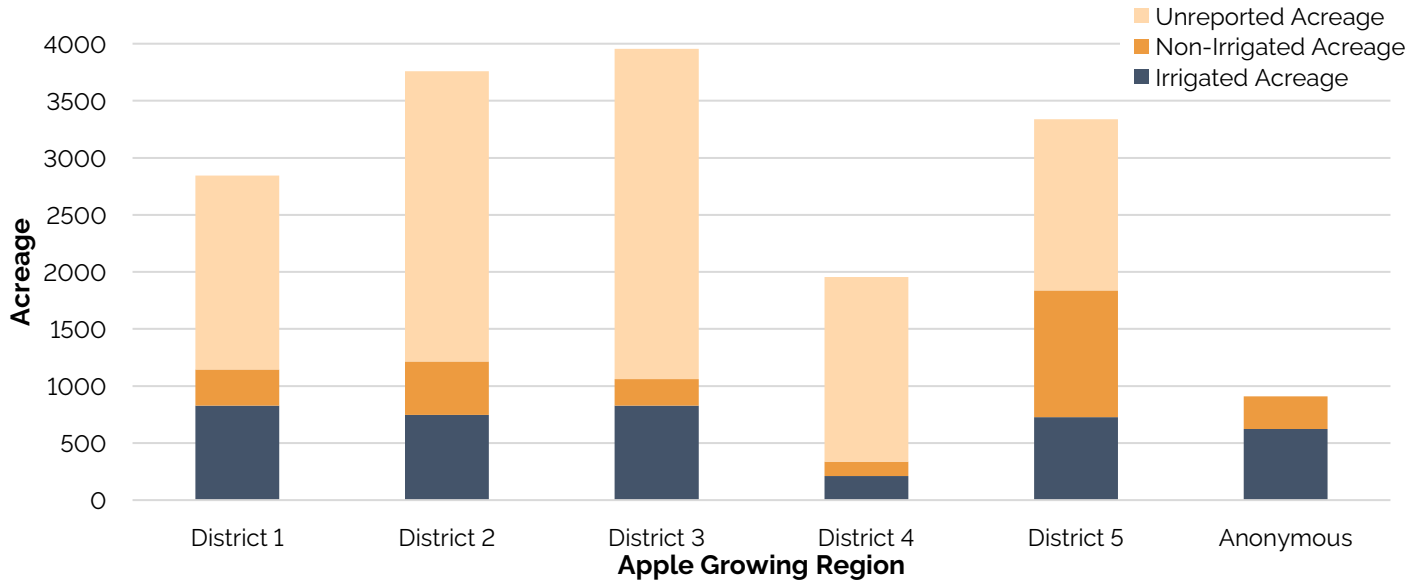

Figure 3. *Table showing irrigated, non-irrgated and unreported apple acreage across Ontario*

N-tuition for the Orchard – Part 1:
Budgeting for Success

Erika DeBrouwer, *OMAFA Tree Fruit Specialist*

Nitrogen (N) is a macronutrient that affects tree growth and development and can impact fruit yield and quality. N drives canopy growth in the form of leaves and shoot extension, spur development, and early cell division within fruitlets. Being a macronutrient means that N is an essential element needed in large quantities for proper plant growth, development, life cycle and critical in physiological processes.

N is moved throughout the tree via the phloem pathway (Figure 1). This is a two-way delivery system that relies on water pressure differences between cells, determining the direction of flow. The nutrient transportation pathway allows for season-long distribution of nutrients between plant organs.

Sources & SeNsibility

Trees have three sources of N supply, banked, borrowed and bought.

Banked refers to the reserves accumulated within the tree over the past growing season. This reservoir is readily available for the spring push, where studies show early N availability supports stronger spur leaves and early fruit growth.

Borrowed refers to the N sourced from the soil. This mineralized N differs in uptake based on soil organic matter content, soil temperature and moisture, along with soil aeration. Soils with high organic matter can provide trees with substantial N availability.

Bought refers to fertilizers. Any additional N sources added to the orchard, whether that be soil or foliar applications are included here.

These sources change in when they are utilized, determined by tree physiology, but also by elemental availability. Dependent on what type of fertilizer is used, uptake can differ.

Can You Feel the N-ergy?

N is highly needed during early season canopy development, where peak demand occurs when fruitlets are sizing and shoots extend. Tree N demand throughout the season is outlined below:

Dormant to Green Tip

When trees are just waking up from the winter, there is minimal demand for N. Nutrient movement is low due to dormancy, but things start to move as the tree awakens. N is remobilizing during this time, where N reserves are preparing for use.

Green Tip to Full Bloom

Demand of N is needed during this period as buds are growing, but need has not reached its peak. N reserves are heavily relied upon during this stage, and as the soil warms, N uptake begins.

Full Bloom to Fruit Set

Climbing demand begins for N, where leaves, shoots and early fruit development need the nutrient. Reserves and soil-derived N are used at this time.

Fruitlet Sizing

Fruitlet sizing combined with continued shoot growth is when the highest demand of N is required. N reserve pools usually deplete at this period, where the tree heavily relies on mineralized N uptake through the soil.

Fruit Maturation

N is still needed to encourage good fruit quality, but demand tapers off, as leaf tissues cease growth slowing overall N requirements. Trees continue to uptake N for use.

Harvest to Post Harvest

Trees rebuild N reserves in preparation for the dormant season and the N drive early next season. This accumulation occurs through soil-derived N sourcing.

As a note, dependent on the rootstock and cultivar, nutrient requirements and **physiological timings may differ**, but generally **most apples** follow the timeline shared.

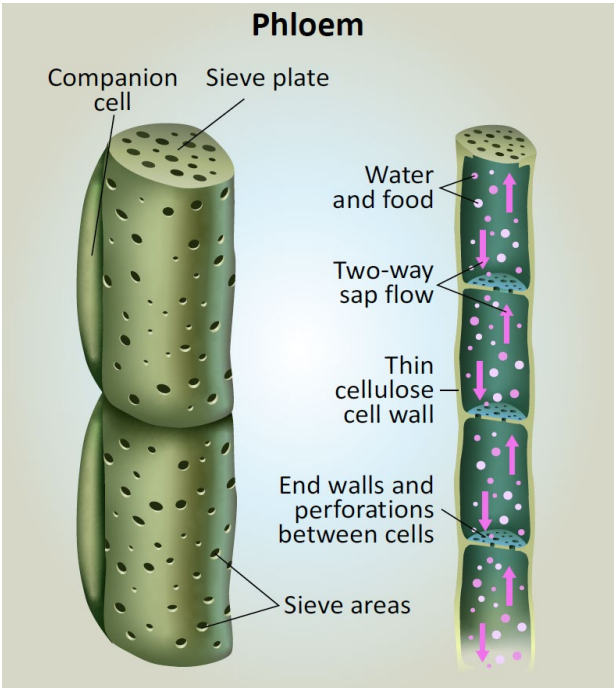

Figure 1. *Illustration demonstrating phloem activity within the tree. (OMAFA,)*

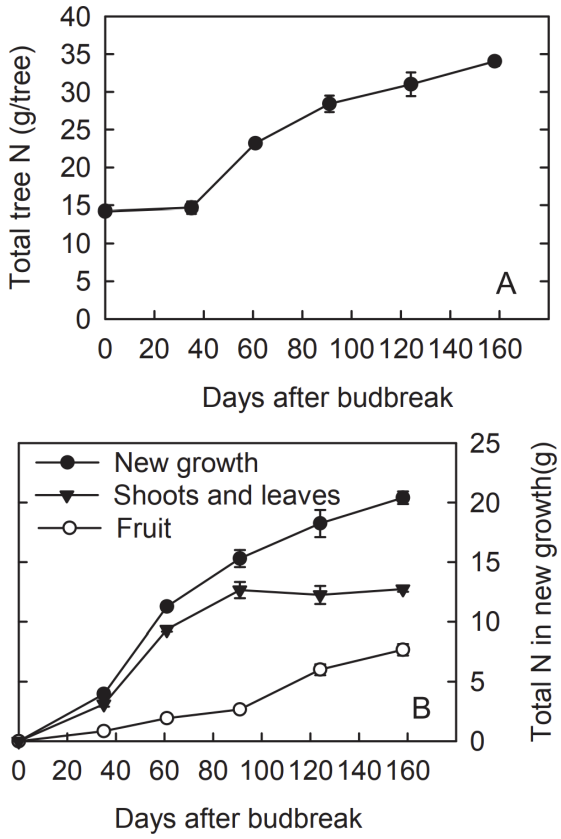

Figure 2. *Graphs demonstrating total tree nitrogen (top) and in new growth (bottom) on 6-year-old Gala/M.26 throughout the season. (Cheng, L., 2010).*

N-Sync Supply & Demand

As noted earlier, N drives shoot growth, leaf development, and fruit quality. Understanding both the tree's demand for N and how to supply it at the right time is essential, not only for maximizing uptake and yield, but also for reducing losses, such as leaching.

Tree growth is directly correlated with a tree's **nitrogen status.**

DemaNd

In 2010 Cheng specified values of N demand in 6-year-old Gala trees grafted onto M.26 rootstocks (Figure 2). Cheng conducted the experiment with six collection points that align with critical growth processes:

- Point 1: bud break (Day 0)
- Point 2: bloom (~Day 40)
- Point 3: end of spur leaf growth (~Day 60)
- Point 4: end of shoot growth (~Day 90)
- Point 5: rapid fruit expansion period (~Day 120)
- Point 6: fruit harvest (Day 160)

The top graph (Figure 2) shows that N is needed at bud break and increases dramatically during leaf and shoot growth. Shoots and leaves are in higher demand of N throughout the season when compared to fruit (Figure 2, bottom). Once shoot and leaf growth subside, the N demand plateaus (~Day 90). Fruit requires N throughout the season, where a substantial rise in N is needed during rapid expansion (between 100 and 120 days after budbreak).

Supply-N

Tagliavini *et* al., 2025 summarized the annual apple tree N cycle by conducting a meta-analysis, and visually showing the differences within each season (Figure 3). Figure 3 highlights that the N cycle is in peak motion during the spring and the fall, where N is remobilized either from storage (spring) or from the leaves (fall). In the summer, N used throughout the tree is taken up from the soil, which is not shown within the figure.

Looking closer at how the tree utilizes its N, it can be broken down into the following:

Banked N accounts for 50–70% of N used for early shoot growth, spur leaf expansion and bloom. This pool of N is stored within the woody tissues of the tree from the previous season and is used between bud break to bloom.

Borrowed N, also known as the current season's soil-derived N, supplies trees with 40–60% between post bloom to early fruit set. This is due to the warming of soil; root activity increases and transpiration drives mass flow of nitrates. N is mostly taken up in the forms of ammonium or nitrate. As the season progresses further, between fruitlet sizing and early fruit maturation trees rely more heavily on borrowed N, accounting for 60–80% of N used at this time.

Trees will always **supply the shoots and leaves** with **nitrogen before the fruit**, except during the period of rapid fruit expansion.

Post harvest N is unique, where 20–40% of the N taken up at this time goes towards the N reserve (banked). If leaves senescence early, soils are dry, and/or trees are weak, this uptake drops substantially and impacts early-season spring vigour the next year.

