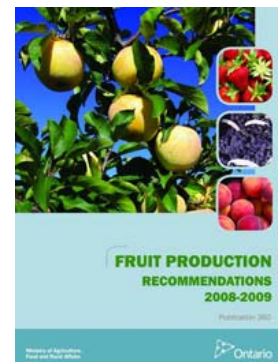


Fruit Production Recommendations 2008-2009

Ontario Ministry of Agriculture, Food and Rural Affairs

Chapter 2: Pest Management



Integrated Pest Management

Integrated Pest Management (IPM) is an approach to pest control that considers all management options to maintain pests below an economic injury level. Tools for pest management include cultural, physical, biological, behavioural and chemical methods. With IPM, adverse effects of pesticides are minimized and economic returns are maintained.

IPM programs make extensive use of information collected in the cropping system and require careful management by the grower. To implement an IPM program you must understand:

- pest identification, biology and behaviour
- beneficial organisms
- monitoring techniques
- use and timing of appropriate management tools
- record keeping
- resistance management strategies
- sprayer calibration

This publication outlines integrated approaches to pest control and includes the use of pesticides, biological controls, cultural management tools and resistance management strategies.

Monitoring

Systematic monitoring of pest populations, weather conditions, plant health and disease symptoms are critical components of an IPM program. Monitoring or scouting results can be subjective and are best done by the same person or service. Information on field history, soil type, spray records and weather is important when you interpret results. Records are important for comparison of the situation from year to year.

Tools needed to monitor pests:

- a 16–20× hand lens
- traps, which include pheromones, sticky cards, tapping trays, sweep nets
- collection bags and vials
- field maps, which indicate varieties, age of planting, surrounding vegetation and features
- flag tape
- shovel or sturdy trowel
- pocket knife
- scouting forms and record sheets

For a list of monitoring equipment suppliers, see Appendix A. *Suppliers of Pest Monitoring Equipment and Biological Control Agents*, on page 209.

Monitoring strategies:

- Learn to identify life stages and damage caused by disease and pests.
- Understand the biology and life cycle of pests and disease.
- Recognize beneficial insects, as well as harmless insects.
- Use historical data to identify hot spots and previous problems.
- Keep a field map and record the location of -damage.
- For each visit, record the stage of crop development, disease severity, population levels of insect pests and beneficials, and damage observed.
- Keep a journal or log of rainfall amounts, daily highs and lows, and weather events.
- Keep a record of pesticides applied and other control measures used.

Monitoring procedures:

- Review pest control calendars to know when certain pests will be active.
- Monitor at least once a week and preferably twice a week during critical stages.
- Monitor at approximately the same time each day and keep the light behind you.
- Inspect plants in several areas across the field to get an accurate idea of pest pressure.
- Stand back and look for patterns, such as patches or areas of poor plant growth or where colour is off.
- Get close and examine fruit clusters, the underside of leaves, inside the canopy, etc.
- Scout the edges of the field and interior of the field separately.
- Give special attention to border areas near wild hosts, such as wild fruit trees, grapevines or raspberries. Many insect pests overwinter in these areas.
- Be aware of variety and rootstock changes and inspect these separately if necessary.

Sampling

Sample collection involves the collection of data to represent the entire area being monitored.

- Divide large areas into sample blocks no larger than 8–10 ha for tree fruit and grapes, and 2.5 ha for berry crops. Cultivar, training system, plant density, soil type, topography and age of the planting should be as consistent as possible in each sample block.
- Walk in a W or zig-zag pattern across the field to collect samples from a representative area. Truly random sample collection is rarely practical in field inspection.
- Look away from the plant when you take samples of leaves and fruit, otherwise you will tend to choose damaged leaves or fruit and bias the sample.

Thresholds

An IPM program uses control guidelines or thresholds to indicate when to apply pesticides to prevent economic loss. In other words, some damage to the crop is tolerated as long as this damage does not exceed the cost of the control.

