

ORCHARD NETWORK

For Commercial Apple Producers

VOLUME #25, ISSUE #1 February 2021 ISSN 2291-5907

In this issue...

Orchard Management

Cutting Limbs Could Cut Your Revenue: An Investigation On Timely Pruning, Cold Hardiness And Winter Injury

Erika DeBrouwer, Tree Fruit Specialist, OMAFRA

Background

Pruning is an essential task utilized annually in tree fruit production, affecting various aspects within the orchard such as: crop load, fruit size, light penetration, water absorption, fruit quality, fruit bud initiation, along with nutrient uptake and mineral content. Pruning is also used to reduce the spread of infection throughout an orchard and is usually performed in late winter or early spring. Although there are many benefits to growers by pruning their trees, negative effects and an increase in cost can occur if pruning is performed too early or too late in the season. Pruning is also about balance, as excessive pruning can result in excess vigour, and lack of pruning can result in shading leading to less fruit bud formation.

This newsletter is made possible by the generous support of the following sponsors:

This newsletter is brought to you by the
Ontario Apple Team:

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

Dr. Jennifer DeEll, Simcoe
Fresh Market Quality Specialist
(519) 426-1408
jennifer.deell@ontario.ca

Dr. John Cline
University of Guelph, Simcoe
(519) 426-7127, ext. 331
jcline@uoguelph.ca

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

Hannah Fraser, Guelph
Entomologist-Horticulture
519-824-4120,ext 52671
hannah.fraser@ontario.ca

Anne Verhallen, Ridgetown,
Soil Management Specialist:
Horticulture
(519) 674-1614
anne.verhallen@ontario.ca

Dr. Jason Deveau, Simcoe,
Application Technology Specialist
(519) 426-8934
jason.deveau@ontario.ca

John Zandstra
University of Guelph, Ridgetown
(519) 674-1500 ext. 63627
jzandstra@ridgetownc.uoguelph.ca

Katie Goldenhar, Guelph
Pathologist: Horticulture
(519) 824-4120 ext. 58910
katie.goldenhar@ontario.ca

Denise Beaton
Crop Protection Specialist
(519) 400-3636
denise.beaton@ontario.ca

This issue of the Orchard Network Newsletter was compiled by:

Jacquie De Fields,
Client Service Representative,
OMAFRA, Simcoe Resource Centre

Best Time to Trim

There is not one correct answer when it comes to the right time to prune your orchard. Many factors influence the best time to prune but the most significant factor is weather. Weather initiates the acclimation and de-acclimation of dormancy in apples, which is pertinent in determining the ideal time to prune. Apples should be pruned in the late winter or early spring – after chances of severe temperature changes have passed. Overall, when determining the best time to prune, weather, dormancy, cold hardiness and winter injury need to be considered before clipping.

Dormancy Phases

Depending on the part of the tree, different levels of cold hardiness are observed and the physiology changes on how plant tissues acclimate to cold. Hardening off of trees begins at the branches and works inwards. The slowest parts of trees to harden off are tree trunks and graft unions, especially at ground level, along with tree crotches. This means that these parts of the tree are more susceptible to cold temperatures and could result in trunk splitting or damage in crotches if cold temperatures occur in late fall or early winter.

Deep supercooling occurs in the xylem and pith tissues in the wood and are able to retain cellular water in liquid form at low, subfreezing temperatures due to cryoprotectants. Apple buds and bark become dehydrated as water is drawn between the cells to decrease the possibility of damage and to retain cell structure when ice forms. This occurs through the creation of a water potential gradient preventing freezing inside the cell or penetration of ice crystals through the cell wall. Apple buds have a high tolerance to dehydration. Dehydration is crucial in the beginning and end of dormancy for apples to start acclimation and de-acclimation based on the season.

Dormancy of trees is separated into three different phases:

1. **Paradormancy** (correlation inhibition or dormancy establishment)
   - Begins when external physiological factors restrict growth of the bud
   - Takes place in the late summer and early fall
2. **Endo-dormancy** (true dormancy)
   - Growth stops due to internal factors, even in favourable conditions
   - Prevents buds from bursting in mild conditions
   - Maximum hardiness is usually assumed to occur mid to late January
3. **Eco-dormancy**
   - Growth is prevented by unsuitable conditions
   - The tree is freezing tolerant at this stage, but not deeply dormant

Eco-dormancy is the most important when it comes to late winter and early spring tree pruning as this phase occurs during this time, yet no visible external changes are seen on the tree. The tree is not fully dormant at this stage and temperature fluctuations can impact trees phasing out of dormancy or de-acclimation. The paradormancy phase is also important in the late summer and early fall in regard to pruning as the trees may not be fully dormant and new growth may even be initiated.

Late Fall/Early Winter Pruning

During the late fall and early winter apple trees are not fully acclimatized to tolerate cold temperatures, therefore pruning is not recommended. During this time, pruning trees would increase sensitivity to cold temperature injury. Another potential risk when fall pruning is the introduction of boring insects and canker disease that are still active at that time into pruning wounds.

Late Winter/Early Spring Pruning

Although this is the ideal time to begin pruning, severe changes in weather can be detrimental to the bottom line of your production. It can take up to two weeks for trees to regain their cold hardiness after pruning has occurred, as pruning stimulates meristematic cellular activity of latent buds near cuts. If pruning is performed within an orchard and a cold snap follows, severe damage, such as winter injury, and/or potentially tree death could occur. This is especially important in the late winter season, as trees could be in the eco-dormancy phase and with mild temperatures trees may de-acclimate prematurely due to warm spells. Another factor to consider when pruning in the late winter/early spring is that apples could reach their chilling requirement, meaning that the trees lose the ability to reacclimate to their previous cold hardiness levels attained earlier in the winter.

Cold Hardiness

Apple trees are cold hardy, withstanding temperatures between -25 to -30°C without a killing frost, although cold hardiness is not guaranteed as variation depends on multiple factors. Variety, rootstock, location, production systems, tree stress (e.g. water, fertility, pests), weather occurrences and pruning practices all impact cold hardiness within the orchard.

Cold hardiness of apple trees can decrease when:

- Pruning occurs too early in the winter
- Too much pruning occurs the previous fall
- Infected buds or wood is present
- Crop load isn't managed
- Fall applied nitrogen
- Deficient in nutrients (Nitrogen, Potassium, Zinc, Magnesium and Boron)

Compromising the cold hardiness of apple trees potentially impacts the growth and production of fruit and increases the susceptibility of winter injury to trees.

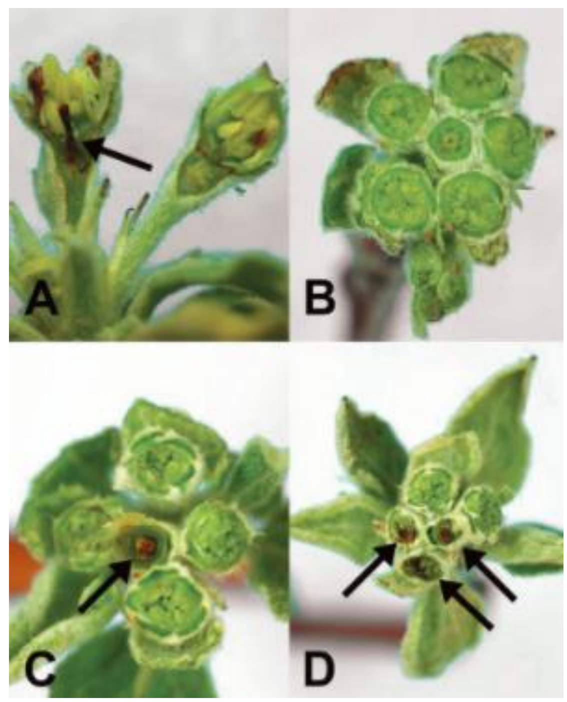


Figure 1. (A) Vertical section of apple buds, where the left flower is killed. **(B)** Six live flowers from apple (**C)** King bloom pistil killed in apple bud **(D)** King bloom and two side blooms killed in apple bud
(Photo: HJ Larsen, Utah State University)

Winter Injury

Winter injury occurs when freezing damage to leaves, bud tissues or wood is found, caused by cold temperatures. Winter injury can cause so much damage that trees are no longer recoverable or could lead to the death of the tree.

