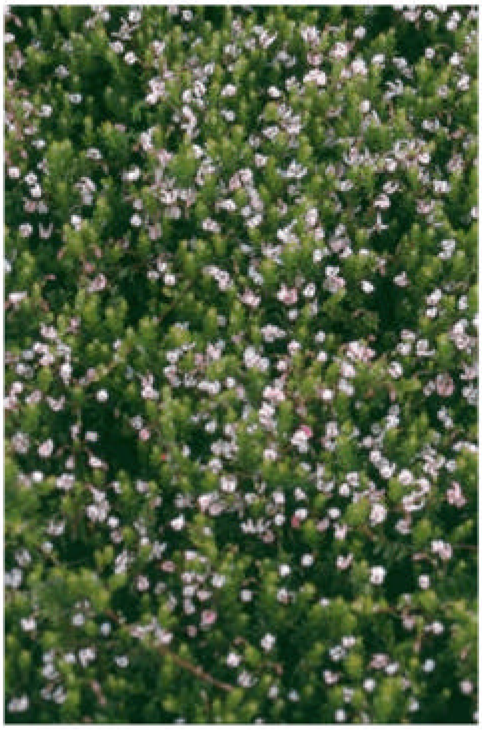
Club Environnemental et Technique
Atocas Québec

PMRA ARLA

Integrated Pest Management

Eastern Canada Cranberry IPM Manual



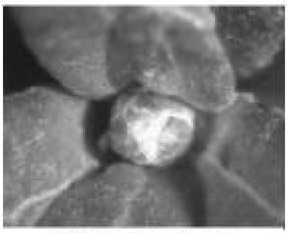
Isabelle Le Duc
Caroline Turcotte
with input from France Allard

Health Canada Santé Canada

Canada

DEVELOPMENT STAGES IN CRANBERRY PLANTS

TIGHT BUD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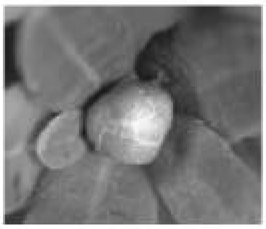
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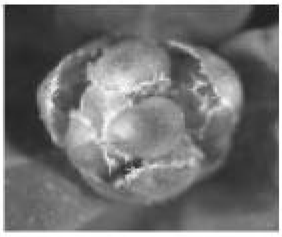
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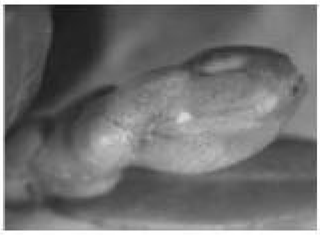
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ROUGHNECK


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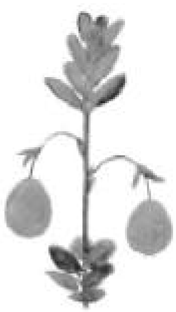
BLOOMING & FLOWER SETTING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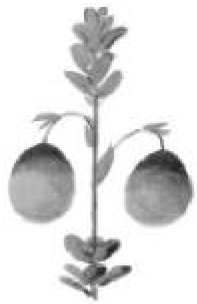
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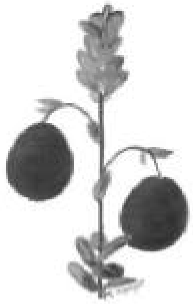
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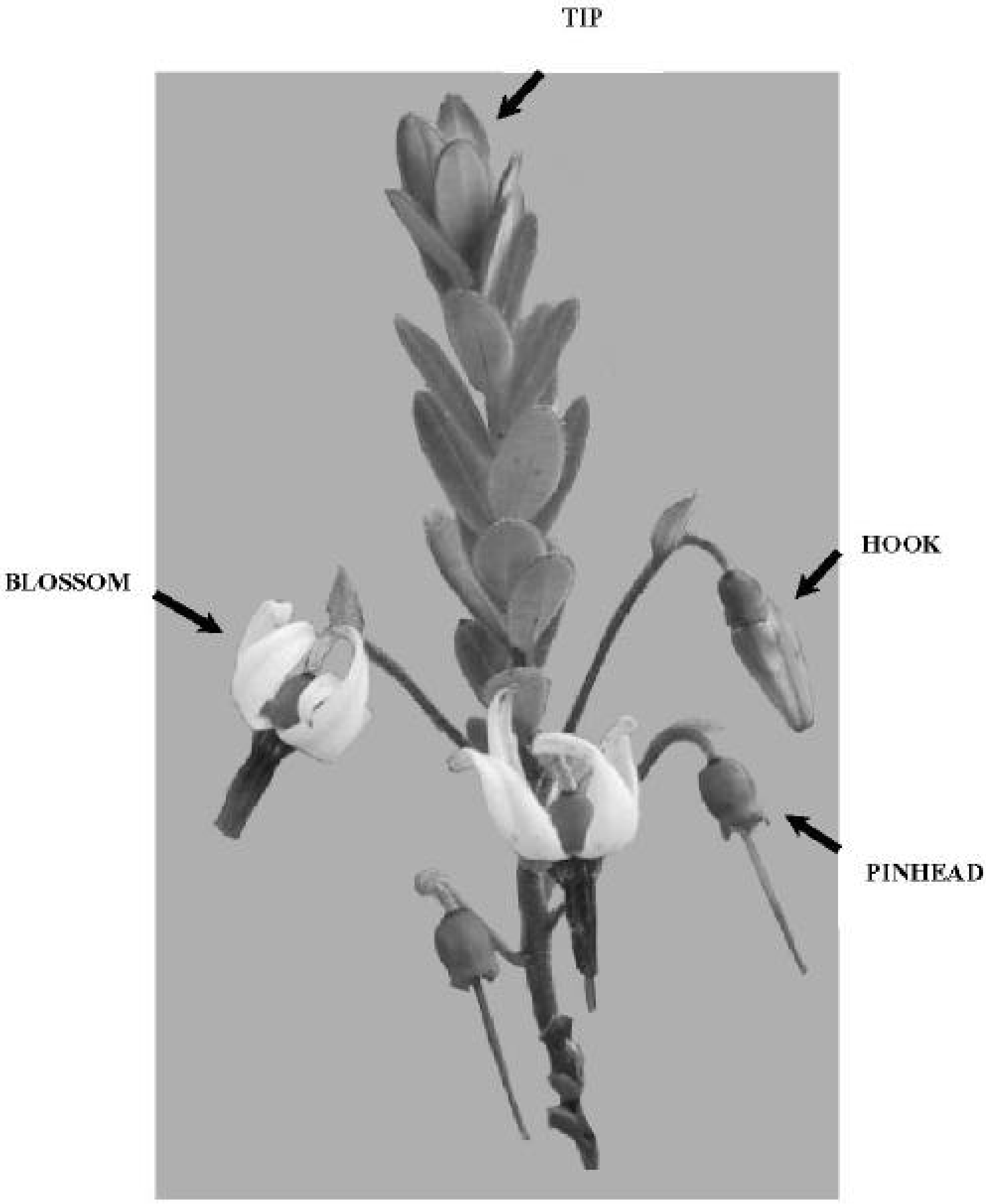
BUD DEVELOPMENT


TIP
HOOK
BLOSSOM
PINHEAD

This Eastern Canada cranberry IPM manual is intended as a tool to guide growers and plant health professionals in the application of integrated pest management.

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CHAPTER 1: CONCEPTS OF INTEGRATED PEST MANAGEMENT[1]

Definition

Integrated pest management (IPM) is a planning and control approach aimed at minimizing problems caused by harmful organisms to crops (and other sites), and at reaching decisions on when to take action and what action to take when those problems do arise. It is a sustainable approach, combining biological, agricultural (e.g., seeding depth), physical and chemical methods of controlling pests with a view to maximizing the resulting benefits and minimizing health hazards and environmental risks. The major concept underlying integrated pest management is that spraying should be carried out only when the numbers or impact of pests warrant such action, instead of spraying on a regular basis. Integrated pest management represents much more than the application of pesticides, regardless of whether the pesticides in question are chemicals or "new" products. It may entail a broad range of prevention techniques and treatments. Integrated pest management reduces dependence on pesticides as the only approach to dealing with harmful organisms (definition taken from the Pest Management Regulatory Agency).

IPM in six steps

1. Identifying beneficial and harmful organisms

Most living organisms are beneficial. It is unnecessary to destroy them indiscriminately. The first step in integrated pest management is to correctly identify the beneficial and harmful species that inhabit agricultural ecosystems, such as a cranberry bog.

Identifying the pests is the first, and by far the most important, step. If pests are misidentified, the subsequent steps will consequently be incorrect and could result in inappropriate actions. To address this first step, several major studies have been conducted, of which one was in Quebec. This study made it possible to identify the species of insect pests associated with cranberry production, determine their pest status and describe the essential components of their biology as well as infestation signs and the type of damage they cause. A guide to the identification of cranberry insect pests in Quebec (Landry et al., 2000) was produced as a result of this study. Other reference works from the United States and Western Canada are also available.

2. Monitoring and assessing the situation

To justify decisions, it is important to assess the environmental conditions, the populations of harmful and beneficial organisms, as well as the health status and development stage of the crops and the pests. For a number of market vegetable and fruit crops, regular monitoring of fields makes it possible to use pesticides more effectively and to reduce their use without loss of quality or yield.

Monitoring crop enemies involves regularly inspecting the fields under cultivation in order to:

- quantify the populations of pests present in a monitoring unit
- understand the evolution of the monitored pest populations
- evaluate their distribution
- locate the areas of infestation.

Effective monitoring requires an ability to understand pests and accurately assess the risks of infestation based on current climatic conditions, and the development of the crop and pests.

The data obtained through pest monitoring, over a number of years and with models, can also be used to predict the emergence and evolution of pest populations.

3. Using action thresholds

An action threshold makes it possible to use pesticides or any other means of control at the right time, with maximum effectiveness. It also makes it possible to realize significant savings by avoiding unnecessary treatments.

Pest control must be cost-effective. The economic benefit of controlling the pests must be greater than the cost of doing nothing or vise versa. According to this logic, there is a

[1] Some of the information presented in this chapter is taken from the guide entitled *Je passe à l'action, j'adopte la lutte intégrée* published by the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), 2002.

break-even point at which the costs associated with pest control are equal to the losses incurred by not acting.

In integrated pest management, the term action threshold is used. This term designates the limit at which a treatment is cost-effective in terms of the large quantity of pests. There are a number of parameters that must be taken into consideration in establishing an action threshold. The most important are:

- the effect of damage caused by a single insect
- the total number of pests/sample unit
- the cost of the control method
- the value of the crop.

The action thresholds mentioned in this guide have not been subject to studies in Canada. They come from data from Massachusetts and Wisconsin, where they have been used for several years. These action thresholds are defined only for insect pests. Action thresholds are not available for diseases or weeds.

4. Adapting the ecosystem

A number of harmful organisms can survive along field edges, in neighbouring crops, in crop residues and in the soil. They can also be carried by agricultural machinery and workers. Several ways exist to make the ecosystem hospitable to beneficial organisms and to crops, but inhospitable to pests, pathogens and undesirable weeds:

- choosing resistant or tolerant cultivars
- maintaining wind breaks, dikes and ditches
- proper water management
- maintaining an ideal pH in soil and water
- controlling plantation density
- adequate fertilization
- sanding and pruning
- establishing gardens to attract pollinators
- etc.

5. Combining pest control methods

Integrating various preventive or curative pest control methods, whether biological, mechanical, cultural, genetic or chemical, often results in a more effective and longer-lasting reduction of populations of harmful organisms. They reduce the risks associated with exclusive reliance on chemical pesticides. Chemical pesticides are only one link in the integrated pest management chain and must be used only when circumstances warrant.

Biological control methods

Biological control involves using living organisms to control others. This requires identifying the natural enemies of pests and understanding the relationships between the two in order to use them to our advantage. Natural predators and parasitoids often play an important role in regulating crop insect pest populations.

The presence of natural predators of pests in commercial cranberry beds can be increased by eliminating unnecessary applications of broad-spectrum insecticides. Biological control methods include biopesticides (bacteria, fungi, viruses, etc.), pheromones, entomophagous nematodes and predatory and parasitoid insects. It must be noted that not all biological control methods are necessarily approved by organic certification organizations.

See Chapter 5: Biological pest control

Pheromones

A pheromone is a chemical substance secreted by an animal that, when released into the environment, influences the behaviour of other animals of the same species. Some pheromones can be synthesized. They can be used to monitor some types of pests by means of traps.

See Chapter 2: Insect pest monitoring techniques

The pheromones used in biological pest management are known as sexual confusion pheromones, or reproductive behaviour disruption pheromones. Sexual confusion disrupts the reproductive success of targeted insects.

Mating disruption

During the mating period, the females release a small quantity of pheromone that attracts the males. This pheromone can be artificially synthesized and released into the environment in larger quantities in order to prevent the males from finding the females. Since they are no longer able to mate, their life cycle is disrupted.

Synthetic pheromones can be applied either in the form of microcapsules, using conventional equipment, or in the form of plastic bags placed in the fields. These bags slowly disseminate the pheromone for the entire mating period of the adults.

Mating disruption is used for a number of different crops and helps to significantly reduce the application of insecticides. Since it is selective, it does not affect the surrounding fauna. However, each species of pest requires a different treatment. Although this method is used in Western Canada to control the blackheaded fireworm, it is still not very popular among cranberry producers in Eastern Canada.

Biopesticides

Biopesticides are microbial pesticides that are used as a method of biological pest control. They are made from micro-organisms such as fungi, viruses or bacteria or their toxins. In cranberry production, microbial pesticides based on *Bacillus thuringiensis kurstaki* (Btk) are used to control various species of spring caterpillars.

Biopesticides are selective; they are effective against the target pests while posing no risk to other non-targeted species such as humans, wildlife, pets, aquatic organisms, pollinators and natural enemies.

Entomophagous nematodes

Entomophagous nematodes are microscopic cylindrical worms that live in the soil and are pest to certain species of insects. They are used in cranberry production mainly to control the cranberry girdler and a root weevil complex. The high purchase cost and limited availability of high-quality nematodes are factors that limit their use with cranberries.

Predatory insects and parasitoids

This group of biological agents includes insects and mites capable of attacking the pest on their own. Predators catch and eat their prey in the field, whereas parasitoids consume their host as they grow, and kill it in the process.

In cranberry production, the most well-known parasitoids are the trichogrammas. The species *Trichogramma sibericum* is used to control blackheaded fireworm, while *Trichogramma deion* can be used for controlling cranberry fruitworm and Sparganothis fruitworm.

Cultural control methods

Using cultural practices involves manipulating the agricultural environment in specific ways in order to make it less hospitable to pests. Cultural practices have the advantage of generally being long-lasting and inexpensive. In cranberry production, the main cultural practices generally used for pest control are flooding and sanding.

Flooding

Flooding is routinely used in Massachusetts to control pests. Late water or spring flooding, involves flooding the beds for a one-month period in spring. This practice helps control false armyworm, cranberry blossomworm, gypsy moth and cranberry fruitworm. A short period of spring flooding from bud break to bud elongation, lasting 24 to 48 hours, makes it possible to control various spring caterpillars (green spanworm, false armyworm, blackheaded fireworm, etc.)

Fall flooding for one week in September helps control cranberry girdler. A two-week post-harvest flood is effective in controlling black vine weevil and strawberry root weevil. Flooding, whether of long or short duration, is seldom used as a pest control method in Eastern Canada. Studies are necessary to examine its effectiveness.

Flooding helps remove residues from leaves, fruit and twigs during harvesting. This debris, which floats to the top, should be collected and disposed of far from the beds because it can harbour insect pests such as cranberry girdler, as well as weed seeds and certain pathogens over the winter.

Caution! Extended periods of flooding entail a number of hazards. They may create favourable conditions for certain diseases. They may also cause asphyxiation of cranberry plants. The critical oxygen content of the water, below which damage from oxygen deficiency may occur, is 5.7 ppm (Eck, 1953).

Sanding

Sanding the beds during winter is a common practice in cranberry production in Eastern Canada. Young beds are often sanded annually and mature beds are sanded every three to five years. Sanding involves spreading an even layer of sand 1.2 to 2 cm (½ to ¾ inches) thick on the ice that covers the fields during winter. When the ice melts in the spring, the sand covers the leaf residues as well as the stems. Like pruning, this encourages the formation of new roots and new stems. Healthy plants are less vulnerable to insects, pathogens and weed infestation.

Sanding is an important method for controlling cranberry girdler. Research has also shown its effectiveness in reducing populations of green spanworm and cranberry tipworm. Even sanding is also known to reduce the germination of dodder seeds, as well as reducing the appearance of certain diseases, such as the decline of sprouts and fruit rot.

This practice should be avoided at sites where there is a large accumilation of sand as damage to plants may result. Plantations on sites of this kind may also be vulnerable to sclerotic rot.

Strategic chemical control methods

Integrated pest management calls for using the least toxic registered pesticides in order to safeguard the environment and beneficial organisms. Whenever possible, products of different types should be rotated in order to prevent the emergence of pest resistance. Integrated pest management aims for strategic and effective use of chemical control methods only when they prove necessary.

Resistance means the process whereby an animal or plant population gradually loses its sensitivity to a toxin. When a population is exposed to a pesticide, some individuals that are genetically predisposed to resist the pesticide in question will survive. Most of those individuals' descendants, bearing as they do their parents' genes, will inherit the natural ability to survive exposure to that particular pesticide.

It is essential to choose judiciously the appropriate pesticide to control the pest targeted, to read the label and to follow the manufacturer's recommendations. This reduces cases of toxicity and risks to the environment.

Consult an advisor or a specialist in order to obtain appropriate information about which control methods to use. If the use of pesticides is necessary, choose products that have less risk for the environment and human health.

6. Evaluating the consequences and effectiveness of actions

Every decision-making process involves evaluating the results. By using control plots and monitoring and evaluating performance and quality, we can quantify the effectiveness and cost-effectiveness of the actions taken and gradually improve pest control strategies.

Integrated pest management can produce concrete results such as a reduction in the quantity of pesticides applied and the risks associated with their use by improved effectiveness of actions, use of less harmful pesticides, targeted actions, etc. All of the above leads to better protection of the surrounding environment, users and consumers, while maintaining fruit quality and yields.

A personalized approach to integrated pest management

Growers can evaluate their own progress in terms of managing pests affecting their crops using the *Cahier d'auto-évaluation en lutte integere - canneberges*. This publication is available free of charge from the persons responsible for Plant Health Strategy at the Quebec Department of Agriculture, Fisheries and Food.

www.agr.gouv.gc.ca/dgpar/agroenv/slv-strategie.html

To find out more

In order to be better prepared to manage your crops, a list of contacts, references and Web sites is provided in Appendix E.

See Appendix E: For more information

CHAPTER 2: INSECT PEST MONITORING TECHNIQUES

Monitoring provides data on the population levels and species of pests present in the fields, as well as on the development stage of pests and the extent of damage. Two key factors in an effective monitoring program are the establishment of a regular monitoring schedule (e.g., once a week) and data collection. Monitoring must also take into account the period of activity of the target pest. That is why it is essential to identify and understand both the pests and the beneficial organisms. The monitoring data must then be compared with available action thresholds or charts to determine the recommended treatments.

Decisions must be based on the potential damage caused by the pest and its density, the level of natural predators present, the phenological stage of the plant and climatic conditions.

Many insect species are found in a cranberry bog, but only about 30 are considered as pests of economic importance. It is therefore essential that you be able to distinguish these species of insect during monitoring in order to avoid being distracted by species that do not cause economic damage. There are a number of insect pest monitoring techniques; a few are specific to a particular pest species. Sweep netting and the use of pheromone traps are the most commonly used methods in cranberry production.

Sweep netting techniques

Figure 2.1: Net used for net sweeping

Nets are an essential tool for monitoring. They are used to monitor the various species of insects that feed on buds and foliage at the start of the season.

A sweep is a 180º arc around the person sweeping. A "sweep set" is a given number of sweeps determined based on the net's diameter. Two net diameters are used: 30 cm (12 in.) and 38 cm (15 in.). A sweep set made with a 30 cm (12 in.) net comprises 25 sweeps, while 20 sweeps are needed with a 38 cm (15 in.) net.

The material at the rim of the net wears out quickly upon contact with woody stems. It must therefore be made from a strong material.

When should you monitor

Sweep netting begins from bud break of plants. It is carried out once a week, usually until flowering. However, if one suspects the presence of cranberry weevils, blackheaded fireworms or redheaded flea beetles, it is recommended that sweep netting and visual observations of the beds be continued until August. The frequency of the monitoring can be reduced, but constant monitoring is essential.

It is generally not recommended to carry out net sweeps during flowering to avoid damaging the flowers.

The first few weeks of monitoring correspond to the period of emergence of the caterpillars. Caterpillar populations must be estimated when the caterpillars are young. As they grow, the caterpillars cling to the stems or hide during the day. This makes them more difficult to detect.

Most species are active during warm, calm days. In the morning, it is preferable to wait until the plants are dry before beginning monitoring. When the plants are wet because of dew, rain or irrigation, the leaves stick to the net, making it difficult to see the caterpillars.

If an infestation of nocturnal insects such as black vine weevil or strawberry root weevil is suspected, night monitoring is recommended in June and July.

Sweep net monitoring: day vs night

A sweep net monitoring study conducted in Massachusetts has successfully identified the periods when various types of insect pests are active.

These findings show that spanworms and cranberry cutworms have similar activity models. The young larvae are active during the day, even though more specimens are captured at night (between nightfall and midnight). As the larvae grow, they tend to become active exclusively at night. In the case of the climbing cutworm, the best monitoring period is approximately 11 p.m., for all larval stages. The cranberry weevil, for its part, is active during the day. Adult flea beetles are found both during the day and at night, but captures appear to be more abundant during the afternoon. This behaviour may be related to temperature.

One possible explanation for the nocturnal activity pattern displayed by cranberry cutworms and spanworms is that feeding at night helps them avoid predation by birds. Birds actively forage during the day; therefore, they may be good indicators of areas where there are infestations of cranberry cutworms or spanworms. Of the insects that are active during the day, some rely on a form of protection (e.g., blackheaded fireworms hide in shelters made of silk; cranberry fruitworms are concealed in the fruits), others are not of much interest as prey for birds (e.g., very small larvae, weevils), while still others have means of evading bird predation (e.g., flea beetles).

The study referred to above has shown the importance of conducting monitoring operations during the day on a weekly basis, in order to capture young lepidopteran caterpillars before they become active only at night. Monitoring at night may be necessary at least once before flowering, to ensure that no infestations have been overlooked.

Action thresholds are based on monitoring by day. Some adjustment may be necessary for night monitoring.

How to monitor

Before beginning sweep netting, it is necessary to observe the entire bed in order to verify the appearance of the plants and check for any areas of damage. Then, it is necessary to:

- Sweep the net among the plants, making 180° arcs around you;

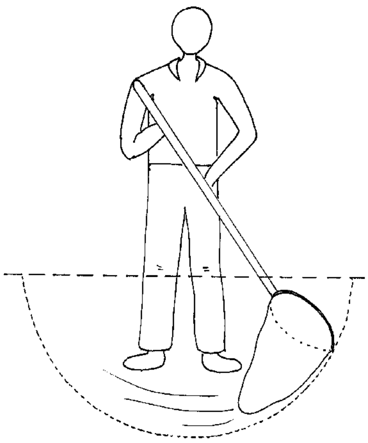


Figure 2.2: Outline of net sweeping crops

  - apply strong pressure to the net to ensure that it penetrates the crops;
  - net movements should be made smoothly;
- Perform one sweep set per acre (1 set/acre);
  - preferably walk in a straight line or perform an arc sweep with the net;
- Tap the net after each set in order to make the insects fall to the bottom of the net;
  - always wait a few seconds before unfurling the net when counting; this way the larvae will begin to move and will be easier to observe;
  - always check for the presence of caterpillars around the rim of the net;
  - pick a spot sheltered from the wind to take the count;
- Correctly identify the species of insects present and count them in the net;
  - record the species present in the net and the number of individuals of each species;
  - enter the following information in a notepad: date, name of the farm, bed number, phenological stage of the plant, summary map of the bed, name of the insect and number of insects of each species caught;
- For a given bed, calculate the overall average for each species or group of species;
- Before and after each sweep set, check the plants closely to determine the phenological stage, then check for any damage.

See Appendix A: Sample Reports

Where to monitor

In order to obtain an accurate estimate, it is important to sample the entire bed. The route must therefore cover as large an area as possible. In rectangular beds, a V-, Z- or W-shaped route is preferred. Change the route every week in order to cover the maximum surface during the season.

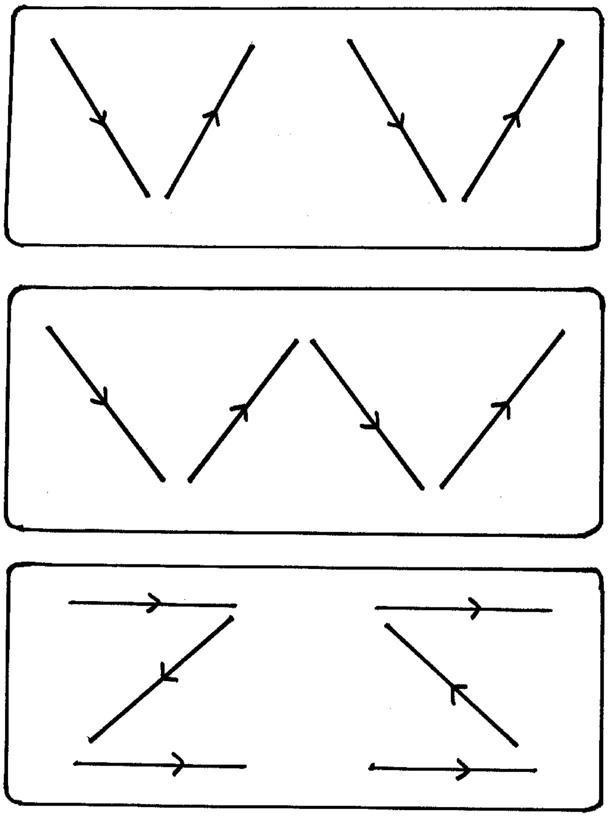


Figure 2.3: Types of net sweeping routes

Certain insects, such as the cranberry weevil, gypsy moth, big cranberry spanworm, spiny looper, blackheaded fireworm, flea beetle, etc. may be concentrated in very specific areas. Therefore, it is essential to change the route in order to cover the most area during the season.

Weedy or bare areas should be avoided so as not to bias the sampling. It is recommended that the edges of the beds be monitored separately if a heavy infestation is suspected. These areas should be spot treated. Regular net sweeps should therefore be begun at least 3 m (10 ft) from the edge.

Tools required for monitoring

- A net 30 cm (12 in.) or 38 cm (15 in.) in diameter
- A notebook and a pencil
- A magnifying glass and good eyes
- A sample jar
- A marking pen
- Plastic bags
- A brush to collect the caterpillars
- Labels

Pheromone Traps[2]

Definition

Pheromone traps are a monitoring technique that indicate the period of emergence of adult males. They make it possible to define the peak flight of butterflies, i.e., the time when the greatest number of adults is present. This also allows us to estimate the egg-laying period of the females, in order to synchronize treatments and to control the pest at the best time. Note that pheromone traps indicate when action must be taken, but they do not indicate whether it is necessary.

In Eastern Canada, pheromone traps are used to determine the presence of cranberry girdler, cranberry fruitworm, blackheaded fireworm and Sparganothis fruitworm.

Some difficulties may arise with respect to the identification of adult specimens caught in traps. Trapped specimens gradually lose their colouring, and must then be identified from their general appearance. Individuals of different species may resemble those of the target species; vigilance is essential.

Description

A pheromone trap is comprised of a sticky inside part and a pheromone capsule. The purpose of this pheromone-containing capsule, made of rubber, attracts male moths. It is suspended from the inside of the top of the trap or inserted at the end. The trap is solidly attached to a stake and placed in the field at a certain height. There are several different types of traps of different shapes. The choice of trap depends upon the pest one hopes to capture.

[2] Source: *Integrated Pest Management in Western Canada—a guide to identification, monitoring and decision-making for pests and diseases* (Maurice et al., 2000)

Table 2.1: Summary of pheromone traps use for each species

Pest	Cranberry girdler	Cranberry fruitworm	Blackheaded fireworm	Sparganothis fruitworm
Type of trap	Pherocon II or Diamond Trap	Delta I	Pherocon II or Diamond Trap	Pherocon I CP
Distance of trap above the plant	20–25 cm (8–10 inches)	75 cm (28 inches)	20–25 cm (8–10 inches)	20–25 cm (8–10 inches)
Number of traps	1 per 4 hectares (1 per 10 acres)	Undetermined*	1 per 4 hectares (1 per 10 acres)	1 per 4 hectares (1 per 10 acres)

*To date, there is no scientific recommendation. Since the pheromone is expensive, it is recommended that approximately one trap be installed per 20 ha (50 acres).

In New Brunswick, 2 traps for every 5 hectares (1 trap for every 6 acres) are usually set for these four insect species. For a field that is more than 10 hectares in area, a lower density may be used. Pherocon I C or Wing Trap I C types tend to be preferred for capturing cranberry girdler, cranberry fruitworm and blackheaded fireworm specimens.

Essential monitoring tools

- Traps (Pherocon II, Pherocon IC, Delta I)
- A capsule of pheromone for each target species
- Metal wire (clip)
- A wooden or metal stake 0.60 m to 1.20 m (2 to 4 feet) in lenth
- A scraper
- Straws 3 cm (1? in.) in length
- Gloves or a plastic bag
- A pin

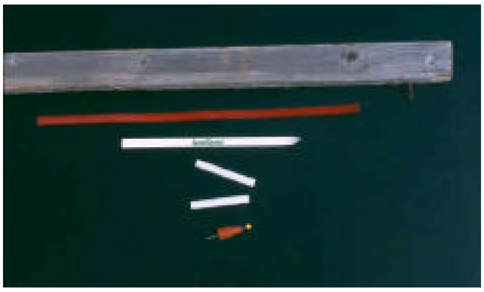


Figure 2.4: Essential equipment for the use of pheromone traps

Directions for assembly

In order to better understand how to use a pheromone trap and guarantee its effectiveness, it is important to follow the instructions below:

1. Assembling the trap

In order to work correctly, it is important that the pheromone trap be well assembled. Different types of trap are assembled in a particular way.

a) Pherocon II (or Diamond trap)

- Unfold the trap into a diamond shape.
- Insert the pheromone capsule according to the instructions provided in the following section.
- Fold the lower flaps inward.

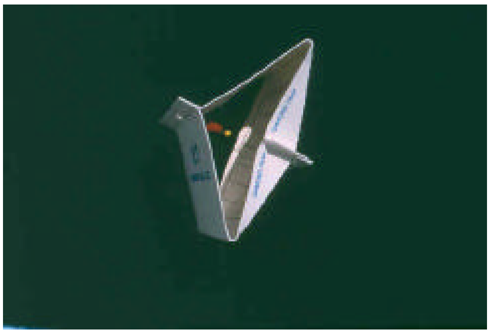


Figure 2.5: Pherocon II trap - with the pheromone

b) Pherocon I CP

- Fold each part of the trap along the marked lines to make a wedge shape.
- Form a “V” with a wire hanger approximately 60 cm (2 ft) long; make a loop at the open end of the “V” in order to form an attachment point.
- Attach the hanger to the upper part of the trap (i.e. non-sticky part), inserting each end in the perforations provided.
- Add the 3 cm (1 ? inch) straws to each end of the hanger.
- Insert this hanger in the perforations of the lower part (i.e. sticky part); the straws will be used to hold the two parts of the trap a couple of centimetres apart.

