

9. Organic and Biopesticide Products

Organic and Biopesticide Products

Organic pest control products are pesticides that are approved for use in organic production. Both the active ingredient and all additional ingredients must be derived from natural sources, which are typically biological or botanical.

Organic products and biopesticides are no different from other pesticides in that they must be registered by the federal Pest Management Regulatory Agency and classified by the Ontario Ministry of the Environment and Climate Change. Additionally, all organic pest control products must meet the requirements of the Canadian Organic Standards and any additional requirements of the local organic certification body. Products in Table 9–1, *Organic and Biopesticide Products Used on Fruit Crops*, page 281, may be acceptable to some, but not all, certifying bodies. Growers must confirm that products are acceptable to their organic certifier.

Biopesticides are pest control products derived from natural materials such as animals, plants, and bacteria. In Canada, biopesticides are divided into two major classes: microbial and biochemical pesticides.

- *Microbial pesticides* contain a beneficial bacterium, fungus, virus or protozoan as the active ingredient. They are relatively specific to their target pest. Examples include the various subspecies and strains of *Bacillus thuringiensis*.
- *Biochemical pesticides* are naturally occurring substances and/or manufactured molecules that resemble naturally occurring substances. They generally control pests by different mechanisms than conventional pesticides, such as disrupting insect mating (e.g., Isomate) or by making crops unsuitable for feeding (e.g., Surround). While many biopesticides are less toxic and pose a lower risk than conventional pesticides, some may be quite toxic.

Not all biopesticides are organically acceptable and not all organic products are biopesticides. In some cases, the active ingredient may be organic, but it may be formulated with other ingredients that are not acceptable for organic production (e.g., some formulations of the bacteria *Bacillus thuringiensis*).

Similarly, there are organic pest control products that do not meet the definition of a biopesticide (e.g., copper).

Pest Management in Organic Production

Pest management in organic fruit production involves the use of numerous control strategies aimed at preventing pest problems before they appear. In organic production, pest control products should be used as a last resort, only when other management practices have not been sufficient to prevent the pest from causing economic damage to the crop.

Cultural controls

Cultural controls are practices that make the cropping environment less favourable to the development of pests, including:

- *Site selection* – Choose sites less favourable for pest development.
- *Crop rotation* – Plant non-related crops in successive years to minimize the chance of plant-specific pests building up in the soil.
- *Cover crops* – Use cover crops to add organic matter, improve soil structure, or reduce pest populations, depending on the type of cover crop. See *Cover Crops and Building a Healthy Soil*, page 23, for more detail.
- *Resistant varieties* – Some varieties can be more tolerant in their response to pests. When available, select varieties known to be resistant to the particular pests present in your area.
- *Crop health* – Keep the crop healthy by maintaining optimum nutrition, plant moisture levels, plant population densities and soil conditions to help plants resist or tolerate pests.
- *Adjust planting or harvest dates* – If you know the biology of the pest attacking your crop, schedule planting or harvest to avoid damage.
- *Sanitation* – Remove material (e.g., weeds or plant debris) that allows pests to survive or be transported between plants or crop. Plant only high quality nursery

material known to be free of insects and diseases. Take appropriate measures to avoid transferring pests between plants or fields on contaminated tools, farm equipment or worker clothing.

- **Crop diversity** – A wide variety of plants grown in a small location can impede the movement of flying insects or the spread of disease, as well as provide a habitat for beneficial insects. This can be achieved by intercropping, farmscaping or other methods.
- **Trap crops** – Keep insect pests out of the crop by planting preferred hosts along borders or between crop rows. Make sure to manage trap crops to prevent movement of the pest back into the commercial crop.

Mechanical controls

Mechanical control methods physically remove the pest or otherwise prevent it from injuring the crop. These can be effective but have a high cost. Choose methods appropriate to the crop situation and scale of production.

- **Physical removal** – Physically remove pests by hand, dislodge them with strong jets of water, prune diseased plant parts, use vacuums or other means.
- **Mulches** – Use covers (wood chips, fabrics, plastics, etc.) on the soil surface to help for weed control, or in some cases to deflect certain insects.
- **Row covers or other barriers** – Construct barriers around and over plants to help protect them from pest attack.

Biological controls

Biological control involves using natural enemies (or “beneficials”) to help suppress the pest. These may be predatory insects, parasites, pathogens or nematodes.

- **Promoting beneficial insects** – Promote and attract natural enemies by providing them with favourable habitat and avoid pesticides that negatively affect them.
- **Augmentation** – Release of natural enemies into a crop for biological control has been very successful in greenhouses. This method may have less value in crops grown outdoors where it is difficult to contain introduced natural enemies.

While use of these strategies to prevent pest problems is a requirement for organic producers, they are also the basis for integrated pest management in any production system. More information can be found on the OMAFRA website at ontario.ca/crops.

Organic and Biopesticide Products in Conventional Production

While organic and biopesticide products are used most widely by organic producers, they can be a useful tool for conventional growers as well. Advantages of using these tools in conventional production could include:

- lower potential for pest resistance
- providing a rotational option to help manage resistance development to other conventional products
- shorter re-entry intervals
- shorter preharvest intervals
- potentially lower toxicity to non-target organisms

Organic products and biopesticides may not provide the same high level of control as conventional pesticides. Biopesticides are often labelled for suppression, or partial suppression, of pests (see Table 11–1. *Pesticide Efficacy Ratings*, page 309). To improve control, combine their use with the pest control tactics mentioned in the previous section.

Using Organic and Biopesticide Products

Although many organic and biopesticide products are formulated, packaged and applied in a very similar fashion to conventional pesticides, the active ingredients are different. They have unique, specialized modes of action which make them more susceptible to numerous biological and environmental factors.

Some of the possible challenges associated with using these products are:

- more frequent applications needed to control pests
- slower action than conventional pesticides
- may provide suppression but not control of the pest
- more expensive than conventional pesticides
- fewer pests controlled

Table 9–1. *Organic and Biopesticide Products Used on Fruit Crops*, page 281, provides details on important factors that affect the success of these pest control products. Knowing the specific requirements for these products can improve the success of their use.

Most organic pest control products fall under class 3 or 4 of the Ontario Pesticides Advisory Committee’s (OPAC) classification system. In order to purchase or use class 3 products in Ontario, you must take the Grower Pesticide Safety Course and become a Certified Farmer. For more information, see the Ontario Pesticide Education Program website, www.OPEP.ca.

Table 9–1. Organic and Biopesticide Products Used on Fruit Crops

Products listed as potentially acceptable for organic use are those included in:

- (1) the Canadian database of brand name inputs for organic production (www.organicinputs.ca)
- (2) the 2013 Atlantic Canadian Organic Regional Network (ACORN) directory of organic inputs (www.acornorganic.org/index.html)
- (3) the Organic Materials Review Institute (OMRI) Canada (www.omri.org/omri-canada) product list or
- (4) the list issued by the Réseau d'avertissements phytosanitaires, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) (www.agrireseau.qc.ca/documents/Document_90106.pdf).

This information does not replace that included in product labels. Always check the label before use.

These products may not be accepted by all certifying bodies. Organic growers must always check with their certifying bodies to verify the acceptability of any product listed below prior to using it.