Winter injury on the trunk tends to have a dark external bruise on the bark that can be soft to the touch. To confirm observations, peeling back the bark would reveal a dark brown inner stem tissue. This can be further clarified during the growing season if patchy, irregular and poor growth are observed.

Winter injury to bud tissues is more difficult to determine. The best way to confirm winter injury of buds is through observation. First, collecting buds throughout your orchard and then cutting the buds horizontally and vertically to analyze the ovules and styles. If brown or black tissue is revealed, winter injury or frost damage has occurred (Figure 1). To better understand when winter injury damage could occur on apple buds Table 1 demonstrates the critical temperatures during the spring in relation to growth stage.

Table 1. Critical Spring Temperatures in °C for Apples

	Silver Tip	Green Tip	½ inch Green	Tight Cluster	First Pink	Full Pink	First Bloom	Full Bloom	Post Bloom
10% Kill	-9.4	-7.8	-5.0	-2.8	-2.2	-2.2	-2.2	-2.2	-2.2
90% Kill	-16.7	-12.2	-9.4	-6.1	-4.4	-3.9	-3.9	-3.9	-3.9

Winter injury can be found in many different forms on various parts of the tree, including:

- Blackheart: Occurs when the pith is killed, and the heartwood is darkened. Gumming also occurs with cell death.
- Cambium injury: Gumming could be a symptom. Cambium is one of the last parts to harden off, where cambium injury results in a weakened tree.
- Crotch injury: Could result in injury up and down limbs. Crotches are one of the last parts of the tree to harden off, where narrow crotch angles are more at risk.
- Crown injury: Results in the killing of the bark close to the ground. Certain varieties could be more susceptible.
- Southwest Injury: Occurs when the tree trunk is heated during a sunny day followed by a dramatic drop in temperature. Use of white latex paint is recommended.
- Trunk splitting: Commonly occurs most often in the late fall or early winter due to a rapid temperature drop. Cracking and splitting can occur all the way to the pith and may not heal over or close.
- Shoot death and dieback: Normally occurs with very cold weather when trees are not fully acclimated. Prevalence could be increased with nitrogen fertilization and late pruning.
- Leaf and flower bud injury: Temperatures required to damage buds varies between 5˚ and 6˚C due to acclimation and de-acclimation of trees. Below -35˚C could result in tree damage.
- Root death: This is exacerbated by bare ground and can begin at -4˚ to -12˚C.

Winter injury not only impacts the growth of the apple trees but increases the susceptibility to other pests and diseases. This leads to more expense through mitigation strategies and loss of income through death of trees.

The possibility of winter injury increases if pruning is performed too early in the winter, followed by severely cold weather. Fall pruning also enhances vulnerability to winter injury, specifically around the pruning wound.

Mitigation of Winter Injury

Improving the cold hardiness of trees can increase the resilience against winter injury.
Cold hardiness of apples trees can increase when:

- Timely pruning occurs
- Trees are healthy
- Crop load is managed
- Growth Regulators are used
- Late season Nitrogen application are avoided

To reduce or eliminate damage from winter injury utilize the following mitigation strategies:

- Avoid pruning in the fall or early winter
- Prune cold hardy varieties/species first
- Prune older trees first (late winter) younger trees (early spring)
- Use soil-applied nitrogen in the early season
- Select hardier cultivars
- Select sites with minimal low spots or location with low air movement
- Use weather risk reduction technologies

- Paint tree trunks with white latex paint
- Choose cold hardy rootstocks
    - B.9 (Budgovsky 9) has excellent winter hardiness
    - O.3 (Ottawa 3) has good winter hardiness
    - V.2 (Vineland 2) has moderate to good winter hardiness
    - M.9 (Malling 9) has moderate to good winter hardiness
    - M.27 (Malling 27) has moderate to good winter hardiness

References

Arora, R., and Rowland, L.J. 2011. *Physiological research on winter-hardiness: Deacclimation resistance, reacclimation ability, photoprotection strategies, and a cold acclimation protocol design.* HortScience. 46(8): 1070-1078.

Fadón, E., Fernandez, E., Behn, H., and Luedeling, E. 2020. *A conceptual framework for winter dormancy in deciduous trees.* Agronomy: 214(1): 1-20.

Palonen, P., and Buszard, D. 1997. *Current state of cold hardiness research on fruit crops*. Can. J. Plant Sci. 77(3): 399-420.

Schupp, J.R., Cheng, L., Stiles, W.G., Stover, E., and Iungerman, K. 2001. *Mineral nutrition as a factor in cold tolerance of apple trees.* NY Fruit Quarterly. 9(3): 9-12.

Wisniewski, M., Bassett, C., and Gusta, L.V. 2003. *An overview of cold hardiness in wood plants: Seeing the forest through the trees*. HortScience. 38(5): 952-959.

Zhang, L., Koc, A.B., Wang, X.N., and Jiang, Y.X. 2018. *A review of pruning fruit trees*. IOP Cenf. Ser: Earth Environ. Sci. 153(6): 1-6.

Considering Organic? Insights from Washington Grower Panel

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Organic farming involves more than just farming without chemicals. It requires changes to many parts of the crop production system such as enhanced use of integrated pest, weed and nutrient management techniques. These include using such preventative measures as crop rotations, cover crops, resistant cultivars, stress management and sanitation. They are essential to improving plant health since many chemical tools for pest control are not used in organic production.

The transition to organic needs to be carefully considered. Making the transition too quickly can create financial hardship or crop failure. To help with planning, it can sometimes help to hear from others who have gone through similar experiences and the lessons they have learned in the process.

The Washington State Tree Fruit Association hosted their annual meeting on Dec 7-9, 2020 during which they held an Organic Transition Panel with three growers from the Washington area: Don Gibson (Mt Adams Orchards), Jason Matson (Matson Fruit Co.) and Ray Schmitten (Schmitten Orchards). The following are some key insights shared from these growers for those considering transitioning to organic production.

Keep in mind, there are differences in organic standards and regulations between the United States and Canada. Refer to Resources for Ontario Growers at the end of this article or speak to your certifying body for more information.

Location, Location, Location

Proper site selection is key in the success of ANY orchard, but organic farming is a long-term choice and one that is not easy to move locations. Climate, neighbouring pest pressure, soil health and surrounding landscape present significant challenges.

Consider the impact climate will have on winter hardiness and select cultivars and rootstocks that are suitable for the area. Winter injury can leave trees more prone to seasonal issues and secondary infection. Climate can also directly influence pest pressure. If you are in a region where spring tends to be warmer, fire blight is a big risk and not one that is easily managed organically. Understand conditions that are conducive to the development of critical pests.

Get to know the neighbouring farms and landscape around the block you plan to transition. Unfortunately, pests like scab and fire blight don't follow farm boundaries and your neighbour's issue could become your own very quickly. Movement of pests such as codling moth, plum curculio and apple maggot are known to come from adjacent woodlots and wild apple or crabapple trees. Potato leafhopper or tarnished plant bug in neighbouring hay fields can migrate in large numbers to a new host when the hay is cut. Knowing what you may be up against will help you be prepared.

Soil type and health, including drainage, fertility, pH and organic matter are critical factors to maintaining tree health. You'll likely find more success with loamier soils and high organic matter. Management practices that enhance soil flora and fauna are essential to prepare a site, reduce pest pressure and build soil diversity. Depending on the situation, poor soil health may take years to reverse.

