



ORCHARD NETWORK

For Commercial Apple Producers

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Orchard Management

Apple of My Robotic Eye

Erika DeBrouwer, Tree Fruit Specialist, OMAFRA

Two-dimensional trellis systems have been widely adopted throughout the province over the years for various reasons, whether it be to increase labour efficiency, ease of management, improvement of quality and yield, production strategies etc. But more recently, growers have been adopting these 2D systems in hopes of further automation throughout the orchard to become more "robot-ready".

These developments have been on growers' radars for a long time but waiting for these substantial movements to drive their competitiveness in the apple game can be taxing. This is especially pertinent in Ontario now with labour shortages, increase in minimum wage, supply shortages, and increase in input costs, all stacked on top of a global pandemic. Although there have been setbacks, progress is still being made on the robotic front. Here are a few updates regarding various robotic project occurring globally with applicability in the apple frontier.

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Maintenance Robots

Maintenance in the orchard is very time consuming for orchard operations, and most of these tasks are repetitive. Robots may have the power to increase labour efficiency and potentially improve economic feasibility through the completion of many tasks. These tasks include weeding, mowing, spraying, seeding, chopping, soil sampling, amongst many others. Listed below are a few maintenance robots to keep an eye on.

Origin: Canada

Robot Name: RoamIO (HCT, Mini, A6)

Stage: Prototype

Power: Electric

Korechi developed a prototype robot for corn fields but has been adapted for other uses. Korechi has tested the RoamIO in various horticultural fields (not orchards) in 2021 and continues to develop and expand their robotic lineup. The RoamIO has various robots that utilize cameras, LiDAR and Artificial Intelligence for obstacle detection.

Pros	Cons
Multitask robot (cultivating, weeding, mowing, chopping, soil sampling)	9km maximum speed
Voice feedback capabilities	Mechanical connectors required for certain implements
Can use various implements	Unknown Cost
Lightweight with obstacle detection	

For a video reference of the RoamIO HCT robot please click [here](#). For a video reference of the RoamIO Mini please click [here](#). For more information on the robot please click [here](#).

Origin: Poland

Robot Name: GTrack

Stage: Available to order

Power: Diesel

GTrack isn't exactly a robot, but a tractor upgrade that allows you to utilize your current tractor with an unmanned operating system. GTrack uses sensors to track the tractors position, orientation and speed. This system works by performing a route once and GTrack will repeat that over and over – with changes available as needed.

Pros	Cons
Utilizes current machinery	
Obstacle detection	

For a video reference of the GTrack please click [here](#) and [here](#). For more information on the control system please click [here](#).

Sitia

Origin: France

Robot Name: Trektor

Stage: Prototype

Power: Hybrid (Diesel to Batteries)

Sitia is a French-based company that has a clear focus on hybrid design and integration within the agricultural industry. Sitia developed a platform that is fully open, meaning any idea has the opportunity to be tested with potential integration in the future. They hope to have 500 robots operational in the field by 2023.

Pros	Cons
Multitask robot (cultivating, weeding, mowing, chopping, rolling)	Unknown Cost
Changeable wheelbase and height (ground clearance)	
Regular three-point hitch and connectors	
24 hour run time	

For a video reference of the Trektor robot please click [here](#) and [here](#). For more information on the robot please click [here](#).

CEOL

Origin: France

Robot Name: Agreenculture

Stage: Available to order

Power: Electric

Another French-based company stemming from satellite guidance backgrounds, focusing on autonomous agricultural solutions. The company wants to develop tools to assist the farmer. Their goal is to make the Agreenculture robot complete repetitive tasks that would normally take 8 hours to just 1 hour. This robot can perform multiple tasks with various tools listed on their website. The robot can also be managed on your smartphone, adjusting the robot in real time.

Pros	Cons
Multitask robot (cultivating, weeding, mowing, chopping, rolling)	Limited battery life (60-90 mins)
Geo-positioning	6km maximum speed
Lightweight	Unknown Cost
Adjustable width (72 to 110cm)	

For a video reference of the Agreenculture robot please click [here](#). For more information on the robot please click [here](#).

AgXeed and Hol Spraying Systems (H.S.S.)

Origin: The Netherlands

Robot Name: AgXeed AgBot 2.055W3

Stage: Available to order

Power: Diesel

This robot allows growers to perform multiple tasks in the orchard utilizing the same robot. The AgXeed HSS robot is an intelligent sprayer that only sprays when there are leaves in front of the sensor, while creating a 3D map of the orchard. Some perceived benefits include a reduction of labour, fuel and tractor use.

Pros	Cons
Multitask robot (weeding, mowing, chopping, spraying, liquid fertilizer application)	One size
8 nozzles on each side	Unknown Cost
Regular three-point hitch and connectors	

For a video reference of the AgXeedy AgBot 2.055W3 from AgXeedy and H.S.S. please click [here](#). For more information on the robot please click [here](#).

Farmertronics

Origin: The Netherlands

Robot Name: eTrac

Stage: Prototype

Power: Electric

This company started in 2012 with a vision to develop an unmanned clean technology tractor. This robot currently mows, but there hasn't been much update regarding its progress since 2020.

Pros	Cons
Small / Lightweight	Single task
	One size
	Unknown Cost

For a video reference of the eTrac please click [here](#). For more information on the robot please click [here](#).

Aigro UP

Origin: The Netherlands

Robot Name: Aigro UP

Stage: Prototype

Power: Electric

This robot has been designed to work in suboptimal conditions and requires only GPS of rows to navigate between them. The company states that if you are capable of fixing a lawnmower, then you can fix Aigro UP as well. The company wants to improve agricultural process by reducing heavy machinery use, manual labour and herbicide needs. They also plan to expand their diversity in the sector through further development of clean-energy powered robots.

Pros	Cons
Multitask robot (weeding and mowing)	10 hour run time
Small / Lightweight	One size
	Unknown Cost

For a video reference of the Aigro UP robot please click [here](#). For more information on the robot please click [here](#).

Harvesting Robots

Ines Hanrahan (Washington Tree Fruit Research Commission) brought forward some thoughts at the 2022 International Fruit Tree Association (IFTA) Annual Conference that should be noted. There hasn't been a commercially successful apple robot harvester in 10+ years, where companies require \$50-100 million in investments. Currently, the best apple picking robot has only worked for consecutive hours, picked dozens of bins in 5 years, has a picking rate of 1 bin per hour and has an unknown cost per fruit. Another challenge is that most robotic harvesters today rely on colour and/or size to determine whether apples are ready for harvest. Although colour and size can be an indicator of ripeness, there are many other factors that should be utilized in unison to determine whether apples are ready to harvest.

With that in mind, there is a need and desire for robotic apple harvesters. And although no commercial success has been seen in orchards, there has been success in other agricultural commodities. Labour shortages and costs are stacking up and making orchard operations rethink how they run their business. There are many challenges facing growers and robotic technology advancements but working together to build a harvester that is reliable, efficient and serviceable is possible. Listed below are a few harvesting robot companies to keep an eye on.

Fresh Fruit Robotics

Origin: Israel

Robot Name: FFRobot

Stage: Orchard trials

Power: Electric

This company started hitting headlines in 2017 and have since developed a robot that is almost ready to harvest at commercial orchards. They state that their robot is “a reliable, robust harvesting platform emulating (the) human-hand picking process for efficient, cost-effective and bruise-free fruit harvesting”. The company also claims that their robot is 10 times more productive at harvesting fruit to the average human picker, requiring only one supervisor during use.

Pros	Cons
Soft suction harvester	Complexity
Multiple arms for double picking	Unknown Cost
Can harvest two fruiting walls at once	
Conveyer, bin allocation and bin drop	

For a video reference of the FFRobot from Fresh Fruit Robotics please click [here](#).

Ripe Robotics

Origin: Australia

Robot Name: Eve

Stage: Pilot trials, per bin charge

Power: Electric

This small start-up company has developed two robots since its inception, one named Clive, which was utilized as a “proof of concept” to better understand the needs of the robot in the orchard. Eve is the second-generation robotic harvester for Ripe Robotics, where the company is focused on developing a robot that can be upgraded continuously, transported easily, more efficient than human labour and leave the grower with a higher marketable yield.

Pros	Cons
Vacuum and soft suction harvester	Bruising may be an issue
‘IKEA’ robot due to assembly on-site, ease of transport	Single point of harvest
Bin allocation	Unknown Cost
Tried on apples, pears and oranges	
Currently works alongside pickers	

For a video reference of EVE from Ripe Robotics please click [here](#).

Tevel Aerobotics Technologies

Origin: Israel

Robot Name: FAR™ (Flying Autonomous Robots)

Stage: Offering contracts in limited countries

Power: Electric

Tevel has become more popular due to the recent articles being written about the company. Tevel claims to have fruit transfer figured out, but their videos suggest otherwise. Currently fruit is being dropped from the drone directly into bins without any concern for bruising or a cushioning system. That being said, Tevel has recently partnered with Blueline to transport bins alongside harvest.

Pros	Cons
Tethered drone-based harvester	Drops fruit, no allocation for bins/conveyers
Detects fruit, foliage and classifies fruit based on colour and size	Trialing different suction cups
Ease of transport	Single point of harvest
Scalable service	Unknown Cost

For a video reference of Tevel's drone picking robots please click [here](#).

Monash University

Origin: Australia

Robot Name: Robot Harvester

Stage: Prototype

Power: Electric

This robot was developed by researchers at Monash University, where an 85% success rate of apple picking in trial orchards was determined. This pneumatically powered robot can work in various lighting and weather conditions but is still in early development. The robotic system is to be mounted on a vehicle developed by *Thor Tech*.