- Fold the ends of the hanger in toward the centre of the trap in order to solidly attach it.
- Insert the pheromone capsule according to the instructions provided below.

Figure 2.6: Pherocon IC trap

c) Delta 1

- Fold and assemble the cardboard base in order to form a triangle.
- Insert the pheromone capsule according to the instructions provided below.
- Insert the sticky base in the trap (sticky side up).
- Fold the edges inward, inserting them in the slits provided.

Figure 2.7: Delta I trap

2. Handling the pheromone capsule

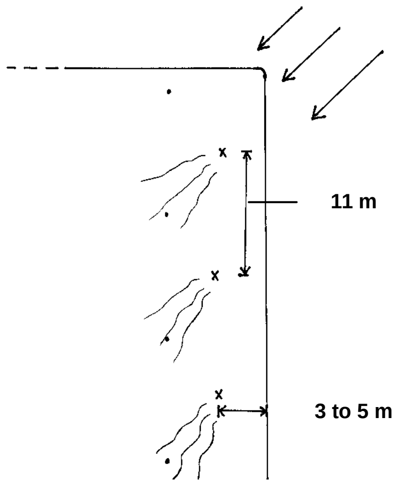
- Do not touch the pheromone capsule directly; disposable gloves or a plastic bag should preferably be used.
- Prick the capsule using a hanger (without touching the capsule if using your fingers).
- Hang the pheromone capsule inside the trap, from the middle of the top or insert it in the base.

The capsule of pheromone is odourless. However, the pheromone will stick to the fingers and to the surface of the glove or plastic bag that is used to handle the capsule. Consequently, it is important not to touch other parts of the trap with the fingers or with the gloves or the plastic bag in order to avoid spreading the pheromone. The same gloves or plastic bag should not be used to handle capsules for different pest species. When all the capsules have been placed in the proper traps, the gloves or the plastic bag should be discarded.

3. Installing the traps in the cranberry beds

- Place the traps at least one week before moth flight begins, that is, around early June. Adult flight for cranberry fruitworm begins approximately one week before that of the blackheaded fireworm, Sparganothis fruitworm and cranberry girdler.
- Determine the trap locations based on the prevailing winds (trap opening facing the prevailing winds).
- Place the number of traps required based on the crop surface area.
- Install the traps between 3 and 5 m (10 to 15 ft) from the edge, while keeping them away from the sprinkler nozzles.
- Place a wooden stake at each location, leaving at least 11 m (30 ft) between each stake. The distance between each stake can be much greater if they are placed lengthwise in the field.
- Attach the trap to the stake using a wire hanger, so that the base of the trap is at the proper height, at the head of the plants.

Figure 2.8: Pherocon II trap in a field



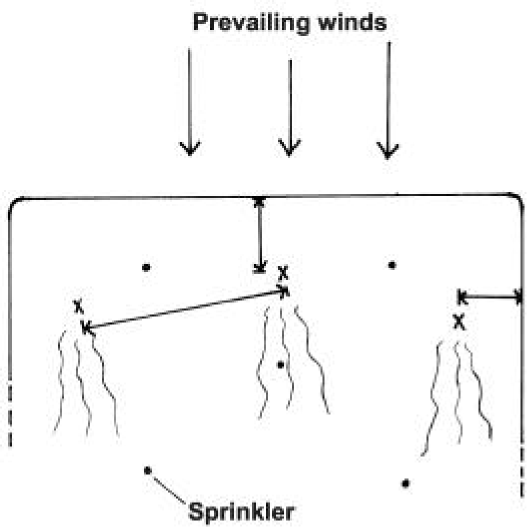


Figure 2.9 a & b: Positioning the traps in a field

Example: a grower with 20 hectares (50 acres) will set 1 cranberry fruitworm trap for every 5 traps designed to catch other species, making a total of 16 traps in 50 acres. The grower may set 1 trap for each species in the same field. In New Brunswick, it will be preferable to set 8 traps for each species.

4. Checking the captures in traps

- Check the traps once or twice a week, on the same day each week (for example, every Wednesday or every Monday and Thursday).
- Count and clean the insects caught on the sticky bottom of the trap, (remove the bodies and wings); if the glue is filled with insect bodies or sand, replace the sticky cardboard or the trap.
- Record the number of insects captured in a notebook and then in the monitoring report.

See Appendix A: Sample Reports

5. Replacing the capsule

- Change the pheromone capsule every three or four weeks following the directions provided above.
- Place the old capsule in a bag and then dispose of it. It should not be left in the pheromone trap or thrown into the field.
- Keep unused capsules in a tightly sealed plastic bag and store them in the freezer until used.

6. Releasing the pheromone

When a new capsule is placed in the trap, the pheromone is quickly released into the air. The release rate of the pheromone from the capsule decreases after several days and stabilizes. The quantity of pheromone released is therefore sufficient to attract insects.

Four to six weeks after placing the new capsule in the field, most of the pheromone will have been released. The capsule still contains a certain quantity of pheromone after this period and can still attract insects. However, its attractive power is reduced and the capsule has to be replaced as described above in order to allow adequate monitoring of the target pests.

Other monitoring techniques

A variety of other monitoring techniques are used in cranberry production. Each is specific to a species of insect pest. They are described in detail for each insect in Chapter 3—Insect pests.

See Table 3.6: Monitoring and control methods of cranberry pests

Table 2.2: Chronology of cranberry pest monitoring

Pest	Bud break (May – June) · Bloom (June – July) · Fruit set (July) · Fruit development and maturation / Bud development (August – September)
Small spanworms	Sweep net sampling
	Infested areas darker
Large spanworms	Sweep net sampling
	Mapping of localized infested areas (darker)
Other spanworms	Sweep net sampling
Redheaded flea beetle	Sweep net monitoring of adults in infested areas
	Infested areas slightly brownish
Cranberry girdler	Installation of traps and checking of traps once a week
	Inspection of larvae
	Inspection of visible signs of damage
	Inspection of adults in flight
	Infested areas reddish or brownish
Cranberry tipworm	Monitoring and binocular examination of eggs and larvae on 100 stems/field
	Infested stems with cupped leaves and brownish apex
Cranberry weevil	Sweep net monitoring
	Fruit pierced
	Browning of buds and orange flower buds
Strawberry root weevil	Sweep net monitoring at night
	Dieback and browning of plants
Black vine weevil	Net monitoring at night
	Dieback, wilting, browning and sometimes death of plants
Tussock moth	Sweep net monitoring
	Infested areas localized, dark
Noctuid moth	Sweep net monitoring
	Buds, new shoots, leaves, flowerbuds eaten
Cranberry fruitworm	Installation of traps and checking of traps at least once a week
	Premature reddening of fruit
	Calculation of percent fruit set
	Viable eggs**
Blackheaded fireworm	Installation of traps and checking of traps at least once a week
	Inspection of larvae on stems and sweep net monitoring
	Infested areas where plants look burned
	Leaves tied together with silk
	Fruit pierced or eaten, tied together with silk
Sparganothis fruitworm	Installation of traps and checking of traps at least once a week
	Sweep net monitoring
	Fruit pierced, eaten, redden prematurely
	Leaves tied together with silk

** Number of viable cranberry fruitworm eggs in 200 fruits/field

CHAPTER 3: INSECT PESTS[3]

Table 3.1: List of insect pests on cranberries in Eastern Canada

ENGLISH NAME	FRENCH NAME	LATIN NAME	PAGE
Big Cranberry Spanworm	Arpenteuse bituberculée	*Eutrapela clemataria* (J. E. Smith)	23
Black Vine Weevil	Charançon noir de la vigne	*Otiorhynchus sulcatus* (Fabricus)	19
Blackheaded Fireworm	Tordeuse des canneberges	*Rhopobota naevana* (Hübner)	36
Blueberry Spanworm	Arpenteuse noire	*Macaria argillacearia* (Packard)	25
Chain-spotted Geometer	Arpenteuse caténaire	*Cingilia catenaria* (Drury)	26
Cleft-headed Looper	Arpenteuse cornue	*Biston betularia* (Linnaeus)	24
Cranberry Blossomworm	Ver-gris des fleurs d'atocas	*Epiglaea apiata* (Grote)	30
Cranberry Fruitworm	Pyrale des atocas	*Acrobasis vaccinii* (Riley)	34
Cranberry Girdler	Anneleur de la canneberge	*Chrysoteuchia topiaria* (Zeller)	32
Cranberry Tipworm	Cécidomyie des atocas	*Dasineura oxycoccana* (Johnson)	20
Cranberry Weevil	Charançon des atocas	*Anthonomus musculus* (Say)	17
False Armyworm	Fausse légionnaire	*Xylena nupera* (Lintner)	29
Green Spanworm	Arpenteuse verte	*Macaria sulphurea* (Packard)	22
Gypsy Moth	Spongieuse	*Lymantria dispar* (Linnaeus)	28
Hemlock Looper	Arpenteuse de la pruche	*Lambdina fiscellaria* (Guenée)	26
Horned Spanworm	Arpenteuse à pointes	*Nematocampa resistaria* (Herrich-Schäffer)	25
Impressed or Printed Dagger Moth	Acronicte impressionnée	*Acronicta impressa* (Walker)	30
Putnam's False Looper	Fausse-arpenteuse de Putnam	*Plusia putnami* (Grote)	30
Rannock Looper	Arpenteuse brune	*Macaria brunneata* (Thunberg)	22
Rear-humped Caterpillar	Ver-gris bossu	*Amphipyra pyramidoides* (Guenée)	30
Redheaded Flea Beetle	Altise à tête rouge	*Systena frontalis* (Fabricius)	16
Rusty Tussock Moth	Chenille à houppes rousses	*Orgyia antiqua* (Linnaeus)	27
Small Engrailed or Saddleback Looper	Arpenteuse bossue	*Ectropis crepuscularia* (D.& S.)	26
Sparganothis Fruitworm	Tordeuse soufrée	*Sparganothis sulfureana* (Clemens)	38
Speckled Green Fruitworm	Orthosie verte	*Orthosia hibisci* (Guenée)	29
Spiny Looper	Arpenteuse épineuse	*Phigalia titea* (Cramer)	23
Stout Spanworm	Arpenteuse piquée jaune	*Lycia ursuria* (Walker)	23
Strawberry Root Weevil	Charançon de la racine du fraisier	*Otiorhynchus ovatus* (Linnaeus)	18
Triangle-marked or Pale-winged Grey Moth	Arpenteuse à taches	*Iridopsis ephyraria* (Walker)	25
Zebra Caterpillar	Chenille zébrée	*Melanchra picta* (Harris)	31

With a view to facilitating the identification of insect pests, several identification guides have been included among the references placed at the end of this work.

[3] The information in this chapter is taken in part from the following works: *Insectes ravageurs de la canneberge au Québec – guide d'identification* (Landry et al., 2001), *Cranberry Insects of the Northeast* (Averill and Sylvia, 1998) and *Integrated Pest Management in Western Canada* (Maurice et al., 2000).

Classification of insect pests

In this chapter, insect pests of cranberries have been classified by phylogeny (order and family). It was not feasible to use pest status as a basis for classification, as the status of many of them is different in different provinces.

Key to the colour code

A colour code has been used as a means of visualizing the status of pests in provinces of Eastern Canada.

RED: Major pest

Well adapted to cranberries. Can cause extensive economic damage if uncontrolled.

GREEN: Secondary pest

Can cause economic damage in some years. Should be watched if no action is taken to control the main pests.

BLUE: Minor or potential pest

Occasionally found in cranberry plantations, or present in other crops, but not found in cranberries.

Abbreviations denoting provinces

The abbreviations below, when placed in the box at the head of each section, denote provinces, as follows:

NB: New Brunswick
NS: Nova Scotia
PE: Prince Edward Island
QC: Quebec
NF: Newfoundland & Labrador

Plant growth stages

A description of the stages in the growth of cranberry plants when they are vulnerable to pest damage will also be found in the box at the beginning of each section.

Table 3.2: Taxonomic classification of pests

ORDER	FAMILY	GENERA OR SPECIES	PAGE
Coleoptera	Chrysomelid	Redheaded flea beetle	16
	Curculionidae	Cranberry weevil	17
		Strawberry root weevil	18
		Black vine weevil	19
Diptera	Cecidomyiidae	Cranberry tipworm	20
Lepidoptera	Geometridae (Spanworms)	**SMALL SPANWORMS**	**21**
		Green spanworm	22
		Rannock looper	22
		LARGE SPANWORMS	**22**
		Big cranberry spanworm	23
		Spiny looper	23
		Stout spanworm	24
		Cleft-headed looper	25
		OTHER SPANWORMS	**25**
		Blueberry spanworm	25
		Horned spanworm	25
		Triangle-marked or pale-winged grey spanworm	25
		Small engrailed or saddleback looper	26
		Chain-spotted geometer	26
		Hemlock looper	26
	Lymantriidae (Tussock moth)	Rusty tussock moth	27
		Gypsy moth	28
	Noctuidae (Noctuid moths and cutworms)	False armyworm	29
		Cranberry blossomworm	29
		Speckled green fruitworm	29
		Impressed dagger moth	30
		Putnam's false looper	30
		Rear-humped caterpillar	30
		Zebra caterpillar	31
	Pyralidae	Cranberry girdler	32
		Cranberry fruitworm	34
	Tortricidae	Blackheaded fireworm	36
		Sparganothis fruitworm	38

COLEOPTERA

The order Coleoptera includes a large number of species. These insects are characterized by the presence of elytra covering their wings at rest. The larvae are known as “white grubs”. The specific pests that affect cranberry production are the cranberry weevil (Curculionidae family) and the redheaded flea beetle (Chrysomelidae family).

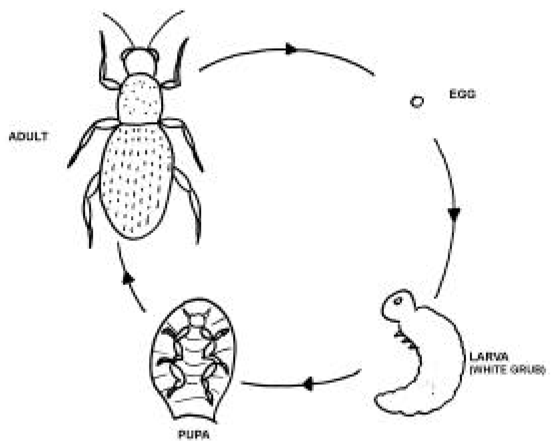


Figure 3.1: Life cycle of Coleoptera

Redheaded Flea Beetle

Systena frontalis (Fabricius)

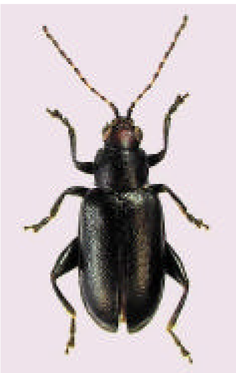


Figure 3.2: Adult redheaded flea beetle

NB NS PE QC NF	Fruit sizing to ripening

- One generation per year.
- This insect has a wide geographic distribution. Although it is common in several crops in Eastern Canada, it is rarely found in cranberry crops.
- The shiny black adult has a reddish frontal section between its two eyes that gives it its name. It is 4 to 5 mm (3/16 in.) in length.
- The larva has a creamy white body with scattered short hairs and a brown head.
- This insect overwinters in the egg stage. The eggs hatch in late spring. The larvae, which live in the soil, are difficult to observe. Little is known about their behaviour. The adults emerge from mid-July to August. They move by jumping. In late summer, the females lay their eggs just beneath the surface of the soil.

Damage

The damage is caused by the adults, which eat the underside of the leaves, leaving only the cuticle and veins. They may also pierce holes in the berries. Infested beds, noticeable in August, exhibit slightly brownish areas. In Massachusetts, adults have been observed feeding on new shoots, compromising development of the buds. The larvae, which feed on roots and stolons, seldom cause damage.

The redheaded flea beetle can attack about 40 cultivated or indigenous plants. It is therefore likely to be found in greatest abundance in heavily weed-infested fields. It also seems to prefer young plantations. It may attack older plants, but less frequently.

Figure 3.3: Leaf damage caused by redheaded flea beetle

Monitoring and action threshold

Around late July, check carefully for any signs of damage. Sweep netting is carried out in beds where damage is visible, even if fruit are present. Note that the insects at the adult stage, which we are trying to catch using a net, are distributed unequally in the beds.

The action threshold used is based on net captures of 15 adults per sweep set. However, this threshold is provisional, since it has not been established based on scientific research. In Massachusetts, producers treat on the basis of the extent of the damage and whether they believe it will affect the buds for the following year.

Control methods

Strategic chemical control

When the action threshold is reached, application of a registered insecticide is recommended. Whenever possible, choose a low-toxicity insecticide.

Cranberry Weevil

Anthonomus musculus (Say)

Figure 3.4: Adult cranberry weevil

NB NS PE QC NF Bud break to harvest

- One generation per year.
- There are several similar weevil species that may be found in or near cranberry plantations. The cranberry weevil has a number of hosts, including the genera Vaccinium and Gaylussacia.
- At emergence, the adult is brown in colour, but subsequently turns a dark reddish-brown. It is 1.5 to 2.0 mm (1/16 to 3/16 in.) in length. It is characterized by a head that is prolonged into a long snout known as a proboscis. The proboscis, which accounts for approximately one third of the weevil's body length, has antennae in the centre and jaws at the tip.
- This insect overwinters in the adult state under plant residue or underground, in or near cranberry plantations. It can survive the spring flooding. In the spring, after the high water of winter has receded, the adults become active. Mating occurs in late spring. At the hook stage and early in the flowering period, the females bore into the flower buds and insert one egg into each. Fifty or more eggs may be laid. Hatching takes place late in June. The larvae develop inside the flower, and pupate there when they reach maturity. The adults emerge in July, just as the fruits are beginning to form. They are active on hot, windless days. Toward mid-August, they migrate to ground level in search of plant residue that will provide them with a shelter for the winter.

Damage

In the spring, the adults climb up the stems and feed on dormant terminal buds and leaves. As the cranberry plants develop, the adults alter their diet, feeding on new leaves and flower buds.

The larvae inside the flowers feed on the flower buds, leaving only the walls of the ovary and the petals. The buds are unable to open; they change colour, turning orange instead of pink and eventually fall off. When a female bores into a flower bud to lay an egg in it, she sometimes damages the pedicel by which the bud is attached to the stem, causing the bud to fall off prematurely.

In July and August, the new adults devour the leaves, the fruits, which are just beginning to grow, and the terminal buds. Damage caused by the adults, both in spring and in summer, appears in the form of tiny holes in the flower buds and terminal buds and small black, crescent-shaped spots under the leaves. Buds that the adult weevils have bored into turn brown, looking as though they had been touched by frost. Damaged fruit is recognizable by the presence of holes. These marks detract from fruit quality.

Figure 3.5: Cranberry weevil larva (circled) in flower

Monitoring and action threshold

From bud break to flowering, monitoring is carried out by means of sweep netting on hot, sunny, windless days. The action threshold is from four to five adults per sweep set. If adults are captured, it is advisable to conduct a visual inspection of the plantations and to continue sweep netting until August.

Control methods

Biological control

A native parasitic wasp, Habrocytus sp., which attacks the larvae of the cranberry weevil, can help keep infestations of this pest under control.

Nematodes may be applied in spring or early in the fall.

Cultural control

Sanding and flooding are not effective means of controlling this insect.

Strategic chemical control

In Eastern Canada, it is seldom necessary to spray to control this pest. Treatments applied early in the season to control the blackheaded fireworm or the cranberry tipworm can also control cranberry weevil populations. If the action threshold is reached, application of a registered pesticide is recommended. Adults should be sprayed before the females lay their eggs, i.e. before the cranberries are in flower.

Strawberry Root Weevil

Otiorhynchus ovatus (Linnaeus)

Figure 3.6: Adult strawberry root weevil

NB NS PE QC NF Fruit sizing to harvest

- One generation per year.
- A serious pest of strawberries in Eastern Canada. Also attacks other small fruits, fruit trees, shrubs and a number of coniferous species in plantations.
- The individuals are exclusively females. The adults are 5 to 6 mm (¼ in.) in length. The body is brownish to blackish, while the antennae and legs are dark brown. These insects are flightless. The adults are active at night.
- This species may overwinter either in the larval stage or in the adult stage. This gives rise to two different scenarios.
  1. Larvae that have overwintered develop and make a cocoon during the season. The adults emerge at the end of the summer. They lay their eggs until September. The larvae that hatch remain active until the first frosts.
  2. Adults that have overwintered become active in the spring. They lay their eggs during the summer. The larvae hatch and develop until pupation. New adults are present in the fall.

Damage

This pest is usually found in plantations that are seldom flooded. The larvae feed on the small roots and the bark of larger roots in the same way as the black vine weevil. Infestations are usually local in nature. The adults do not cause damage.

Monitoring and action threshold

Monitoring of adults is carried out by sweep netting at night if an infestation is suspected. No action threshold has been determined.

Control methods

Cultural control

Flooding at the time of harvesting or during the winter may help control the larvae of this pest.

Biological control

In areas where the strawberry root weevil is a problem, nematodes may be applied. *Heterorhabditis bacteriophora* is a species that is known to afford effective control of larvae in the ground.

Strategic chemical control

Spraying is seldom necessary to control this pest. However, if an infestation is observed, the use of a registered pesticide may be required. For maximum effectiveness, the treatment should be applied on a windless evening, when the adults are feeding on the leaves.

Black Vine Weevil

Otiorhynchus sulcatus (Fabricus)

Figure 3.7: Adult black vine weevil

NB NS PE QC NF	Fruit ripening to harvest

- One generation per year.
- This polyphagous insect has a number of hosts, but its favourites are members of the Rosaceae family.
- The larvae are legless and are whitish in colour with brown heads. They frequently curl up into the shape of the letter “C”. At maturity, they are from 10 to 12 mm (7/16 in.) in length.
- The individuals are females exclusively. The adults are flightless. The body is hard and is black in colour, with yellow hairs. They are 9 to 11 mm (? to 7/16 in.) in length. The back is characterized by parallel rows of small depressions. The mouthparts are extended into a snout with the antennae near its tip.
- This insect overwinters underground in larval form. In the spring, a prepupa forms, which subsequently develops into a pupa. The adults emerge in June and July. They spend the daylight hours hidden in plant residue on the ground, becoming active only at night. The eggs are laid from July to September. Each female lays an average of 300 eggs, which she deposits on the surface of the ground. The larvae are present in August and September.

Damage

The adults eat the leaf margins, causing damage that is usually slight. More serious damage results from the larvae feeding on the roots and the bark of the stems, sometimes even causing the death of the plant. Infestations are usually local in nature. The damage that is observable is similar to damage caused by the cranberry girdler: dieback, wilting, browning and sometimes death of plants.

Figure 3.8: Overview of damage caused by the black vine beetle

Monitoring and action threshold

If an infestation is suspected, adults may be detected by means of monitoring operations conducted at night in June and July. These insects are most commonly found in plantations that are seldom flooded. If damaged plants are observed, the grower should lift them up and look at the bottom five centimetres, to see whether the stems display insect damage or whether larvae curled up into a “C” shape are present. The larvae, however, are difficult to see in the fall, because they are so small. No action threshold is available.

Control methods

Cultural control

Flooding at the time of harvesting or during the winter may eliminate most black vine weevil larvae.

Biological control

In areas where the black vine weevil is a problem, nematodes are applied in the spring and fall to attack the larvae in the ground. *Heterorhabditis bacteriophora* is a species that is known to afford effective control of this pest.

Strategic chemical control

Most soil-applied insecticides are ineffective against this pest.

DIPTERA

Diptera are flies of varying sizes. The larvae are called maggots. They include parasitic and predatory species of various pests. In cranberry production, this order includes one pest, the cranberry tipworm.

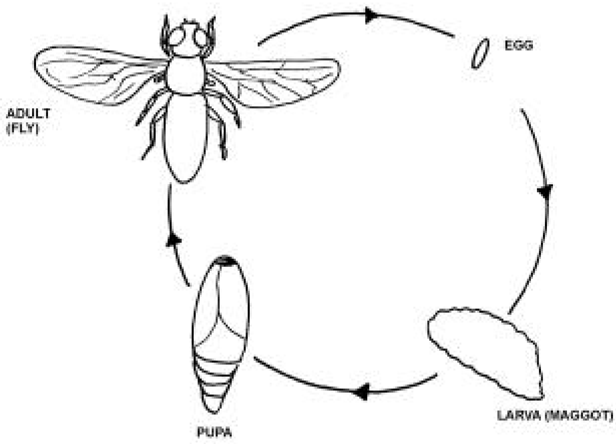


Figure 3.9: Life cycle of Diptera

Cranberry Tipworm

Dasineura oxycoccana (Johnson)

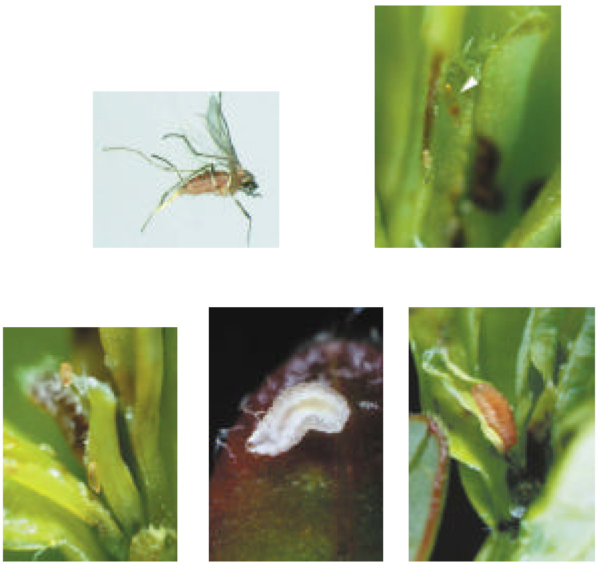


Figure 3.10: Cranberry Tipworm (adult, egg and larve)

NB NS PE QC NF Bud break to harvest

- Three generations per year in Quebec, two generations per year in New Brunswick and Nova Scotia, unknown number of generations per year in Prince Edward Island.
- The adult is a tiny fly 1.5 mm (1/16 in.) long. The larvae, called maggots, are legless. They are characterized by three successive colour instars: first clear, then white, then orange.
- This insect overwinters on the ground in the pupal stage. During bud break, the adults emerge and mate, and the female lays one to five eggs at the base of the terminal leaves. The larvae emerge and feed on these young leaves. Over a 10-day period, the larva passes through the clear, the white and then the orange instar; it then spins a cocoon inside a damaged leaf and enters the pupal stage. The adult emerges five days later and a new cycle begins, which will last two to four weeks. The first generation is present in May–June. The second generation can be observed in July. In Quebec, a third generation appears in August.

Damage

Leaves damaged by the larvae curl up, become cupped, discolour (from brown to silvery) and fall off. The damage caused by the first generation becomes apparent around late June (early June in southern New Brunswick). This is followed by damage from the subsequent generations.

Damage from the first generation leads to the development of new lateral stems. These stems usually compensate and recover from the damage done by the larvae.

The second-generation larvae are more numerous. They ravage the leaves and buds, possibly reducing fruit production the following year. The extent of the damage is influenced by the length of the growing season. In some regions, the growing season is long enough to enable the damaged stems to reform an auxiliary bud. The damage will be minimal since these buds will produce fruit the following year. However, in regions where the growing season is shorter, the plants generally do not have this opportunity. The stems will remain vegetative the following year, resulting in more extensive damage.

The larvae of the third generation, if there is one, directly damage the buds. However, this generation has far fewer individuals and therefore causes little damage.

Monitoring and action threshold

Monitoring begins at bud break. It involves taking a random sample of 100 stems/bed; the tips of the stems are examined using a binocular loupe in order to detect and record the number of eggs, larvae of each instar and pupae. Regular monitoring of the first generation will identify the period when the number of freshly hatched eggs is highest. It is at this peak that treatment must be carried out, since the older larvae as well as the pupae are less vulnerable to insecticide treatment.

This monitoring technique is very time-consuming, i.e. 40 to 50 minutes per bed. Attention should therefore be focused on the beds that have a history of infestations, where the tipworm is more likely to be found. Greater vigilance is necessary in young beds and heavily fertilized beds, which are more likely to harbour this insect because of the abundance of attractive young leaves, whose growth is stimulated by nitrogen. Susceptibility to infestation can also be affected by the choice of cranberry varieties. The Ben Lear, Howes, Searles and Stevens varieties are apparently susceptible to attack by this insect.

No action threshold has been determined; each producer's decision to act depends on his own tolerance threshold.

Control methods

Cultural control

Flooding is not an effective means of control of this insect because it can remain submerged for long periods of time.

Uniform sanding, to a depth of approximately 1 to 2 cm, can help reduce tipworm infestations by preventing emergence of the adults. This practice can be carried out every 2 years, but must be applied to all the beds in order to prevent the insects from recolonizing a bed from an adjacent unsanded bed.

Since it is known that nitrogen-rich plants attract the tipworm, it is recommended that beds not be fertilized late in the season. Indeed, the females prefer to lay their eggs on actively growing tissues.

Biological control

Research studies have identified several parasitoids that attack tipworm larvae. However, parasitism is not very effective as a control method. There is also one known predatory syrphid: Toxomerus marginatus. Other natural predators, such as spiders and other generalist predators, can play an important role. Their impact will vary and will be affected by the use of broad-spectrum pesticides.

Strategic chemical control

If warranted by monitoring data, a registered insecticide can be used during the peak egg hatch of the first or second generation. The first generation must be targeted insofar as possible, since the second often occurs during full bloom. Treatments against the third generation are useless since the worst of the damage has already been done. Preference should be given to insecticides with little environmental risk.

A subsequent sampling is recommended 2 to 3 days after a treatment, in order to check for dead larvae. Remember that only the larvae of the first (clear) instar will be affected. If a second treatment is necessary, act as quickly as possible.

LEPIDOPTERA

This order includes the butterflies and moths. They are characterized by the presence of scales on their wings. The Lepidoptera are of economic importance since the larvae, called caterpillars, are often pests in various crops or plantations. The members of this order undergo complete metamorphosis, from the egg stage to caterpillar, pupa and then adult. This order includes several families.

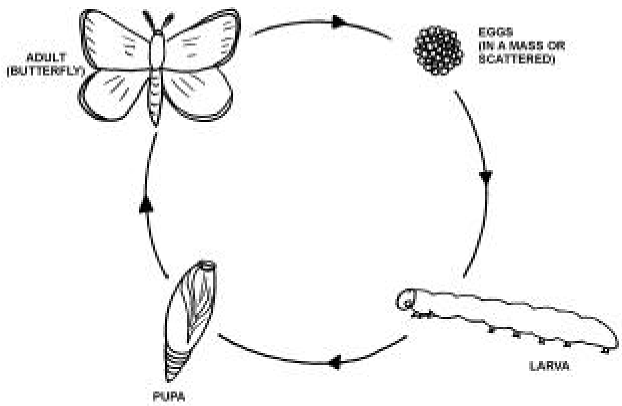


Figure 3.11: Life cycle of Lepidoptera

The caterpillars are called spanworms. They have two or three pairs of prolegs. The body is hairless or more rarely has scattered stiff hairs. The spanworms move characteristically by arching the middle of their bodies. If disturbed, they freeze and become stiff, imitating a stem.

For monitoring purposes, the spanworms are divided into three categories: small, large and other spanworms.