To protect organic crops from potential spray drift generated by neighbouring farms, organic growers must establish specific buffer zones from an adjacent non-organic block. The ability to maintain this buffer zone throughout production should be considered during the site selection process.

Plan Your Orchard Design

With the large investment required to be successful, it is important to plan well and consider all details. All three growers on the panel were in agreement that an ideal organic system is a small, high density block with drip irrigation. Yields can be lower in organic blocks compared to non-organic if not managed properly.

Irrigation is important to prevent water stress which could leave the tree susceptible to other stressors and reduce fruit quality. Mulch works similarly but an organically acceptable source can be difficult to find at times and may introduce new weed species.

Selecting resistant cultivar and rootstock combinations is essential for dealing with pest pressure from scab, fire blight and *Phytophthora*. However, it is a fine balance selecting resistant cultivars that will grow well and still sell to your customer base.

Be Prepared to Maintain Records for Audits

To be "certified organic" is to produce products according to organic standards as certified by a provincial certifying body (see Resources for Ontario Growers below for more information). To maintain certification, numerous documents, records and inspections are required on top of the standard documentation most growers in the province provide. Research and understand the standards and regulations required. Ensure there is someone in your operation who can properly keep track of these records.

Know Why You Went Organic

Many hardships and challenges can be faced when transitioning to organic. It is important to always keep in mind why you wanted to grow organically in the first place:

- Environmental? – To protect the environment, reduce agricultural chemical use, minimize soil degradation, maintain biological biodiversity
- Economics? – Access to a premium market
- Social? – Concerns of over personal or community health, consumer market demand

Take your time to research, understand the market, learn the organic standards and assets needed, and then set realistic expectations about your own farm.

Determine Market Requirements

Before even planting, ensure you have a market or potential buyers and are aware of the quality specifications. Does your operation match what customers want in regard to cultivar type and size profile? Size and grades that are standard for conventional are not always the choice for organic.

How to Transition

Interestingly, growers on the Washington panel start a new orchard block conventionally to build up soil fertility, fumigate and reduce pest pressure before transitioning to organic production. The logic for this approach is that there are more conventional tools available to get an orchard to full production and reduce potential stressors that could be detrimental when managed organically. However, the intention is of converting in 3-4 years, so it is not just 'manage as usual' until then. The focus is on building soils and managing weeds and other pests so that you're setting yourself up for a successful transition.

The first few years of organic production can be difficult. In Canada, there is a required 'transition period' prior to harvest of the first certified organic crop. Cash flow can be a problem due to the unstable nature of the yields and the fact that price premiums are often not available until the fruit is 'certified organic'.

Carefully prepare a plan for conversion. Try small orchard blocks initially and expand organic acreage as knowledge and confidence are gained. It may take 5-10 years to become totally organic, but a long-term approach is often more successful than a rapid conversion, especially when financial constraints are considered.

When Does Organic Not Work?

Unfortunately, there are situations when pest pressure is too high to maintain an economically viable organic program. There may be conditions conducive to epidemic-level infection of fire blight or scab, insect pests like codling moth or apple maggot may be resident in the orchard block or weed escapes may occur. Transitioning an orchard block with scab susceptible varieties is very likely to fail.

Specialty varieties are also difficult to produce organically, not because of management but rather the market. Specialty varieties are a niche as it is; producing organic specialty varieties then becomes a niche of a niche. If the market is too small, return will be low regardless of yield.

Understand Pest Biology and Available Control Strategies

The first step to effective pest control is understanding the biology of the pest. In organic production, available pest management tools are often limited, can be labour intensive and have a focus on integrating multiple strategies. The following are some specific pest-related approaches from the Washington grower panel:

Rodent Control

- Till next to tree.
- Use predators such as cats.
- Rake debris to remove habitat.

Weed Control

- Rely on burning and cultivation.
- Use herbicides sparingly since quite expensive.
- Often organic weed control is the most serious pest problem.

Disease Control

- Orchard sanitation is critical including removing / destroying infected wood, leaves and fruit.
- Application timing of many biofungicides are different from conventional fungicides and need additional time prior to disease development to:
    - alter the environment (e.g., citric acid in Blossom Protect).
    - inhibit establishment and growth (e.g., Blossom Protect, Serenade, Double Nickel).
    - trigger natural defense mechanisms of plants (e.g., Regalia).

Insect Control

- Cultural practices are important such as dust abatement on roads or borders, avoid sucker growth, remove overwintering sites.
- Use preventative codling moth measures including mating disruption, granulovirus, tree banding and following degree day models for precise timing of control materials.
- Know your enemies.
    - Enhance natural enemy habitat (landscape modification) in and around the orchard, including partial mowing (i.e. leaving strip unmowed in alley).
    - Know impact of spray on beneficial insects.

An important note for Canadian growers considering organic production, certifying bodies are accredited by the Canadian Food Inspection Agency to certify food commodities as organic in accordance with the requirements of the Canada Organic Regime. While your certifying body is able to tell you if a control product is considered organically acceptable, **it is the grower's responsibility to determine if the control product can be LEGALLY used on their crop**.

Resources for Ontario Growers

Looking for more information on transitioning to organic production? Resources are available on the OMAFRA Organic Agriculture website (full link: http://www.omafra.gov.on.ca/english/crops/organic/organic.html) or other organic links in Ontario (full link: http://www.omafra.gov.on.ca/english/crops/organic/orglinks.htm).

Juice Characteristics of Ontario-Grown Culinary (Dessert) Apples for Hard Cider

Dr. John Cline, Pomologist and Tree Fruit Physiologist, University of Guelph
Dr. Derek Plotkowski, Former Graduate Student, University of Guelph
Amanda Beneff, Research Technician – Pomology Research Program, University of Guelph

Key Findings

- The juice characteristics of 18 common culinary dessert apple cultivars grown in Ontario were characterized.
- There are significant differences in cider juice characteristics among culinary apple cultivars. Levels also vary by year and orchard.
- It is important to measure these juice characteristics every growing season prior to fermentation.
- Cultivars that are higher in acidity and tannins include Cortland, Crimson Crisp, Honeycrisp, Jonagold, McIntosh and Northern Spy.
- When making cider from Ambrosia, Crispin, Empire, Fuji, Gala, Golden Delicious or Idared, cidermakers would benefit from blending juice from these cultivars to create a more fully balanced product.
- This study will help inform cidermakers which culinary apple cultivars might be preferable for fermentation as well as how they might be blended to optimize cider quality.

Introduction

In order to produce a high-quality hard apple cider, it is important to understand the balance of sugar, acidity, and tannins, the main components of the pre-fermentation juice. Sugar determines the alcoholic concentration of a cider and the residual sugar after fermentation determines sweetness. Sugar can also be added to back-sweeten dry ciders. Acidity provides refreshing flavour and balances alcohol and sweetness. Tannins provide both astringency and bitterness to enhance flavor and mouthfeel. For centuries, hard cider produced in Europe has been made from bittersweet and bittersharp apples specifically suited for cider production. In contrast, most apples grown in North America are typically selected for their culinary or fresh-eating qualities and typically contain much lower tannin and acidity levels than their European counterparts. North American cidermakers often use juice from a blend of culinary and/or cider apples; however, culinary apples are produced at greater volumes and therefore are more readily available.

In a two-year study we measured the juice characteristics of several culinary apples grown in Norfolk and Georgian Bay regions with the overall goal to aid cidermakers in their selection of and blending of juice from culinary apple cultivars to optimize product quality.

Methods

This study, conducted over two years, used dessert (culinary) apple cultivars from mature apple trees grown from several orchards in Norfolk and Grey-Bruce counties. The cultivars Ambrosia, Cortland, Crimson Crisp, Crispin, Empire, Fuji (Aztec), Gala (Brookfield, Buckeye, Royal), Golden Delicious, Honeycrisip, Idared, Jonagold, McIntosh, Northern Spy, Red Delicious, and Spartan. The juice attributes from these apples were characterized using oenological methods. Juice was measured for extraction efficiency, soluble solids concentration (SSC), pH, titratable acidity (TA), juice extraction efficiency, yeast assimilable nitrogen (YAN), and polyphenols (which includes tannins).