Pros	Cons
Soft gripper	Twists off fruit, removing leaves and spurs
High success rate	Drops fruit, no allocation for bins/conveyers
Low damage with stem removal	Single point of harvest
Detects fruit, foliage and classifies fruit based on colour	Unknown Cost
Detects and avoids obstacles in the tree (i.e. branches, leaves)	

For a video reference of the Robot Harvest from Monash University please click [here](#).

Abundant Robotics - Advanced Farm Technologies, Wavemaker Labs

Origin: United States of America

Robot Name: Robot Harvester

Stage: Unknown

Power: Electric

Dubbed as “one of the most promising robotic apple pickers” in 2020 and early 2021, with many patented attributes including: a sensory vacuum system, world-class vision system and various software patents, this company shut down last summer. Before closing shop, Abundant Robotics trialed their robot in New Zealand beginning in 2017 and expanded their trial in 2020 to commercial orchards within the United States.

The software portion of the company has been purchased by *Wavemaker Labs* and is seeking funding to continue their endeavors.

Hardware was purchased by *Advanced Farm Technologies*, where they have seen success in the past with a robotic strawberry harvester. For a video reference of the strawberry harvester (TX Robot), please click [here](#). They hope to have an apple harvesting robot ready in 3 to 5 years.

Pros	Cons
Vacuum harvester	Separated into two companies
Unmanned	Unknown future
Bin allocation (1 bin)	Unknown Cost
Belt for sorting before bin drop off	

Summary

Progress in agricultural robotics, although slow, is showing steady success. These are technologies developed to support growers and improve orchard operations. With any new technology there is a definitive learning curve and potential for change in the way orchards are managed. In summary the pros and cons of robotic technology use in apple orchards are listed below.

Pros	Cons
Labour Savings	Unknown Costs
Potential for increased efficiency	Unknown Regulations: safety and accountability
Data driven orchard management	Servicing of machinery (costs and convenience)
Potential operation 24/7	Learning Curve

Resources

van Sonsbeek, Bert. "First AgBot fruit growing robot available this spring". *European Fruit Magazine*. 1 (155) 2022, pp. 8-10.

Hanrahan, Ines. 2022, February 12-15. Status of Apple Harvest Automation in Washington [conference presentation]. International Fruit Tree Association 2022. Hershey, Pennsylvania.

Ontario Apple Growers and Ontario Tender Fruit Growers. 2021. Ontario Tree Fruit Innovation and Technology Roadmap. [Robots for Apple | ducksize](#)

Blossom Thinning with Lime Sulphur and ATS

Dr. John A. Cline, University of Guelph; Erika DeBrouwer, Tree Fruit Specialist, OMAFRA

Introduction

Thinning the apple crop early by mechanical or chemical means is beneficial to reduce fruit set, crop load, and the high labour costs associated with hand thinning after natural fruit abscission. In addition, thinning early to improve fruit size and return bloom, particularly of biennial bearing cultivars such as Honeycrisp, is important.

There is increasing grower interest in thinning multiple times during the spring, starting with judicial pruning, followed by blossom thinning, and finally fruitlet thinning. Many growers are already doing this with the overall goal of early thinning to enhance flower bud initiation for the flowing season's crop, and to reach a target crop load with minimal hand thinning. Managing the crop load of apples remains a significant challenge to producers, in part because of the unpredictability of fruit set and fruitlet abscission.

My program has conducted blossom thinning experiments over the past decade and decided to revisit these efforts with a study starting in the spring of 2021.

Experimental Details

In 2020 and 2021 a 4-yr-old block of 'Brookfield Gala'/M.9 T337 rootstock located at the University of Guelph Horticultural Experiment Station, Simcoe, ON was used for this study. Trees were spaced 0.90 m x 3.5 m (3175 trees per ha) and trained to a spindle solid hedgerow orchard system. Treatments consisted of:

1. Untreated control
2. Hand thinned control (flower clusters were singled, fruit space ~10 cm apart)
3. 75 mg/L 6-BA combined with 750 mg/L carbaryl (applied at 12 mm king fruitlet diameter)
4. 2% ammonium thiosulphate (ATS) at bloom (two applications)

5. 2% ATS at bloom (two applications) follow by 75 mg/L 6-BA combined with 750 mg/L carbaryl applied at 12 mm king fruitlet diameter
6. 2.5% lime sulphur (LS) combined with 2% (v/v) mineral oil applied at bloom (two applications)
7. 2.5% LS combined with 2% oil (two applications) followed by 75 mg/L 6-BA combined with 750 mg/L carbaryl applied at 12 mm king fruitlet diameter.

Commercial products used in this study

- 6-BA: Maxcel, Valent Bioscience. Guelph, ON
- Carbaryl (CB): Sevin XLR; Tessengerlo Kerley Inc., Phoenix, Arizona
- ATS: 12-0-0-26S Norwich Fertilizer, Norwich, ON
- Lime Sulphur: Oligo-S, Axter Agrosience, Mont-St-Hilaire, QC
- Mineral Oil: Purespray Green Spray Oil 13E, Intelligro, Mississauga, ON

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the University of Guelph of the products named and does not imply criticism of similar ones not mentioned.

All spray treatments included 0.05% Regulaid® non-ionic spray adjuvant. The experimental design consisted of a randomized complete block with 5 replications and 7 treatments. All sprays were applied using a commercial air blast sprayer at 1379 kPa, 1217 L/ha carrier volume, which equated to tree row volume (TRV) pesticide dilute. To minimize treatment interference caused by spray drift, experimental units were separated by at least one guard tree.

Blossom thinners were applied at approximately 30% full bloom when most of the king flowers were open but prior to lateral flowers opening. Blossom sprays were repeated 27 h later (2020) and 82 h later (2021). A propriety computer model known as the pollen tube growth model (PTGM) was used to time when to apply and re-apply the blossom spray (Peck et al, 2016; Peck and Olmstead, 2018). Using cultivar-specific pollen tube length, pollen growth rate, and air temperature, the model predicts the time required for the flowers to be fertilized after the pollen reaches the stigma. In addition, the predicted time to apply blossom thinners is based on the desired number of flowers to be fertilized per tree, which is approximate 25% higher than the desired number of fruit per tree.

Fruitlet thinners were timed by periodically measuring the longitudinal diameter of 50 king and 50 lateral fruits (5 fruits of each across 10 trees) using digital calipers. The date of full bloom was 24-May 2020 and 10-May 2021. Only the hand-thinned control trees were thinned on 8 July 2020 and 13 July 2021 by removing all but one fruit per cluster and spacing fruit ~10 cm apart.

Horticultural Measurements

Tree trunk circumference at 30 cm above the graft union was measured at the beginning and end of each growing season, from which trunk cross-sectional area (TCSA) was calculated. Four scaffold branches—two on the east and two on the west side of the tree—were selected prior to bloom to determine fruit set. On 13-May 2020, the number of flower clusters per branch were counted on each marked limb. The number of fruit set per limb were counted again after natural abscission ('June drop') on 24-June 2020. These datasets were averaged and used to calculate percent fruit set (number of fruit set divided by number of flowers).

Leaf fruit phytotoxicity was assessed on various dates by rating the incidence and severity (0= none, 1= very slight; 2= slight, 3= moderate, 4= high, 5= very high), the incidence and severity of leaf necrosis was also assessed in a similar rating style (0= none, 1= very slight; 2= slight, 3= moderate, 4= high, 5= very high).

Fruit were harvested on 14-Sept 2020 and 13-Sept 2021. During harvest, the total number and weight of fruit was recorded. The number of unmarketable fruit (undersize, poor colour, premature fruit drop) were also counted and weighed. Mean fruit size was estimated by dividing total mass of marketable fruit by the number of fruit in the sample. A random sample of 20 kg fruit per tree was taken from each experimental unit and in cold storage (~2°C) for subsequent grading on a commercial colour sorting and sizing grading line in November of 2020 and 2021.

Results

Fruit Set

In 2020, there was a significant treatment effect on fruit set ($P < 0.0001$) (Figure 1). The untreated control and ATS blossom thinning treatments had the highest fruit set, whilst the LS blossom thinning followed by the CB and 6-BA fruitlet thinning treatment had the lowest fruit set. The post-bloom fruitlet treatment, LS blossom treatment and ATS blossom thinning followed by CB and 6-BA fruitlet thinning treatment resulted in moderate reduced fruit set. Fruitlet thinning alone reduced fruit set by 54% compared to the untreated control. ATS alone was not effective in reducing fruit set, while trees treated with LS and oil had 37% lower fruit set compared with the untreated control. The addition of the fruitlet thinner following the ATS and LS blossom thinning treatments decreased fruit set, but the response was sufficiently variable that the effect was not statistically significant.

In 2021, there was a significant treatment effect on mean fruit set ($P < 0.0001$) (Figure 1). The untreated control, hand-thinned control and LS blossom thinning only treatments resulted in the highest mean fruit set, whilst the blossom thinning combined with fruitlet thinning treatments had the lowest fruit set. The grower standard CB and 6-BA fruitlet thinning treatment resulted in a moderate amount of thinning. Based on the means separation, ATS blossom thinning with and without fruitlet thinning and the LS blossom thinning + fruitlet thinning treatments were statistically similar to CB and 6-BA fruitlet thinning treatment despite considerable numerical differences. Fruitlet thinning alone resulted in a greater degree of thinning than the blossom thinned treatments, 17.6 fruit/100 clusters compared to 31.3 fruit, respectively ($P = 0.001$). The addition of fruitlet thinning to the blossom thinning treatments decreased fruit set from an average of 31.3 to 7.1 fruit/100 clusters ($P = 0.001$).

