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For Commercial Apple Producers

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Orchard Management

The Trend Is Your Friend, Weather You Like It or Not

Erika DeBrouwer, Tree Fruit Specialist, OMAFRA

Climate and Weather Data

Major climactic factors that affect any crop production include temperature, solar radiation and precipitation. Over time, these factors have been changing, causing unrest in crop production globally.

Spring has been moving quickly these past few weeks, yet a cold snap is upon us, analyzing past data could give light as to how the growing season could go and factors to consider in the future.

Below are charts representing the past few years of weather data, including monthly temperature averages, precipitation values and growing degree days from several locations across Ontario.

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Growing Degree Days (GDD)

GDD are an important tool utilized in apple production, as it is can give growers an idea for pest and disease predictions, but also allows us to observe seasonal changes over time.

Figures include the ongoing 2021 season (to April 20th, 2021) with a five-year history, along with comparisons to the 2015 and 2012 season, as frost and advanced growth staging occurred.

Although this spring has advanced quickly, Figure 1 and 2 demonstrate that GDD aren't as advanced as in 2012 but are similar. This can be concerning due to the earliness of growth staging. Apple staging across the province varies, but are generally a week or two ahead depending on the variety.

Monthly Temperatures

Weather is single handedly one of the most important measures to a fruit tree grower. Temperature impacts apple trees physiologically in many processes, including respiration, photosynthesis, dormancy, growth patterns, chilling requirements, root growth, pollination, fertilization and the list goes on. These processes have major implications as to apple production and that is why analyzing temperature data is important.

When observing the 2021 season temperature data (Figure 3), irregularities in the fall and spring stand out. May stood out as well, showing that 2020 had cooler temperatures by 2 degrees. Generally speaking, June through October of 2020 followed the 5-year average with some higher temperatures in July. Taking a closer look at the fall and winter, Figure 4 shows that the 2021/2020 season was more mild from November through January, along with March and April compared to the 5-year average (Figure 4). February was the only month where 2021 was cooler than the average. When comparing the 2021/2020 season to 2012, generally 2021/2020 has been more mild, but April has recently surpassed 2012. Given the lower temperatures in the past few days, the average in 2021/2020 will decrease.

Looking back at 2012, roughly 80% of Ontario apple crop was lost due to a frost event. The advancement of apple staging and a cold temperature drop for an extended period caused this devastation. Thus far, apples in 2021 aren't as advanced as they were in 2012 and hopefully the weather doesn't give us many more cool nights in the next month.

Monthly Precipitation

Rainfall is another measurement that is important for all crop production. Although some orchards have irrigation to mitigate drought stress within their orchard, timely rainfalls, especially before the beginning of irrigation season, are crucial to the success of the apple crop. Lack of rain has been associated with loss of production, delay in flower differentiation, spur death, decreased fruit size and other implications in tree health.

Overall, Ontario has had a dry season in 2021/2020 compared to the 5 year average (Figure 5) with a major increase in August. The only other month during the 2021/2020 season that showed a higher value in precipitation compared to the

the 5-year average was December. When observing the 5-year average compared to 2012 similarities in trend lines are shown, yet the 2012 year is more erratic in changes, showing peaks and valleys throughout the year. Looking more closely at the late fall to early spring (Figure 6), the 2021/2020 season has slightly lower precipitation in comparison to the 5-year average.

Summary

Overall, the 2021 spring season following the trend of the 2012 season in terms of GDD, but temperature and precipitation have been less erratic in comparison to 2012.

- GDD continue to advance, but are not as far along as in 2012
- Temperatures were cooler in the fall and early spring, but April has been warmer compared to 2012 and the last 5 years
- The fall of 2020 and the spring of 2021 have been more dry in comparison to the past 5 years

GDD, temperature and precipitation are all important in having a successful apple season. And although these are aspects out of our control, data on temperature and precipitation assist growers in making decisions within their orchards, data could increase apple production through strategic planning over time and data based on new production techniques change the way we produce apples in the future through technological advancements.

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Caprio, J.M. and Quamme, H.A. 1999. Weather conditions associated with apple production in the Okanagan Valley of British Columbia. Can. J. Plant. Sci. 79(1): 129-137.

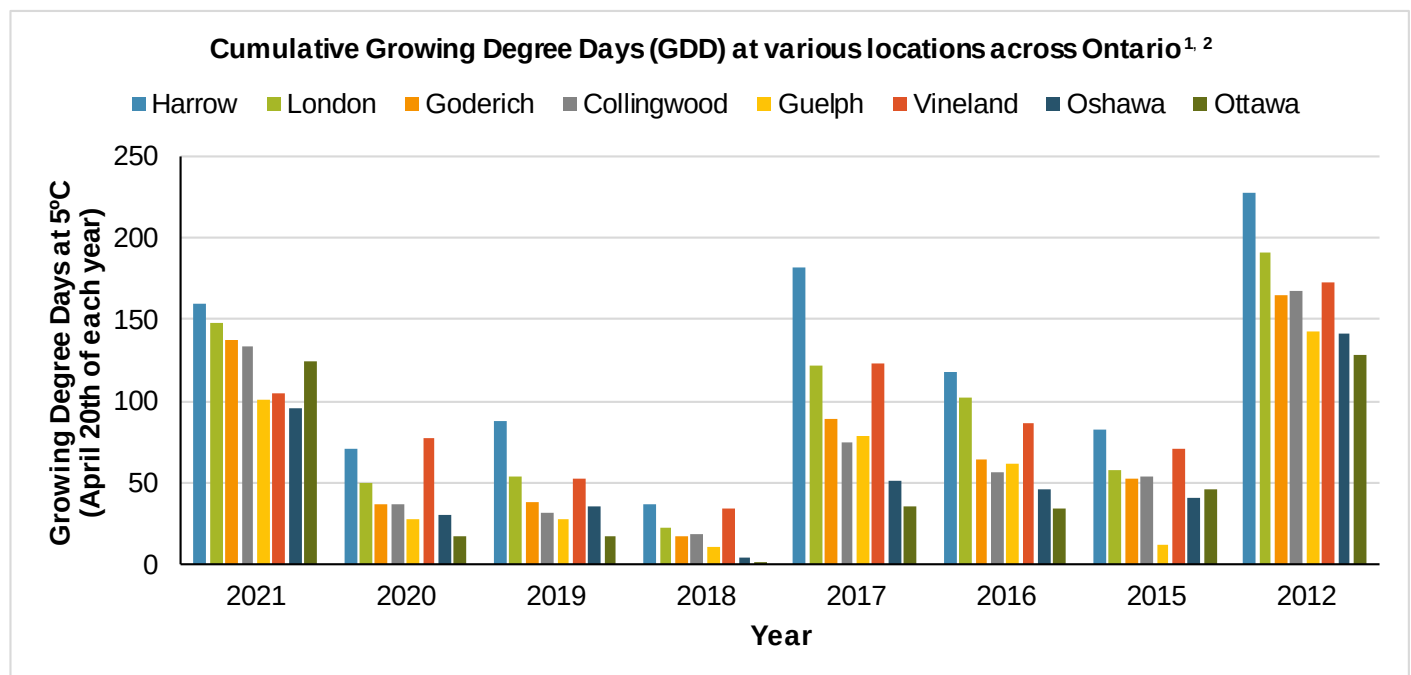


Figure 1. Growing degree days of apple growing regions in Ontario over multiple years

¹5°C was used as the base temperature

²Biofix date was January 1st of each year

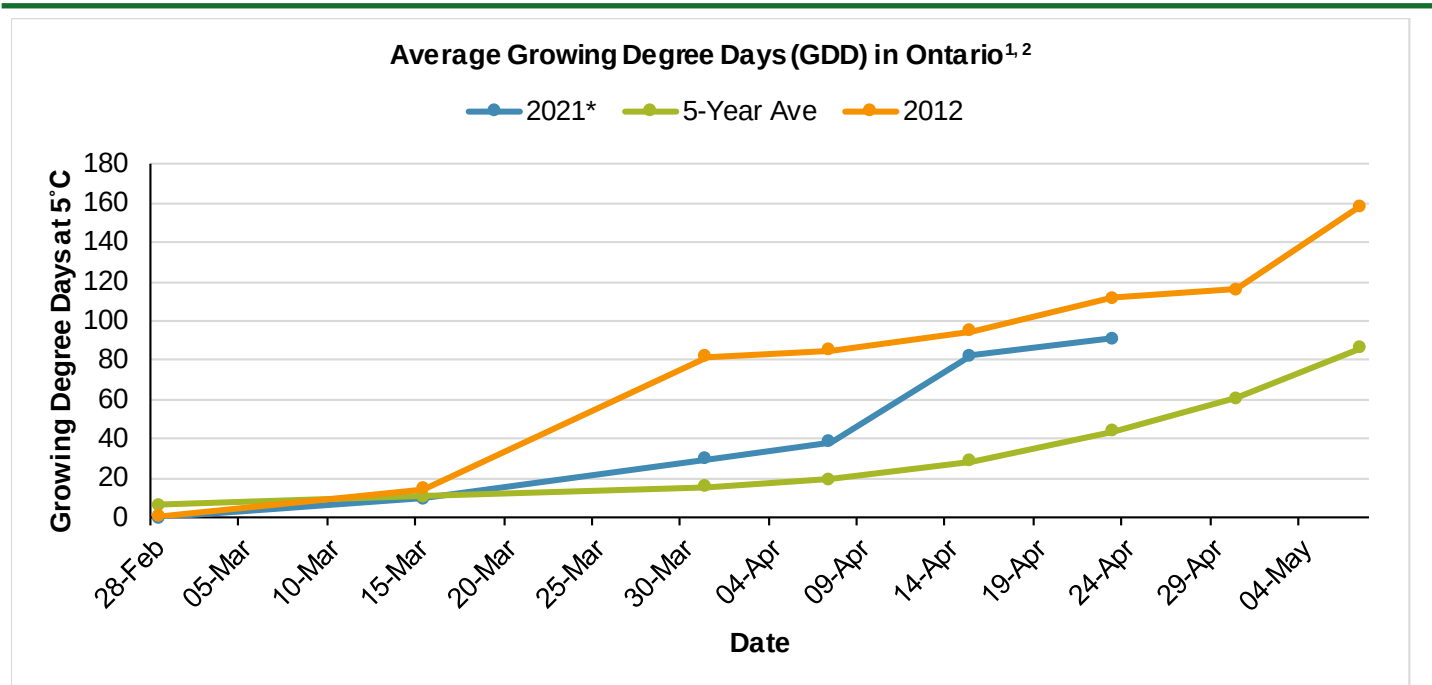


Figure 2. Growing degree days of apple growing regions in Ontario over multiple years.

¹5°C was used as the base temperature.

²Biofix date was January 1st of each year.

*Last date used for 2021 was April 20th

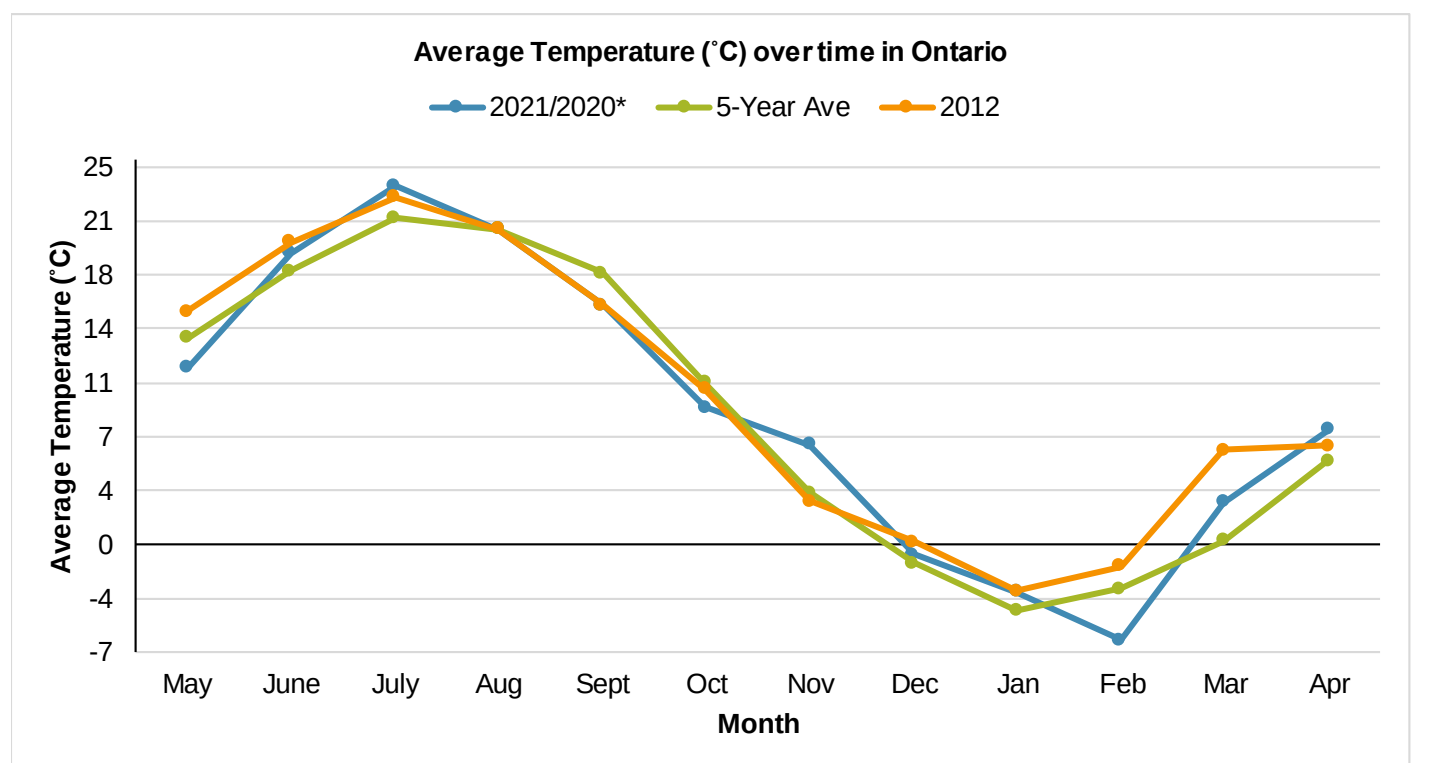


Figure 3. Average temperatures (°C) of apple growing regions in Ontario over multiple years

*2021/2020 season consists of January through April (2021), May through December (2020)

