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For Commercial Apple Producers

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In this issue…

Orchard Management

Effects of Cold Temperatures and in Late Fall 2019

Amanda Green, Tree Fruit Specialist, OMAFRA

In mid-November many areas of Ontario experienced a severe drop in temperature. There were many areas that went down to -16 or -17 ˚C (Table 1). November was generally a colder month; on average, November was 2-4˚ less than the climate normal for November (Table 1). Harvest was also delayed by 5-10 days and growers were either just finished or finishing harvest. Leaves were quite green on the trees when we received the severe drop in temperature. These conditions makes one wonder if trees were hardened off enough for this sudden drop.

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

Amanda Green, Simcoe
ONNL Editor
Tree Fruit Specialist
(519) 426-1102
amanda.green@ontario.ca

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

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

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

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

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

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

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

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

This issue of the **Orchard Network Newsletter** was compiled by Jacquie De Fields, Client Service Representative, OMAFRA, Simcoe Resource Centre

Table 1: Temperature data for October and November 2019 for 5 locations in Ontario

	Location				
	Simcoe	**Harrow**	**Vineland**	**Oshawa**	**Collingwood**
Lowest temperature in November (˚C)	-16	-16	-10	-17	-17
Number of days below -2 prior to the severe temperature drop	7	5	4	6	5
Lowest temperature one-to two- weeks prior to severe temperature drop (˚C)	-3	-4	-1	-3	-2
Average degrees **below** climate normal for November (˚C)	3	3	3	4	2
Average degrees **above** climate normal for October (˚C)	1	1	1	0	1

Cold Acclimation

There are two stages of cold acclimation, one stage triggered by shorter days, the second stage is triggered by hard frosts. Apple leaves sense the shorter days through phytochromes which triggers growth to stop and cold acclimation to begin (Westwood, 1993). Even without many sub-zero temperatures, apple trees are beginning the cold acclimation process. Trees are hardy to -15 to -20˚C at the first stage (reviewed by Quamme and Hampson, 2004). The second stage of cold acclimation occurs when trees experience hard frosts (less than -2˚C); cold hardiness increases rapidly over 40 to 50 days to a maximum hardiness down to -35 to -40˚C (Howell and Weiser, 1970; Quamme, 1976). Without a killing frost, cold hardiness does not increase to more than -25 to -30˚C (Howell and Weiser, 1970).

Regarding the sudden drop of temperatures Ontario experienced in early November, trees should have already been at the first stage of cold acclimation with the short photoperiod signalling the induction. Many parts of the province had already had a couple nights where temperatures dropped to below -2˚ Celsius (Table 1) so trees would have started the second stage of cold acclimation.

Temperatures during the first stage of cold acclimation have shown to be a factor in causing winter injury. In a study analyzing temperatures throughout the year and incidences of winter injury in New Brunswick, a higher than average mean temperature in October is one of the main contributing factors to winter injury (Coleman, 1992). Fortunately, the average temperature in October was only 1 degree above the climate normal (Table 1).

If trees don't exhibit winter injury from this early freeze event, there could be effects on yield in the following year. A paper from British Columbia analyzed weather data and production levels over 72 years and found that low temperatures in November were associated with poor production in the following season (Caprio and Quamme, 1999). The threshold for poor production was -9 ˚C in early November down to -13˚ C in late December (Caprio and Quamme, 1999). Temperatures in November were below both of these thresholds (Table 1) which means that there could be an impact on yield in 2020.

Significance of Green leaves or Fruit Still Present

It is difficult to find evidence on the impact of going through a hard freeze when trees still had green leaves intact. There is a belief that leaf abscission is a sign of acclimation, but it is not always associated with greater winter hardiness (Palmer et al., 2003). There is more of an association with fruit still hanging on the tree than there is with leaves still being present. Leaves play a positive role in the induction of cold acclimation with sensing the shortening of day length (Westwood, 1993). Leaves are also still producing carbohydrates in the fall which are necessary for cold acclimation and obtaining maximum cold-hardiness (Palmer et al., 2003).

In an experiment on leave removal, leaves were removed at the beginning of September and put under a natural, short-day light regime in Minnesota or an artificial long-day regime (Howell and Weiser, 1970). Under short days, trees that weren't defoliated acclimated first and the defoliated trees were the last to acclimate, longer than trees under a long-day regime (Howell and Weiser, 1970). Under the long-day regime the defoliated trees acclimated before the trees that weren't defoliated (Howell and Weiser, 1970). The explanation for this is that under shorter days, leaves are a source of promotors of cold acclimation where as under long days leaves act as an inhibitor of cold acclimation (Irving and Lanphear, 1967 and Howell and Weiser, 1970)

The presence of fruit on the tree influences the foliage colour and the hardiness of trees (Westwood, 1993). There are observations from a cold incident from November 1955 in Washington state which trees that still had a crop had their leaves killed and obtained more damage than trees of the same variety that had been picked a few days earlier (Westwood, 1993). An exclamation for this greater freeze damage would be due to fruit being a source of the plant hormones auxins and GA (gibberellins) and a strong sink for carbohydrates and the plant hormone ABA (abscisic acid) (Westwood, 1993). Once fruit is removed, the reduced source of auxin and GA and greater amount of carbohydrates aids in cold (Westwood, 1993).

Outlook

It is difficult to know how much of an impact the November freeze will have on apple trees in Ontario. There may be an impact on late-harvested trees and on production of all cultivars. In the following season ensure trees are well watered and fertilized in the case that there is damage to the xylem.

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Crop Protection

But Is It Resistance? Considering All Factors Involved in Pesticide Failure

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

How frustrating! After spending the time (and money) applying a pest control product, the results are just not what you wanted to see. Your scouting reports are indicating the pest is still there or damage continues to develop. Pesticide failure can happen to even the most diligent applicator. But is this failure due to the development of pesticide resistance? In most cases, the answer is no. It is important to be aware that resistance is not the only cause of a pesticide failure. Before assuming a pest population is resistant to a product, consider the following factors which may impact the effectiveness of a pesticide's performance.