Results and Conclusions

There are marked cultivar differences in juice SSC, pH, TA, YAN, juice extraction efficiency and polyphenols, all of which can vary by both orchard and year (Tables 1 and 2).

This variation indicates the importance of assaying the juice every growing season prior to fermentation when possible. In addition, while not investigated in this study, fruit maturity and time and method of storage are likely to affect juice characteristics – especially SSC, pH, and TA. The results of this study can be used to inform cidermakers on the selection of culinary apples when pressing juice for hard cider. Cidermakers should focus on juice characteristics from culinary apples that are more difficult to alter pre-fermentation; using juice with higher acidity and tannin levels, lower pH, and moderate to high YAN will lead to a more flavourful, high-quality fermented product. Cultivars that meet these criteria include Cortland, Crimson Crisp, Honeycrisp, Idared, Jonagold, McIntosh and Northern Spy. We expect that cidermakers fermenting juice from Ambrosia, Crispin, Empire, Fuji, Gala, or Golden Delicious, would benefit from blending with juice made from higher tannin and acidic apples to produce a more fully balanced product.

Complete details of this study will appear in an upcoming 2021 issue of the Canadian Journal of Plant Science.

Acknowledgements

We acknowledge the University of Guelph for partial funding of this project. We would also like to thank Tom O'Neil and the Norfolk Fruit Growers' Association and Jim Dolmer and Bay Grower's Co-operative for contributing fruit to this study.

Table 1. Levels of juice soluble solids, pH, titratable acidity, yeast assimilable nitrogen, polyphenols, sugar to acid ratio of culinary apples as a whole, over a two-year study.

Cultivar	SSC (% Brix)	Juice pH	TA (g malic acid / L)	YAN	Juice extraction efficiency (mL / kg fruit)	Polyphenols (µg GAE / 100 mL)	Sugar : Acid Ratio
Ambrosia	M	H	M	M	M	L	M
Cortland	M - H	L - H	M - H	M	M - H	M	L - M
Crimson Crisp	H	L - VH	M - H	M - H	M - H	M - H	L - H
Crispin	M	L	H	L	M	L	L
Empire	L	L	H	M	M	L	L
Fuji, Aztec	M	M - VH	M	M	H	M	M
Gala, Brookfield	H	H	H	H	H	M	M
Gala, Buckeye	H	H	M	M	M	M	M
Gala, Royal	M	H	L - M	M	M - H	L - M	M
Golden Delicious	H	M - VH	H	L – M	M - VH	L - M	M - H
Honeycrisp	M	L - M	L - M	M	H	M	L - M
Idared	L - M	L - M	M - H	L	M - H	M	L - M
Jonagold	M - H	L - VH	L - H	L - M	M - H	M	M
McIntosh	L - M	L - H	M - H	L - M	M - H	H	L - M
Northern Spy	M	L - M	H - VH	L - M	L - M	M	L
Red Delicious	M	H	L	L	M	M	H
Spartan	L	L	M	L	M	M	L

Table 2. Ranges given in relation to Table 1

	SSC (% Brix)	Juice pH	TA (g malic acid / L)	YAN	Juice extraction efficiency (mL / kg fruit)	Polyphenols (µg GAE / 100 mL)	Sugar : Acid Ratio
Low (L)	<11	<3.3	<3	<60	<600	0 to < 100	0 to <2
Moderate (M)	≥11 to <13	≥3.3 to <3.6	≥3 to <6	≥60 to <140	≥600 to <700	≥100 to 200	≥2 to <4
High (H)	≥13	≥3.6 to <4	≥6 to <9	≥140	≥700 to <800	≥200	≥4
Very High (VH)		≥4	≥9		≥800		

Crop Protection

Put Out the Fire – Part 1: Managing Rootstock Fire Blight

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Since the outbreak year in 2016, fire blight has been a hot topic for many growers across the province. Many have been battling to prune out cankers and shoot blight in susceptible blocks each year. Unfortunately for some, with the higher inoculum present in the orchard, tree death from rootstock blight has caused (and is continuing to cause) extensive loss in some blocks.

Rootstock blight often occurs at ground level just below the graft union in susceptible rootstocks such as M.9 and M.26. Infections initially appear water-soaked, purplish to black discolorations with cracking or crevices (Figure 1). Fresh ooze can sometimes be seen during hot, humid conditions or signs of dried ooze from previous activity (Figure 2). Poor vigour is typically the first indication of infection, with little to no growth and sparse, yellowing leaves (Figure 3). Depending on the cultivar, branches may have a distinct yellow or golden colour. Tree collapse can occur rather suddenly in some situations but usually occurs the following season.

Figure 1. Purple fire blight canker extending up from rootstock.

Figure 2. Dried ooze around top margins of fire blight canker.

Figure 3. Tree infected with rootstock fire blight.

Figure 4. Reddish-orange discoloration on roots and rootstock below soil of apple tree infected with *Phytophthora* root and collar rot.

Figure 5. Dark ring in vascular cambium of apple rootstock infected with fire blight.

Removing the bark, the affected area shows red-brown streaking in the internal tissues. It is common to mistake tree decline caused by rootstock blight for *Phytophthora* root and collar rot; however, fire blight does not cause reddish-orange necrosis below the soil line and roots that is characteristic of *Phytophthora* (Figure 4). The fire blight bacteria, *Erwinia amylovora* also moves through the vascular cambium leaving a black ring if looking at a cross section of the affected area (Figure 5). For accurate identification – and to prevent an expensive mistake – send a sample of the diseased rootstock to a qualified pest diagnostic lab.

Rootstock infection can occur through infected suckers or water sprouts, as well as washing *E. amylovora* bacteria from infected twigs and fruit down the trunk in an existing wound. However, a very important avenue of infection is internal translocation of the pathogen from the infected cultivar scion above ground to the rootstock. In young, vigorous trees, *E. amylovora* can move from infected blossoms or shoots to the roots in one month under favourable weather conditions.

First Line of Defense

The first line of defense for fire blight management in an orchard is prevention. There is no silver bullet to eradicate this disease once it becomes well established. This means management is a year-long process to reduce inoculum in the orchard and prevent the spread of bacteria to healthy trees. Once infection has spread to the rootstock, there is nothing that can be done to eliminate the pathogen.

Winter and early spring is a good opportunity to clean up any remaining infected limbs, cankers or – in the case of rootstock blight – trees that will act as sources of inoculum and get as much fire blight out of the orchard as possible. These overwintering cankers will be the source of disease in the coming year, oozing in the spring as the tree begins to push.

Dormant pruning is effective for many reasons. Firstly, *E. amylovora* is not active in the cold temperatures and therefore will not be spread on pruning shears, tools or infected tissue. There will be no need to disinfect tools between cuts. Secondly, the cankers are easier to see in the orchard without foliage.

What to Look for When Pruning

Scout thoroughly for cankers while pruning. It is recommended to do this more than once during the 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.

Cankers may not be as obvious. They can vary in size on twigs, limbs or trunks of trees (Figure 6). 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 obtuse*

Figure 6. Fire blight cankers can appear as rough, dark regions with cracked margins often around pruning stubs, infected limbs or wounds.

Pruning cuts should be made at least 30 cm (12 inches) beyond the canker or visible infected tissue into 2nd year wood. For young trees (less than 3 years old), trees that appear to be infected perennially or trees that have the canker established in the trunk should be removed altogether. Mulch limbs in the row middles in the early spring. An application of urea applied in the early spring for apple scab may help with degradation as well.