Biology Beats Bookkeeping

N has been framed as a nutrient budget, where the tree has income (soil uptake), savings (stored reserves), expenses (shoots, leaves and fruit), and losses (leaching, volatilization, pruning removal). The budget metaphor also provides the following:

- This year's growth is partly paid for with last year's N
- Overspending has downstream penalties
- Losses matter as much as inputs

Although a budget has worked in the past, the metaphor implies that N can be precisely calculated (it cannot) and that the N applied equals the N taken up and is used by the tree (it does not).

It may be better to approach N in the orchard as a conveyer belt.

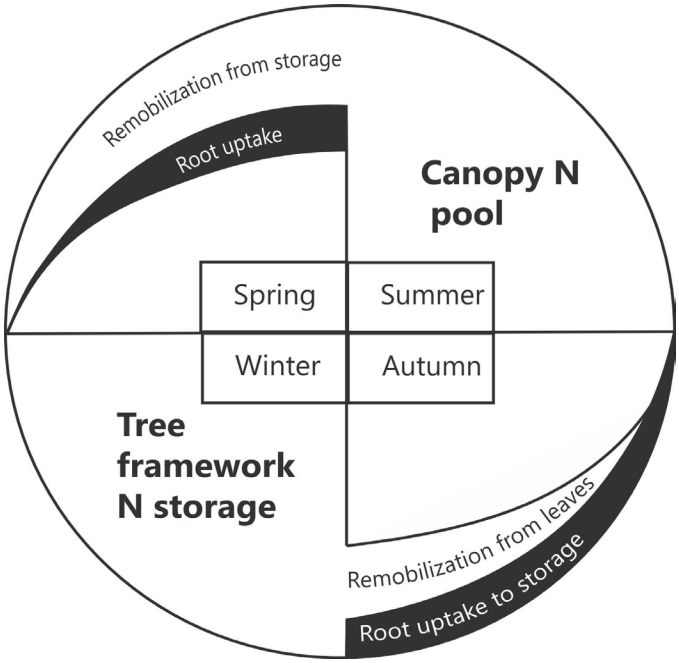

Figure 3. *Diagram showing the annual cycle of tree nitrogen storage and remobilization. Graph does not show the soil nitrogen uptake that continue also in the summer period. (Tagliavini et al., 2025)*

- The belt is loaded before you see it move. This represents the N from the previous season (banked N).
- The belt speed changes throughout the season, demonstrating the shift in demand as the tree grows.
- Conveyer drop-off points matter more than the load. N isn't distributed evenly to each tissue, and certain tissues will have more of a draw for the nutrient than other (i.e. leaves over fruit).
- Missed timing(s) mean N falls off the system. Representing applied N at the wrong time, the belt isn't running, and the N doesn't get rerouted later. This N is lost through leaching and/or volatilization.
- Postharvest loading for next year's spring kick-off. The belt slows and fills when conditions permit. N is taken up and stored in tissue reserve pools when soils are moist, and leaves are healthy.

Using this mindset, we shift from 'how much N?' to 'when is the tree responsive?'. Thinking about when the demand of N is not only more efficient for the tree, but from a product use perspective and from a financial feasibility standpoint.

N-tinct Isn't Enough

The best way to approach your N program is to test. This gives you a baseline and the option to adjust accordingly.

Leaf tissue sampling should be conducted in the last two weeks of July. For more information on (i) overall apple nutrition with nutrient ranges (ii) nutrient mobility and facilities, along with (iii) how to conduct a leaf tissue analysis, refer to the following resources:

- Apple Nutrition, Ontario.ca
- Orchard Leaf Tissue Sampling, ONfruit.ca
- Leaf Tissue Sampling, ONfruit.ca

Generally, apple leaves should range between 2.0–2.7%, where the typical ideal range is 2.2% N, but levels are cultivar and tree age dependent.

Soil sampling is not the best indicator when discussing tree N uptake, as the nutrient is mobile, environmentally driven and is often remobilized within the tree. But, it is helpful in determining your organic matter and can be used in conjunction with leaf analysis test(s) for a better overall orchard view. If conducting a soil test, consider this every 2 or 3 years, ideally in the fall with moisture (but consistency is more important than timing). Check out Assessing Nutrient Needs for more details.

Visual assessments of leaves can aid in certain respects regarding deficiencies, but visual assessments are not definitive and can often be confused with one another and/or mistaken for a pest injury. Confirmation with a leaf analysis is the suggested strategy.

Remember, it is **always best to test**!

Leaf It to Nitrogen

N deficiency symptoms are seen on older leaves first and can result in:

- Light green/yellow leaves
- Reduced leaf size
- Thin, spindly, stunted shoot growth

If severe, N deficiency can result in the dying of older leaves, reduction of bud formation and fruit set, smaller fruit size, and a decline in yield.

N-toxicated

Excess and mis-timed N can severely impact the trees overall health, impacting nutrient balances, increasing susceptibility, delaying maturity and increasing vegetative growth.

If N is applied at an improper time, it can result in the following:

- Promotion of vegetative growth
- Delayed shoot hardening
- Reduction in winter hardiness
- Reduced fruit colour

Excess N can lead to the following symptoms:

- Large, dark green leaves
- Promotion of vegetative growth
- Increased susceptibility to fire blight
    - See N-tuition for the Orchard – Part 2: Balancing Fruit & Pests for more detailed information
- Reduced fruit quality, poor colour
- Loss in fruit firmness

If continued excess of N occurs, it could lead to tree death, commonly coined "loving your tree to death".

Ill-timed and excess N application not only affects the trees but can cause leaching and volatilization of products. Leaching of N can potentially affect groundwater, surface water, soil nutrient balances, while volatilization can impact the air and water through pollution, greenhouse gas emissions and ecosystem acidification.

N-sight: It Depends...

N uptake depends on a multitude of factors, including timing, soil conditions, tree demand. orchard soil, tree age, rootstock, cultivar and previous management. The complexities of N uptake are illustrated in Figure 4 where factors affecting N uptake are categorized by soil properties, plant properties and biotic interactions.

Although there are many factors regarding N uptake, main points for grower awareness and influence include: **Soil properties**, such as moisture, pH, N form availability and potassium availability (can compete with

N). **Biotic interactions**, such as plant competition (cover crops, weeds) and microbial uptake and release (organic matter). **Plant properties**, such as growth stage, cultivar and rootstock, and current N status.

Generally, consider these concepts when thinking about your N program:

- Sandy soils are prone to leaching, fertigation or split applications can mitigate this.
- Clay soils are slow at N mineralization.
- Soils higher in organic matter (> 5%) are more efficient at mineralizing N.
- Dry soils result in minimal N uptake, potentially leading to a lower N reserve for spring.
- Cold soils slow mineralization and uptake of N.
- Between row plantings can reduce N leaching, especially in winter.
- Younger trees will require more N due to high amounts of growth and development of orchard framework.
- Higher crop loads will require more N to meet growth and renewal needs.
- High vigour cultivars normally have high N availability.
- Vigorous rootstocks are more efficient at taking up N

Because of the extensive differences associated with each orchard (soil, tree age, rootstock, cultivar, yield and previous management), it is strongly recommended to fine-tune your N program slowly through an on-farm trial. Applying different rates to a small amount of similar trees can allow you to compare tree growth and fruit quality over multiple years.

No N Left Behind

Timing, rates, application methods, irrigation, climate and soil all play a role in how N is taken up and potentially lost. To mitigate N loss, it is important to understand all the above and how best to use these to your advantage. Applying the "**split, modest, early**" approach is a simplified version to aid in N use efficiency.

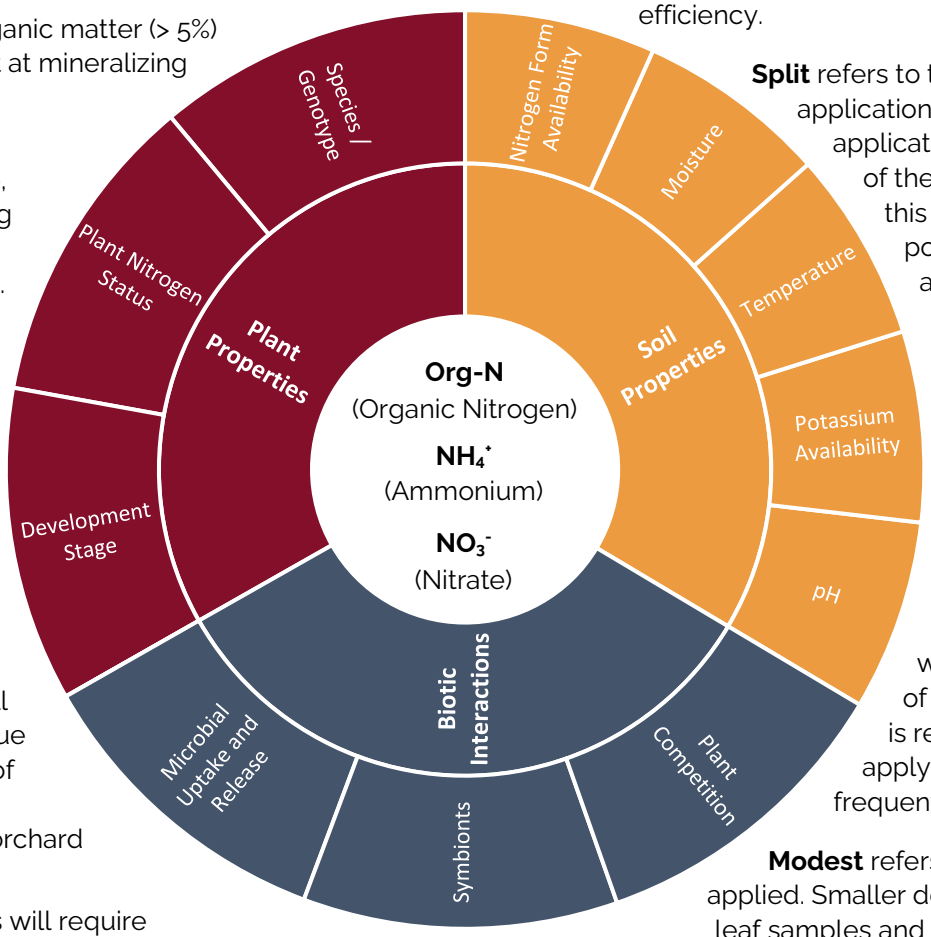

Figure 4. *Factors affecting nitrogen forms uptake by plants (Adapted from Moreau, D. et al., 2019)*

Split refers to the timing and applications of N. Match your N application with the needs of the tree. Not only does this decrease the potential of leaching and volatilization of products but decreases potential for over-application. Splitting applications of N is especially pertinent in coarse soils or soils with low organic matter where the probability of leaching is higher. It is recommended to apply smaller, more frequent doses of N.

Modest refers to the amount of N applied. Smaller dosages based on leaf samples and crop load can reduce excess N application. This allows for development of a well-balanced tree that can provide quality wood and fruit.

Early refers to the demand and timing of N application. When applying N earlier, there is less risk to cause detrimental effects to tree health than applying later and there is less of a chance of leaching.