Product selection

Does the product actually have activity against the target pest? Proper identification and a good understanding of pest biology and life cycle is the first step to effective management. The current products now registered on the market for use in apples have changed the way management needs to be approached. Where previously registered broad-spectrum products could knock down several different types of key pests, the active ingredients now being registered tend to be more selective and target-specific. This means mis-identification could result in an expensive mistake. For instance, is the limb dieback

caused by fire blight, Nectria twig blight, black rot or oriental fruit moth? Is the leaf curling or stippling caused by aphids, leafhoppers or mites? Is the early fruit damage caused by plum curculio, tarnished plant bug or spring feeding caterpillar? Once the pest has been properly identified, use the information in the efficacy tables in Publication 360, *Activity of Insecticides and Miticides on Apple Pests* and *Activity of Fungicides on Apple Diseases*, to assist with choosing the best product for the pest complex present.

If the product selected does have efficacy on the targeted pest, was it applied as directed on the label? For instance, Perm-Up/Pounce, Cormoran, Delegate, Rimon and Altacor are registered for dogwood borer control. However, these applications are directed trunk sprays. Foliar applications will not have efficacy on this pest. Another example are the *Phytophthora* products, Aliette and Ridomil Gold. Aliette should be foliar applied as it moves up and down the tree. Ridomil, on the other hand, should be drench applied (on non-bearing trees) as it moves up the tree only.

The time a product takes to knockdown pests can vary. San Jose scale, leafcurling midge or woolly apple aphid control using Movento may not be apparent for 2-3 weeks. A summer miticide such as Envidor will have a much slower knockdown compared to others like Nexter or Kanemite. Be sure you are assessing pest pressure after the appropriate length of time depending on the product used.

Also be aware of how long the knockdown effect will last. You may be seeing a resurgence of the pest activity because the life of the product has passed. Refer to the product label for recommended spray intervals which will indicate if the product has a short-lived activity.

Rate

Was the rate used that which was listed on the product label for the target pest? It is not an uncommon practice to reduce rates of Group M fungicides after primary scab period is over if there are no signs of scab in the orchard. However, lower rates do not provide effective control on summer diseases such as fruit rots, fly speck and sooty blotch, especially if intervals between sprays are extended as well. Escapes may happen for this reason.

In general, all pesticide rates are labelled at the lowest effective dose. Using rates below this will not only reduce the pesticide's performance but may also increase selection for resistance.

Weather conditions

Weather conditions can have a major role in the efficacy of a pesticide in the field. Systemic pesticides are typically best applied under humid and cloudy conditions to allow quicker absorption into the tissue. Contact or protectant fungicides are best applied during dry, sunny weather to have time to set on the leaf surface.

Some products may specify ideal weather conditions or timing on the label. For example, *Bacillus thuringiensis* (Bioprotec, Dipel, Foray, Xentari) and granulovirus (Cyd-X, Virosoft) products are best applied late afternoon/early evening or on cloudy days to avoid exposure to sunlight.

The wet spring of 2019 was a challenge for many growers and showed how weather conditions during or after application can affect spray coverage or pesticide efficacy. The windy, wet conditions caused less than full coverage within the canopy and frequent, hard rains washed off residue. Scab escapes happened as well as issues with black rot particularly around bloom.

Understanding the rainfastness of the product you are using will help with your decision making regarding the necessity of reapplying or the interval between sprays. Some product labels provide rainfast information. You can also refer to the August 2019 Orchard Network Newsletter article, *Rainfastness of Insecticides and Fungicides on Fruit*.

For a general rule of thumb, most insecticides and fungicides require 2-6 hours of drying time without rain after an application to set on the leaf surface or penetrate the tissue if systemic; however, 24 hours without rain is optimal for systemic products. At 24 hours after application, most products can sustain up to 1 inch of rain. By 2 inches of rain, assume a significant amount of the residue has been depleted. Also note, the older the residue, the less rainfast it tends to be. Be aware of the reapplication interval and consider this when weather conditions are less than ideal.

For some products, rain is not the only weather condition that can affect performance. As mentioned previously, certain biological products such as *Bt* and granulovirus are sensitive to direct sunlight. Streptomycin degrades rapidly in high UV conditions. During conditions conducive to blossom blight infection, reapplying at 2-3-day intervals may be required, especially during times when new blooms are rapidly opening.

Timing

Now more than ever with more selective products, understanding the biology of the pest is critical to determine the appropriate life stage to target. For instance, the Publication 360 table, *Activity of Miticides Registered on Apple and/or Pear in Ontario*, identifies which life stage each registered miticide affects. In some cases, an application too early or too late can result in poor mite control if not all life stages are controlled by the product (e.g., Agri-Mek and Minecto Pro target nymphs of European red mite and two-spotted spider mite, Nexter targets nymphs and adults of European red mite but only nymphs of two-spotted spider mite and Apollo targets primarily mite eggs).

With codling moth, the time from egg hatch to when the larva enters the fruit is often less than 24 hours. That means if effective residues are not in place while the larva is chewing its way out of the egg or beginning to feed on the flesh of the fruit, there are few products - with the exception of Imidan and, to a lesser extent, Calypso - that

have some absorption into the fruit to kill actively feeding larva. Timing in this case needs to be precise.

Water volume / quality

For some pests, lower volumes of water are sufficient to achieve good control. However, depending on where the target pest is found (under leaf, on trunk, etc.), high-volume sprays are essential to ensure coverage. Miticides and oils are examples of this and should not be applied in less than 1,000 L/ha of water. Slow down when spraying and make sure the target areas are getting hit.