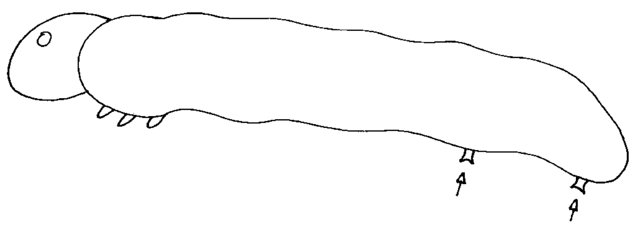


Figure 3.12: Caterpillar with two pairs of prolegs

Small spanworms

On maturity, the small spanworms are no more than 30 mm (1 3/16 in.) long. Individually, they are not very voracious. However, a large population can cause serious damage.

Green Spanworm

Macaria sulphurea (Packard)

Figure 3.13: Green spanworm caterpillar

NB NS PE QC NF Bud break to bloom

- One generation per year.
- The caterpillar is green with white longitudinal stripes.
- It overwinters in the egg stage. The eggs hatch in the spring. The caterpillars are present from May to June. After a short pupation period, the adults emerge in July. The females lay their eggs singly in plant residue
in August.

Rannock Looper

Macaria brunneata (Thunberg)

Figure 3.14: Rannock looper caterpillar

NB NS PE QC NF Bud break to bloom

- One generation per year.
- The mature caterpillar is brown with a yellow-white longitudinal stripe.
- It overwinters in the egg stage. The eggs hatch in the spring, around mid-May. The caterpillars are present from May to June. After a short pupation period, the adults begin to emerge in mid-June.

Damage

In the spring, the young caterpillars climb to the tips of the stems to feed on the buds at bud break. These small spanworms feed freely on the buds, new leaves and flower buds. They do not spin webs like tortricids. Heavily damaged areas appear darker because the new foliage will be less apparent and the flowers less abundant.

Monitoring and action threshold

Sweep netting is used to monitor the caterpillars from mid-May to flowering. Concentrations of caterpillars are frequently seen in one section of a bed.

The action threshold in current use is 18 larvae per sweep set.

Control methods

Cultural control

Late water does not affect green spanworms. However, a short flooding of 10 to 15 hours at the end of May reduces part of the population.

Sanding helps reduce populations. The sand covers the eggs located in the plant residue, preventing them from hatching. The thickness of the sand must be at least 2.5 cm (1 inch).

Biological control

Registered biopesticides containing *Bacillus thuringiensis kurstaki* (Btk) can be an alternative to chemical insecticides. For maximum effectiveness, these Btk-based products should be applied when the caterpillars are in the early stages of their development. The infestations must therefore be detected early.

See Chapter 5: Biological Pest Control - Bacteria

Strategic chemical control

A registered chemical insecticide should be applied only if the action threshold has been reached. Whenever possible, choose a low-toxicity insecticide.

Large spanworms

At maturity, these spanworms can reach a length of up to 60 mm (2 3/8 in.). Individually, these spanworms are very voracious. They are generally found in localized areas.

Big Cranberry Spanworm

Eutrapela clemataria (J.E. Smith)

Figure 3.15: Big cranberry spanworm caterpillar

NB NS PE QC NF Bud break to fruit sizing

- One generation per year.
- Grey caterpillar with two brown tubercles near the middle of the back.
- It overwinters in the pupal stage on the ground. The adults emerge in the spring. The females lay their eggs in clumps on the stems. The caterpillars are present in June and July.

Spiny Looper

Phigalia titea (Cramer)

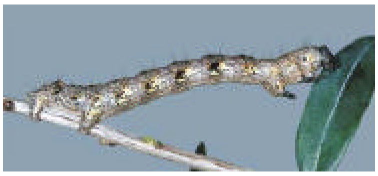


Figure 3.16: Spiny looper caterpillar

NB NS PE QC NF Bud break to fruit set

- One generation per year.
- Greyish caterpillar with a series of irregular yellow or orange-coloured spots, with black tubercles on the side. Body spiked with black hairs.
- It overwinters in the pupal stage on the ground. The adults emerge early in the spring. The females, which are flightless, lay their eggs in clumps on the stems. The caterpillars are present from mid-May to mid-June.
- First-instar caterpillars float and are carried by the wind to new sites. They cling by silk threads to the dead twigs on which the eggs were laid. These young caterpillars complete their development and overwinter in the pupal stage. The following spring, the females attract a male to mate and lay their eggs on the new site.

Stout Spanworm

Lycia ursuria (Walker)

Figure 3.17: Stout spanworm caterpillar

NB NS PE QC NF Bud break to fruit set

- One generation per year.
- Caterpillar ranging in colour from black with white rings to greyish with yellow stripes.
- It overwinters in the pupal stage on the ground. The adults emerge early in the spring. The females lay their eggs en masse. The caterpillars are present beginning in June.

Damage

These three species of large spanworms feed on new shoots, including leaves, stems and flower buds. The spiny looper can completely defoliate the plants. The big cranberry spanworm appears to be more attracted by flower buds and flowers.

Infestations are generally localized and the damage is visible by a difference in coloration: infested areas are darker.

Figure 3.18: Overview of damage caused by the stout spanworm

Monitoring and action threshold

Sweep netting is used to monitor the caterpillars of these large spanworms from mid-May to July. There are, however, certain points that must be borne in mind:

- Infestations of these spanworms are localized, since the eggs are laid en masse. It may not be possible to locate all the infested areas with sweep netting. It is therefore recommended that more intensive monitoring be carried out if an infestation is suspected (i.e. more sweep sets within and on the edge of the bed).
- Mapping of the infested areas is recommended in order to facilitate spot treatments.
- As they grow, the caterpillars cling more and more tightly to the stems, which makes it more difficult to trap them in the net.
- The emergence of some of these spanworms, such as the big cranberry spanworm, may occur later at the start of flowering. Monitoring during flowering is therefore recommended if an infestation is suspected. Observing damaged areas or a concentration of birds can also be helpful in detecting an infestation.
- These caterpillars are very voracious and can completely consume the new shoots and flowers in the infested area.

There is no official action threshold for these large spanworms. It is advisable to count captures of big cranberry spanworms as though they were captures of noctuids.

Control methods

Biological control

Registered Btk-based biopesticides can be an alternative to chemical insecticides.

For maximum effectiveness, these Btk-based products should be applied when the caterpillars are in the early stages of their development.

See Chapter 5: Biological Pest Control – Bacteria

Natural factors generally keep the population of spiny loopers at normal levels. There are various parasitoid wasps that attack the eggs, larvae and pupae.

Strategic chemical control

Often, the presence of these pests in cranberry beds does not necessarily require a generalized insecticide application. Pinpointing infested areas during monitoring allows spot treatments to be carried out. Spot applications of a registered chemical insecticide are generally sufficient and effective. Whenever possible, choose a low-toxicity insecticide.

Cleft-headed Looper

Biston betularia (Linnaeus)

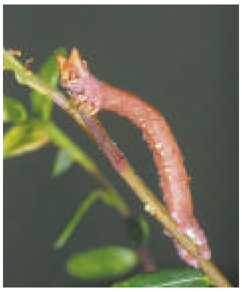


Figure 3.19: Cleft-headed looper caterpillar

NB NS PE QC NF From bloom to harvest

- One generation per year.
- The mature caterpillar is grey with a slight purplish cast. Its head has two protuberances that resemble cats' ears.
- This spanworm overwinters in the ground in the pupal stage. The adults emerge from late May to early August. The females lay their eggs en masse on the vegetation. The caterpillars are present from July to September.

Damage

These insects can cause localized damage. The caterpillars devour the foliage, causing visible defoliation.

Monitoring and action threshold

No action threshold is currently available.

Control methods

Strategic chemical control

Chemical control is generally not necessary for these pests. However, if infested areas are present, spot treatment is recommended. The use of a registered insecticide is acceptable. An insecticide of low environmental risk should preferably be used. The treatment targets the young larvae, which are more sensitive to insecticides.

Other spanworms

This category comprises minor or occasional pests. These spanworms are generally uncommon and not very widespread.

Blueberry Spanworm

Macaria argillacearia (Packard)

Figure 3.20: Blueberry spanworm caterpillar

NB NS PE QC NF Bud break to bloom

- One generation per year.
- Black caterpillar with a yellow stripe with scattered black dots and white spots on the sides It measures about 20 mm (¾ in.) long at maturity.
- It overwinters in the egg stage. The caterpillars are present from May until early June. They are usually more active at night than during the day. The adults emerge in June. The females, which are flightless, lay their eggs in plant residue.

Horned Spanworm

Nematocampa resistaria (Herrich-Schäffer)

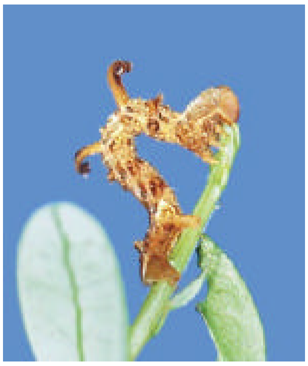


Figure 3.21: Horned spanworm caterpillar

NB NS PE QC NF Bud break to bloom

- One generation per year.
- The mature caterpillar is dark brown with two sets of extendable dorsal tentacles. It measures about 20 mm (¾ in.) long at maturity.
- It overwinters in the egg stage. The caterpillars are present in May and June. After a short pupation period, the adults emerge and are present from mid-June to mid-August.

Triangle-Marked Moth (or Pale-Winged Grey Moth)

Iridopsis ephyraria (Walker)

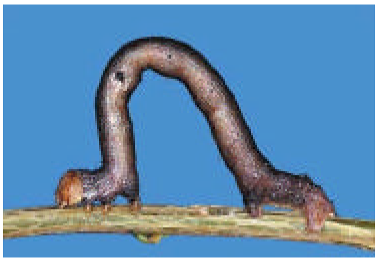


Figure 3.22: Triangle-marked moth caterpillar

NB NS PE QC NF Bud break to fruit sizing

- One generation per year.
- The caterpillar is grey-brown or brown with a red head; 22 to 66 mm (¾ in. to 2 ? in.) long at maturity.
- It overwinters in the egg stage. The caterpillars are present in June and July. After a short pupation period, the adults emerge and are present in July and August. The females lay the eggs in bunches.

Small Engrailed (or Saddleback) Looper

***Ectropis crepuscularia* (Denis & Schiffermüller)**

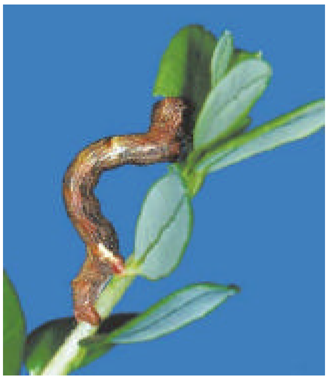


Figure 3.23: Small engrailed looper caterpillar

NB NS PE QC NF	Bud break to bloom

- Two generations per year.
- The mature caterpillar is marbled brown-grey, with a pale marking near the first pair of prolegs. It measures approximately 32 mm (1¼ in.) long at maturity.
- It overwinters in the pupal stage. The adults of the first generation are present in May and June. The eggs are laid in groups of 10 to 20. The caterpillars are present from June to September. The adults of the second generation are present from late June to September.

Chain-Spotted Geometer

***Cingilia catenaria* (Drury)**

Figure 3.24: Chain-spotted geometer

NB NS PE QC NF	From bloom to fruit ripening

- One generation per year.
- Medium-sized mature caterpillar has yellow, white and black longitudinal stripes. It measures approximately 45 mm (1¾ in.) long at maturity.
- It overwinters in the egg stage on the ground. The caterpillars are present from the start of flowering and reach maturity in late July or early August. After a pupation period of three to four weeks, the adults emerge in September. The females lay their eggs on the surface of the leaves.

Hemlock Looper

***Lambdina fiscellaria* (Guenée)**

Figure 3.25: Hemlock looper caterpillar

NB NS PE QC NF	From bloom to fruit ripening

- One generation per year.
- The mature caterpillar is light grey with a pair of small black dots on each segment. It measures approximately 32 mm (1¼ in.) long at maturity.
- It overwinters in the egg stage. The caterpillars are present from the start of flowering, from mid-June to mid-August. After a short pupation period, the adults emerge and are present from August to September. The females lay their eggs singly.

Damage

The caterpillars of the blueberry spanworm seem to be strongly attracted by the buds at bud break. They bore a hole in the bud and eat the inside. Stems damaged in this way will not produce berries, since the caterpillars will have eaten the flower buds on the inside of the bud.

Figure 3.26: Overview of damage caused by the blueberry spanworm

The other species of spanworms mentioned above feed mainly on deciduous or coniferous trees. However, they can be found in cranberry beds, where they cause damage by feeding on the new shoots.

Monitoring and action threshold

Nets can be used to monitor these “other” spanworms from bud break to flowering.

The larvae of the blueberry spanworm feed mainly at night and they can be difficult to spot during the day.

No action threshold is currently available.

> In lowbush blueberry production, nets are used for hemlock looper monitoring in the same way as in cranberry production. The action threshold in this case is 12 caterpillars per sweep set for producing beds and 7 caterpillars per sweep set for vegetative beds; 30 cm (12 in.) nets are used.

Control methods

Cultural control

Keeping ditches clean and partially filled with water helps prevent infestations of the chain-spotted geometer.

Biological control

The biopesticide *Bacillus thuringiensis kurstaki* has proved to be very effective in controlling blueberry spanworm in blueberry production in Maine.

Several species of wasps are parasites for the blueberry spanworm. These parasites help keep populations under control most of the time; however, populations fluctuate from year to year.

Parasites, predators, diseases and unfavourable weather conditions are important factors that can reduce populations of the small engrailed looper during infestations. Polyhedral viruses may be a major factor in controlling infestations.

See Chapter 5: Biological Pest Control – Bacteria

Strategic chemical control

The presence of these pests in cranberry beds does not necessarily require an application of insecticides. The cranberry is not the preferred host plant of any of these spanworms except the blueberry spanworm. In many cases, populations of these pests will be controlled by the actions taken against the main or secondary pests.

Lymantriidae (tussock moths)

These polyphagous caterpillars are very common. They have five pairs of prolegs and a brightly coloured, very hairy body. The adult females are wingless and cannot fly.

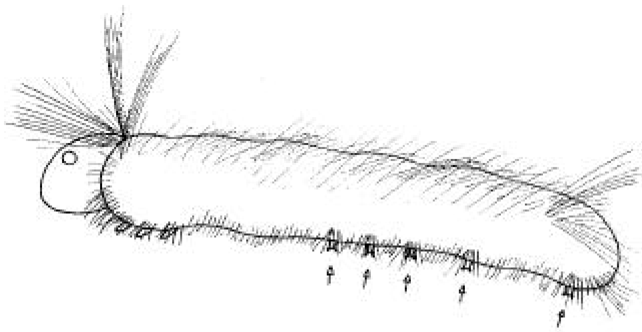


Figure 3.27: Caterpillar with five pairs of prolegs

Rusty Tussock Moth

Orgyia antiqua (Linnaeus)

Figure 3.28: Rusty tussock moth

NB NS PE QC NF	From bud break to fruit ripening

- One generation per year.
- The caterpillars are grey or black with long golden, white and black hairs. Four white or red brush-like tufts arise from the back. There are bright red protuberances on the posterior and sides. Two black brushes can be seen on the front, two on the sides and one at the rear. At maturity they measure 25 to 35 mm (1 in. to 1? in.) long.
- This species overwinters in the egg stage. The caterpillars begin to emerge in May. Because they have long hairs and are light, the young larvae can be easily dispersed by the wind. The mature larvae make cocoons and pupate on stems. The adults are present in August and September. The females lay their eggs in clumps on the cocoon from which they emerge.

Gypsy Moth

Lymantria dispar (Linnaeus)

Figure 3.29: Gypsy moth caterpillar

NB NS PE QC NF	From bud break to fruit ripening

- One generation per year.
- The greyish caterpillars have tufts of long hairs on their bodies. They have 11 sets of red and blue tubercles on their backs. They measure 60 mm (2 ? in.) long at maturity.
- The gypsy moth overwinters in the egg stage; hatching begins in May. The mature caterpillars pupate in a silk cocoon. The adults are present from mid-July to late August. The eggs are laid indiscriminately in spongy masses.
- Gypsy moth populations vary from year to year and tend to be cyclical. The caterpillars arrive in the beds by falling from overhanging trees, hanging from a silk thread and then allowing themselves to be carried by the wind and also by crawling from one bed to another.
- The gypsy moth is a major forest pest.

Damage caused by tussock moths

The caterpillars feed on the leaves, buds and flower buds. Although the females cannot fly, the caterpillars' mode of dispersion enables the species to easily invade the beds. The eggs are laid en masse, resulting in localized damage the following year.

The rusty tussock moths cause damage that results in the appearance of dark areas in the beds.

Gypsy moth caterpillars become very voracious at maturity. When abundant, they devour the old foliage and may even gnaw the bark of the stems.

Monitoring and action threshold

The caterpillars are monitored by sweep netting, from bud break to flowering. Gypsy moth infestations are usually found at the edges of beds. The action threshold, which is determined from the combined total of gypsy moth and noctuid larvae present in the net, is 4.5 larvae per sweep set.

Pheromone traps are available for the gypsy moth but are rarely used in cranberry bogs.

Control methods

Cultural control

In Massachusetts, producers commonly practice spring flooding of their beds late in May in order to kill the eggs and larvae. However, this practice is not used in Eastem Canada.

Biological control

Registered biopesticides containing *Bacillus thuringiensis kurstaki*, are commonly used against the larvae of this pest.

Tussock moths are naturally heavy parasitized. Predators, diseases and abiotic conditions also influence population control.

See Chapter 5: Biological Pest Control– Bacteria

Strategic chemical control

In cranberry beds, infestations of tussock moths are generally limited. If the action threshold is reached during monitoring, application of a registered insecticide is recommended. Whenever possible, choose a low-toxicity insecticide. The treatment targets the young larvae. Older larvae are less sensitive to the treatment and are present at flowering, a period when pollinators are active.

Noctuids and cutworms

Most noctuid and cutworm caterpillars feed on foliage. Most of them are somewhat fat and stubby in appearance. They are active during the day and at night; however, they become active only at night during a later stage, hiding under the plants during the day. Most noctuids have 3 to 5 pairs of prolegs; the young caterpillars of the first and second instars have only 3 pairs of prolegs and move like spanworms.

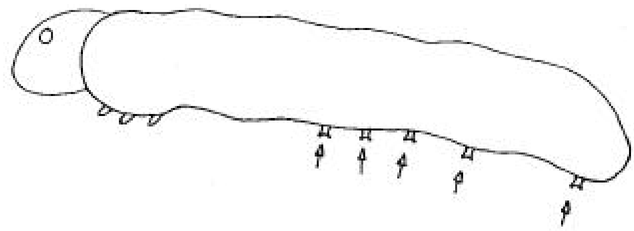


Figure 3.30: Caterpillar with five pairs of prolegs

Do not confuse with sawflies. These have 6 or 7 pairs of prolegs. Sawfly larvae feed mainly on weeds and small trees. In cranberry production, they do not cause damage of economic importance.

Figure 3.31: Cranberry sawfly larva

False Armyworm

Xylena nupera (Lintner)

Figure 3.32: False armyworm caterpillar

NB NS PE QC NF Bud break to fruit set

- One generation per year.
- The young caterpillars are yellowish with small black dots and have three pairs of prolegs. In the subsequent instars, the caterpillars turn green and have three fine yellowish lines on the back and a white longitudinal stripe on the sides. By the time they reach maturity, they have five pairs of prolegs and have turned blackish in colour. They measure 60 mm (2 ? in.) long.
- The false armyworm overwinters in the adult stage; in April, the adults become active again and the females lay their eggs en masse on the stems and leaves. The eggs hatch and the caterpillars are present around mid-May and are active until late June. The mature caterpillars enter diapause for a period of two to six weeks and pupate in late July. The adults emerge in August.

Cranberry Blossomworm

Epiglaea apiata (Grote)

Figure 3.33: Cranberry blossomworm caterpillar

NB NS PE QC NF Bud break to fruit set

- One generation per year.
- The caterpillars are reddish brown with a broad white stripe on the sides and 3 pale fine lines on the back. At maturity, the caterpillars measure 38 mm (1½ in.) long.
- The cranberry blossomworm overwinters in the egg stage. The caterpillars are present around mid-May and are active until July. The mature caterpillars enter diapause for a period of 2 to 4 weeks and pupate in August. The adults emerge in September and may be active until November. The females lay their eggs singly in October.

Speckled Green Fruitworm

***Orthosia hibisci* (Guenée)**

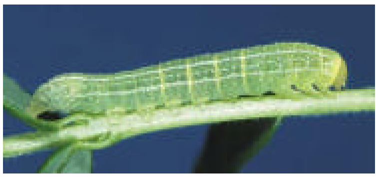


Figure 3.34: Speckled green fruitworm caterpillar

NB NS PE QC NF	Bud break to fruit set

- One generation per year.
- The caterpillars change from leafy green to apple green, then to pale green. They have five distinct white longitudinal stripes. At maturity, they measure 40 mm (1½ in.) long.
- The speckled green fruitworm overwinters in the pupal stage. The adults emerge in late April and the females lay their eggs in irregular masses soon after their emergence. The caterpillars are present from mid-May and may be present until August.
- The specked green fruitworm is a major pest of apple trees.

Impressed Dagger Moth (or Printed Dagger Moth)

***Acronicta impressa* (Walker)**

Figure 3.35: Impressed dagger moth caterpillar

NB NS PE QC NF	Bud break to fruit set

- Two generations per year.
- The body of the caterpillar is spiked with tufts of stiff hairs. Their colour is variable; mature caterpillars are black with an orange stripe on the sides; the hairs on the front and anterior parts are orange-coloured and those in the middle are white.
- The impressed dagger moth overwinters in the pupal stage. The adults of the first generation emerge in June and those of the second generation in July and August. Caterpillars are present from mid-June until September.

Putnam's False Looper

***Plusia putnami* (Grote)**

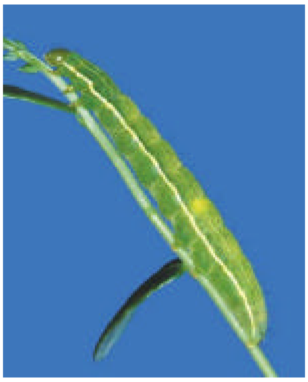


Figure 3.36: Putnam's false looper caterpillar

NB NS PE QC NF	Bud break to fruit set

- Two generations per year.
- The caterpillars are green with a white longitudinal stripe. There are four fine white lines on the back and sparse black bristles on the body. They have three pairs of prolegs throughout their development.
- This false looper overwinters in the egg stage. The caterpillars of the first generation are present in May. After pupation, the adults emerge from mid-June to October, with the two generations overlapping.

Rear-humped Caterpillar

***Amphipyra pyramidoides* (Guenée)**

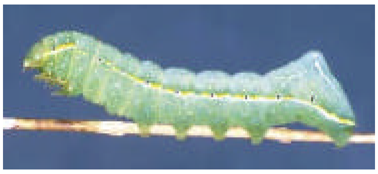


Figure 3.37: Rear -humped caterpillar

NB NS PE QC NF	Bud break to fruit set

- One generation per year.

- The young caterpillars are yellowish green with 5 longitudinal white lines. At maturity, the caterpillars turn light green with a longitudinal yellow line on the sides and a pyramidal dorsal hump at the end of the body. They measure 40 mm (1½ in.) long.
- The rear-humped caterpillar overwinters in the egg stage; the caterpillars are present in May and June. After pupation, the adults emerge in July and are present until September. The females lay their eggs singly in September.

Damage

In the spring, the young caterpillars of noctuids climb to the tip of the stems to feed on the buds at bud break. These caterpillars feed freely on the buds, new leaves and flower buds. Like spanworms, noctuids do not spin webs.

The young caterpillars feed both by day and at night. In the middle of their development, the caterpillars become active mainly at night, hiding on the ground under the plants during the day.

Cranberry blossomworms are considered very wasteful, since they cut the flowers but do not eat them.

Occasionally, some noctuids may bore holes in the young berries, but the caterpillars do not remain inside the berry as does the cranberry fruitworm. Noctuid caterpillars are generally very voracious as they approach maturity.

Monitoring and action threshold

The caterpillars are monitored by means of sweep netting from mid-May to flowering. When the caterpillars are young, representative samples can be obtained with sweep netting. However, as the season advances, sweep netting during the day underestimates the populations, since the larvae become active at night; furthermore, they cling to the stems and consequently are difficult to capture.

Since some noctuid caterpillars are active only at night, it becomes difficult to detect them before visible damage has been observed. In such cases, monitoring at night is strongly recommended, at least once before flowering.

The action threshold currently used as a reference for all noctuids is 4.5 larvae per sweep set. Note that the action thresholds were established for day monitoring.

Control methods

Cultural control

Late water is a control method that can be effective in preventing severe false armyworm infestations. Spring flooding of the beds for about 10 hours around mid-May is also an effective control method against false armyworm and cranberry blossomworm.

Biological control

Registered biopesticides containing *Bacillus thuringiensis kurstaki* may be a good alternative to chemical insecticides. For maximum effectiveness, these Btk-based products should be applied when the caterpillars are in the early stages of their development. Infestations must therefore be detected early.

See Chapter 5: Biological Pest Control - Bacteria

A number of parasitoids can attack noctuid caterpillars and prevent them from completing their development. If the rate of parasitism is high, this can reduce noctuid populations for the following year, while also reducing the immediate damage caused by the final larval stages.

Strategic chemical control

A chemical insecticide should be applied only if the action threshold is reached. Insecticides of low environmental risk should be preferred.

Zebra caterpillar

Melanchra picta (Harris)

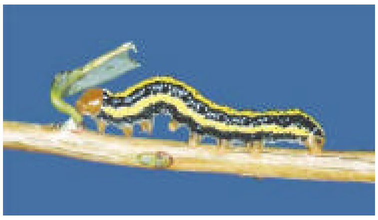


Figure 3.38: Zebra caterpillar

NB NS PE QC NF From bloom to harvest

- Two generations per year in southern Quebec, only one generation in Newfoundland and Labrador, unknown number of generations in Prince Edward Island.
- The caterpillars are yellow with broad black stripes streaked with white.
- This noctuid overwinters in the pupal stage. The adults of the first generation emerge in the spring. The eggs are laid in clumps on the leaves. The caterpillars of the first generation are present in June and July and those of the second generation from July to September.

Damage

These insects can cause localized damage. The caterpillars devour the foliage, causing visible defoliation. In the case of the zebra caterpillar, the plants take on a brownish colouration.

Monitoring and action threshold

No action threshold is currently available.

Control methods

Biological control

A natural parasite for the larva of the zebra caterpillar is the tachinid fly, Winthemia quadripustula.

Strategic chemical control

Chemical control is generally not necessary for these pests. However, if infested areas are present, spot treatment with a registered insecticide is recommended. Insecticides of low environmental risk should preferably be used. The treatment targets the young larvae, which are more sensitive to insecticides.

PYRALIDAE

Cranberry girdler

Chrysoteuchia topiaria (Zeller)

Figure 3.39: Adult cranberry girdler

Figure 3.40: Cranberry girdler larva

NB NS PE QC NF Fruit sizing to harvest

- One generation per year.
- The adult appears whitish in flight. It possesses a long, pointed appendage resembling a long snout. It has striated yellow and silver wings that are marked with black dots. It measures 9 to 13 mm (? to ½ in.) long.
- The larva is whitish in colour, hairy, with a brown head. It has 5 pairs of prolegs.
- The girdler overwinters as a mature caterpillar, inside a cocoon. In the spring, the prepupae continue their development for approximately 3 weeks. The adults emerge in late June and are present until August. In July and August, the eggs are laid randomly on the ground, among the plant residue. The larvae emerge 1 to 2 weeks later and feed until September.

Damage

The larvae remain hidden under the litter of organic matter, where they feed on the stems, stolons and sometimes even the roots, nibbling the bark and wood. When young, the larvae do little damage. Once they mature, they are much more voracious, even eating entire stolons. The larvae look for well-drained sites, where the ground is covered by a thick carpet of dead leaves and other debris. Black earth or peat beds and old beds that are not frequently sanded are an ideal habitat for the girdler. This insect can do more serious damage in beds where the plants have been stressed due to the use of Casoron. In effect, these weakened plants are more susceptible to attack by the pest.

The damage caused by the larvae begins to appear in the fall, or sometimes not until the following spring. In damaged areas, the plants turn reddish or brownish in colour and wither. These areas may be mistaken for damage from field mice. Field mice, however, sever the stems cleanly rather than gnawing them as do the girdler larvae. Orangish-brown excrement or frass held in place by silk threads may be visible near the stems damaged by the girdler. The larvae girdle the roots and underground stems located in the topmost five centimetres of soil, leaving grooves. If the roots are severely attacked, the plants may die. Even if they survive, fruit production may be affected. If the insect is not controlled, the ravaged areas will grow larger over the years. Following severe infestations, it will take several years of growth before the plant will be able to produce fruit again and to enable the stolons to recover the denuded surfaces, even if the insect is eliminated. In addition, weeds will have a tendency to colonize these areas.

Figure 3.41: Damage to underground stems caused by the cranberry girdler

Monitoring and action threshold

Various methods can be used to monitor the cranberry girdler.

Pheromone traps

Monitoring begins with the setting of pheromone traps in late spring. Throughout the season, the numbers of adults captured are counted every week. The young larvae will reach their maximum density two to four weeks after the peak flight of the adults.

A species very similar to the girdler may be found in the traps. This imposter can be distinguished from the girdler by the presence of a white strip in the middle of the wings.

Inspection of adults in flight

In Western Canada, where the girdler is very widespread, a technique involving the monitoring of adults in flight has been developed. In Eastern Canada, this technique can be used in beds where an infestation is suspected. It is a means of finding where the adults are hiding, in order to determine the spots where the eggs are most likely to have been laid. The method consists in walking through the beds in a zig-zag pattern or in two circles: one in the middle and one around the outer edge. When disturbed by a person walking by, the adults fly up in quick, jerky movements and then land on plants several metres away. The monitor simply counts the adults seen in flight and indicates their location on a map. This count is taken 1 or 2 weeks after the first adult has been caught in a pheromone trap. Little or no wind, with sunny or overcast skies and a temperature of at least 16ºC (60ºF) are the preferred monitoring conditions, since they are conducive to the flight of the moths. It is important to be sure that the girdler adults have been accurately identified, since other similar-looking species may be present in the beds at the same time.

Inspection of caterpillars

The caterpillars are difficult to detect since they are small, not distributed uniformly and hidden among the residue on the ground. The presence of dead or withered plants in the fall may indicate the location of girdler larvae. To detect them, inspect the damaged area, pulling the dead plants aside. Then, follow the stems and roots down to a depth of 5 cm below the soil surface and look for gnawed parts and excrement. Finally, check for the presence of whitish larvae, approximately 15 mm long. Old beds with a thick mat of organic matter which can harbour the larvae, will have to be monitored more closely.

Action threshold

No action threshold is currently available for either adults or larvae.

In New Brunswick, the plantation is sprayed if the cumulative count of captured adults has reached 100 per trap by the first days of August. However, it is essential to check to determine whether spraying to control other pests reduces the numbers of adult girdlers in the traps.

Control methods

Cultural control

Flooding infested beds in the fall is one possible means of controlling girdler larvae. Since the larvae can survive flooding for protracted periods of time, the bed must be left flooded for at least five days. The water must cover all the plants in order to prevent the larvae from avoiding drowning by clinging to the plants above the water. Timing of this action is critical since if the larvae have spun their cocoons, they can survive flooding. Because of this protection, spring flooding is not an effective means of control.

During severe infestations, some American producers keep the water from the winter ice in their beds until mid-summer. Girdler populations are controlled in these beds, but the result is loss of the harvest for the current year.