For insect pests, thresholds are usually based on the presence of the pest at certain levels. Thresholds for direct pests, which feed on fruit and have an immediate effect on fruit quality, are generally lower than thresholds for indirect pests that feed on leaves, stems or roots.

For diseases, guidelines may be based on the pest's damage potential. This is estimated through the use of weather models, crop tolerance, stage of crop development and field observations.

Thresholds have not been developed or validated for all pests in Ontario. Even established thresholds require adjustment for different varieties, markets and crop vigour. Established thresholds may also require revision to optimize the use of new, reduced-risk products.

Use the thresholds in Table 2-1. *Examples of Thresholds Used for Fruit Pests in Ontario*, on page 7, together with information on sampling techniques and sample size, crop phenology, spray times and pesticide characteristics discussed in detail in each crop chapter.

TABLE 2-1. Examples of Thresholds Used for Fruit Pests in Ontario

Crop	Pest	Spray Timing	Minimum Sample Size	Threshold	Comments
Strawberries	Tarnished plant bug	Bloom-green fruit	20 clusters	Approx. 0.25 nymphs per cluster	Sequential sampling methods are preferred. See OMAFRA Factsheet, <i>Tarnished Plant Bug: A Major Pest of Strawberries</i> , Order No. 92-108 on the OMAFRA website at ontario.ca/crops .
Strawberries	Clipper weevil	Before 1st bloom	5 locations	13 clipped buds per 2 ftl row	Sample outer rows.
Strawberries	Two-spotted spider mite	Before harvest, or July-August	50 leaflets	Low threshold: 5 mites per leaflet High threshold: 20 mites per leaflet	Use low threshold on sensitive varieties before bloom or when using beneficial mites for control. Use high threshold after harvest.
Raspberries	Raspberry crown borer	October, or when primocanes begin to grow in spring	Entire block	5% of canes with die back	
Apples	Mullein bug	Petal fall to calyx	25 taps per block	7 to 9 nymphs per 25 taps	Sample susceptible varieties such as Red Delicious and Northern Spy.
Apples	Spotted tentiform leafminer	Pink to calyx	50 spurs	3 to 5 eggs per spur	Apply insecticide at first egg hatch.

Trapping

Use traps and monitor insects to provide:

- information on pest activity
- information on insect numbers
- validation of degree-day models, which predict insect emergence
- information to optimize spray timing

Most traps catch only the adult stage of the pest and may not provide information on the destructive larval stage.

Pheromone traps

Volatile chemicals emitted to attract the opposite sex are known as sex pheromones. For some insects these unique chemicals have been identified and synthetically produced into lures, which are placed in sticky traps and attract male insects of a specific species.

Use pheromone traps to determine the presence or absence of pests and the first sustained flight or activity peaks of certain pests. Pheromone traps are less useful for providing information on population levels.

To determine the first sustained catch in pheromone traps, ignore early sporadic catches. A sustained catch is the start of a continual period of moth activity, which continues for at least two successive collection periods. When first sustained catch is used as a biofix, it is important to have pheromone traps set for one to two weeks before first flight of the pest is expected.

Visual attractants

Yellow sticky boards and red spheres are attractive to certain insects, especially flies, because they provide a visual stimulus. These traps reflect wavelengths of light recognized by the insect and can be used to indicate the presence and relative abundance of a pest.

How to use traps

- Place traps in the field one to two weeks before the expected emergence of the insect.
- Follow pest-specific guidelines in regard to the number and location of traps for the crop.
- Clear foliage and branches away from the trap.
- Use separate traps for each species and label traps clearly.
- Pheromone lures are pest-specific. They are very sensitive to contamination from other types of pheromones. When you use several types of pheromones at once, wear disposable latex gloves to prevent cross-contamination and maintain a minimum of 40 m between traps, or the distance recommended by the manufacturer, to avoid interference.
- Use flagging tape to clearly mark the location of traps.
- Check traps twice weekly and record the number of pests caught. Remove the insects at each visit.
- Traps require maintenance. Replace the trap when it becomes too dirty or no longer sticky. When you replace traps, simply transfer the old lure into the new trap.
- Pheromone lures generally have a 3–6 week life span but longevity varies with different products. Replace the lures according to the manufacturer's instructions. Store unopened, unused pheromone lures in the refrigerator.