Water quality, i.e. pH, hardness and turbidity/cleanliness, can make pesticides unable to dissolve in water, penetrate target tissue, reach the action site and, in turn, reduce efficacy. Some products are particularly sensitive to subtle changes in pH. Captan has a half-life of 3 hours at a pH of 7.1 but only 10 min at a pH of 8.2. Imidan has a half-life of 15 days at a pH of 4, 1 day at a pH of 7, 4 hours at a pH of 8.3 and only 1 min at a pH of 10.

Read the product label for water quality requirements. The addition of a product in the tank can modify the pH, rendering other active ingredients ineffective. Test strips can be used to quickly check water quality before and after addition of pesticides. Changes to water quality can also be monitored by accredited laboratories.

Lastly, ensure your sprayer is properly calibrated for the time of year. The spray target changes significantly from bud break to harvest so having only one calibration setting is likely not sufficient. Consider calibrating your sprayer at various times during the season to ensure you are continuing to get effective coverage. For more information on calibration, sprayer coverage and water quality, visit the Sprayers101 website.

Once other possible causes of the pesticide failure have been eliminated, resistance can be considered a likely factor. Testing may be available depending on the pest. Contact myself or your registrant representative if you suspect a resistance issue.

Coming Soon! 2020-2021 Publication 360, Fruit Crop Protection Guide

Kristy Grigg-McGuffin, Horticulture IPM Specialist, OMAFRA

A full revision of Publication 360, *Fruit Crop Protection Guide* will be available in Spring 2020. This will have the latest information on crop protection and resistance management for commercial production of fruit crops, including apples, berries, grapes, tender fruit and tree nuts. This year, crops will be divided into separate smaller guides which will be available for individual download, purchase or bundled together. Subscribe to ONfruit to receive updates when the guides will be available online and in print.

In the meantime, here is a list of new product additions, label expansions or changes to the apple guide.

For information on:

- **Diplomat 5 SC** – powdery mildew (suppression)
- **Harvanta 50 SL** – obliquebanded leafroller, codling moth, oriental fruit moth, plum curculio (suppression), apple maggot (suppression)
- **Kopa** – two-spotted spider mite
- **Minecto Pro** - codling moth, oriental fruit moth, tentiform leafminer, obliquebanded leafroller, European apple sawfly, two-spotted spider mite, European red mite
- **Oxidate 2.0** – powdery mildew (suppression), fire blight (partial suppression), scab (partial suppression), black rot (partial suppression)
- **Parasol Flowable** – fire blight (dormant)
- **XenTari** – obliquebanded leafroller

refer to the 2019 Publication 360 Supplement.

New registrations

- **Cevya** (*mefentrifluconazole*) is a Group 3 fungicide registered for the control of apple scab and suppression of powdery mildew at a rate of 250-375 mL/ha. For resistance management, tank-mix with a compatible protectant fungicide from a different group. Use preventatively but may provide some kickback activity if applied within 2-3 days following a scab infection period. The unique binding activity of this product has shown to control scab populations resistant to other Group 3, 7, 9 and 11 fungicides. However, practicing best resistance management strategies such as tank-mixing with a protectant and rotating between fungicide groups will ensure the long-term efficacy of this product.

Preharvest interval (PHI): 0 days; *Restricted entry interval (REI):* 12 hours; *Maximum # of applications per year (on label):* 1.125 L/ha.

- **Cormoran** (*acetamiprid* + *novaluron*) is a Group 4A + 15 insecticide registered for the control of leafhoppers, tentiform leafminer, rosy/green apple aphid, spring-feeding caterpillars (gypsy moth, green fruitworm), mullein bug, Japanese beetle, apple maggot, codling moth, European apple sawfly, oriental fruit moth, plum curculio, tarnished plant bug, dogwood borer. Refer to the label for specific rates. Apply in a spray volume of 1,000 L/ha and no less than 12 days apart, if repeat applications are needed. This product is a pre-mix of Assail and Rimon so may be harsh on beneficial insects. Limit application of these insecticide groups to twice per season to prevent mite flare-ups. Do not allow Cormoran to drift onto grapes as leaf spotting may occur.

Preharvest interval (PHI): 14 days; *Restricted entry interval (REI):* 12 hours (general re-entry) / 7 days (thinning); *Maximum # of applications per year (on label):* max. 6.9 L/ha.

- **Kudos 27.5 WDG** (*prohexadione calcium*) is a plant growth regulator similar to Apogee registered to reduce vegetative growth, making trees less susceptible to fire blight shoot infection. This product has no impact on blossom blight or fire blight bacteria but can slow the spread of infection to the shoot should blossom infection occur. For maximum reduction in fire blight susceptibility, apply at a rate of 450 g/1,000 L water at least 10 days before the occurrence of weather conditions favourable for shoot infection. Often the target timing is king bloom petal fall or when terminal shoots are 2.5-5 cm long. However, there is some new research out now that suggests an application at pink could be effective. Reapply as needed at 14-21-day intervals. Do not tank-mix with calcium or boron. Severe cracking can occur on Empire and Stayman cultivars and decrease yield in Cortland. For more information on vegetative growth control, refer to the label.

  Preharvest interval (PHI): 45 days; Restricted entry interval (REI): 12 hours*; Maximum # of applications per year (on label):* 4 (max. 5.4 kg/ha).

- **Maestro 80 WSP / Supra Captan 80 WSP*** (*captan*) are Group M fungicides registered for the control of apple scab, sooty blotch, fly speck, brook's spot, bitter rot, black rot and bull's eye rot at a rate of 3 kg/ha. These are new formulations that will be replacing Maestro 80 DF and Supra Captan 80 WDG. See below for important information on changes to re-entry and number of applications for high-density and standard orchards. Effective control of summer diseases including fly speck, sooty blotch and fruit rots requires the high rate. Do not use within 14 days of oil or as a tank-mix or sequential application with products containing oil such as Fontelis or Exirel. When restricted entry interval exceeds preharvest interval, follow restricted entry interval.