Routine sanding of beds by producers helps reduce the severity of infestations. Normally, 1 to 2 cm (? to ¾ in.) of sand is spread uniformly, over a 3- to 5-year cycle, thus burying plant residue. In heavily damaged areas, sanding to a thickness of 5 cm (2 in.) is recommended. In areas where the damage is minimal, sanding of 2 to 3 cm (¾ to 1? in.) is sufficient. These conditions are not conducive to the survival of the larvae and encourage the injured plants to develop new shoots.

The girdler also feeds on other species of plants that may be found near cranberry beds. This insect is fond of various types of grass. Keep an eye on dikes and grassy areas that can serve as a source of infestation. Other hosts, such as some coniferous species, can attract the girdler. Eliminating them will help destroy part of its habitat.

Biological control

The cranberry girdler has a number of natural enemies, such as birds, viruses, fungi, hymenoptera (e.g., parasitic wasps), spiders and various soil-dwelling insects.

Girdler larvae can be parasitized by nematodes. The species Steinernama carpocapsae is commercially available. These microscopic parasitic worms are applied two to four weeks after peak flight of the adults. The recommended rate ranges from 2.5 to 7.5 billion per hectare (1 to 3 billion per acre).

See Chapter 5: Biological Pest Control – Nematodes

Strategic chemical control

As yet no insecticides have been registered in Canada for use against cranberry girdler larvae. However, treatments applied for the purpose of controlling other pests may help control the adults of this one as well.

Cranberry Fruitworm

Acrobasis vaccinii Riley

Figure 3.42: Adult cranberry fruitworm

NB NS PE QC NF Fruit set to harvest

- One generation per year.
- The egg is oval, 0.4 mm (1/64 in.) long. Freshly laid eggs are green. An orange-coloured line appears 1 or 2 days before hatching.
- The caterpillar has 5 pairs of prolegs. The head is yellow or brownish. The young caterpillar is brownish or greenish. The mature caterpillar is glistening green with a pink-tinged back. It measures 12 to 16 mm (½ to ? in.) long.
- The adult is a moth 9 to 10 mm ? in.) long. It is greyish, mottled with white. At rest, its wings give it the appearance of a rounded, elongated tent.
- Cranberry fruitworms overwinter as mature larvae, inside cocoons. In the spring, the larvae pupate. The adults emerge approximately 5 weeks later. They are present from mid-June to August. They are active at night, remaining hidden among the plants during the day. They can be very mobile and visit various host plants such as the blueberry.
- The females begin to lay their eggs when the plants are at the fruit set stage and continue until August. They each produce approximately 50 eggs that they lay singly under the lobe of the calyx of the berries. Sometimes more than one egg per berry can be seen. After 5 to 10 days' incubation, the larvae emerge and develop in the berries from July to September. When they reach maturity, they drop to the ground and construct a cocoon out of silk and sand.

Damage

The cranberry fruitworm is considered a major pest because it directly attacks the berries. Sometimes the newly hatched larva enters at the calyx end of the cranberry, although it usually climbs toward the top of the berry and bores a hole near the peduncle. It enters the berry and then seals the entrance hole with a silken web. The larva eats all the seeds and pulp of the fruit, leaving only frass inside. It then moves on to another berry and begins the process all over again. However, it is not as consistent in its choice of entry position and does not do as good of a job sealing the hole. Excrement can even be seen protruding.

The larva tends to weave together the infested berries and adjacent intact berries with silk threads and excrement. The infested berries turn red prematurely. They shrivel up, then turn blackish brown, resembling raisins. They often remain attached to the plant until the following spring. Infested fruit can be seen from late July until mid-September. In the course of its development, the larva can eat up to eight berries, depending on their size. It usually completes its life cycle before harvest, but may be present during that period.

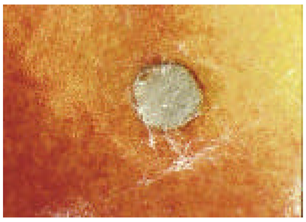


Figure 3.43: Silken web made by cranberry fruitworm after entering a berry

Figure 3.44: Cranberry fruitworm larva in an infested berry

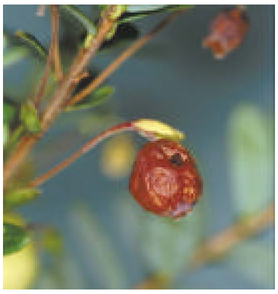


Figure 3.45: Berry infested by cranberry fruitworm larva with premature reddening

Studies have shown that the females prefer to lay their eggs on the largest berries. Early-flowering varieties, such as Ben Lear, are therefore more susceptible to the attacks of the fruitworm. It has also been noted that infestations are more severe on the edges of beds.

Monitoring and action threshold

Pheromone traps are set in order to determine whether adults are present in large numbers. While the peak flight of the adults can be noted, the relationship between the time of captures and egg-laying is not yet well established.

Producers use the plant's phenology to determine the best time to treat with insecticides, because the time when egg-laying occurs coincides with the fruit set stage. The method consists of estimating when 50% of the fowers will be setting fruit. To do so, the producer must sample at random 10 stems per acre in each bed. The stems are shaken gently so that petals that are ready to fall are detached. The number of fruits, pinheads, flowers and unopened flowers are counted. A count must be done at least twice, on different dates. The percentage of fruit set is calculated as follows:

$$\% \text{ fruit set} = \frac{\text{Total number of pinheads + fruits}}{\text{Total number of pinheads + fruits+flowers+unopened flowers}} \times 100$$

Example:

June 25 = 40% fruit set and July 2 = 61% fruit set.

A 21% difference over a 7-day interval = fruit set increasing at a rate of 3% per day. 50% fruit set occurred on
June 28 or 29.

Monitoring the number of eggs viable makes it possible to assess if a treatment is necessary. It is generally recommended that 50 fruits per acre be sampled at random, with a minimum of 200 fruits per bed. Using a binocular loupe, check for the presence of viable eggs. Some may be blackish in colour: these are infected or dead. Others may be empty, meaning that the larva has hatched and is probably inside the fruit. If no eggs are found, continue the inspection every three or four days until mid-August.

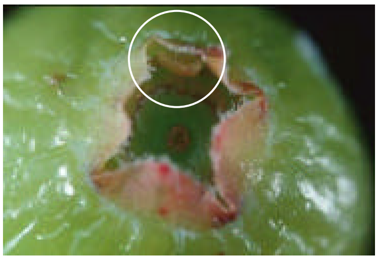


Figure 3.46: Cranberry fruitworm egg under the lobe of the calyx of a berry

Table 3.3: Fruit sampling to monitor cranberry fruitworm

Number of hectares (acres) per bed	Number of fruit sampled	Number of viable eggs determining the action threshold
0–2 (0–5)	200–250	1
2–3 (5–7)	251–350	2
3–3.5 (7–9)	351–450	3
For every additional 2 acres	add 100 fruit	add 1 egg

Control methods

Cultural control

Late water is an effective means of control that is rarely used in Eastern Canada. Recent studies in Massachusetts have demonstrated that post-harvest flooding lasting three weeks can reduce the population of cranberry fruitworm.

Biological control

The cranberry fruitworm has a number of natural enemies. A parasitoid, *Trichogramma deion*, attacks the eggs of this pest. This Trichogramma is available commercially. The parasitoids are introduced into the field either by aerial application or broadcast application.

Strategic chemical control

The cranberry fruitworm is the only pest in Eastern Canada that requires regular application of control measures. Beds should be treated when the monitoring of eggs indicates that this action is necessary. The purpose of the treatment is to destroy the eggs or the newly hatched larvae. Larvae inside berries will be less affected by an application of insecticide. The treatment is carried out at the peak of egg-laying, which varies depending on the variety of cranberry. Table 3.4 presents the treatment period. If viable eggs are observed thereafter, a second treatment must be applied as soon as possible.

Table 3.4: Period of treatment of cranberry fruitworm eggs by variety

Variety	Number of days after the day when 50% of flowers are at fruit set stage
Stevens	3–5
Ben Lear	5–7
Howes	7–9
Early Black	7–9

In New Brunswick, a second treatment is applied as a preventive measure approximately 10 days later. A count of viable eggs is subsequently done in order to determine whether a third treatment is required.

Use a registered insecticide. Whenever possible, choose a low-toxicity insecticide. It is not necessary to treat young beds with mild infestations since they are not productive.

TORTRICIDAE

Blackheaded Fireworm

***Rhopobota naevana* (Hübner)**

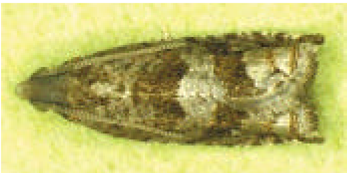


Figure 3.47: Adult blackheaded fireworm

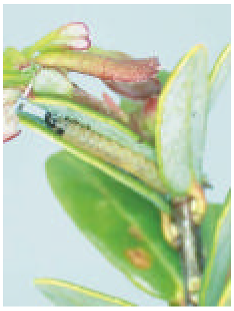


Figure 3.48: Blackheaded fireworm larva on a stem

NB NS PE QC NF	From bud break to fruit sizing

- Two generations per year.
- The caterpillar has 5 pairs of prolegs. Its body is greenish-yellow. Its head, neck and legs are black. At maturity, it measures 10 mm (? in.) long. When disturbed, the caterpillar wriggles vigorously.
- The adult is a grey or olive brown moth, with a coppery tinge. At rest, its wings give it a tent shape. It has a wingspan of 9 to 11 mm (? in.).
- The eggs are pale yellow or whitish and turn red during overwintering. They are oval and more or less transparent. They measure approximately 0.7 mm (1/32 in.) long.
- This insect overwinters in the egg stage, under a leaf. The eggs hatch in May. The larvae of the first generation are present until June. The mature larvae pupate in the soil or sometimes in a silk cocoon on a plant. The adults of this generation emerge in June. The females lay their eggs singly under the leaves of new shoots. The second-generation caterpillars can be seen in July. In August, the adults emerge and are active until mid-September. Eggs laid at this period go into diapause in the fall.
- The adults are not very mobile. They are active during the day, except during hot, overcast days. Their peak activity is at dusk.

Damage

In the spring, the newly hatched larvae feed on the leaves from which they have just emerged. They burrow into the old foliage and then weave a silk web joining several leaves at the tip of a stem. There they eat the terminal buds and leaves, leaving only the veins. As they eat, they add stems to their web. During a severe infestation, the foliage turns brownish and looks as though it has been scorched by fire.

In summer, the second-generation caterpillars devour the new shoots, flowers and fruits. They weave a silk web joining several berries, into which they may bore holes or nibble furrows. Eventually, the leaves they have devoured fall off, leaving the stem bare and giving the plant this scorched appearance. The fruits that are eaten affect the current production, while the damaged buds have an effect on the following year's production.

Figure 3.49: Stems woven together by the blackheaded fireworm

Monitoring and action threshold

Sweep netting is recommended at the start of the season in order to detect the presence of larvae. However, they are difficult to catch since they are protected by their silken shelters. The action threshold is one to two larvae per sweep set. If larvae are caught, a visual inspection is advisable to see whether there are any webs. The infested areas are then mapped.

The first sign of infestation is the presence of leaves webbed together at the tip. Plants that look scorched also indicate the presence of blackheaded fireworm larvae.

Pheromone traps are used to identify the period of activity of the adults. The peak flight of first-generation adults is in late June and early July. The traps are maintained until September in order to monitor the adults of the second generation. Proper identification of the moth is essential, since the pheromone can attract other species. If an infestation is suspected, it is essential to monitor the fields by visual observations.

> The edges of beds are preferred sites for the blackheaded fireworm larvae. They also seem to be attracted by abundant lush vegetation.

Control methods

Cultural control

A short period of spring flooding enables the reduction of populations of this pest. In Massachusetts, a 48-hour period of flooding is recommended when the plants are starting to lengthen and the blackheaded fireworm eggs are starting to hatch. It is essential to monitor the level of oxygen in the water in order to avoid asphyxiating the plants.

Biological control

Various natural enemies attack blackheaded fireworm eggs and larvae: viruses, fungi, insects, spiders and parasites. However, the silken tent they weave protects the larvae from their enemies.

In Western Canada, where the blackheaded fireworm is a problem, there are two indigenous parasites that attack the eggs of this pest: *Trichogramma minutum* and *Trichogramma sibericum*. The latter is available commercially and is used to effectively control blackheaded fireworm.

The application must be carried out at the end of the season so that the parasites attack the overwintering eggs. It is nevertheless advisable to verify the effectiveness of each treatment by monitoring by sweep netting or by visual inspection of the plants.

See Chapter 5: Biological Pest Control

Mating disruption is a promising means of reducing the population of this pest. The mating disruption pheromone developed by 3M, which is specific to the blackheaded fireworm, is registered in Canada. It must be applied when the first adults are caught in the pheromone traps. Two or three applications, at intervals of two and a half to three weeks, will be effective in reducing the mating success of first-generation adults. As soon as adults of the second generation begin to be captured, further applications are required, at the same intervals, until the end of this flight period.

Strategic chemical control

If the action threshold is reached, an application of insecticide could be required. This targets the newly hatched first-generation larvae. The timing of the treatment is critical, since hatching must be completed. Furthermore, the insecticide will not be effective against larvae that have woven their silken shelters.

Treating the larvae of the second generation is trickier, since they are present during blossoming. Generally, it is advisable to apply the treatment 10 days after captures of adults in the pheromone traps have peaked. The second generation must be treated during the first larval stages, which are more sensitive to insecticides. The treatment will be less effective against larvae that have burrowed inside the berries.

In Eastern Canada, in some years, treatments aimed at controlling the cranberry fruitworm can also control second-generation blackheaded fireworm larvae. In the United States, this insect has developed resistance to a number of insecticides.

Sparganothis Fruitworm

Sparganothis sulfureana (Clemens)

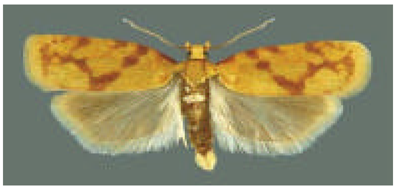


Figure 3.50: Spargonothis fruitworm adult

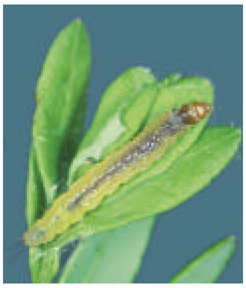


Figure 3.51: Spargonothis fruitworm larva

NB NS PE QC NF Bud break to fruit ripening

- Two generations per year.
- The caterpillar has five pairs of prolegs. The first-instar caterpillar is yellow with a black head, resembling the blackheaded fireworm. In subsequent instars, the caterpillar is green or grey with a yellow or red head and the back is spotted with white dots. It measures 13 to 17 mm (½ to ? in.). It wriggles vigorously if disturbed.
- The adult is a bright yellow moth, with two red X-shaped bands on its wings at rest. It measures 7–8 mm (¼ in.) in length.
- This species overwinters as first-instar larvae. At bud break of the plants in the spring, the larvae become active again and continue their development until June. The mature larvae pupate in a cranberry or weed leaf. The adults emerge between late June and mid-July, mate and the females each lay a mass of 20 to 50 greenish yellow eggs on a leaf, fruit or weed. The eggs hatch in July or early August. At maturity, the larvae enter the pupal stage inside a fruit or on a leaf. The adults emerge in late August and are active until late September. The eggs laid several days following emergence of the adults are deposited on a fruit or a leaf. They hatch 9 to 10 days later, in September. The first-instar larvae enter diapause, hidden among the plant residues on the ground.

Damage

In the spring, the young larva feeds on new leaves and flower buds. With silk thread, it weaves together several leaves of a stem, where it hides and feeds. As the leaves are eaten, the larva adds other adjacent stems to its web.

The larva of the second generation feeds on leaves and preferably berries, if the fruit is at least at the mid-point of development. The first-instar larva enters the berry devouring it from the inside, leaving its excrement inside. This behaviour is similar to that of the cranberry fruitworm, except that the Sparganothis fruitworm does not seal the entrance hole to the fruit with a web. When the larva is larger, it webs together several fruits and gnaws the surface. No excrement is found in these damaged fruits. This is a second way of differentiating the Sparganothis fruitworm from the cranberry fruitworm, since the latter leaves its excrement inside the damaged fruit.

The greatest damage is caused by the second-generation larvae, which feed on the growing berries. Each larva attacks three to five berries.

The damage can be seen in localized areas, mainly around the edges of beds. The most severe infestations are generally found in high-yielding beds and in beds with few weeds.

Figure 3.52: Damage to fruit caused by the spargonothis fruitworm

Observations in Massachusetts have shown that the Ben Lear variety appears to be more susceptible to attack by the Sparganothis fruitworm, probably because of its large fruits and the fact that it is an early variety.

Monitoring and action threshold

Sweep netting indicates the presence of larvae. The aim is to catch the larvae of the first generation at the time of bud break. At the same time, look for webs at the tips of the stems. The larvae can be found by gently pulling on the web holding the leaves together. It can be difficult to catch the larvae with sweep netting since they are protected by this web. The action threshold is based on net captures of five larvae or more per sweep set.

It is recommended that pheromone traps be set beginning in early June in order to catch adult male Sparganothis fruitworms. Weekly monitoring during the season determines when the adults are present and in what numbers. The timing of treatments is based on the period of peak flight of the adults.

In August, infestations can be detected by the presence of prematurely red fruits. They have a small entrance hole, a gaping hole at the base and are sometimes shrivelled. These fruits may be webbed with green fruit and with surrounding vegetation.

Control methods

Cultural control

Flooding and sanding have no impact on the survival of the larvae.

Biological control

There is a wide variety of natural parasites, pathogens and natural predators that are known to control the Sparganothis fruitworm. Parasites include, amongst others, Trichogrammatidae (such as *Trichogramma minutum* and *Trichogramma deion*), Tachinidae, Braconidae and Ichneumonidae. These organisms are effective, although susceptible to the application of insecticides.

Mating disruption is a method that has been tested with great success in controlling the Sparganothis fruitworm. However, this method is registered only in the United States and since Sparganothis fruitworm is a secondary pest in Eastern Canada, using mating disruption to control it is not a priority.

Strategic chemical control

In Eastern Canada, there is no insecticide treatment that is applied specifically to control this pest. In some years, treatments aimed at controlling the cranberry fruitworm may coincide with the ideal period for controlling the Sparganothis fruitworm. The insecticides generally used against the former are also effective against the latter.

A treatment is more effective when it targets the young larvae. It must therefore be carried out two weeks after the peak flight of the adults caught in the pheromone traps. Nevertheless, the larvae are difficult to kill, since they are protected inside the webbed leaves or the berries.

In the United States, infestations of Sparganothis fruitworms can be much more severe. Broad-spectrum insecticides have been applied for many years. This has contributed to the appearance of resistance to some insecticides. In addition, frequent applications have led to a decrease in populations of natural predators and parasites in cranberry beds.

Table 3.5: Pest behaviour and damage in cranberry production

Pest	# of Generations	Over-wintering Stage	Stage Causing Damage	Food	Damage
Black vine weevil	1	Larva in the soil	Adults and larvae	Leaves, roots, stems	Dieback, wilting, browning and sometimes death of plants
Blackheaded fireworm	2	Egg	Larvae	1st gen.: old foliage, terminal buds new leaves 2nd gen.: new shoots, flowers and fruit	Furrows on underside of old foliage Veins of leaves all that remain, brownish in colour, burned appearance Tips of leaves webbed together Larvae bore holes, feed on or cut fur-rows in the fruit, tied together with silk
Cranberry fruitworm	1	Mature caterpillar in cocoon on the ground	Larvae	Fruit	Holes bored in fruit are plugged with silk with frass inside Fruit reddens prematurely, shrivelled, resemble raisins Infestations mainly along edges of fields
Cranberry girdler	1	Mature caterpillar in cocoon	Larvae	Stems, roots, stolons	Areas reddish or brownish Furrows on roots or underground stems Presence of orange-brown frass
Cranberry tipworm	2 or 3	Pupa on the ground	Maggots	1st gen.: new leaves 2nd gen.: leaves and buds	Leaves become cupped, discoloured and eventually dr op
Cranberry weevil	1	Adults in soil or under plant debris	Adults and larvae	Leaves, buds, flower buds and fruit	Buds that have been bored into turn brown Flowers drop, flower buds turn from pink to orange Holes in the fruit in late summer
Large spanworms	1	Pupa on the ground	Caterpillars	Leaves, stems, new shoots and flower buds	Darker, localized areas
Noctuid moth	1 or 2 depending on the species	Egg, pupa or adult depending on the species	Caterpillars	Breaking buds, new shoots, leaves, flower buds	Buds, leaves and flower buds eaten
Other spanworms	1 (2 in small engrailed)	Egg (pupa in small engrailed)	Caterpillars	New shoots, breaking buds in black spanworm	With black spanworm, stems with no fruit
Redheaded flea beetle	1	Egg	Adults	Underside of leaves, holes in fruit	In August, areas slightly brownish
Small spanworms	1	Egg	Caterpillars	Breaking buds, new leaves, flower buds	Areas darker in appearance, flowers are less abundant
Sparganothis fruitworm	2	Larva	Larvae	1st gen.: new leaves and flower buds 2nd gen.: leaves and fruit	Leaves tied together with silk Holes chewed in the fruit not plugged with silk Larvae feed on the surface of the fruit, no frass inside Localized areas, primarily along field edges
Strawberry root weevil	1	Larva or adult in the soil	Larvae	Roots	Dieback and browning of plants
Tussock moth	1	Egg	Caterpillars	Leaves, buds, flower buds	Localized dark areas

Table 3.6: Monitoring and control methods of cranberry pests

Pest	Monitoring Technique	Action Threshold	Cultural Control	Biological Control	Chemical Control
Black vine weevil	Sweep netting at night	No established threshold	Fall and winter flooding	Entomophagous nematodes (*Heterorhabditis bacteriophora*)	No registered insecticides
Blackheaded fireworm	Pheromone traps Sweep netting Inspection of webbed stems Mapping of infested areas	Sweep netting: 1 to 2 larvae per sweep set	Spring flooding (48 h)	Predators, parasites, viruses and naturally occurring fungi (e.g., *Trichogramma sibericum*) Mating disruption*	1st gen.: application targeting newly hatched larvae if threshold reached 2nd gen.: application 10 days after peak flight
Cranberry fruitworm	Pheromone traps Calculation of % fruit set Number of viable eggs	1 viable egg/200 berries examined (1 viable egg/100 additional fruit)	Flooding (see text)	Parasitoids (e.g., *Trichogramma deion*)	
Cranberry girdler	Pheromone traps Inspection of adults in flight Inspection of caterpillars where damage	No established threshold	Sanding Fall flooding (~5 days) Elimination of hosts	Predators, parasites, viruses and naturally occurring fungi Entomophagous nematodes	No registered insecticides
Cranberry tipworm	Inspection of eggs, larvae and pupae on 100 stems/field	No established threshold	Sanding Proper fertilization	Natural predators	Application during peak hatching of 1st generation eggs
Cranberry weevil	Sweep netting Inspection of eggs and larvae	4.5 adults per 25 net sweeps		Natural predators and parasites	If threshold reached Entomophagous nematodes
Noctuids and tussock moths	Sweep netting: daytime and once at night before bloom	Sweep netting: 4.5 larvae per sweep set	Short spring flooding for certain species	Parasites, predators and naturally occurring diseases B.t. kurstaki*	If threshold reached
Redheaded flea beetle	Inspection and sweep netting if damage present	Sweep netting: 15 adults per sweep set (provisional threshold)			If threshold reached or depending on extent of damage
Spanworms (large)	Sweep netting Mapping of infested areas	Include them in noctuid moth count		Natural parasites B.t. kurstaki*	Localized action
Spanworms (other)	Sweep netting	No established threshold	Keep ditches clean, filled with water to control chain-spotted geometer	Predators, parasites, viruses and naturally occurring diseases B.t. kurstaki*	Application generally not necessary (may be required for black spanworm)
Spanworms (small)	Sweep netting	Sweep netting: 18 larvae per sweep set	Sanding Short spring flooding	B.t. kurstaki*	If threshold reached
Sparganothis fruitworm	Pheromone traps Sweep netting Inspection of silk webs	Sweep netting: >5 larvae per sweep set		Parasitoids (e.g., *Trichogramma minutum*) and naturally occurring fungi	Application 2 weeks after peak flight
Strawberry root weevil	Sweep netting at night	No established threshold	Fall and winter flooding	Entomophagous nematodes (*Heterorhabditis bacteriophora*)	Application of an insecticide at night (seldom necessary)

*Commercially available

CHAPTER 4: POLLINATION

Pollination is defined as the transfer of pollen from the stamens to the stigmas of a flower. It may occur by means of any of a number of factors, such as the wind, gravity or mechanical agitation. However, it is insects that pollinate flowers most effectively. Cranberry yields depend to a large extent on the effectiveness of pollinators during blossoming. In fact, fruit production is proportional to the numbers of pollinated flowers and hence to the degree of pollination.

Flowering

As a rule, cranberries flower between mid-June and mid-July. The flowers are hermaphroditic, i.e. each flower is both male and female. The petals are retroflexed, exposing the reproductive parts, which consist of a central pistil surrounded by eight stamens. Each stamen comprises two anthers, which contain the pollen and a tube ending in a terminal pore. The pollen is produced in a group of four cells known as tetrads. Nectar-secreting organs termed nectaries are located at the base of each of the stamens. The pistil, which is the female reproductive organ, is made up of an ovary, a style and a stigma.

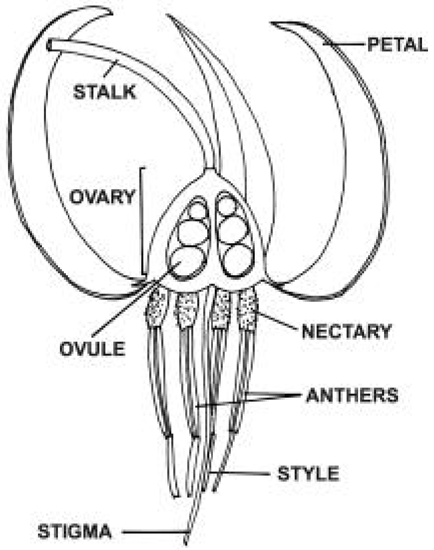


Figure 4.1: Morphology of the cranberry flower

Description of pollination

The development of a fruit takes place in a number of stages: pollination, germination of the pollen grain, fertilization of the ovules and ripening of the seeds and fruit.

A flower's pollen becomes mature shortly after the petals open. When the flower opens, the style is concealed by the stamens. In the course of the next few days, the style grows steadily longer until it extends beyond the stamens. The stigma, which is now exposed, becomes moist and sticky to facilitate the adherence and germination of the pollen grains. The stigma is receptive during a period of at least seven days.

When pollinizing, insects flit from flower to flower gathering nectar or pollen, the pollen clings to the hairs on their bodies and legs. As they move from flower to flower, the pollen they are carrying adheres to the receptive stigma. The pollen grains then germinate and four pollen tubes develop in the style. These tubes carry genetic material to the ovules, fertilizing them. The fertilized ovules then produce growth hormones, inducing cellular multiplication and the storage of nutrients. These ovules grow and develop into seeds. The seeds are green at first, subsequently swelling and turning brown as the fruit ripens. The fruits then turn red as they ripen. Seeds that remain small and yellowish are unfertilized ovules. The number of fertilized ovules is closely correlated with fruit size: the more pollen is deposited on the stigma, the more ovules will be fertilized within the flower concerned and the larger the fruit will be.

Self-pollination and cross-pollination

There are three types of pollination:

Self-pollination

A process whereby the pollen of a flower fertilizes the ovules of that same flower, or a process whereby the pollen of a flower fertilizes the ovules of flowers of the same variety (self-fertilization).

Cross-pollination

Pollination where the ovules of a flower are fertilized only by pollen from other, genetically different flowers, or flowers of different varieties but the same species (cross-fertilization).

Mixed pollination

Both of the above two types of pollination occur.

For cranberry growing purposes, the most effective type of pollination is cross-pollination. Insects are essential to the pollination process, as they carry pollen to the flowers; self-pollination and wind pollination are less satisfactory. In the absence of insects, the pollen tends to fall to the ground because of its weight, with very little lateral movement. Pollinating insects are thus essential for fruit production.

The cranberry flower is adapted to a specialized type of pollination known as vibration pollination. The vibration produced by the wing muscles of some types of insects, such as bumblebees, causes the flower to release its pollen. Other pollinizing insects, including honeybees, tap the stamens with their feet to make the pollen fall. There are various insects that forage from cranberry flowers, but the most important of them, from the standpoint of pollination, are representatives of the order Hymenoptera. Of these, bumblebees, honeybees and leafcutting bees are most useful to a cranberry grower.

Pollinizing insects

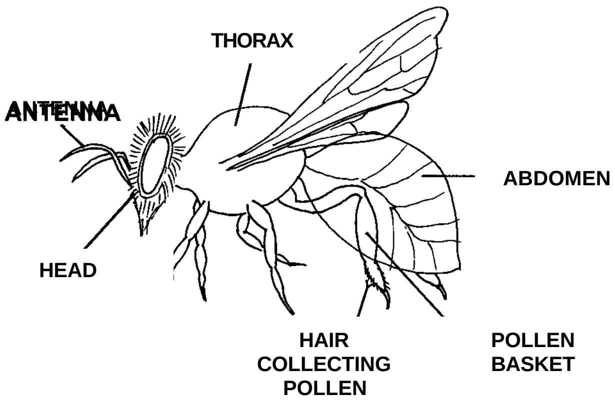


Figure 4.2: Morphology of the honey bee

Honeybees

Hymenoptera: Apidae

Figure 4.3: Honeybee

The main species is Apis mellifera L. They are golden brown in colour with yellow rings on the abdomen. They are domesticated insects that live in artificial hives. Worker bees have special glands that produce wax, from which they make the comb, and pollen-collecting structures known as pollen baskets located on their hind legs. The queen bee, in contrast to the workers, has neither wax-producing glands nor pollen baskets.

Biology

The queen bee is royal from birth. Her activity consists exclusively of egg-laying: she does not participate in any of the domestic tasks of a hive (building the nest, raising the brood, foraging for provisions, guarding the colony and the like). Honeybees have a caste system in which the young bees are raised with older, experienced bees and perform most of the subordinate tasks such as raising the next generation. The older bees, for their part, do most of the foraging. Queen bees lay both fertilized and unfertilized eggs. The latter develop into males, known as drones.

Worker bees are ready to lead an active life as soon as they leave their cells. When they are from one to four days old, their first task is to clean the cells. Over the next few days, they begin to ingest pollen and honey to feed the larvae. By the time they are approximately two weeks old, their main activities are secreting wax, compacting pollen, transporting and ripening nectar, propolizing, cleaning and doing guard duty. At about the same age, workers begin to make short excursions outside the hive in order to get their bearings. Subsequently, some workers become guards at the entrance to the hive. They are responsible for defending the colony against the danger of looting and pillaging by intruders. Other workers go out foraging in search of nectar or pollen. These forager bees that gather pollen are recognizable from the pollen baskets on their hind legs. Approximately 7 to 10 per cent of worker bees in this category act as scouts.

Worker larvae are fed a glandular secretion known as royal jelly for two to three days; after that, they are fed a mixture of royal jelly, pollen and honey known as bee bread. A new queen is produced when a young female larva is fed exclusively on royal jelly. The new queen (there is only one queen per colony) emerges in late spring or early summer.

The queen bee leaves the hive only on the occasion of two specific events: the nuptial flight and swarming. She is fertilized during the nuptial flight, which usually occurs five to ten days after her emergence. A few days later she begins to lay her eggs; she will remain in the hive for the rest of her life, unless she leaves with a swarm. In swarming, the old queen leaves the nest or hive with a large number of workers. A mass migration of this kind takes place when conditions in the hive have become unsatisfactory. Most colonies nest in hives; however, a swarm of bees will occasionally escape and nest in a hollow tree or other cavity.