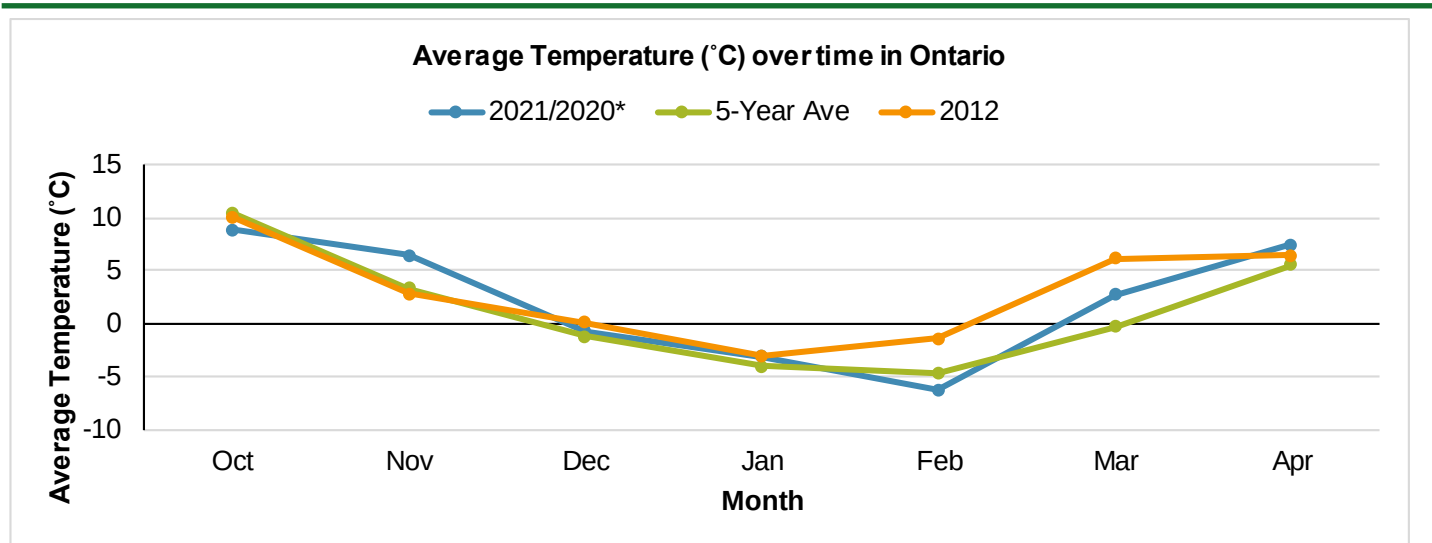


Figure 4. Average fall, winter and spring temperatures (°C) of apple growing regions in Ontario over multiple years
 *2021/2020 season consists of January through April (2021), May through December (2020)

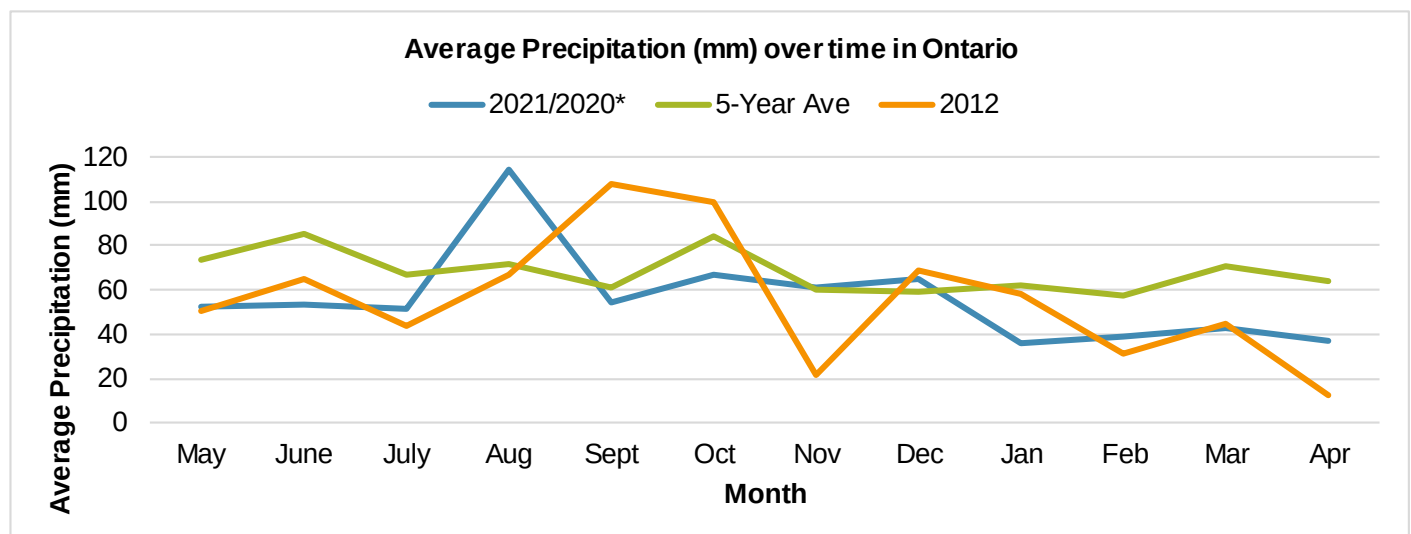


Figure 5. Average precipitation (mm) of apple growing regions in Ontario over multiple years
 *2021/2020 season consists of January through April (2021), May through December (2020)

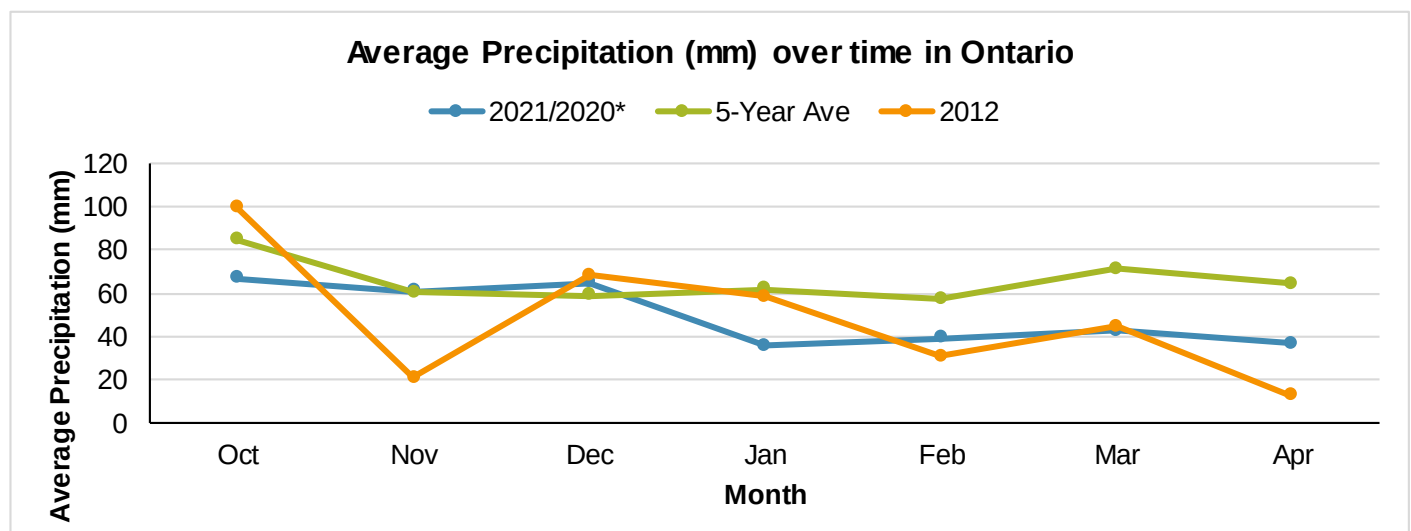


Figure 6. Average fall, winter and spring precipitation (mm) of apple growing regions in Ontario over multiple years
 *2021/2020 season consists of January through April (2021), May through December (2020)

Jack Frost Nipping At Your Buds

Erika DeBrouwer, Tree Fruit Specialist, OMAFRA

Frosty Future?

Freezing temperatures, changing winds and snowfall have been factors testing the resiliency of apple buds across Ontario in 2021. Apples have been staged from ½ inch green to early pink as of April 23, displaying variances in frost susceptibility and potential kill percentage (Table 1). The weather will continue to challenge apple growers as frost can persist until mid-May. Thankfully growth staging has slowed across the province even with higher temperatures during the day, but this may not last long. For resources regarding [strategies to mitigate frost](#) and how to [assess frost damage on apple](#), articles are available on the [ONfruit Blog](#).

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

Freezing Dates

Last frost dates give us an idea of how late in the season a frost can occur, but some of the most detrimental frost crop losses occur over sequential days/nights of freezing temperatures or extremely low temperatures, and is also dependent on how far along the apple buds are.

Figure 1 shows the amount of days below freezing in Ontario in 2021, a 5-year average, 2015 and 2012 for the month of January through April. This figure demonstrates that although 2012 had comparable days below freezing in January, February, and April, it had a low amount of days below freezing in March, yet an 80% apple crop loss occurred. In 2015 a crop loss of roughly 25% occurred, where a higher amount of days below freezing occurred in March. This shows a piece of the puzzle in respect to what can be related to frost crop loss and prediction. The 2021 season seems to follow the 5-year average until April, where the number of days below freezing is minimal.

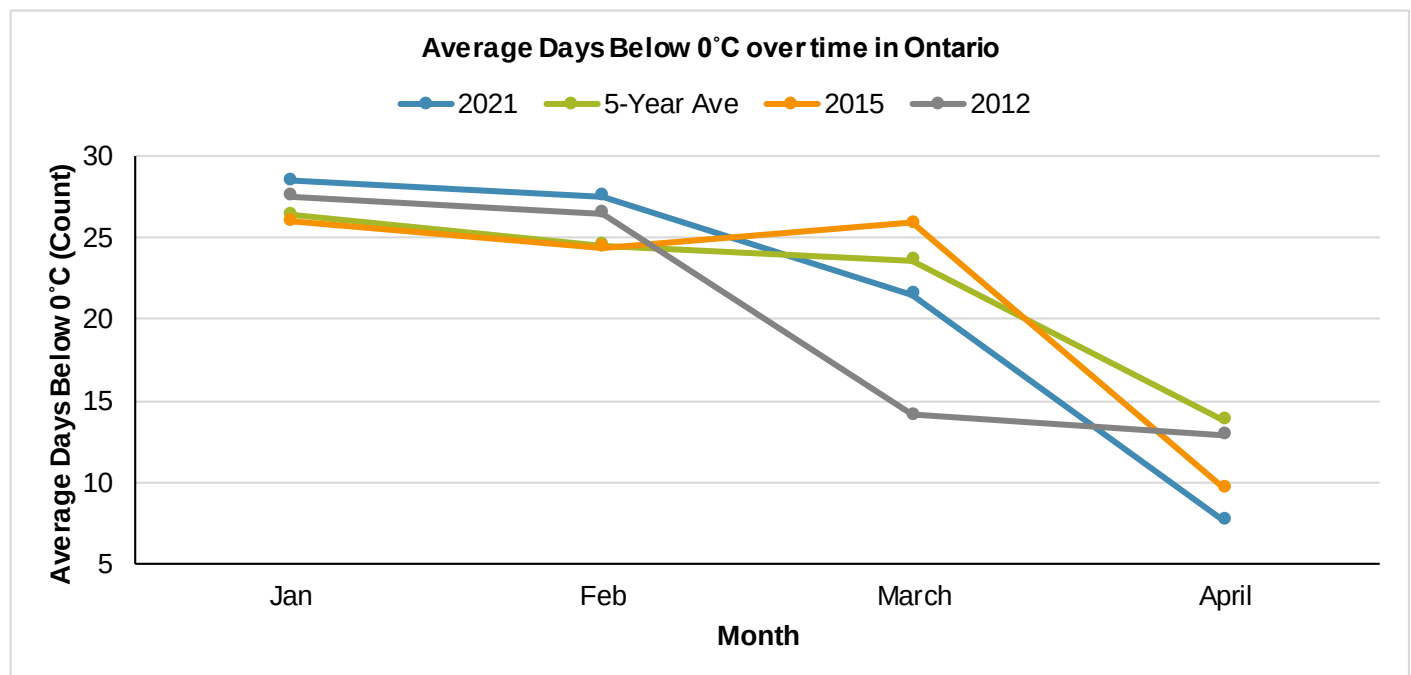


Figure 1. Average days below 0°C in Ontario during the winter and early spring months

Minimum Temperatures

Figure 2 illustrates minimum temperatures in 2021, the 5-year average, 2015 and 2012 within Ontario. 2015 consisted of constantly low temperatures throughout January, February and March, which could err to the decrease in crop production (25% loss). A comparable January, March and April, with the exemption of having warmer temperatures in February, 2012 showed regular minimum temperatures. 2021 is shows consistent minimum temperatures in comparison with the 5-year average.