Yield Parameters

In 2020, based on the relatively low crop load of 4.2 fruit per cm^2 TCSA for the untreated control trees, in retrospect all trees required little additional blossom or fruitlet thinning apart from singling fruiting clusters. The light fruit set can be attributed to a spring frost in early May. Trees during this period were in the tight cluster stage, were subject to air temperatures that fell below -2°C . On 8-May, 9-May, 12-May, and 13-May minimum temperatures fell to -1.8°C , -3.4°C , -1.2°C and -1.9°C , respectively. Notwithstanding, total number of fruit per tree (Figure 2) and total yield (Figure 3), marketable yield and crop load were highest from the untreated control trees, followed by the ATS blossom thinning treatment. Trees receiving LS alone, or LS or ATS followed by CB and 6-BA, or CB and 6-BA alone had the lowest total yield (Figure 3), marketable yield, total number of fruit per tree (Figure 3) and crop load. Generally, treatments that resulted in the greatest degree of fruit thinning also produced the lowest yield, number of fruit and crop load. The percent of marketable fruit ($P = 0.693$) and adjusted mean fruit weight ($P = 0.3217$) (Figure 3) was unaffected by the thinning treatments. However, it is notable that fruit weight from trees treated with LS, without CB and 6-BA, was numerically (but not statistically; $P = .0697$) lower than any of the other treatments, even though they were thinned that greatest.

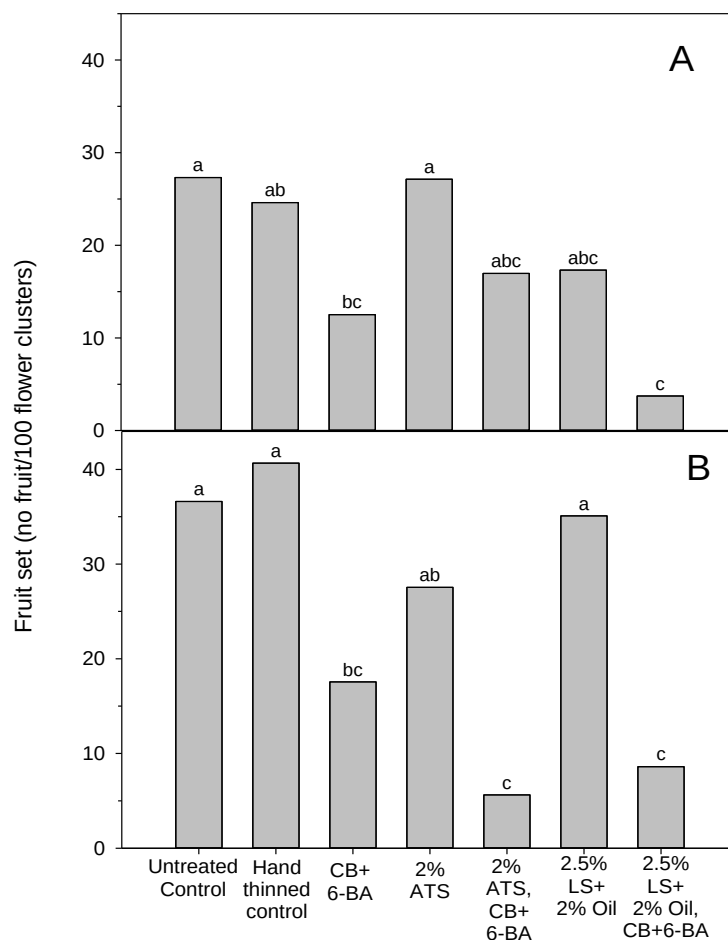


Figure 1. Fruit set of Gala trees in response to blossom and fruitlet thinners in 2020(A) and 2021(B). Mean values with the same letter within a given year are not significantly different according to Tukey's HSD test at $P = 0.05$. Note that fruit set counts were recorded prior to hand-thinning, so no differences in fruit set between the untreated and hand-thinned controls should be inferred.

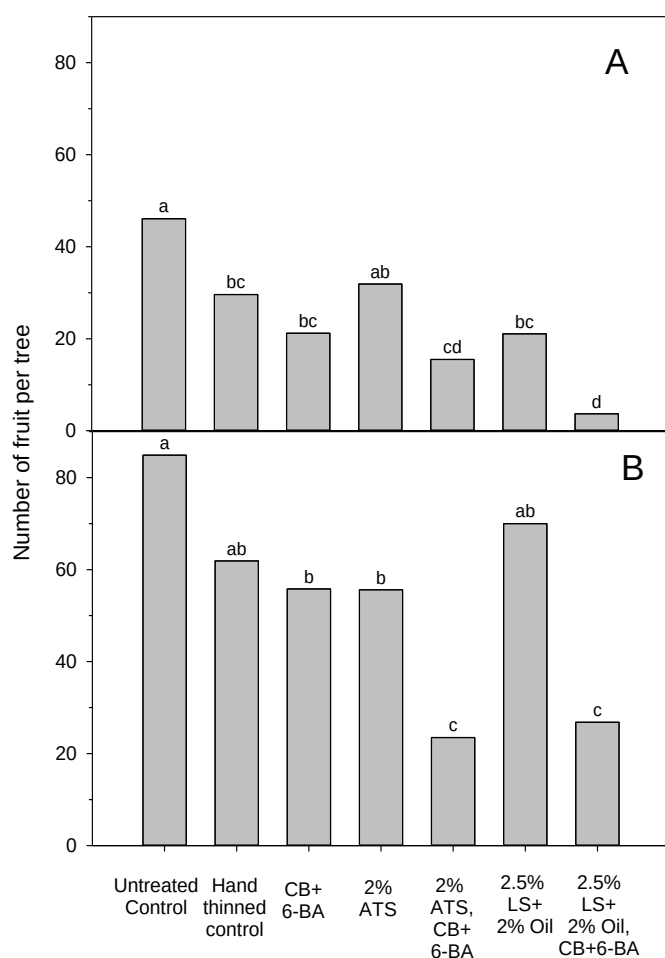


Figure 2. Number of Gala fruit per tree in response to blossom and fruitlet thinners in 2020(A) and 2021(B). Mean values with the same letter within a given year are not significantly different according to Tukey's HSD test at $P=0.05$.

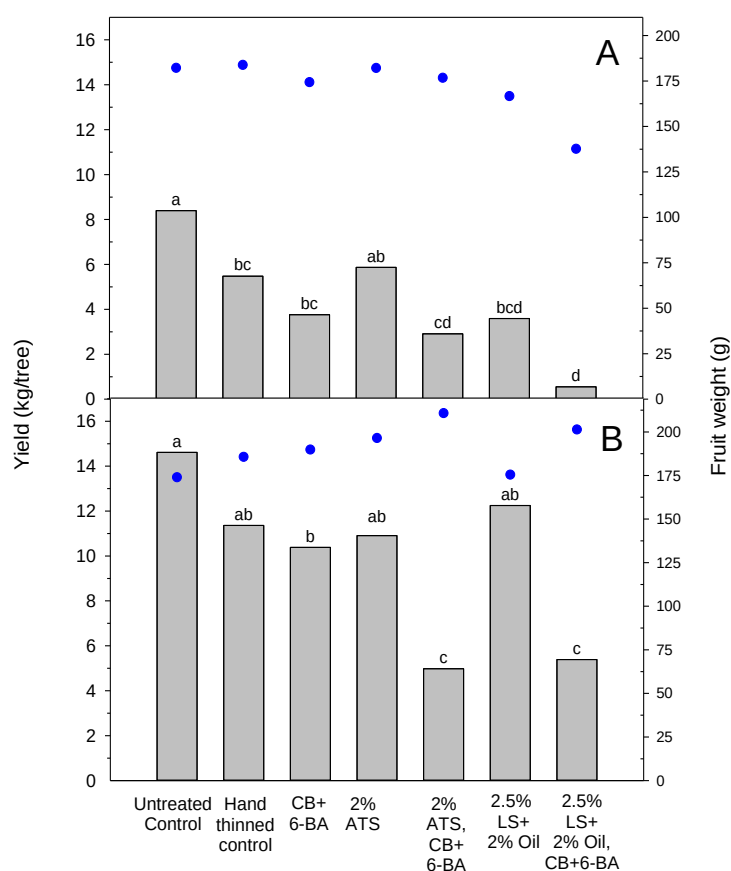


Figure 3. Total yield per tree (bars) and average fruit weight (dots) of Gala in response to blossom and fruitlet thinners in 2020(A) and 2021(B). Mean values with the same letter within a given year are not significantly different according to Tukey's HSD test at $P=0.05$.

In 2021, yield parameters were influenced by the thinning treatments with the exception of percent marketable fruit and average fruit weight. Total yield was highest from the untreated trees, followed by the hand-thinned trees and those that received a blossom thinning treatment only (Fig. 3). All of the thinning treatments, except for the blossom thinning combined with fruitlet thinning treatments, were similar to the hand-thinned control and 6-BA and CB fruitlet thinning treatments. Generally, treatments that resulted in the greatest amount of fruit thinning had produced the lowest yield. This was particularly apparent by the additive effect fruitlet thinning treatments, which on average, significantly reduced total yield compared to blossom thinning alone ($P=0.001$). The combination of blossom and fruitlet thinning also reduced marketable yield compared to the other treatments.

Total number of fruit per tree (Figure 2) followed a similar trend as total yield (Figure 3), with the highest number of fruit on the untreated control trees, followed by LS blossom thinned trees and the hand-thinned control. The total number of fruit on trees treated with fruitlet thinning alone or blossom thinning alone was statistically similar to the hand-thinned control. Trees treated with a combination of blossom and fruitlet thinning resulted in the lowest total number of fruit per tree.

Average fruit weight (Figure 3) of both all fruit harvested and those that were marketable were highest in treatments that resulted in the greatest degree of thinning, however all treatments were statistically similar to the hand-thinned control and the 6-BA combined with CB fruitlet thinning treatment except for the ATS blossom thinning combined with fruitlet thinning

treatment. Fruit weight was significantly higher when trees were both blossom and fruitlet thinned compared to blossom thinning alone ($P=0.001$).