TABLE 2-2. Examples of Traps Used for Monitoring Fruit Pests

Pest	Crop	Type of Trap
Codling moth	Walnuts	CM pheromone Diamond traps
Walnut husk maggot fly	Walnuts	Yellow sticky cards
Currant fruit fly	Currants, gooseberries	Yellow sticky cards
Cranberry fruitworm	Blueberries	Cranberry fruitworm pheromone Wing traps
Cherry fruitworm	Blueberries	Cherry fruitworm pheromone Wing traps
Sharp-nosed leafhopper	Blueberries	Yellow sticky cards
Blueberry maggot	Blueberries	Yellow sticky cards
Oblique banded leafroller	Apples, pears	Pheromone Diamond traps
European apple sawfly	Apples	3-D white sticky traps

For a list of trap and pheromone suppliers, see Appendix A. *Suppliers of Pest Monitoring Equipment and Biological Control Agents*, on page 209.

Degree-day modelling and determining a biofix

Temperature, light and moisture affect the growth and development of plants and their pests. Of these, temperature is the most important factor. Insect and mite development is closely related to the daily accumulation of heat. These pests need a certain amount of heat, or energy, to move to the next development stage.

The amount of heat required for insect and mite development remains constant from year to year, but depending on weather conditions, the amount of actual time can vary. Insects and mites have a minimum and a maximum base temperature below or above which development does not occur. These base temperatures are different for each organism.

Growing Degree-Days (GDD) are used to estimate the growth and development of pests in the growing season.

Events such as egg-laying, egg hatch, movement of crawlers or the appearance of disease can be predicted and used to schedule inspection and spray programs. For example, degree-day calculations can predict the first flight of codling moth adults or the percentage of apple scab ascospores that have matured in the orchard.

There are several methods used to calculate GDD, but the method commonly used with simple monitoring equipment is the averaging method or “max/min” method. GDD for a given organism are calculated as follows:

GDD =	(Daily max °C)+(Daily min °C)	– minimum base temperature
	2	

GDD are accumulated daily until a pest-specific total is reached. The averaging method works quite well in most years but can lead to errors in application time during long, cool springs or very hot summers because it can either underestimate the actual GDD in cool weather or overestimate it in hot weather.

An example of the averaging method on a relatively cool spring day:

For a given pest:

Lower base temperature = 10°C

Upper base temperature = 35°C

On a given day:

Minimum temperature = 5°C

Maximum temperature = 15°C

Growing degree-days (GDD) for
that day is = $(15+5)/2 - 10 = 0$

Note that the maximum temperature was higher than the base temperature for the insect, so growth and development were possible for at least part of the day. However, no GDD were accumulated. This illustrates how cool temperatures, especially over several days, could lead to an underestimation of insect development.

GDD are either accumulated from a set start date, such as April 1, or from a specific event known as a biofix. A common biofix used for insects is the first sustained catch in pheromone traps.

Use of a biofix provides more accurate predictions and requires tracking temperatures over a shorter period of time.

There are several limitations to degree-days models:

- Factors such as humidity, light intensity and rainfall also affect pest development. As a result, GDD predictions are only estimates of pest development. The prediction must be verified with field observations.
- Temperatures used to determine GDD must represent the environment where organisms develop. Use weather data collected from within a mile or less of the actual orchard or field being monitored.
- GDD have been developed and validated for only a few fruit pests in Ontario.

TABLE 2-3. Examples of Degree-Day Models Used in Fruit Crops

Pest	Model
Tarnished plant bug (strawberries)	Degree-days are used to predict first nymphs in strawberries 30–40 GDD (base 12.1°C) after April 1
Codling moth (apples)	Degree-days are used to predict first egg hatch 100 GDD (base 11°C) after biofix (first sustained moth catch)

For a list of crop consultants that provide monitoring services, contact OMAFRA's Agricultural Contact Centre at 1-877-424-1300.