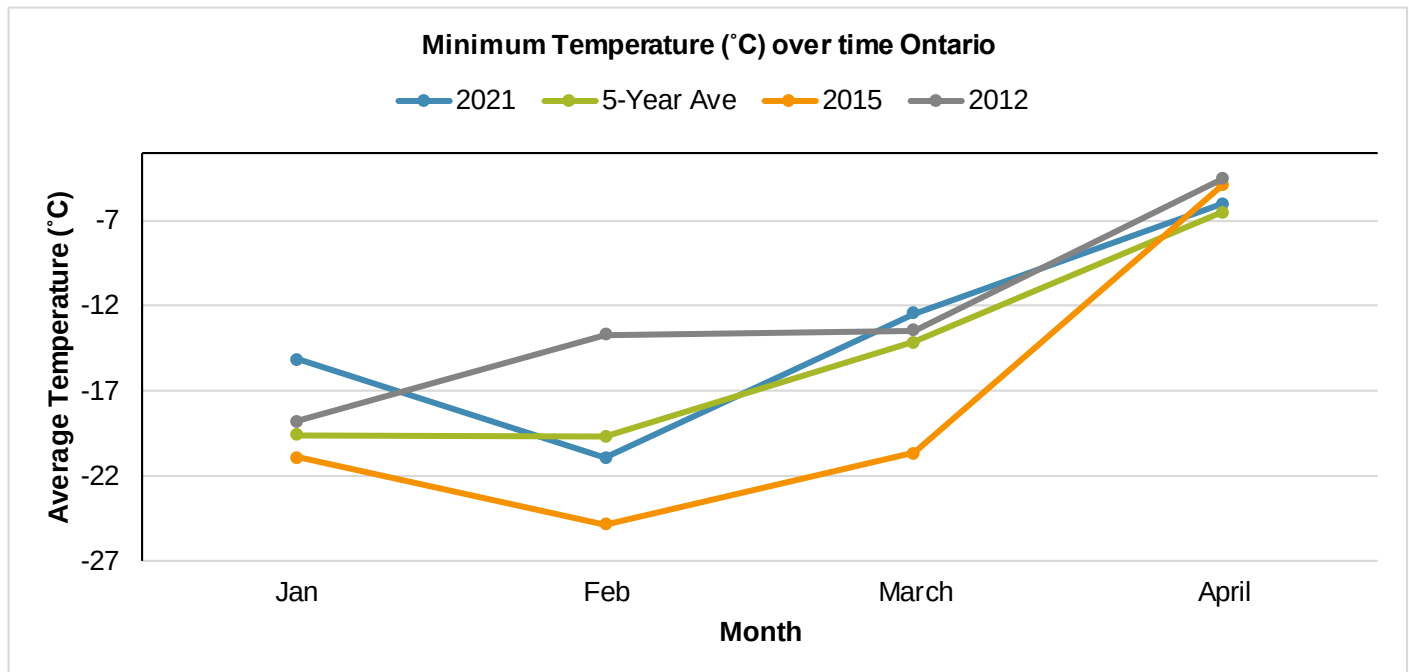


Figure 2. Minimum temperatures (°C) in Ontario during the winter and early spring

Staging, Temperature & Crop Production

As we know, there is never one answer for issues in crop production. Below, Figure 3 combines temperature information in relation to crop production and bud break. Last frost date and bud break follow the vertical Julian Day axis, while the last frost temperature follows the temperature vertical axis. When comparing bud break to last frost date, it seems that a larger gap between the two decreases apple production, which would relate to lower resiliency as apple buds progress in staging (Table 1). 2012 had an early bud break date (Julian Day 79) with a late last frost date (Julian Day 119) and low last frost temperature (-3.5), all of which played a significant role in the major drop in crop production. 2015 had a large gap between bud break (day 109) and last frost date (Julian Day 136) as well, with a last frost temperature of -0.76°C. Crop production in 2015 was decreased to 63%. In 2021, we are on trend with 2017 in relation to bud break timing and last frost date (thus far) where there was a decrease in crop production, representing only 74% of the average crop produced.

Fair Weather?

Looking back at previous years, temperature has become more erratic – which has been commonly associated with climate change. Frost dates continue to occur until mid-May, yet spring warming has started to move earlier within the season, allowing trees to come out of dormancy and advance their growth staging. By keeping track of bud break dates, analyzing historical frost dates and temperatures, along with marketable yields, and contrasting them to the current year, growers will have a better idea of what is to come. Every orchard is different and the more precise your data is, the better you can address issues on your site.

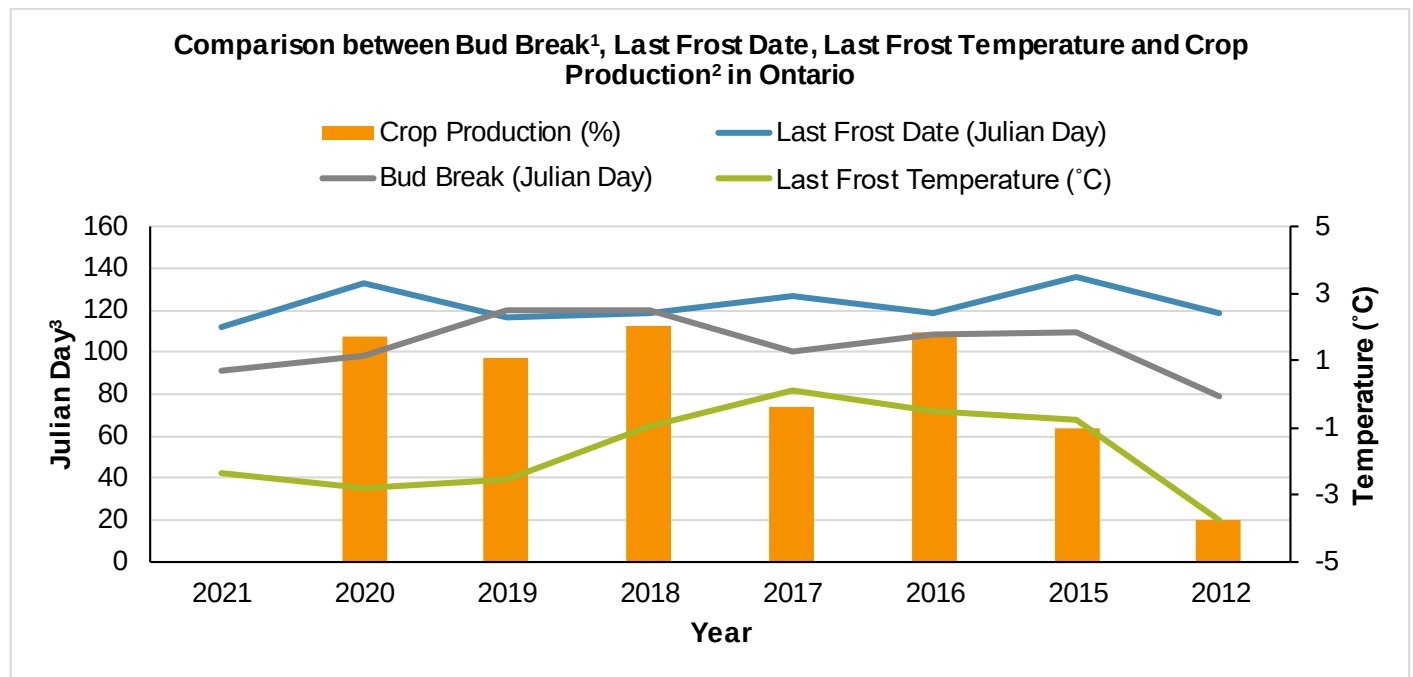


Figure 3. Bud break (Julian Day), last frost date (Julian Day), last frost temperature and crop production (%) in Ontario over multiple years

¹Bud break data was taken from Norfolk Fruit Growers Association where 50% of MacIntosh apples were between silver and green tip staging

²Crop production percentage was based on a 5-year average taken from Ontario Apple Growers 2019/2020 Annual Report

³Julian day is calculated as a numerical value based on the amount of days in a given year (i.e. April 1 2021 is 91 Julian Days, while April 1 2020 is 92 Julian Days due to a leap year)

The March of Spring – 2021 Update

Dr. John A. Cline, Pomologist and Tree Fruit Physiologist, University of Guelph

The objective of this article is to provide an update on the progression of the growing season, and how the recent warm weather may impact bloom and other early season activities in the orchard. Plants develop and grow in response to their environment. Air temperature is the single most important environmental factor contributing to plant development. Because of this, and because data on air temperatures is readily available, apple tree bud development can be estimated using heat units -- expressed as growing degree days (GDD). The GDD concept assumes that each plant species has a specific base or threshold temperature below which growth does not occur. For fruit trees, 5°C is widely used as the base temperature. The amount of heat accumulated during a particular day can be obtained by simply subtracting the plant's base temperature from the mean temperature this is referred to as growing degree-day accumulation.

GDD calculations have been made over several years at the Simcoe Research Station. As of April 14, 2021, the GDD accumulation has been estimated to predict how advanced the growing season is compared to other years. This will help inform growers how this spring compares with other years, and to plan according.

Table 1. Dates of full bloom for apples, Simcoe Research Station, Simcoe¹

Date
May 14, 2021 (Predicted)
May 25, 2020
May 25, 2019
May 20, 2018
May 15, 2017
May 17, 2016
May 13, 2015
May 21, 2014
May 16, 2013
April 26, 2012

¹Not cultivar specific

Results

As of April 14, 2021, 131 GDD have accumulated at the Simcoe Research Station, Simcoe (Figure 1). This is approximately 52% of the total GDD required for apples to reach full bloom. With the unusually warm weather this spring, the 2021 season is currently well advanced of the past five years. This is concerning news because the irreversible advancement of flower development predisposes trees to a greater risk of frost injury. Fortunately, the 2021 season is not as far advanced as 2012 – the year when we had major frost and crop losses throughout most of the province. There appears to be some good news, however; the predicted short-term trend is for cooler weather to prevail for the latter part of April. This will slow bud develop and push bloom later.

Using forecasted temperature and a growing degree day model that I've developed, as of April 14 (the deadline for this article) full bloom for apples should occur very close to May 14th in Simcoe. It is worth noting that this prediction is only as good as the daily temperature data it relies on – and it is generally difficult to accurately estimate data five weeks in advance.

In summary, based on the observation using cumulative GDD, the 2020 spring growing season is shaping up to be about one week ahead of 'normal' by the predicted date of full bloom, well ahead of the past 3 years, but similar to 2017 (Figure 1).

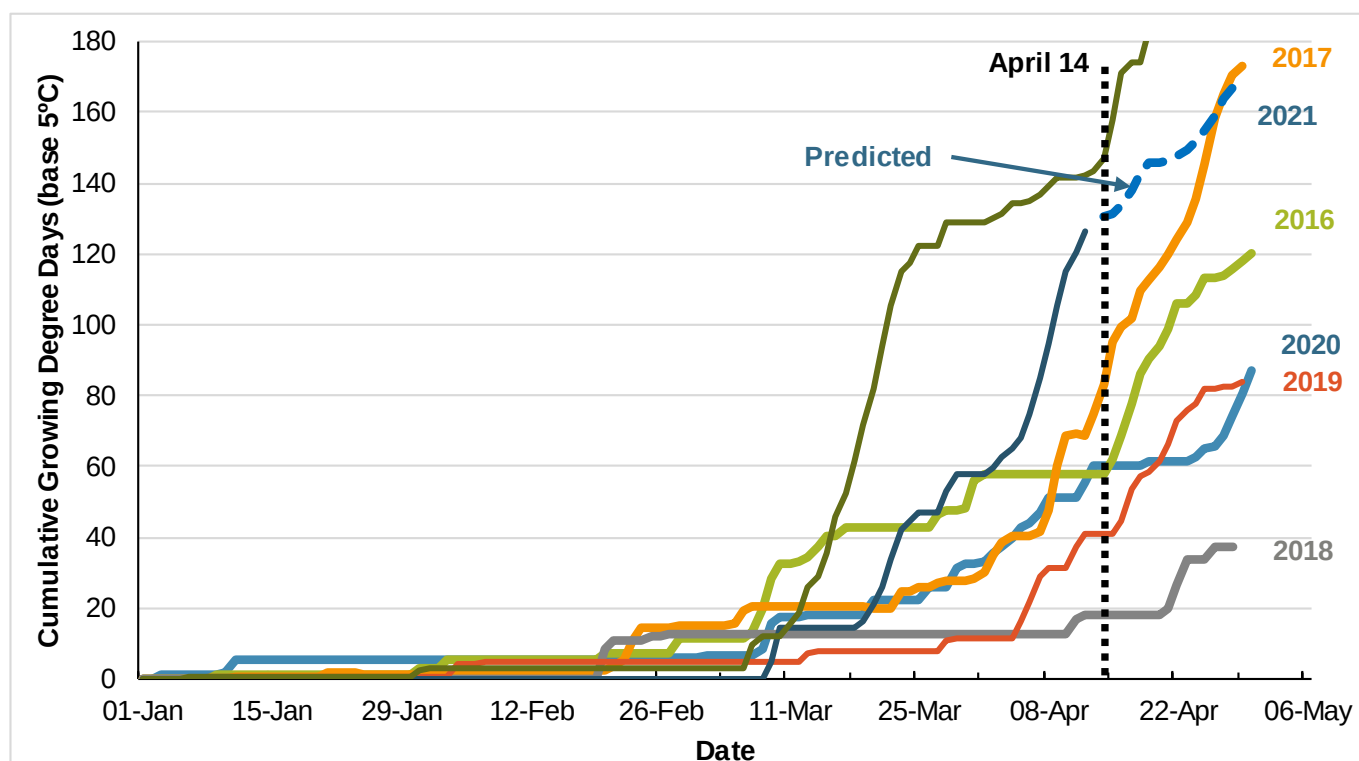


Figure 1. Heat accumulation from Jan 1 – April 30 at the Simcoe Research Station, as expressed as cumulative growing degree days (base 5°C) for the 2012, 2016 - 2021 growing seasons. The data from April 14 – 30, 2021 (dashed line) has been estimated based predicted daily minimum and maximum temperatures.

Select weather resources you may wish to investigate:

Growing Degree Resource:

- A useful interface for calculating growing degree days for various locations in Ontario (<https://farmwest.com/climate/calculators/growing-degree-days/>)
- Farmzone.ca

Online Weather Data and Forecasting

- Weather and forecasting (<https://farmwest.com/climate>)
- Environment Canada -current weather, past weather (https://climate.weather.gc.ca/historical_data/search_historic_data_e.html)
- Accuweather (current weather and forecast 30-60 days (<https://www.accuweather.com/en/ca/canada-weather>)
- Weather Underground – useful interface (<https://www.wunderground.com>)
- Meteoblue – detailed weather forecasting (https://www.meteoblue.com/en/weather/week/toronto_canada_6167865)

Preliminary Results of Blossom Thinning with Lime Sulphur and ATS

Dr. John A. Cline, University of Guelph

Amanda Green (formerly OMAFRA Tree Fruit Specialist)

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 judicious 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 following 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.

I have conducted blossom thinning experiments over the past decade and decided to revisit these efforts with a study in spring of 2021.

Experimental Details

In 2020, 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 ha⁻¹) 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 (Maxcel, Valent Bioscience, Guelph, ON) combined with 750 mg/L Carbaryl (Sevin XLR; Tessenderlo Kerley Inc., Phoenix, Arizona) applied at 12 mm king fruitlet diameter
4. 2% ammonium thiosulphate (ATS; 12-0-0-26S Norwich Fertilizer, Norwich, ON) at bloom
5. 2% ATS at bloom 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; Oligo-S, Axter Agrosience, Mont-St-Hilaire, QC) combined with 2% (v/v) mineral oil (Purespray Green Spray Oil 13E, Intelligro, Mississauga, ON) at bloom
7. 2% (v/v) ammonium thiosulphate combined with mineral oil followed 75 mg/L 6-BA combined with 750 mg/L Carbaryl applied at 12 mm king fruitlet diameter.