N the Right Direction?

When thinking about your N program, consider the following questions:

- What is your cultivar × rootstock?
  - Is it a high-vigour combination or more moderate/precocious?
- What is your leaf N from previous year (mid-July sample)? Is it below, at, or above ~2.0-2.2%?
- What is your soil texture and organic matter status?
  - Do you have sandy, leaching-prone soil or heavier, high organic matter soils?
- What is your orchard age, density and target yield?
  - Young trees need more canopy growth; bearing trees need more balance toward fruit quality.
- Do you have fertigation infrastructure?
  - If yes, plan N supply from bloom through to the end shoot growth
  - If no, plan ground application between bud break through petal fall (and/or split applications for low organic matter soils)

To manage nitrogen effectively in apple orchards, start by **aligning applications with tree demand**. The most critical period for nitrogen uptake is early in the season, from bloom until shoot growth ends, so focus your applications during this window and **avoid heavy nitrogen late in the season** to prevent delayed fruit maturation and winter hardiness issues.

Next, **determine a preliminary nitrogen rate** based on tree status. If signs of nitrogen deficiency appear, review past records and adjust by increasing the rate or splitting applications. If leaf nitrogen levels are on target, reduce the rate accordingly. Use **soil and leaf analysis** to guide these decisions.

Continue **monitoring throughout the season**. Pay attention to **vegetative indicators** such as shoot length, vigor, and canopy density, as well as **reproductive indicators** like fruit size, color, and the strength and number of floral buds or spurs. These observations will help you fine-tune your program.

After harvest, consider a reserve-building spray if tree nitrogen status was marginal, but **avoid heavy soil nitrogen applications late in the season**, as they can delay maturation and affect winter hardiness.

Finally, **repeat this process annually**, adjusting rates based on **soil and leaf tests, tree performance, and yield results**. Where possible, conduct **on-farm nitrogen rate trials** to optimize efficiency and ensure your program meets the orchard's needs.

There isn't a "one size fits all" approach for N. This is a nutrient that **must be continuously monitored** to manage it correctly.

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CROP PROTECTION

N-tuition for the Orchard – Part 2:
Balancing Fruit & Pest

Kristy Grigg-McGuffin, *OMAFA Horticulture IPM Specialist*

As discussed in *N-Tuition for Orchard Part 1*, nitrogen (N) sits at the centre of orchard productivity. It drives canopy development, yield potential, and fruit size – but it also shapes pest pressure, disease risk, and soil microbial processes in ways that are not always obvious. Increasingly, research and field experience show that how, when, and why N is applied can either support pest management or quietly undermine it.

For Part 2 of N-Tuition for Orchards, we'll look at the benefits and challenges of N use in orchards, with particular attention to excessive canopy growth, impacts on foliar insects and disease, and the dual role of urea as both a N source and a sanitation tool for disease.

Feeding the Framework

Nitrogen availability directly influences:

- Shoot extension and internode length
- Leaf size and chlorophyll content
- Canopy density and light interception

Adequate N supports photosynthesis and fruit development. However, excessive N promotes lush, dense canopies that alter the orchard microclimate in ways that favour insects and disease.

Dense canopies:

- Dry more slowly
- Have higher relative humidity
- Reduce light penetration
- Limit spray coverage

Fuel for Disease

From a disease management perspective, N is not just about yield but also a microclimate and canopy management tool.

For example:

- **Apple scab** (Figure 1) – Dense canopies increase leaf wetness duration, making conditions conducive for both primary and secondary infections.
- **Powdery mildew** (Figure 2) – High N promotes prolonged shoot growth and higher proportions of young, susceptible tissue.
- **Fire blight** (Figure 3) – Excessive N promotes vigorous shoot growth, extending the window for shoot blight susceptibility later into the season.

Figure 1. *Apple scab*

Figure 2. *Powdery mildew*

Figure 3. *Fire blight*

Better Bug Buffet

Nitrogen also affects insect pressure through changes in leaf nutritional quality, particularly soluble N and amino acid content.

Studies across perennial cropping systems show that:

- **Aphids** (Figure 4), **leafhoppers** (Figure 5) and **mites** are more persistent and have higher fecundity (reproduction) on high-N foliage.
- Higher N increases phloem amino acid concentration and makes the leaves more succulent for **sap-feeding insects**.
- Prolonged vegetative growth maintains tender tissue that is more attractive and suitable for foliar-feeding insects such as **leafrollers** (Figure 6) or **leafcurling midge** (Figure 7).

Nitrogen doesn't directly cause insect problems, but it does contribute to an environment that favours development. This can reduce the effectiveness of biological control with the rapid pest population growth and result in greater reliance on insecticides due to prolonged crop vulnerability.

The Good Side of N (for IPM)

Urea occupies a unique space in the orchard-N debate because it can be applied not for nutrition, but for

Figure 4. *Green apple aphid on developing terminal.*

Figure 5. *Hopperburn caused by potato leafhopper*

Figure 7. *Leafroller caterpillar on developing terminal*

Figure 6. *Apple leafcurling midge on developing terminal*

inoculum reduction, particularly for apple scab management.

Fertilizer with a Side Hustle

Understanding how apple scab survives the winter is key to understanding why urea is effective as a sanitation tool.

Scab's winter bunker

At the end of the growing season, the apple scab pathogen, *Venturia inaequalis*, transitions from secondary (conidial) reproduction on leaves and fruit – aka producing spores for secondary infection – to an overwintering state on infected leaves. Infected leaves (not fruit!) on the orchard floor become the primary overwintering site (Figure 8).

Within this leaf litter, the fungus forms fruiting bodies, called pseudothecia, which mature, produce and protect ascospores. In the spring, these ascospores are forcibly ejected during wetting events and cause primary infection on new tissue.

The amount of overwintering scab inoculum in fallen leaves directly determines the ascospore dose available in the spring. In fact, 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.

Hitting scab where it hides

Fall or early spring applications of urea to leaf litter can disrupt this overwintering process in several ways:

- Stimulate microbial activity that accelerates leaf decomposition.
- Interfere with pseudothecia development and ascospore maturation.
- Reduce the amount of viable primary inoculum available the following spring.

Numerous studies have documented 50-90% reductions in ascospore production, particularly when urea is applied at 95% leaf drop and combined with leaf shredding (flail mowing). The effect is not fungicidal in the traditional sense; it's ecological by removing or degrading the pathogen's overwintering habitat.

Figure 8. *Scab infected leaves on the orchard floor serve as the primary inoculum source for next season.*

Figure 9. *Marssonina leaf blotch*

A Different Purpose

For disease management, urea is applied with the explicit goal of reducing overwintering inoculum, not feeding trees.

A typical program includes 45 kg agricultural grade urea per 1,000 L water/ha applied to leaves on orchard floor in late fall.

Nitrogen Accounting Matters

While applied for sanitation, urea is still 46% N. A 45kg/ha application contributes approximately 20 kg actual N per ha.

Key considerations is that not all of this N becomes immediately available to the tree. Some is:

- Immobilized by microbes during leaf decomposition.
- Lost through volatilization, especially if applications are made during dry or warm conditions.

Nonetheless, this N input is large enough to increase the total N load and should be considered when planning spring N programs. Not accounting for this could result in over-fertilization, particularly in blocks already prone to excessive vigour.

Collateral Benefits

While apple scab is the primary disease targeted by urea sanitation, it is not the only orchard pest that overwinters in leaf litter or orchard floor debris.

Faster decomposition may also reduce overwintering success of:

- Other foliar fungal pathogens that survive in leaf tissue, such as Marssonina leaf blotch (Figure 9).
- Saprophytic fungi on wood or decaying fruit, such as black rot, bitter rot, or *Alternaria* spp..
- Bacterial cankers in mulched pruning cuts, such as fire blight or *Nectria*.

- Some insect pests that overwinter in or beneath leaf litter, such as leafrollers, codling moth, plum curculio, stink bug, or tarnished plant bug.

While urea is not a stand-alone control tactic for these species, orchard floor sanitation can contribute overall to lower early season pest pressure.

Holding On

In theory, applying urea at 95% leaf drop is ideal for reducing scab inoculum. In practice, this window can be very narrow – or disappear entirely. Warm falls, slow leaf senescence, or leaf drop (especially in cultivars like Ambrosia), and/or sudden snowfall and freezing temperatures can prevent timely applications. Fortunately, when leaves remain on trees or access to the orchard floor is limited, there are still options. Effective scab sanitation is less about hitting a perfect timing and more about stacking multiple orchard-floor strategies to disrupt overwintering inoculum.

Chop It Where It Drops

Across studies, leaf shredding consistently reduces scab inoculum 40-70%. Mechanical shredding:

- Physically destroys pseudothecia.
- Increases leaf surface area for faster microbial breakdown.
- Enhances the effectiveness of urea when used together.

Shredding should be viewed as a year-round orchard floor management practice and done post-harvest, after leaf drop, and again in early spring if leaves remain intact.

Missed Fall? Try Spring

When fall applications are missed, early spring urea applied to overwintered leaf litter can still reduce scab inoculum, particularly if applied as soon as the snow melts, before bud break. While spring applications are generally less effective than fall treatments, studies show meaningful reductions when urea is combined with shredding and adequate moisture.

Spring treatments should target the orchard floor, not branches, and be viewed as a salvage sanitation strategy, not a replacement for fall management.

Not Quite Leaf Drop

Applying urea as a foliar spray before natural leaf drop can be effective for scab sanitation, but timing matters. If applied too early – while trees are still actively photosynthesizing – urea may be taken up by the tree, contributing to N reserves rather than remaining available for leaf decomposition. Refer to *N-Tuition for Orchard Part 1* for more information on N reserves.

If used, foliar urea should be timed as close to leaf drop as possible to minimize uptake while still targeting the pathogen's overwintering substrate.

Helping Leaves Let Go

In years when leaves are slow to senesce (drop), copper applied in late fall may be used promote leaf drop, enabling subsequent urea application to fallen leaves. Copper does not replace urea for scab sanitation and should be viewed strictly as a facilitator, not a control measure.

Any copper use must consider:

- Cultivar sensitivity and risk of phytotoxicity
- Label restrictions
- Potential impacts on tree health and soil copper accumulation

Balancing Act

Nitrogen inputs, especially urea applied to leaf litter influence soil microbial communities.

Short-Term Effects

- Increased microbial activity and rapid decomposition of carbon-rich leaf litter.
- Temporary N immobilization as microbes incorporate N into biomass.
- Increased soil ammonium levels following urea hydrolysis.

Longer-Term Considerations

- Shift in microbial communities toward bacteria-dominated systems, potentially reducing fungal diversity.
- Microbial imbalances may influence disease suppressiveness of soils over time.
- Accelerated organic matter decomposition,

reducing long-term soil carbon if not balanced with organic inputs.

- Reduced dependence on mycorrhizal fungi for nutrient foraging and altered nutrient cycling efficiency.
- Reduced fungal biomass can degrade soil structure, potentially affecting water retention and overall soil health.

These effects reinforce the need to view N as part of a whole-system soil management strategy, especially when sanitation applications are repeated annually.