  High-density (canopy width less than 2m, or 1 m from trunk to row alley)
  Preharvest interval (PHI): 7 days; *Restricted entry interval* (*REI):* 2 days (general re-entry) / 6 days (pruning, training) / 15 days (hand thinning, hand harvest); *Maximum # of applications per year (on label):* 10.

  Standard density (canopy width greater than 2m, or 1 m from trunk to row alley)
  Preharvest interval (PHI): 7 days*; Restricted entry interval (REI):* 2 days (general re-entry) / 4 days (pruning, training) / 19 days (hand harvest) / 24 days (hand thinning); *Maximum # of applications per year (on label):* 2 (when hand thinning, make 1 application before thinning and 1 application after).

  **Supra Captan 80 WSP was only recently registered and is not in the 2020-2021 Publication 360.*

- **Scorpio Ant and Insect Bait** (*spinosad*) is a Group 5 insecticidal bait registered to control ants which "farm" aphids. This interesting mutualistic relationship between ant and aphid provides benefits for both sides. By maintaining (or farming) an aphid colony, the ants ensure a continuous food supply of the sticky honeydew aphids produce when they feed. Meanwhile, the ants protect the aphids from predators such as lady beetles and help disperse the colony to new feeding sites. The idea of this bait is to kill the farmer ants and thereby, have better control over managing aphid pressure. Broadcast bait around the base of the tree at a rate of 6-45 kg/ha. Reapply every 4 weeks, as the bait is consumed or following a heavy rain.

  Preharvest interval (PHI): 7 days*; Restricted entry interval (REI):* 12 hours*; Maximum # of applications per year (on label):* 3.

- **Versys** (*afidopyropen*) is a Group 9D insecticide registered for the control of rosy and green apple aphid at a rate of 100 mL/ha. For rosy apple aphid, spray if 20% of clusters are infested. For green apple aphid, spray if 10% of terminals are infested. Apply in a minimum spray volume of 1,000 L/ha.

Preharvest interval (PHI): 7 days; *Restricted entry interval (REI):* 12 hours; *Maximum # of applications per year (on label):* 4.

Label expansions or changes

- **Buran** *(garlic powder)* is a Group NC biopesticide now registered for control of powdery mildew at 1.2-1.8 % v/v (i.e., 9 L in 500-800 L water/ha). This product was previously registered for suppression only of powdery mildew. Control can be achieved under low to moderate disease pressure with the addition of a non-ionic surfactant at a rate of 0.1% v/v. Begin applications preventatively when conditions are conducive to disease development. Reapply every 7-10 days if needed. Do not apply if rain is forecast within 48 hours. This product is also registered for suppression of apple scab as a post-infection treatment.

- **Closer** *(sulfoxaflor)* is a Group 4C insecticide that has received a label expansion to include the control of tarnished plant bug at a rate of 300 mL/ha as well as mullein bug and woolly apple aphid at a rate of 400 mL/ha. This product was previously registered for suppression only of woolly apple aphid at a lower rate.

- **Twinguard** *(sulfoxaflor + spinetoram)* is a Group 4C + 5 insecticide that has received a label expansion to include the control of tarnished plant bug at a rate of 360 g/ha as well as mullein bug and woolly apple aphid at a rate of 500 g/ha. This product was previously registered for suppression only of woolly apple aphid at a lower rate.

- **Nexter SC** (*pyridaben*) is a new formulation (PCP 33433) of the Group 21 miticide, replacing Nexter

WP (PCP 25135). The new rate for motile stages of European red mite and apple rust mite is 500 mL/ha. The new rate for nymph and larva stage of two-spotted spider mite is 500-1,000 mL/ha. Use the higher rate for a faster knockdown and control late season.

Important notices regarding cancellation of registered products

- For the following re-evaluation decisions, consult the most recent label on the PMRA website and/or the product registrant to verify dates of last sale and use.

- For more information, see the December 2019 Orchard Network Newsletter article, Out with the Old? Keeping Track of Recent Pesticide Re-Evaluation Decisions in Apples.

- **Granuflo T** *(thiram),* Ferbam 75 WDG (ferbam) – Last date of use is December 14, 2021.

- **Polyram DF** *(metiram)* – Last date of use is June 21, 2021.

- **Maestro 80 DF / Supra Captan 80 WDG** *(captan)* – Last date of use is May 10, 2021. Where these products are still available, follow all precautions and restrictions as indicated on the container label until last date of use. If using the new water-soluble packet formulations list above in "new registrations", all re-evaluation use pattern requirements outlined on container label are to be followed.

- **Actara 25 WG** *(thiamethoxam),* Admire 240 Flowable / Alias 240 SC (imidacloprid), Clutch 50 WDG (clothianidin) – Last date of use is April 11, 2021. A 1-year extension has been granted for Actara and Clutch for suppression of brown marmorated stink bug to April 11, 2022.

- Other re-evaluation final decisions are expected in 2020 including mancozeb and phosmet (Imidan). Stay tuned to ONfruit for more information.

Sprayer Loading and the Jar Test

Jason Deveau, Application Technology Specialist, OMAFRA
Mike Cowbrough, Weed Management Specialist – Field Crops, OMAFRA

The time and attention spent during sprayer loading is a worthy investment. It ensures that the products in the tank perform as intended and reduces the chance of physical incompatibilities.

The Label

Pesticide labels are always the first point of reference. Labelled mixing instructions should be obeyed even if they contradict conventional practices (see Mixing order, below). Consult the article *Tank Mix Compatibility* also found in this issue of the *Orchard Network Newsletter* for more information on how to quickly and easily consult labels for each of your tank mix partners.