Trees with rootstock blight should be removed as soon as possible to reduce any chance of further spread. Cut off and remove the scion from the orchard, making sure to leave enough to allow the roots to be pulled out. Leave the remaining trunk to let the roots dry out prior to removal.

Plan Ahead

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 management – what products you will use (antibiotics, coppers, biologicals, Apogee, etc.) and how (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.

Stay tuned for Part 2 of this fire blight series in the next issue of Orchard Network Newsletter.

Mating Disruption for San Jose Scale

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Each year, more growers in the province seem to be having increasing problems with San Jose scale (SJS). With such a small size, early infestations are often overlooked. In most cases, growers aren't even aware there is a problem until it is too late. By the time they see obvious symptoms on the fruit (Figure 1) or signs of poor tree vigour (Figure 2), the scale population is well established and very difficult to eradicate. Intensive management is needed for a number of seasons to help bring population pressure down, only after which can a maintenance program be put in place.

Figure 1. San Jose scale damage on apple.

Figure 2. Limb dieback of apple tree caused by San Jose scale. (Photo: Peter Shearer, Oregon State University)

Becoming A Bigger Problem?

There are many reasons for why growers may be seeing an increase in SJS pressure:

- **General decline of dormant oil sprays** – Finding a reasonable window in the early season suitable for an application of oil can be very difficult. As well, concerns over impact to tree and/or yield and increased cost of some oil products have resulted in fewer growers applying dormant oil.
- **Re-evaluation decisions cancelling or limiting use of effective products** – In some orchard blocks, increasing SJS populations began shortly after the loss or restrictions of organophosphate insecticide use, including Guthion, Diazinon and Imidan.
- **Resistance?** – Scale species are known to be prone to insecticide resistance development; however, no recent studies have looked at resistance status.

- **Newer active ingredients not as lethal** – While newer insecticides may be providing some control, the overall knock-down or length of residual toxicity may not be as effective as previous products used.
- **Lack of active monitoring** – Since SJS is so small, it is hard to know a population is present unless using pheromone traps, scouting for immobile scales and conducting harvest assessments.
- **Insufficient spray volume / coverage** – As Peter Shearer from Oregon State University says: how much water is enough? A lot more than you want to use!

Biology 101

San Jose scale overwinters as immatures, known as "black caps" (Figure 3) under a thin waxy covering on trunks and branches. The blackcap stage can tolerate temperatures as low as -23˚C. They begin maturing as soon as sap begins to flow in the spring. Males emerge around pink and continue activity over bloom.

Figure 3. Overwintering San Jose scale on trunk of apple tree.

Figure 4. Small, yellow San Jose scale crawlers on limb of apple tree.

While male SJS fly, they travel only short distances - such as a few trees - and often times, walk to females. This is why populations can often be overlooked as they begin in small pockets throughout orchard blocks.

The adult female SJS are immobile so release pheromones to attract males to the area. Each mature female can live for 6 weeks, producing approximately 10 crawlers (Figure 4) per day, or 150-500 crawlers per female per generation.

The first-generation crawlers emerge as live young generally beginning mid- to late June and can continue for 4-6 weeks. Crawlers are most active for the first few hours before finding a suitable place for development (bark or fruit). Feeding starts within 24 hours after emergence. Once feeding, the immature scale begins secreting wax, forming the protective shell.

There are two generations of crawlers in Ontario. As mentioned, the first generation begins mid- to late June. This emergence is typically synchronized, and peak emergence occurs 7-10 days following first crawler activity. The second-generation crawler activity tends to begin early August and can continue into harvest of early varieties.

Could Mating Disruption Work?

In 2019 and 2020, Dr. Larry Gut and Extension Educator, Emily Pochubay from Michigan State University studied the efficacy of mating disruption for SJS in apple and sweet cherry orchards. Experimental twist-tie dispensers (currently not commercially available) were applied to multiple <1 ac plots at the Trevor Nichols Research Station in Southwest Michigan, the Michigan Horticultural Research Center in Northwest Michigan as well as 1 commercial apple orchard and 5 commercial cherry orchards in the state. Blocks treated with mating disruption at ~200 dispensers / ac were compared to untreated blocks using a grower standard program. Population density in all blocks was measured using pheromone traps for male SJS flight and black electrical tape wrapped around tree branches for crawler activity.

In all sites, trap shutdown was observed in the mating disruption blocks in 2019 and 2020 (Figure 5). In some cases, blocks treated with mating disruption in 2019 but not 2020 still saw less SJS than the grower standard, suggesting carryover from the previous season may provide enough control for at least the early part of the following year. However, since there currently is not an economic threshold for SJS, it is unclear if alternative year use could maintain acceptable control for this pest. The Michigan research team will continue their trials to determine if the strategy is viable.

Gut's research also looked further into the mechanism of mating disruption in SJS, finding it appears to be a hybrid between 'competitive', or creating a false trail away from females, and 'non-competitive', or desensitization of males so they're unable to find females. In other words, some portion of males in the population are taken out non-competitively while others can still respond to the pheromone so compete between dispensers and females. This is positive news for the effectiveness of mating disruption for SJS, as non-competitive mating disruption can achieve close to 100% control and is often not considered density-dependent. This means lower dispenser densities may still be effective if pest populations are not too high, potentially reducing the cost of this kind of program.

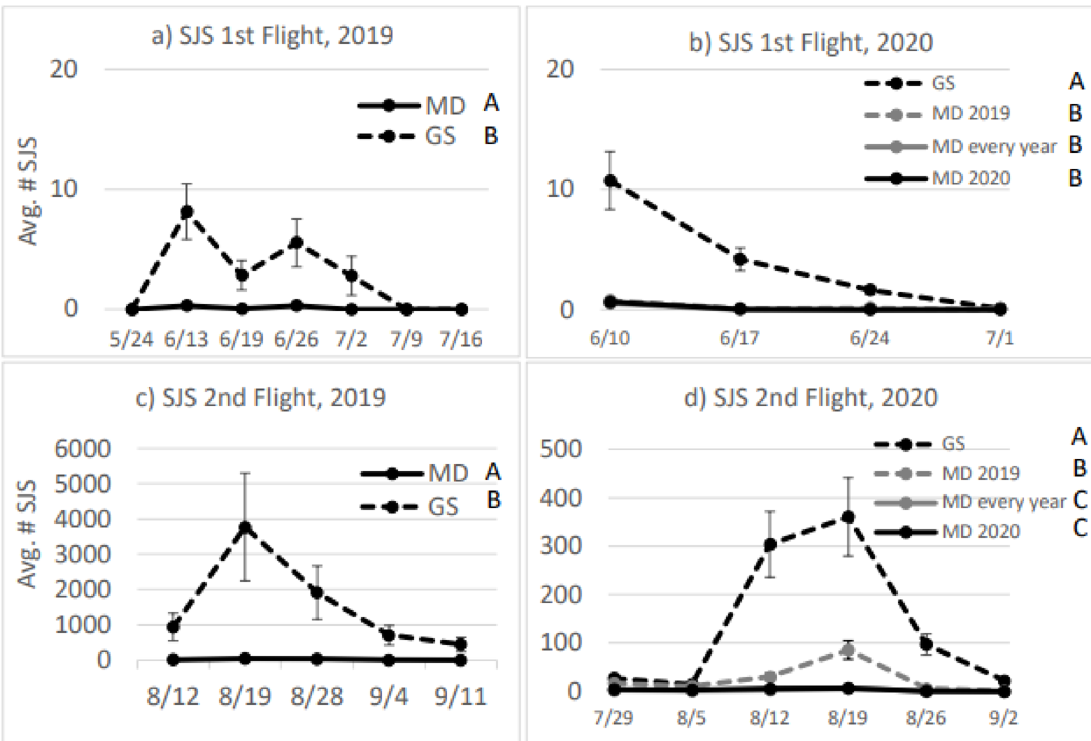


Figure 5. The average number of San Jose scale on traps per treatment per week during the first flight in: (a) 2019 (top left), and (b) 2020 (top right) and during the second flight in: (c) 2019 (bottom left), and (d) 2020 (bottom right) in Northwest Michigan cherry orchards treated with mating disruption (MD) or grower standard (GS). Treatments followed by a different letter tested significantly different from each other (p<0.05). *Source*: Pochubay et al. (2020)

Dormant Oil Still an Important Tool!