Applying N-Tuition

When planning nitrogen use in orchards, consider the following:

- **Match rate to tree demand.**
  - Use leaf and soil testing to guide rates.
  - Avoid excess N in high-vigour blocks.
- **Time N to minimize pest risk.**
  - Prioritize early season N to support canopy establishment.
  - Avoid late or excessive N that prolongs shoot growth and pest susceptibility.
- **Account for all N sources.**
  - Include urea for orchard sanitation.
- **Integrate nutrition with disease management.**
  - Align N rates with pruning severity and disease pressure history, especially fire blight.
- **Protect soil biology.**
  - Balance N inputs with organic matter.
  - Avoid repeated applications that increase microbial imbalance.

Feed the Tree, Not the Problem

Nitrogen is one of the most powerful tools in orchard management – and one of the easiest to misuse. Excessive nitrogen can quietly increase disease pressure, favour foliar-feeding insects, and complicate IPM programs, even as yields appear strong.

Conversely, strategic N use with urea for overwintering inoculum reduction can support both productivity and pest management when its contribution to the overall N budget is properly accounted for.

In modern orchard systems, N management is no longer just about feeding trees – it's about managing the orchard ecosystem.

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What's Really in the Tank:
A Quick Guide to Adjuvants

***Jason Deveau**, OMAFA Application Technology Specialist*

The number of adjuvants available in Ontario continues to grow, so it's likely you've been tempted to try something new. Here are a few considerations before you add to your airblast or boom sprayer tank mix.

What is an Adjuvant?

Many think "adjuvants" are synonymous with "surfactants" and that their role is to improve spray deposition, retention and/or absorption. That's only a subset of what adjuvants do.

> More formally, an **adjuvant** can be defined as any substance, either in a formulation or added to the spray tank, that modifies biological activity or application characteristics.

In other words, ***all surfactants are adjuvants, but not all adjuvants are surfactants***. Let's break them up into two groups: Utility Modifiers and Activators.

Utility Modifiers

Most of these products are added by the operator when conditions require it. This list isn't exhaustive, but utility modifiers can:

- Mask pesticide odor
- Adjust carrier quality (e.g. pH or hardness)
- Reduce foaming
- Mitigate drift
- Improve tank mix compatibility
- Improve the effectiveness of cleaning

Here are brief descriptions of the most common functions of utility modifiers.

Drift Mitigation

Generally used with herbicides, not all drift retardants are created equal. The best are able to reduce the number of drift-prone droplets (<150 µm diameter) without significantly adding to the larger droplets. As a result, they make better use of spray volume.

But they don't always perform as expected. For example, Interlock was originally developed to reduce the drift of dicamba herbicide, but it was discovered that certain air induction nozzles made drift worse. This has since been rectified. They may not have the same utility in airblast sprayers as they do from horizontal booms, as discussed here: Evaluating an Anti-Drift Adjuvant in an Airblast Sprayer – Sprayers 101.

Drift retardants are a good choice if all other environmental and operational conditions for reducing drift potential have been exhausted. At that point, they can be used as additional insurance, but they don't make you bullet proof.

Improve Water Quality

Always have your carrier water tested. It's a cheap and easy way to avoid unwelcome surprises. Based on what you find it might be worth correcting some aspect of the carrier.

Hardness

In 2022, Winfield United surveyed Ontario water, and while they found minor problems, our water is really very good. In 2024, we did a small survey of well, municipal and surface and saw no issues: Hardness < 600 ppm, TDS < 325 ppm and alkalinity (esp. bicarbonate) <500 mg/L.

But that's not always the case. In Western Canada, water from sloughs can have high turbidity, and water from aquafers can absorb minerals and sodium, which antagonize herbicides. Generally, 1% AMS (1 kg / 100 L) handles most issues, but only use it when you need it, and be aware that it does not play nice with dicamba.

pH

pH is usually a consideration with herbicides. Group 2 herbicides are pH sensitive. BASF's imidazolinones ("imi's") prefer lower pH. The rest include sulfonylureas (SU) which prefer high pH for proper solubility. The consequence of poor solubility may include poor weed control and increased risk of tank and plumbing residues.

Many fungicides and insecticides are most stable – and therefore most effective – within a specific pH range. Depending on the product, when carrier water is too acidic or too alkaline, their half-life can be shortened within minutes of mixing.

This will be a recurring theme, but read the label!

Improve Tank Mix Compatibility

The more products added to a tank, the more likely you are to experience some manner of tank mix incompatibility (physical or chemical antagonism). Sometimes this is simply a matter of observing the mixing order on the label, or if it's silent, you can use:

W.A.L.E.S.

- **W**ettable powders
- **A**gitate
- **L**iquid flowables
- **E**mulsifiable concentrates
- **S**urfactants

W.A.M.L.E.G.S. (coined by Rob Miller, BASF)

- **W**ettable powders
- **A**gitate + Anti-foam
- **M**icrocapsule suspension
- **L**iquid + Soluble
- **E**mulsifiable concentrates
- High-load **G**lyphosate
- **S**urfactants

But these orders always have exceptions. The label will warn when the conventional order isn't appropriate. Sometimes it's utility modifiers first, and sometimes last. Liberty, for example, defies the rules and should be mixed in this order: AMS, surfactant, Liberty, Select herbicide.

Sometimes, you don't get a choice in mixing order when products come premixed. Once again, this tends to be a herbicide issue, and it tends to be a bigger deal when adding micro nutrients to fertilizer carrier rather than water. Enter the compatibility agent.

In 2023, Mike Schryver at BASF looked at compatibility agents and how they helped with different herbicide formulations mixed into UAN:

- EC is soluble in water - 2x dose added to cold UAN stabilized and resuspended (from top).
- SC is not water soluble - 2x dose added to cold UAN stabilized and resuspended (from bottom).
- When UAN +ATS comes premixed, add stabilizer next, then herbicide and it stabilized and resuspended.

The take home here is that before trying out untested tank mixes and trusting the compatibility agents, first be sure the label permits the mix. Second, if there's still doubt, conduct a jar test and keep good records.

Activator Adjuvants

These are the adjuvants we mentioned at the beginning of this article. They can improve:

- The degree of contact between droplets and the plant surface
- Product uptake
- Droplet survivability
- Rainfastness

All these functions can be described in the following two categories:

Surfactants

Surfactants (**SURF**ace **ACT**ive ag**ENTS**) improve the degree of contact between droplets and the plant surface.

For example, crop oil concentrates (COCs) are emulsifiers made of vegetable or petroleum oils whose primary function is to enhance the uptake into the plant. Methylated Seed Oils (MSOs) are a more versatile choice, but essentially do the same thing. What works well with one pesticide may not work at all with another. For example, crop oil concentrates do not work with glyphosate and should not be used with it.

Both can reduce surface tension of a spray solution allowing the droplet to "relax" and interact with other surfaces. This leads to less bounce and more spread. Generally, surfaces that are difficult-to-wet benefit

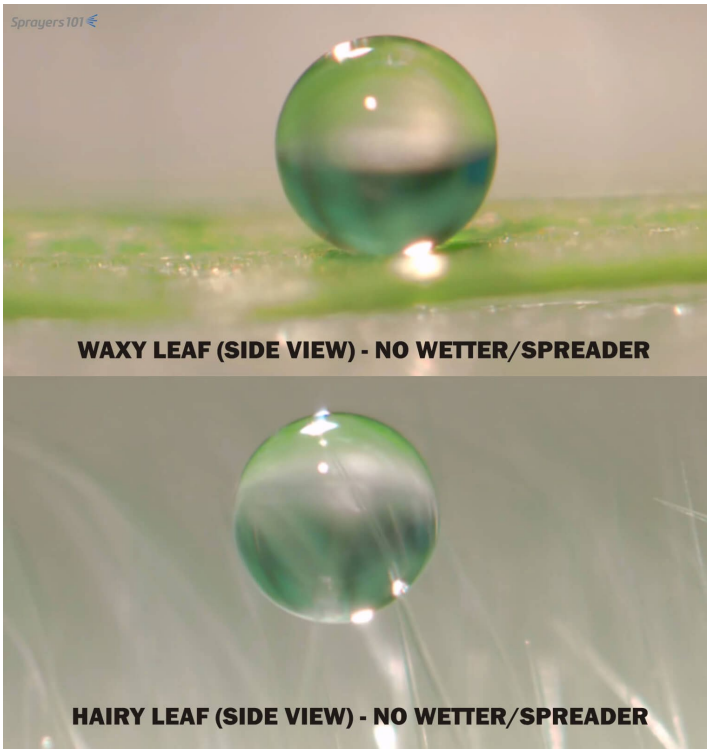


Figure 1. *A spray droplet on a hydrophobic (waxy) surface (TOP) and caught on a trichome (hairy leaf surface) (BOTTOM). Images from work by Dr. Heping Zhu, USDA Ohio.*

more from surfactants than those that are easy-to-wet (Figure 1). However, spreaders can also incur run-off far more quickly at the same volume, so beware.

Humectants

Systemic product uptake is often driven by diffusion, which is the movement of substance from an area of high concentration to low concentration, and it is much easier for a liquid than a dry deposit to diffuse across a barrier. The most effective way to slow drying is to use larger droplets that simply take longer to evaporate, but formulations that can slow the drying of droplets may also enhance uptake under these conditions.

Canadian Regulatory – Follow the Label

According to the Pest Management Regulatory Agency (PMRA), the rules surrounding the tank mixing of adjuvants remain the same as they have been since 2009, and ***are not included under the new guidance document, Tank Mix Labelling***.

While the Pest Control Product Act (PCPA) does not reference adjuvants specifically, they are prescribed to be pest control products in the regulations (Pest Control Products Regulations s.2(b)). The general reference in the PCPA that applies is s.6(5)(b).

> Therefore, in the case of **activator adjuvants**, the label for ***at least one*** tank mix partner must specify the use of an adjuvant, and only registered adjuvants ***labeled for the crop*** and for tank mixing are permitted.

For example, tank mixing the herbicide Reflex with a registered soybean oil adjuvant not labelled for the use, or with an unregistered food grade activator adjuvant, would not be acceptable.

> **Utility adjuvants** have registration numbers, but their use is not prescribed or specified on pesticide labels, leaving their use ***to the discretion of the operator***.

Learn more about changes to Canada's tank mix policies here: Tank mix compatibility – Sprayers 101.

Activators

The US has the Council Producers and Distributers of Agrotechnology, which is a self-regulated set of 17 standards. In Canada, we require proof of effectiveness. If a registrant submits an activator with a pesticide, they need efficacy data supporting the claims.

For example, many Group 2 herbicides come with a co-pack surfactant. Formulating it all together in the same jug might negatively impact product stability (e.g. can't add to dry formulations), increase bulk (e.g just won't fit in a 10L jug with 40 parts) and/or increase expense.

This regulatory cost tends to exclude third-party activators from the market. On the upside, it makes life simple for users who need only follow the label.

Activator adjuvants are always included in product formulations or recommended on product labels.

Utility Modifiers

Utility modifiers are easier to register, because they are not as complicated to prove (e.g. a drift retardant needs only demonstrate a reduction in drift-prone droplets, or pH adjuster shows the adjustment). We are seeing a larger number of utility modifiers in Canada.