Pest management tools

Cultural pest controls

Many crop management practices can prevent or delay the development of pest outbreaks. Follow these cultural control tools:

- Choose sites less favourable for pest development. Avoid planting in poorly drained locations.
- Select cultivars less susceptible to disease or insect pressure.
- Rotate to a non-host crop where possible to break the pest cycle. Some insects and many diseases overwinter in crop refuse.
- Use plants tested and determined to be free from disease or virus.
- Remove all sources of the pest, such as cull piles and dropped fruit, from the field or orchard.
- Maintain good weed control and eliminate wild hosts from within as well as the perimeter of the planting. Weeds and wild fruit trees, grapevines and brambles often act as alternate hosts to many crop pests.
- Use non-related crops planted in close proximity as a barrier to insects and diseases. Avoid inter-cropping plants with similar pest complexes.
- Modify insect habitat through the introduction of cover crops to promote beneficial organisms.
- Prune and remove infected plant material to reduce pest pressure. Pruning and training plants to improve air movement within the canopy will also improve spray coverage.
- Timely irrigation can reduce plant stress during drought and increase plant tolerance to pests. Schedule irrigation so that plants are not wet overnight.
- Manage nutrients to avoid excessively lush growth, which is more susceptible to some diseases and more attractive to some insect pests.

Chemical controls

Chemical controls include synthetic, inorganic, botanical and biological pesticides. They kill target pests, limit subsequent populations and are important tools for crop protection when used in an IPM program.

Understand the pest's life cycle and apply chemicals at the stage when the pest is most vulnerable.

- To manage insects and mites, monitor blocks closely and spray according to action thresholds established for each species.
- To manage disease, apply protective fungicides when weather conditions are favourable and before damage occurs.

Biological control

Biological control uses a pest's natural enemies to help suppress pest populations. These natural enemies, collectively known as beneficials, may be predatory insects, parasites, pathogens or nematodes. Beneficials are most effective against indirect pests such as aphids, leafhoppers and mites. They are less effective at keeping populations of direct pests, which attack the harvested product, at levels acceptable for commercial production. Important beneficial insects and mites in Ontario fruit crops include ground beetles, mullein bugs, minute pirate bugs, lacewings, lady bird beetles and phytoseiid mites.

Natural enemies can be adversely affected by the crop environment and the pesticides used to manage pest populations. IPM programs attempt to minimize adverse effects of pesticides on beneficials and take advantage of the pest suppression these insects provide.

- Avoid use of pesticides that are toxic to the most important beneficials in a cropping system. See *Prevent Bee Poisoning*, on page 2.
- Encourage a diverse habitat around the perimeter of the field where beneficial insects can live. Small flowering plants are an important food source for parasitic wasps.
- Avoid ultra-clean cultivation. Crop residue, mulch or ground cover will encourage ground beetles and other important predators in the soil.

For additional information on predators and parasitoids, see OMAFRA Publication 208, *Predatory Insects in Fruit Orchards* or OMAFRA Factsheet, *Beneficial Insects in Tree Fruit Orchards in Southern Ontario*, Order No. 96-029.

Biological controls can be purchased for control of certain pests. Beneficial nematodes are being used experimentally to control root weevils in berry crops. Predatory mites can be purchased and released in orchards and berry crops for control of spider mites.

Product quality and shelf life are important considerations when you purchase and use biological control agents. For sources of beneficial insects and mites, check the OMAFRA website at ontario.ca/crops.

Mating disruption

Many adult insects emit volatile chemicals known as sex pheromones to attract members of the opposite sex. When a female moth secretes these chemicals, males use the pheromone trail or plume to pinpoint her location. Synthetically-produced sex pheromones can be used in traps to monitor insect activity patterns.