Product Name (Registration No.)	Potentially Organic/ Biopesticide ¹	Ontario Class ²	Labelled Crops ³	Spray Timing	Limiting Environmental Effects ⁴	Comments
Insect/Mite Controls						
<i>Bacillus thuringiensis (Bt)</i>						
Bioprotec CAF (26854)	O, B	3	CG 13-07, apple, apricot, cherry, grape, peach (Bioprotec only), pear, plum, pecan, sweet chestnut, walnut, hazelnut	young larvae, early infestation	UV, rain	Spray water pH should be less than 8. Agitate during spraying. Must be ingested by insect to be effective. Spray when and where pests are actively feeding. Death may take several days. Spray mix should be used within 12 hours (Dipel) or 18 hours (Bioprotec, Foray). Store between 4°C–15°C (Bioprotec) or 0°C– 25°C (Foray, Dipel) and use within 12 months (Bioprotec, Foray) or 24 months (Dipel) of date of manufacture.
Dipel 2X DF (26508)	O, B	4				
Foray 48 BA (24978)	NL, B	4	apple, blueberry, pear, raspberry			
<i>Cydia pomonella granulovirus</i>						
CYD-X (30120)	NL, B	3	apple	eggs/young larvae	UV, rain	Must be ingested to be effective — apply where/when larvae are feeding. Sprays are only effective for about 1 week. To increase effectiveness, use with other methods, such as mating disruption, or use with other insecticides. Use non-chlorinated water at pH near 7 in spray tank. Store product at 4°C and use within 3 months (Virosoft) or 1 year (CYD-X) of date of manufacture.
Virosoft CP 4 (26533)	O, B	4				
Ferric phosphate						
Sluggo Professional (30025)	O, B	4	fruits and berries	when slugs are active	rain	Apply to soil that is moist but without standing water. Irrigate very dry soil prior to application. Apply in the evening to areas likely to be infested with slugs and snails (e.g., damp areas). Use high rate with heavy rain or irrigation. For trees, apply with standard granular fertilizer spreaders. For berries, apply by hand or with granular spreaders to furrows near base of plants. Do not place in piles.

¹ O = Products that may be acceptable for use by organic growers, as indicated by lists described above. (Always confirm status with certifying body prior to using product). NL = Product is currently not included on organic lists described above. B = Product is considered a biopesticide in Canada.

² See Table 11–8. *Pesticide Classification Schedules in Ontario: Classes 2, 3 and 4*, page 331.

³ Labelled Crops = Fruit crops included on product label. See Appendix C: *Crop Groupings for Pesticide Registrations in Canada*, page 337, for a full listing of crops within each crop group (CG).

⁴ UV = Active ingredient may be inactivated/broken down by sunlight or is more effective when conditions favour slow drying. Spray in early morning, early evening or when cloudy. Rain = Efficacy is reduced or product is readily washed off by rain. Avoid application when significant rainfall is imminent or do not apply to foliage wet to the point of runoff. Heat = Short residual activity under hot, dry conditions. — = Information is not available.

Table 9–1. Organic and Biopesticide Products Used on Fruit Crops (cont'd)

Product Name (Registration No.)	Potentially Organic/ Biopesticide ¹	Ontario Class ²	Labelled Crops ³	Spray Timing	Limiting Environmental Effects ⁴	Comments
Insect pheromones						
Isomate CM/OFM TT (29352)	O, B	4	apple, pear, walnut	prior to adult activity	—	Store product at 4°C until use. Pheromones have specific instructions for use which depend on target pest and crop. See section on <i>Mating Disruption in Fruit Crops</i> , page 290.
Isomate DWB (30589)	NL, B	4	apple, hazelnut, pear, pecan, sweet chestnut, walnut			
Isomate-GBM Plus (27525)	O, B	4	grape			
Isomate OFM TT (31419)	NL, B	4	apple, apricot, cherry, peach, pear, plum			
Isomate-PTB Dual (30042)	O, B	4	apricot, cherry, peach, plum			
Semios OFM Plus (31718)	NL, B	3	pome and stone fruits	prior to adult activity with continued use through the growing season		Canisters for use only with Semios automated aerosol dispensers. Hang dispensers in upper third of canopy with nozzle facing away from foliage and fruit. Evenly place dispensers at an average density of 2.5 dispensers per hectare. Use higher densities (up to double the standard density) at the orchard edge facing the prevailing winds. Under typical dispensing rate, canisters should last for approximately 160 days. For more information regarding the installation or application, contact info@semios.com.
Kaolin clay						
Surround WP (27469)	O, B	4	apple, grape, hazelnut, pear, pecan, raspberry, stone fruit (most of CG 12-09), strawberry, sweet chestnut, walnut	early infestation	rain	Efficacy depends on complete coverage of leaves and fruit. Light to moderate rain will help distribute product. Re-application may be necessary after heavy rain, wind, overhead irrigation or new growth. Do not spray when bees are active. Surround deposits create a white film on plant parts — stop applications once fruit is sizing unless the crop will be washed and waxed. May delay sugar accumulation. Monitor closely to determine best time for harvest. Do not apply postbloom to table grapes. Do not use with anti-foaming agents, white mineral particulate products, spreader/stickers or summer oils.

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Product Name (Registration No.)	Potentially Organic/ Biopesticide ¹	Ontario Class ²	Labelled Crops ³	Spray Timing	Limiting Environmental Effects ⁴	Comments
Mineral oil						
Purespray Green Spray Oil 13 E (27666)	O	4	apple, apricot, berries (most of CG 13-07), cherry, chestnut, hazelnut, peach, pear, plum	early infestation	rain	Product must cover pest to be effective. Thorough coverage is essential. Oils may cause plant injury — follow labels carefully for precautions. Mixture must emulsify (indicated by white colour) to be effective. Do not use within 48 hours of freezing temperatures or when temperatures are above 25°C. Due to phytotoxicity concerns, there are many restrictions regarding the use of oils with products such as Bravo, Echo, Captan, Maestro, Folpan, Cygon, Lagon and sulphur products. See product labels for specific restrictions for each crop and product.
Superior 70 Oil (14981)	O	4	apple, apricot, highbush blueberry, grape, pear, peach, plum, tart cherry			
Potassium salts of fatty acids (insecticidal soaps)						
Opal (28146)	O	4	fruit trees (including apple, apricot, cherry, peach, pear, plum), nut trees (including hazelnut and walnut), small fruit (including blueberry, grapes, raspberry, strawberry, cranberry)	early infestation	UV	Agitate tank mixes during spray. Product must contact pest directly to be effective and has no effect once spray deposits have dried. Thorough coverage is essential. Repeat applications may be needed. Do not allow soap to accumulate at base of fruits. Do not mix with Manzate or Dithane. Do not use within 3 days of sulphur. Do not apply to stressed plants. Use with care on blooms.
Pyrethrin						
Pyganic EC 1.4 II (30164)	O, B	4	blueberry, grape, raspberry	early infestation	UV	Do not use when bees or other beneficials are present. Product has short residual activity — repeat applications may be required after 7 days. Apply in early morning or late evening. Adjust spray solution to pH of 5.5–7.0 and avoid tank- mixing with other products that can affect spray mix pH.
Spinosad						
Entrust (30382)	O, B	4	CG 11 (except loquat and mayhaw), CG 12 (except plumcot), CG 13-07A, 13-07B, 13-07G, grape, walnut	depends on pest — see label	UV	Product kills primarily by ingestion so coverage is important. Do not use when bees are present.
Success (26835)	NL, B	4	CG 11 (except loquat and mayhaw), CG 12 (except plumcot), CG 13-07A, 13-07B, 13-07G, grape			