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⁻¹, 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 will be applied at approximately 30% full bloom when most of the king flowers were open but prior to lateral flowers opening. A propriety computer model, known as the pollen tube growth model, was used to time when to

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. Only the hand-thinned control trees were thinned on 8 July 2020 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 data were averaged and used to calculate percent fruit set (number of fruit set divided by number of flowers).

Leaf fruit phytotoxicity was assessed 14 June 2020 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 (0=none, 1= very slight, 2= slight, 3= moderate, 4= high, 5= very high).

Fruit were harvested on 14-Sept 2020. 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 2020.

Results

Fruit Set

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.

Yield

In 2020, based on the relatively low crop load of 4.2 fruit TCSA-1 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 yield, marketable yield, total number of fruit per tree and crop load were highest from the untreated control trees, followed by the ATS blossom thinning treatment (Figure 2).

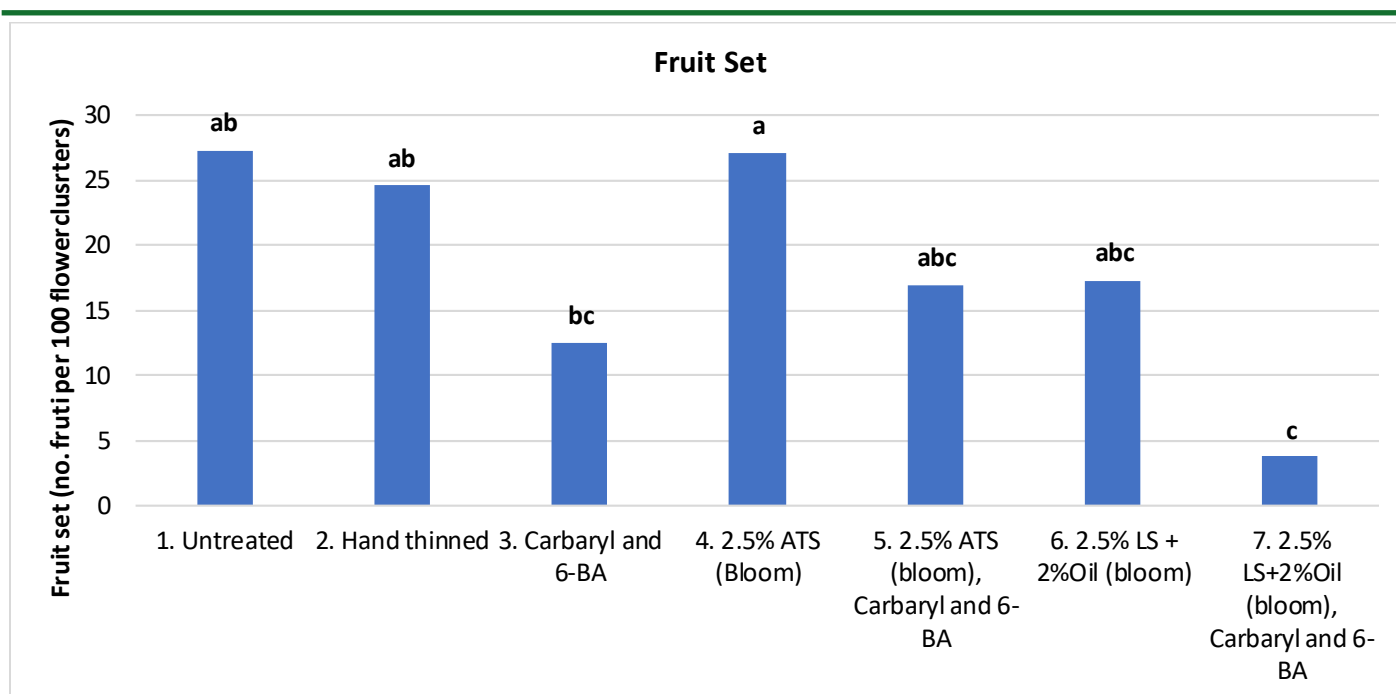


Figure 1. Fruit set of various blossom thinners

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, marketable yield, total number of fruit per tree (Figure 2), 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; $P=0.0697$) lower than any of the other treatments, even though they were thinned that greatest.

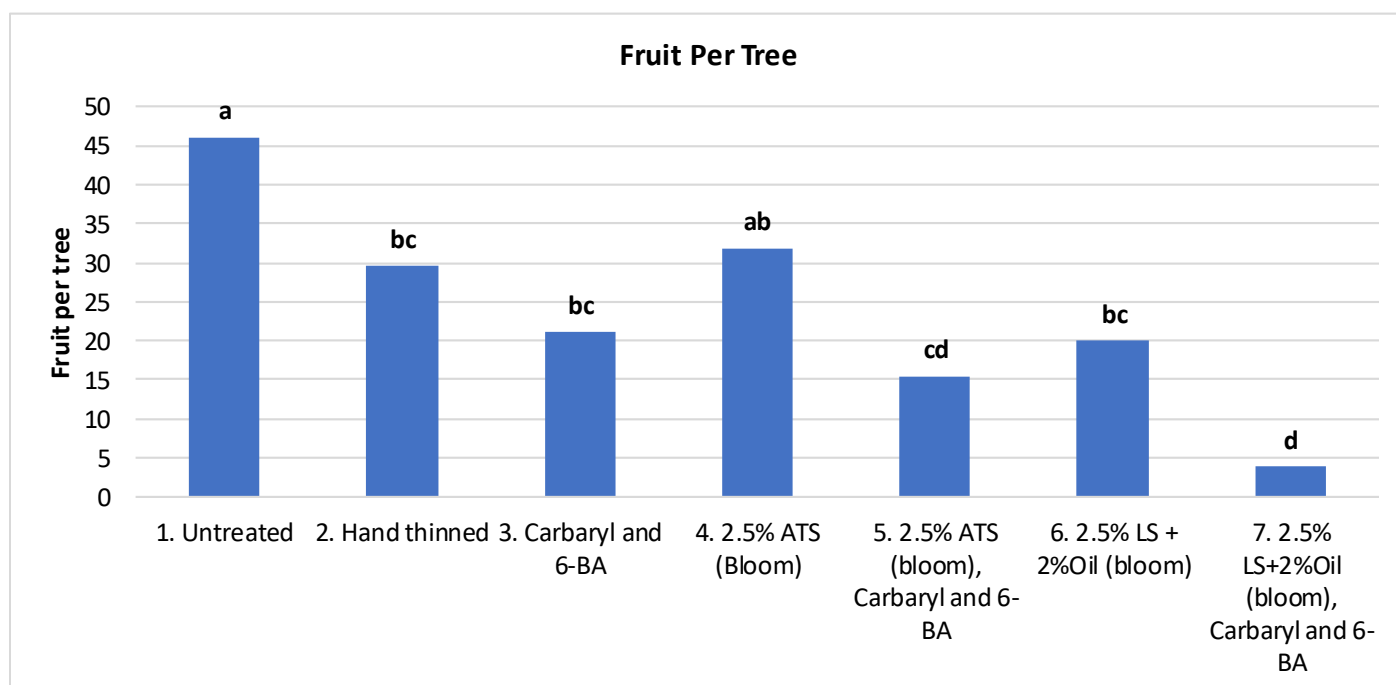


Figure 2. Fruit per tree of various blossom thinners

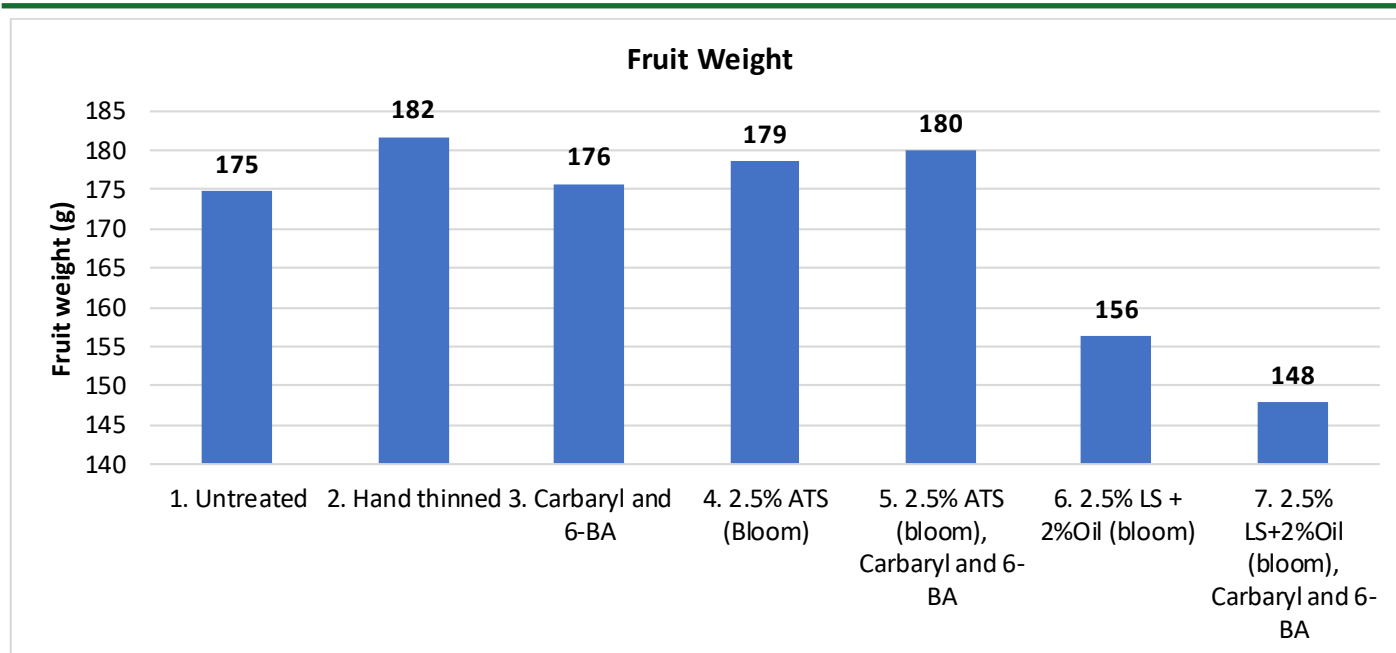


Figure 3. Fruit weight of various blossom thinners

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 severe 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 level overall was low and likely not of any significant commercial importance.

Conclusions

- Lime sulphur plus oil effectively reduced fruit set and number of fruit per tree.
- 2% ATS did not reduce fruit set when applied alone compared with the untreated and hand-thinned control treatments. Perhaps higher rates are required to obtain adequate reductions if fruit set on Gala, but since the data are preliminary, this remains inconclusive.
- When the blossom thinner ATS and LS were combined with the fruitlet thinners (carbaryl and 6-BA) applied at 12 mm, fruit set and number of fruit per tree were reduced further
- Leaf phytotoxicity was slight on trees treated with ATS and lime sulphur plus oil. There was no difference in the amount of leaf necrosis on trees treated with 2% ATS and those treated with 2.5% lime sulphur plus 2% oil.
- In 2020, based on the relatively low crop load of 4.2 fruit TCSA-1 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.
- The preliminary results indicate when early spring frost damage occurs, caution should be exercised when using blossom thinners as over-thinning can occur. Fruitlet thinners can be used during the 6-15 mm window if thinning is deemed necessary.
- One observation of potential concern is the reduced fruit weight in trees treated with LS. While the difference was not significant when compared with the other treatments ($P=0.32$), we would expect fruit weight to increase with decreasing crop load.
- These data are preliminary, and therefore must be interpreted with 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.

Future Research

This blossom thinning research will continue for another two years (with Erika DeBrouwer), and we will have more to report in the future on the benefits of blossom thinning with ATS and LS and using the pollen tube growth model.

Acknowledgements

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Vineland Research and Innovation Centre's Apple Breeding Program Update 2021

Rachael LeBlanc, Research Scientist, Vineland Research and Innovation Centre (Vineland)

Producing apples with a high consumer appeal continues to be the focus of the breeding program. Over 33,000 unique seedling trees have been created since 2011 in the Vineland Test 1 (T1) block. Parents were selected based on their consumer appeal such as texture and flavour along with storage attributes and disease tolerance/resistance.

All T1 selections have rootstock and have undergone three seasons of fruiting before being considered for removal. An extremely large assortment of fruit in every possible characteristic (size, colour, shape, texture, flavour, harvest date, etc.) has been observed. In order to increase breeding efficiencies and minimize land use, seedlings have been culled prior to going into the field by using molecular markers in Vineland's genomics laboratory for disease resistance and fruit quality traits including firmness, acid content and storage stability.



Rachael LeBlanc (Photo: Jordan Snobelen, Metroland)

In an exciting development, Vineland's Biochemistry and Consumer Insights teams have collaborated and identified a number of aroma volatiles that consumers find appealing in apples. Commencing in 2020, molecular markers were developed at Vineland for key aroma chemicals contributing to apple flavour. These markers are being implemented into the breeding program to enrich our population with apples containing aroma attributes that consumers find desirable before they are even planted into the T1 block. Vineland believes these aroma markers will be a distinguishing characteristic of the breeding program that will give us an edge in the marketplace.

Currently, there have been 75 selections advanced from the T1 to the Test 2 (T2) stage at Vineland. The T2 stage consists of eight trees per genotype grafted onto M9 rootstock. Fruit from these selections are being evaluated by Vineland's trained sensory panel and samples have been provided to the apple industry across Canada for impressions.

Information from the sensory panel will be evaluated alongside industry feedback to determine which selections to advance for further testing. Five selections have been sent to the Canadian Food Inspection Agency Centre for Plant Health located on Vancouver Island, British Columbia for virus testing.

A limited amount of T2 material has been further propagated for on-farm testing (Test 3) across Ontario, which will commence this year. Each year we plan to propagate trees and we will slowly increase the number of test sites in Ontario and across Canada.

This research is supported by Ontario Apple Growers through the Agriculture and Agri-Food Canada AgriScience Program and through the Ontario Ministry of Agriculture, Food and Rural Affairs-University of Guelph Partnership Program.

Crop Protection

Put Out the Fire – Part 2: Managing Blossom and Shoot Blight

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

In the February issue of Orchard Network Newsletter, Put Out the Fire – Part 1 looked at rootstock fire blight, overwintering management and preparing for dormant copper applications in early spring.

Ideal timing for dormant copper is between silver tip and ½” inch green but residues need to last until at least pink when cankers are most active. David Rosenberger, Cornell University (retired) suggests fixed copper products such as copper oxychloride (Copper Spray), basic copper sulphate (Copper 53 W) and copper hydroxide (Parasol) are less soluble or prone to wash-off so would provide the longest residual activity. At this point, most regions in the province are beyond this stage and phytotoxicity can occur if these products are applied. However, the use of a softer copper registered for season-long control such as Cueva could be extended into those early spray timings of tight cluster or pink in blocks where fire blight cankers have been a problem or there are concerns of wash-off.