Use or Not?

Adjuvants are always described with positive attributes: wetter, spreader, deposition aid, conditioner, etc. They have positive effects in some cases, negative effects in others, or have no effect on pesticide performance. See how adding a utility modifier can affect canopy coverage here: Adjuvants in the airblast tank – Sprayers 101.

An example is organosilicons, a group of activators with superior spreading activity. While enhanced spreading and wetting are positive attributes, research has shown that too much spreading can result in reduced uptake, in some cases leading to runoff and spreading a droplet out over a leaf also increases its rate of evaporation. All these effects can ultimately reduce efficacy.

When Not to Use – A Few Examples

- Do not use penetrant surfactants (including oils) with copper, sulphur or captan fungicides.
- Do not use penetrant surfactants with contact or surface pesticides.
- Stickers may impede the movement of systemic products.
- Stickers may prevent redistribution to newly emerging leaves early in the growing season (but they may be desirable during wet springs).
- Deposition utility modifiers may negatively affect canopy penetration when employing multi row or alternate row traffic patterns.
- Spreaders are more likely to incur runoff so adjust volumes accordingly.

In the end, if someone is proposing you try an adjuvant, ask to the see the data and get the recommendation in writing. If that gives them pause, then likely all they have is testimonials and the admonition that "it's not expensive and it can't hurt". Many work very, very well and are worthwhile, but do your due diligence before experimenting with them.

If you'd like to read more and hear a few presentations on adjuvants, check this out: Think before adding adjuvants – Sprayers 101.

Rules of the Mix in 2026:
Tank Mix Label Requirements

Kristy Grigg-McGuffin, *OMAFA Horticulture IPM Specialist*

This coming year brings an important regulatory change that affects how growers can legally tank mix pest control products in Canada. The Pest Management Regulatory Agency (PMRA) — the branch of Health Canada that regulates pesticides — published an updated *Guidance Document on Tank Mix Labelling* in January 2025 to clarify the requirements for tank mixes on product labels. This comes after several years of consultation and transitional policy.

Tank Mixing, Redefined

The label is the law.

Under the Pest Control Products Act, growers must use pest control products **exactly** as directed on the label. If a product label is silent on tank mixing, then **tank mixing is not legally permitted**, even if that combination was previously common practice.

For many producers — especially in tree fruits like apples where multiple fungicides, insecticides, or adjuvants are often mixed in the same tank — this guidance specifies what must appear on pesticide labels to permit those mixes after 2025.

The Rules in Brief

The Guidance Document outlines how product labels must be worded to allow tank mixing legally:

Labels That Allow Tank Mixing

A product label must include **explicit text** that permits tank mixes. There are two ways this can be done:

1. **Specific tank mix partners:** The label lists exact products it may be mixed with (e.g., *Product A may be tank mixed with Product B at X rate on apple.*).
2. **General tank mix statement:** A standardized paragraph permitting tank mixing with other registered products whose labels also allow mixing, provided all label directions are followed.

The general statement reads roughly:

"This product may be tank mixed with (a fertilizer, a supplement, or with) registered pest control products whose labels also allow tank mixing, provided all label directions (including Directions For Use, Precautions, Restrictions, Environmental Precautions, and Spray Buffer Zones) are followed for each product. In cases where requirements differ between labels, the most restrictive must be followed."

Importantly:

- Both products in a tank mix must permit tank mixing.
  - If one is silent on mixing, the combination is **not permitted**.
- Products with exclusionary statements (e.g., *Do not mix with any other pesticide*) preclude tank mixing unless specific partners are listed (e.g., *Do not mix with any other products except those listed*).

Labels That Do Not Permit Tank Mixing

If a label:

- has no tank-mix statement
- contains an exclusionary statement

then tank mixing is **prohibited** under the Pest Control Products Act.

To help guide interpretation of the label statements related to tank mixing, the guidance document includes a table to describe various scenarios and whether tank mixing would be allowed (Table 1).

Countdown to Compliance

Growers might remember that originally PMRA set an earlier "two-year" transition period for label updates. In 2025, they extended implementation to **December 20, 2025** – recognizing that the volume of label amendment submissions was high and that registrants would need more time.

Table 1. Permissibility of tank mixing based on various combinations of label statements related to tank mixing

Product X label says	Product Y label says	Can I tank mix? (Y/N)
Nothing (silent on tank mixing)	Nothing (silent on tank mixing)	N
General tank mix statement	Nothing (silent on tank mixing)	N
Nothing (silent on tank mixing)	General tank mix statement	N
General tank mix statement	General tank mix statement	Y
General tank mix statement	Tank mix with Product X	Y
Tank mix with Product Y	General tank mix statement	Y
Tank mix with Product Y	Nothing (silent on tank mixing)	Y
Nothing (silent on tank mixing)	Tank mix with Product X	Y
Tank mix with Product Y	Tank mix with Product X	Y
Tank mix with Product Y	Exclusionary statement (and label does not include a specific Product X tank mix)	N*
Exclusionary statement (and label does not include a specific Product Y tank mix)	Tank mix with Product X	N*

* There may be registered labels that have tank mix scenarios like this. Note that this is not allowed for new tank mix label amendments. Further, any product labels that have tank mix scenarios like this must be amended to alleviate the contradictory scenario. To do this, using the last scenario in Table 1 as an example, one of the following must occur: 1) remove the Product X tank mix from the Product Y label, 2) remove the exclusionary statement from the Product X label, or 3) add a specific tank mix for Product Y on the Product X label. Source: PMRA Guidance Document Tank Mix Labelling 2025

What that means now:

- **Major changes in label language must be in place by late December 2025**
- Until then, unlabelled mixes may still be legally sprayed as a grower has always done, where tank mixing was assumed permitted unless the label prohibited it.
- After December 2025, tank mixes without clear statements on each product label will be off-label.
- Registrants are required to revise promotional and marketing materials (e.g., technical sheets, product guides, websites) to meet these new requirements as well.

The Label Gap

Many growers trying to plan ahead have noticed that updated labels with tank mix language aren't always showing up yet on the PMRA's pesticide label search tool. This is a function of how labels are reviewed and posted – registrants submit changes, PMRA approves them, and then they are published. With the high volume of amendments in the queue, labelling updates can lag what's actually been approved internally.

What You Can Do Now

Check the Most Recent Label Available Online

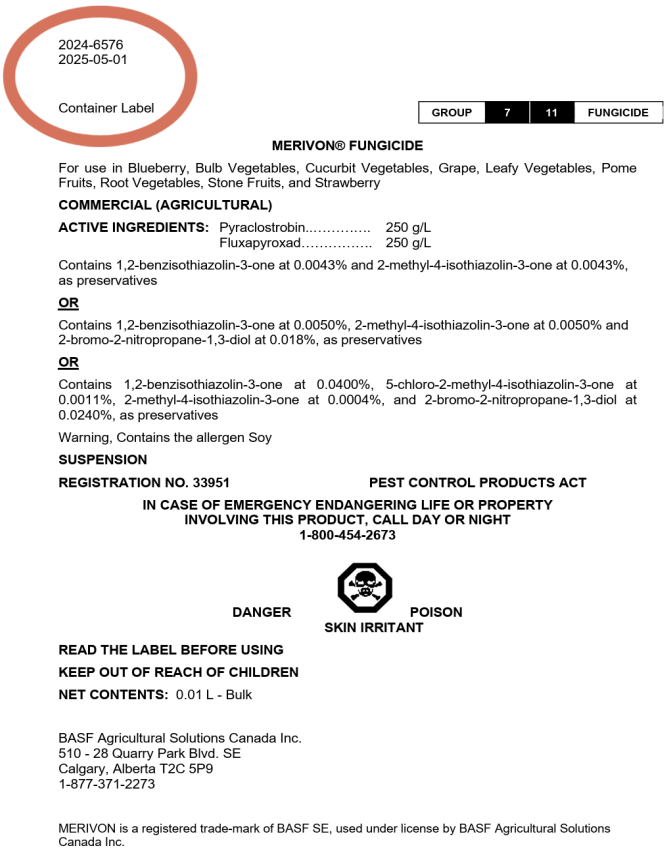
Start with the label posted on the PMRA label search.

All labels have a date of publication in the top left corner of the first page (Figure 1). This date is one of the quickest ways to assess if the label has been amended.

- If the date is **several years old**, there's a good chance the label has not yet been updated to reflect the new tank mix labelling requirements.
- If the date is **recent but there is no tank mix statement**, assume that tank mixing is not permitted under the post-2025 regulations – unless updated guidance is available elsewhere.

Confirm Tank Mixing is Allowed on *ALL* Products

- Every product in the tank must:
  - Either list specific permitted tank mix partners, OR
  - Include the general tank mix statement
- If even one product is silent or exclusionary, the mix is off-label after December 2025.



2024-6576
2025-05-01

Container Label

GROUP 7 11 FUNGICIDE

MERIVON® FUNGICIDE

For use in Blueberry, Bulb Vegetables, Cucurbit Vegetables, Grape, Leafy Vegetables, Pome Fruits, Root Vegetables, Stone Fruits, and Strawberry

COMMERCIAL (AGRICULTURAL)

ACTIVE INGREDIENTS: Pyraclostrobin..... 250 g/L
Fluxapyroxad..... 250 g/L

Contains 1,2-benzisothiazolin-3-one at 0.0043% and 2-methyl-4-isothiazolin-3-one at 0.0043%, as preservatives

OR

Contains 1,2-benzisothiazolin-3-one at 0.0050%, 2-methyl-4-isothiazolin-3-one at 0.0050% and 2-bromo-2-nitropropane-1,3-diol at 0.018%, as preservatives

OR

Contains 1,2-benzisothiazolin-3-one at 0.0400%, 5-chloro-2-methyl-4-isothiazolin-3-one at 0.0011%, 2-methyl-4-isothiazolin-3-one at 0.0004%, and 2-bromo-2-nitropropane-1,3-diol at 0.0240%, as preservatives

Warning, Contains the allergen Soy

SUSPENSION

REGISTRATION NO. 33951 **PEST CONTROL PRODUCTS ACT**

IN CASE OF EMERGENCY ENDANGERING LIFE OR PROPERTY INVOLVING THIS PRODUCT, CALL DAY OR NIGHT 1-800-454-2673

DANGER **POISON**
SKIN IRRITANT

READ THE LABEL BEFORE USING

KEEP OUT OF REACH OF CHILDREN

NET CONTENTS: 0.01 L - Bulk

BASF Agricultural Solutions Canada Inc.
510 - 28 Quarry Park Blvd. SE
Calgary, Alberta T2C 5P9
1-877-371-2273

MERIVON is a registered trade-mark of BASF SE, used under license by BASF Agricultural Solutions Canada Inc.

Figure 1. *Example of pest control product label showing date of publication in top left corner (red circle).*

Look to Registrant Resources When Labels Lag

Once PMRA approves a revised label, registrants are often able to post updated technical sheets, product guides, and tank mix guidance faster than the official label appears in the label search.

If you're unsure:

- Check the registrant's website.
- Review current product guides or marketing bulletins.
- Ask your distributor or registrant rep directly whether a label update has been approved and is available.