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Product Name (Registration No.)	Potentially Organic/ Biopesticide ¹	Ontario Class ²	Labelled Crops ³	Spray Timing	Limiting Environmental Effects ⁴	Comments
Spinosad + bait						
GF-120 Fruit Fly Bait (28336)	O, B	4	apple, blueberry, cherry, walnut	adult trap catch	rain, heat	Do not use when bees are present. Large droplet sizes optimize the attractiveness of the bait. Apply using an all-terrain vehicle fitted with an appropriate sprayer and nozzle to ensure large drops. Re-apply every 7–10 days or after rain.
Disease Controls						
<i>Aureobasidium pullulans</i> strains DSM 14940 and 14941						
Blossom Protect (30552)	O, B	3	CG 11-09	1–2 days before infection risk	—	Rate is dependent on tree height — for every 1 m of tree height, mix 5.25 kg of Component A in 500 L water and add 0.75 g Component B. Apply 500 L spray solution per ha for every 1 m of tree height. See label for details. May increase fruit russetting on sensitive varieties if applied more than 2 times. Do not tank-mix or apply within 2 days of captan, dodine, strobilurin or copper fungicides, as these are toxic to the yeasts. Use in rotation with streptomycin to reduce risk of resistance. Store product up to 10 months at room temperature (20°C) or up to 24 months at 8°C.
Botector (31248)	O, B	3	grape	preventative — see label for timing	heat	Keep water temperatures of spray mix below 25°C and use spray mix within 8 hours of preparation. Do not tank-mix or apply within 2 days of Flint, Kumulus, Quadris, Switch or certain other fungicides (see www.bio-ferm.com for full list). Store product up to 10 months at room temperature (20°C) or up to 24 months at 8°C. Apply during cool temperatures.
<i>Bacillus amyloliquefaciens</i> strain D747						
Double Nickel 55 (31888)	NL, B	3	apple, grape, pear, strawberry	when conditions favour disease development	—	Mix product in cool water in a tank that has been cleaned prior to use. Maintain a spray mix pH of 6–8. Maintain agitation during mixing and application and apply immediately after mixing. Do not allow spray mix to stand overnight. Store away from direct sunlight at 4°C–25°C for up to 1 year.
<i>Bacillus subtilis</i>						
Serenade MAX (28549)	O, B	4	CG 11, CG 12, CG 13A, CG 13B, grape, saskatoon berry, sea buckthorn, strawberry	early disease development	—	May not provide complete control — use in conjunction with other cultural or chemical controls. When conditions are conducive to high disease pressure, rotate with other fungicides.
Serenade OPTI (31666)	NL, B	3				

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Table 9–1. Organic and Biopesticide Products Used on Fruit Crops (cont'd)

Product Name (Registration No.)	Potentially Organic/ Biopesticide ¹	Ontario Class ²	Labelled Crops ³	Spray Timing	Limiting Environmental Effects ⁴	Comments
BLAD polypeptide						
Fracture (31782)	NL, B	4	apricot, cherry, grape, nectarine, peach, plum, strawberry	depends on pest and crop, see label	rain	Requires 2–4 hours drying time for active ingredient to absorb into plant. If significant rain follows application, re-apply within 4 days. Maintain agitation of spray mix and do not store mixture overnight. Do not mix with foliar fertilizers. Use within 12 months of date of manufacture.
Citric acid + lactic acid						
Tivano (30468)	O, B	4	grape, strawberry	when conditions favour disease development	—	Use the minimum spray volume to obtain full coverage on both sides of the leaves (e.g., minimum 120 psi, ConeJet nozzles). Spray quality should be very fine. Coverage can be improved by using a non-ionic surfactant. Use preventatively or in rotation with other fungicides. May cause injury to other plants if not mixed or applied according to label instructions.
Copper products (copper sulphate, copper oxychloride, copper hydroxide)						
Copper 53 W (9934)	O	3	See Table 9–2. <i>Copper Products for Use on Fruit Crops</i> , page 295	preventative	—	Copper products are non-systemic and have no effect on pathogens that have already invaded plant tissue. Repeat applications will be required to protect new growth. For detailed instructions on using copper, see the section on copper products, starting on page 294.
Guardsman Copper Oxychloride 50 (13245)	O	3				
Copper Spray (19146)	O	4				
Cueva (31825)	NL	4				
Kocide 2000 (27348)	NL	3				
Garlic powder						
Buran (30601)	O, B	3	apple, grape, pear	early disease development	rain	Time applications for after rain or periods of prolonged leaf wetness, when conditions are conducive to disease development. Repeated applications and thorough coverage required for efficacy. For apple scab, apply at green tip to tight cluster for primary infections and systematically for secondary infections. Store product between 4°C –20°C. Cooler temperatures within this range are preferred. This is a new product in Ontario and little evidence of its efficacy is available.

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Product Name (Registration No.)	Potentially Organic/ Biopesticide ¹	Ontario Class ²	Labelled Crops ³	Spray Timing	Limiting Environmental Effects ⁴	Comments
Lime sulphur						
Lime Sulphur (16465)	O	4	apple, blueberry, gooseberry, grape, pear, peach, raspberry, strawberry	delayed dormant and preventative	—	Do not spray when foliage is wet. Thorough coverage is essential. May cause leaf damage, particularly when applied at calyx or early summer. Also labelled for scale/mite control and general clean up on some fruit crops.
Mineral oil						
Purespray Green Spray Oil 13 E (27666)	O	4	apple, apricot, cherry, currant, elderberry, gooseberry, grape, jostaberry, peach, plum, nectarine, raspberry, saskatoon berry, strawberry	at first sign of disease	rain	See comments for mineral oil under <i>Insect/Mite Controls</i> on page 282.
Oriental mustard seed meal						
MustGrow (30263)	O, B	3	CG 11-09, CG 12-09, CG 13-07, CG 14-11	early spring when soil is cool but above 10°C	—	Allow at least 2 weeks between treatment and planting. Incorporate into upper layer of soil to a depth of 10–15 cm and follow with irrigation to activate product.
<i>Pantoea agglomerans</i>						
Bloomtime Biological FD (28436)	O, B	4	apple, pear, raspberry, saskatoon berry	first spray at 15%–20% bloom	—	Thorough coverage is important. Do not use close to copper sprays. Repeated applications will likely be required. Store product between -10°C–0°C.
Potassium bicarbonate						
MilStop (28095)	O, B	4	apricot, grape, peach, plum	at first sign of disease	rain	Use high rate and shorter intervals when conditions are conducive for disease development. Do not acidify spray solution or adjust pH after preparing spray mix. Do not mix with other chemicals that are not compatible with mild alkaline solutions, or add surfactants or wetting agents. Thorough coverage is essential. Short residual — repeat applications may be required.
Sirocco (31091)	O, B	4				
<i>Pseudomonas syringae</i>						
Bio-Save 10 LP (29673)	NL, B	4	apple, cherry, pear	postharvest within 24 hours of harvest	—	Apply after harvest as an aqueous dip, drench or spray after washing and rinsing but prior to waxing. Thorough coverage is essential. Agitate suspension during application. Store up to 3 weeks at 23°C or up to 1 year at 4°C.
<i>Reynoutria sachalinensis</i> extract						
Regalia Maxx (30199)	O, B	3	apple, highbush blueberry, grape, strawberry,	when conditions favour disease development	—	Use higher rate and shorter intervals when conditions are conducive for disease development. Repeat applications may be required. For grapes, do not use as a solo powdery mildew product from prebloom through berries pea-sized stage — use 0.125% in a tank-mix or rotation with other powdery mildew fungicides.