When it comes to in-season fire blight management, there are two critical factors for success: 1) prevent blossom blight, and 2) prevent shoot blight. Control of blossom blight does not mean you are out of the woods for shoot blight. In this article, we will take a deeper dive into summer management including risk prediction, control products and pruning.

What’s the Risk?

Fire blight bacteria overwinter at the edges of cankers. In the spring, as temperatures increase above 18°C, cankers become active and droplets containing high numbers of bacteria ooze out of infected bark tissue (Figure 1). The ooze can be rain-splashed or carried by insects to open blossoms and developing shoot tips within the orchard. The bacteria can also move into the orchard from nearby infected ornamental and wild hosts or neighbouring orchards, making fire blight a significant regional issue.

In order for infection to occur, three key events must happen simultaneously:

1. The bacteria is present.
2. A wound or natural opening is created on a susceptible host.
3. Weather conditions are favourable to disease development.

Open blossoms are the most susceptible tissue since they provide a natural opening for the bacteria to enter. Once the bacteria are introduced to an open blossom by wind, rain and insects, they multiply very rapidly on stigmas. Free moisture (e.g. rain, heavy dew, sprayer, overhead irrigation) washes the bacteria into the nectaries.

Fire blight bacteria are capable of existing in the orchard without causing disease symptoms. Once favourable conditions occur, bacteria multiply rapidly and enter susceptible tissue. The bacteria grow over a range of temperatures



Figure 2. Overwintering fire blight canker with amber-coloured ooze on trunk of apple tree in April 2021.

from 4 – 32°C, with rapid multiplication leading to infection occurring most frequently when temperatures are between 24 – 28°C. Infection risk is highest during extended periods of hot, wet weather as this favours the multiplication of the pathogen and encourages the succulent growth of susceptible plant tissue. That said, cooler temperatures when preceded by warmer temperatures can still be conducive to infection. If the cells are in the flowers from that warmer period, they can grow even if temperatures then cool down so risk remains high.

Interesting new research from the Sundin lab at Michigan State University found most new growth happens overnight between 10:00 pm and 2:00 am. This is likely because the drop in temperature at night results in the formation of dew, which encourages the growth of the fire blight bacteria.

Once infection occurs, the disease moves quickly into succulent new growth (Figure 2). In young vigorous plantings, movement of the pathogen from infected blossom to the root can occur in one month under favourable weather conditions (20 – 28°C). With most infections, ooze is often one of the earliest and more obvious signs of infection (Figure 3 & 4). This can be seen within 3 days of infection, often in the early morning, during humid conditions or following a rain.



Figure 3. Blossom blight on apple infected with fire blight



Figure 4. Ooze on developing apple fruitlet

Shoot blight (Figure 5) can develop throughout the growing season either by spread from infected blossoms or oozing cankers. Growers can sometimes be caught off guard by shoot blight after having good blossom blight control. This is

often an indication there are overwintering cankers that were missed during dormant pruning.

The fire blight bacteria enter the developing shoots through wounds made by foliar feeding insects, strong wind, hail or spread from contaminated equipment. It has also been determined that during period of rapid growth, there can be microscopic tears in the susceptible tissue that can act as entry points. As the season progresses, infection slows and overwintering cankers develop in the bark.



Figure 5. Amber ooze on succulent apple shoot infected with fire blight



Figure 6. Shoot blight on apple

Predicting Infection

Infection can occur any time temperatures exceed 18°C with high humidity, heavy dew or rainfall. According to George Sundin from Michigan State University, favourable conditions for growth can result in fire blight populations multiplying to one million cells per flower within 1-2 days. Imagine how quickly flies or bees could spread infection around an orchard with bacterial populations like that!

Prediction models such as [Maryblyt](#) and [Cougar Blight](#) are extremely valuable decision-making tools to determine conditions in the orchard that could lead to fire blight infection. This allows for precise application timing and strategy selection (i.e., what product to use and when).

The [Ontario fire blight prediction maps](#) (based on the Cougar Blight model) for apple and pear are now available for the 2021 season. Bookmark these maps and predicted forecast for your area to prepare for potential infection periods. The risk is based on the 7-day weather forecasts from over 70 locations throughout the province and updated three times per week (Monday, Wednesday and Friday) until bloom period is over.

As with any model, the fire blight risk maps are a general guide. Environmental conditions may be more conducive for fire blight infection in a particular orchard than what is indicated by the maps. **All apple and pear growers are encouraged to run either the Cougar Blight or Maryblyt model with data generated from their orchards for a more accurate prediction.**

Control During Bloom

As mentioned earlier, the first factor to a successful fire blight management program is control of blossom blight. Depending on the level of infection risk and percent bloom, control options include antibiotics, copper, biologicals and systemic acquired resistance (SAR) inducers.

Antibiotics

The antibiotics, Streptomycin and Kasumin provide the most effective control for blossom blight during periods of high infection risk. Frequent protective sprays may be needed during extended risk as new blossoms are opening daily and will not be protected by sprays made while these blooms were closed. As well, antibiotics degrade rapidly in sunlight so are only active for **2-3 days MAXIMUM**. Apply these products as close to a wetting event as possible. For resistance management with antibiotics, rotate between Streptomycin and Kasumin.

During the [OFVC Educational Series fire blight webinar](#) on February 3, 2021, Dr. Sundin recommended timing antibiotic applications for the evening before high risk to account for the rapid bacterial growth that seems to occur overnight. He also suggested limiting use of antibiotics during early bloom when risk is not as high. Instead, try targeting for the last spray coming out of bloom to be Streptomycin.

Biologicals

The use of antibiotic-alternatives in early bloom has become more widely discussed for fire blight management in recent years. The early timing for products like biopesticides is important for several reasons:

- Most of these products work by competitive exclusion, inhibiting growth or triggering a defense mechanism in the plant. Time is needed for colonization and establishment.
- Many of these products provide only limited control under high pressure or during certain environmental conditions. These are a good substitute during low to moderate infection risk.
- Using these suppression products when there are few blooms and risk is lower, allows you to save your uses of antibiotics like Streptomycin and Kasumin for peak bloom and high infection risk events.

Research trials by Quan Zeng (Connecticut Agricultural Experiment Station [CAES]), Dan Cooley (UMass) and Neil Schultes (CAES) looked at non-antibiotic control methods such as Double Nickel, Blossom Protect, Bloomtime, Cueva and Oxidate over 4 years on Red Delicious. Blossom Protect consistently out-performed the other products as a stand alone program and was not significantly different from Streptomycin control in some years. This efficacy was only improved with the addition of the surface sterilant, Oxidate. The recipe for the most effective non-antibiotic method they found were:

- Early to full bloom – 2 applications of Blossom Protect
- Full bloom – 1 application of Oxidate
- 24 hours after bloom – 1 application of Oxidate, if pressure is high or if there is a history of fire blight in the orchard

Trials out of Oregon State University (Ken Johnson) for organic apple production recommend the use of Blossom Protect early to full bloom similar to above, followed by Serenade OPTI from full bloom through petal fall every 2-4 days. Keep in mind, we have a much wetter climate in the northeast so may see differences in consistency or efficacy.

Copper and some fungicides are not compatible with certain biologicals. Check the label before use.

Systemic Acquired Resistance Inducers

Products that do not directly affect the pathogen but rather elicit a response from the host plant are known as systemic acquired resistance (SAR) inducers. These inducers activate plant defense mechanisms such as the production of thicker cell walls or anti-fungal proteins.

Lifeguard WG was recently registered in Canada for suppression of fire blight. Initial plant defense response occurs soon after application, but 3-5 days are required to attain maximum level of protection. This product is toxic to bees so applications should be made at pink and again beginning at petal fall.

Secondary Bloom

Secondary blossoms, referred to as “rattail” bloom (Figure 6) often open when environmental conditions for infection are high or extreme. Since they open much later than the majority of blossoms, they are often unprotected and therefore extremely vulnerable to fire blight infection. If possible, remove secondary blossoms immediately since they rarely produce marketable fruit and are more of a liability. Otherwise, continue with a bloom control program when a forecasting model predicts that there is a fire blight infection risk. Be mindful of preharvest intervals when using these products.

Managing Shoot Blight

Shoot blight management strategies include:

- Plant **less susceptible varieties** where possible
 - For more information, see Table 3-8. *Disease Susceptibility Ratings of Common Apple Cultivars* in the 2021 Publication 360A, Crop Protection Guide for Apples.
- Plant blocks such that more resistant varieties surround susceptible ones
- **Control blossom blight**
- **Prune out cankers and infected tissue** (see ‘Summer Pruning’ below)
 - Limit any hand labour activities such as thinning, pruning or removing suckers to dry conditions to avoid the potential spread of bacteria.
- **Apply prohexadione calcium** (Apogee, Kudos) to manage vigour, except on Empire, Stayman or Winesap (see ‘Prohexadione Calcium’ below)
- **Avoid excessive succulent growth caused by excess nitrogen**
 - Apply nitrogen fertilizer only where warranted by annual leaf analysis.
 - Consider a split application of nutrients, half in the spring before growth starts and half again after petal fall. If severe blossom blight occurs, withhold the later application.
 - Similarly, avoid late cultivation that can make nitrogen available to the tree resulting in late succulent growth.
- **Maintain good insect control**, especially plant-sucking insects such as leafhoppers, aphids and plant bugs.



Figure 7. Secondary, or rattail bloom in apple can pose a significant fire blight risk if left unmanaged.

Prohexadione Calcium

Prohexadione calcium, or Pro-Ca (Apogee, Kudos) use for fire blight management is becoming more common in the province. Most growers try to aim for king bloom petal fall for management of fire blight shoot infection with subsequent applications at 2 week intervals. However, some growers are applying Pro-Ca earlier between pink to bloom if there is terminal growth.

This product works by:

1. Reducing vegetative growth of susceptible shoots and limiting spread of fire blight infection
2. Thickening the cell wall to provide a physical barrier from bacterial infection
3. Stimulating plant defense system and production of antimicrobial compounds to reduce infections.

[OFVC fire blight webinar](#), George Sundin described Pro-Ca as the best tool for fire blight as it provides physical barrier and no chance for resistance development.

Following the Apogee or Kudos label, Pro-Ca can be applied between 2.5-5.5 cm of new shoot growth. That early range can easily occur prebloom depending on the spring.

Since the use of Pro-Ca has been known to reduce shoot blight largely due to the thickening of the cell walls within the shoot, recently published research by Anna Wallis and Kerik Cox from Cornell University proposed Pro-Ca could do the same to reduce blossom blight by thickening the cell walls of blossom pedicels. With their trials on mature Gala, they saw over 70% control of blossom and shoot blight with a pink application of Pro-Ca and minimal effect on tree growth.

Trauma Blight

Unsettled weather common in Ontario summers can bring hail, strong winds or heavy rains that could trigger trauma blight. These can be very isolated events, occurring in one area but not another nearby. Assess for signs of damage in all blocks following any storm. Winds and rain can spread inoculum while injuries caused by these events provide an entrance for the pathogen and shock or traumatize trees, reducing their natural defense mechanisms. Shoot or fruit blight can develop as a result.

Be sure to apply Streptomycin, Cueva or Cueva + Double Nickel **as soon as possible** after the trauma event, especially if foliage damage is extensive or fire blight is known to be active in the orchard (ie., cankers, etc). New research is now suggesting ideal timing is 4 to 12 hours after a storm. Anything applied later runs the risk that the bacteria will have already established and begun to grow, reducing the efficacy of the product.

Like all coppers, there is the risk of russetting with Cueva. However, if fire blight is active in your orchard at the time of trauma, better to lose some fruit this season than trees later.

Because Pro-Ca will take 7-10 days to activate, Apogee or Kudos should not be used as a trauma blight treatment. However, if the trees are on an existing program, this can slow the spread of infection in a tree.

Summer Pruning

When trying to decide when the best time to prune out fire blight infection, Figure 7 summarizes some key points to consider based on tree age and vigour.

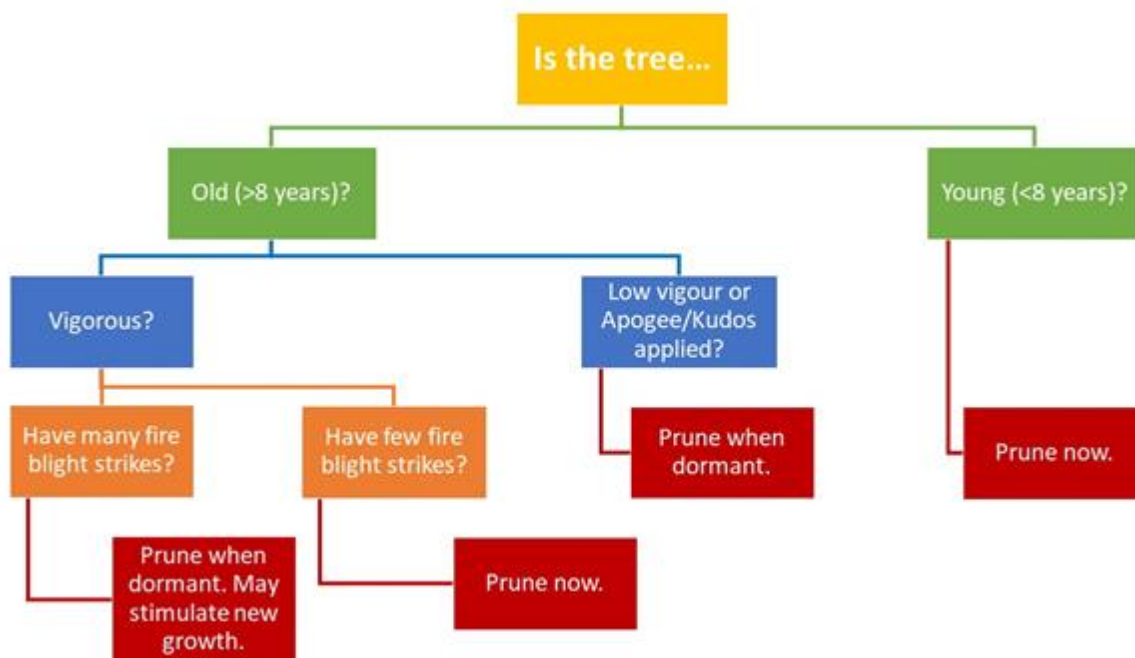


Figure 7. Fire blight pruning decision tree.