Crop load was highest for the untreated control trees (data not shown). Blossom thinning alone resulted in similar crop load to the hand-thinned control and CB and 6-BA fruitlet thinning treatments. The addition of fruitlet thinning to blossom thinning resulted in the lowest crop load.

Leaf Phytotoxicity

Leaf curling and necrosis was observed in all treatments, including the untreated control, but severity was low, ranging from very slight to slight (data not shown). The severity of leaf curling, however, was similar among all treatments. Leaf necrosis was more prevalent in treatments that were bloom thinned compared to the untreated control. Bloom thinning increased the incidence of necrosis compared to fruitlet thinning ($P=0.05$). Trees blossom thinned with ATS, with or without fruitlet thinning, exhibited significantly greater severity of leaf necrosis compared to untreated trees. On average, leaf necrosis was also more severe in trees that were bloom thinned compared to trees that were fruitlet thinned ($P=0.001$). Some leaf phytotoxicity is expected when using caustic blossom thinners, but overall levels were relatively low.

Product Costs

The cost of blossom thinners needs to be considered in the context of a thinning program and weighed with the benefits.

Based on list prices received in January 2022, the product costs are as follows:

2.5 % Lime sulphur (Oliogo-S) + 2% oil

- 25 L Lime Sulphur @ \$10.53/L = \$263.25
- 20 L Purespray green (13E) @ \$8.19/L = \$163.80
- 0.5 L Agral 90 @ 18.25/L = \$9.12
- Total = \$436/1000 L x 2 applications = \$872/1000 L spray solution

2% ATS (12-0-0-26S)

- 20 L Oligo-S ATS @ \$7.15/L = \$143
- 0.5 L Agral 90 @ 18.25/L = \$9.12
- Total = \$152/1000 L x 2 applications = \$304/1000 L spray solution

Key Conclusions

- 2.5% LS plus oil effectively reduced fruit set of Gala and the number of fruit per tree in one of two years.
- In 2020, 2% ATS applied alone as a blossom thinner reduced fruit set compared to the untreated and hand-thinned control treatments, but this did not translate into reduced crop load or number of fruit per tree. In 2021, 2% ATS applied alone reduced the number of fruit per tree and crop load compared to the untreated control, at a level similar to fruitlet thinning with carbaryl and 6-BA.
- Rates higher than 2% ATS may be required to obtain adequate reductions of fruit set and crop load on Gala.
- When the blossom thinner ATS and LS were combined with the carbaryl and 6-BA fruitlet thinners applied at 12 mm, fruit set and number of fruit per tree were reduced further
- Fruit size was lower for LS with comparable crop loads to ATS, fruitlet thinners and hand-thinning. This may be the effect of LS reducing photosynthesis and sensitivity to stress during this critical period of rapid cell division. Further testing is required to evaluate the effect of LS on fruit size under Ontario conditions and cultivars.
- Leaf phytotoxicity was slight on trees treated with ATS and LS plus oil. Leaf phytotoxicity was slightly higher using 2% ATS compared to 2.5% LS plus oil in one of two years.
- These data are preliminary, and therefore must be interpreted with some caution. Annual variations in thinning response can occur, and cultivars may also respond differently to the blossom thinner compounds and rates used in this study.

Recommendations

- Consider using LS+Oil or ATS alone in a thinning program, especially for biennially bearing cultivars such as Honeycrisp and Fuji.
- Blossom thinning is not recommended when frost damage has injured flowers earlier in the season.
- Consider single applications of ATS or LS or lower rates if less thinning is desired.
- Do not apply during slow drying times in order to avoid russetting
- In the absence of the pollen tube growth model, other research (Allen et al, 2021) suggests applying the first blossom thinner at 20% open bloom followed by a second application 48-72 hr later (lower temperatures will increase this interval from 48 to 72 hr)

Overall, the benefits of early crop load reduction using blossom thinners need to be balanced with the product costs, potential low efficacy and risk of frost, leaf phytotoxicity and potential fruit russetting.

Acknowledgements

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An Extension Perspective of Factors Related to Bitter Pit in 'Honeycrisp' Apples in New York

Erika DeBrouwer, Tree Fruit Specialist, OMAFRA

Dan Donahue, an Extension Associate and Regional Tree Fruit Specialist in New York with Cornell Cooperative Extension discussed various factors that could be influencing bitter pit in 'Honeycrisp' apples including rootstocks, harvest timings, a predictive model, fruit to shoot ratios, and the effect of PGR applications. He addressed these topics to make decisions more economically viable for growers within New York State.

Dan started his presentation with a quote that really stood out. "If you always do what you've always done, you'll always get what you've always got – Henry Ford". Making changes in your orchard isn't always a bad thing; they can have the potential to help your bottom line.

Dan performed an extensive bitter pit study on 'Honeycrisp' apples over multiple years that focused on soil dynamics, shoot to fruit ratios, mineral peel analysis in storage, foliar calcium efficacy, fruit location in canopy, fruit location in flower cluster, timing of crop load reduction, and rootstocks. Below is a summary of his findings.

Rootstocks

- Bitter pit incidence and severity were lower in B.9, compared to M.9 and M.26

Harvest Timing

- Bitter pit incidence was comparable at the 1st, 2nd, and 3rd pick, which were taken a week apart.
- Bitter pit incidence after 120 days in storage:
 - 1st pick had the highest bitter pit incidence
 - 3rd pick had the lowest bitter pit incidence

Fruit Size

Based on a survey study, apple size played a small role in whether a 'Honeycrisp' apple would get bitter pit or not. Data ranged from apples sizing from 48 to 140 count, where count size from 64 to 100 represented 76% of the apples with bitter pit. Management to increase or decrease size to mitigate bitter pit may not be economically viable.

Environment Mineral Rootstock (EMR) Model

Over time Dan developed a model to predict bitter pit using 3 variables:

- Post bloom heat accumulation
- Peel mineral ratio (Magnesium to Calcium)
- Rootstocks

This EMR Modelling system (Table 1) continues to be explored and developed based on the variables listed above.

Table 1. Summary of EMR Model Prediction on Bitter Pit in 'Honeycrisp' Apples conducted by Dan Donahue, Cornell

Year	Predicted (EMR Model) Bitter Pit Incidence (%)	Actual Bitter Pit Incidence (%)
2016	28	31
2017	12	14
2018	49	34
2019	20	19
2020	15	20
2021	31	31

This model is a great indication of bitter pit and assists during the production season by allowing growers to prioritize mitigation strategies, if warranted. The EMR modelling system is also beneficial for the marketability of 'Honeycrisp' apples by assisting in determining whether the apples should be stored for long-term or if they should be marketed more quickly.

Shoots to Fruit Ratio

To look at the effect of shoots to fruit, Dan wanted to reduce the competition between the two to observe whether this would impact bitter pit prevalence. This was achieved through the application of prohexadione calcium, (commercially sold as Apogee and Kudos), which is a gibberellin biosynthesis inhibitor.

A significant difference was found between treatments across 3 years of the study (Table 2). The treatments included:

- Control:** No application
- Pink:** Apogee applied at pink
- 3-Spray:** 3 applications of Apogee starting at petal fall

Table 2. Yearly Bitter Pit Percentages (%) of Plant Growth Regulators, *Trial conducted by Dan Donahue, Cornell*

Year	Control	Pink	3-Spray (Petal Fall)
Year 1	44.4	25.6	57.8
Year 2	8.4	14.1	4.7
Year 3	35.6	19.1	26.3

This study suggests that applications of prohexadione calcium at the **pink stage** could reduce bitter pit incidence more so than 3 applications of prohexadione calcium starting at petal fall. **Timing is crucial!** Note that prohexadione calcium **increased bitter pit** significantly **when applied post-petal fall**.

Suggestions

Please keep in mind that this is a trial, and that these are initial findings.

Also consider that Apogee and Kudos are currently registered for earliest application from 2.5 to 5.5cm of new growth, which can occur pre-bloom depending on the spring.

Dan's suggestions for New York growers are listed below, but please use these strategies with caution due to our different growing conditions.

New Plantings	B.9 Rootstock	M.9, M.26 or other Rootstocks
- Adjust soil pH to 7.0 - Try to maximize vegetative growth in the first few years - Avoid cropping in second leaf - Avoid replant sites. If unable, perform remediation efforts.	- Maintain pH and a balanced soil fertility program. Less potassium is needed in an off year. - Avoid prohexadione calcium at any timing – <i>you already have a low bitter pit rootstock with low vigour</i> - Maintain a consistent crop load year-to-year - Set kings, avoid doubles - Don't spend money on bitter pit predication - Allocate 2nd and 3rd picks for longer-term storage 1st pick should be marketed within 60-90 days of storage	- Maintain pH and a balanced soil fertility program. Less potassium is needed in an off year. - Apply prohexadione calcium at pink (if possible) at 15.5°C - Do not apply prohexadione calcium after bloom - Maintain a consistent crop load year-to-year - Set kings, avoid doubles - Implement bitter pit prediction protocols of your choice - Allocate 3rd pick into longer-term storage if you must 2nd pick stored for 60-90 days 1st pick for immediate sale if bitter pit predictions are in the 10-20% range

Further Research

Dan focused on four areas to advance knowledge on the bitter pit issue in Honeycrisp apples:

1. Identify a low bitter pit rootstock for 'Honeycrisp' that is more vigorous than B.9
2. Work with PGR's to find materials/combinations that improve delivery and distribution of calcium within the fruit
3. Identify gene(s) that influence calcium delivery and distribution within the fruit
4. Production economic studies of established Honeycrisp orchards that produce low quality fruit

In closing, bitter pit has been commonly defined as a calcium-related disorder, but this doesn't mean that calcium is the sole issue. Many factors are influencing bitter pit prevalence with Honeycrisp and research continues to identify these factors. Overall, a multi-faceted approach to mitigate bitter pit in your orchard is needed to decrease presence.