Mating Disruption (MD) technology uses these same chemicals to confuse males and limit their ability to locate calling females. The release of large quantities of synthetic sex pheromone into the crop atmosphere interferes with mate location by masking the trail or pheromone plume. Mating is either delayed or prevented because the probability of males finding females is reduced. Consequently, fewer larvae are present to cause crop damage. Synthetic pheromones used in mating disruption are a form of biological control.

For additional information on synthetic pheromones and their use in pest management, see:

- OMAFRA Factsheet, *Mating Disruption for Management of Oriental Fruit Moth in Stone Fruit and Pome Fruit*, Order No. 04-029
- OMAFRA Factsheet, *Mating Disruption for Management of Insect Pests*, Order No. 03-079
- *Mating disruption (MD) technology for management of grape berry moth*, on page 139

Particle film technology

Particle film technology protects crops from certain insects, heat stress and sunburn by coating plant surfaces with a white particle barrier film. Surround WP Crop Protectant is registered in Canada for use in apples, pears, grapes and cucumbers for several insect pests. The active ingredient in Surround WP Crop Protectant is kaolin clay, a non-toxic compound that leaves a white, powdery film on the surface of leaves, stems and fruit. This film acts as a barrier between the pest and the host plant. Insects that come into contact with Surround-treated crops may either be repelled or disoriented, which makes the host unrecognizable or unsuitable for feeding.

Good spray coverage is essential when using Surround. The fruit and/or leaves must be completely covered with the product, so re-application may be necessary after heavy rainfall. Light to moderate rains will aid in the uniform distribution of the particle film on leaf and fruit surfaces without the removal of large amounts of residue.

During the growing season, Surround-treated tree and grape canopies take on a bluish-green hazy look.

Precautions when using Surround

- Do not mix Surround with spreaders, stickers or anti-foaming agents.
- Do not spray when bees are active.
- Do not re-enter the treated area for four hours after application.

In orchards treated with Surround, use starch iodine tests to monitor fruit maturity in the last two weeks of crop development. For grapes, Surround may delay brix accumulation. Closely monitor harvest parameters to determine optimal time to harvest.

For detailed application instructions, see the product label.

Reduced-risk pesticides and biopesticides

Many IPM programs for fruit crops were developed using older, broad-spectrum pesticides to manage key economic pests. The number of reduced-risk and biopesticide alternatives available for use in Canada continues to increase.

Reduced-risk pesticides are products that present a reduced risk to human health and the environment, when compared to other alternatives. These pesticides are of interest because they have some of the following characteristics:

- low risk to human health
- low toxicity to non-target organisms
- low potential to contaminate ground water, surface water or other valued environmental resources

The use of reduced-risk pesticides should help to improve integrated pest management strategies.

TABLE 2-4. Examples of Reduced-Risk Pesticides Used on Fruit Crops in Ontario

Product name	Active ingredient	Type of product/use
Acramite 50 WS	bifenazate	miticide
Apogee	prohexadione calcium	plant growth regulator
Assail 70 WP	acetamiprid	insecticide
Confirm 240 F	tebufenozide	insecticide
Elevate 50 WDG	fenhexamid	fungicide
Flint 50 WG	trifloxystrobin	fungicide
Intrepid 240 F	methoxyfenozide	insecticide
Lance WDG	boscalid	fungicide
Ridomil Gold 480 EC	mefenoxam (active isomer of metalaxyl)	fungicide
Scala SC	pyrimethanil	fungicide
Success 480 SC Entrust 80 W GF-120 NF	spinosad	insecticide
Switch 62.5 WG	cyprodinil + fludioxonil	fungicide
Vanguard 75 WG	cyprodinil	fungicide

Source: Pest Management Regulatory Agency (PMRA) Reduced Risk Update Document RR2007-01 Update on Reduced Risk Pesticides in Canada can be found at www.pmra-arla.gc.ca/english/pdf/rr/rr2007-01-e.pdf. The Pest Management Regulatory Agency Initiative for Reduced-Risk Pesticides (Regulatory Directive DIR2002-02) can be found at www.pmra-arla.gc.ca/english/pdf/dir/dir2002-02-e.pdf.