The Carrier

Typically, the carrier is water. Water plays a very important role in tank mixing that is often underappreciated. Take some time to read Les Henry's 2016 Grainews article called "The Coles Notes of Water Chemistry" (https://www.grainews.ca/columns/the-coles-notes-of-water-chemistry-les-henry/). You can also read about pH and water hardness.

Carrier Volume

Products dissolve better in higher volumes. The sprayer tank (vat, inductor, etc.) should be at least ½ full of water before adding the first product. In the case of a fertilizer carrier, it may look like water, but it contains high levels of salts that tie up free water and reduce solubility. For fertilizers, a higher initial volume of ¾ full is required.

The incomplete dissolution of products can leave hard-to-clean residues, plug fluid lines, and result in a non-uniform application that reduces efficacy. The risk of incompatibility is greater with low carrier volumes and high product rates (especially dry formulations). This is a common problem in regions that use low water volumes to apply multiple tank mix partners.

Carrier and Product Temperature

Both carrier and product temperature affect mixing. Imagine mixing sugar in hot tea versus iced tea – more sugar dissolves more quickly in hot liquid. Water and fertilizer are very different carriers. Beware of carrier-specific incompatibilities. Here are three common temperature-related issues:

- Dry formulations and liquid flowables take more time to disperse (consider using a pre-mixed slurry).
- Emulsified concentrates and oil might form gels rather than milky blooms.
- Water soluble packages might not dissolve completely and could plug filters and nozzles – or clog the pump intake.

Agitation

Agitation should be on-going during mixing and spraying. When agitation is too low, products may not disperse or suspend and can settle out. In the case of leaving a sprayer overnight without agitation, settled product may or may not resuspend. See this article: https://sprayers101.com/storing-pesticide-mix-overnight/

When agitation is too aggressive (e.g. full agitation when tank is less than half full) product can foam, causing overflows or breaking pump suction during spraying. Over agitation can also cause dispersed products (e.g. emulsifiable concentrates) to separate and cause clumping that looks like curds. When agitating, the surface of the carrier should be closer to a simmer than a rolling boil.

Pace

Products may require as much as five minutes between additions. This is especially important when carrier or product is cold, or when adding dry products. When products are added too quickly, they will not entirely disperse or suspend, which could result in a physical incompatibility with subsequent additions.

While efficient sprayer loading is an excellent opportunity to improve your work rate, complicated tank mixes still require time between additions. To save some time, sprayer operators pre-hydrate dry products in a smaller tank or use an extra tank to pre-mix whole loads and simply transfer them over. Even when dry products appear to be dissolved, they may not be. Be patient.

Product Formulation

Product formulation is a complicated science. In the 1950's a formulation might have three active ingredients and an inert filler. Today, a product can include ~40 ingredients with formulation testing lasting two to four years! The more products you add to the tank, the higher the risk of antagonism. If you experience physical incompatibility during loading, don't blame the last product you put in the tank!

Mixing Order
Labelled or unlabeled, the order in which you add tank mix partners is critical. There are several acronyms around to help you decide on your mixing order. Here are the top three:

- **W.A.L.E.S.** (Wettable powders, Agitate, Liquid flowables, Emulsifiable concentrates, Surfactants).
- BASF's **W.A.M.L.E.G.S.** (Wettable powders, Agitate, Microencapsulated suspensions, Liquid flowables, Emulsifiable concentrates, high-load Glyphosates, Surfactants)
- **A.P.P.L.E.S.** (Agitate, Powders soluble, Powders dry, Liquid flowables and suspensions, Emulsifiable concentrates, Solutions)

W.A.L.E.S. is not broken. In fact, formulation chemists expect it to work ~95% of time. Generally, soluble liquids are forgiving and can be added early or late. It's the dry formulations and emulsifiable concentrates that require more care. When there are exceptions to the order, they are clearly indicated on the pesticide label.

W.A.L.E.S is, perhaps, a bit simplistic. Products that fall within each "letter" have their own preferred mixing order that isn't specified by the acronym. What follows is an expanded generic mixing order.

- Water-Soluble Bags (WSB) – Allow them to fully dissolve and disperse.
- Wettable Powders (WP)
- Water Dispersible Granules (WDG, WG, SG)
- Agitation to allow dry products to mix and disperse
- Liquid Flowables (F, FL): Including, in order, Suspension Concentrates (SC), Suspo-emulsions (SE), Capsule Suspensions (CS/ZC), Dispersible Concentrates (DC), Emulsions in water (EW)
- In order: Emulsifiable Concentrates (EC): Microemulsifiable Concentrates (MEC) and Oil Dispersions (OD)
- In order: Solutions (SN), Soluble Liquids (SL), Liquid Fertilizers and Micronurients (when not already premixed with fertilizer).
- NOTE: Compatibility agents and anti-foamers should be added before pesticides. Non-Ionic Surfactants (NIS), Crop Oil Concentrates (COC), Drift Retardants (DR), and spreader/stickers should be added per their label instructions.

The Jar Test

Performing a jar test is like filling a sprayer in miniature. Follow all the same rules as filling your sprayer. Always wear personal protective equipment when performing a jar test. Do so in a safe and ventilated area, away from sources of ignition.

Read all product labels. Know the product formulation (which affects mixing method and order). Look for information about the influence of carrier pH, hardness and any requirement for adjuvants. Defer to label instructions should they differ from these mixing steps.