For further information or access to Dan's webinar, please contact Erika DeBrouwer (erika.debrouwer@ontario.ca, 226-931-4098).

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Crop Protection

What's New in 2022 for Apple Crop Protection

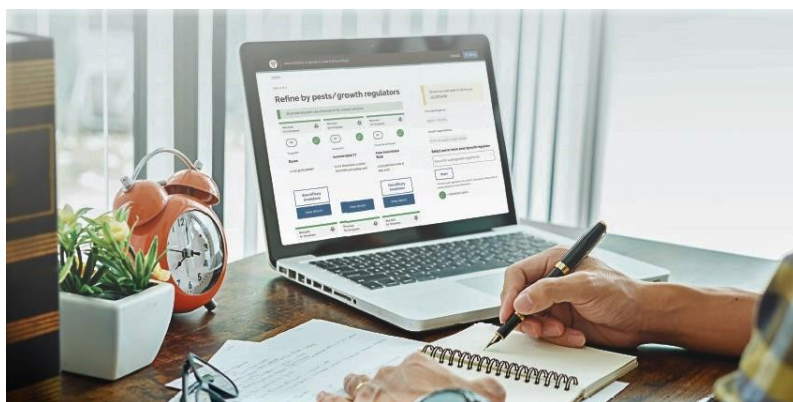
Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Ontario Crop Protection Hub

The Ontario Crop Protection Hub will replace the OMAFRA crop protection publications, including Publication 360 Fruit Crop Protection Guides beginning Spring 2022. All Ontario Apple Grower members will receive an email with the link once it is live. This link will also be provided on the OMAFRA website at ontario.ca/crops. Training videos will be available to help introduce new users to the system.

Over the next year, OMAFRA will continue to update and expand the application to meet the needs of growers in the province. ***Your feedback on this system is important to make this tool useful for you in your operation!*** Details on how to provide feedback to enhance your experience will be available in the online application.

Based on the regular 2-year publication schedule for Publication 360, the 2022 season is a "Supplement" year. A supplementary package with important updated tables will be provided to Ontario Apple Grower members this spring to be used alongside the existing content in the 2021 Publication 360A edition. In the meantime, here is a list of new product additions or changes to available products for Ontario apple growers:



New Registrations or Additions

Fungicides

- **Merivon** (Fluxapyroxad+pyraclostrobin) is a Group 7+11 fungicide registered for the control of apple scab, powdery mildew, black rot, bitter rot, fly speck and sooty blotch at 300-400 mL/ha. The active ingredients in this premix product are also found in Sercadis (Group 7) and Pristine (Group 7+11). For resistance management, tank-mix with a compatible protectant apple scab fungicide from a different group. Do not use with crop oil concentrate, methylated seed oil (MSO) adjuvants, emusifiable concentrates (EC formulations) or Exirel insecticide. *Preharvest interval (PHI): 5 days (hand harvest); Restricted entry interval (REI): 12 hours (general re-entry), 5 days (hand harvest), 12 days (hand thinning); Maximum # of applications per year (on label): 4.*

- **Manzate Max** (mancozeb) is a Group M fungicide registered for the control of apple scab and rust at 9.38 L/ha. This mancozeb product is also subject to the Pest Management Regulatory Agency (PMRA) re-evaluation decision. At present, the label on the PMRA website does not reflect the upcoming changes that will be in place as of November 2022. Growers can follow current use restrictions until that date. *Preharvest interval (PHI): 45 days; Restricted entry interval (REI): 24 hours; Maximum # of applications per year (on label): none specified.*
- **Follow WDG** (folpet) is a Group M fungicide registered for the control of apple scab, black rot, fly speck and sooty blotch at 3.0-3.75 kg/ha. This is the same active ingredient as Folpan 80 WDG with similar cautions. May cause russetting to sensitive cultivars when used pink to 30 days after petal fall. Do not use within 14 days of oil. *Preharvest interval (PHI): 1 day; Restricted entry interval (REI): 12 hours (general re-entry), 24 hours (hand harvest), 6 days (hand thinning); Maximum # of applications per year (on label): 6.*
- **SuffOil-X** (mineral oil) is a summer oil registered for suppression of powdery mildew at 13 L/1,000 L water. Apply in a high-volume spray to ensure thorough coverage but do not apply more than 1,000 L/ha. Cautions apply during unfavourable weather similar to other mineral oils. Do not use in combination or subsequent to Sevin or sulphur or within 14 days of Supra Captan, Maestro, Folpan or Follow. *Preharvest interval (PHI): 0 days; Restricted entry interval (REI): 12 hours; Maximum # of applications per year (on label): 8.*

Insecticides

- **SuffOil-X** (mineral oil) is a summer oil registered for suppression of spider mites and feeding deterrent of aphids at 13 L/1,000 L water. Apply in a high-volume spray to ensure thorough coverage but do not apply more than 1,000 L/ha. Cautions apply during unfavourable weather similar to other mineral oils. Do not use in combination with or before / after Sevin or sulphur, or within 14 days of Supra Captan, Maestro, Folpan or Follow. *Preharvest interval (PHI): 0 days; Restricted entry interval (REI): 12 hours; Maximum # of applications per year (on label): 8.*
- **Ship 250 EC** (cypermethrin) is a Group 3A insecticide registered for control of spring feeding caterpillars, tarnished plant bug, leafcurling midge, tentiform leafminer, white apple leafhopper, obliquebanded leafroller, plum curculio, apple maggot and codling moth at 400 mL/ha. This product has the same active ingredient as Up-Cyde 2.5 EC. Products belonging to Group 3A are highly toxic to beneficial insects. To preserve natural enemies and reduce potential for secondary pest outbreaks, do not make more than 1 application per season. Use is discouraged for summer generations of labelled pests. *Preharvest interval (PHI): 7 days; Restricted entry interval (REI): 12 hours; Maximum # of applications per year (on label): 3.*
- **Zivata** (lambda-cyhalothrin) is a Group 3A insecticide registered for control of spring feeding caterpillars, leafcurling midge, tentiform leafminer, aphids, codling moth, obliquebanded leafroller and white apple leafhopper at 83 mL/ha and plum curculio, tarnished plant bug and woolly apple aphid at 104 mL/ha. This product has the same active ingredient as Labamba, Matador 120 EC and Silencer 120 EC. Products belonging to Group 3A are highly toxic to beneficial insects. To preserve natural enemies and reduce potential for secondary pest outbreaks, do not make more than 1 application per season. Use is discouraged for summer generations of labelled pests. *Preharvest interval (PHI): 7 days; Restricted entry interval (REI): 24 hours; Maximum # of applications per year (on label): 3.*
- **Theme 480 SC** (thiacloprid) is a Group 4A insecticide registered for control of tentiform leafminer and leafhopper at 145 mL/ha, mullein bug at 290 mL/ha, and oriental fruit moth, codling moth, plum curculio and apple maggot at 440 mL/ha. This product has the same active ingredient as Calypso 480 SC. Use a maximum of 2 applications of products from Group 4A per season. Repeated use may result in mite outbreaks. *Preharvest interval (PHI): 30 days; Restricted entry interval (REI): 12 hours; Maximum # of applications per year (on label): 3 (875 mL/ha).*
- **Madex HP** (*Cydia pomonella* granulovirus) is a Group 31 insecticide registered for the control of oriental fruit moth and codling moth at 50-100 mL/ha. Similar to other granulovirus products, the product must be ingested to be effective. After death, larvae will disintegrate and release new viral bodies which may infect other larvae. Product can be broken down by sunlight. *Preharvest interval (PHI): not specified; Restricted entry interval (REI): 4 hours; Maximum # of applications per year (on label): 5 per generation.*
- **Spiro SC** (spirodiclofen) is a Group 23 miticide registered for the control of European red mite, two-spotted spider mite and apple rust mite at 710 mL/ha. This product has the same active ingredient as Envidor 240 SC. Control

may not be apparent for 1 week. For resistance management, do not use any miticides more than once per season. *Preharvest interval (PHI): 7 days; Restricted entry interval (REI): 12 hours; Maximum # of applications per year (on label): 1.*

Product Removal or Cancellations

Re-evaluation decisions:

- **Clutch 50 WDG** (clothianidin) – all uses on apples including brown marmorated stink bug have been removed. Last date of use is April 11, 2022.
- **Actara 25 WDG** (thiamethoxam) – all uses on apples including brown marmorated stink bug have been removed. Last date of use is April 11, 2022.
- **Granuflo T** (thiram) – last date of use was December 2021
- **Ferbam 76 WDG** (ferbam) – last date of use was December 2021
- **Polyram DF** (metiram) – last date of use was June 2021

Product no longer being sold:

- **Mako** (cypermethrin)
- **Sovran** (kresoxim-methyl)

PROWL® H₂O Herbicide label expanded via Minor Use Program to help manage labelled weeds in listed Pome and Stone Fruits

Josh Mosiondz, Minor Use Coordinator, OMAFRA

The Pest Management Regulatory Agency (PMRA) recently announced the approval of a minor use label expansion registration for PROWL® H₂O Herbicide for control or suppression of labelled weeds listed pome and stone fruits (new and established plantings) in Canada. PROWL® H₂O Herbicide was already labeled for management of weeds on a wide range of crops in Canada. These minor use proposals were submitted by Agriculture & Agri-Food Canada, Pest Management Centre (AAFC-PMC) as a result of minor use priorities established by growers and extension personnel.

The following is provided as an abbreviated, general outline only. Users should be making weed management decisions within a robust integrated weed management program and should consult the complete label before using PROWL® H₂O Herbicide.