As with other mating disruption programs, control of SJS would be most effective under low pest pressure. One of the key management tools remains dormant oil and would have a great fit in any mating disruption program, offering a soft chemical alternative while still providing good control of the pest.

However, while a dormant oil application can be an excellent management tool, timing and thorough coverage are critical to achieve good control. Understanding how oil works, as well as the biology of the pests will help to optimize control applications and avoid tissue damage.

Oil can work by suffocation, interfering with mite egg development and/or prevent settling of scale crawlers. If applied properly, the use of dormant or delayed dormant oil can sufficiently reduce the amount of sprays that may be needed for both scale and mites later in the season. Early season oil sprays also fit well into IPM programs because the product is applied before predatory mites and other beneficial insects are present. Despite warnings by some in the northeast, there is no published scientific evidence that oil may reduce the overall health of the trees.

Unfortunately, conditions in early spring in Ontario are not always optimal for good coverage. Do not apply oil within 48 hours of freezing temperatures, before rain or within 14 days of captan. If multiple applications are needed, drop to a 1% solution when green tissue is present.

References

Gut, L. (2020, December 8-10). *Insect Control* [conference presentation]. Great Lakes Expo, Michigan, United States.

Pochubay, E., Gut, L. & Rothwell, N. (2020). *Further investigation of hand-applied mating disruption for San Jose scale in sweet cherries*. Northwest Michigan Horticulture Research Center Research Report: https://www.canr.msu.edu/nwmihort/research/field-efficacy-of-hand-applied-mating-disruption-for-san-jose-scale-in-sweet-cherries.

AAFC Research Update on Sudden Apple Decline and Fruit Tree Decline Disorders in Ontario

Dr. Oualid Ellouz, Research Scientist – Plant Pathology, Agriculture & Agri-Food Canada
Dr. Jonathan Griffiths, Research Scientist – Plant Virologist, Agriculture & Agri-Food Canada

Research Highlights

In 2018 and 2019 researchers collected samples of dead, diseased and healthy trees from multiple orchards across the province to evaluate the disorders and identify potential pathogens. The research team identified a number of pathogenic fungi in apple and stone fruit trees in Ontario.

Researchers are investigating potential links to Sudden Apple Decline (SAD) and FTD, such as:

- Viruses and nematodes may contribute to tree disorders
- Decline orchards often contain ambrosia beetles and identification to species level is underway
- Reduced water pathways in dead and dying trees due to the weakened water transport capacity in the dwarfing rootstocks, particularly at the graft union.
- To date, no single pathogen has been identified as the direct cause of these disorders.

Current research is investigating the possibility of biotic and abiotic factors working together to contribute to tree decline and death.

Background

Rapid decline and death of apple and stone fruit trees was first observed five years ago in Canada. While the economic impact to growers has been considerable; to date the full economic impact has yet to be tabulated. To differentiate between the crops, the disorder was named SAD in apples and FTD in pears and stone fruit.

Agriculture and Agri-Food Canada (AAFC) provided funding in 2019-2022 to researchers in British Columbia, Ontario, Quebec and Nova Scotia. The research teams were to identify biological and environmental stresses that may be associated with the disorder.

Fungal and bacterial involvement in SAD and FTD

In 2018 and 2019 seven apple and nine stone fruit orchards were sampled in Ontario, Canada. Scion, graft union and root samples were collected from healthy and symptomatic trees. Fungal appearance, or morphology, was used to place the 1,500 fungal isolates into species:

- *Alternaria*
- *Diaporthe*
- *Diplodia*
- *Paraconiothyrium*
- *Cytospora*
- *Fusarium*
- *Penicillium*
- *Epicoccum*
- *Aureobasidium*
- *Rhizopus*
- *Ilyonectria*
- *Trichoderma*

Known plant pathogens in this group will be further tested in potted tree inoculations and characterized by molecular technologies to genus and species level. Thirty potential bacterial pathogens have been isolated from the woody samples, maintained in pure culture and greenhouse trials are under way to test if any of the bacterial isolates are associated with decline symptoms in peach. Similar greenhouse pathogenicity trials will follow in apple.

Fungal inoculation trials with *Cytospora* spp., *Diaporthe* sp. and *Diplodia* sp. showed "decline like" symptoms on fungus inoculated apple, apricot and nectarine trees. Early research has indicated that these fungi are not the primary cause of tree fruit decline; however, they could be key components associated with the disease complexes for both SAD and FTD.

Viral involvement in SAD and FTD

Genomic-based approaches were used to identify a number of plant viruses in apple and stone fruit trees. Tomato ringspot virus was detected in approximately 30% of apricots and peaches. Peach latent mosaic viroid was identified in a number of diseased peach samples. Many other viruses were identified in diseased samples from the Niagara region including: Peach latent mosaic viroid, Prunus necrotic ringspot virus, Prune dwarf virus, and other virus types. None of these viruses were consistently identified in dead and dying trees. We are still investigating the role viruses might be playing in FTD through more targeted surveys to determine the distribution and diversity of Tomato ringspot virus in the Niagara region.

Apple leaf samples were collected from 40 trees from five farms in Ontario. Total RNAs were extracted and two mixed samples from each farm were sequenced. Preliminary data analyses identified the following viruses:

- Apple stem pitting virus
- Apple luteovirus 1
- Apple chlorotic leaf spot virus
- Prokaryotic dsDNA virus
- Winged bean alphaendornavirus 1
- Bell pepper alphaendornavirus
- Bell pepper endornavirus
- Apple rubbery wood virus
- Pepper cryptic virus
- Hymenoscyphus fraxineus mitovirus 1
- Apple rubbery wood virus 2

- Pepper cryptic virus 2
- Ophiostoma mitovirus
- Pyricularia oryzae ourmia-like virus 2
- Cladosporium uredinicola ourmiavirus 1
- Alternaria alternata chrysovirus 1
- Citrus concave gum-associated virus
- Apple green crinkle associated virus
- Brome mosaic virus
- Maize stripe virus MStV NSF4
- Broad bean mottle virus

Nematode involvement in SAD and FTD

To understand the association of plant parasitic nematodes (PPNs) with tree fruit decline, the present study isolated and characterized PPNs from several apple and stone fruit orchards in Ontario, Canada from May-October 2019. The sampled trees from the selected fruit orchards were visually scored as three categories; healthy, moderately and severely stunted/dead. A composite sample consisting of 10 deep soil cores were collected from within 40 cm of trunks of several individual trees of each category/orchard. Nematodes were extracted from 50 g of soil sample from a mix of these soil cores using the sugar centrifuge technique at the AAFC nematology lab.

The dagger nematode (*Xiphinema* spp.) was present in 72% of the 29 apple samples collected from four different locations. In addition, other PPNs such as the lesion (*Pratylenchus* spp. 27%), ring (*Criconemella* spp. 10%), pin (*Paratylenchus* spp. 34%) and spiral (*Helicotylenchus* spp. 41%) were also present.

A total of 33 apricot soil samples were collected from five different locations. Presence of lesion, ring, dagger and pin nematodes were significantly high (more than 50%) within these samples. For plum soil samples, 100% of them were ring nematode positive, and 75% of them were positive for dagger. Most of the samples collected from peach and cherry orchards were positive for both ring and dagger while nectarine was positive for only dagger. All samples were positive with presence of other parasitic nematodes like lesion, pin, stunt and spiral.