The drones have no function apart from fertilizing the queen and keeping the hive warm. Males that have not succeeded in mating wander from flower to flower until they are wiped out by the first frost. At the end of the season, any drones still remaining in the hive are driven out by the workers.

A queen bee may live for four to five years, a drone approximately 75 days and a worker bee 36 days during the active season and six months during overwintering. Only workers of the last generation, which have not fed any young larvae, are likely to live that long.

A colony may sometimes comprise more than 80 000 bees, but a population of 30 000 to 40 000 is more usual. The colony spends the winter inside the hive. Beekeepers, however, can keep adult bees in controlled-temperature chambers.

Behaviour

Honeybees have two ways of collecting nectar: the normal way, by sucking it from the base of the stamens, as bumblebees do, or the roundabout way, by sucking it from the side of the flower, without touching the stigma. A study conducted in Massachusetts found that only 40 per cent of foraging honeybees touched the stigma when sucking nectar; the others did it without touching the stigma, i.e. without transferring any pollen. Honeybees can collect pollen by drumming on the anthers with their forelegs, but fewer than 5 per cent of all foraging honeybees are in search of pollen; owing to the fact that a great deal of nectar is needed in the hive, most foraging honeybees gather nectar. This is especially the case in a cranberry plantation, where few honeybees are observed foraging for pollen as a rule. Pollen-gathering by honeybees appears to be affected by weather conditions, the availability of other sources of pollen or nectar, genetic factors and the state of the hive's pollen stocks.

Honeybees have a communication system: workers can inform their colleagues exactly where a source of food is located by dancing. The dancing pattern is determined by the position of the sun. Cranberries are not honeybees' favourite source of food. Their preference depends on pollen odour quality, the sugar concentration in the nectar and how abundant the nectar is. Cranberry flowers produce a rich nectar containing from 45 per cent to 50 per cent sugars, but they produce it only in very small quantities.

Honeybees are unpredictable pollinizers. As a rule, few of them are foraging for pollen at any given time, and consequently they do not transfer much pollen to the stigmas. Moreover, sources of pollen may be mixed (that is, a mixture of pollen from different plant species), and bees behave differently at different sites. These remarks suggest that honeybees are not ideal for pollinating cranberries. In large numbers, however, honeybees may pollinate a cranberry plantation satisfactorily.

Characteristics of a good hive

It is advisable to rent only good-quality hives that have at least five frames of bees and brood. The hives should contain at least 30 000 bees. It has been demonstrated that smaller colonies are less effective in fields than larger colonies. As well, bees from strong colonies can forage at lower temperatures. Newly established colonies are not as effective for pollination as overwintered colonies.

Beekeepers can encourage pollen collection by adding frames that are well covered with eggs, larvae and brood. They can also reduce the pollen reserve.

The strength of a colony is determined by counting the number of bees leaving the hive in a specified time. When the temperature is above 15°C (59°F) and there is little or no wind, there should be about 60 bees per minute leaving the hive.

The rental contract should ensure that colonies can be introduced at the right time and in the right place and guarantee that they are strong and healthy.

Bumblebees

Hymenoptera: Apidae

Figure 4.4: Bumblebee

The genus *Bombus* consists of the familiar bumblebees. The body is black and covered with hairs. Bumblebees occur in various colours (yellow, orange, black and sometimes white). Within a single species, size is variable, depending on the season and on individual status as queen, drone or worker. The females have pollen baskets on their hind legs that they use to carry pollen.

Biology

Early in the spring, every queen makes a new nest and there raises the first generation of workers. The workers are sterile females that help build the nest, gather food and take care of the new generations of workers. First-generation workers are usually smaller than those from subsequent broods. This difference is due to the fact that the first-generation workers have only the queen to care for them, with the result that they do not receive enough food. As conditions in the nest improve (with warmer temperatures, larger cells and more food), workers of successive new generations tend to be larger.

Once the colony has reached a particular stage in its development, the males and young queens appear. Males hatch from unfertilized eggs, and it is virtually impossible to distinguish their cocoons from those of workers. Cocoons containing young queens, in contrast, are larger than those that contain drones or workers. Toward mid-August, the young queens mate with the males. These queens will produce new colonies the following year. The drones contribute little to the colony, apart from incubating the young on occasion.

Bumblebee colonies are annual: the new queens overwinter underground, while the rest of the colony is wiped out by the arrival of cold weather in the winter. A queen bumblebee lives from 12 to 15 months, while a worker lives from three to five months, depending on the species.

It is the largest worker bumblebees that become foragers, since they are better able to fly under adverse weather conditions. Of all pollinators, native or introduced, bumblebees are the least affected by weather.

Behaviour

The bumblebee has its own characteristic approach to a cranberry flower. It holds on to the petals with its legs while keeping its body below the flower's reproductive parts. Perched in this way, it sucks the nectar located at the base of the flower and makes its wing muscles vibrate to collect the pollen. A cloud of pollen then settles on its body hairs, especially those on its abdomen. During subsequent visits, the receptive stigmas come into contact with the accumulated pollen on the bumblebee's abdomen and pollen transfer takes place. After visiting several flowers, the bumblebee uses its hind legs to collect the pollen that has accumulated on its hairs and deposit it in its pollen baskets and then carries it to the nest.

Bumblebees almost always collect pollen and nectar simultaneously. A number of studies have shown that bumblebees are more efficient than honeybees in pollinating cranberry flowers. Bumblebees begin foraging early in the morning, and continue later into the evening than honeybees. In a cranberry plantation, they work faster than honeybees, and they try to reach flowers that are out of sight.

Field observations have shown that 74 per cent of bumblebees gather pollen, compared to only 3 per cent of honeybees. Bumblebees are more reliable than honeybees at pollinating cranberries because of their technique of approaching the flowers, which is such as to ensure that pollen reaches the stigmas.

Bumblebees nest in a wide variety of locations. Some species burrow underground, while others prefer an above-ground site.

Queens establish their colonies in abandoned birds' nests, bales of hay or straw, the thatch of sheds or barns, hollow trees, or even the stuffing material of discarded sofas and mattresses.

Leafcutting bees

Hymenoptera: Megachilidae

Figure 4.5: Leafcutting bee (*m. rotundata*) on a cranberry flower

Leafcutting bees are solitary or non-social insects, not characterized by worker castes or co-operation among individuals. Each female selects and builds her own nest, fashioning individual cells for her progeny. The larvae are abundantly supplied with food: the female provides them with all the pollen and nectar they require for their development before sealing the cells.

The indigenous species observed in cranberry-growing operations in Massachusetts and New Jersey are *Megachile addenda* (Cresson), *M. frigida* (Smith), *M. gemula* (Cresson), *M. texana* (Cresson) et *Osmia atriventris* (Cresson). All species of the genus Megachile are black with white streaks on a number of abdominal segments. They range in size from 7 to 20 mm (¼ in. to ¾ in.) and are stoutly built.

Megachile rotundata (Fabricius) is an introduced species that has become naturalized, like the honeybee. It is commonly known as the alfafa leafcutter. Studies have shown that this species is an efficient cranberry pollinator and it is available commercially.

Biology

Leafcutting bees make their brood cells out of cut fragments of leaves (*Megachile sp.*) or other materials such as leaf pulp, resin or mud (*Osmia sp.*). The female makes a cell and lays an egg in a mass of pollen. Upon hatchng, the larvae feed for four weeks on their store of provisions and then overwinter, still in the form of larvae (*Megachile sp*.) or in the form of adults (*Osmia sp*.).

Some leafcutting bee species nest underground. Most species, however, nest in stems of plants, fissures in rocks or ready-made cavities such as tunnels excavated by wood-burrowing insects. They need good sources of pollen and nectar and materials with which to build their nests.

Behaviour

In general, leafcutting bees are not aggressive. Their flight and working range is limited, and consequently they do not go far from their nesting-place. Every female gathers pollen and nectar. These bees forage even under adverse weather conditions. *M. addenda* is known to be an effective cranberry pollinizer, as are two other native species, *Megachile* sp. and *O. atriventris*.

Studies on *M. rotundata* have suggested that that species, too, can be a useful pollinator of cranberries. On the other hand, it may be too small for convenient foraging from cranberry flowers. One study conducted in Nova Scotia found that this species of leafcutting bee collected mainly nectar from cranberry flowers, gathering pollen from other plants, especially the St. John's wort. However, other studies conducted in New Jersey, Nova Scotia and Quebec have shown that *M. rotundata* gathers both cranberry nectar and cranberry pollen: the investigators observed cranberry pollen both in individual bees' pollen baskets and in nests. Despite the fact that the mean density of leafcutting bees in cranberry plantations was observed to be four individuals per square metre over a five-minute period, it has proved impossible to demonstrate any significant effect on fruit set because of the presence of other pollinizing species at the same time. Furthermore, these bees need other plant species to make their nests. Further research will be necessary before leafcutting bees can definitely be identified as alternative cranberry pollinators.

Table 4.1: Differences in characteristics and behaviours of the main pollinators of cranberry

Characteristics	HONEYBEES	BUMBLEBEES	LEAFCUTTER BEES (M. rotundata)
Foraging distance	1.6–4.8 km (1–3 miles)	1–2 km (0.6–1.2 miles)	Limited flying distance
Foraging hours	11 h–16 h	10 h–19 h	Not known
Foraging temperature	Between 12°C and 32°C (54°F and 90°F) Ideally 18°C (64°F) or higher	Between 10°C and 35°C (50°F and 95°F) Ideally between 18°C and 23° (64°F and 73°F)	Needs higher temperature than honeybee and bumblebee (>18°C)
Weather conditions	Affected by heavy cloud cover and a wind speed greater than 27 km/h (17 mi/h)	Affected little by rain, wind, temperature, drizzle, dew, etc.	Affected by heavy cloud cover and needs more sun
Behaviours			
Nectar robbing*	60%	4%	Not available
Collection	95% of foragers collect nectar and 5% collect pollen	74% of bumblebees collect pollen	Most foragers collect nectar and a high percentage of pollen (1.2% to 100%)
Purity of pollen collected	72% Vaccinium pollen is present in a load**	89–96% Vaccinium pollen is present in a load**	Not available
Working speed	9–9.5 flowers/minute	12–13.5 flowers/minute	5.9 flowers/minute

Source: Foraging by bee pollinators of cranberry (MacKenzie et al., 1993).

* nectar robbing - Collection of nectar without touching the stigma, therefore no pollination

** A load is defined as the quantity one individual can carry in a single trip.

Other pollinators

There are four main families of pollinators besides those mentioned above: the Anthophoridae, the Halictidae, the Andrenidae and the Mellitidae. Most of the species in these groups are solitary, not aggressive and nest underground. They are similar to the leafcutting bees in that every female builds her own nest, gathers her food and stores up provisions for her larvae. Most of them are seldom observed foraging among cranberry flowers, but Halictidae specimens are quite commonly seen.

The halictids (Hymenoptera: Halictidae), which are commonly known as "sweat bees", are usually black or dark-coloured, although some species are metallic green. They are very small, ranging in length from 5 mm to 15 mm (3/16 in. to ? in.) and most of them are solitary. They nest underground, often very close together. Individuals overwinter as larvae or pupae.

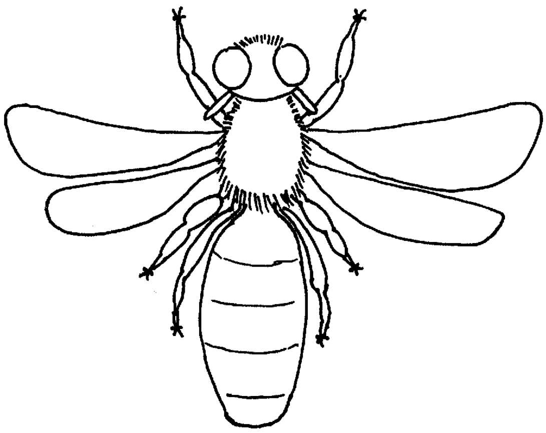


Figure 4.6: General morphology of halictids

Other foraging insects

There are a number of other insects that forage among cranberry flowers in search of nectar and/or pollen. A foraging insect, however, is not necessarily a pollinator. In order to count as a pollinator, an insect must transfer pollen among flowers of the same plant species. Insects belonging to the vespids, ichneumons and syrphids are commonly observed foraging among cranberry flowers. They are not known to be pollinators, as research to date has not shown that they transfer pollen. However, they are useful predators and parasites in a cranberry-growing operation.

The vespids (Hymenoptera: Vespidae), or social wasps, have a brown or black body with various yellow or white markings. Some species live in underground nests, while others build aerial nests.

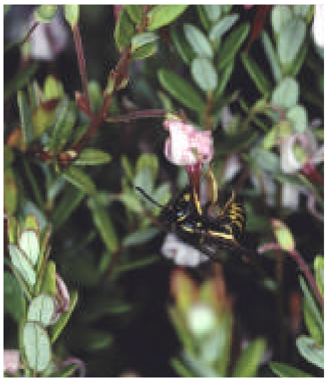


Figure 4.7: Vespid on a cranberry flower

The ichneumons (Hymenoptera: Ichneumonidae), or solitary wasps, vary widely in shape and colour, but are more slender in appearance than other wasps. They do not nest in colonies.

Figure 4.8: Ichneumon

The syrphids (Hymenoptera: Syrphidae) are characterized by colour patterns mimicking those of wasps, bumblebees and honeybees. They have large eyes that cover almost the entire head. Unlike wasps, syrphids do not sting. They are recognizable from their ability to hover over flowers.

Figure 4.9: Syrphid

See Appendix B: List of the main beneficial species in cranberry production

Use of commercial hives

Because bumblebees and other native pollinators do not frequent commercial cranberry plantations in large numbers, it is important to introduce pollinators in order to obtain a good harvest. Most cranberry growers rent hives of honeybees or bumblebees during the flowering period in order to maximize yields. It is noteworthy that these two types of hive are compatible. Hives should not be placed in the plantation any time when poisoning from insecticides is a hazard and toxic chemicals should never be sprayed while the pollinators are out foraging.

Honeybees

Honeybees are the most commonly used pollinators in cranberry growing. These useful insects are easy to manage and make few demands on the grower's time. Weeds in flower may attract the bees away from the cranberry plantation during the flowering period, and for that reason, it is desirable to order a larger quantity of hives or even cut or remove nearby weeds.

Figure 4.10: Honeybee hives in a field

When?

In a commercial cranberry operation, the hives should be placed near the plantations when between 15 per cent and 25 per cent of the flowers have opened. It is not advisable to set them out before flowering begins, as the bees would be likely to forage on other plants. Honeybees are known to develop a measure of "fidelity" to sites and flower species that they have previously visited. Tests have shown that at the height of the flowering period, under favourable weather conditions, honeybees will successfully pollinate most of the cranberry flowers in under 10 days. The hives should be removed when the flowering period is over.

How many?

The recommended number is 2 to 5 hives per hectare (1 to 2 per acre). Where weather conditions are unfavourable, as many as 12 hives per hectare (5 hives per acre) may be used. A hive or colony contains between 30 000 and 40 000 individuals.

Where?

It is advisable for the cranberry grower to:

- set the hives near a source of water;
- set the hives 15 to 20 centimetres (6 to 8 inches) above ground level;
- select a location such that the distance between plantation and hives is as short as possible;
- select a location that affords a maximum of protection from the prevailing winds (e.g., near a wooded area) and is exposed to the sun's rays in the morning;
- orient the hives on the basis of the prevailing wind direction: the bees should be flying into the wind on their way out to forage and have the wind behind them when returning to the hive;
- distribute the hives uniformly by setting them individually equal distances apart; however, it is also satisfactory to set them in groups of seven to nine, with a space of 200 m (650 ft) between groups.

If the hives must be moved, this should be done at night in order to avoid losing any bees that may not yet have returned from foraging.

Bumblebees

(Bombus impatiens)

Despite the fact that bumblebees are better pollinators than honeybees, cranberry growers use hives of them less frequently. It is desirable for colonies of bumblebees to be set out near the plantations a little earlier than would be done with honeybees, as the former need a few days in which to get their bearings in their new location.

A colony contains a queen and between 100 and 200 workers. Two to eight hives are used per hectare under cultivation (one to three colonies per acre).

Location of hives is as for honeybees.

Leafcutting bees

Hives of leafcutting bees are available for rental. Ask an agricultural representative for information.

Establishment of native pollinators

Encourage nesting

To improve cranberry pollination, attempts can be made to attract natural pollinators to fields. Bumblebees will be the target insects, as they are the best pollinators.

The first step is to identify the survival requirements of bumblebees. A suitable site for nesting, mating and hibernation is essential for the establishment of bumblebee colonies.

An environment with a variety of flowers close to the fields is considered an excellent way to maximize the establishment of native bumblebee populations. Bumblebees will nest where there are sufficient food sources from early spring to late fall.

Bumblebees can store food to last them only a few days. They are therefore obliged to forage constantly for their survival. After mating in the fall, the new queens eat to build up reserves to get through the winter. The more nectar and pollen there is available, the greater the odds that a large population of queens will manage to survive the winter.

The conservation of natural sites and the creation of refuges appear necessary to ensuring the maintenance or adaptation of pollinating insects. Windbreaks and the planting of shrubs can also be used, as long as the ground between the trees is not tilled and the dry grasses are not burned, so that nesting areas are not destroyed.

Feed pollinators artificially

It may be advantageous to provide newly emerged bumblebee queens with a nectar supplement in the spring if flowers are scarce. This supplement should consist of about 30% honey and 70% water. A very small amount of this sweet solution should be put in a small container and placed close to plants that will soon flower.

Establishing flower gardens

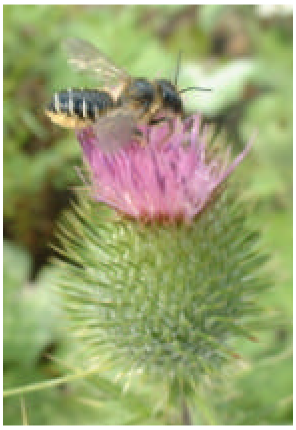


Figure 4.11: Wild honeybee on a thistle flower

We can attract natural pollinators by locating plants close to the farm. When choosing plants, the following criteria should be observed:

Flowering time

Particular attention should be paid to the plant varieties selected and their flowering period. It is also important to ensure that the different plant species flower from early spring to late fall. If pollinators do not have enough food, they will move on, relocate, or die.

The plants introduced should not flower at the same time as cranberry. This could draw pollinators away from cranberry fields. Plants that bloom at the wrong time can always be pinched back or sheared (e.g., clover).

Some members of the Ericaceae family (Calluna, Erica, Kalmia, Vaccinium), lilac and several members of the Rosaceae family (rose, raspberry, plum, saskatoon, spirea and crabapple) are spring-flowering plants.

Fleabane, asters, sedums and goldenrod are fall sources of nectar and pollen. These sources are especially important as they are available when the new future queen begins foraging to build up her body fat reserves.

See Appendix D: Plants that attract pollinators

Ability to attract pollinators

Bumblebees prefer flowers that:

- are cup-shaped or bell shaped, so they can get a grip when landing (e.g., crabgrass, Mimulus, bellflowers, legumes, etc.);
- have a wide opening (e.g., rhododendron, Hibiscus syriacus, etc.);
- have irregular and jagged contours (e.g., thistles);
- have nectar at the base of the corolla (e.g., sedums and asters);
- are velvety in texture (e.g., Baptista australis) rather than smooth;
- are decorated with stripes reflecting the ultraviolet spectrum;
- are grouped in inflorescences that open gradually (e.g., buckeye, phacelia).

See Appendix D: Crops that attract pollinators

Bumblebees can perceive and distinguish scents. Many observers have noted the preferences of bumblebees for different plant species. The thistle, heath, legume and rose families are some of the plant families of agronomic interest that are most attractive to pollinating insects.

Simple plant management

To simplify life, it is strongly suggested that low-maintenance, long-blooming plants be selected. These plants should be able to adapt well to the surroundings, in terms of soil type, water requirements, exposure to wind, amount of available light, etc. A number of plant species described in Appendix D will attract pollinators but can be harmful if they invade cranberry fields (e.g., dandelion).

Preparation of artificial nests

Bumblebee nest boxes

The absence of natural sites may be a factor limiting the establishment of bumblebee populations. Building wooden boxes may encourage bumblebees to nest near cranberry fields in spring.

The boxes are cube-shaped or parallelepiped-shaped wooden boxes, in which are placed materials usually used by bumblebees to construct their nest: moss, leaves, dry grasses, or carded cotton, old mattress stuffing, etc. Each box should have a small opening at the base. The roof can be removable to facilitate cleaning or access by the producer.

These artificial nest boxes are distributed in nature according to the ecological requirements of the various bumblebee species. Some are placed on the ground and others underground. In either case, the interior of the artificial nest must be protected from rain or excess moisture. A roof with an overhang can be made or a waterproof material can be applied (avoid water-repellent coatings that might put bumblebees off with their smell). Place the nest boxes in a sheltered spot and protect them from prevailing winds, rain and direct sun.

Placing the boxes at the edges of crop fields and turning the exit hole towards the flowers to be pollinated will ensure a good dispersion of foragers in the field. These artificial nest boxes should be adjacent to fields. Bumblebees cannot travel any farther than about 1–2 km (0.6–1.2 miles) from their nest or they may become disoriented. The best time for placement of these nests is early spring, just before the bumblebee queens are seen flying along the ground and landing from time to time to inspect a site more carefully.

In fall, when bumblebees are no longer active, the boxes are collected, cleaned with a disinfecting solution and stored until the following spring.

The rate at which bumblebees accept boxes is low compared with the number of visits the insects make. As well, this method depends on a number of factors that are difficult to control: weather conditions that are unfavourable for establishment of the nest, invasion of the nest by ants and the presence of earwigs and other small animals that are apt to disturb or destroy the colony.

Since this method has a low success rate, the best solution for encouraging native pollinators is the conservation of natural sites.

Protection of pollinators

General advice

Insects that are beneficial to the crop should be protected. Here are some tips:

- Do not apply pesticides without identifying the pest(s) involved;
- Do not apply pesticides when populations are below the action threshold;
- Apply pesticides at the recommended rate;
- Choose pesticides having a minimal effect on natural enemies and the environment.

Useful species are more sensitive to pesticides than harmful species. The reason is very simple: species that have been feeding on plant matter for thousands of years have developed an impressive enzyme system that can eliminate the various defensive substances produced by plants. They are therefore better equipped to make such substances safe than are species feeding on other insects and animals that do not usually contain toxic substances. By their very nature, pests are also exposed more to pesticides applied on crops and are therefore more likely to develop resistance.

Many pesticides are used in agriculture, in particular to get rid of harmful insects. Organophosphate insecticides (Diazinon, Guthion, Malathion) and carbamates (Sevin), used to control the cranberry fruitworm, are extremely toxic to bees. It is recommended that no insecticides be applied during flowering or once pollinators are introduced.

Pesticide effects and bee poisoning

Insecticides are toxic at all stages of bee development. Insecticide application in cranberry fields directly affects bees by reducing the abundance and diversity of species. The spraying of insecticides during the pollination period also has repercussions on the control of bee colonies.

Bees are poisoned when they touch a contaminated leaf or flower, or contaminated water, and when they collect contaminated pollen or nectar. A bee that returns to the hive with a load of contaminated pollen or nectar can cause extreme agitation and the death of many bees, including larvae. A number of workers can be seriously disturbed and this can cause damage in the colony. Under the influence of insecticide poisoning, bees may perform abnormal communication dances, horizontally, close to the ground, and near the boards at the hive entrance. The most common symptom of bee poisoning is the presence of an abnormally high number of dead bees in front of the hive.

Aggressiveness in bees may be caused by organophosphate insecticides. Stupefaction, paralysis and abnormal activities of bees are commonly caused by these insecticides.

Toxicity of pesticides to honeybees

Pesticides that can affect honeybees have different levels of toxicity. They are classified in three distinct groups, based on the effect they have on these pollinators.

In all cases, it is important to adhere strictly to the application rate, timing and method of application and the instructions on the product label.

Table 4.2: Toxicity of pesticides to honeybees

Level	Description	Toxicity	Pesticides
I	Hazardous: kill bees on contact during application and for one or more days after application;	**High**	Azinphos methyl, Diazinon, Guthion, Imidan, Malathion, Orthene, Sevin
II	Moderately hazardous: limited risk to bees if not applied on bees in the field or on hives;	**Medium**	Funginex, Poast Ultra, Touchdown
III	Relatively Nonhazardous: can be applied with little harm to bees.	**Low**	Bravo, Casoron, Copper oxychloride, Devrinol, Ferbam, Folpan, Round Up

Source: Protecting Honey Bees From Pesticides (http://ohioline.osu.edu/hyg-fact/2000/2161.html)

CHAPTER 5: BIOLOGICAL PEST CONTROL

A number of organisms present in cranberry production can be beneficial in controlling pests. These include so-called entomophagous insects, acting as predators or parasitoids. Certain pathogenic micro-organisms, such as bacteria, viruses and fungi, can also help reduce populations of harmful insects. Nematodes, microscopic worm-like organisms, can be used to parasitize insects; some types are commercially available. Other predators, such as spiders, birds and small mammals, also have a role to play in controlling pests.

See Appendix B: Index of key main beneficial Species for Cranberry Crops

The various families of insects are generally distinguished by their morphological features. Colour and the shape of their various body parts such as wings, antennae, mouthparts and ovipositor are often particular to one species. The ovipositor is an elongated organ, located at the end of the abdomen in females, which is used to deposit eggs in or on an appropriate substrate (on the ground, on vegetation, in an insect, etc.) to allow the development of larvae that hatch from the eggs.

Parasitic insects

A parasite is defined as an organism living in or on another living organism, called the host, from which it obtains all or part of its organic nutriment. Parasites may or may not kill the host. Among parasites, we can distinguish the parasitoid, which lives at the expense of another organism for only part of its existence. Parasitoids kill their hosts. The insects that kill cranberry pests are parasitoids whose larvae feed on a host. These parasitoids are mainly found in two orders: the Diptera and the Hymenoptera.

Diptera

The Diptera, commonly called flies, comprise one of the largest orders of insects. They are characterized by the presence of a single pair of visible wings. The second pair being reduced to a kind of small wing stumps called halters. The family Tachinidae is one of the most important families of parasitic insects.

Tachinid flies

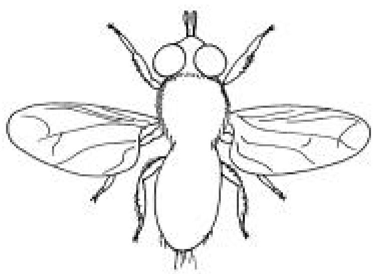


Figure 5.1: General morphology of tachnid flies

Tachinid flies are insects that usually physically resemble bees or house flies. Their body, varying in size from 3 to 14 mm (? to 9/16 inches) long, is black and hairy. Their eyes are brightly coloured.

The female fly deposits one or two eggs on or near a host. The larva penetrates the insect and consumes its organs, thereby killing it. When it reaches maturity, the larva buries itself in the soil until the pupal stage.

Tachinid flies are known to play an important role in controlling pests. *Hemisturmia tortricis* attacks blackheaded fireworm, *Nemorilla maculosa* attacks Sparganothis fruitworm and *Sarcophaga* sp. attacks the cranberry girdler.

Hymenoptera

This group includes ants, bees and wasps. It has the largest number of beneficial species. They have two pairs of wings, long antennae and usually a constriction between the thorax and abdomen. Their ovipositor is usually well developed. Several families are observed in cranberry crops.

Ichneumonids

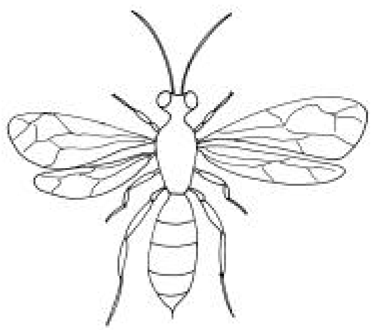


Figure 5.2: General morphology of ichneumonids

These insects are common and almost ubiquitous. These are slender wasps, usually measuring from 5 to 36 mm (3/16 to 1 7/16 inches) long. They are various colours, depending on the species, are equipped with a very long external ovipositor and their long antennae are curved backward. They usually do not sting, but try to when they are handled.

The ichneumonids attack the eggs, larvae or adults of different insects. One or more eggs are deposited inside or outside a host. The larvae from eggs placed on the outside, hatch and penetrate inside the host. They then consume the host from the inside, which automatically brings about its death. They emerge when they reach the pupal stage. In some cases, the pupal stage occurs while in the host, and it is the adult which emerges.

The species *Itoplectis conquisitor, Chorinaeus funebris carinatus* and *Glypta* sp. helps control populations of Sparganothis fruitworms.

Braconids

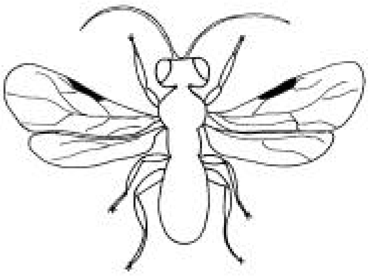


Figure 5.3: General morphology of braconids

These wasps are similar in appearance to ichneumonids, but are usually more stout. Their body is black and measures between 2 and 15 mm (1/16 to 9/16 in.) long. Their ovipositor is internal, except when used.

Female braconids inject one or more eggs inside a host. The larvae hatch, then consume the host from the inside, killing it. The larvae generally spend their pupal stage inside the host, but some species may also pupate in a silk cocoon attached to the host.

This family includes a large variety of insects, most of which are important pest control agents. The order Lepidoptera is often attacked by these parasites. The genus Cotesia sp. includes species that attack Sparganothis fruitworm.

Trichogrammatids

Figure 5.4: Trichogrammatids attacking eggs

These are tiny wasps, 0.3 to 1.0 mm (1/128 to 1/16 in.) long.

Trichogramma attack lepidopteran eggs by inserting their ovipositor and laying one or more eggs inside. The affected eggs often turn a blackish colour. The newly hatched parasitic larvae feed on the contents of the host eggs.

Several species of trichogramma are commercially available. In Western Canada, *Trichogramma sibericum* is used against the larvae of blackheaded fireworm. In Eastern Canada, *Trichogramma deion* is commercially available and is used for controlling cranberry fruitworm. Studies under way demonstrate that using *Trichogramma pretiosum* and *Trichogramma minutum* would be a promising means for controlling cranberry fruitworm.

Trichogra mmas are active in ideal climatic conditions, when temperatures are over 20°C (68°F). More than one application may be required to obtain optimum results.

Predatory insects

A predatory insect obtains its food by catching prey and consuming all or part of it. The Coleoptera, Diptera and Hymenoptera are among the main orders comprising predatory insects.

Coleoptera

The order Coleoptera includes several families that are important for controlling pests. Coleoptera can be distinguished by the presence of two pairs of wings. The first pair, called an elytron, is hard and its sole purpose is to protect the second pair when at rest. Only the second pair are used to fly. Coleoptera are hard-bodied organisms, varying widely in shape and colour.

Ground beetles

Figure 5.5: Ground beetle

These insects live at ground level, preferring to walk rather than fly. The members of this family exhibit wide morphological diversity. They are generally black or brightly coloured, shiny, with striated elytra. Their body, which is variable in size, is flattened. They have well-developed mouthparts.

Female ground beetles lay their eggs in the soil or in dark, moist places. The newly hatched larvae are mobile and search for their prey. Larval development can last one to two years.