Crop(s)	Target	Rate (L product/ha)	Application Information
Apple Apricot Cherry, sweet Cherry, tart Crabapple Nectarine Peach Pear Plum Plum, Chickasaw Plum, Damson Plum, Japanese Plum, prune Plumcot	Labelled Weeds	3.7	Apply PROWL H ₂ O herbicide as a broadcast or banded treatment using ground equipment before weed germination. Apply the spray directly to the ground beneath the trees and/ or in areas between rows. Uniformly apply with properly calibrated ground equipment using a minimum of 200 L water per hectare. DO NOT apply over the top of trees with leaves or buds or fruit. Contact by the spray mixture with leaves, shoots, or buds may cause injury.

TOXIC to aquatic organisms and non-target terrestrial plants. Observe buffer zones specified under DIRECTIONS FOR USE. Follow all other precautions, restrictions, and directions for use on the PROWL® H₂O Herbicide label carefully.

For a copy of the new minor use label contact Kristy Grigg-McGuffin, Horticulture IPM Specialist OMAFRA, Simcoe (519) 420-9422, Wendy McFadden-Smith, Horticulture IPM Specialist OMAFRA, Vineland (905) 932-8695, your regional supply outlet, or visit the PMRA label site <http://www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php>

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

ASSURE® II Herbicide label expanded via Minor Use Program to help manage labelled weeds in CG 11-09 (Pome Fruit), 12-09 (Stone Fruit), and 13-07F (Small fruits climbing vine)

Josh Mosiondz, Minor Use Coordinator, OMAFRA

The Pest Management Regulatory Agency (PMRA) recently announced the approval of a minor use label expansion registration for ASSURE® II Herbicide for control or suppression of labelled weeds CG 11-09 (Pome Fruit), CG 12-09 (Stone Fruit), and CG 13-07F (Small fruits climbing vines). ASSURE® II Herbicide was already labeled for management of weeds on a wide range of crops in Canada. These minor use proposals were submitted by Agriculture & Agri-Food Canada, Pest Management Centre (AAFC-PMC) as a result of minor use priorities established by growers and extension personnel.

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

Crop(s)	Target	Rate (L product/ha)	Application Information	PHI (days)
CG 11-09 (Pome Fruit)	Labelled Weeds	0.38 – 0.75	For the control of grassy weeds listed on the label, apply ASSURE® II Herbicide as a single post-emergent broadcast spray directed at the ground with a recommended surfactant at 5 litres per 1000 liters of spray. Use ground application only. Use a directed spray application to minimize the amount of spray coming into contact with the fruit trees. Use a minimum of 100 litres of water/ha.	14
CG 12-09 (Stone Fruit)				
CG 13-07F (Small Fruits climbing vine, except fuzzy kiwifruit)	Labelled Weeds	0.38 – 0.75	For the control of grassy weeds listed on the label, apply ASSURE® II Herbicide as a single post-emergent broadcast spray directed at the ground with a recommended surfactant at 5 litres per 1000 liters of spray. Use ground application only. Use a directed spray application to minimize the amount of spray coming into contact with the fruit trees. Use a minimum of 100 litres of water/ha.	15

This product contains an active ingredient and aromatic petroleum distillates, which are toxic to aquatic organisms. TOXIC to non-target terrestrial plants. Observe buffer zones specified under DIRECTIONS FOR USE. To reduce runoff from treated areas into aquatic habitats avoid application to areas with a moderate to steep slope, compacted soil, or clay. Avoid application when heavy rain is forecast. Contamination of aquatic areas as a result of runoff may be reduced by including a vegetative filter strip between the treated area and the edge of the water body. Follow all other precautions, restrictions, and directions for use on the ASSURE® II Herbicide label carefully.

For a copy of the new minor use label contact Kristy Grigg-McGuffin, Horticulture IPM Specialist OMAFRA, Simcoe (519) 420-9422, Wendy McFadden-Smith, Horticulture IPM Specialist OMAFRA, Vineland (905) 932-8695, your regional supply outlet, or visit the PMRA label site <http://www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php>

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

The Enemy of My Enemy Is My Friend: Biological Control in Orchards

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

What is biological control?

Biocontrol, natural enemies, beneficials... Several words are often used, all which have the same meaning – biological control. This control measure uses beneficial organisms to help suppress pest populations. Biological control agents may be:

- predators – e.g., lady beetles, mullein bug, minute pirate bug, birds
- parasites – e.g., nematodes
- parasitoids – e.g., braconid wasps, tachinid flies
- pathogens (virus, fungi, bacteria, etc) – e.g., streptomycin, mycorrhizal fungi, *Bacillus thuringiensis*, granulovirus

Many beneficials occur naturally in the environment and can be supported in agricultural systems; others may be introduced.

Does it work in orchards?

Beneficials will not completely eliminate damage by pests. However, once they are established, they can maintain pest populations at lower levels. Often, they can be effective against indirect pests such as aphids, leafhoppers and mites, but may be less effective at keeping populations of direct pests, which attack the fruit, at levels acceptable for commercial production. Biological control is a strategy to be considered as part of an integrated program. It can help keep pest populations to lower levels, reducing selection pressure on pesticides used. Presence of beneficials may also allow sprays to be delayed or avoided, saving labour and input costs.

Some pest control products registered for use on apples are toxic to beneficials. This may be through means of:

- *Direct toxicity* – such as a broad-spectrum insecticide immediately killing a pest and its insect predators
- *Indirect toxicity* – such as impacts to feeding behaviour, reproduction, development, mobility or longevity

Often insecticides tend to be the primary focus when talking about impacts to beneficials. However, herbicides and fungicides should be considered as well. Herbicides can reduce habitat and shelter for natural enemies or floral diversity for pollinators. Some fungicides such as mancozeb can be directly toxic to certain predatory mites while other fungicides can also cause indirect effects, such as changing the microbiome in a pollinator's gut.



Hoverfly larva feeding on green apple aphid colony.

Considering toxicity when determining product choice during critical periods in the season is important to protect the beneficial populations that are naturally established or those biological control agents you are planning to release.

For more information on toxicity of registered pesticides to honeybees and common orchard beneficial insects, refer to Table 3-6. Toxicity of Pesticides to Honeybees and Mite/Aphid Predators in the [2021 Publication 360A, Crop Protection Guide for Apples](#).

Releasing beneficial insects

Releasing biological control agents, or beneficial insects are typically well-suited for isolated systems like greenhouses where dispersal can be contained. In the field, those insect life stages that can easily fly away should be avoided. However, focusing instead on the less mobile life stages (e.g., larval stage of lady beetle or lacewing) or those species that tend not to disperse widely (e.g., predatory mites, small parasitoids) could make for an effective biological release program.

There are a number of distributors of beneficial insects that Ontario growers can access. For more information, refer to [Beneficial Insects and Mites Suppliers](#) on the OMAFRA website. Talk to your supplier about the appropriate timing for release as this will depend on the beneficial insect system as well as the intended target pest.

Unlike some conventional pest control products that can be applied at the time of a pest outbreak, the use of biological control needs a preventative approach. In other words, release or application needs to be frequent until populations become established and done prior to a pest outbreak. Regular monitoring of pest populations prior to release and of pest and beneficial populations after release is crucial to track the success of the program.

If releasing predators such as predatory mites or minute pirate bug (*Orius*), supplemental prey and alternative habitat needs to be considered to keep these predators present even when pest populations are low. Keep in mind, these small insects don't often move large distances so if there is little linkage between cropped and frequent alternative habitats, movement could be limited.



Predatory mites feeding on European red mite (Photo: UConn IPM)

Supporting what you've got

For some operations, releasing biological control agents may not be appropriate or feasible. Good news – supporting natural enemy populations is just as beneficial (pun intended)! Augmenting habitat, or creating diverse landscape can provide natural enemies and pollinators with shelter, protection or refuge, alternative prey or sources of nectar and pollen. Consider your farm landscape and how you could:

- Protect habitat you have
- Improve existing sites
- Create new areas
- Promote linkages between habitats



Minute pirate bug feeding on white (Photo: H. Jung Yoo, Purdue)

Follow these practices to conserve and encourage beneficial insects in your orchard:

- **Avoid use of pesticides that are toxic to beneficials present at key times during the season** – For instance, the parasitic wasp, *Aphelinus mali*, is capable of complete control of aerial colonies of woolly apple aphid. However, *A. mali* are very sensitive to many commonly used insecticides belonging to groups such as organophosphates (Group 1B), pyrethroids (Group 3), neonicotinoids (Group 4A), spinosyns (Group 5) and diamides (Group 28) so parasitism is often quite limited in conventional managed orchards. As mentioned previously, refer to Table 3-6. Toxicity of Pesticides to Honeybees and Mite/Aphid Predators in the [2021](#)

Publication 360A, [Crop Protection Guide for Apples](#) for toxicity ratings to common orchard beneficials for registered products.

- **Encourage a diverse habitat within and/or around the perimeter of the orchard where beneficial insects can live** – Flowering strips surrounding an orchard or companion planting (e.g., cover crops under trees or flowering plants in row middles) provide pollen and nectar, habitat and biodiversity to support beneficials. Research in Washington observed significantly lower aphid densities on trees adjacent to plantings of sweet alyssum and a diverse group of generalist predators compared to control plots. Table 1 identifies plant species that could be selected to attract or support beneficial insect populations.
- **Seed or protect flowering plants, trees and shrubs with different floral characteristics and blooming times** – Wild bees and some predatory insects such as mullein bug sustain themselves on diverse sources of pollen and nectar throughout the season. Providing floral resources that bloom at different times will support these populations when other food sources are limited.
- **Avoid ultra-clean cultivation** – Crop residue, mulch or ground cover will encourage ground beetles and other important predators in the soil, as well as provide nesting sites for key pollinators such as bumble bees.