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Product Name (Registration No.)	Potentially Organic/ Biopesticide ¹	Ontario Class ²	Labelled Crops ³	Spray Timing	Limiting Environmental Effects ⁴	Comments
<i>Streptomyces lydicus</i>						
Actinovate SP (28672)	O, B	4	blueberry, grape, strawberry	when conditions favour disease development	rain	Use higher rates or shorter intervals when conditions are conducive for disease development. Use spray mix within 4 hours of preparation. Do not combine with other pesticides (especially bactericides), adjuvants, surfactants or fertilizers. Thorough coverage is essential. Repeat applications every 7–14 days. Can be stored at room temperature but should not be frozen or exposed to high temperatures.
Sulphur						
Kumulus DF (18836)	O	4	apple, cherry, grape, pear, peach, plum, saskatoon berry	—	—	Sulphur can be phytotoxic under certain conditions. Do not use on sulphur-sensitive varieties. Do not use when high (>25°C) temperatures are expected during the 3 days after application. Be cautious when using sulphur products close to sprays of certain other pesticides, such as oils or copper — refer to product label for specific instructions. Some product labels also list control of certain mite or scale pests on some crops.
Microscopic Sulphur (14653)	O	4	apple, cherry, currant, gooseberry, grape, peach, pear, plum	prior to or at first sign of disease development	—	
Microscopic Wettable Sulphur (873)	O	4	apple, cherry, grape, peach, pear, plum	—	—	
Microthiol Disperss (29487)	O	4	apple, cherry, grape, peach, pear, plum, saskatoon berry	—	—	
Tea Tree Oil						
Timorex Gold (30910)	O	3	grape, strawberry	early stage of disease development	—	Thorough coverage and wetting of foliage is required — use sufficient spray solution to completely penetrate canopy. Thoroughly agitate spray mix before application and use solution within 24 hours.

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⁴ UV = Active ingredient may be inactivated/broken down by sunlight or is more effective when conditions favour slow drying. Spray in early morning, early evening or when cloudy. Rain = Efficacy is reduced or product is readily washed off by rain. Avoid application when significant rainfall is imminent or do not apply to foliage wet to the point of runoff. Heat = Short residual activity under hot, dry conditions. — = Information is not available.

Organic and Biopesticide Products for Insect Control

Bacillus thuringiensis var. *kurstaki* (Bioprotec CAF, Dipel 2X DF, Foray 48 BA)

Bacillus thuringiensis products are registered for control of various caterpillars, including leafrollers and fruitworms. The active ingredients in these products are proteins produced by the bacteria *Bacillus thuringiensis*, or *Bt*. *Bt* is commonly found in soil, dead insects, plants and other locations. There are many subspecies, and some have proteins that are toxic to specific groups of insects. The *kurstaki* subspecies is toxic only to caterpillars, although it is not equally effective against all species of caterpillar. Insects affected by *Bt* stop feeding within a few hours and die in 2–5 days.

Because the product must be consumed, thorough coverage is essential. Evening applications may be particularly important if the target pest feeds predominantly at night. Younger larvae are more susceptible to these products. These products have short residual activity, so repeat applications will often be required. Do not apply in high volumes of water, use the least amount of water required to get good coverage on both sides of the leaf.

Crop-specific strategies

Apple – Due to their photosensitivity, *Bt* products are often used early in the season prior to petal fall. However, they can be used later in the season to manage obliquebanded leafroller where populations are low.

Grape – When hatching, larvae must consume eggshell treated with *Bt* in order for the product to be effective. Apply *Bt* to coincide with grape berry moth egg hatch, earlier than the traditional timing for organophosphate and pyrethroid insecticides.

Cydia pomonella granulovirus (CYD-X, Virosoft CP 4)

The *Cydia pomonella* granulovirus is a naturally occurring pathogen which is highly specific to codling moth larvae. Ingested virus particles invade the gut wall, attacking and degrading the insect's tissues. The insect eventually stops feeding and dies 2–5 days later. Since larvae must ingest the virus to be infected, damage to fruit may occur before the insect dies.

Apply granulovirus when young larvae either are on the surface of the fruit or will encounter the virus before entering the fruit. The best method is to have the virus present on the eggs, so the virus particles are consumed as the codling moth larvae hatch. If granulovirus is to

be the only control, apply the first application at 139 DDC, base 10°C after biofix (first sustained moth catch), followed by subsequent applications to cover the egg hatch period.

These products are most effective when used in conjunction with other materials. One option would be to apply a chemical insecticide at the start of egg hatch (139 DDC, base 10°C after biofix), with the virus serving as the second spray, when more eggs are present to be covered by the virus. Follow this with another rotation of insecticide and virus, or simply with additional applications of the virus.

Another option is to target only the first generation with the virus product. Although some virus-infected larvae will not die immediately, very few of these larvae will actually pupate and emerge as summer generation adults. Using this active ingredient for the first generation greatly reduces the size of the summer generation, which can be controlled with other pesticides.

Ferric phosphate (Sluggo Professional)

Sluggo Professional is registered for control of certain species of slugs and snails in fruit and berry crops. It consists of the active ingredient ferric phosphate, a compound commonly found in soils, formulated in a bait. When snails or slugs eat the bait, the active ingredient damages their digestive tissue, causing them to rapidly stop feeding, and die within 3–6 days.

Kaolin clay (Surround WP)

Surround WP is based on kaolin clay, a non-toxic compound which protects crops from certain insects, heat stress and sunburn by coating plant surfaces with a white particle barrier film. This barrier repels and disorients insects, making the host plant unrecognizable for feeding.

Crop-specific strategies

Apple – In orchards treated with Surround, use starch iodine tests to monitor fruit maturity in the last 2 weeks of crop development. Check with your packer before using Surround on fruit for export to Europe. Applications at petal fall may interfere with leaf miner parasitism, requiring additional control measures.

Grape – Surround may delay sugar accumulation. Closely monitor harvest parameters to determine optimal time to harvest.

Raspberry and Strawberry – Avoid application when fruit is present. Surround is most useful for potato leafhopper control in non-bearing plantings.

Mineral oil (Purespray Green Spray Oil 13 E, Superior 70 Oil)

Mineral oil is a highly refined petroleum product that is different from dormant oil. Purespray Green Spray Oil 13 E is also registered for the control or suppression of certain diseases. Mineral oil acts as an insecticide/miticide by suffocation and is effective only when the film deposited covers every scale or mite. Eggs are most vulnerable to control with oil just before hatching.

Oils may cause plant injury when they are applied in conjunction with certain chemicals or conditions. There are restrictions regarding the use of oils with products such as Bravo, Echo, Captan, Maestro, Folpan, Cygon, Lagon, and sulphur products, or under environmental conditions that may cause plant stress (e.g., extreme cold or heat). See product labels for specific restrictions for each crop and product.

Crop-specific strategies

Apple – Bark injury caused by oil may occur on Red Delicious, Empire and Mutsu. Oil will provide control of overwintering European red mite (ERM) and suppression of summer populations of ERM and powdery mildew.

Grape – Oil provides significant eradicant activity against existing infections. However, this product works strictly by contact, hence thorough spray coverage is essential.

Do not tank-mix oil and copper more than once per season. Do not use copper and oil together when fruit is present. In research trials, 2 or more applications of oil near veraison have resulted in a modest but consistent lowering of Brix values (1°–2°) at harvest. In contrast, applications before this period generally have had no effect on Brix values.

Stone fruit – Oil may be used for cherry mildew management between petal fall and pit hardening. Do not apply between pit hardening and harvest. Certain varieties of plums and prunes may be injured by oil sprays. Check for tolerance prior to treatment. Do not apply oil to sensitive varieties. Do not apply to trees under moisture stress. Postharvest sprays may be made to maintain control and reduce overwintering powdery mildew pressure.

Potassium salts of fatty acids/Insecticidal soap (Opal)

Insecticidal soaps are registered for control of aphids, scale and other soft-bodied insects and mites. They work by coating the bodies of soft-bodied insects, smothering

them and interfering with their cuticles. Thoroughly cover all plant parts, including under leaf surfaces, where soft-bodied insects such as aphids are found. Apply these products when drying conditions are slow, in the early morning or evening, or when it is cloudy.