Ground beetle larvae and adults are nocturnal hunters that feed on larvae and soft-bodied insects. Several species of ground beetles such as *Carabus serratus*, *Carabus maeeander*, *Pterostichus commutabilis* and *Chlaenius sericeus* are commonly found in cranberry crops. The genus *Calosoma* is called "caterpillar hunter." This is a very efficient predator. Note that ground beetles are very sensitive to insecticides.

Ladybird beetles

Figure 5.6: Adult ladybird beetle

Figure 5.7: Ladybird beetle larva

Ladybird beetles are common insects. They are often called ladybugs. The adults are bright red or orange, with black spots. Their colouration warns predators that they taste bad.

The eggs are deposited in clusters on foliage, near a food supply. The larvae feed mainly on aphids. The larvae of ladybird beetles are very different from the adults. With an elongated shape, they have distinct colour patterns that identify the species.

The larvae and adults are excellent predators. They can attack aphids, eggs and small caterpillars like those of spanworms and other species.

Odonata

Figure 5.8: Odonata

The order Odonata comprises several families including the damselflies and dragonflies, important enemies of several pests. These are large, colourful insects with slender bodies. They have two pairs of membranous wings and large compound eyes. They are very fast flyers, capable of catching their prey in the air. These insects have an incomplete metamorphosis, i.e. the egg develops into an immature stage, which in turn becomes an adult.

The females lay their eggs on vegetation near water. The larval stages, called nymphs, are aquatic. When they reach maturity, the nymphs climb out of the water and shed their skin, changing into adults.

The prey of adult Odonata are quite varied and include certain cranberry pests.

Neuroptera

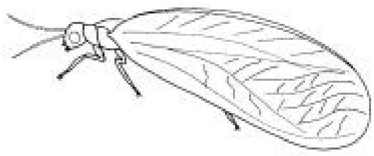


Figure 5.9: Morphology of neuroptera

These nocturnal insects have a soft body and are characterized by very membranous wings. They have long, segmented antennae. Their eyes appear to be disproportionately large relative to the size of their head. Their mouth has large, well-developed mandibles that are used to hold their prey.

Most neuroptera larvae and adults are predators. Two families are described here.

Brown lacewings

Brown lacewings, which are greyish brown, are observed near wooded areas. Their eggs, white when freshly laid, turn orange or pink and then brown just before hatching.

Green lacewings

Figure 5.10: Larva and adult green lacewings

Green lacewings, which tend to be found in or near cranberry beds, have green wings and golden or coppery-coloured eyes. They give off an unpleasant odour when disrupted.

These are natural enemies of the larvae and adults of soft-bodied insects, such as aphids, mites, thrips and small caterpillars. Certain species of lacewings are available for sale.

Diptera

Syrphids

The family Syrphidae includes some efficient predators. Adult syrphid flies resemble wasps and bees, but do not sting. Syrphids are distinguished by their ability to hover. They feed on nectar, pollen and a sugary secretion called honeydew that is produced by aphids.

The females lay white eggs in small masses among the aphids. The larvae can thus hunt the aphids and feed on them by piercing them and sucking out their body fluid. When they reach maturity, the larvae bury themselves in the ground or in a rolled-up leaf for the duration of the pupal stage. Several generations per year can be observed.

The larvae of syrphid flies are formidable predators of aphids and other small soft-bodied insects.

Hymenoptera

Vespids

Within the order Hymenoptera, the family Vespidae includes predatory wasps such as hornets and yellow jackets. They are recognized by the fact that their wings are folded on the body when at rest or when not flying.

Yellow jackets measure 12 to 16 mm (½ to ? in.) long. They are black and yellow with white markings. Hornets are 16 to 20 mm (? to ¾ in.) long and are white and brown.

They live in colonies composed of a queen, workers and males. The adults take care of the larvae until they reach maturity, feeding them pre-digested insects. The adults, for their part, feed on pollen, nectar, honeydew, ripe fruits and insects.

They build their nests out of a paper-like material, made from saliva and chewed wood. Yellow jackets nest in the ground. Hornets build free-hanging nests, attached, for example, to a tree or house.

Vespids are generalists. One species often found in cranberry crops is *Vespula maculata*.

Spiders

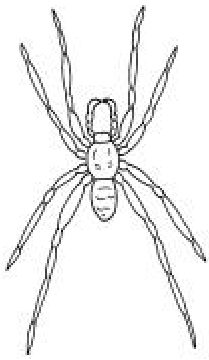


Figure 5.11: Spider

Spiders are not insects. They belong to the class Arachnidae. Their four pairs of legs distinguish them from insects, which have only three. Another distinctive trait is that they do not go through the larval stage to pupa then to adult. Immature spiders look like adults, only smaller.

All species of spiders are predators and feed mainly on insects. They are generalists, i.e. they do not feed on a single species. They generally use a silk web to catch their prey, but may also pursue them or attack them by surprise.

Spiders are believed to play an important role in controlling cranberry pests by attacking aphids, gnats, caterpillars of Lepidoptera and other pests. Despite the fact that they are efficient predators, spiders produce only one generation per year and cannot quickly increase in number in response to pests. They are also sensitive to broad-spectrum insecticides.

Birds and mammals

Certain insectivorous birds are present in cranberry beds. The swallow is an efficient predator that can catch insects in flight, such as adult girdlers and blackheaded fireworms. Birdhouses for nesting can be built and installed to attract swallows to the site. The crow, an omnivorous bird, is also present, and tends to feed on insects on the ground, such as girdler larvae and various caterpillars.

Mammals that help control pests include small rodents as well as bats. Rodents eat various insects found on the ground, while bats catch insects in flight. Bats locate their prey by echolocation, i.e. by emitting high-frequency sounds that produce an echo, indicating the position of the targeted prey. These nocturnal hunters live in colonies, hiding during the day in nooks and crannies of buildings. Specially designed nesting boxes can be installed in an effort to attract them. For these mammals, lepidoptera are the targets of choice.

Pathogenic micro-organisms

An agent that causes disease is called a pathogen. Pathogenic micro-organisms include bacteria, viruses and fungi. Since these organisms are relatively immobile, pests must ingest them or come into contact with them in order to become infected. They can be applied in a liquid solution in the same way as an insecticide or, in the case of certain pathogens, they are found naturally occurring in the environment.

See Table 5.1: Characteristics of different types of biological pest control

Bacteria

Bacteria are single-celled organisms that reproduce by simple division. Certain entomopathogenic bacteria live naturally in the soil. They have been used as biological control agents to reduce the populations of various insect pests in forestry and agriculture.

The best-known bacterium is *Bacillus thuringiensis* (Bt) When larvae (or caterpillars) feed on foliage treated with Bt, they ingest the toxin. The bacteria produces spores and protein crystals which case the cells of the host's digestive tube to burst. The insects generally stop feeding within hours following exposure to Bt, causing them to die two to five days later.

There are various subspecies of *Bacillus thuringiensis*, specific to certain groups of insects. In cranberry production, *Bacillus thuringiensis kurstaki* (Btk) is used, which attacks only the caterpillars of Lepidoptera. This order of insects includes most of the insect pests of the cranberry in Eastern Canada.

The toxicity of Btk is expressed only inside the digestive tract of the larval stages of Lepidoptera. If inhaled or ingested by any other organism (such as other insects, birds, fish, mammals including humans), the product is quickly eliminated without any risk to health. Furthermore, there are no precautions which health authorities require users to observe during application. The toxin is also quickly biodegraded in the environment by micro-organisms and solar radiation. On foliage, biodegradation takes place in one to four days. Furthermore, there is no risk of contaminating groundwater since Btk does not infiltrate beyond the first 25 cm (10 in.) of the soil.

Several applications of Bt may be necessary in order to ensure that the foliage has been adequately covered and new foliage is protected and to replace organisms washed off by rain. The time of treatment is important since the bacterium is more effective against the young larval stages of insects.

This biopesticide is affordable since it can be produced using inexpensive methods. However, its effectiveness can be limited by its weak persistence in the environment and by its sensitivity to UV radiation. The development of resistance in some insects has even already been observed. The use of this biopesticide nevertheless remains an effective biological control method that is non-polluting and safe for humans and the environment.

Viruses

Viruses are micro-organisms made up of nucleic acid (DNA or RNA), protective protein complexes called capsids and an elective membrane. They reproduce by replicating their genetic material. They can only reproduce in host, animal or plant material. Viruses work by penetrating host cells after being ingested, or by transmission from one generation to another (i.e., mother-child). They multiply in the tissues of the digestive system and in fat, eventually killing their host. They are very specific. They are sensitive to UV radiation and thus do not survive long in the environment if they are exposed to it. They are naturally present in cranberry production, and mainly attack tussock moths, certain spanworms and blackheaded fireworm. The limited effectiveness of these viruses, as well as the unfavourable environmental conditions, mean that they do not keep insect populations under the action threshold. Their use, however, could prove advantageous if they were available and registered in Canada.

Fungi

Fungi are organisms that lack chlorophyll and reproduce by spores. Fungi affect all stages of development of the targeted insects since they act by contact, not by ingestion. Their spores germinate, pass through the cuticle of a host and invade its tissues. One well-known species of fungus, *Beauveria bassiana*, has been tested with success against cranberry girdler. Commercial products are not, however, registered in Canada.

Fungi have limited specificity and need a high rate of humidity. However, they can survive in the environment for a long time in the form of spores.

Entomophagous nematodes

Entomophagous nematodes are microscopic roundworms. These are mobile organisms that can locate their hosts by themselves. Nematodes of the genera *Steinernema* and *Heterorhabditis* live in symbiosis with a bacterium, which lives in the intestine of the infectious juvenile stages of the nematodes. A nematode at the juvenile stage finds an insect host and penetrate it via natural routes (mouth, anus, injury). It then releases into the host the bacterium, which digests the host's internal tissues, converting them into matter that the nematode can assimilate. The host is killed in two days. The nematode then completes its life cycle in the cadaver.

Entomophagous nematodes generally attack insects in the soil. However, their specificity is limited. They are present in nature but rarely in sufficient numbers to control the pests effectively. They can be produced industrially and are available commercially for use in large quantities.

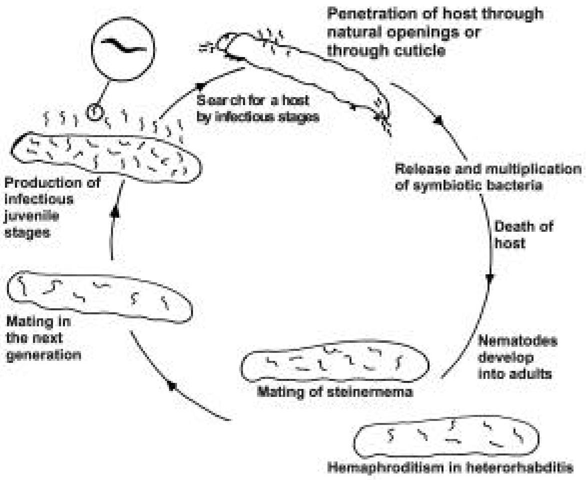


Figure 5.12: Life cycle of nematodes

Entomophagous nematodes are used as biopesticides in cranberry production to control the cranberry girdler and a root weevil complex *Steinernema carpocapsae* can parasitize cranberry girdler among others. They are applied in a liquid solution using conventional insecticide application methods. The soil temperature must reach at least 13°C (55°F) and long-term irrigation should be implemented in the field following application.

Nematodes present no danger to fauna and the environment. However, their effectiveness is not consistent. The infectious juvenile stage of the nematodes is sensitive to certain environmental factors. Certain directions should therefore be followed when using these parasites:

- Follow the manufacturer's instructions carefully
- Irrigate before and after an application
- Avoid exposure to the sun
- Avoid extreme temperatures
- Do not store these biopesticides for long periods.

The presence of competitors and antagonists is a biotic factor that can also hamper the effectiveness of nematodes. The use of entomophagous nematodes is also limited by the availability of high-quality nematodes and because they are more expensive than conventional chemical control methods.

Establishing beneficial insects

To encourage beneficial insects to become established near cranberry crops, specific environmental interventions aimed at promoting their survival are suggested. It is necessary to ensure that the parasites and predators always have available food sources so that they do not starve if the pest populations decline.

A number of natural enemies such as ladybird beetles, lacewing larvae, syrphid flies and parasitic wasps feed on nectar, pollen or the honeydew of aphids. Flowers provide these food sources essential to a number of beneficial insects. In addition, the plants harbour many alternative prey.

There is a wide variety of flowering plants that are attractive to beneficial species. Certain selection criteria are recommended. Different factors influence the attractiveness of flowers, such as their size, colour, shape, amount of nectar or pollen present, etc. Each insect species has its own preferences. The plants must not attract pests and encourage their establishment. Plants must not require much care. Where possible, choose hardy plants well adapted to the natural conditions.

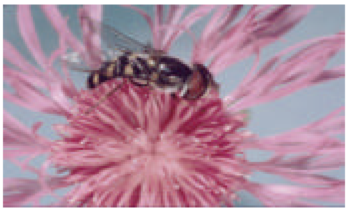
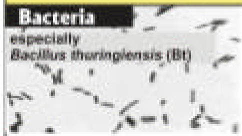
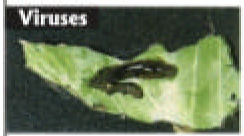
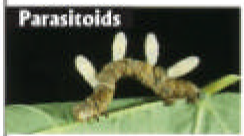


Figure 5.13: Adult syrphid on a garden flower

See Appendix C: Plants favouring the establishment of natural predators

For more information about the environmental conditions needed to attract beneficial species, consult Chapter 4: Pollination Establishment of native pollinators.

Table 5.1: Characteristics of different types of biological pest control

Agents	Mode of Action	Benefits	Limitations
Bacteria especially *Bacillus thuringiensis* (Bt) 	• Bt produces a toxin. When ingested, the toxin causes the intestinal cells to burst and leads to the death of the insect.	• Broad spectrum action on a group of insects (e.g., Lepidoptera). • Commercially produced. • Aqueous suspension.	• Sensitivity to UV rays resulting in a low level of persistence in the field. • Development of resistance already observed. • Lack of mobility.
Viruses 	• When ingested, viruses infect the tissues of the digestive tract and, in some cases, other tissues.	• Transmitted horizontally (from one individual to another) and vertically (from one generation to another). • Highly specific. • Aqueous suspension.	• Sensitivity to UV rays and low persistence in the field. • High application rates required. • Lack of mobility. • Public concerns about their use.
Fungi 	• Germination, penetration of the cuticle of the insect, and invasion of tissues. • Some species also produce powerful toxins.	• Can infect all stages of insect development (from egg to adult). • Persists in the environment in the form of spores. • Aqueous suspension.	• Requires high moisture conditions to grow. • Low specificity. • Low efficacy of spores produced in vitro.
Parasitoids 	• Parasitoids locate a host and lay their eggs inside or outside of it. The larvae develop at the expense of the host, which ultimately dies.	• Highly mobile. • Capacity to locate the host. • Highly specific (precise host and development stage).	• Live material sensitive to rearing and shipping conditions. • Efficacy affected by weather conditions. • Migration of parasitoids can occur when pest densities are low.
Predators 	• Capture and immediate consumption of prey.	• Highly mobile. • Can consume an insect pest at several stages of development. • Can attack other prey in the same environment when the pest density is low.	• Live material sensitive to rearing and shipping conditions. • Efficacy affected by weather conditions. • Migration of predators can occur when pest densities are low.
Nematodes 	• Penetration of the body of the insect through natural orifices and release of symbiotic bacteria which cause fatal septicemia.	• Good potential against insects that develop in soil. • Aqueous suspension. • Commercially produced.	• Low mobility and specificity. • Sensitivity to UV rays and dehydration.

Photos: Jean-Charles Côté, Claude Godin, Guy Bélair, Agriculture and Agri-Food Canada/Thérèse Arcand, Canadian Forestry Service/Insectarium de Montréal

Source: L'entomologie au Québec, une science à découvrir. Société d'entomologie du Québec, 1999.

CHAPTER 6: DISEASE[4]

The diseases observed in cranberry crops are caused by various species of fungi. Fungi are micro-organisms that reproduce by sexual or asexual spores and are spread by dispersal of the spores. They grow in the soil or on organic substrates (living or dead).

In the case of fungi that affect the aerial parts of cranberry vines, infection occurs following germination of a spore on plant tissue (primary infection), resulting in the development of a mycelium. The mycelium is the vegetative portion of the fungus and is composed of hundreds of filaments called hyphae. During the season when conditions are favourable, the fungus will produce many asexual spores called conidia. They are dispersed by various vectors and are responsible for secondary infections. At the end of the growing seasons, several species of fungus produce fruiting bodies containing sexual spores. The fungi may overwinter at this stage.

There is a wide variety of diseases affecting cranberry production. In Eastern Canada, few diseases are commonly observed.

Colour coding, like that found in the chapter on insect pests, indicates the extent of disease in each province.

RED: Major pests

GREEN: Secondary pests

BLUE: Minor or potential pests

Upright dieback (phomopsis canker)

NB NS PE QC NF From blossoming to harvest

Upright dieback is caused by several fungi. Two main species have been identified: *Phomopsis vaccinii*, the most common, and *Synchronoblastia crypta*, which is less frequently observed. Other species have been isolated from infected vines but their role is not well understood.

Biology

The life cycle of this disease is not perfectly understood. Although the fungus has the ability to overwinter, the low incidence of the fungus in spring in beds where dieback was severe the previous year indicate that it does not persist well over the winter. Nevertheless, damage is sometimes still present in the spring.

The fungus generally infects young cranberry shoots during shoot elongation, but can attack the vines at any time during the growing season. The development of symptoms is favoured by prolonged periods of hot, dry weather, i.e., when the vines are under stress. Spring and fall temperatures are therefore not favourable to the development of the disease.

Symptoms

The fungus causes yellowing of all or part of the terminal leaves of the uprights. Orange coloration or bronzing may develop and eventually the leaves turn brown and drop off. The vines eventually die back, from the tips of the shoots to the underground stems. If berries are attached to affected uprights, they wither and desiccate as the upright dies. The roots of diseased vines are unaffected. The uprights sometimes die after withdrawal of the winter flood when the plants resume active growth.

Figure 6.1: Stem damage caused by upright dieback

Figure 6.2: Overview of damage c aused by upright dieback in the field

[4] The information presented in this chapter are mainly taken from the *Compendium of blueberry and cranberry diseases* (Caruso and Ramsdell, 1995).

Monitoring

Monitoring of the beds can reveal the presence of uprights showing signs of dieback. In well established beds, diseased uprights are generally dispersed among healthy vines, giving the planting a "salt and pepper" appearance. In young beds, however, entire sections can be affected.

The fungus must be isolated in order to obtain a reliable and accurate diagnosis of the disease. In the spring, *P. vaccinii* can occasionally be isolated from stems formed the previous year. The fungus can also be isolated from flowers (pistils and pedicels) in June and from current-year stems in July.

Young beds and areas of rank growth appear to be more susceptible to infection by the fungus.

Control methods

Cultural control

Upright dieback causes less damage if the vines are not under stress. Proper irrigation during dry spells can reduce heat stress on vines. Avoidance of oxygen deficiency, picking injury and winter injury should help limit infections by the fungus.

Current cultural practices (sanding, flooding) that encourage vigorous but not rank vine growth should make beds more tolerant to the fungus.

Some cultivars appear to be more susceptible to upright dieback. Early Black and Howes in Massachusetts and Searles in Wisconsin are more susceptible to this disease, whereas the Franklin cultivar shows some resistance.

Strategic chemical control

The use of a registered fungicide may be necessary to control upright dieback. It must be applied in the spring, between bud break and bud elongation, ideally when the shoots have approximately 1 cm (½ in.) of new growth. Treatment at the bloom stage or later is ineffective because the fungus is protected inside the plant.

In beds in which the disease is chronic, the lack of treatment could result in a persistent and potentially serious disease if summer temperatures are very high.

Fruit Rots

Fruit rots are caused by some fifteen species of fungus. Most attack the fruit, causing them to rot, but some also infect the flowers, stems and leaves. The three most common types of fruit rot are described in the following sections.

Early rot

NB NS PE QC NF	From blossoming to harvest

Early rot is caused by the fungus *Phyllosticta vaccinii*. It infects the flowers, stems, leaves and fruit. However, only damage to fruit in storage is economically important.

Biology

P. vaccinii can overwinter in the leaves of diseased vines. Pycnidia, fruiting bodies containing spores, appear on the infected leaves soon after the winter flood is removed. These black pycnidia release spores in the spring and early summer. Spores are also produced on blasted flowers and berries. Young leaves are infected very early in the season, whereas berries are infected only after completion of the bloom stage or shortly thereafter.

Symptoms

The first symptom appears on the fruit in July in the form of a small, light-coloured watery spot. Under favourable conditions, this spot enlarges rapidly until the whole berry becomes soft. The spots often forms dark concentric rings. However, diseased fruit may show little discolouration if the rots develops rapidly.

When flowers and fruit are infected, they shrivel, discolour and may become covered with black pycnidia. Occasionally, flowers and shoot tips are killed and turn brown. Infected leaves have irregular, reddish brown spots which cover most of the leaf surface. These leaves also bear pycnidia on their surface.

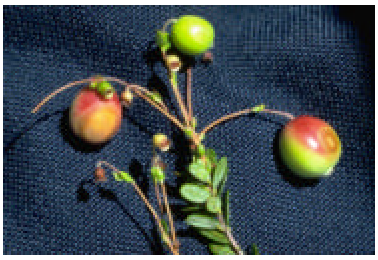


Figure 6.3: Symptoms of early rot

Monitoring

Scouting of the beds during the season and of the fruit during harvest may reveal symptoms of this disease. If a large percentage of fruit exhibits rot at harvest time, it is important to determine the beds from which they came and to isolate the fungus responsible in order to obtain a reliable diagnosis so that appropriate action can be taken the following year.

Control methods

Cultural control

The recovery of debris floating in the water after harvest helps to reduce the risks of rot because the debris can serve as a reservoir for plant pathogens. Good drainage is necessary in order to avoid the wet conditions required for the development of the fungus.

Sanding reduces the quantity of plant pathogens in the environment and promotes vigorous vine growth.

Mechanical control

Because the fungus grows at high temperatures (optimal germination at 28°C), refrigeration of harvested cranberries prevents development of the disease in storage.

Strategic chemical control

If an infection is present, the application of a registered fungicide is recommended. Several applications are required: the first at 10–20% bloom, the second 10 days later and a third, if necessary, 10 days after that. If late flooding is used, the third application will not be required. Cranberries thus treated seldom develop early rot in storage.

End rot

NB NS PE QC NF	From the ripening of fruit to harvest

End rot is caused by the fungus *Godronicassandrae*. This fungus is probably present in the cranberry beds, but causes only minor or occasional damage. Even if the fungus is present in the flowers, stems, leaves and fruit, it causes damage only to the leaves and fruit. End rot does not usually occur until after harvest, hence its name in French. The English name "end rot", however is so named because the rot is normally found on the apex of the fruit.

Biology

This pathogenic fungus overwinters in older woody tissues, dead leaves and rotted fruit in underlying debris left after harvest. It may also be present in apparently healthy vines throughout the year. The spores are released primarily from spring until August. Infection probably takes place when fruit are damaged during harvest.

Symptoms

The symptoms appear after the fruit has finished growing. End rot manifests itself as soft, watery tissue which is clearly delineated from the sound portion of the berry. As the rot progresses, the whole berry becomes soft and spongy. These berries become distended with gas produced by the rotting process. They eventually collapse, shrink and assume a yellowish or brownish cast.

Infected leaves have spots. Leaf spots are reddish brown at first, turn grey or bronze in the centre and develop a black border. The surrounding tissue outside the black border turns brilliant or dark red. These symptoms can cover most of the leaf. Affected leaves may eventually drop.

See photo in the Compendium of Blueberry and Cranberry Diseases (Caruso and Ramsdall, 1995).

Monitoring

Field scouting can reveal symptoms of this disease. The fungus can be isolated from new shoots as early as June. If a large quantity of rotten fruit is observed at harvest, it is important to determine the bed from which they were harvested and to isolate the fungus responsible in order to be able to take action the following year. There is a higher incidence of end rot in flooded beds than in dry-harvested beds.

Control methods

Cultural control

As in the case of early rot, good drainage and the recovery of floating debris are effective in controlling this disease.

Excessive use of nitrogen fertilizer during the growing season and prolonged periods of continuous flooding should also be avoided. Bruising of berries during harvesting also favours the development of end rot.

Some cultivars appear to be more resistant to end rot. In Wisconsin, these include Howes, McFarlin, Franklin, Pilgrim, Early Black, Wilcox, Beckwith, Bergman and Stevens, while Ben Lear, Searles and Crowley are more sensitive to the disease. In the Pacific Northwest, Stevens and Bergman are the most susceptible varieties.

Sanding is an effective control method for this disease.

The refrigeration of fruit in storage only delays end rot development because the fungus can survive low temperatures (optimal germination at 20°C, minimum 8°C).

Strategic chemical control

If infection is present, the use of a registered pesticide is required only if the harvested berries are to be used for the fresh market. Berries that undergo processing (e.g., juice) will be frozen and therefore exempt from rot. Three applications are usually required. They must be carried out between late bloom and early berry development.

Viscid rot

NB NS PE QC NF	From the ripening of fruit to harvest

Viscid rot generally affects fruit in storage, but occasionally appears in the field. This rot does not cause economically significant losses. This rot is caused by *Phomopsis vaccinii*, the same fungus that causes upright dieback.

Biology

This fungus overwinters in diseased vines and fruit and in apparently healthy stems. It forms spores in the stems and fruit. Spore release begins at bud break and continues until harvest.

Symptoms

Infected fruit are soft, pale and may be mottled and wrinkled. A viscous substance can leak from the cut surfaces of rotten berries. This substance is characteristic of viscid rot.

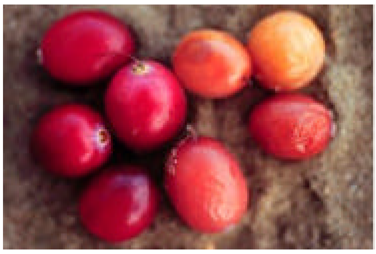


Figure 6.4: Symptoms of viscid rot

Monitoring

Field monitoring can reveal signs of the presence of viscid rot. However, isolation of the causal organisms is the only way to reliably diagnose this disease. It can be found in apparently healthy stems and flowers as early as June. Later, it can be present in current-year stems and in fruit during early berry development. At harvest, if a number of berries are affected by viscid rot, it is important to determine the beds from which they were harvested and to isolate the fungus in order to be able to take control measures the following year.

Development of viscid rot is favoured by high temperatures and the presence of vines under stress.

Control methods

Cultural control

Cultural practices that promote vigorous but not rank vine growth and minimize heat and drought stress can help minimize the incidence of this disease. Adequate fertilization and irrigation, as well as good drainage, are necessary.

Strategic chemical control

If there are symptoms of a disease, use of a registered fungicide is recommended. Three applications may be required during blossoming and after the fruit begin to develop.

Cottonball

NB NS PE QC NF	From bud break to harvest

Cottonball is caused by the fungus *Monilinia oxycocci (synonym: Sclerotinia oxycocci)*. The disease has two stages: the primary infection, called tip blight and the secondary infection, called fruit rot.

Biology

Primary infection

The fungus overwinters in the residue of infected fruit as sclerotia, which are small, very hard structures ranging in colour from brown to black. The sclerotia overwinter in or on the soil or attached to the upright. In the spring, high humidity and moderate temperatures favour the germination of sclerotia. They produce ascospores (primary spores), which are released from bud break to early bloom. The tips of new shoots are more susceptible to infection by the fungus when they are 1 to 3 cm in length (½ to 1¼ in.).

Secondary infection

Three to four weeks later, conidia (secondary spores) form on infected stems. These spores are transported to open flowers by the wind and pollinating insects. The fungus becomes established in the ovaries of the flowers. It then invades the cavities and tissue of the set fruit. By harvest, sclerotia develop in 25 to 50 percent of infected berries. Berries without sclerotia decompose during winter and the following spring.

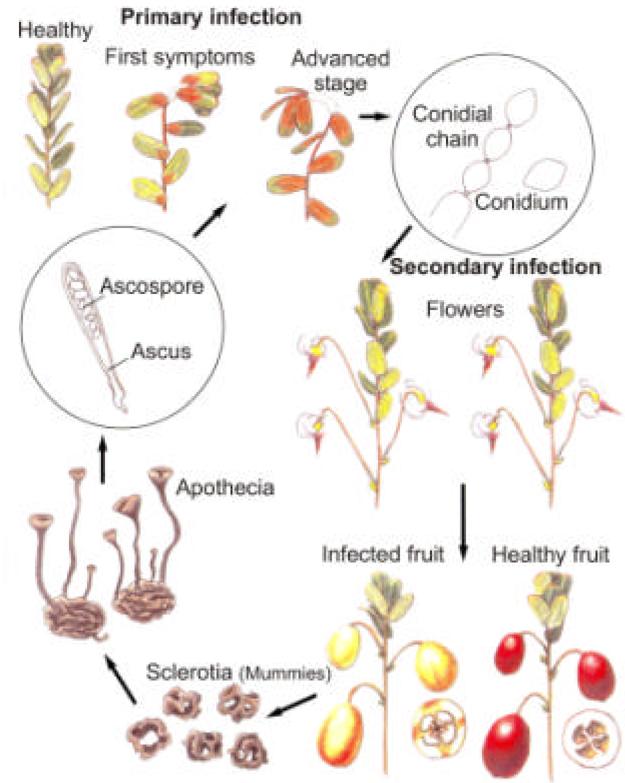


Figure 6.5: Life cycle of fungi causing cottonball

Symptoms

Primary infection

The tips of new shoots infected by the fungus wilt, turn rust-coloured and become crooked over. These symptoms appear about three weeks after bud break. The infected tips assume a tan coloration, which spreads down the stem and into the leaves. V-shaped lesions form on the veins of the leaves. A whitish powder forms on infected shoots and sometimes on the flowers, before or during bloom.

After bloom, blighted shoots desiccate and become brittle. Infected leaves also desiccate and then die and eventually drop. The distal section of the dried stem may break away from the healthy portion of the shoot and fall off.

Secondary infection

Young developing berries that are infected show no external symptoms of fruit rot even if completely invaded by the fungus. The internal cavities of infected berries become filled with a white substance resembling cotton balls. Symptoms do not become visible externally until healthy berries begin to ripen and turn red (August–September). Diseased berries may take on a slight reddish hue, but they generally turn yellow with brown striations. These berries remain firm but cannot be sold on the fresh fruit market or for processing.

Figure 6.6: Fruit infected by cottonball fungus

Monitoring

Scouting for rust-coloured shoot tips and V-shaped lesions on the leaves is carried just prior to bloom. Infected shoots are often scattered in beds among healthy shoots, which usually overgrow the infected shoots, making it very difficult to detect them by simple observation. Threshold levels of cottonball tip blight have not been determined. If infected shoots can be easily found, a fungicide treatment is probably justified.

High-risk areas are those that remain wet for prolonged periods, such as along ditches and dikes where dense moss is growing and in areas where recently applied sand has remain saturated for several days.

The presence of rotten fruit at harvest indicates that action must be taken the following year.

Control methods

Cultural control

During harvest, infected berries and sclerotia float to the surface of the water. To reduce the risk of spread of the disease, sclerotia can be removed from the beds at the same time that the healthy fruit are pumped out of the water. However, this method is time-consuming and costly. Some growers find it effective to re-flood beds after harvest and remove the floating debris that contain the sclerotia.

Since the incidence of the disease is higher in beds where the soil remains wet for prolonged periods, good drainage is essential. It is also important to control moss, which is a favourable environment for the germination of the sclerotia.