1. Shake any liquid products. This ensures the active ingredient and inert ingredients are thoroughly mixed.
2. If using water as a carrier, add 250 ml to a 1 litre glass jar. For oil or fertilizer, add 375 ml.
3. Agitate (stir) between additions. In a sprayer, agitation should continue throughout the mixing process.
4. Add products in order (see Mixing order, above). Scale back the weights/volumes used to match the concentration intended for an actual sprayer tank (e.g. 1 kg product in a 1,000 litre sprayer tank is 0.5 g product in a 500 ml jar test). In a sprayer, you would flush an inductor with water between additions.
5. Wait and check. Dry products and water-soluble packets must fully disperse and/or dissolve before adding the next product. Several factors affect the duration, but 3-5 minutes is typical. If testing water-soluble packets, include a ~1cm^2 cutting of the PVA packaging.
6. Top up the carrier to 500 ml.
7. Measure pH using a digital meter (litmus papers may not be readable). This is best done after all products are added to account for their impact on pH and buffering capacity. If required, pH adjusters can be added at the end of mixing to ensure the solution is in the range required by the label.
8. Let the solution stand in a ventilated area for 15 minutes and observe the results. If the mixture is giving off heat, these ingredients are not compatible. If gel or scum forms or solids settle to the bottom (except for the wettable powders) then the mixture is likely not compatible.

A jar test will only reveal physical incompatibility between products – it will not reveal any other form of antagonism.

Records

Keep detailed records of what you mixed and how you mixed it. This is important for traceability (e.g. CanadaGAP) and for tracking successes and failures for next year.

The jar test itself can become a valuable record if it's labelled and left in the chemical shed. You will see if products separate, precipitate or form residues. This may indicate if you can let a tank mix sit overnight or if it will require special attention during rinsing.

For More Information

Learn more about physical and chemical incompatibility in our article on *Tank mix compatibility* (https://sprayers101.com/tankmix/). Be sure to download a copy of Purdue University's 2018 *"Avoid Tank Mixing Errors"* https://ppp.purdue.edu/wp-content/uploads/files/PPP-122.pdf . It is an excellent reference.

Tank Mix Compatibility

Jason Deveau, Application Technology Specialist, OMAFRA
Mike Cowbrough, Weed Management Specialist – Field Crops, OMAFRA

In Canada users of commercial class pest control products for crop protection or vegetation management are permitted to apply unlabeled tank mixes of registered pest control products as long as:

- Each partner is registered for use on the crop.
- The tank mix only includes an adjuvant when specifically required by one of the mix partners.
- The application timing of each partner is compatible with crop and pest staging.
- Each partner is used according to the product label.
- No partner is specifically excluded on any other partner label.

Positives

- *Efficiency:* If the timing makes sense, a single pass saves time and reduces trample/compaction. E.g. A "weed-and-feed" application of fertilizer and herbicide in corn.
- *Resistance management:* Multiple modes of action help prevent resistance development and combat existing problems.
- *Improved performance:* Labels may require adjuvants to improve spray quality and potency, which enhances performance.

Negatives

Tank mixing requires caution and careful investigation. Should tank mix partners prove to be incompatible, the consequences can be subtle or dramatic, but are always negative. There are two kinds of incompatibility.

Biological or Chemical Incompatibility

This form of incompatibility may not be immediately apparent following an application. Some level of crop damage or impaired efficacy occurs, which may impact yield or warrant an additional "clean-up" application. This is the result of product synergism or antagonism.

Synergism (Crop Damage)

When products synergize, the application becomes too potent. For example, an adjuvant could affect crop retention or uptake, exposing it to more active ingredient or overwhelming crop metabolism. The result is damage to the crop we are trying to protect.

Antagonism (Reduced Efficacy)

When products antagonize, the application becomes less potent. There are several examples:

- pH adjusters in one product may reduce the half-life of another product (e.g. The fungicide Captan has a half-life of 3 hours at a pH of 7.1 and only 10 minutes at a pH of 8.2.)
- Active ingredients may get tied-up on the clay-based adjuvants in other products (e.g. glyphosate tied up by Metribuzin).
- One product changes the uptake/retention of another. For example, a contact herbicide burns weed foliage beyond its ability to take up a lethal dose of systemic herbicide.

Physical Incompatibility

Physical incompatibility affects work rate and efficacy. Products form solids that interfere with or halt spraying. It can also make sprayer clean-up more difficult. For example, weak-acid herbicides lower the pH of the spray mix, reducing the solubility of Group 2 herbicides (i.e. imidazolinones, sulfonylureas, sulfonanilides). The oily formulation then adheres to plastic and rubber surfaces in tanks, connectors and hoses.

There are many forms of physical incompatibility:

- Liquids can curdle into pastes and gels that clog plumbing to such an extent that flushing cannot clear it and a manual tear down is required.
- Dry formulations don't hydrate or disperse, becoming sediment that clogs screens and nozzles. Even if they are small enough to spray, they reduce coverage uniformity. For example, a dry product added behind an oil gets coated, preventing it from hydrating.
- Certain product combinations may cause settling, or one partner is more prone to settling. If the sprayer sits without agitation, settled products may or may not resuspend. Even if they do resuspend in the tank, they may remain as sediment in lines.
- Certain product combinations may cause foaming, or one partner may be prone to foaming, causing overflows or breaking pump suction. When products foam, dry products added through the foam may swell, preventing hydration.

- Phase separation occurs when products layer in the tank. Consider oil and water. Even with agitation, the active ingredients may not be uniformly suspended in the tank and coverage uniformity will be reduced during spraying.

Prevention

Incompatibility is often a function of the inert ingredients in pesticide formulations (e.g. thickeners, adjuvants, defoamers, stabilizers, solvents, etc.) and not the active ingredients. The more products you add to the tank, the more likely you'll encounter an issue.

Do not decide on a new tank mix during loading. Even if you've used these products successfully in the past, formulations change without notice. Plan as much as possible off season when there is time to do the following:

Consult the Pesticide Labels

Pesticide labels are always the first point of reference. They should be obeyed even if they contradict conventional practices. Booklet-style labels that come with the products are long, difficult to search and may not be up-to-date.