Insecticidal soaps often will not give complete control because it is difficult to cover 100% of the pests present in a crop. They are generally most effective when pest populations are low. Combine the use of insecticidal soaps with other pest management techniques (other chemicals or cultural controls).

Pyrethrins (Pyganic EC 1.4 II)

Pyganic is a botanical insecticide registered for control of aphids and leafhoppers. The active ingredient, pyrethrum, is a mix of compounds produced by chrysanthemums which act on the nervous system of insects, inducing paralysis. Pyrethrum is also the precursor to synthetic pyrethroid insecticides, which are widely used in conventional agriculture, but not permitted for organic. Unlike many other organic products, Pyganic is relatively broad-spectrum, and may have negative effects on beneficial insects as well as the target pest. However, Pyganic is also rapidly broken down by sunlight and thus has a short residual activity on plants, so it is considered less harmful to beneficials than conventional pyrethroids.

Spinosad (Entrust)

Entrust is registered in a number of fruit crops for control of various insect pests. Similar formulations (e.g., Success, Delegate) are not organically acceptable. The active ingredient, spinosad, is derived from the fermentation of the soil bacterium *Saccharopolyspora spinosa*, although further chemical modification occurs in the production of spinetoram. It kills susceptible insects by rapidly exciting their nervous systems, causing them to essentially die of exhaustion within 1–2 days of ingestion. Although it kills insects primarily by ingestion, it is partly taken up in leaf tissue, which enhances its effectiveness over time. Direct contact with spinosad is toxic to honeybees.

Spinosad + bait (GF-120 Fruit Fly Bait)

GF-120 is registered for control or suppression of various maggot pests. It is not considered a biopesticide, however, it is similar to a biopesticide in having a unique formulation that requires special consideration to optimize efficacy. The active ingredients are spinosad, which is derived from the fermentation of the soil bacterium *Saccharopolyspora spinosa*, plus a feeding attractant that serves as a bait to draw adult flies to the product. Because the bait attracts insects to the spray

deposits, only a small amount of insecticide is required. It has low toxicity to mammals and birds, but is toxic to adult flies of various pest species, exciting their nervous systems and causing death from exhaustion within 1–2 days of ingestion. Direct contact with spinosad is toxic to honeybees.

Crop-specific strategies

Apple – Research conducted in Ontario has shown suppression of apple maggot in organic orchards. However, GF-120 does not provide adequate management of this quarantine pest in orchards where there is zero tolerance for damage. Monitor apple maggot emergence using sticky traps and apply GF-120, at a rate of 1.5 L per 6 L water, after the first fly is caught. To improve efficacy, prune trees to ensure penetration of the product to the cooler, shaded inner canopy where its residual activity may be prolonged. Uniform spray coverage of foliage is not critical.

Blueberry – Begin application when first blueberry maggot flies are trapped, or when berries begin to turn blue (about 2–3 weeks before fruit begins to ripen). Repeat application at least every 7–10 days.

Cherry – Spray as soon as traps indicate flies are present or 2–3 weeks before ripening.

Mating Disruption in Fruit Crops

Insect pheromones formulated to reduce populations of certain pests are considered biopesticides by the Pest Management Regulatory Agency (PMRA).

Many female insects emit volatile chemicals known as sex pheromones to attract males of the same species. Mating disruption products release large quantities of synthetically produced sex pheromone into the crop atmosphere, which confuses male insects and interferes with mate location. Consequently, fewer larvae develop as mating is either delayed or prevented and crop damage is reduced.

Managing insects using mating disruption is very different from using insecticides. Mating disruption products are highly specific, targeting a single or few very closely related insect pests. They do not kill the target pest, nor will they control immigration of mated females from untreated or poorly managed areas. Mating disruption products must be applied before adults begin to fly. Late applications allow some mating to occur, with subsequent damage to the affected crop. Where pest populations are moderate to high, some mating will occur due to random chance encounters between males

and females. Mating disruption works most effectively where the target pest populations are low.

When applied to a block over multiple years, mating disruption products reduce overall population pressure so that insecticides may be reduced or, in some cases, eliminated.

The many advantages of using mating disruption products include improved safety to humans and non-target organisms, resistance management, and no re-entry or preharvest intervals.

Limitations include a requirement for large, regularly shaped blocks, low to moderate pest pressure, and the need for insecticides for other orchard or vineyard pests.

Wild or unsprayed hosts (i.e., wild grapes, abandoned orchards), poorly managed blocks, or areas with high pest pressure within 300 m of areas where mating disruption is used can be major sources of mated female moths. Moths moving from these sources into treated areas may significantly reduce the level of control achieved.

To overcome this problem:

- Treat entire blocks with pheromones or practise area-wide management to reduce border effects.
- Treat sources of OFM with a registered insecticide or with appropriate mating disruption products as permitted by the label. Treat border rows of the pheromone-treated block with a registered insecticide.

Supplementary applications of registered insecticides are advised when mating disruption is used in orchards or vineyards with high pest populations.

There are several mating disruption products available for use in orchards and vineyards. While general use strategies remain similar for each, some are more effective than others at keeping damage at or below economically acceptable thresholds. Mating disruption programs are not stand-alone strategies for all pests. Every orchard has different pest pressures, which affect the successful integration of mating disruption into IPM programs.

For more information, see OMAFRA Factsheet, *Mating Disruption for Management of Insect Pests*.

Mating disruption for oriental fruit moth (Isomate OFM TT, Semios OFM Plus)

There are two different types of products available for mating disruption of oriental fruit moth (OFM):

- Isomate OFM TT — fixed-point twin tubes, applied at high densities (125–250 per hectare) throughout a treated block
- Semios OFM Plus — automated canister aerosol dispensers (2.5–5 units per hectare) that release puffs of pheromone at timed intervals

Both dispenser types should be hung in the upper portion of the tree canopy. Regardless of which product is used, application/set-up should be done prior to moth emergence in the spring. Delayed applications will require the use of registered insecticides to manage the first generation. For best results, area-wide use of mating disruption products is encouraged.

Isomate OFM TT is a long-season product and there is no risk of the pheromone running out during the season of application. For well-managed orchards with a previous history of mating disruption, low population pressure and low economic damage from the targeted pests in the previous season, a minimum rate of 125 dispensers per hectare may be used. On the outermost border of the mating disruption area (outermost rows and trees at ends of rows) the rate should be doubled to the equivalent of 250 dispensers per hectare (100 dispensers per acre). For orchards under organic production or where significant injury was experienced in the previous season, apply 250 dispensers per hectare throughout the entire mating disruption area. Minimum block size is 4 ha. Research in Ontario demonstrated high rates of success in managing OFM using area-wide mating disruption.

For Semios OFM Plus, the typical dispensing rate is 1 puff every 15 minutes over a maximum of 12 hours per day (5PM to 5AM). Under typical dispensing rates, canisters last up to 160 days. Minimum recommended block size is typically 8 ha. For use only with Semios automated aerosol dispensers. For more information regarding the installation or application of Semios OFM Plus, contact Semios at info@semios.com at least 6–8 months prior to the planned use of this product.

If using mating disruption products for the first time, or in areas of high pest pressure, use an insecticide to manage the first generation of OFM. For late-harvest varieties located near untreated areas or host crops, application of insecticides may be required.

Monitor treated blocks with OFM pheromone traps to ensure moths are not being captured. Captured moths are a sign of some level of failure or weakness in the mating disruption program.

Routinely look for signs of damage from OFM. If unacceptable levels of damage have occurred, use

insecticides until the source of the failure has been determined.

For more information, see OMAFRA Factsheet, *Mating Disruption for Management of Oriental Fruit Moth in Stone and Pome Fruit*.