Supplementary materials do not replace the label, but they can provide early confirmation that updated tank mix language is coming – and help with season planning.

Understand How Information Gets to the Hub

Information on the Ontario Crop Protection Hub depends on notification from registrants or distributors when label updates or changes occur.

That means:

- If a registrant has not yet shared updated information, the Hub may still reflect older label language.

- Delays do not necessarily mean the product is non-compliant – only that updated information hasn't yet been communicated through official channels.

Flag Issues Early

If you notice:

- Tank mix information that appears incorrect or outdated
- A label that seems inconsistent with that a registrant is advising
- Missing updates that you believe have already been approved

Please reach out directly to Kristy or Erika, PMRA contact centre, or your registrant / distributor contact.

Timely feedback from growers helps ensure Ontario-specific resources remain accurate and up to date for everyone.

Spray Planning, Reworked

For experienced growers, the immediate regulatory bottom line is straight-forward:

Tank mixes you plan for 2026 must be explicitly allowed on the labels of all partner products.

But the practical reality on the farm is more nuanced. There's no denying this shift adds complexity when you're balancing labour, weather and fruit quality.

Less Flexibility Means More Field Passes

Many growers have relied on mixing pest control products in one pass to reduce spray hours and labour.

Under the new framework:

- If products don't all carry compatible tank mix statements, you may have to break that into **two or more applications**.
- That can translate into **more labour, more fuel, and tighter windows for optimal pest control** – especially during conducive weather or critical timings.

It's a shift that may feel less efficient, particularly in peak season, but it's also an opportunity to re-evaluate spray timings and strategize for compliance.

Planning Ahead with Labels

Start now to build your 2026 spray program around labels that already or will likely include tank mix permissions.

Some strategies:

- Cross-check new labels as they are posted and flag products that lack tank mix language.
- When labels are updated, save both the PDF version and date of download – the label itself is the legal reference if compliance questions arise.
- Work with your advisor/consultant, registrant, supplier, or your friendly OMAFA specialist 😊 early in the season to find combinations that will work for you.

For more information on Health Canada's new policy for tank mix statement requirements, see the PMRA Guidance Document, Tank Mix Labelling or visit the Health Canada website.

Pest control product labels registered for use in Canada can be found on the PMRA Pesticide Label Search.

Questions? Contact the PMRA Info Service at pmra.info-arla@hc-sc.gc.ca

Parched & Persistent:
Implications of Drought for Weed Management in Orchards

***Cesar Cappa**, OMAFA Weed Management Specialist*

Climate change and natural weather patterns led to a very dry growing season in 2025. As shown in the map below, most of Ontario received considerably below-average precipitation during the late summer-fall period.

Such dry conditions affect all plants in the orchard ecosystem – not just trees, but also weeds. In this article, I'll explore how drought alters weed populations, soil behaviour, and herbicide performance, and what we can do to manage them heading into the following seasons.

Effects on Weeds

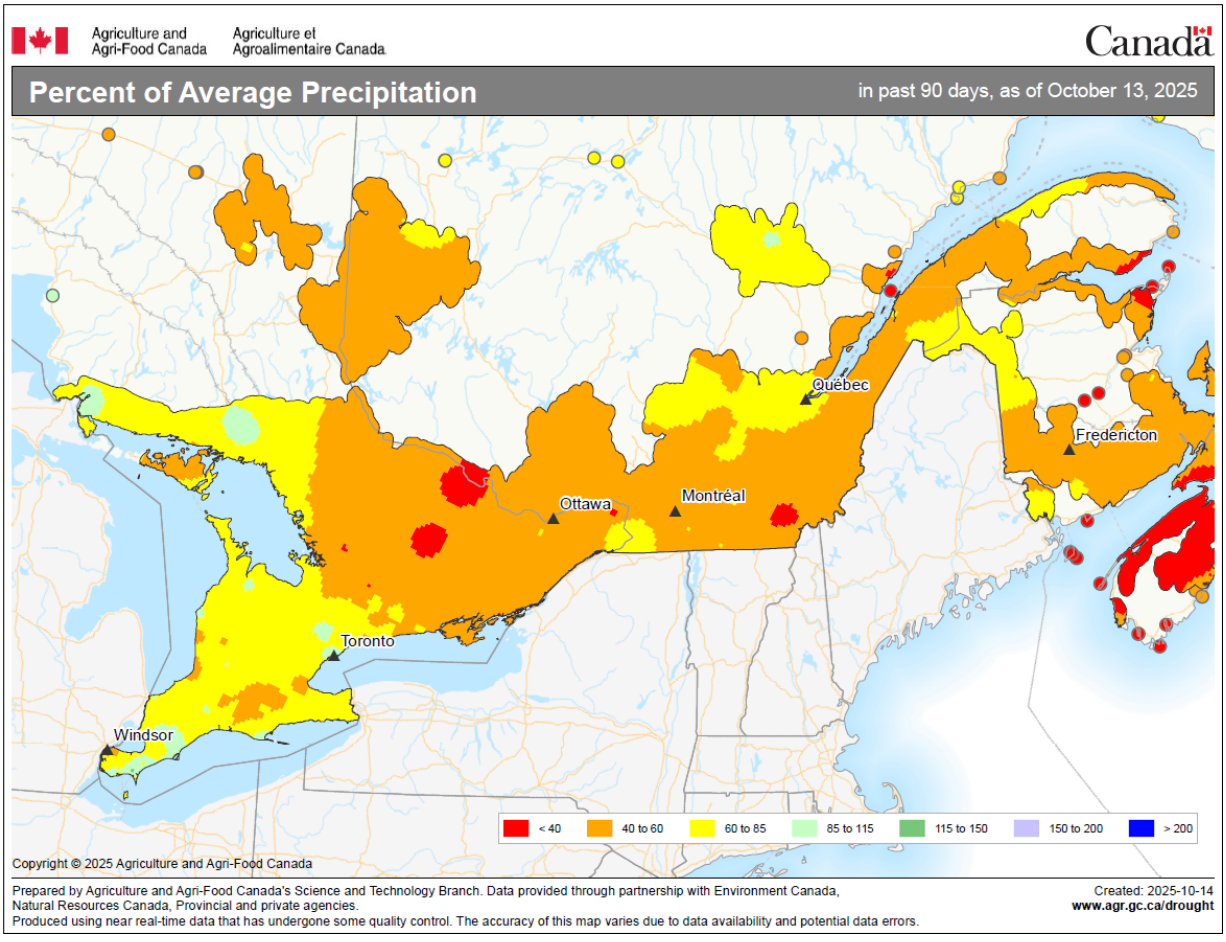
Drought doesn't simply "reduce weeds". Instead, it shifts the weed community and changes how weeds respond to control strategies.

Lower Overall Weed Density – But Not Across the Board

In general, weed emergence often declines under low moisture. However, reduced competition gives drought-tolerant species room to thrive and these can become more problematic.

Increase in Drought-Tolerant Weeds

Weeds such as Canada fleabane, waterhemp, lamb's-quarters, annual grasses, and deep-rooted perennial species gain an advantage in dry years. These weeds may grower larger than expected, develop more robust root systems, and set significant seed, shaping next year's pressure.



Morphological Changes

Water-stressed weeds will adapt by:

- Increasing root expansion and depth, leading to more below-ground competition with trees.
- Triggering early or faster seed production.
- Develop thicker or altered cuticles that limit herbicide absorption.

Reduced Herbicide Efficacy

Generally, water-stressed weeds are harder to control. Reduced translocation and cuticle changes reduce herbicide movement inside the plant. Treatments targeting large, hot, or moisture-stressed weeds in dry soil should not be expected to perform well.

In some cases, exposure under drought-stress has been reported to accelerate the development of herbicide resistance.

Effects on Trees

Although this article focuses on weeds, it's important to consider how drought affects tree sensitivity.

Tree Susceptibility Increases Under Drought

Drought-stressed trees are more susceptible to any additional stress, including herbicide exposure. Trees might not fully recover the following spring, even if the fall and spring had normal precipitation. Both drought and glyphosate exposure have been linked to increased risk of basal cankers, reinforcing the need for careful, targeted applications.

Fall Herbicide Timing Considerations

Herbicide safety improves once trees are fully dormant.

- Dormancy typically occurs late November into early December.
- Applying burndown or residual products after full leaf drop reduces the chance of unintended uptake and phytotoxicity.
- Dormancy provides a valuable window to clean up weeds while minimizing risk to stressed trees.

Effects on Soil

Drought significantly alters soil behaviour and therefore herbicide performance.

Reduced Microbial Activity

Lower soil moisture slows microbial breakdown of many residual herbicides compared to average years.

This can lead to:

- Longer persistence of soil-applied products.
- Increased carry-over risk.
- Potential injury to replants or young trees in following seasons.

Soil Cracking and Root Exposure

In heavier textured soils, cracking can:

- Allow weeds to germinate through crevice gaps, avoiding the herbicide-treated layer.
- Exposure shallow tree roots to herbicide spray or run-off.

Residual Herbicide Persistence and Carry-Over

Residual products such as Chateau, Authority, Sencor, and Prowl may persist longer in dry years.

- Soil moisture and microbial activity drive degradation; with reduced activity, residues remain longer.
- Follow best practices for resistance management by rotating herbicide modes of action, where possible.
    - This also reduces the likelihood of excessive accumulation of residues from a single active ingredient in the soil, particularly in dry years when degradation is slower.
- If replanting is planned, consider extending the labeled plant-back interval by an additional year.
- For high-risk sites, a soil bioassay (growing a sensitive test crop in collected orchard soil) could be used to confirm degradation before spring.

Practical Considerations for Weed Management

Bringing together the above impacts, several considerations can help for effective weed management after a drought year.

Weed Management Will Be Critical

Stressed trees and drought-adapted weeds are not a good combination. Drought-adapted weeds aggressively pursue scarce water. Don't assume weeds are less of an issue because they grow smaller. They compete strongly below ground, often with extraordinarily developed root systems, and can produce large amounts of seeds that will affect future seasons.

Widening the herbicide strip may be beneficial during severe drought years to reduce resource competition.

Adapt to Changes in Weed Populations

Scout regularly and take notes of the weed species, density, and changes from previous years. You might need to adjust the cultural methods and herbicides used to better deal with the dominant species under drought conditions.

Improve Timing for Post-Emergence Applications

Water-stressed weeds might look smaller and less dense, but they will also be much harder to control. Post-emergence treatments will be generally less effective.

For annual weeds, target treatment when weeds are:

- Small
- Well-hydrated
- Actively growing

Optimize adjuvants and spray conditions. Avoid applications to large or stressed weeds in dry soil – performance will be poor.

Avoid Unnecessary Stress on Trees

With drought-weakened trees, precision is critical:

- Prevent drift onto foliage or trunks.
- Be cautious if the soil is cracked and shallow roots are potentially exposed.
- Prioritize applications after full dormancy to minimize unintended uptake.

Consider Residual Herbicide Persistency

If replanting:

- Recognize that drought slows herbicide breakdown.
- It might be necessary to wait an additional year beyond what is stated on the label. Check label for specific instructions on drought scenarios.
- For isolated replants, remove approx. 3.8 cm (1.5 inches) of surface soil in a radius of 45.7 cm (1.5 feet) around the planting hole and refill with clean soil.
- Use soil bioassays where carry-over risk is uncertain.