Sanding is ineffective in controlling this disease because the sclerotia are able to germinate through sand. It is therefore important to avoid having areas of saturated sand in the spring when the sclerotia germinate.

Strategic chemical control

The application of a registered fungicide is recommended in beds where infection is present. There are two types of treatment, depending on the severity of the disease that was present the previous year.

1. If fewer than 15% of the berries were infected the previous season, the fungicide is applied when 10 to 20% of the flowers have opened and again seven to ten days later.

2. If more than 15% of the berries were infected the previous season, the fungicide is applied when half of the shoots have started to elongate, again seven to ten days later, again when 10 to 20% of the flowers have opened and again seven to ten days later.

If it is felt that four treatments are not warranted despite the fact that more than 15% of the berries were infected, it is recommended to treat twice during bloom as in the first approach.

If early and late varieties are present, it is important not to treat all fields at the same time. Rather, spray according to the developmental stage of each variety.

Red Leaf Spot

NB NS PE QC NF From bud break to harvest

Red leaf spot generally causes little damage. It is caused by the fungus *Exobasidium rostrupii*.

Biology

This fungus overwinters in stems and leaves infected the previous year. Only the leaves and young shoots can be infected. The disease is closely associated with meteorological conditions. The fungus is active in rainy, cloudy or misty weather as soon as vine growth begins in the spring.

Black spot disease, caused by *Mycosphaerella nigromaculans*, is often associated with red leaf spot. It enters the vines through red leaf spot lesions and can result in the death of the young shoots. These two diseases can seriously damage cranberry vines.

Symptoms

The most striking symptom of red leaf spot is the presence of circular, bright red spots on the surface of leaves. The undersides of leaves become covered with a dense white powdery deposit, consisting of fungal spores. More than one spot can develop on a single leaf. *E. rostrupii* distorts the leaf tissue and can cause infected leaves to drop prematurely. Spots can also develop on young green fruit.

Infections can spread from the leaf through the petiole to the aerial and underground stems of young growing vines, causing reddening and hypertrophy of the affected portions of the stems. The part of the vine above the hypertrophied zone may continue its normal growth or wither and die, depending on the amount of distortion of the stem tissue.

If black spot disease invades red leaf spot lesions, the lesions turn black and severely affected leaves turn brown. The infection of stems results in girdling, i.e., the presence of incisions in the bark which cause death or reduced vigour of the vine.

Figure 6.7: Symptoms of red leaf spot

Monitoring

Field scouting can reveal symptoms of this disease. It tends to be more severe in shaded parts of fields, in areas where air circulation is poor and in areas of beds with poor drainage. Luxuriantly growing vines, such as those found in young beds naturally rich in nitrogen or heavily fertilized fields, are particularly susceptible to red leaf spot.

Control methods

Cultural control

Cultural practices that favour rank vine growth and excessive nitrogen fertilizers must be avoided.

Good drainage is essential to control the development of the disease.

The varieties Ben Lear and Stevens appear to be highly susceptible to this disease.

Chemical control

There are no registered products for red leaf spot control in Canada.

Protoventuria Leaf Spot and Berry Speckle

NB NS PE QC NF	From the end of bud break to harvest

This disease generally produces little damage. It is caused by the fungus *Protoventuria myrtilli*.

Biology

P. myrtilli overwinters in lesions on infected leaves. The perithecia—sexual organs containing spore-bearing asci—mature in midsummer. The infection of the leaves and fruit occurs in July and August. The fungus is slow growing.

Symptoms

In early fall, small but distinct red to purple lesions appear on current-year leaves. By late spring the following year, the lesions have enlarged but are less distinctly outlined. Infected leaves become deficient in chlorophyll. The perithecia present in July may have prominent black spines. Affected leaves become more chlorotic and the lesions looks like smudgy spots. Many of the affected leaves drop prematurely.

Speckling appears on fruit in midsummer as tiny red lesions on the fruit. These speckles increase in size and number as the season progresses. Lesions on ripe fruit may be pale yellow, dark red or black and may reach 1 to 2 mm (~1/16 in.) in diameter. The centre is slightly depressed and lighter in colour than the margins and small black speckles may develop.

The speckles on berries are superficial and do not affect the quality of the fruit. They do, however, make berries less attractive for fresh-market sale.

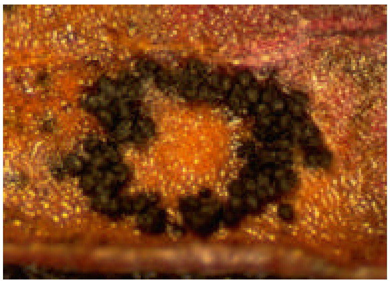


Figure 6.8: Symptoms of Protoventuria leaf spot - black perithecia

Figure 6.9: Symptoms of Protoventuria leaf spot - infected leaf

Monitoring

This disease is common only in beds that have not been treated with fungicides. Scouting of these beds may reveal the presence of symptoms of this disease.

Control methods

Strategic chemical control

Fungicide treatments applied in July and early August for fruit rot are also effective in controlling *P. myrtilli*. The leaf spots are thus controlled and speckles on the fruit are avoided.

Ringspot

NB NS PE QC NF	From ripening of fruit to harvest

Ringspot generally does not cause economically significant damage, except in fruit of the variety Searles, which are more susceptible.

Biology

The causal agent of ringspot is thought to be a virus. It has no known vector. The disease apparently spreads only through the use of infected planting stock.

Symptoms

The symptoms of this disease are generally observed on the fruit. Light coloured rings appear on the fruit, varying in shape and colour according to the variety. On the variety Howes, the rings are especially prominent because the fruit are dark red. The area within the rings is often deeper red than the area outside the rings. On Early Black, the spots are more like light-coloured circular patches. On Searles, the spots are less prominent, but the berries are usually malformed, with some necrosis at their base. In some cases, entire berries are necrotic.

Cranberry leaves may sometimes have symptoms of this disease. Light-coloured and reddish rings appear on the leaves, as normally occurs in the fall.

Ringspot is a systemic disease, affecting all uprights on a given runner and all berries on a given upright. However, it does not reduce plant vigour or how much fruit they produce.Only the quality of the Searles variety is affected.

See photo in Compendium of Blueberry and Cranberry Diseases (Caruso and Ramsdell, 1995)

Control methods

Cultural control

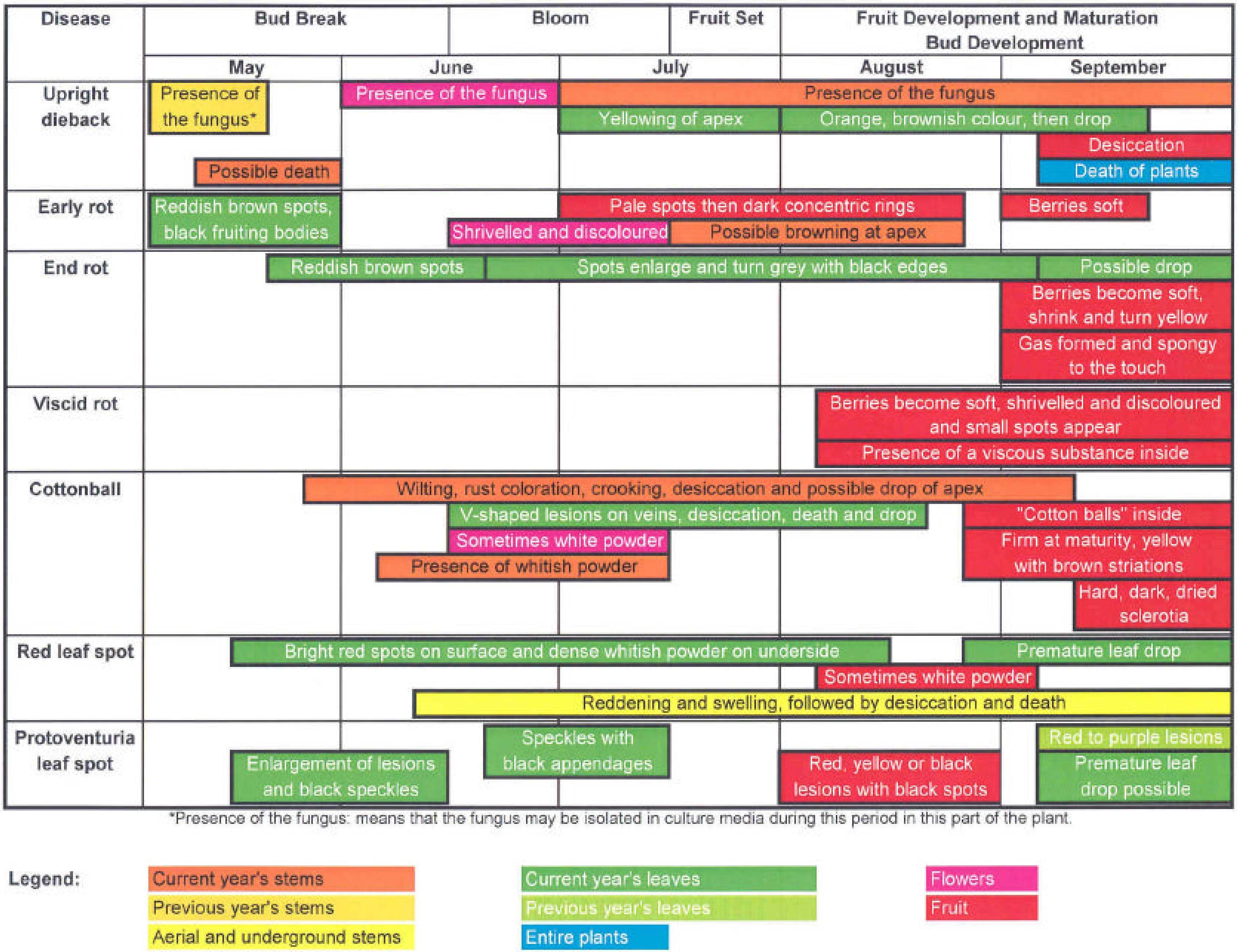
The best way to prevent the disease is to use non-infected vines when planting new fields.

Table 6.1: Characteristics of diseases in cranberry production

DISEASES & FUNGI	PARTS AFFECTED	SYMPTOMS	PHYSICAL CONTROL	CHEMICAL CONTROL
Upright dieback *Phomopsis vaccinii and Synchronoblastia Crypta*	New shoots (elongation stage)	Yellowing of shoot tips. Leaves turn bronze or orange, then brown and drop.	Proper irrigation. Avoid oxygen deficiency. Reduce picking injury. Sanding and flooding (plant vigour). Avoid rank vine growth.	Fungicide treatment. During elongation, when shoots have 1 cm (3/8 in) of new growth.
	Plants	Vines die back from tips to underground stems.		
	Fruit	Berries dry up if attached to affected uprights.		
Early rot *Phyllostica vaccinii*	Fruit	Small pale spots that form dark concentric rings. Berries shrivel and rot.	Sanding. Good drainage. Remove floating debris at harvest. Refrigerate stored fruit.	Fungicide treatments: 1) at 10-20% bloom; 2) 10 days later; 3) 10 days after that, if necessary.
	Flowers	Withering and discoloration (possible browning). Presence of black fungal fruiting bodies.		
	Leaves	Irregular, reddish brown spots. Presence of black fungal fruiting bodies.		
End rot *Godronia cassandrae*	Fruit	Soft tissue clearly delineated from sound tissue. Spongy to the touch. Gas formed. Shrinking, yellowing and deformation.	Sanding. Good drainage. Remove floating debris at harvest. Avoid excessive use of nitrogen fertilizer. Avoid prolonged periods of flooding.	Fungicide treatment (if fruit is to be used for the fresh market). Three applications between late bloom and early berry development.
	Leaves	Reddish brown spots on surface. Spots turn grey or bronze at centre with dark border. Surrounding tissue turns brilliant or dark red.		
Viscid rot *Phomopsis vaccinii*	Fruit	Softening and discoloration. Shrivelling and appearance of small spots. Presence of a viscous substance if fruit is cut.	Cultural practices that promote vigorous plant growth. Avoid rank vine growth and minimize heat and drought stress.	Fungicide treatment. Three applications, during bloom and at early fruit development.
Cottonball *Monilinia oxycocci (Syn: Sclerotina oxycocci)*	Apex of stems	Wilting, rust coloration and crooking. Desiccate and drop.	Good drainage. Remove floating debris at harvest. Control moss. Avoid having areas of saturated sand.	Fungicide treatments. If over 15% of berries affected:* 1) when 1/2 shoots elongate; 2) 7 to 10 days later; 3) when 10-20% flowers open; 4) 7 to 10 days later. If less than 15% of fruit infected:* 1) when 10-20% flowers open; 2) 7 to 10 days later.
	Leaves	V-shaped lesions on veins. Desiccate, die and drop.		
	Stems	Presence of a whitish powder. Wilt and dry up.		
	Fruit	Presence of "cotton balls" inside. Mature berries firm, yellow with brown striations. Formation of dark, hard, dried up sclerotia.		
Red leaf spot *Exobasidium rostrupii (Syn: E. vaccinii)*	Leaves	Bright red spots on surface of leaves. Dense white powder on underside of leaves. Distortion of leaf tissue.	Good drainage. Avoid rank vine growth. Avoid excessive use of nitrogen fertilizer.	None.
	Stems (aerial and underground)	Become red and swollen. Stem above infected area withers and dies.		
Protoventuria leaf spot *Protoventuria myrtilli (Syn: Gibbera m.)*	Leaves	Red to purple lesions with black spots in centre. Chlorophyll deficiency. Prominent black fruiting bodies may appear. Possible leaf drop. Red, yellow or black spots, black speckles in centre.	Cultural practices have no effect.	Fungicide treatment applied to control fruit rot is effective against *P. myrtilli*.
Ringspot	Fruit	Pale rings. Necrosis at base (Searles).	Use non-infected vines when planting new fields.	None.

***** Berries infected the previous year

Table 6.2: Chronology of disease symtoms in cranberry



CHAPTER 7: WEEDS[5]

Weeds are an inevitable problem for cranberry producers. They compete with the cranberry plants for water, light, space and nutrients and serve as hosts to a number of insects and diseases. They can cause yield losses and therefore must be effectively managed.

A weed is defined as an undesirable plant that is harmful to a specific crop. It is a good colonizer that can have a high germination rate, vigorous reproduction and rapid growth.

Weed seeds can be introduced into fields by a variety of vectors, such as wind, water, animals, humans and machinery. Wind and water easily spread seeds and can carry them over large distances. A number of human activities can cause the dispersal of weeds, for example the planting of new fields with plants from weed-filled fields, or the spreading of sand containing weed seeds or rhizomes. Machinery also serves as a dispersing agent when sanitation measures are inadequate.

The pattern of weed distribution in a field is influenced mainly by soil type, soil pH and moisture, the space available and the border effect. Weeds have preferences for specific environmental conditions, which vary by species. Thus some weeds can be indicator plants, indicating underlying environmental problems.

Table 7.1: Examples of plant species indicating environmental problems

Conditions	Weed species
Soil compaction	Prostrate knotweed
Lack of nitrogen	Legumes (e.g., clovers, black medic)
Drainage problem	Sedges
Alkaline pH	Plantains, clover, cinquefoil
Excess surface moisture	Mosses and algae

Figure 7.1: Common plantain

Monitoring

Identification

To manage weeds adequately, the producer must know which species are present, where they are in the fields and their life cycle. Using a weed identification guide with colour photographs, or searching for information on the Internet is strongly advised.

Note that no official identification of cranberry weeds is available for Eastern Canada. The data from Massachusetts is used for monitoring purposes, since no methods specific to Eastern Canada have been developed.

See Appendix E: For more information

Plants that are considered weeds are classified in three distinct groups: monocotyledons (grasses, sedges, etc.), dicotyledons (broadleaves) and pteridophytes (horsetails, ferns, club mosses). Within these divisions are found annual, biennial or perennial plants. An annual plant is one that completes its full life cycle (germination, flowering, seed production and death) in a single year. Some plants require two years to complete their life cycle and they are called biennial plants. Annual and biennial plants reproduce only by seed. A perennial plant is one that continues growing and flowering for several years. Depending on the species, it may reproduce by means of seeds, rhizomes, runners, tubers or spores.

[5] The information presented in this chapter is taken in part from *Guide d'identification des mauvaises herbes du Québec* (Bouchard and Néron, 1998) and *A Field Guide to Common Weeds of Cranberries in Southeastern Massachusetts* (Sandler and Else, 1995).

Monocotyledons (grasses, sedges, etc.)

These are flowering plants, which have seeds only one cotyledon (first seedling leaf). Grasses and sedges belong to this group. Grasses have inconspicuous flowers grouped on spikes or panicles. Some grasses are annual, while others are perennial. Sedges grow in wet environments. They are closely related to grasses but have a triangular stem (e.g., flat sedges, bulrushes), while rushes have round stems and leaves.

The identification of monocotyledons is based on the morphology of several specific parts of the plant. The following features should be observed:

- form of sheath and blade;
- ligule type;
- collar;
- tillering (vegetative growth);
- spikelets and inflorescence;
- seed.

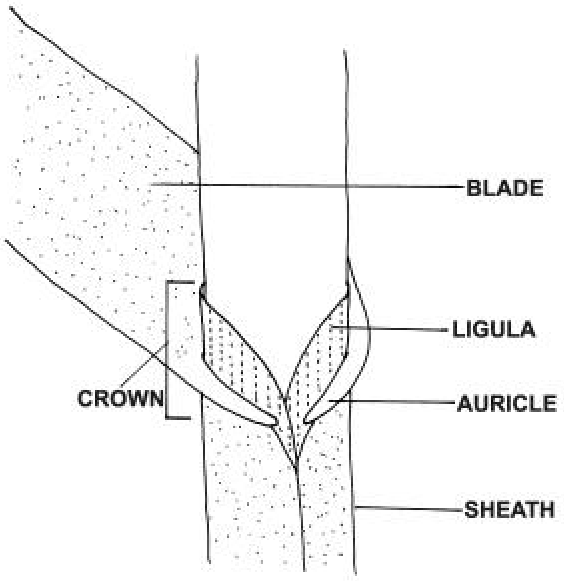


Figure 7.2: Morphology of a monocotyledon stem

Identifying monocotyledons is not easy. The cranberry producer may encounter problems, especially when it comes to differentiating grasses, rushes and sedges. Following is a table summarizing the characteristics of each.

Table 7.2: Differences between grasses, rushes and sedges

Parts	Grasses	Sedges	Rushes
Stem	Round	Triangular	Round
Leaves	Often flat	Often V-shaped	Often reduced, hollow
Leaves	In twos	In threes	Few
Fruit	Single seed	Single seed	Several seeds
Nodes	Present	Absent	Absent
Ligule	Generally present	Absent	Absent

Dicotyledons (broadleaves)

The seed of these plants has two cotyledons. These are the first two leaves that emerge from the soil when the seed germinates. This group constitutes the broadleaf weeds. Dicotyledons are identified by:

- cotyledon shape
- leaf morphology (blade shape and margin);
- type of growth (stem plant or rosette plant, alternate or opposite leaves).

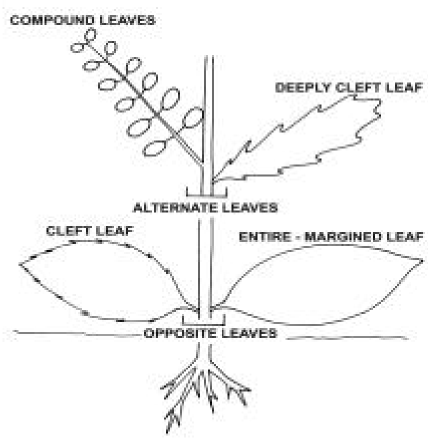


Figure 7.3: Morphology of different dicotyledon leaves

Table 7.3: Differences between grasses and broadleaf plants

Characteristics	Monocotyledons (grasses, sedges, etc.)	Dicotyledons (broadleaves)
Leaves	Narrow, all alike; Parallel veins;	Quite broad, variety of shapes; Quite netted veins;
Flowers	Inconspicuous;	Often very colourful;
Types	Herbaceous;	Woody and herbaceous.

Pteridophytes (horsetails, ferns and club mosses)

These are perennial plants that produce neither flowers nor seeds, but reproduce by spores. They spread mainly vegetatively by underground stems (rhizomes) or above-ground stems (stolons). The pteridophytes include horsetails, ferns and club mosses. Only a few species of these plants are found in cranberry production.

Figure 7.4: Ferns

Field profiles

Weed surveys indicate the species present and their location. They may take the form of maps representing the density of weeds present. These maps show the tolerance level and infestation level for each species. The tolerance level defines the control priorities described below.

The tolerance level corresponds to the percentage of coverage beyond which the weed's presence is no longer acceptable.

Weeds are classified according to their invasiveness, their ability to compete with crop plants and the level of control they require. A priority chart, which was established in Massachusetts, shows the tolerance level for various species.

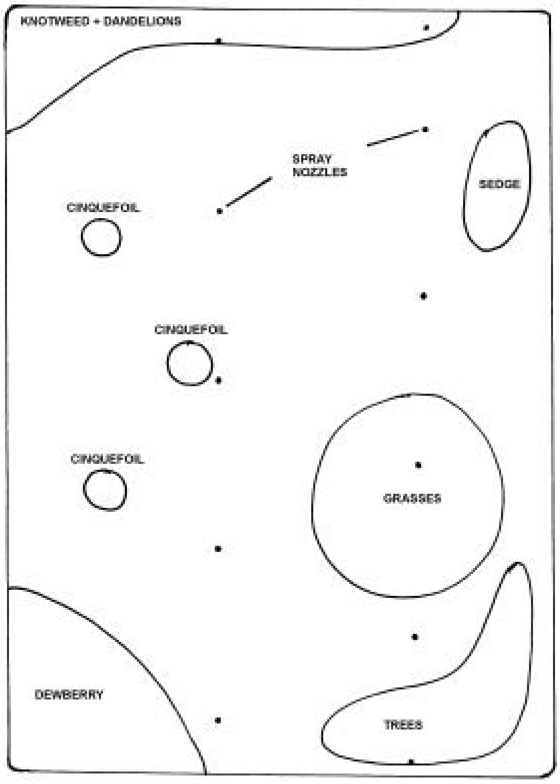


Figure 7.5: Field profile

Control priorities[6]

Priority 1—Zero tolerance

Weeds in this group cause severe yield losses. They can even cause cranberry plants to die. They quickly invade the environment and are difficult and expensive to control. They must be eliminated as soon as they appear in a field. A number of these species have a creeping habit.

Examples: swamp blackberry, cinquefoil.

Figure 7.6: Cinquefoil

Figure 7.7: Dodder

Priority 2—Low tolerance

These are less damaging weeds than those in the first group, but they are still aggressive.

Examples: goldenrod, asters.

Figure 7.8: Goldenrod

Priority 3—Medium tolerance

Weeds in this group may reduce yields, but yield impact is low. They grow and propagate fairly slowly. They are not as difficult to control as those in the preceding groups.

Examples: sedge, leatherleaf, clovers.

[6] Source: *A Field Guide to Common Weeds of Cranberries in Southern Massachusetts* (Sandler and Else, 1995)

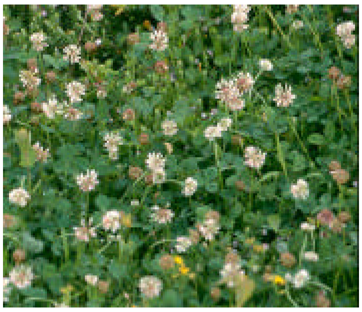


Figure 7.9: White clover

Figure 7.10: Leatherleaf

These tolerance levels remain flexible; producers should adapt this system to the particular characteristics of their farm.

Priority 4—High tolerance

These weeds are generally observed in bare spots, weak areas, or along the edges of fields. Most are easy to control. This can be done by increasing vegetative cover in the fields.

Examples: beggartick, fleabane, annual grasses.

Figure 7.11: Beggartick

See Table 7.4: Weed control priorities in cranberry production

Table 7.4: Weed control priorities in cranberry production

Type	English name	French name	Latin name
Priority 1	Blackberry trailing	Ronce hispide	*Rubus hispidus*
	Cinquefoil silverweed	Potentille ansérine	*Potentilla anserina*
	Dodder	Cuscute	*Cuscuta spp.**
	Old-field Cinquefoil	Potentille simple	*Potentilla simplex*
Priority 2	Aster	Aster	*Aster spp.*
	Goldenrod	Verge d'or	*Solidago spp.*
Priority 3	Clover	Trèfle	*Trifolium spp.*
	Leatherleaf	Cassandre caliculé ou faux bleuets	*Chamaedaphne calyculata*
	Marsh Yellow Cress	Rorippe d'Islande	*Rorippa islandica*
	Rush	Jonc	*Juncus spp.*
	Sedge	Carex	*Carex spp.*
	St. John's wort	Millepertuis	*Hypericum spp.*
	Tufted vetch	Vesce jargeau	*Vicia cracca*
	Willow	Saule	*Salix spp.*
Priority 4	Aspen poplar	Peuplier faux-tremble ou tremble	*Populus tremuloides*
	Barnyard grass	Échinochloa pied-de-coq	*Echinochloa crusgalli*
	Beggarticks	Bident	*Bidens spp.*
	Birch	Bouleau	*Betula spp.*
	Ditch Stonecrop	Penthorum faux-orpin	*Penthorum sedoides*
	Fleabane	Vergerette	*Erigeron spp.*
	Horsetail Fern or Field Horsetail	Prèle des champs ou queue de renard	*Equisetum arvense*
	Large crab-grass	Digitaire sanguine	*Digitaria sanguinalis*
	Meadowsweet	Spirée	*Spiraea spp.*
	Red maple	Érable rouge	*Acer rubrum*
	Rough cinquefoil	Potentille de Norvège	*Potentilla norvegica*
	Smartweed	Renouée	*Polygonum spp.*
	Sphagnum	Sphaigne	*Sphagnum spp.*
	Verticillate Mountain-Mint	Pycnanthème verticillé	*Pycnanthemum verticillatum*
	Willow-herb	Épilobe	*Epilobium spp.*
	Witch grass	Panic capillaire	*Panicum capillare*
	Yellow foxtail	Sétaire glauque	*Setaria glauca*

* spp. indicates that there is more than one species of the same genus.

Source : *A Field Guide to Common Weeds of Cranberries in Southeastern Massachusetts* (Sandler and Else, 1995)

Action threshold

No action threshold is available for cranberry weeds.

Control methods

Cultural control

When planting a new field or applying sand, it is important to use excavated sand rather than surface sand. The latter may contain a larger number of weed seeds that have been scattered by the wind. It is also essential to ensure that the cranberry cuttings to be planted come from a field with a minimum of weeds. For greater certainty, it is preferable to visit this field before it is mowed.

Good field drainage can keep weeds to a minimum. Some weeds prefer wet areas and adequate drainage will therefore slow their growth. Drainage also promotes cranberry vine growth. A dense canopy of healthy plants will compete more effectively with invading plants.

Unlike most weeds, cranberry grows better in an acidic soil, ideally with a pH of between 4.0 and 5.0 (Eck, 1990). Maintaining a proper soil pH for the crop will therefore discourage the growth of several undesirable species.

A nutrient shortage or soil compaction can adversely affect the health of cranberry plants and encourage invasion by some species of weeds. It is therefore important to ensure adequate fertilization and soil aeration.

Clean and tidy fields will reduce the spread of weeds. Dikes covered in grass and mowed as necessary will serve as barriers to seed dispersal and will help prevent these undesirable plants from becoming established.

The removal of debris by post-harvest flooding helps to eliminate seeds that may be present in the debris.

Mechanical control

Manual hoeing can be an alternative to herbicides. It is the most effective way to eliminate some persistent weeds. In the case of perennials, it is important to note that all the roots must be pulled out, otherwise the plant may multiply. If there are few weeds, hoeing is generally used in combination with the localized application of herbicides.

Biological control

The number of biological weed control methods is very small. In nature, some insects attack weeds and play a role in crop maintenance (e.g., Chrysolina sp. on St. John's wort). There are some virus-based or fungus-based bioherbicides that attack weeds. However, such methods have not yet been developed in cranberry production and no product has been registered for use on cranberries.

Strategic chemical control

The application of herbicides is a common and useful method of controlling most weeds. To be effective, the herbicide must be present at the desired site in sufficient quantity to be active when the target weeds are most susceptible.

Herbicides act by disrupting some critical plant function (e.g., photosynthesis, protein formation, root growth). How successful a treatment is depends, in particular, on the herbicide's mode of action, its location in the plant and its persistence in the environment.

Herbicide effectiveness may also depend on factors that are beyond the producer's control, such as soil pH, temperature, humidity and organic matter. Some herbicides vaporize easily. If a herbicide is absorbed by a non-susceptible plant, the plant will not be affected.

Each herbicide eliminates a number of specific weeds. It is therefore important to correctly identify the weed species present and to choose the appropriate herbicide.

Herbicides can be divided into two groups: pre-emergent and post-emergent. Pre-emergent herbicides inhibit germination or, more often, interfere with rooting or seedling growth. Post-emergent herbicides are applied to weeds that are actively growing, at a clearly defined stage of development.

To maximize their effectiveness, herbicides must be carefully managed. The selection and application of a herbicide should be based on the species and number of weeds present, their priority and their distribution. It is preferable to use a registered low-toxicity herbicide. A consultant or expert should be consulted regarding the recommended active ingredient. Read the label carefully before using and carefully follow the recommendations.

Table 7.5: Herbicides used to control various weed species in cranberry production

Weed species	POAST ULTRA	2,4-D AMINE	LONTREL	ROUND UP, GLYPHOS, TOUCHDOWN	DEVRINOL	CASORON
Absinth				X		X
Alsike clover			X			
Annual sow-thistle		X	X	X	X	X
Barnyard grass	X			X	X	
Bindweed spp.				X		X
Blue grass spp.				X		X
Bull thistle		X				X
Buttercup spp.		X		X		
Canada thistle		X	X	X		X
Chickweed		X		X	X	X
Common barberry		X				
Common groundsel			X			X
Common peppergrass		X				
Dandelion		X				X
Dog mustard		X				
Field bindweed		X				
Field horsetail						X
Groundsel spp.		X			X	X
Heal-all		X				
Lady's thumb				X		X
Lamb's-quarters		X		X	X	X
Large crab grass	X					X
Maritime chamomile			X			
Mouse-ear chickweed		X				X
Mustard spp.		X		X		X
Ox-eye daisy			X			
Ox-eye daisy			X			
Perennial rye grass						X
Perennial sow-thistle		X	X	X		X
Pigweed spp.*					X	X
Pineappleweed		X	X		X	
Plantain spp.			X			X
Prickly lettuce		X		X	X	
Prostrate knotweed					X	X
Purple loosestrife				X		X
Purslane		X			X	X
Quack grass	X			X		X
Ragweed (common)			X	X		X
Ragweed (giant)		X				X
Redroot pigweed		X		X	X	X
Sheep sorrel			X	X		X
Shepherd's purse				X		X
Smartweed spp.		X				
Sow-thistle spp.				X		X
Stinkweed		X		X		
Tufted vetch			X			
Vetch spp.			X	X		X
Wild buckwheat			X	X		X
Witch grass	X					X
Yellow foxtail	X				X	
Yellow nutsedge				X		X

*spp. Indicates that there are several species for a given genus.

Source: Utilisation sécuritaire des pesticides, *in Guide de gestion intégrée des ennemis du pommier*, pp. 9-52 (Morin et al., 2001).

Chapter 8: PESTICIDES[7]

Nature and formulation of pesticides

Pesticides are chemical compounds which, although potentially hazardous, are in most cases essential to the economic viability of a cranberry-growing operation.

Different types of pesticide are used to control different pests, as will be seen from the table below.