Mating disruption for codling moth and oriental fruit moth (Isomate-CM/OFM TT)

Mating disruption alone will not provide adequate control of codling moth (CM) in most commercial orchards. When used together with existing IPM programs, pest populations and pesticide use can be reduced over a number of seasons.

- During the first year of using mating disruption for CM, follow a standard spray program for both generations and monitor extensively for this pest.
- In the second year of a mating disruption program, and where populations are low, limit insecticides to the first generation.
- In subsequent years, use results from monitoring and damage assessments to determine if insecticide applications can be reduced further when mating disruption products are used.

Many of the new reduced-risk products and the granulovirus (Virosoft, CYD-X) work very effectively together to reduce CM populations to levels where insecticide use may be reduced in subsequent years.

Apply Isomate-CM/OFM TT (twin tubes) prior to CM emergence in the spring. Set dispensers in the upper third of the canopy, in a uniform grid. In older orchards interplanted with small numbers of replacement trees, bias the application to adjacent larger trees. In sections with large numbers of interplanted rows, insecticides may be required to supplement control from mating disruption.

The dispenser is designed to provide sufficient pheromone to control CM for the entire season and OFM for up to 90 days. While some OFM may have emerged prior to deployment of the dispensers, several petal fall insecticides have activity against this pest. Insecticides may be needed in late varieties when high OFM populations exist or when immigration from untreated blocks late in the season may occur.

Monitoring for codling moth flight in mating disruption blocks

Codling moth populations in disrupted orchards must be monitored to determine pest pressure and the need

for supplemental insecticides. Because of the high concentration of pheromone used for mating disruption, traps loaded with standard lures are not effective and specialized lures are needed. The industry standard is the CM DA Combination Lure, which contains a chemical extracted from ripe pears to attract both male and female codling moths. These lures last up to 8 weeks.

Traps should be placed in the upper third of the canopy in disrupted blocks (same height as the mating disruption dispensers). Use a minimum of 1 trap per hectare, with traps located near high-risk areas and borders (5–6 rows in).

Thresholds for the application of insecticides are based on the number of moths captured per trap per week in disrupted blocks. As a general guideline, 3–5 moths per trap per week indicate a need for caution. More than 5 moths per trap per week indicate the need for insecticides to supplement control from mating disruption. Do not average the number of moths per trap per week. Trap captures are an indication of potential local hot spots where intervention may be required.

Damage assessments

Conduct in-season visual assessments for fruit damage toward the end of each generation and whenever moths are caught in traps. Fruit damage can occur even when no moths are caught in traps.

At the end of the first CM generation, examine a minimum of 500 fruit from throughout the orchard as well as in high-risk and border areas. If damage exceeds 0.5%, insecticides are required for the next generation. Where damage is localized, insecticides may be directed to those areas and along borders. Continue to assess damage weekly (200 fruit) throughout the season, to ensure the pheromones are working and to allow for timely intervention with insecticides, if required.

Mating disruption for grape berry moth (Isomate-GBM Plus)

Mating disruption works best in vineyards with low grape berry moth (GBM) populations. Avoid using mating disruption next to vineyards with known high populations. Vineyards should be at least 2 ha in size.

To use Isomate-GBM Plus, place the appropriate number of pheromone dispensers uniformly through the vineyard prior to or at the onset of first flight of moths in spring. Delayed application results in increased mating and reduced control. Attach dispensers securely to the highest trellis wire.

Conduct damage assessments throughout the season to ensure that GBM are adequately controlled.

Monitoring for grape berry moth

Use 5 pheromone traps for vineyards up to 5 ha in size. These traps are used as sentinels: captures of moths in pheromone traps should be very low to zero in vineyards using mating disruption.

- Place traps along a line that transects the vineyard or at the 4 corners of the vineyard.
- Place at least 1 extra trap along the windward edge of the vineyard.
- Where vineyards are located adjacent to wooded areas, place traps within the border area at least 40 m apart.

Damage assessments

Closely inspect fruit weekly in the outer 5 panels and rows for infestation, especially on the windward side.

- If more than 5% of the grape clusters in this outer area are infested with GBM larvae, continue sampling another 5 rows and panels in.
- If more than 5% of the grape clusters in the outer 5 rows but less than 5% of grape clusters in the inner 5 rows are infested, then apply an insecticide to the border of the vineyard.
- If more than 5% of grape clusters in the inner 5 rows are infested, apply an insecticide to the entire block.

Mating disruption for dogwood borer (Isomate-DWB) and peach tree borer (Isomate-PTB Dual)

Immigration of mated females into the orchard from adjacent areas will reduce control. Supplemental insecticides may be required for several years to help bring populations down to levels where mating disruption can be used alone for management of borers.

For dogwood borer:

- Place dispensers on lateral branches at chest height within the canopy.
- Apply before adult borer emergence begins (typically end of May).
- Use a high rate (375 dispensers/ha) for the initial treatment year and for high populations. Increase the rate (maximum 500 dispensers/ha) around borders of treatment area.

For lesser peach tree borer and peach tree borer:

- Apply uniformly throughout the treatment area.
- Place dispensers on lateral branches in mid-point of tree canopy.
- Apply before adult borer emergence begins (typically at or before shuck split).
- Dispensers are designed to last for the entire season.
- Use a higher rate (maximum 675 dispensers/ha) when pest pressure is high.

Organic and Biopesticide Products for Disease Control

Aureobasidium pullulans (Blossom Protect, Botector)

Blossom Protect is a biopesticide registered for the control of fire blight. Live strains of the yeasts *Aureobasidium pullulans* and a citric acid buffer are mixed together prior to application. The citric acid buffer lowers the pH in the blossoms which inhibits the growth and multiplication of the fire blight bacteria when they enter the blossoms. The lower pH also allows the yeast strains to colonize the same areas of the blossoms, blocking the infection site and utilizing the same nutrients as the fire blight bacteria.

Blossom Protect can be applied up to 5 times per season. If available, use a forecast system (e.g., Cougar Blight or MaryBlyt) to target the sprays 1–2 days before infection. If no forecast system is available, apply at 10%, 40%, 70% and 90% open blossoms. The yeast must colonize open blossoms before fire blight bacteria infect the blossom, so early application is important.

Apple varieties such as Elstar, Golden Delicious, Idared, Jonagold, Sansa, Santana, Braeburn and the pear variety Conference appear to be sensitive to increased russetting. Studies have shown that applications after petal fall will also result in increased russetting, particularly with the onset of fruit set, so this product should not be used to control fire blight in rattail blossoms.

A formulation of *A. pullulans*, Botector, is also registered for the suppression of botrytis grey mould in grapes. When applied as a bunch zone treatment to grapevine, the yeast competes for space and nutrients with the grey mould pathogen, preventing it from colonizing and infecting the flower or fruit. The product must be applied preventatively at various stages of growth, as specified on the product label. If the bloom/postbloom period is wet, spray immediately to control latent infections in susceptible varieties (Gamay Noir, Pinot Noir, Pinot Gris, Riesling, Chardonnay, Gewurztraminer, Sauvignon Blanc, Seyval Blanc).

The product is optimally applied in the evening or during cool temperatures. Spray directly at the fruiting zone. Botector is not compatible with certain fungicides, including Flint, Kumulus and Switch (see www.bio-ferm.com for product compatibilities) and these should not be applied within 3 days (before or after) a Botector application.

Bacillus amyloliquefaciens (Double Nickel)

Double Nickel is a biopesticide registered for the suppression of powdery mildew, botrytis grey mould and fire blight in certain fruit crops. The active ingredient, *Bacillus amyloliquefaciens*, is a naturally occurring bacterium typically found in association with plant parts. It is reported to act in multiple ways against plant pathogens, including colonizing plant root hairs to prevent pathogen establishment, and by producing compounds that disrupt the production of cell walls in plant pathogens.