Final Notes

The effects of drought carry into the next season. Weeds that thrived under stress, shifts in species composition, stronger root systems, reduced herbicide breakdown, and lingering tree stress do not just reset once rainfall returns to normal. Being aware of these impacts can help growers anticipate challenges and make informed decisions in the fall and spring.

The goal isn't to redo your entire weed management program, but to fine-tune it based on what you observed this season. Detailed scouting, good records, and targeted adjustments in herbicide strategy can make a big difference during and after drought-affected years.

Dormant Defenses:
Winter Management Strategies for Fire Blight

Kristy Grigg-McGuffin, *OMAFA Horticulture IPM Specialist*

Fire blight, caused by the bacterium *Erwinia amylovora*, remains one of the most challenging and economically significant diseases affecting apples and pears in Ontario. Effective management requires a season-long, integrated approach that begins well before bloom.

Winter Hideout

Erwinia amylovora is a facultative anaerobic bacterium - simply put, it's a bacterium that can "breathe" oxygen when it's around but doesn't die without it – that infects host tissues through natural openings (floral nectaries, stomata, hydathodes) or wounds.

During the growing season, the pathogen spreads rapidly via rain splash, insects (particularly pollinators), and contaminated tools or equipment. In the winter, however, *E. amylovora* does not survive freely in the orchard on exposed surfaces, in soil, or on dead plant debris. Instead, it persists almost exclusively within living host tissue, primarily in:

- Cankers on shoots, limbs and trunk (Figure 1)
- Occasionally in infected rootstock, particularly in young trees (Figure 2)

As trees enter dormancy, bacterial populations become metabolically inactive and are confined to the margins of cankers, often several centimeters beyond visibly necrotic (damaged) tissue. These overwintering cankers are the primary inoculum source for the following season.

Survival Mode

During late summer and fall, as host tissues harden and temperatures drop, *E. amylovora* transitions from an actively multiplying pathogen to a latent, overwintering state with survival depending solely on remaining inside living woody tissue.

Figure 1. *Fire blight canker on limb of apple tree.*

Figure 2. *Rootstock fire blight.*

Within cankers, *E. amylovora* persists primarily in the cambial and phloem tissues at the canker margin – the interface between healthy and necrotic tissue. This zone provides protection from desiccation, UV radiation, and lethal winter temperatures. Importantly, the bacterium can extend well beyond the visible edge of the canker, which is why superficial pruning fails to get rid of inoculum.

Winter survival is influenced by several factors:

- **Canker type and age** – Fresh, actively expanding cankers formed the previous season are more likely to harbour viable bacterial populations than old, fully callused lesions.
- **Tree vigour and cultivar susceptibility** – Vigorous trees and highly susceptible cultivars often develop larger, more persistent cankers that support bacterial survival.
- **Winter conditions** – Extremely cold temperatures can reduce bacterial viability, but typical Ontario winters are rarely cold enough and for long enough to reduce populations within protected tissue.

As temperatures rise in spring (generally above 10-12˚C), bacteria within surviving cankers resume metabolic activity and multiply rapidly. Increased internal pressure and sap flow force bacterial cells to the surface, where they are exuded as sticky, sugar-rich bacterial ooze (Figure 3). This ooze is highly attractive to insects and readily spread by rain splash, making each active canker a highly efficient point source of inoculum.

Figure 3. *Sticky, amber-coloured bacterial ooze exuding from fire blight canker.*

Linking Biology to Practice

Research has consistently shown that orchards with aggressive dormant canker removal have lower disease pressure during bloom and fewer secondary infections later in the season, particularly in high-risk blocks with a history of fire blight.

This is because dormant pruning exploits weaknesses in the pathogen's life cycle:

Localized Inoculum

During winter, *E. amylovora* is confined to discrete infection sites (cankers). Removing these tissues physically removes the pathogen from the orchard.

Pathogen Inactivity

Cold temperatures limit bacterial multiplication and movement, reducing the risk of pathogen spread on tools or cut surfaces. There is typically no need to disinfect tools between cuts while dormant pruning, provided cuts extend well beyond infected tissue.

Improved Detection

The absence of foliage – assuming trees like Ambrosia actually drop their leaves! - improves visibility of fire blight symptoms, including overwintered strikes and cankers that may be obscured with lush canopy.

Hide and Seek

Scout thoroughly for cankers while pruning. It is recommended to do this more than once during the late winter or early spring and at different times during the day. While this does take additional time, that extra work may save you trees down the road by removing inoculum sources.

Shoot blight can be easily identified by the characteristic shepherd's crook. Since the limb is dead, blighted leaves often remain on the limb throughout winter (Figure 4).

Figure 4. *Blight leaves often remain on shoot infected with fire blight over the winter.*

Cankers may not be as obvious. They can vary in size on twigs, limbs or trunks of trees (Figure 5). Typical characteristics of fire blight canker include:

- Sunken or wrinkled area with a narrow ridge along the margin
- Rough or darkened bark often located around a spur, wound or pruning stub
- May develop cracks within or around the margins
- Inner bark of canker may appear reddish brown and ooze a sticky amber substance during the spring and early summer, especially in humid conditions
- Black sooty mould can grow on the sugary substances, giving the canker a black appearance
- May become colonized by other fungi such as the black rot fungus, *Botryosphaeria obtusa*

Figure 5. *Fire blight cankers can appear sunken, discoloured, and with cracked margins.*

Cankers can be small and subtle or large and perennial, particularly on susceptible cultivars or in vigorous blocks. Importantly, the visible margin of a canker does not define the true extent of bacterial colonization.

Prune With Purpose

To effectively remove infected wood:

- **Cut well beyond visible infection** – Make cuts at least 30-45 cm (12 – 18 inches) beyond the visible canker margin, into healthy 2-year-old wood. This helps account for asymptomatic bacterial spread within the vascular tissue.
- **Prioritize high-risk trees** – Young trees, highly susceptible cultivars, and trees with rootstock or trunk infections should be priority.
  - Trees with trunk cankers often serve as chronic inoculum sources and may warrant complete removal.
  - Older trees to be removed can be cut a few feet above the soil and left to dry out while prioritizing high-risk trees.

Common Pruning Mistakes (Dormant & In-Season)

- **Cutting too close to visible canker** – Shallow cuts often leave asymptomatic bacteria behind, allowing cankers to reactivate in spring.
- **Leaving trunk or rootstock cankers in young trees** – These infections frequently act as chronic inoculum sources and can lead to rapid tree loss.
- **Delaying removal of heavily infected trees** – Leaving high-inoculum trees in place increases disease pressure on surrounding blocks.
- **Ignoring small or subtle cankers** – Small, first-year cankers are often the most epidemiologically important contributors to spring inoculum.
- **Failing to sanitize tools** – When bacteria are active in-season, contaminated tools can move *E. amylovora* between trees.
- **Pruning during wet weather or when tissues are actively oozing** – Moist conditions facilitate bacterial movement into fresh wounds and increase the likelihood of new infections.
- **Excessive pruning** – Heavy pruning when the tree is active can stimulate lush (susceptible) growth.
- **Mixing fire blight pruning with general canopy pruning** – Combining tasks increases the risk of spreading bacteria from infected to healthy tissues; fire blight removal should be prioritized and completed separately.
- **Over-reliance on in-season controls** – Chemical and biological tools perform best when overwintering inoculum has already been reduced through sanitation.
- **Tool sanitation** – During true dormancy, disinfecting tools between cuts is generally unnecessary when cuts extend well into healthy wood.
  - Caution during warm periods late winter or early spring when bacterial activity may resume.

Beyond Pruning

Dormant pruning is most effective when integrated with complimentary winter management practices:

- **Removal or breakdown of prunings** – Leaving infected wood intact can prolong survival of bacteria. Chipping or mulching prunings in-row facilitates drying and tissue breakdown.
- **Urea application** – spring urea applied to pruned wood (ideally chipped or mulched) can enhance microbial activity and accelerate decomposition of infected tissues.
- **Tree removal decisions** – In young orchards, trees with trunk or rootstock blight should be removed promptly to prevent spread to adjacent trees.
- **Pruning timing and vigour management** – Avoid excessively aggressive pruning that may stimulate vigorous shoot growth in spring, as succulent tissue is most susceptible to infection.

Spring Ahead

In Ontario's climate – where bloom periods now often coincide with highly conducive weather – winter sanitation remains one of the most cost-effective and biologically sound fire blight management strategies available. Reducing overwintering inoculum through dormant pruning does not eliminate fire blight risk, but it significantly lowers the baseline disease pressure entering bloom.

Winter is also a good time to start to prepare for in-season management as bloom can come quickly. Having products ready and at your fingertips will allow you to act fast should conditions for infection occur. Don't get caught unprepared!

- Have enough control product to cover all rows of susceptible blocks every 3 days during bloom.

- Become acquainted (or refresh your memory) with forecasting models such as Cougar Blight or MaryBlyt if you will be running these for your farm. Otherwise, bookmark the Ontario Fire Blight Prediction Maps in your browser for quick reference during bloom.
- Make a plan for bloom and shoot management
  - What products will you use (antibiotics, coppers, biologicals, PGRs, etc.)
  - How will you use them – biologicals early bloom? Bactericides full bloom to petal fall?
  - Don't forget to consider your action plan in case of trauma blight
- Be prepared to apply copper at silver tip to help protect the spread of bacteria from any oozing cankers that were missed during dormant pruning.

Dormant Defense Recap

- **Overwintering inoculum is localized** – *E. amylovora* survives primarily in living tissue at canker margins. Every canker left in the orchard is a potential point source of bacteria at bloom.
- **Visible symptoms underestimate risk** – Bacteria frequently extend well beyond the visible edge of a canker. Pruning cuts must reach sufficiently into healthy wood (30-45 cm) to remove asymptomatic infections.
- **Timing matters** – During true dormancy, bacterial populations are inactive and confined, making winter pruning the lowest-risk period for physical removal.
- **Tree age influences decisions** – Trunk and rootstock cankers in young trees or chronic strikes often indicate systemic infection; whole-tree removal is likely more effective than selective pruning.
- **Fewer cankers = lower bloom pressure** – Reducing the number of active cankers before spring directly lowers blossom infection risk and improves the effectiveness of in-season management tools.

RESEARCH HIGHLIGHTS

2025 Vineland Apple Breeding Program Update

Rachael LeBlanc, *Vineland Research and Innovation Centre*

Vineland has been breeding apples since 2011. There are over 125 selections in the second stage of replicated testing on Vineland's Research Farm and 13 in third stage testing at grower sites in Ontario, Quebec and Nova Scotia. Initial selections have been made based on predicted consumer liking, ensuring that apples that are released from the program have high consumer appeal.

In 2025, Vineland initiated a pilot project to examine the response of some advanced selections to fire blight (*Erwinia amylovora*) infections. The level of disease resistance will be one factor to consider when determining if an apple selection should be released as a commercial cultivar.