Parasitized woolly apple aphid.
(Photo: E. Beers, Washington State University)

Creating landscape to support natural enemy and pollinator populations can also present challenges. For instance, refuge or unsprayed sites can also harbour the very pests you're trying to control. Regularly monitor the perimeter of the orchard and implement appropriate control measures, including mowing or tilling the land if pest populations increase. Establishment and maintenance of naturalized areas can be costly depending on the site. Careful planning and site preparation can offset this and ensure success of the area.

There are great resources and organizations available for growers interested in diversifying the landscape in or around an orchard including native plant selection:

- [Alternative Land Use Services \(ALUS\)](#)
- [Farms At Works](#)
- [Pollinator Partnership Canada](#)
- [Wild Pollinators of Eastern Apple Orchards](#)

Table 1. Plant selections to attract or support beneficial insects.

Beneficial	Targeted Pests	Plants to consider
Aphid midge	Aphids	Dill, mustard, thyme, sweet clover
Aphid parasitoids	Aphids	Nectar-rich plants with small flowers (anise, caraway, dill, parsley, mustard family, white clover, Queen Anne's lace, yarrow)
Assassin bug	Many insects, including flies and large caterpillars	Permanent plantings for shelter (e.g., hedgerows), sunflower family*, fennel, alfalfa, spearmint
Big-eyed bugs	Many insects, including other true bugs, flea beetles, spider mites, insect eggs and small caterpillars.	Berseem and subterranean clovers, common knotweed, sunflower family*, fennel, alfalfa, spearmint

Beneficial	Targeted Pests	Plants to consider
Braconid wasp	Caterpillars (such as codling moth, leafminer, European corn borers), beetle larvae, flies, aphids	Nectar plants with small flowers (caraway, dill, parsley, Queen Anne's lace, fennel, mustard, white clover, tansy, yarrow), sunflower, hairy vetch, buckwheat, cowpea, common knotweed, crocuses, spearmint
Chalcid wasps	Caterpillars (such as codling moth, leafminer, European corn earworm)	Diversity of plants, including sunflower family*, carrot family*, buckwheat, common knotweed, white clover
Damsel bug	Aphids, thrips, leafhoppers, treehoppers, small caterpillars	Sunflower family*, alfalfa
Ground beetle	Aphids, scale, midge, caterpillars, beetle larvae, slugs, snails, pupae of flies, beetles or moths	Amaranth, white clover
Lacewing	Soft-bodied insects including aphids, thrips, midge, mealybug, scale, caterpillars and mites	Sunflower family*, carrot family**, buckwheat, corn, holly leaf cherry
Ladybird beetle or ladybug	Soft-bodied insects including aphids, thrips, midge, mealybug, scale, caterpillars and mites	Sunflower family*, carrot family**, crimson clover, hairy vetch, grains and native grasses, butterfly weed, black locust, buckwheat, rye, hemp sesbania, buckthorn, black locust
Mealybug destroyer	Mealybugs	Sunflower family*, carrot family**
Minute pirate bug	Soft-bodied insects including aphids, thrips, midge, mealybug, scale, caterpillars and mites	Sweet alyssum, black-eyed Susan, sunflower family*, carrot family**, alfalfa, spearmint
Parasitic nematodes	Nematodes	Marigolds, chrysanthemum, gaillardia, helenium, <i>Eriophyllum lanatum</i> , horseweed, hairy indigo, castor bean, <i>Crotalaria</i> spp., <i>Desmodium</i> spp., sesbania, lupines, <i>Phaseolus atropurpurens</i>
Plant bugs (mullein bug)	Soft-bodied insects including aphids, thrips, midge, mealybug, scale, caterpillars and mites	Diversity of plants, including sunflower family*, carrot family**, sweet alyssum, chrysanthemum
Praying mantis	Any insect (including beneficials)	Cosmos, brambles
Predatory mites	Mites, scale, small soft-bodied insects (such as leafhoppers)	Diversity of plants
Predatory thrips	Soft-bodied insects including aphids, thrips, midge, mealybug, scale, caterpillars and mites	Diversity of plants
Spiders	Many insects	Caraway, dill, fennel, cosmos, marigold, spearmint
Spider mite destroyers	Mites	Carrot family**, mustard family (sweet alyssum, candytuft, etc.)
Spined soldier bugs	Caterpillars, sawflies, beetles	Sunflower family*, bishop's weed
Syrphid flies (Hoverflies)	Soft-bodied insects including aphids, thrips, midge, mealybug, scale, caterpillars and mites	Sunflower family*, carrot family**, candytuft, sweet alyssum, ceanothus, holly-leaved cherry, buckwheat, scabiosa, spearmint, knotweed, California lilacs, soapbark tree, meadow foam, baby-blue-eyes
Tachinid flies	Beetle and fly larvae, caterpillars, squash bugs, stink bugs	Carrot family*, goldenrod, sweet clover, <i>Phacelia</i> spp., sweet alyssum, buckwheat, amaranth, buckthorn, <i>Heteromeles arbutifolia</i>
* Sunflower (aster) family: coreopsis, Gloriosa daisy, yarrow, cosmos, sunflower, marigolds, goldenrod, daisies, golden marguerite (Anthemis), dandelion etc.		

Beneficial	Targeted Pests	Plants to consider
** Carrot family: Queen Anne's lace, dill, fennel, caraway, tansy, parsley, coriander, etc. Adapted from Wallace et al. (2021) and OMAFRA (2016)		

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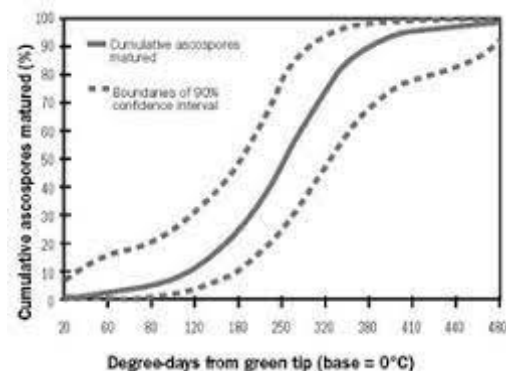
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Does Snow Cover Influence Primary Ascospore Release?

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

A silver lining to the pandemic has been the ability to access real-time information from regions and events I would often miss in a normal year. During one of these events this winter (New York State Tree Fruit Conference - January 28, 2022), New York State's IPM Coordinator, Juliet Carroll presented some historical apple scab data alongside the question – does snow cover influence ascospore release?

Carroll's team took that question and dug into historical records dating back to 1986. They compared squash mount data from overwintering leaf litter (used to detect early season ascospore, or primary apple scab spore development) to the ascospore degree day model (shown at right) and snow fall accumulation from the previous winter. An interesting pattern began to appear: snow cover later winter and early spring resulted in advanced ascospore maturation and discharge compared to what was predicted by the degree day model. In years with little to no snow cover, the biological data more closely matched that from the model.



Apple scab ascospore maturity model

So, what does this mean? Carroll believes these findings make assessing 'Potential Ascospore Dose', or PAD all the more important for apple scab management. Knowing the pressure in your orchard from overwintering inoculum could influence how you approach spring scab control. If fall counts determine a clean orchard, those first early spring sprays could potentially be delayed. However, if scab was found in fall PAD counts followed by a snowy winter, you may want to be prepared for early spring management as soon as buds break even if degree-day accumulation is still low.

For a refresher on determining orchard inoculum level using the PAD method, refer to Management Notes in the [Apple Scab module of Ontario CropIPM](#).

Snow cover can also influence overwintering apple scab populations by slowing leaf litter decomposition. In years of little to no snow cover, fluctuating winter temperatures and moisture can facilitate rapid breakdown of the overwintering leaves harbouring apple scab inoculum. The more leaves decompose, the fewer intact pseudothecia (containing immature ascospores) remain. Fall-applied urea would help speed up this process all the more. Snow cover, on the other hand, provides a layer of insulation for these overwintering spores, prevents significant leaf breakdown, protects from winter winds blowing the leaves out of the orchard and allows for ascospore maturation in the early spring.

Funding Available to Continue Testing Herbicide Resistant Weeds

Kristen Obeid, Weed Management Specialist – Horticulture, OMAFRA

Funding is available for producers, agri-business, consultants and extension personnel to submit weed samples to be tested for herbicide resistance again this year. Sample collection kits with sampling procedures can be obtained from kristen.obeid@ontario.ca. These tests only require a small amount of leaf tissue from the suspected resistance weeds. DNA is extracted from the leaf tissue to determine if there is a molecular change where the herbicide acts to kill the weed, making the weed resistant.

There are 19 molecular tests (more in progress) to assist in identifying herbicide resistance in 14 weed species. Tests are also available to differentiate between *Brassica* (mustard) and *Amaranthus* (pigweed) species. Tests differentiating pigweed species have been instrumental in confirming new cases of waterhemp in Ontario, Manitoba and Quebec. Once confirmed, the waterhemp is tested for Groups 2, 5, 7, 9 and 14 resistances.

Results:

1. 121 new cases of herbicide resistance in Ontario crops since 2016.
2. New tests developed in 2021 for:
 - a. Groups 2, 5 and 7 resistant giant ragweed
 - b. Group 9 resistant Italian ryegrass
 - c. Group 9 resistant common ragweed
 - d. Group 14 resistant green pigweed
3. New mutation conferring resistance to Groups 5 and 7 was found in green pigweed.
4. Continued increase in the number of fields with multiple resistant weed species:
 - a. Common ragweed resistant to herbicide Groups 2 and 5 in pumpkins and 2, 5 and 7 in soybeans and sunflowers.
 - b. Redroot and green pigweed resistant to herbicide groups 2 and 5 in tomatoes.
 - c. Redroot and green pigweed resistant to herbicide Groups 5 and 7 in carrots and potatoes.
 - d. Waterhemp resistant to herbicide Groups 2, 5, 9 and 14 in asparagus, peppers, corn, soybeans and white beans.
5. Continued increase in the number of horticulture crops with glyphosate (Group 9) resistant Canada fleabane (apples, blueberries, carrots, grapes, onions, pumpkins and strawberries).