Under moderate to high disease pressure, or conditions that are conducive to disease development, use higher labelled rates, more frequent applications or rotate with other fungicides to improve performance.

This is a new product in Ontario and little evidence of its efficacy is available. Test on a small scale before using it more broadly.

***Bacillus subtilis* (Serenade MAX, Serenade OPTI)**

Serenade MAX and Serenade OPTI are registered for the suppression of a variety of diseases on fruit crops. Before using these products, consider whether suppression will be adequate in a commercial crop.

The active ingredient is *Bacillus subtilis*, which colonizes plant parts and helps prevent disease microorganisms from becoming established.

Crop-specific strategies

Apple – For suppression of fire blight, begin applications at early (1%–5%) bloom at the beginning of a warming trend, and follow with a streptomycin spray 2 or 3 days later if warm temperatures continue to favour blossom infection. Serenade should be used as part of an integrated fire blight suppression program, which includes a risk assessment model, as well as cultural controls and the use of streptomycin sprays when necessary. Serenade is also registered for suppression of powdery mildew and scab.

Berry crops – Serenade provides suppression rather than control of botrytis grey mould and powdery mildew, when multiple applications are made before disease symptoms appear. Expect best control when Serenade is used in rotation with other more effective products. Large ranges in rates are labelled for berry crops, with little information on when to use high or low rates. When using Serenade, always leave an untreated area to evaluate the efficacy of this product.

Grape – Serenade provides protection from botrytis bunch rot but has no post-infection activity. It also provides suppression of powdery mildew.

BLAD polypeptide (Fracture)

Fracture (formerly ProBlad) is a contact biopesticide registered for control or suppression of powdery mildew and botrytis grey mould on grapes and strawberries and blossom blight of stone fruit. The active ingredient, BLAD (Banda de Lupinus albus doce) is a polypeptide or fragment of a naturally occurring protein found in seed of the sweet lupine plant. It acts by coating and altering the cell wall structure of fungal pathogens, ultimately fracturing the wall and killing the cell.

Fracture is a contact fungicide that can penetrate plant tissue, but requires 2–4 hours of drying time to be

absorbed by the plant. Reapplication will be required if significant rain occurs within 12 hours of application. Under conditions of moderate to severe pressure, use the highest labelled rate and shorter spray intervals.

This is a new product in Ontario and little evidence of its efficacy is available. Test on a small scale before using it more broadly.

Citric acid + lactic acid (Tivano)

Tivano is registered for suppression of downy mildew on grapes and angular leaf spot and powdery mildew on strawberries. The active ingredients, citric and lactic acids, are the fermentation products of a particular strain of the bacteria *Lactobacillus casei*. They work by causing the plant pathogen's cell membranes to tear from the cell wall, due to water loss, thus killing the cell. This product also creates a physical barrier on the leaf surface, inhibiting infection spread.

This is a new product in Ontario and little evidence of its efficacy is available. Test on a small scale before using it more broadly.

Crop-specific strategies

Strawberry – Multiple applications at 7–10-day intervals are required for maximum suppression.

Grape – Use the higher rate and shorter application intervals with moderate to high disease pressure. Multiple applications at 7–10-day intervals are required for suppression.

Copper (Copper 53 W, Guardsman Copper Oxychloride 50, Copper Spray, Cueva, Kocide 2000)

Copper works by destroying plant pathogen enzymes which are required for cell function. Spraying these products leaves a suspension of copper particles on the plant surface that forms a chemical barrier to protect plants from invasion. They do not affect pathogens that have already entered the plant tissue. It is important to use only copper products approved as crop protection products for application on agricultural crops that have a federal label with a Pest Control Product (PCP) number. For a summary of available products and crop uses, consult Table 9–2. *Copper Products Used on Fruit Crops*, page 295.

Free copper ions provide most of the activity that copper mixtures have on fungal and bacterial diseases. However, free copper can also be toxic to plants, as it can cause burned leaves and russeted or scarred fruit, especially when spray solutions dry slowly.

Table 9–2. Copper Products Used on Fruit Crops

Registered Copper Products	Rate of Formulated Copper ¹	Rate of Hydrated Lime ²
Apples		
Copper 53 W	1 kg	6 kg
Copper Spray	4 kg	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Blueberries (Highbush)		
Guardsman Copper Oxychloride 50	2–4 kg ⁴	no lime required
Copper Spray	2–4 kg ⁴	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Currants		
Copper 53 W	3–5 kg	4 kg
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Filberts, Hazelnuts		
Guardsman Copper Oxychloride 50	3–9 kg/ha	no lime required
Copper Spray	3–9 kg/ha	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Gooseberries		
Copper 53 W	3–5 kg	4 kg
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Grapes		
Copper 53 W ⁵	3 kg	6 kg
Guardsman Copper Oxychloride 50 ⁶	3 kg	6 kg
Copper Spray ⁶	3 kg	6 kg
Kocide 2000	1.6 kg/ha ⁷	454–1,360 g lime per 454 g Kocide ⁸
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	do not mix with lime
Nectarines		
Copper 53 W	4 kg	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Peaches		
Copper 53 W	1.9 kg	no lime required
Guardsman Copper Oxychloride 50	2 kg	no lime required
Copper Spray	2 kg	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Pears		
Copper 53 W	1 kg	6 kg
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Raspberries		
Copper 53 W	4–5 kg/ha	no lime required
Guardsman Copper Oxychloride 50	2.5–3.0 kg/ha	no lime required
Copper Spray	2.5–3.0 kg/ha	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required

¹ Rate is expressed kg/1,000 L of water unless otherwise stated. Also check label for maximum rate/ha.

² Rate is expressed kg/ha unless otherwise stated.

³ Use a 0.5%–2% solution, applied at 470–940 L/ha.

⁴ Rate is expressed in kg/500–1,000 L of water/ha.

⁵ Do not use on French hybrids or vinifera varieties.

⁶ Do not use on Seibel varieties.

⁷ Rate is expressed in kg/500–1,400 L water/ha. Foliage injury may occur on copper-sensitive varieties such as Concord, Delaware, Niagara and Rosette. Always test for sensitivity.

⁸ Addition of hydrated lime at this rate may reduce phytotoxicity.

⁹ Use 2 kg/ha with 4 kg/ha of hydrated lime for brown rot and leaf spot control. Use 6–9 kg/ha without lime for bacterial canker control.

Registered Copper Products	Rate of Formulated Copper ¹	Rate of Hydrated Lime ²
Strawberries		
Copper 53 W	2.5–3.8 kg/ha	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Sweet cherries		
Guardsman Copper Oxychloride 50	6–9 kg/ha	no lime required
Copper Spray	6–9 kg/ha	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Tart cherries		
Copper 53 W	2 kg	4 kg
Guardsman Copper Oxychloride 50	2 kg ⁷	4 kg
Copper Spray	2 kg ⁹	4 kg
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required
Walnuts		
Copper Spray	4 kg/ha	no lime required
Cueva	1% solution v/v, i.e., 5 L in 500 L water/ha ³	no lime required

¹ Rate is expressed kg/1,000 L of water unless otherwise stated. Also check label for maximum rate/ha.

² Rate is expressed kg/ha unless otherwise stated.

³ Use a 0.5%–2% solution, applied at 470–940 L/ha.

⁴ Rate is expressed in kg/500–1,000 L of water/ha.

⁵ Do not use on French hybrids or vinifera varieties.

⁶ Do not use on Seibel varieties.

⁷ Rate is expressed in kg/500–1,400 L water/ha. Foliage injury may occur on copper-sensitive varieties such as Concord, Delaware, Niagara and Rosette. Always test for sensitivity.

⁸ Addition of hydrated lime at this rate may reduce phytotoxicity.