Keep in mind that once the terminal buds have set, fire blight stops spreading within infected trees. Summer pruning in vigorous trees can encourage new shoot growth and extend the susceptibility period for shoot blight. However, leaving the disease in the orchard may serve as a source of inoculum, and cause increased infections in the result of hail, severe storm, or high wind damage.

If you decide to prune out fire blight strikes, remember:

- Cut at least 30 cm (12 in) beyond the visible infected tissue, preferably into 2nd or 3rd year wood. However, recent trials by Kari Peter, Penn State University (PSU) and Ken Johnson, Oregon State University (OSU) found significantly more aggressive cuts greater than 75 cm (30 in) yielded best results.
- Only prune out strikes when there are 2-3 consecutive days of low humidity and temperatures below 25°C to allow pruning wound time to heal without conditions conducive to disease spread.
- Pruning flush to another healthy limb or spur may result in more cankers based on PSU and OSU trials. Where possible, leaving a pruning stub.
- When pruning in-season, disinfect pruning tools between each cut by soaking them in a solution of 1 part bleach to 5 parts water or in a 65-70% alcohol solution.
- In sections where trees are severely affected or trees are continuously infected year after year, it may be more cost-effective to simply remove the whole tree.

Remove Pruning Cuts

If time and labour allows, remove any small pruning cuts from the orchard as soon as possible and burn. Take extra caution during removal to not touch branches to healthy trees along the row. To prevent potential spread of bacteria, some growers immediately bag cuts, while others place cuts directly in a covered wagon.

For large cuts or if limited on time, prunings can be tossed in the row middles and dried thoroughly before flail mowing. The general research community suggests dry cankers do not present a danger to spreading the disease. However, trials at OSU sprayed cankers on pruning cuts with red paint, flailed and returned 30 days later. Fire blight bacteria and ooze could still be found on the painted wood.

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Is This The Year For Gypsy Moth?

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

If you noticed small black caterpillars munching on flower buds or leaves on your trees last year, you weren't alone. These were gypsy moth larva (Figure 1) which were quite a problem across the province – and may be an even bigger issue this spring.

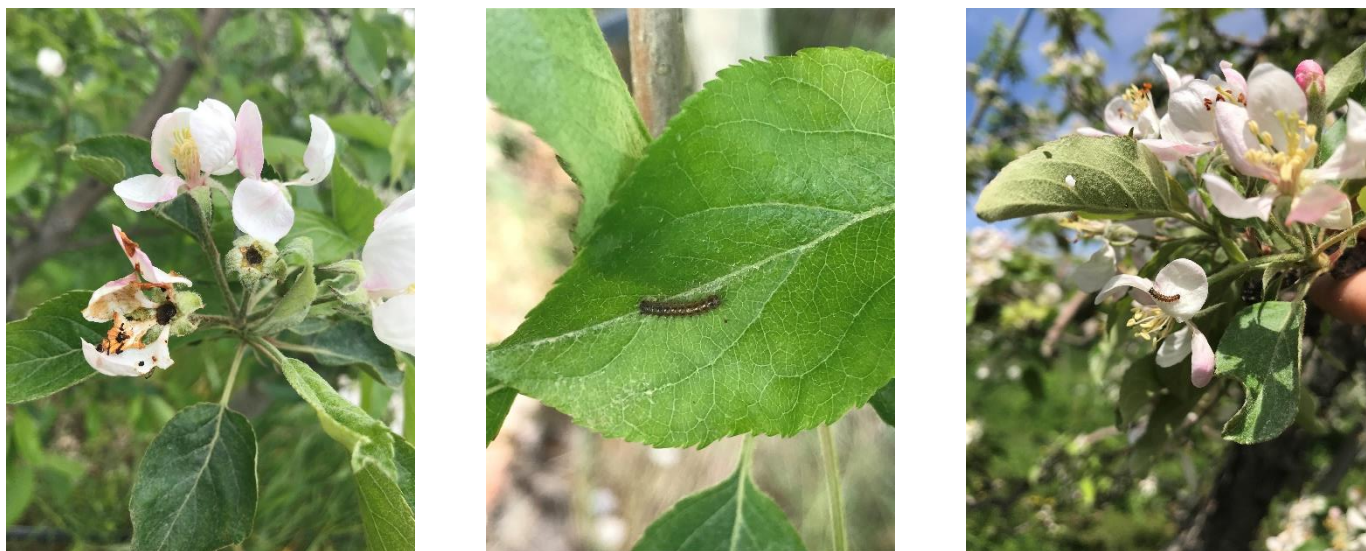


Figure 1. Gypsy moth and it's damage on apple in 2020.

Gypsy Moth Boom

The Ontario Ministry of Natural Resources and Forestry (MNRF) reported that defoliation caused by gypsy moth in Ontario increased from approximately 47,000 ha in 2019 to nearly 600,000 ha in 2020 (Figure 2), beating the original record of 350,000 ha from 1991. Egg mass surveys conducted over this last fall and winter suggest that this year, defoliation is likely to be severe in many regions (Figure 3). Any natural assistance on reducing moth populations by climate, fungus, virus and parasites will not be known until later this spring. More information on these surveys can be found on the [MNRF website](#).

While gypsy moth have a wide host range of over 300 species of trees, they tend to prefer maple, beech, linden, birch, oak, poplar, Prunus and willow. Outbreaks occur about every 7 – 10 years and have a boom/bust life cycle. In other words, populations build to large numbers every few years until their predators and/or pathogens catch up, causing numbers to crash again. What we're seeing right now is definitely a boom for gypsy moth!

Activity in the Orchard

Gypsy moths overwinter as spongy egg masses on tree trunks (Figure 4), fence posts, buildings and other sheltered locations. Typically, eggs hatch mid-May. Though with the early spring this year, activity may start sooner.

Once hatched, larvae disperse to new foliage by wind. Initially, larva feed during the day which is why monitoring for spring-feeding caterpillars is so important. As the larvae mature, feeding switches mainly to night and can often delay detection of a problem if not caught early.

If you see holes in leaves, turn them over and look for tiny, gray or black caterpillars with wispy hairs (Figure 5). These will change in appearance as they grow, developing distinct spots that are unique from other hairy caterpillars. Starting just after the head, there are five pairs of blue spots followed by six pairs of red spots down the back.

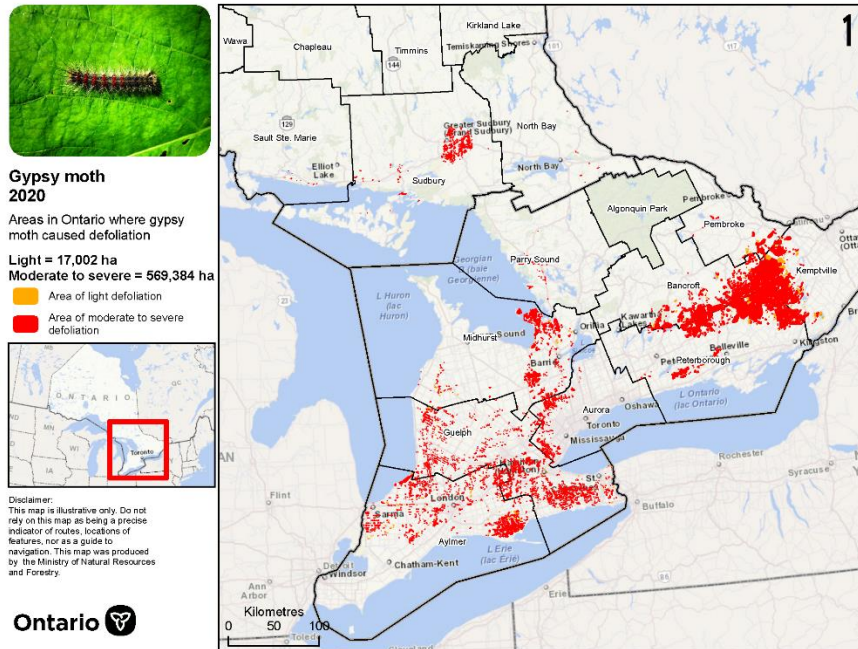


Figure 2. Map of areas defoliated by gypsy moth in 2020 across Ontario
(Source: Ministry of Natural Resources & Forestry)

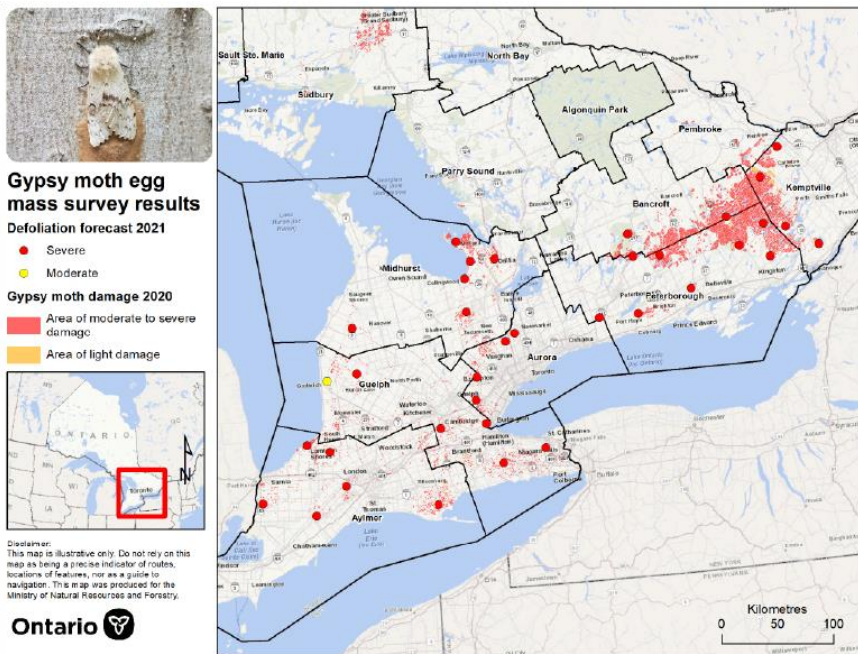


Figure 3. Map of projected 2021 gypsy moth defoliation across Ontario
(Source: Ministry of Natural Resources & Forestry)



Figure 4. Gypsy moth egg mass on Norway maple bark.
Note how faded in colour the egg masses appear after winter
(Source: Jen Llewellyn, OMAFRA)



Figure 5. Gypsy moth larva: (left) Newly hatched larvae are small, dark caterpillars with wispy hairs, and (right) Mature gypsy moth larvae have a double row of blue, then red dots running down the back, which distinguishes this insect from other caterpillars. (Source: Melanie Filotas, OMAFRA)

Larva will feed on leaves for several weeks before pupating. Most damaging activity is only present in orchards until July. Adults do not feed and there is only one generation of larvae per year. So, after they pupate, there will not be any further damage. Unfortunately, that early season larva can feed pretty voraciously until then.

Monitor For Damage

Despite the trees' ability to produce a new crop of leaves over the summer, the damage can cause significant impacts to growth. This is an even greater issue with young plantings. Defoliation also makes the trees more susceptible to other issues like secondary pests, drought and winter injury.

Take note of gypsy moth activity during regular springtime orchard monitoring. Between tight cluster to petal fall, check 5 terminal shoots and 5 fruit buds from 10 trees (50 terminals and 50 fruit buds in total) for signs of caterpillar feeding activity. After petal fall, monitor 10 terminals on 10 trees (100 terminals total) until mid-summer. An insecticide is generally recommended when the action threshold of 12-15 larvae per 100 terminals and fruit buds is observed. This threshold can serve as a general guide to help determine whether control is warranted, but growers should use their experience and judgement of what their crop can tolerate. Higher density or young orchard blocks may require control at lower moth populations due to the limited leaf area on these trees.

Management Options

If there are a small number of larva or limited area affected, there are a number of cultural controls that can be done (Figure 6):

- Gypsy moth can be handpicked from the tree and crushed.
- Wrapping the base of the tree with burlap when larvae are active (late May) creates a sheltered area for larvae to hide during the day and is also a management option for smaller blocks.
 - However, be sure to check these burlap wraps and underlying bark crevices daily (1-3 pm is best) and destroy any larvae found.
- Sticky bands can also be placed around trunks during the June/July flight period to help trap flightless females and keep them from laying eggs on the bark.



Figure 6. Gypsy moth life stage and control options
(Source: Ministry of Natural Resources & Forestry)

Obviously, these cultural strategies may not be practical in larger orchards. Products applied for leafrollers in apples such as *Bacillus thuringiensis* (Bt), e.g., Dipel, Bioprotec, Foray and Xentari should also provide control of gypsy moth. Other products listed under spring-feeding caterpillars in Publication 360A, Crop Protection Guide for Apples may be registered for this pest, including some pyrethroids (Group 3) and Cormoran (Group 4A+15). Always refer to the label for registered pests. For best efficacy, apply within the first few weeks after larval emergence and close to the time larvae are actively feeding to ensure exposure. Good coverage of leaf surfaces is also important.

Aside from the options mentioned above, many predators (eg., birds, ground beetles, stink bugs, assassin bugs, spiders) and parasitic insects can attack spring-feeding caterpillars. Encourage natural enemies by applying insecticides only if an action threshold is reached and select materials that have lower toxicity to non-target organisms. See Table 3- 6. *Toxicity*

of Pesticides to Honeybees and Mite/Aphid Predators in Publication 360A, Crop Protection Guide for Apples for more information. A number of fungal and viral diseases also impact gypsy moth, particularly during warm, wet springs.

A great resource on gypsy moth in Ontario landscape including high quality photos for identification is [this video](#) from OMAFRA's Nursery & Landscape Specialist, Jennifer Llewellyn.

Considerations for the Future of Apple Scab Management

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Recent Re-Evaluation Decisions

The Pest Management Regulatory Agency (PMRA) has released a number of re-evaluation decisions recently that impact apple growers. Table 1 is a summary of these changes including important dates of last use.

All information on past and present re-evaluations can be found in the [Pesticide Product Information Database](#) on the PMRA website. The PMRA's [Re-evaluation and Special Review Work Plan 2020-2025](#) is also available on the PMRA website and lists anticipated dates for public consultation or final decision for pest control products. However, with the on-going pandemic, there may be some delays in the release of certain documents.