The preliminary data indicates that an association exists between SAD/ FTD and ring and dagger nematode in Ontario. Thereby, research continues on these two plant parasitic nematodes. Pure cultures of ring and dagger have been initiated in AAFC greenhouses and growth chambers. In addition, a micro-plot study has been set up on the AAFC Jordan farm, Vineland Station, Ontario using Haroblush and Harlayne apricots on Krymsk 86 rootstock. This planted orchard is under observation and we will study plant growth, vigor, nematode counts, etc. to understand the pathogenicity of these nematodes for upcoming years.

Ambrosia beetle involvement in SAD and FTD

In early May to mid Sep 2019, ethanol-baited traps were set-up in nine apple orchards and five stone fruit orchards in Ontario. Traps (six per orchard) were checked weekly; captured beetles were sorted, pinned and identified.

Over 6,600 ambrosia beetles were captured over the 14 sites. In stone fruit orchards in Niagara, 49% of captures were black stem borer (*Xylosandus germanus*), a well-known, invasive pest of deciduous trees. Fruit tree pinhole borer (*Xyleborinus saxesnii*) and a relatively new invasive ambrosia beetle species in Canada (*Anisandrus maiche*) were 30 and 12% of captures, respectively. Captures were higher during a “second peak” (mid-July to early Sep) than in late spring/early summer.

In apple orchards (Norfolk, Middlesex and Durham regions), black stem borer was most frequently captured, at 67-75% of the total catch. Ambrosia beetles and fruit tree pinhole borer were the second and third most captured species at most sites. Captures were typically greater later in the summer than late spring/early summer. In many orchards, beetle captures in traps placed in an edge row were greater than in traps placed in an interior orchard row. Damage assessments in trapping blocks was not conducted.

Trapping was not conducted in 2020 due to the pandemic, and captured ambrosia beetles were not assessed for associated pathogenic fungi as planned.

Plant-water relations in SAD and FTD

A preliminary study of the area of active transporting tissue at grafted union of apple variety 'Salish'/M.9 from a conventional orchard in Summerland, BC, showed that the declining trees had a significantly smaller area of active transporting tissues at the cross sections below, at and above the grafted union, being only 23%, 17% and 12% of the corresponding cross sections in the asymptomatic trees, respectively. In the declining trees, less than 10% of the grafted union was actively transporting, whereas in the asymptomatic trees on average, 35% of the grafted union was actively transporting. The damage around the grafted union on this site was associated with apple clearwing moth (not a pest in Ontario), woolly apple aphid and winter injury on the trunk.

In a plant-water relations study on Ambrosia/M.9 in three sites in Okanagan-Similkameen region, it was observed that in symptomatic trees, leaf stomatal conductance and plant tissue water potential decreased, and fruit dry matter accumulation also reduced, in 2019 and 2020.

The results indicate that the water relations of the declining trees were undermined, at least partially due to the weakened water transport capacity around the grafted union.

Metabolite profiling for an early detection of FTD

Metabolomics identified thousands of metabolites with a clear distinction between FTD healthy, diseased, and dead trees. This preliminary work, based on nine trees, indicated that FTD can be identified by tree metabolite profile. Prunasin, a cyanogenic glycoside, was present in significantly higher concentrations in collapsing and dead trees compared to healthy trees. Scientific literature has linked prunasin with severe weather events and graft incompatibility issues. Our working hypothesis is that some compounds, like prunasin, were induced during recent severe weather events. These compounds are transported from the tree root stock to the scion, where they negatively impact the scion. This activity may initiate a graft incompatibility reaction, reducing water transport which then in turn allows pathogens to enter the weakened tree and kill the scion. Based on availability of funds, research would need to study the presence of FTD metabolites in a larger sample size (75 trees) in healthy, diseased, and dead trees.

Acknowledgments

Antonet Svircev, Tahera Sultana, Aiming Wang, Justin Renkema and Hao Xu (AAFC).

The authors gratefully acknowledge the technical assistance provided by Karin Schneider, Andrea Lofano, Lori Bittner, Darlene Nesbitt, Evgeny Ilyukhin, Jessica Prosser, Qing Yu (AAFC); Kristy Grigg-McGuffin and Kathryn Carter (OMAFRA).

Keep Watch for Marssonina Leaf Blotch

Katie Goldenhar, Pathologist – Horticulture, OMAFRA
Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Marssonina leaf blotch could become a concern for Ontario apple growers. With recent maximum application reductions of several broad-spectrum fungicides used in apple disease management, this fungus may be able to build up in orchards.

Marssonina leaf blotch of apples is caused by the fungus *Marssonina coronaria* and was first identified in Ontario in the early 1900s. Despite this, Marssonina leaf blotch has been sporadic in Ontario apple orchards. In recent years, eastern states including Pennsylvania and New York have identified an increase in Marssonina leaf blotch in apples causing premature defoliation, resulting in lower tree health and yield loss. When foliage infection is severe, fruit lesions can occur, although they are uncommon. There is little known about the presence and impact of this disease in Ontario apple orchards.

Symptoms typically appear mid-summer on the upper surface of mature leaves. Lesions start small (5-10mm), have a greyish, brown centre with a darkened, purple border (Figure 1). As the infection progresses, lesions darken and coalesce, with the surrounding tissue turning yellow, resulting in premature defoliation (Figure 2). At any stage of infection, when examined closely with a hand lens or dissecting scope lesions contain raised black dots or bumps which are the fruiting bodies of the fungus (Figure 3). To distinguish this disease from scab lesions, Figure 4 shows the two diseases on a mature leaf. Apple scab lesions are more web-like and do not contain the black bumps. Fruit lesions are less common but can be found on trees with severe foliar infection. Fruit spots are small, dark brown/black and stay on the fruit surface with minor indentation (Figure 5). This fungus needs a long duration of leaf wetness to infect, and symptoms can take as long as 40-45 days after infection to appear.

Figure 1. Initial Marssonina leaf blotch symptoms on mature apple leaf appears as a brown or gray lesion with purple border.
(Photo: Kari Peter, Penn State University)

Figure 2. Progressed Marssonina leaf blotch on apple leaf with chlorotic, or yellowing tissue surrounding lesions.
(Photo: Kari Peter, Penn State University)

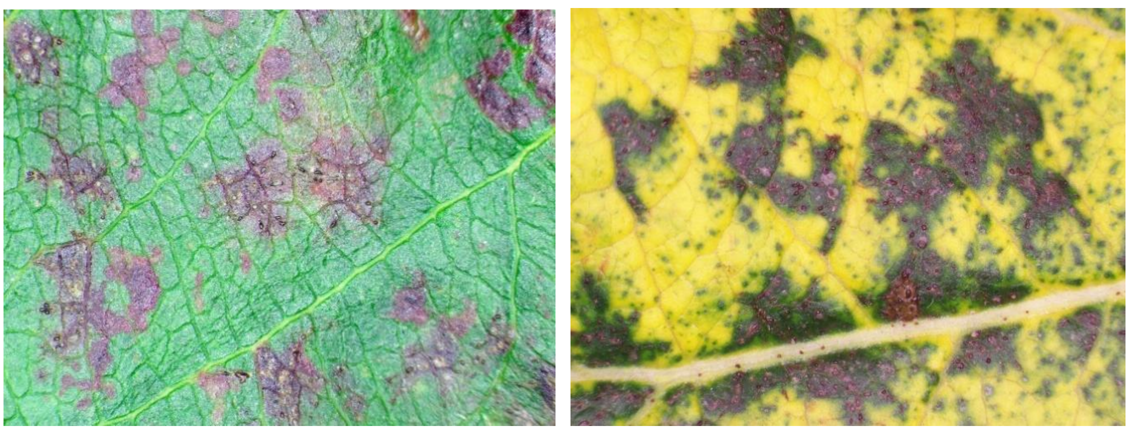


Figure 3. Close up of new (left) and progressed (right) Marssonina leaf blotch lesions with black bumps (Photo: Kari Peter, Pennsylvania State University)

This fungus overwinters in infected leaves in the orchard. Sanitization is important in limiting the disease, reducing the inoculum for disease occurrence. There are no registered fungicides in Canada, however research shows that Marssonina leaf blotch is susceptible to most conventional apple scab fungicides. Captan and mancozeb have shown excellent efficacy against this disease, but both have been recently re-evaluated and application numbers reduced (see 2020 Orchard Network Newsletter article, Re-Evaluation Round-Up: Updates on Recent Registration Decisions Impacting Apple Growers), which could lead to an increase of this disease in Ontario. Cultivars differ in their susceptibility to Marssonina leaf blotch (Table 1).