The fire blight study was modeled after Tegtmeier *et al.* (2023) to assess the tolerance of Vineland selections to infection in a controlled setting. Thirteen Vineland and 5 commercial control (Crimson Crisp, Fuji, Honeycrisp, Liberty and Winter Banana) apple selections (n=4 to 10 per cultivar) were bench grafted onto M26 rootstock and stored at 4°C for approximately one month until they were potted and maintained in a greenhouse. Grafted trees were assigned ambiguous codes to mask their identity and randomized. One shoot per scion was maintained. Once shoots reached approximately 10cm, the trees were transferred to Vineland's Advanced Pathology Lab where they were inoculated with fire blight using a scissor dip method. Shoot length and shoot necrosis were measured at 0, 7, 10 and 14 days post-inoculation.

In general, commercial controls displayed an expected pattern when challenged with fire blight. Susceptible cultivar 'Winter Banana' displayed high levels of shoot necrosis, and moderately resistant cultivar 'Crimson Crisp' displayed low levels of shoot necrosis (Figures 1 &

Figure 1. *Inoculated shoot of Winter Banana (left) and Crimson Crisp (right) at day 14 post-inoculation with fire blight (Erwinia amylovora). (Photos: Vineland Research & Innovation Centre)*

2). While Honeycrisp and Liberty – both known to be moderately resistant to fire blight – displayed low levels of shoot necrosis as well, Fuji – most often reported to be a susceptible cultivar – did not show high levels of shoot necrosis as expected (Figure 2). These results may have been impacted by the small sample size (n=4) for this cultivar.

Vineland selections ranged in their response to the pathogen (Figure 2). Vineland 22 to 25 had moderate to low levels of shoot necrosis and were all significantly different than Winter Banana. All other Vineland selections appear more susceptible than fire blight - resistant commercial controls.

We have successfully adapted Tegtmeier's method to the conditions at Vineland and have observed a range of responses to *Erwinia amylovora*. The experiment will be repeated with these and additional genotypes and replicates. A full-scale experiment is necessary before we can confidently report on the resistance or susceptibility of any Vineland genetics.

Resources & References

Ontario Crop Protection Hub – Disease Susceptibility Rating of Common Apple Cultivars.

Beckerman, J. Disease Susceptibility of Common Apple Cultivars. Purdue Extension BP-132-W. Purdue University.

Tegtmeier, R., Cobb-Smith, D., Zhong, GY., & Khan, A. 2023. Identification and marker development of a moderate-effect fire blight resistance QTL in *M. sieversii*, the primary progenitor of domesticated apples. Tree Genetics & Genomes 19:50. https://doi.org/10.1007/s11295-023-01626-6

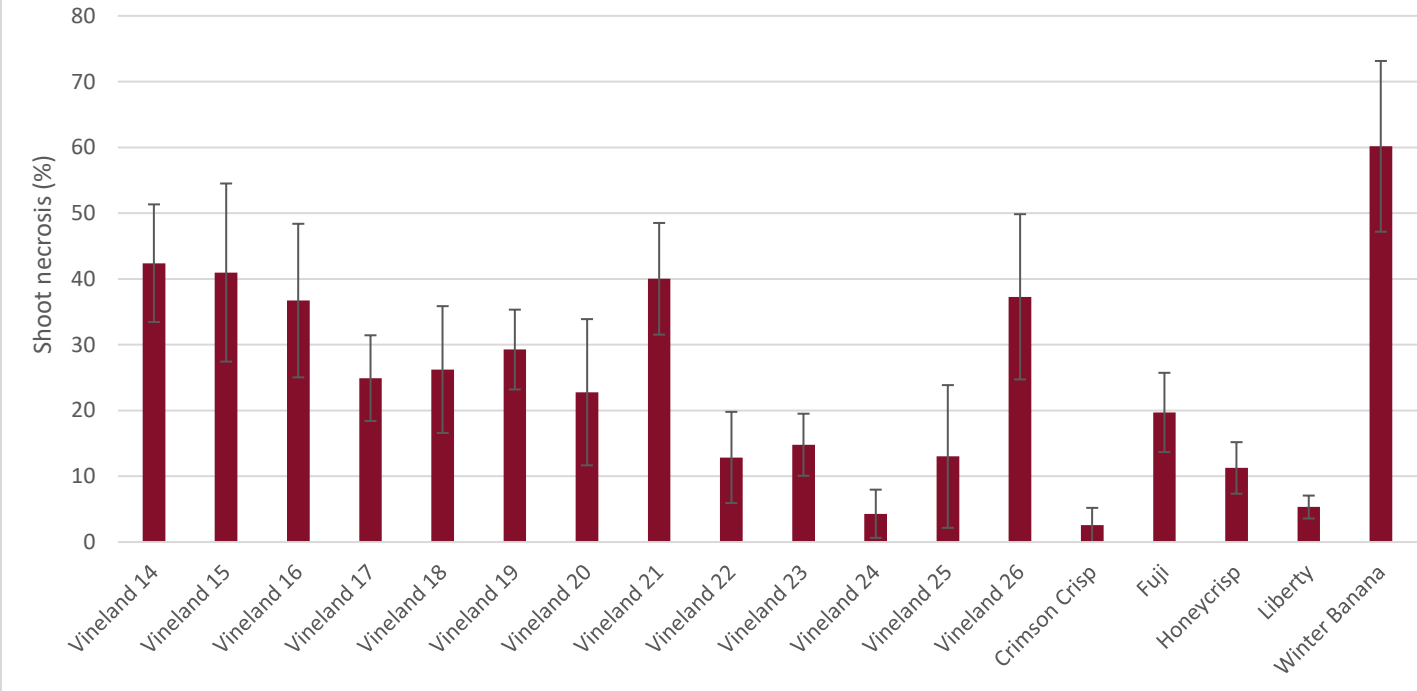


Figure 2. *Percent of shoot (10cm) that was necrotic at day 14 post-inoculation with fire blight (Erwinia amylovora) for 13 Vineland selected cultivars and 5 commercial control cultivars.*

ANNOUNCEMENTS

Ontario Fruit & Vegetable Convention, Feb 18-19

The Ontario Fruit & Vegetable Convention (OFVC), Canada's premier horticultural event, is returning to the Niagara Falls Convention Centre in Niagara Falls, ON on **February 18-19, 2026.**

Want the inside scoop? Take a sneak peek at the apple sessions below or check out the full schedule online.

Wednesday, February 18 - Afternoon

2:00PM- Increasing Premium Quality Fruit by Choosing the Right Rootstock

- Dr. Lee Kalcsits, Washington State University, US

2:45PM - Replant Disease Tolerance, Nutrient Uptake and Other Unique Ways Geneva Apple Rootstocks Interact With Soil

- Dr. Gennaro Fazio, USDA-ARS Plant Genetic Resources Unit, US

3:30PM - Physiological Links Between Rootstock Cold Hardiness and Tree Decline in Apples

- Dr. Jason Londo, Cornell University, US

Thursday, February 19 - Morning

9:30AM – Integration of On-Site Weather Data With Decision Support Systems (DSS's)

- Jon Clements, University of Massachusetts, US

10:00AM – Best Antibiotic Alternatives for Fire Blight Management in Apples

- Dr. Kerik Cox, Cornell University, US

10:30AM – The Effect of Crop Load in Relation to Hard Cider Juice Quality

- Dr. Shanthanu Krishna Kumar, Pennsylvania State University, US

11:00AM – From Orchard to Market: Climate Impacts on Apple Quality in Long Cold Chains

- Dr. Carolina Torres, Washington State University, US

Thursday, February 19 - Afternoon

2:00PM – Tree and Fruit Physiology as a Basis for Precision Management

- Dr. Luigi Manfrini, University of Bologna, Italy

2:30PM – Apple Physiology as a Basis for Precision Management: Case Study

- Dr. Luigi Manfrini, University of Bologna, Italy

3:00PM – PACMAN: No, it's Not a Video Game!

- Jon Clements, University of Massachusetts, US

3:30PM – The Core of the Problem: Plum Curculio Basics for Apple Growers

- Hannah Fraser, Ontario Ministry of Agriculture, Food & Agribusiness

Register Now! Ontario Sweet & Craft Cider Competitions

Calling all Ontario cider makers! Get ready to showcase your best ciders at the 2026 Ontario Cider Competitions at the Ontario Fruit & Vegetable Convention in Niagara Falls.

Ontario Sweet Cider Competition

Wednesday, February 18, 2026,

Niagara Falls Convention Centre

This competition welcomes sweet ciders made with 100% Ontario apples – with medals awarded to the top entries.

Only one sweet cider per business is permitted.

Registration is required by **Wednesday, February 4, 2026**. Entries can be shipped in advance or delivered in-person from 8:30-10:00am on the day of the competition.

Ontario Craft Cider Competition

Tuesday, February 17, 2026

Niagara Falls Convention Centre

Craft cider producers can enter up to *four categories* including Modern, Fruit & Botanical, Hopped & Barrel Aged, and Traditional/Heritage – all made with 100% Ontario apples. Medals, industry recognitions, and judging panel feedback are all on the line! Entries must be shipped in advance.

Important Deadlines

ONLINE REGISTRATION – February 4, 2026
SHIPPING DEADLINE – February 11, 2026

Don't miss this chance to elevate your cider's profile and earn bragging rights across Ontario's growing cider community.

REGISTER TODAY! For full details and to register, click on the links below:

- Ontario Sweet Cider Competition
- Ontario Craft Cider Competition

Thank you to the Ontario Apple Growers and the Ontario Craft Cider Association for sponsoring these competitions!



The Past, the Present, and the Future of PACMAN

January 12, 2026 — 11am - 3pm EST / 8am - 12pm PST

Precision Apple Crop Load Management Updates & Beyond!

Register now:

https://cornell.zoom.us/webinar/register/WN_f_zjuqCWQp2nM47F2CiM3Q

Join nationally renowned scientists and extension specialists for this nationwide PACMAN webinar. After more than five years of scientific research and ground-truth evaluations, the latest results will be presented. The session will also explore new research directions and foster collaborations for the next phase of the PACMAN project in the coming years.

Agenda

- **11:00** Introduction to PACMAN - Terence Robinson, CU
- **11:10** Optimum bud and fruit number of Honeycrisp and Gala - Terence Robinson, CU
- **11:30** Economics of thinning Honeycrisp and Gala, Mauricio Guerra Funes, CU
- **11:50** Fruit Growth Rate Model results - Todd Einhorn, Michigan State; Tom Kon, North Carolina State University
- **12:30** WA-38 crop load management - Stefano Musacchi, Washington State University
- **12:50** Pollen Tube Growth Model improvements - Greg Peck, CU
- **1:10** Engineering Results PA - Long He, Pennsylvania State University
- **1:30** GPS and Variable Rate Spraying - Brian Lawrence, CU; Yu Jiang, CU
- **2:00** Extending the results of PCLM - Jon Clements, University of Massachusetts
- **2:20** Discussion
- **2:40** Future SCRI proposal to continue PCLM - Yu Jiang, CU; Terence Robinson, CU

Cornell Cooperative Extension
Lake Ontario Fruit Program

Cornell University

MICHIGAN STATE UNIVERSITY

University of Massachusetts Amherst

PennState Research

WASHINGTON STATE UNIVERSITY

USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

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