Table 1. Date of last sale and use for registered apple fungicides being phased-out based on recent final re-evaluation decisions

Active Ingredient	Trade Name	Last Date of Use
captan	Maestro 80 DF Supra Captan 80 WDG	May 10, 2021
metiram	Polyram DF	June 21, 2021
thiram	Granuflo T	December 14, 2021
ferbam	Ferbam 76 WDG	December 14, 2021

Captan

A requirement of the final decision for captan was for the change of all formulations to a water soluble packet which is why Maestro 80 DF and Supra Captan 80 WDG are listed for phase-out in Table 1. The new WSP formulations have different PCP numbers. Any growers with existing stock of the old formulations can still use the product **as per the label on the container** until May 10, 2021. This includes a 48-hour re-entry interval, 7-day preharvest interval and no restrictions to the number of applications per year.

However, if using the new formulations, Maestro 80 WSP or Supra Captan 80 WSP, you are **legally** required to follow the new use patterns based on the final re-evaluation decision and stated on the label. These new patterns are summarized in Table 2.

Table 2. New use pattern requirements for Maestro 80 WSP and Supra Captan 80 WSP.

Label Specification	High Density (tree canopy width <2m/tree)	Low Density (tree canopy width >2m/tree)
Rate (per application)	2.4 kg a.i./ha, or 3 kg/ha	2.4 kg a.i./ha, or 3 kg/ha
Maximum applications per year	10	2 (if hand thinning, max. 1 before and 1 after thinning)
Restricted entry interval	15 days (hand thinning/harvest) 6 days (hand pruning/training) 2 days (all other activities)	24 days (hand thinning) 19 days (hand harvest) 4 days (hand pruning/training) 2 days (all other activities)

Mancozeb

The group of fungicides commonly referred to as EBDCs include the active ingredients, metiram (Polyram DF) and mancozeb (Penncozeb 75 Raincoat, Manzate Pro-Stick, Dithane Rainshield). An earlier review determined the cancellation of metiram due to worker exposure with a last date of use **June 21, 2021**. However, at that time, the PMRA retracted a similar final decision for mancozeb and a new re-evaluation decision was released in November 2020.

While strict risk-reduction measures have been put in place for use on apples, the good news is registration has been maintained for mancozeb. Registrants and retailers will have until **November 19, 2022** to transition to newly amended labels.

The risk-reduction measures include:

- New rate – 4.5 kg a.i. / ha
- Minimum interval between applications – 7 days
- Maximum applications per year – 4 (full rate)
- Restricted entry interval – 12 hours (general re-entry), 35 days (hand thinning)
- Preharvest interval – 77 days

What is still a moving target is how half rates will be accounted for. It is widely understood that half rates are used as a resistance management strategy. However, the wording used on the final mancozeb labels will determine the number of acceptable half rates allowed. If, for instance, the label states - as proposed above - maximum 4 applications per year rather than a seasonal total (e.g., 18 kg a.i./ha), this will be the restriction regardless of whether the application was a full or half rate. The US label accounts for this by including a half rate program as a labelled use pattern.

Recommendations have been provided to the Mancozeb Task Force to consider this approach on the new Canadian labels. Stay tuned.

Folpet

On a lighter note, the final re-evaluation decision released in February 2020 for another registered Group M fungicide, folpet (Folpan 80 WDG) maintained all uses on apples. The new restricted entry interval will be 6 days for hand thinning with a maximum of 6 applications per year and 1-day preharvest interval.

This product has not been widely used over the years due to russetting risk of sensitive cultivars and as it has tended to be more expensive than captan. Reports from old trials consider it's efficacy relatively comparable to captan though there may be some reduced control under moderate to high pressure. Throughout cover sprays, this could be used as a tank-mix or rotational alternative for resistance management of other registered fungicides for summer disease control.

Be sure to read the label carefully as there are phytotoxicity risks early season on Delicious varieties. No information is available on newer cultivars such as Ambrosia.

Why Are Group M Fungicides Important?

The Group M fungicides mentioned in the previous section are important disease management tools for several reasons:

1. Multi-site (low resistance risk), contact fungicides
2. Broad-spectrum pest range
3. Relatively inexpensive
4. Critical component to resistance management for single site fungicides

This brings to question, without the use of Group M fungicides, how and when do we use the tools left to manage apple scab and summer diseases? Let's take a closer look at management options available at times during the season. For the remainder of this article, I will not be considering metiram, thiram and ferbam as options for scab control. As well,

you will also need to incorporate in-season fire blight management plans which are not discussed here.

Dormant

The efficacy of dormant copper sprays to reduce the spread of fire blight inoculum from overwintering cankers has often been debated. Its effectiveness really comes down to how it is applied and post-application weather. Copper provides an unfriendly environment over the bark and bud surfaces of the tree, preventing bacteria from getting established or spreading. Thus, it must be applied as a high-volume spray to ensure sufficient coverage.

Copper sprays applied to green tissue may also provide some protection against apple scab overwintering in buds equivalent to mancozeb applied at this stage.

Dormant copper such as Copper Spray, Copper 53W, Cueva and Parasol can safely be applied up to ¼" green (possibly ½" green) without risk of phytotoxicity. However, the use of a softer copper registered for season-long control such as Cueva could be extended in those early spray timings to ½" green or tight cluster in blocks with low scab inoculum (ie., free of scab last year). Residual activity typically last about 7-10 days under ideal spring conditions. However, once rainfall exceeds 2" from last copper application, it should be assumed all residue has been washed off.

Using 1-2% dormant oil, unless the label states otherwise, will act as a sticker/spreader as well as provide efficacy on scale, European red mite and suppression of powdery mildew. Cueva is formulated with a fatty acid so there is little benefit to adding oil as a sticker. If using dormant oil, do not apply captan or sulphur products within 14 days of application. Oil can enhance penetration of these products into sensitive tissue, resulting in phytotoxicity issues.

Green Tip to Tight Cluster

Unfortunately, the cool temperatures we often experience in early spring do not kill scab spores. Spores will continue to mature in overwintering leaf litter and release so long as there is a wetting period long enough for infection to occur. For more information on leaf wetting hours required for infection at various temperatures, refer to Table 3-9, Relationship of Temperature and Moisture to Apple Scab Infection in the 2021 Publication 360A, Crop Protection Guide for Apples. While mature spores are released more during warm rains than in colder ones, they can still cause infection, nonetheless, if they land on green tissue.

Green tip to tight cluster is a period of extensive new growth. Keep covered with a good protectant fungicide program and re-apply fungicides every 5-7 days during periods conducive to disease development or following heavy (greater than 1") rain.

A protectant program consists of contact fungicides such as captan or mancozeb and does not provide effective post-infection or anti-sporulant activity. That means if sprays are applied in less than ideal conditions, ie., windy, alternate rows, or washed off in rain, the risk of scab infection is increased. The redistribution characteristics of a fungicide are often considered when selecting appropriate control products. See Table 3-7. *Characteristics of Apple Scab Fungicides* in the 2021 Publication 360A, Crop Protection Guide for Apples for more information on redistribution of registered scab fungicides. However, it is important to also consider leaf growth since last application, scab pressure and residue wash off when determining an appropriate chemistry, dose and spray interval.

During cool, wet springs, protectant fungicides may not be enough. Consider tank-mixing with one of the products listed in Table 3 that provide post-infection activity. Syllit and Scala should be used early season only, up to tight cluster and pink, respectively. As you approach tight cluster, consider any issues with powdery mildew and/or rust in previous years. If these have been a problem, use a Group 9-containing product that also has activity on these diseases as well, such as Inspire Super or Luna Tranquility. Buran (garlic extract) which is registered for scab and powdery mildew can also be used as an eradicant, or for early post-infection activity following a rain event when protectant efficacy may be reduced. This product does not have pre-infection activity.

In warmer, dryer springs, you could also consider products such as Fontelis or Aprovia Top at the tight cluster stage,

both of which have efficacy on scab, powdery mildew and rust.

Table 3. Registered fungicides for apple scab for use during cool, wet springs

Product	Properties	Timing	Max app	Tank mix req	Scab efficacy	Other disease
Syllit (U12)	retention, redistribution, anti-sporulant	Green tip – tight cluster	2	Yes	+++ ⁽⁺⁾ ¹	No
Scala (AP)	post-infection, retention	Prebloom	2	Yes	++ ⁽⁺⁾	No
Inspire Super (DMI+AP)	post-infection, retention, redistribution, anti-sporulant	Prebloom	4 ²	Yes	++++	Mildew, rust
Luna Tranquility (SDHI+AP)	post-infection, retention	Prebloom	4 ²	Yes	+++ ⁽⁺⁾	Mildew
Buran (NC)	post-infection, anti-sporulant	Season long	– ³	No	++ ⁽⁺⁾	Mildew

++ = suppression; +++ = good control; ++++ = excellent control

¹ Dodine resistance is stable in ON and some scab populations may not be sensitive to this product.

² As stated on label. For resistance management, limit to 2 applications from fungicide group per year if possible.

³ Information is not specified on the product label.

It is important to note protectant fungicides do not control powdery mildew. Include 3-5 kg/ha sulphur (Microthiol Disperss, Microscopic Sulphur, Kumulus, Cosavet DF Edge) with the protectant sprays until tight cluster when more effective mildew products will be used. Keep in mind mildew does better in dry conditions with high relative humidity. Protectant sprays may be needed during dry periods when there is little risk from scab. During wet springs like 2019, powdery mildew escapes can happen relatively quickly during breaks in rain events if fungicide residues are washed off.

Pink to Petal Fall

By tight cluster or pink, apples are typically entering a time of critical infection period for scab and powdery mildew with higher daily temperatures, large amounts of lush growth and rapid maturation of spores. Management programs at this point should begin incorporating systemic fungicides (Groups 1, 3, 7 and 11). However, keep in mind that unlike protectant fungicides, which have multi-site activity and low resistance potential, systemic fungicides are typically single-site and are at high risk of resistance development. For resistance management:

- Include at least half rate protectant fungicides with all applications.
- Do not use products containing the same chemical group in consecutive applications.
- Do not use Group 3 fungicides including Nova, Fullback and Inspire Super after bloom as they are weak on fruit scab. Trials with Cevya have indicated good efficacy on fruit scab.
- Do not use systemic fungicides for post-infection activity.

While captan and folpet do not provide effective rust control, mancozeb does. Be sure to keep mancozeb as the protectant tank mix particularly at petal fall if rust is a concern in your orchard. It's best to avoid the use of captan and folpet in general during this growth period to avoid phytotoxicity by complicated tank-mixes, use of adjuvants or other incompatibility issues. Instead, save captan or folpet for summer disease control.

While this section does not focus on Buran, the use of this product as a post-infection and/or tank-mix option would still be effective against scab during this timing until the first summer covers.

The remainder of this section and Table 4 look at systemic fungicides registered for control of apple scab in more detail.

Methyl Benzimidazole Carbamate (MBC) Fungicides

The fungicide Senator belongs to the MBC fungicides (Group 1) and is registered for control of apple scab and powdery mildew. This product may also have efficacy on black rot, fly speck and sooty blotch if applied for scab when these pests are active.

Historically, Benlate-resistant forms of apple scab have been present in Ontario. Senator belongs to the same chemical group as Benlate. Use caution if Benlate was used in your orchard in the past. For resistance management, tank-mix with a compatible protectant scab fungicide from a different group. See label for more information on suggested tank-mix partners.

Sterol Inhibitor (SI) fungicides

The SI fungicides (Group 3), now including Nova, Fullback, Cevya, Aprovia Top (Group 3+7) and Inspire Super (Group 3+9) have been a standard for control of apple scab, powdery mildew and rust for many years. Resistance to Nova has been documented in Ontario scab populations and suspected in powdery mildew populations. For this reason, SIs should not be used in orchards with resistant scab populations and should always be tank-mixed with a protectant fungicide, including the recently registered product, Cevya. The benefit to keeping Group 3 fungicides in rotation is the good powdery mildew and rust control they offer (so long as resistance is not present) as well as to help reduce resistance pressure for the other single-site fungicides.

Succinate dehydrogenase inhibitor (SDHI) fungicides

The SDHI fungicides (Group 7) are the newest group of systemic fungicides including Aprovia Top (Group 3+7), Excalia, Fontelis, Kenja, Luna Tranquility (Group 7+9), Merivon (Group 7+11), Pristine (Group 7+11) and Sercadis. These products are registered for control of apple scab, powdery mildew, rust (Fontelis, Aprovia Top only) and summer disease (Merivon, Pristine only). Some formulations within this group contain mineral oil or require a surfactant, which can result in injury under certain conditions if used in combination with captan. Always refer to the label.

At the present time, there is no known resistance to any Group 7 product in Ontario. For this reason, more applications of these products can be used compared to the Group 3 and 11 fungicides. A maximum of 4 applications of Group 7 fungicides is allowed each season, with ideal placement between tight cluster and first covers. However, Merivon and Pristine are also very effective products for the control of fruit rots, fly speck and sooty blotch. Since these pre-mix products include Group 7, it may be worthwhile to save 1-2 applications for summer use.

As with all sound resistance management practice, do not apply consecutive sprays from the same fungicide group. This is where other fungicide groups can come into play with product rotation.

Strobilurin Fungicides

Similar to the SIs, the strobilurin fungicides (Group 11) such as Flint, Sovran, Merivon (Group 7+11) and Pristine (Group 7+11) have been used for many years for control of apple scab, powdery mildew and rust. Scab resistance to Flint has also been documented in Ontario to this group so tank-mixing with a protectant fungicide is critical. Where strobilurins are working, an ideal fit may be at petal fall and into cover sprays as this group has good efficacy on summer diseases such as fruit rots, fly speck and sooty blotch.

Resistance management

One key strategy to good resistance management is rotating between products of different chemical groups. This does not just mean rotating from one product to another. Fungicides are grouped based on their mode of action, or how the product actually affects the disease. For example, all products in Group 3 have the same mode of action, so

Table 4. Efficacy of registered systemic fungicide groups on apple scab, powdery mildew, rust, black rot, bitter rot and fly speck/sooty blotch on apples.

Fungicide Group	Scab	Powdery mildew	Rust	Black rot	Bitter rot
1 (Senator)	+++	+++	--	+++ ¹	+ ¹
3 (Cevya, Fullback, Nova)	+++(+) ²	++++	++++	--	--
3+7 (Aprovia Top)	++++	+++	+++	--	--
3+9 (Inspire Super)	++++	+++	++++	--	--
7 (Excalia, Fontelis, Kenja, Sercadis)	++++	++(+)	+++ (Fontelis only)	--	--
7+9 (Luna Tranquility)	++++	+++(+)	--	--	--
7+11 (Merivon, Pristine)	+++(+)	+++(+)	--	+++(+)	++++
11 (Flint, Sovran)	++++ ²	++++	--	+++ ¹	++(+) ¹

+ = poor control or partial suppression; ++ = suppression; +++ = good control; ++++ = excellent control

¹ Not registered on this disease.