⁹ Use 2 kg/ha with 4 kg/ha of hydrated lime for brown rot and leaf spot control. Use 6–9 kg/ha without lime for bacterial canker control.

Fixed copper collectively describes a group of copper formulations that contain complex copper sulphates (Copper 53 W), copper oxychlorides (Guardsman Copper Oxychloride 50, Copper Spray), copper octanoate (Cueva) and copper hydroxides (Kocide 2000).

These copper formulations have a small particle size and have added materials to improve spreading and sticking qualities. Always check the product label for use patterns, rates and timings for each crop.

Procedures to tank-mix copper formulations and lime

Some fixed copper labels suggest mixing the copper with lime. If problems occur while mixing fixed coppers with lime, follow these instructions:

1. Start water flow into the spray tank.
2. When the tank is about one-third full and the mechanical agitator is on, wash the powdered copper product into the tank through a screen with water from the supply hose. Use a wooden spoon to help work the copper product through the screen. The screen prevents large granules of copper, which form if opened product gets wet then dries, from getting into the tank. Premix the copper product with hot

water to help the product dissolve. Put all of the copper in the tank by the time the tank is two-thirds full.

3. Wash the lime mixture through the screen into the copper solution in the tank. Use hydrated or builder's lime. Pre-soaking the lime before you add it to the copper solution in the tank may be preferable to washing powdered lime directly through the screen into the tank. Use sufficient water from the supply hose to dilute the lime as much as possible before it meets the copper solution.
4. Keep the agitator running continuously and apply the copper mixture immediately. Do not allow the mixture to settle out.

Garlic powder (Buran)

Buran is a biopesticide registered for the suppression of certain fungal pathogens. The active ingredient works by inhibiting germination of fungal spores on plant surfaces, and by interfering with the growth of the fungal mycelium. This product provides suppression only, and should be used in rotation with other fungicides. This is a new product in Ontario and little evidence of its efficacy is available.

Mineral oil (Purespray Green Spray Oil 13 E)

As a fungicide, mineral oil acts as both an eradicant and a protectant, providing the destruction of lightly established infections and providing modest protection for a short period of time. It is susceptible to wash-off and activity is significantly reduced by as little as 5 mm of rain. It provides an alternative mode of action in a disease control program, reducing the likelihood of resistance to fungicides with specific modes of action.

Oils may cause plant injury when they are applied in conjunction with certain chemicals or conditions. There are restrictions regarding the use of oils with products such as Bravo, Echo, Captan, Maestro, Folpan, Cygon, Lagon, and sulphur products, or under environmental conditions that may cause plant stress (e.g., extreme cold or heat). See product labels for specific restrictions for each crop and product. See crop specific strategies for mineral oil, page 289.

Oriental mustard seed meal (MustGrow)

MustGrow is a biofumigant, registered for suppression of certain nematodes and soil-borne diseases. The active ingredient is derived from a particular variety of oriental mustard, which contains high levels of glucosinolates, that is formulated as pellets. Enzymes convert glucosinolates to allyl isothiocyanate (AITC), which has activity on the labelled pests similar to conventional fumigants. These enzymes are activated by moisture in the soil after application.

Pantoea agglomerans (Bloomtime Biological FD)

Bloomtime is registered for suppression of fire blight. It is based on a strain of the non-pathogenic bacteria, *Pantoea agglomerans*, which colonizes the same areas of blossoms as the fire blight bacteria, but without causing any damage or plant disease. Once present, it competes with the fire blight bacterium for nutrients, keeping the number of harmful bacteria low. This product is preventative rather than curative – its efficacy depends on being applied and allowed to colonize plant surfaces before infection by the fire blight bacteria.

This product only suppresses fire blight, providing approximately 60% control without additional measures, and should be part of an integrated fire blight management program that includes monitoring, use of a risk assessment model, cultural controls and chemical sprays. Suppression of the fire blight bacteria can still be very beneficial. Lower numbers of colonizing fire blight bacteria will result in more effective and fewer streptomycin applications in some orchards. Fewer applications of streptomycin can help reduce

the risk of development of streptomycin-resistant fire blight bacteria.

Potassium bicarbonate (MilStop, Sirocco)

Potassium bicarbonate is a biochemical pesticide registered for suppression or control of powdery mildew. The active ingredient, potassium bicarbonate, is a colourless, odourless powder. It acts as a contact fungicide that kills the powdery mildew fungus by pulling water from its spores and cell walls. It also alters the pH on the leaf surface, which inhibits enzymes needed for formation of fungal cell walls, providing the plant with residual protection.

Pseudomonas syringae (Bio-Save 10 LP)

The active ingredient in Bio-Save, *Pseudomonas syringae*, is a naturally occurring bacterium that is normally present on the surface of produce. Bio-Save is a biopesticide registered for postharvest suppression of blue mould and botrytis grey mould on cherries, apples and pears, and for the suppression of mucor rot on apples and pears. The Bio-Save bacterium enters wounds on fruit where pathogen spores live and competes with plant pathogens for nutrients. At produce storage temperatures, it can outgrow the pathogens.

Reynoutria sachalinensis extract (Regalia Maxx)

The active ingredient of Regalia Maxx is an extract of the giant knotweed plant that triggers the natural defense mechanisms of plants, inhibiting the development of certain plant pathogens. Regalia Maxx is a biopesticide labelled for the suppression rather than control of certain fungal diseases on grapes, strawberries, apples and highbush blueberries, and works best when applied prior to the development of disease symptoms.

Crop-specific strategies

Berry crops, apple – This is a new product in Ontario and little evidence of its efficacy is available.

Grape – Do not use as a solo product for powdery mildew from prebloom through berries pea-sized growth stage. Use 0.125% in a tank-mix or rotation with other powdery mildew fungicides.

***Streptomyces lydicus* (Actinovate SP)**

Actinovate is a microbial pesticide registered for suppression of botrytis fruit rot and powdery mildew and reduction in symptoms of anthracnose fruit rot. Before using this product, consider whether suppression, or reduction in damage, will be adequate in a commercial crop.

The active ingredients are spores of *Streptomyces lydicus*, a naturally occurring bacterium commonly found in soil. Researchers think that this bacterium helps protect plants by growing over the plant surface, parasitizing fungal pathogens and producing antibiotics that are detrimental to these fungal diseases. When using Actinovate, always leave an untreated plot to evaluate the efficacy of this product. This is a new product in Ontario and little evidence of its efficacy is available.

Sulphur (Kumulus DF, Microscopic Sulphur, Microscopic Wettable Sulphur, Microthiol Disperss, Lime Sulphur)

Sulphur products are not biopesticides, but some formulations may be organically acceptable. The active ingredients are elemental sulphur (obtained from rocks, underground deposits and other sources) or, in the case of lime sulphur, calcium polysulphide (obtained by combining elemental sulphur and calcium hydroxide). Sulphur inhibits spore germination and mycelial growth of plant pathogens. Sulphur can also have some secondary suppression or control activity against certain arthropods, and some products also list certain species of mite or scale on their label. Sulphur products can be phytotoxic under certain conditions.

Tea tree oil (Timorex Gold)

Timorex Gold is a biofungicide registered for suppression of powdery mildew on grapes and strawberries and downy mildew on grapes. The active ingredient, tea tree oil, is a plant extract which destroys the cell walls and membranes of fungal pathogens. It can be both preventative, by contacting fungal spores on plant surfaces, or curative, by penetrating plant tissue.

Thorough coverage and wetting of crop foliage is required for optimal control by this product. Apply sufficient spray solution to cover leaf tops and undersides to runoff.

This is a new product in Ontario and little evidence of its efficacy is available. Test on a small scale before using it more broadly.