In Canada, it is faster and easier to go to the PMRA Label Search website and search labels in PDF format. In other countries, consult the manufacturer's website for label information. For each tank mix partner, use <CTRL>+F to find the following keywords:

- Do Not Mix
- Mix
- Hours
- Agitation
- Fertilizers

Consult Manufacturer and Crop Advisors

It's likely you are not the first to consider a certain tank mix. You can learn lessons from others

- Consult your chemical sales representative. They know their products best and want to see you succeed. They may have insight that is not found on the product label.
- Consult local government or academic extension programs for an unbiased opinion.
- Enlist the help of a professional crop advisor.
- Be wary of advice obtained from other growers at coffee shops

It is a good practice to get tank mix recommendations in writing. If something should go wrong, liability is an important concern.

If you are considering mixing partners not listed on the label, beware that local regulations may or may not permit you to do so. When there is no information available, or when labels contradict or are silent, it is best to perform a jar test for physical compatibility.

When You've Made a Mess

It happens. We'll use this real-world situation as an example:

> *"I mixed up a batch of MCPA 500 A and Glyphosate at ¾ recommended label rate, but then got delayed on application with a stuck drill. I came back to the sprayer and found a nasty chemical precipitate – like waxy chunks. Agitation didn't break them down. I dumped the tank out as I didn't want to pump it through the booms. How do I clean up the chunks in the system?"*

We forwarded this question to ag chemists Dr. Eric Spandl (Land of Lakes) and Dr. Jim Reiss (Precision Laboratories) and developed this response:

> *"Wearing appropriate personal protective equipment, physically remove the "chunky" material. A lot of time can be wasted (and rinsate water created) by experimenting with various concoctions, but if you do choose to try a compatibility agent, first try it in a mason jar. If it works to dissolve the material, it can be added to the tank with water and agitated. If not, you are down to manual cleaning: hot water under pressure."*

We dubbed this process "The Reverse Jar Test". Do not add hot water, cleaners or compatibility agents until the reverse jar test confirms success. You may create a larger problem. Of course, the best advice is to not put yourself in this position to begin with. Don't make mixing decisions at the inductor bowl – make them before ordering product.

For more information

Even when products are potentially compatible, issues can arise from errors in mixing order, pace, carrier volume, carrier quality and agitation. These are discussed in the https://sprayers101.com/loading-jartest/ article on loading and jar testing. Be sure to download a copy of Purdue University's 2018 "Avoid Tank Mixing Errors" https://ppp.purdue.edu/wp-content/uploads/files/PPP-122.pdf . It is an excellent reference.

Postharvest

Risk of Chilling Disorders in Apples for 2019-20 Storage Season

Dr. Jennifer DeEll, Fresh Market Quality Specialist - Hort Crops, OMAFRA

CIPRA is a computer-based program developed by the research team of Dr. Gaétan Bourgeois (AAFC-QC) that uses weather data to predict the risk susceptibility of apples to specific storage disorders (Bourgeois, DeEll, and Plouffe). According to the CIPRA model, there is

some risk of chilling-related disorders developing this storage season, using weather data from Simcoe (Norfolk County), Ontario. This risk level is just over 10% (Figure 1), based on weather until September 17, 2019.

Regardless of growing season and annual risk susceptibility, it is important to use the recommended storage temperatures and regimes for specific apple cultivars. 'Honeycrisp', 'Empire', and 'McIntosh' are especially susceptible to chilling-related disorders (i.e. soft scald, soggy breakdown, flesh browning, low temperature breakdown, core browning) and therefore, symptoms can develop by using lower than optimum storage temperatures in any year. Late harvested apples are also more prone to developing chilling-related disorders, such as flesh browning in 'Empire' or soft scald and soggy breakdown in 'Honeycrisp'.

At the time of writing, there has already been soft scald found this season in 'Honeycrisp' stored below the recommended temperature of 3°C, as well as in those without conditioning at 10°C prior to storage at 3°C.