Biopesticides are pesticides derived from natural materials such as animals, plants, bacteria and minerals. While many are less toxic and pose a lower risk than conventional pesticides, others can be quite toxic. Biopesticides include microbial pesticides and biochemical pesticides.

Microbial pesticides contain beneficial microorganisms like bacterium, fungus, virus or protozoan as the active ingredient. They are relatively specific to their target pest and include the various subspecies and strains of *Bacillus thuringiensis*.

Examples of microbial pesticides used on fruit crops in Ontario are:

- Dipel 2X DF, Foray 48 BA and Bioprotec CAF (contain *Bacillus thuringiensis*)
- Virosoft (*Cydia pomonella* or codling moth granulosis virus)
- Bloomtime Biological FB and Blightban C9-1 (contain strains of *Pantoea agglomerans*)

Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Examples of biochemical pesticides used on fruit crops in Ontario are:

- synthetically-produced insect sex pheromones used for mating disruption
- particle film technology using kaolin clay, such as Surround WP Crop Protectant
- spinosyns derived from the fermentation of a soil-dwelling bacterium *Sacharopolyspora spinosa* (Spinosad)

Not all products in Table 2-5. *Biopesticides Registered in Ontario Fruit Crops*, have been included in the crop calendars. More experience is required for the incorporation of these products into recommended Ontario IPM programs.

TABLE 2-5. Biopesticides Registered in Ontario Fruit Crops

Product name	Active ingredient	Type of product/use
Accel	benzyladenine	plant growth regulator
Bioprotec CAF	<i>Bacillus thuringiensis</i> Berliner ssp. <i>Kurstaki</i>	insecticide
Biosafe StorOx	hydrogen peroxide	bactericide/fungicide
Blightban C9-1	<i>Pantoea agglomerans</i> C9-1	bactericide
Bloomtime Biological FB	<i>Pantoea agglomerans</i> E325	bactericide
Deer-Away	putrescent whole egg solids	deer deterrents
Dipel 2X DF	<i>Bacillus thuringiensis</i> Berliner ssp. <i>Kurstaki</i>	insecticide
Dygal	<i>Agrobacterium radiobacter</i>	bactericide
Foray 48BA	<i>Bacillus thuringiensis</i> Berliner ssp. <i>Kurstaki</i>	insecticide
Isomate C-Plus Codling Moth Pheromone	codling moth pheromone	insect mating disruption
Isomate-CM/LR Pheromone	codling moth and leaf roller pheromone	insect mating disruption
Isomate-GBM Plus	grape berry moth borer pheromone	insect mating disruption
Isomate-M 100, Isomate-M Rosso	oriental fruit moth pheromone	insect mating disruption
Isomate-P Pheromone	greater peach tree borer pheromone	insect mating disruption
MilStop Foliar Fungicide	potassium bicarbonate	fungicide
Promalin	benzyladenine, giberellins A ₄ , A ₇	plant growth regulator
ReTain	aminoethoxyvinylglycine hydrochloride	plant growth regulator
Safer's Insecticidal Soap	soap	insecticide/miticide
Serenade Max	<i>Bacillus subtilis</i> QST 713	bactericide/fungicide
Sluggo Slug and Snail Bait	ferric phosphate	slug control
SmartFresh Technology	1-Methylcyclopropene (1-MCP)	post-harvest
Surround WP Crop Protectant	kaolin	particle film technology
Virosoft	<i>Cydia pomonella</i> granulosis virus	insecticide
<p>Source: Pest Management Regulatory Agency (PMRA) Reduced Risk Update Document RR2007-01 Update on Reduced Risk Pesticides in Canada can be found at www.pmara-arla.gc.ca/english/pdf/rr/rr2007-01-e.pdf. The Pest Management Regulatory Agency Initiative for Reduced-Risk Pesticides (Regulatory Directive DIR2002-02) can be found at www.pmara-arla.gc.ca/english/pdf/dir/dir2002-02-e.pdf.</p>		