This testing has been instrumental in documenting new cases of herbicide resistant weeds. In 2021, 96% of the fields tested in Ontario were resistant to at least one herbicide group. These tests deliver a result and recommendation to the producer within the same growing season, sometimes in as little as 5 days. Traditional resistance testing in the greenhouse can take from three months to a year to get results. Once confirmed producers were provided the resistance profile enabling a change in management to help prevent spread. Participants were pleased with the timely results, welcomed the in-season management recommendations, and highly value this service.

There are many more undocumented cases of herbicide resistant weeds in Canada. The resistance mechanism is unknown for most of them. The major concern is their distribution and economic impact for producers. Knowing where resistant biotypes are located will improve management and maintain the longevity of our crop protection tools.

Contact Kristen Obeid (kristen.obeid@ontario.ca, 519-965-0107) for sample collection kits, sampling procedures and how to submit samples to Harvest Genomics www.harvestgenomics.ca

Thank-you to the project partners, that have provided funding and/or in-kind support: AAFC, AAFC-PMC, Bayer CropScience Inc., FMC Canada, FVGO, MAPAQ, OAG, OFVGA, OPVG, and Syngenta Canada Inc.

Table 1. Available Genetic Tests

Weed Species	Herbicide Group (s)	Common Herbicide Trade Name (s) (provided ONLY as example herbicides commonly used in horticulture)	Target Site Mutation / Metabolic / Species Identification
Amaranthus species	-	-	Species Identification
Brassica species	-	-	Species Identification
Brassica species	9	Glyphosate	Presence of transgene
Canada fleabane	9	Glyphosate	Target-site (P106S)
Common chickweed	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (P197Q & unpublished)
Common ragweed	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (W574L)
	5	Atrazine, Sencor, Simazine, Sinbar	Target-site (V219I)
	7	Lorox	Target-site (V219I)
	9	Glyphosate	Target-site (P106S)
Eastern black nightshade	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (A205V)
Giant foxtail	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (unpublished)
Giant ragweed	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (W574L)
	5	Atrazine, Sencor, Simazine, Sinbar	Target-site (V219I)
	7	Lorox	Target-site (V219I)
Green foxtail	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (unpublished)
Green pigweed	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (S653N & W574L)
	5	Atrazine, Sencor, Simazine, Sinbar	Target-site (A251V, S264G, V219I & F274L)
	7	Lorox	Target-site (A251V, V219I & F274L)
	14	Aim, Authority*, Chateau*, Goal, Reflex*	Target-site (Δ G210 in PPX2L)
Italian ryegrass	9	Glyphosate	Target-site (P106S)
Lamb's-quarters	5	Atrazine, Sencor, Simazine, Sinbar	Target-site (S264G)
Large crabgrass	1	Assure, Poast Ultra, Select, Venture	Metabolic: ACCase gene amplification
Redroot pigweed	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (S653N & W574L)
	5	Atrazine, Sencor, Simazine, Sinbar	Target-site (A251V, S264G, V219I & F274L)
	7	Lorox	Target-site (A251V, V219I & F274L)
Waterhemp	2	Pinnacle, Prism, Pursuit, Sandea	Target-site (S653N & W574L)
	5	Atrazine, Sencor, Simazine, Sinbar	Target-site (A251V, S264G, V219I & F274L)
	9	Glyphosate	Metabolic: EPSPS gene amplification
	14	Aim, Authority*, Chateau*, Goal, Reflex*	Target-site (Δ G210 in PPX2L)

Several of these tests were developed by other researchers and reproduced from the scientific literature.

*Soil applied/preemergence herbicides are still effective against Group 14 resistant species because they prevent the weed from germinating or kill the weed as it germinates. However, much more research is required in this area.

Post Harvest

Timing of Postharvest 1-MCP Treatment Affects Greasiness in ‘Ambrosia’ Apples

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

‘Ambrosia’ apples with advanced maturity were harvested from a commercial orchard as their main harvest began. Fruit firmness averaged 18.1 lb, internal ethylene concentration 1.0 ppm, starch index 5.9 (Cornell chart, 1-8), 12.8% soluble solids concentration, 266 mg malic acid per 100 ml of juice, and 0.5 index of delta absorbance (DA meter).

Apples were cooled to 3°C and then treated with 1-methylcyclopropene (1-MCP) the next day and/or 4 days after harvest. 1-MCP treatment was with SmartFresh™ tablets for 1 ppm and lasted ~24 hours. One month later the temperature was decreased from 3°C to 0.5°C. Slower cooling was to promote storage disorders, to exacerbate any 1-MCP effects. Fruit quality and storage disorders were evaluated after 1, 7, and 14 days at ~13°C (room temperature (RT) with control problem).

After 4 months of air storage, apples treated with 1-MCP had less greasiness than those not treated, and greasiness became more severe with more days at RT (Table 1). After 7 days at RT, apples with no 1-MCP had severe greasiness, while those treated with 1-MCP one day after harvest were the least greasy. ‘Ambrosia’ with two 1-MCP treatments (1 & 4 Days) had the least amount of greasiness after 14 days at RT. Therefore, 1-MCP treatment on the day after harvest provided the best control of greasiness, with a second treatment adding some further benefit during extended shelf-life (subsequent holding at RT).

Apples treated with 1-MCP were 3-4 lb firmer after 4 months of storage, regardless of treatment timing or number of treatments, compared to those with no 1-MCP (Table 1). Internal ethylene concentration was also reduced by 1-MCP, <1 ppm versus 20-29 ppm in apples with no 1-MCP.

There were no significant differences in storage disorders among treatments with or without 1-MCP. Internal browning incidence ranged from 20 to 30%, which was likely high due to the advanced fruit maturity at harvest.

Table 1. ‘Ambrosia’ apples treated with 1-MCP at 1 and/or 4 days after harvest and held at 3°C for 1 month followed by 0.5°C for 3 months, plus 1, 7, and 14 days at ~13°C (room temperature (RT)).

Days at RT	1-MCP Treatment	Greasiness (1-3 scale) ¹	Internal Ethylene (ppm)	Firmness (lb-force)
1	1 & 4 Days	1.1 ^G	0.1 ^C	18.9 ^A
	1 Day	1.1 ^G	0.1 ^C	19.2 ^A
	4 Days	1.2 ^G	0.1 ^C	18.8 ^A
	No 1-MCP	1.6 ^F	20.4 ^B	16.5 ^D
7	1 & 4 Days	2.6 ^B	0.4 ^C	17.8 ^B
	1 Day	1.9 ^E	0.4 ^C	17.5 ^{BC}
	4 Days	2.3 ^{CD}	0.4 ^C	17.8 ^B
	No 1-MCP	3.0 ^A	28.7 ^A	14.1 ^E
14	1 & 4 Days	2.1 ^E	0.7 ^C	16.6 ^D
	1 Day	2.3 ^D	0.7 ^C	16.9 ^{CD}
	4 Days	2.5 ^{BC}	0.8 ^C	16.9 ^{CD}
	No 1-MCP	3.0 ^A	20.4 ^B	12.8 ^F
Significance ²		****	**	***

¹ Greasiness scale: 1 = none or very little greasiness; 2 = moderate greasiness, notable by feel; 3 = severe greasiness, slippery and difficult to hold.

² **, ***, ****, Significant at P<0.01, P<0.001, P<0.0001, respectively. Values within a column with different letters are significantly different.

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Announcements

Electronic Logging Device Mandate Update

Erika DeBrouwer, Tree Fruit Specialist, OMAFRA

On June 12, 2021, the Provincial Electronic Logging Device (ELD) Mandate was implemented, making it mandatory for commercial motor vehicles (CMVs) to use ELDs to record their hours of service. This mandate was then paused until June 12, 2022, to "give sufficient time for industry to obtain and install certified electronic logging devices without penalty" and allow time to elevate education and awareness across the province.

What Does This Mean? Why Does This Matter?

This means that truck drivers operating within Ontario will be required to use a certified ELD as of June 12, 2022. This mandate includes any commercially licensed vehicle that has a yellow tag and requires annual inspection. This is most applicable to growers that have trucks transporting produce and materials.

Approved ELDs

Here is a list of approved ELD's that can be utilized. This list is updated as devices become certified.

<https://tc.canada.ca/en/road-transportation/electronic-logging-devices/list-certified-electronic-logging-devices>

Exemptions

The exemptions listed below are directly from the Ministry of Transportation (MTO) website:

- A CMV driven by a driver within 160 km radius of where they began their day and that returns to the same location at which the driver began.
- A CMV operated by an operator under a certificate issued under section 191 of the Act.
- A CMV that is the subject of a rental agreement of no longer than 30 days that is not an extended or renewed rental of the same vehicle.
- A CMV manufactured before model year 2000.

More exemptions can be found in the resources below.

Resources

[Electronic Logging Devices \(ELD\) for Intra-provincial Carriers \(ontariocanada.com\)](#)

[Electronic logging devices \(canada.ca\)](#)

[Electronic Logging Devices \(gov.on.ca\)](#)

If you have further questions, please contact Erika DeBrouwer, Tree Fruit Specialist, OMAFRA (erika.debrouwer@ontario.ca, 226-931-4098)

Registry of Employers of International Agri-Food Workers

Did you know that the Ontario Ministry of Agriculture, Food and Rural Affairs launched a voluntary registry for employers of international agri-food workers under the Temporary Foreign Worker Program? This registry will help the province better support you and your employees during the growing season and beyond. Find out more at [Ontario.ca/AgEmployerRegistry](https://ontario.ca/AgEmployerRegistry) and consider taking a few minutes to register and complete your information.

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
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