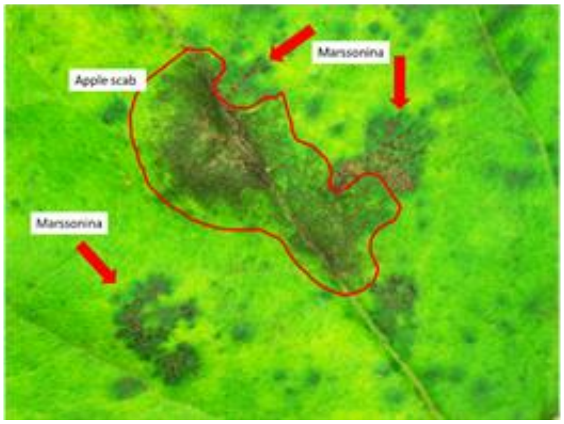


Figure 4. Apple scab and Marssonina lesions under a dissecting scope. Note the black bumps on the Marssonina lesions and the web-like appearance of the scab lesion. (Photo: Kari Peter, Pennsylvania State University)

Figure 5. Fruit lesion caused by *Marssonina coronaria* on apple. (Photo: Kari Peter, Pennsylvania State University)

Table 1. Apple cultivar susceptibility based on observations and research in Pennsylvania experimental orchard (Kari Peter, Penn State University)

Cultivar	Susceptibility (to date)
Rome	Very susceptible[1]
Honeycrisp	Very susceptible[1]
Empire	Very susceptible[1]
Scab-resistant varieties	Very susceptible[1]
Cameo	Susceptible
Fuji	Susceptible
Red Delicious	Susceptible
Gala	Susceptible to moderately resistant
Golden Delicious	Moderately resistant
Stayman	Moderately resistant
Cortland	Moderately resistant

[1](if no fungicides are applied early season)

OMAFRA is planning a survey of susceptible apple cultivars in the 2021 growing season. If you are interested in participating in this survey, please email or call/text Kristy Grigg-McGuffin (kristy.grigg-mcguffin@ontario.ca, 519-420-9422) or Katie Goldenhar (katie.goldenhar@ontario.ca, 519-835-5792).

References

Lee, B. (2011). *Biological Characterization of Marssonina coronaria Associated with Apple Blotch Disease*. Mycobiology, 39(3), 200–205. https://doi.org/10.5941/MYCO.2011.39.3.200

Parmalee, J.A. (1971). *Marssonina leaf spot on apples*. Canadian Plant Disease Survey, 51(2), 91-92. Retrieved online: http://phytopath.ca/wp-content/uploads/2014/10/cpds-archive/vol51/CPDS_Vol_51_No_2_(91-92)1971.pdf

High Quality 'Ambrosia' Apples Depends on Harvest Maturity

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

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

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

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

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

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

Figure 1. 'Ambrosia' ready for harvest.

Figure 2. British Columbia color chart for 'Ambrosia' apples.

Low Oxygen Storage Reduces Internal Browning in ‘Ambrosia’

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

‘Ambrosia’ apples harvested at optimum maturity for storage can be held long-term (i.e. ~8 months) with little firmness loss or disorder development. Optimum fruit maturity at harvest generally consists of more green than yellow background color (2 to 3 on the BC color chart), <1 ppm internal ethylene concentration, fruit firmness above ~18 lb, and starch index between 2 to 4 (Cornell starch chart).

‘Ambrosia’ responds well to 1-MCP, with reduced firmness loss and mealiness, lower internal ethylene, higher acidity, and reduced greasiness. Controlled atmosphere (CA) storage also improves ‘Ambrosia’ fruit quality during storage and oxygen levels below 2% are best.

The following CA regimes at 0.5ºC were evaluated during 2018-19:

1) 2.5% O_2 + 2.0% CO_2
2) 1.7% O_2 + 1.0% CO_2
3) <1% O_2 + 0.5% CO_2

The <1% O_2 regime was based on fruit respiration measurements using LabPod™ technology (Storage Control Systems Inc., Michigan). There was an initial flush down to 1.7% O_2 and then oxygen was decreased gradually to 0.6% over several weeks and to 0.4% after a couple months. Postharvest 1-MCP treatments (SmartFresh™) before or after storage were also evaluated in this study, but there was no significant difference due to application timing so these data were combined.

After 8 months of CA storage at 0.5ºC, apples held in 2.5% O_2 were softer (less ~1 lb) and had more internal browning than those held in 1.7% O_2 (Table 1, Figure 1). Apples held in <1% O_2 had much less internal browning (<1% incidence) than fruit from the higher O_2 regimes. No other storage disorders or fruit splitting were noted.

Table 1. Incidence of internal browning in ‘Ambrosia’ apples after 8 months in CA storage at 0.5ºC.

Treatments	Internal Browning (%)
<1% O_2 (LabPod)	
No SmartFresh	0.7 D
+ SmartFresh	0.4 D
1.7% O_2	
No SmartFresh	8 C
+ SmartFresh	8 C
2.5% O_2	
No SmartFresh	24 A
+ SmartFresh	16 B

Figure 1. Internal browning in ‘Ambrosia’.

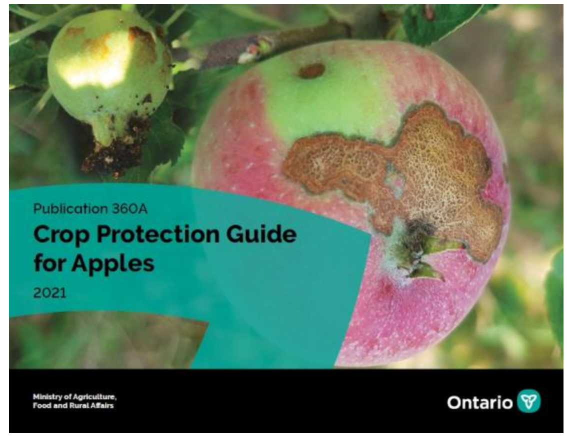
Acknowledgements

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

Coming Soon! 2021 Publication 360, Fruit Crop Protection Guides

A full revision of Publication 360, *Fruit Crop Protection Guide* including:

- Publication 360A, Crop Protection Guide for Apples
- Publication 360B, Crop Protection Guide for Berries
- Publication 360C, Crop Protection Guide for Grapes
- Publication 360D, Crop Protection Guide for Tender Fruit
- Publication 360E, Crop Protection Guide for Tree Nuts



will be available in Spring 2021. This will have the latest information on crop protection and resistance management for commercial production of fruit crops. Each guide will be available for individual download or purchase and can be bundled together with all 5 guides. Subscribe to ONfruit to receive updates when the guides will be available online and in print.

In the meantime, for information on new product additions, label expansions or changes to Publication 360A, Crop Protection Guide for Apples, refer to the December 2020 Orchard Network Newsletter article, What's New in 2021 for Publication 360A. (Full link: https://onfruit.ca/orchard-network-newsletter/)

Agricultural Information Contact Centre: 1-877-424-1300
E-mail: ag.info.omafra@ontario.ca
Northern Ontario Regional Office: 1-800-461-6132

www.ontario.ca/omafra