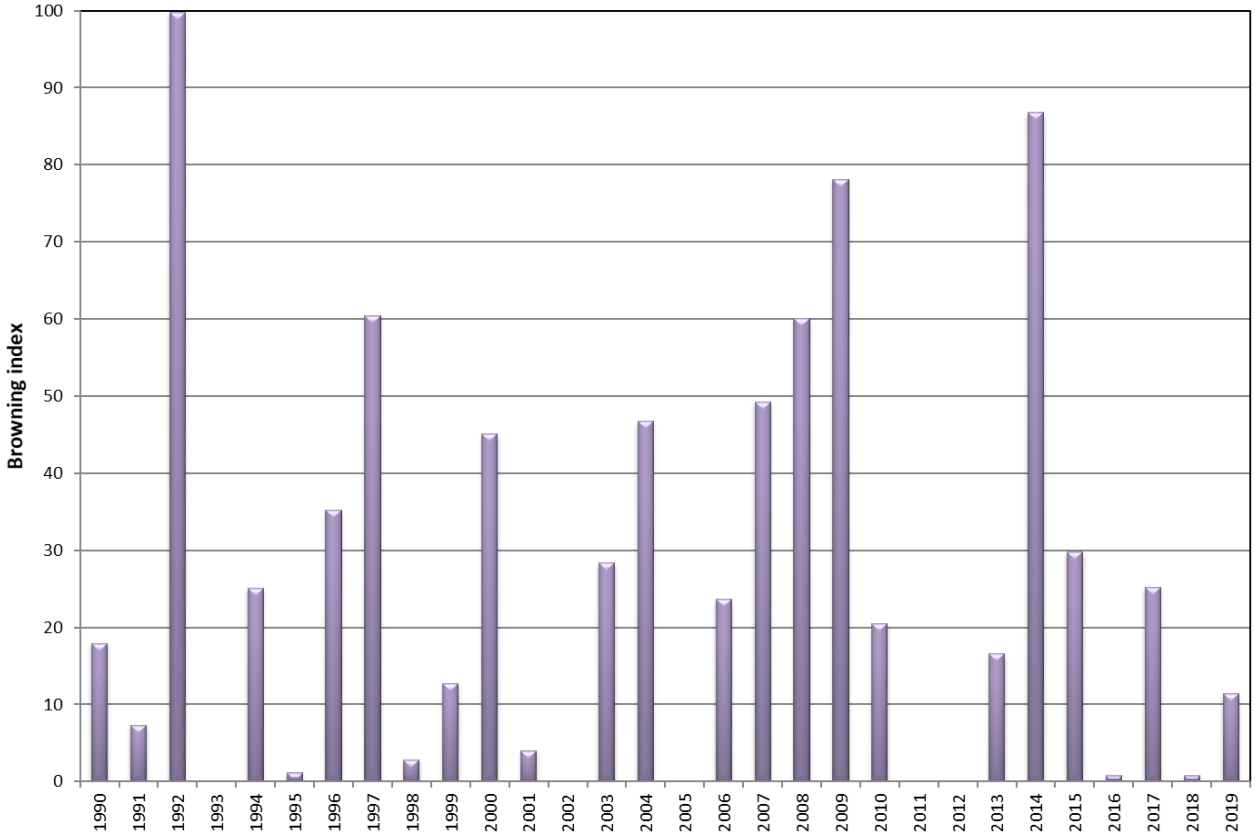


Figure 1. Risk of developing chilling-related disorders during the past 30 years (1990-2019), for the region of Simcoe (Norfolk County), Ontario.

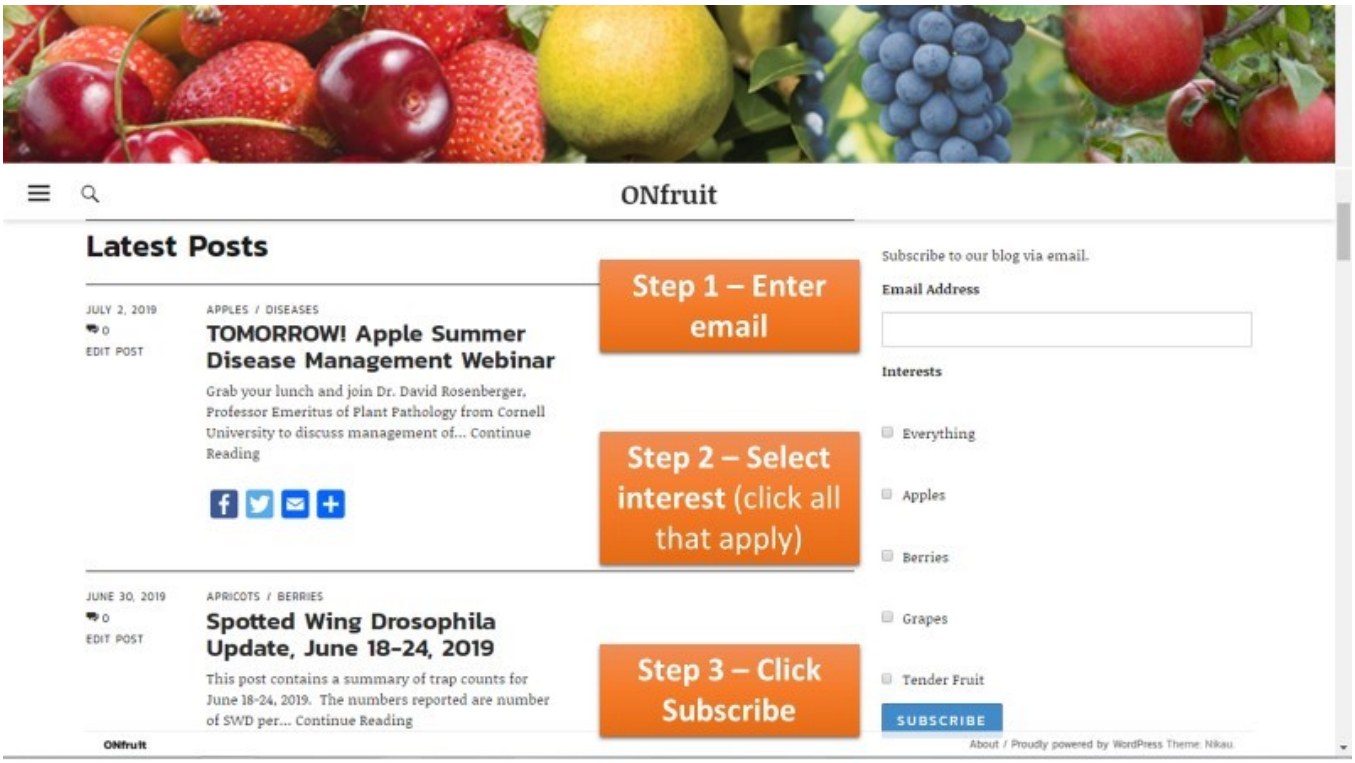
* Graph supplied by D. Plouffe, AAFC-QC

Announcements

Did you know you can modify your ONfruit subscription to receive just apple-related information?

ONfruit currently offers a range of production and pest management information for a variety of fruit crops grown in Ontario. Followers who subscribe to receive email notifications when a new blog is posted can now update their preferences to get timely information specific to only the crop groups (i.e., apples, berries, grapes, tender fruit) they are interested in.

Whether a new or existing subscriber, simply enter your email in the subscription bar on the ONfruit homepage. Select all crops you would like to receive email notifications for when new information is posted. If you are interested in all the information ONfruit has to offer, select “Everything”. Once finished selecting crops, click “Subscribe” to complete your profile. Existing accounts will be automatically updated.



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

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