² Resistance is present in ON to some products from this group

using one product is virtually the same as using all other products within that group. In pre-mix fungicides, both groups need to be considered in all rotation decisions. Figure 1 shows which fungicides belong to Groups 3, 7, 9 and 11. For instance, since Aprovia Top belongs to Group 3 and 7, it should not be followed by Cevya, Fullback, Nova, Inspire Super, Excalia, Fontelis, Kenja, Sercadis, Luna Tranquility or Pristine.

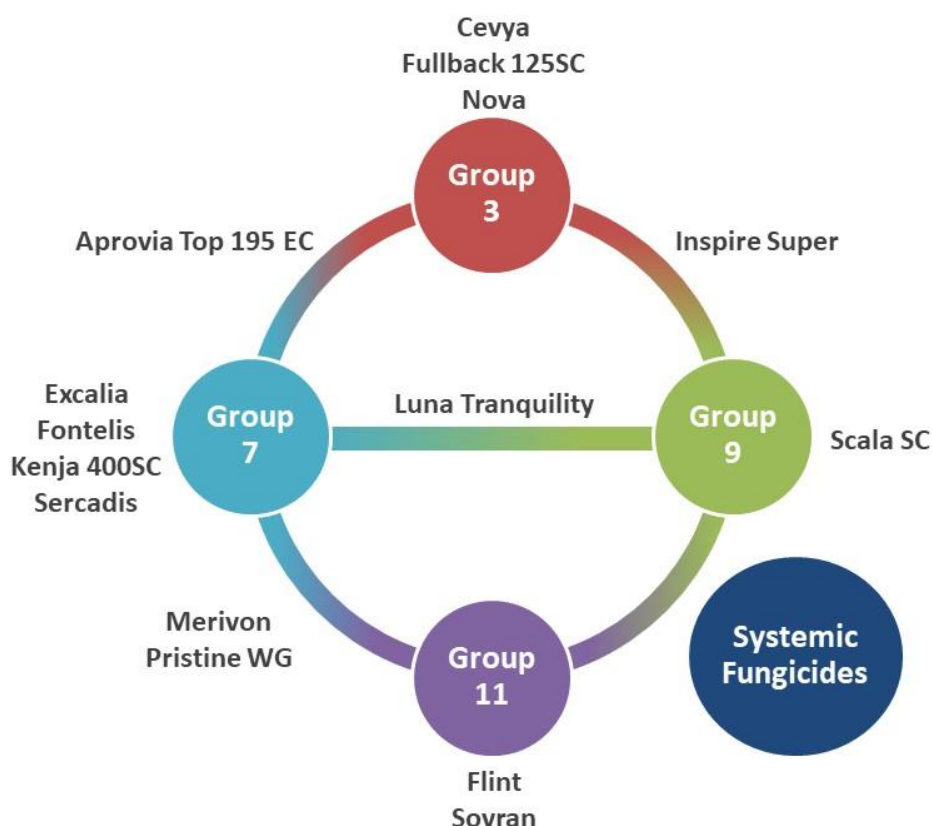


Figure 1. Schematic diagram of Group 3, 7, 9 and 11 fungicides, including pre-mixes registered for use on apples.

Summer Sprays to Harvest

The end of primary scab season can be determined through the use of the ascospore maturity degree-day model as described in the apple scab module on Ontario AppleIPM. At 418 DDC (degree-days Celsius), over 95% of the ascospores supply should be depleted if sufficient rain has occurred. After this point, wait 2 weeks and then check the trees for scab. It can take up to 14 days for lesions to appear after a scab infection period. Be sure to check the top of standard trees or anywhere else spray coverage may not have been adequate, such as a thick tree canopy. Primary scab is often overlooked in these areas and can come as a surprise when lesions suddenly show up on the fruit late season.

If primary scab was controlled, the rates of fungicides may be reduced and the interval between sprays may be lengthened for the remainder of the growing season. Following first or second cover, mancozeb is no longer an option due to the preharvest interval. Summer applications of captan or folpet, however, will only provide efficacy on scab, black rot, bitter rot, fly speck and sooty blotch if the full rate is used. Remember, if using the new captan WSP formulations, low density orchards with a canopy width of 2m will be restricted to a maximum of 2 full rates of captan at 3 kg/ha and a 19-day PHI. Rotation with alternative products effective against summer diseases such as Allegro (28-day PHI), Flint (14-day PHI), Merivon (0-day PHI but 5-day REI for hand harvest) or Pristine (5-day PHI) will be necessary to compensate for the limited captan allowance. Regardless, if summer oil or other tank-mixes that are incompatible with captan or folpet are used, rotation with the above-mentioned products will be important. Allegro will also provide mite suppression.

Organic Management

Organic or biofungicides are not necessarily just options for organic operations but can be effective alternatives to incorporate into a conventional program as well. Their precise fit, however, will depend on the product used. For instance, as mentioned above, Buran should be timed for after heavy rain or periods of prolonged leaf wetness when protectant fungicide activity may be reduced. The products listed in Table 5 provide broad-spectrum activity on a number of key apple diseases.

When used properly, biofungicides can have the following advantages in conventional disease management:

- Lower potential for pest resistance
- Provide protection during times of lower infection risk, allowing more effective products to be saved for critical periods
- Provide a rotational option to help manage resistance development to other conventional products
- Shorter re-entry intervals helpful for times of significant orchard activity (e.g., hand thinning, pruning)
- Shorter preharvest intervals can provide disease suppression up to the day of harvest, helping to reduce potential storage issues
- Potentially lower toxicity to non-target organisms, including honeybees

Biofungicides typically do not provide the same high level of control as conventional fungicides and are often labelled for suppression, or partial suppression, of pests. Control can be improved, however, when their use is combined with other control practices including cover crops, sanitation, promoting tree health and canopy management to name a few.

Table 5. Organic fungicides for management of apple diseases

Product	REI	PHI	Scab	Powdery mildew	Rust	Fruit rot	Fly speck / sooty blotch
Buran	when dry	0 days	++(+)	++	--	--	--
Oxidate 2.0	4 hours	0 days	+(+)	++	--	+(+)	--
Regalia Maxx	when dry	0 days	+(+)	+(+)	++ ¹	++	+(+)
Serenade OPTI	when dry	0 days	+(+)	+(+)	++ ¹	++ ¹	++ ¹
sulphur	24 hours	1 day	++	++(+)	+ ¹	+(+) ¹	+(+) ¹

+ = poor control or partial suppression; ++ = suppression; +++ = good control; ++++ = excellent control

¹ Not registered on this disease.

Postharvest

Following harvest, scab management can continue by reducing the amount of overwintering inoculum and pressure you'll be starting out with in the orchard next season. Applying urea fertilizer at 45 kg/ha (mixed with 1,000 L of water/ha) and/or shredding fallen leaves with a flail mower are two practical and inexpensive methods to minimize scab pressure. Ideally, these practices should be done in the fall and/or before green tip if possible, but there may still be some benefit if this is delayed shortly after bud break.

Summary

The following description and Figure 2 summarizes many points from this article but is only an example conventional scab management program and does not include all control options available. **Select products that fit best for your operation, cultivars, resistance management program and disease pressure as well as current weather conditions.** Product choices in this example were based on a hypothetical cool, wet spring followed by a warm, humid summer and used a somewhat "worst-case scenario", or combination of 7x half rate mancozeb (77-day PHI) and 2x captan (19-day PHI).

An effective scab management program should begin with a delayed dormant copper application between silver tip and ½" green. This will have efficacy on any early season activity of overwintering fire blight cankers or scab infection periods. From green tip to pink consider a protectant fungicide program consisting of a combination of half-rate mancozeb (especially at pink for rust control) and half rate protectants (mancozeb, folpet, captan) tank-mixed with Syllit, Scala, Inspire Super or Luna Tranquility. Over the bloom period into the first and second cover, incorporate systemic fungicides belonging to Groups 1, 3, 7 and/or 11 tank-mixed where possible with half-rate mancozeb. A rotation of Merivon/Pristine or Senator tank-mixed with half-rate captan or Folpan and Allegro as summer cover sprays will provide good control of scab, fruit rots and fly speck/sooty blotch. Allegro can be used up to 3 consecutive sprays before rotating to another fungicide group. A late season application of full-rate captan (within the required pre-harvest interval) or Folpan followed up with a Merivon/Pristine just before harvest (if not exporting) will protect against pinpoint scab and any other fungal infections that may occur. Reduce inoculum by applying urea and/or flail mowing in the fall following harvest or as soon as the orchard can be entered in the spring.

Example Apple Scab Program

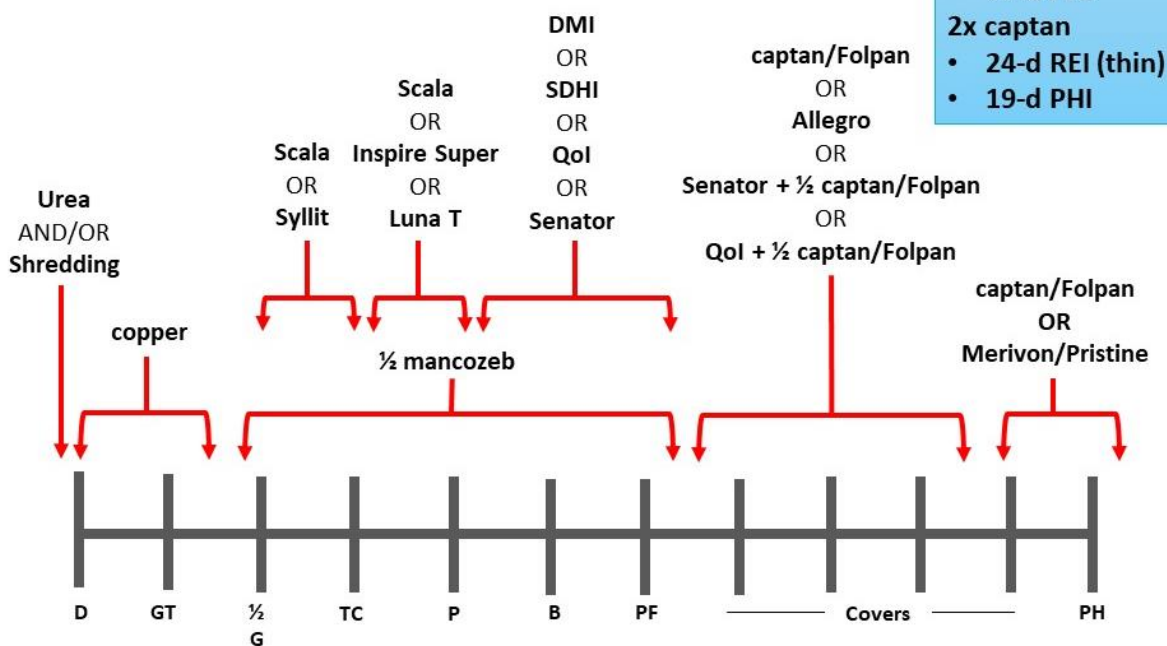


Figure 2. Example of a full-season apple scab management program during a cool, wet spring followed by a warm, humid summer. Fungicides highlighted from tight cluster through covers may also provide efficacy on other diseases.

Announcements

OMAFRA IPM Workshops Going Virtual for 2021

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

Due to current physical distancing measures, the OMAFRA IPM workshops will be available online via Zoom and pre-recorded presentations. **To register, please click the registration link under the specific workshop below.** After registering, you will receive a confirmation email containing information about joining the meeting.

Pre-recorded presentations are available on the [ONhortcrops YouTube channel](#). Where applicable, please watch these presentations prior to attending the webinar.

All presentations are available for anyone to access. Additional video resources from other OMAFRA specialists will also be available on this channel throughout the season.

Workshop	Facilitator	Date	Time	Registration
GENERAL				
Introduction to IPM	Denise Beaton	April 29, 2021	10:00 am – 2:30 pm	Click here to register
FRUIT				
Apple IPM	Kristy Grigg-McGuffin	May 6, 2021	10:00 – 11:30 am	Click here to register
Strawberry & Raspberry IPM	Erica Pate	May 11, 2021	9:00 – 11:00 am	Click here to register
Tender Fruit IPM	Wendy McFadden-Smith	May 25, 2021	9:00 – 11:00 am	Click here to register
Grape IPM	Wendy McFadden-Smith	May 25, 2021	1:00 – 3:00 pm	Click here to register
VEGETABLE				
Tomato & Pepper IPM	Amanda Tracey	May 3, 2021	9:00 am – 12:30 pm	Click here to register
Brassica Crops IPM	Travis Cranmer / Dennis Van Dyk	May 7, 2021	8:45 am – 12:00 pm	Click here to register
Onion & Carrot IPM	Dennis Van Dyk / Travis Cranmer	May 12, 2021	8:45 am – 12:00 pm	Click here to register
Potato IPM	Eugenia Banks / Dennis Van Dyk	May 18, 2021	9:00 am – 12:00 pm	Click here to register
Sweet Corn, Peas & Beans IPM	Elaine Roddy	May 19, 2021	9:30 am – 12:00 pm	Click here to register
Cucurbit IPM	Elaine Roddy	May 26, 2021	9:30 am – 12:00 pm	Click here to register

Call for Grower Participation – Provincial Varietal Growth Staging

OMAFRA is calling upon growers to share data regarding growth stages of Ambrosia, Honeycrisp and Gala varieties across the province. We are also open to receiving historical data if possible.

If you would like more information or would be willing to pass along information, please reach out to Erika DeBrouwer (erika.debrouwer@ontario.ca, 226-931-4098).

Berry & Apple Pick-Your-Own Round Table Event

Join us for a round table discussion on operating pick-your-own this season. This Zoom meeting will include an overview of the guidelines as well as a round table discussion with growers and staff. After changing the way growers operate pick-your-own in 2020, this meeting is a chance to talk about what worked and what didn't, ask questions, and share your experiences to prepare growers for a successful and safe 2021 season. This round table is open for growers and staff of pick-your-own operations. Please feel free to send questions before the round table to Erica Pate (erica.pate@ontario.ca) regarding berry operations or Erika DeBrouwer (erika.debrouwer@ontario.ca) regarding apple operations for them to be addressed during the call.

When: May 18, 2021, 7:00 PM

Registration is required. Please register in advance here: <https://zoom.us/meeting/register/tJYrd--urTkvEt3j3kfBZ313efx5gQZX1zi1>

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