Type of pesticide	Pest category
Bactericide	bacteria
Fungicide	fungi
Herbicide	weeds
Insecticide	insects
Nematicide	nematodes

Composition of a pesticide

The formulation of a commercial pesticide comprises one or more active ingredients and other compounds termed "inert substances" or "additives". The latter are mixed in during the manufacture of the pesticide. They have an important effect on the effectiveness of the active ingredient by, among other things, making the formulation more physically or chemically stable.

These additives include the following:

Solvents

(petroleum distillates such as naphtha, xylenes, alcohols and glycols)

They dissolve the active ingredient in liquid formulations such as emulsifiable concentrates (EC), solutions (SN) and solution concentrates (SC). Solvents are toxic and consequently any product containing more than 10% petroleum distillates is automatically deemed to be a poison, regardless of whether it contains a pesticide.

Stabilizers

(pH buffers, antioxidants)

These inhibit the breakdown of the active ingredient as a result of the action of acids, bases, light or any other agent that may be present in the product, the mix or the environment.

Surface-active agents

(emulsifiers, surfactants, wetting agents)

These lower the surface tension of the water, thereby enhancing:

- spread of the mixture on the plant and pests;
- adherence to sprayed areas;
- leaching resistance.

Defoamers

These reduce the foam formation that would otherwise result from agitator action.

[7] The information in this chapter is taken partly from *Utilisation sécuritaire des pesticides*, from the *Guide de gestion intégrée des ennemis du pommier* (Morin et al., 2001) and from *Pesticides et agriculture : bon sens, bonnes pratiques* (Bourque et al., 1996).

Types of formulation

The main formulations used for purposes of cranberry growing are:

Table 8.1: Types of pesticides formulations registered for use on cranberries

WP, W *	Wettable powders
L, Li	Liquid
EC, E	Emulsifiable concentrates
Soluble packages	Instapak, Solupak, etc.
DF, WG, WDG	Dry flowables
G, GR	Granules for soil application

*These letters are frequently printed after the name of the pesticide (e.g., Malathion 85 EC).

Registered pesticides

The *List of Registered Pesticides in Cranberry production in Canada* includes a list of pesticides registered for use on cranberry crops. This list can change from year to year; it is therefore important to obtain the list for the current year. Products registered in Canada, however, are not necessarily registered in the United States. It follows that a grower planning to export to that country should check to make sure that the use of a particular pesticide is acceptable under American regulations.

It is important to bear in mind that pesticides are not the only way of protecting a crop. They are indispensable in many situations, but they do not constitute the solution to every problem. Moreover, pesticides are not a substitute for good crop management practice and do not eliminate use of other products (biopesticides, parasitoids et predators) when they are available.

Acts and regulations

This section summarizes the main provisions of Acts and regulations that may be applicable in cranberry growing. The material is supplied for information purposes only and has no legal force. The full texts of statutes are available from the governments concerned. Provincial and federal statutes may be consulted on line at the addresses shown below.

http://doc.gouv.qc.ca/home.php

http://laws.justice.gc.ca/en/index.html

Pesticide registration, use and marketing: *Pest Control Products Act*

The registration, importation, manufacture and transport of pesticides are subject to the provisions of the *Pest Control Products Act*, which is administered by the Pest Management Regulatory Agency (PMRA), an arm of Health Canada.

All information shown on pesticide labels is also subject to the provisions of the Act. The label indicates the formulation of the product and provides instructions for its use, together with precautions that should be taken and first aid measures that should be applied in the event of accidental poisoning.

It is unlawful to use a pesticide in any way that is not in accordance with the instructions printed on the label and it is also unlawful to use any pesticide for any crop or application other than those for which it is registered in Canada.

Under the Act, the label also indicates the minimum period that must be allowed to elapse between the last application of a pesticide and the harvesting of the crop. These time intervals before harvesting must be meticulously observed, as must maximum application rates, to ensure that pesticide residues on the harvested fruit do not exceed the maximum limits set by the *Food and Drugs Act*.

In all cases, it is essential to read the label carefully before using a pesticide, in order to avoid errors that may have harmful or even disastrous consequences.

Information about pesticides

The PMRA has set up a Canadian pesticide information network, accessible toll-free, to answer enquiries about registration, precautions, labels and the like. Contact information is shown below.

Telephone: 1-800-267-6315

E-mail: pmra_infoserv@hc-sc.gc.ca

Internet: http://www.hc-sc.gc.ca/pmra-arla/

About residues

A reputation for quality is something that is slowly built up…and can be lost in less time than it takes to say it! Pesticide residues on harvested fruit that exceed the legal limits, for example, may have serious consequences, including health hazards for consumers, seizure and destruction of the crop concerned (with no possibility of compensation from crop insurance), loss of consumer confidence, buyer avoidance and, on a larger scale, a tarnished image for the product, something that adversely affects all growers.

The following are a few useful tips that will help to avoid any danger of pesticide residues in excess of the legal limits:

- The prescribed time intervals between the application of the various pest control products and harvesting should be meticulously observed, as indicated by the manufacturer;
- Recommended application rates and number of applications should never be exceeded;
- Only pesticides that are registered for cranberry production should be used;
- In the case of fruit for export, it is important to use only products that are registered for use with the fruit in question both in Canada and in the importing country;
- Ensure that the sprayer is correctly adjusted;
- Keep a detailed record of applications made and the products used.

Pesticide residues on fruit: Food and Drugs Act

This federal Act sets the maximum pesticide residue levels that may lawfully be found on fruits and vegetables. A crop inspection program under which fruits and vegetables are inspected both before they are placed on sale and at the time they are placed on sale ensures that Canada's food supply does not constitute a consumer health hazard.

Ideally, harvested fruits and vegetables should not contain any detectable pesticide residues. This is feasible, given effective pesticide use. For unregistered pesticides, the maximum residue that is tolerated on food products in Canada is 0.1 ppm (part per million). In the United States, the corresponding limit is, by default, 0.

Importation and exportation of plant products: Plant Protection Act

This federal Act aims to prevent the importation, exportation and spread of harmful insects and diseases or any other type of crop pest into or within Canada. Under the Act, where a person becomes aware of the exis tence of a thing that the person suspects to be a pest in an area where the pest has not previously been known to exist, he or she is required to notify an agricultural representative or a Canadian Food Inspection Agency (CFIA) officer of the suspected pes t.

Plant products may be imported or exported only provided authorization has previously been secured from a CFIA officer. For exportation, such authorization is granted after inspection of the crop and harvest and after submission and examination of written evidence showing that the crop is free from harmful species as defined by the regulations of the importing country.

If you wish to export or import on any substantial scale, you should contact a CFIA plant protection officer early in the season.

See Appendix E: For more information

Acts relating to wildlife conservation

A person who injures or kills some wildlife species (such as birds of prey, snakes and turtles) is liable to prosecution. Some migratory birds or other species are protected under the laws of Canada. Hunting licences are required in the case of other animals, such as the white-tailed deer or the woodchuck. Further details about the Migratory Birds Convention Act, 1994 and the Canadian Wildlife Act can be found at the Internet site:

http://www.cws -scf.ec.gc.ca/laws_e.cfm

Fruit trees may not be sprayed or dusted with products that are toxic to bees when they are in flower. However, cranberries are not subject to this requirement and as yet no regulations on the matter have been issued.

See Chapter 4: Pollination

Other legal instruments

The Acts referred to above have been passed by the Canadian Government. Other laws have been enacted by several provinces. Further details may be obtained from a provincial agricultural representative.

See Appendix E: For more information

Pesticides and your health

When handling a new and dangerous tool, a user will usually take adequate precautions. As he or she becomes familiar with the tool, unfortunately, he or she tends to be progressively less careful about the precautionary measures. As a rule, that is when an accident is most likely to occur. The consequences of inadequate pesticide handling usually occur over a long period of time and then are frequently attributed to some cause other than pesticide use.

See Appendix F: Re-entry intervals

How do pesticides get into the human body?

Through the skin

Most pesticides can be absorbed to varying degrees by ingestion, by inhalation and through the skin. However, most occupational exposure studies have indicated that the skin is the main absorption route. For example, people who come into contact with vegetation shortly after it has been sprayed with a pesticide may get just as much exposure as the actual sprayers, or even more. It is noteworthy that absorption through the skin in the genital region and via the eyes is 10 times as great as absorption through the skin of the hands and forearms.

Inhalation

Absorption through the skin may be the main route by which pesticides get into the system, but inhalation may have a more serious impact. Inhaling a pesticide is more or less tantamount to injecting it directly into the bloodstream.

Ingestion

Ingestion may be the stealthiest absorption route, as a person may swallow pesticide by indirect contact while smoking, drinking or eating during or even after preparing or spraying a pesticide mixture.

Eye contact

Exposure to pesticides through the eye can lead to eye irritation or even absorption of the product into the body. When handling pesticides, adequate eye protection must be worn.

In order to minimize the hazard of pesticide absorption through the skin, it is important to wait for a time before returning to work at a site that has been sprayed. It is also important to wash carefully after spraying and to ensure that work clothing is in good condition and frequently cleaned. Contaminated clothing may be a major source of pesticide absorption through the skin.

Toxicity of pesticides

Acute (short-term) toxicity

The symptoms of acute pesticide poisoning may range from a sudden headache to nausea, vomiting or even unconsciousness. There are various pesticides that can cause systemic poisoning, even after quite a short exposure time.

The symptoms of low-level pesticide poisoning may be difficult to recognize. They are frequently confused with the symptoms of a gastrointestinal upset, fatigue from overwork, or some other cause. The symptoms may appear immediately following exposure, or they may not appear until several hours later. They may appear to be mild, but they may indicate a more serious case of poisoning.

If you suspect that a case of pesticide poisoning has occurred, do not hesitate to get in touch with your province's Poison control centre:

Quebec City: 1-800-463-5060

New Brunswick: 911 and ask for the Poison control centre

Halifax: 1–902-428-8161

St. John's: 1–709-722-1110

Charlottetown: 1-800-565-8161

Toronto: 1-800-268-9017

Ottawa: 1-800-267-1373

Chronic (long-term) toxicity

Chronic or long-term toxicity is a term used to designate the effects observed as a result of repeated exposure (over a period that may range from a few days to several years) to low doses of pesticides. It is persons who are not careful enough about taking precautions who are at risk of this type of poisoning. The symptoms of chronic pesticide poisoning may include headaches, irritability, fatigue and loss of appetite; on occasion, internal organs may be seriously affected and there is a risk of cancer.

Repeated exposure to low doses of pesticides over a long period may cause chronic toxicity problems. Chronic toxicity is a subtle and stealthy condition and symptoms may not develop for several years after exposure. There is no point in taking needless risks: protect yourself from exposure to these products.

In order to avoid any risk of acute or chronic poisoning, the first precaution that should be taken is always to protect the four routes by which a pesticide can get into the system (skin contact, ingestion, inhalation and via the eyes) by wearing appropriate protective equipment. This precaution should become a habit, to the point of being an automatic reflex. Instructions on the type of protective equipment that should be worn are printed on the product label.

Risk levels

On a pesticide label, you will sometimes find a toxicity symbol warning the user of the risk and nature of the risk of handling the product in question. There are several of these symbols and the one used in any given instance depends on the acute toxicity of the pesticide concerned, as determined from the criteria shown below.

DANGER: POISON

oral LD_{50}: <500 mg/kg

percutaneous LD_{50}: <500 mg/kg

Effect on the eyes: corrosive or irreversible

Petroleum distillates: >10%

WARNING: POISON

oral LD_{50}: 500–1000 mg/kg

percutaneous LD_{50}: 500–1000 mg/kg

Effect on the eyes: serious but reversible

Petroleum distillates: 1 to 10%

CAUTION: POISON

oral LD_{50}: 1000–2000 mg/kg

percutaneous LD_{50}: 1000–2000 mg/kg

Effect on the eyes: irritation

Note: The lethal dose (LD_{50}) value is the dose of active ingredient that is sufficient to kill 50% of laboratory animals (rats, mice or rabbits) exposed to these products by ingestion or by absorption through the skin during a predetermined period of time (1 to 6 days). The results are expressed in mg of pesticide per kg of the animal's body weight.

Allergic reactions and dermatological effects

There are some pesticides, including Diazinon and Round Up, that can cause severe skin reactions. Others can produce skin allergies over time: Malathion, for example, can cause allergic dermatitis. When handling pesticides directly, or when bringing in contaminated vegetation, it is important always to wear protective clothing in order to create a barrier between pesticide and skin.

Symptoms of poisoning

Table 8.2 indicates the various symptoms that can appear as a result of pesticide poisoning.

Table 8.2: Symptoms of poisoning characteristic of the various families of pesticides

Insecticides	Symptoms observed
Organophosphate compounds Diazinon, Guthion, APM, Sniper, Imidan	• Headaches, dizziness, sweating, tearing, salivation, blurred vision, chest tightness. • Abdominal cramps, nausea, vomiting, diarrhea, bronchial hypersecretion, irregular heartbeat, trembling, weakness and fatigue.
Carbamates Sevin	• Contraction of the pupils, incontinence, confusion, pulmonary edema, laboured breathing, bluish skin colour, cardiorespiratory failure, convulsions, loss of consciousness and coma.
Herbicides	**Symptoms observed**
Aryloxyacids 2,4-D	• Gastroenteritis, nausea, vomiting, diarrhea, dizziness, weakness, anorexia, lethargy, muscular stiffness, weakness and fibrillation, irregular pulse and respiratory complications, irritation of skin, eyes and mucous membranes.

Source: Utilisation sécuritaire des pesticides, in the *Guide de gestion intégrée des ennemis du pommier* (Morin et al., 2001)

Pesticides and the environment

The use of pesticides on a crop may entail environmental impact. Pesticides in surface water, wells and groundwater may adversely affect the quality of aquifers used for drinking water. Pesticides in streams and rivers may be harmful to the aquatic species that inhabit them. Pesticide residues may also be found in the air and on the soil of adjacent land.

Protection of wells and watercourses

The measures outlined below will help reduce the risk of contaminating bodies of water and nearby wells.

- Pesticide mixtures should never be prepared at a distance of thirty metres or less from a body of water.
- If water must be pumped directly from a well, pond or stream into a sprayer tank, the hose used to draw the water should never be stuck into the pesticide mixture, unless the pump is fitted with a backflow preventer.
- All appropriate precautions should be taken to minimize pesticide drift toward bodies of water.

Pesticide drift

Pesticides may be carried by the wind, leaving residues on neighbouring crops or harming human beings and animals living nearby. In order to minimize the drift hazard and protect the environment and public health, it is important to:

- Ensure that the sprayer or other mechanical equipment used to apply pesticides is well maintained and properly adjusted;
- Never spray when weather conditions are conducive to pesticide drift; preferably spray early in the morning or in the evening (when there is usually less wind), except where counterindicated;
- Follow the Department of the Environment's recommendations relating to good practice aimed at minimizing pesticide drift;
- Use the available drift control methods and equipment in so far as possible.

Protection of beneficial species

Many beneficial species such as pollinators, predators, parasitoids etc. are more sensitive to pesticides than pests are. There is a very simple reason for this: species that have been feeding on plants for thousands of years have developed impressive enzyme systems to neutralize the various chemical substances that plants produce as defence mechanisms. Consequently, they are better equipped to eliminate alien products than species that feed on other insects or animals, which usually do not contain toxic substances. Pests are more extensively exposed to pesticides that are sprayed on crops and hence are more likely to develop resistance to those pesticides.

Some new pesticides that have been marketed in recent years are increasingly specific and compatible with beneficial species. It is important to be careful not to harm insects that are beneficial to crops. Some useful tips are listed below.

- Pesticides should not be applied unless a target species has been identified;
- Pesticides should not be applied when pest populations are below the action threshold level;
- The recommended application rate indicated on the label should never be exceeded and where there is a choice of registered application rates, the lowest rate should be selected;
- Pesticides that have the least impact on the pests' natural enemies and on the environment should be preferred.
- Alternative pest control methods should be used where possible.

Should you use pesticides?

Spraying a pesticide should always be a last resort. Before doing it, you should ask yourself these questions:

- Has the problem been accurately assessed?
- Have all available means other than pesticides (including prevention, cultivar selection, cultivation practices, non-chemical products and the like) been tried in an effort to solve the problem?
- Will spraying be economically advantageous?
- Will spraying do more harm than good?

The information in this guide will help you answer the first and second questions adequately. In order to answer the third and fourth questions, you must be able to estimate how much you can reasonably expect to gain by spraying with pesticide and compare that figure with the cost of the prospective treatment and its probable impact on the crop and on beneficial organisms. Even more to the point, you must also be able to assess the possibility that the pesticide will not succeed in controlling the pest (due to the development of resistance, unfavourable climate conditions).

When buying pesticides, it is important to take the following factors into account:

- **Quantity**: You should buy only as much as you need for the season, in order to avoid having to store the remainder.

- **Effectiveness**: You should purchase only products that are registered for use against the particular pest with which you are dealing.
- **Formulation**: Some formulations are more hazardous to handle than others. Wettable powders, for example, are very dusty to handle. Emulsifiable concentrates of solvents, for their part, are fequently toxic and can penetrate the skin in a short time, thereby increasing the risk of poisoning. Another disadvantage of formulations of this type is that as a rule they must be stored in a place where they will not freeze. Dry flowables and soluble packages are among the safest formulations to handle and the easiest to use.
- **Environmental impact**: A pesticide's environmental impact is the result of a number of factors: the quantity applied, the concentration, its effect on beneficial insects and other non-target organisms, its persistence, whether it will break down into toxic secondary metabolites, how water-soluble it is (leaching and runoff) and how volatile it is. Accordingly, it is essential to check the characteristics of the various products available before making a purchase decision. Do not hesitate to consult an agricultural representative if necessary.
- **Toxicity**: If possible, select the least toxic pesticide available for the environment and human health.

Transporting pesticides

An essential prerequisite for a professional pesticide delivery person is possession of a licence to transport hazardous materials. However, a licence is not required to transport pesticides for the owner's personal use, unless very large quantities are involved.

Safety precautions during transport

- Accept only containers which are in good condition.
- Transport products in their original container.
- When loading a container of pesticide, always wear gloves.
- Pesticide containers should always be placed in the back of the vehicle, i.e. in the box of your truck or the trunk of your car; they should never be carried inside the cab or the passenger compartment. These products do not make good travelling companions; they frequently give off harmful vapours that may adversely affect your health and your alertness at the wheel.
- Pesticide containers that are made of cardboard or paper should be protected from rain and damp.
- Pesticide containers should be securely stowed to avoid the risk of upset during transport.
- If possible, pesticides should not be transported at the same time as other products; if this is unavoidable, the latter should be isolated to avoid contamination.
- Keep absorbent material (such as litter or vermiculite) within reach and make a note of the *Environmental Emergency Centre* telephone number in case a spill should occur.

Storing pesticides

If you have pesticide left over when winter comes, or if you find you must store pesticides for a long period of time, you must take action to ensure that they will keep without deteriorating. Powders and dry flowables can be stored without difficulty. Some liquid formulations, however, such as most emulsifiable concentrates, must be stored in a place where they will not freeze. You should always read the label carefully to determine the extent of the manufacturer's liability.

Safety precautions relating to storage

- Select a location that is out of the reach of children, inaccessible to animals and well away from any river or stream;
- Store pesticides in a well-ventilated place with controlled temperature (if necessary), a place that can be securely locked;
- Store herbicides, fungicides, insecticides and chemicals separately according the manufacturer's recommendations;
- Do not place the containers directly on the floor of the storage area;
- Store pesticides in their original containers;
- Do not store protective equipment in the same place as pesticides;
- Put up signs to indicate that there are pesticides inside.

NEVER store pesticides in your house. Good health is worth a lot more than any leftover pesticides!

Application of pesticides

- Spray only when necessary (i.e., when pest incidence has reached the action threshold level);
- Ensure that application equipment is in good working order and is correctly adjusted;
- Read the label carefully before use and be meticulous about following the instructions;
- Spray only when weather conditions are suitable (e.g., when there is no wind);

- Leave a standard-width pesticide-free strip between the sprayed area and sensitive areas (residences, streams and rivers, wells or other ecologically sensitive areas);
- To avoid poisoning pollinating insects, avoid spraying any cranberry plants that are in flower and be careful not to allow any pesticide drift in the direction of fields in which there are crops at the flowering stage (unless circumstances make this unavoidable). If treatment is necessary, do not spray insecticide between 7:30 a.m. and 5:30 p.m., when pollinating insects are busy in the fields.
- Inform your family and neighbours that you are going to be spraying, for the sake of their safety and your own.

Most pesticides are less effective when applied during very hot and sunny weather.

Warning Signs

It is strongly advisable to put up signs warning people to keep out as soon as you begin spraying an area with pesticide. The signs should be clearly visible and should be left in place throughout the entire period of time that the manufacturer recommends you should allow to elapse before re-entering a field after spraying. These periods are usually indicated on the label. Not only is this practice safety-enhancing, but the signs also serve to reassure people that the grower is concerned for their health.

See Appendix F: Re-entry intervals

Sprayer maintenance

After spraying, the sprayer should be carefully cleaned. The cleaning operation consists of rinsing the tank with water, followed by refilling it to one fifth of its capacity with water and a detergent (a mild one, such as dishwashing liquid, a soap specially formulated for the purpose or ammonia) and starting the agitator. The water-and-detergent solution should then be sprayed through all the spray heads. A final rinse with clean water will serve to clean the tank and pipes. If a particular pesticide requires a special procedure to clean the sprayer afterward, the necessary information will be printed on the label.

For more information, consult the guide entitled *Je passé à l'action, je règle mon pulvérisateur à rampe* (MAPAQ 2002).

Disposing of empty containers

- Empty containers should be washed out immediately (you should rinse them three times) and the waste water poured into the sprayer tank before you take them to the recovery site. A list of empty pesticide container recovery sites is published in the spring in various farm newspapers and magazines. All containers must be clean and dry after having been rinsed three times and their caps and labels must be removed.
- If it is not possible for you to take your empty pesticide containers to a recovery site, you should rinse them out, punch holes in them so that they cannot be used again and put them into the garbage.
- Pesticide containers should not be put into a recycling bin, even if they have been rinsed three times.
- Empty pesticide containers should not be burned.

Personal hygiene

After pesticide treatments, applicators must wash themselves thoroughly. You should shower thoroughly after spraying, or if a break of several hours intervenes in the middle of a long spraying operation.

The following are some useful tips on decontaminating personal protective gear.

- Wear gloves when handling pesticide-contaminated clothing.
- Hang up your protective gear outside in the open air.
- Prerinse. Use one of the following three methods: hose down the protective gear outside, rinse it separately in a tub or large pail, or put it through the washing machine. Boots should be thoroughly rinsed with water and left to dry in the open air (use rubber boots. avoid leather).
- Presoak. Use a heavy-duty liquid detergent.
- If possible use a different washing machine than that used for family laundry. If this is not possible, it should be washed separately from the regular laundry. Clothing that is contaminated with the same pesticide should be washed together.
- Never overload the washing machine so that clothes are thoroughly washed.
- Always use:
  - the highest water level setting;
  - hot water;
  - the regular cycle;
  - a heavy-duty detergent, using the recommended amount;
- Rinse in lukewarm water.
- Heavily contaminated clothing should be washed over again to get rid of all pesticide residues.

- Clean the washing machine. Run the machine empty through a complete cycle, using hot water and a little detergent.
- It is preferable not to use a dryer, to avoid any contamination hazard. Furthermore, fresh air is a means of decontamination in itself. Accordingly, you should hang the clothing out on the clothesline.

Emergency measures

A good emergency plan enables you to save precious time when an accident occurs. The measures outlined below are general in nature; you should take the time to think about others that should be added to the list in the light of **your own situation**. This information is adapted from the publication *Pesticides et agriculture: bon sens, bonnes pratiques* [pesticides and agriculture: common sense, good practice] (Bourque et al., 1996)

In the event of a spill

- First take action to protect yourself, then help any persons who are showing symptoms of poisoning to a safe place and give them first aid.
- Instruct any persons in the vicinity of the spill site to keep away.
- Summon assistance or have someone else do so.
- Wearing appropriate protective gear, take appropriate action to contain the spill, by throwing up an earth barrier, for example.
- In the event of an extensive spill, apply the above measures and call the nearest Environmental Emergency Centre immediately:

Environmental Emergency Centre

Eastern Quebec: (418) 643-4595

Western Quebec: (514) 873-3454

Newfoundland & Labrador:
1-800- 563-2444 or (709) 772-2083 or (709) 729-3395

New Brunswick, Nova Scotia and Prince Edward Island:
1-800-565-1633

Ontario Ministry of the Environment: 1 800 268-6060

Equipment items that should be kept within easy reach

In order to be able to cope with any eventuality, you should have the following items ready at hand:

- Four 25-kg bags of sand or some other absorbent material (vermiculite, or, failing that, earth, cat litter or peat moss);
- Shovels;
- Pushbrooms;
- A fire extinguisher;
- A first-aid kit;
- A container of clean water;
- Ipecac syrup;
- A large (205 L or 45 gal) waste barrel or sturdy plastic bags (the bags containing the vermiculite may be useful, but you will need more of them);
- Protective equipment.

Cleaning contaminated surfaces

- In all cases, work with the wind at your back as much as possible.
- In the event of a spill of granules, powder or dust, the pesticide must be sprinkled with water as soon as possible if wind dispersal is a possibility. It should not be saturated with water. Sweep or shovel the pesticide into a barrel or plastic bags.
- In the event of a spill of liquid, cover the spilled pesticide with a suitably thick layer of absorbent material and wait until it is soaked with the pesticide. Do not use water. Sweep or shovel the pesticide into a barrel or sturdy plastic bags.
- If the pesticide has been spilled directly on to the ground, remove the contaminated soil to a depth of at least 5 cm below the depth to which the pesticide has penetrated. Put the earth into barrels or sturdy plastic bags.
- All receptacles containing earth or absorbent material that is soaked with pesticide should be sealed and labelled and then turned over to a specialized firm.
- After the pesticide has been recovered, the site of the spill should be decontaminated with an appropriate solvent. Information on the most appropriate solvent in any given instance is available from the federal government's bilingual information service.

In case of fire

A fire in a pesticide storage area is highly dangerous, as many pesticides give off toxic vapours when burned.

- Keep an "ABC" type extinguisher, 5 kg size or larger, in your pesticide storage shed so that you can quickly put out any incipient fire.
- Notify the fire department and mention the fact that it is a pesticide fire.
- Avoid using water for firefighting purposes, as it may prove difficult to contain the contaminated runoff water.

First aid for victims of poisoning

- Have the label ready at hand to indicate what pesticide is the cause of the poisoning;
- Keeping a record of the pesticides you spray may, among other things, enable an outside party to determine what pesticide is involved in a case of poisoning.
- The Poison Control Centre will tell you what to do. You may be asked to give the victim Ipecac syrup, which is sold over the counter in pharmacies. You should always have a supply on hand;
- If you must leave an unconscious person unattended briefly (to summon assistance), he or she should be left in a safe position, i.e. lying on his or her side with the upper leg bent and ahead of the lower leg.

Poisoning by skin contact

- Quickly remove contaminated clothing, taking appropriate precautions (in particular by wearing gloves);
- Wash the skin with ample quantities of water and soap;
- If pesticide has been splashed into the victim's eyes, the eyes should be washed out with ample quantities of lukewarm water for 15 minutes, keeping the lids open.

Poisoning by inhalation

- Get the victim out of the contaminated area, taking the usual precautions and wearing a respirator if necessary;
- Give artificial respiration (mouth-to-mouth) if the victim is having difficulty breathing (bluish colouring of the lips).

INSERT

THE CANADA CRANBERRY PESTICIDE CHART

HERE

Appendix A: Sample Reports (Example)

SAMPLER'S NOTEBOOK

Grower's name: Date:

Field No.: Weather conditions:

Phenological stage:

North

Draw the sampling pattern used for each sweep set

Species and number of insects captured per sweep set

Examples:

1st set: 1 green spanworm, 1 chain-spotted geometer

2nd set: 2 cranberry blossomworms, 1 chain-spotted geometer

3rd set: 3 chain-spotted geometers, 4 sawflies, 1 unknown*

4th set: 1 false armyworm, 2 speckled green fruitworms, 1 sawfly

5th set: 12 green spanworms, 3 big cranberry spanworms

Total number of insects captured: (for 5 sweep sets)

13 small spanworms

8 large spanworms

5 noctuid moths

1 sawfly

1 (*to be preserved in a container and identified later)

Average number of insects captured:

2.6 small spanworms

1.6 large spanworms

1 noctuid moth

0.2 sawflies

0.2 unknown

The average must be used to verify whether the action thresholds have been reached.

Report for each field

Sampler: ____________________ Grower: ____________________

Date: ____________________ Field No.: ____________________

Number of insects captured/sweep set

	1	2	3	4	5	6
Small spanworms						
Green spanworm						
Rannock looper						
Large spanworms						
Big cranberry spanworm						
Stout spanworm						
Spiny looper						
Chain-spotted geometer						
Other spanworms						
Cleft-headed looper						
Triangle-marked						
Hemlock looper						
Horned spanworm						
Small engrailed						
Johnson spanworm						
Other						
Sawflies						

Number of insects captured/sweep set

	1	2	3	4	5	6
Noctuids						
False armyworm						
Cranberry blossomworm						
Speckled green fruitworm						
Impressed dagger moth						
Rear-humped caterpillar						
Zebra caterpillar						
Putnam's false looper						
Bog copper						
Other						
Tussock moths and other						
Rusty tussock moth						
Gypsy moth						
Blackheaded fireworm						
Sparganothis fruitworm						
Cranberry weevil						
Strawberry root weevil						
Black vine weevil						
Red-headed flea beetle						
Other						

Comments

North

Club Environnemental et Technique
Atocas Québec
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(Québec) G0S 1T0
Tél.: (819) 385-1053
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Courriel: info@cetaq.qc.ca

DAILY REPORT

Grower:______________________

Sampler:____________________

Date:_______________

		Number of insects/20 net sweeps										Number of moths per pheromone trap					
Field No.	Phenological stage	Small spanworms	Other spanworms	Large spanworms	Tussock moths	Noctuid moths and cutworms	Blackheaded fireworms	Sparganothis fruitworms	Weevils	Redheaded flea beetles	Sawflies	Blackheaded fireworms	Cranberry girdlers	Sparganothis fruitworms	Cranberry fruitworms	% fruit set (fruit-worm)	Observations

APPENDIX B: INDEX OF KEY BENEFICIAL SPECIES FOR CRANBERRY CROPS

PARASITIC AND PARASITOID INSECTS			
Order	**Family**	**Example of species**	**Pest targeted**
Diptera	Tachinidae	*Hemisturmia tortricis* *Nemorilla maculosa*	Blackheaded fireworm Sparganothis fruitworm
Hymenoptera	Ceraphronidae	*Ceraphron pallidiventris*	Cranberry tipworm
	Braconidae	*Cotesia melanoscela*	Gypsy moth
	Ichneumonidae	*Itoplectis conquisitor* *Phanerotoma franklini*	Sparganothis fruitworm Cranberry fruitworm
	Tiphiidae	*Tiphia relativa*	Cranberry girdler
	Trichogrammatidae	*Trichogramma deion* *Trichogramma minutum* *Trichogramma sibericum*	Cranberry fruitworm, Sparganothis fruitworm Sparganothis fruitworm, blackheaded fireworm Blackheaded fireworm
PREDATORY INSECTS			
Order	**Family**		**Pest targeted**
Diptera	Syrphidae		Cranberry tipworm
Hymenoptera	Vespidae		Cranberry tipworm, gypsy moth
Coleoptera	Carabidae Coccinellidae		Weevil, gypsy moth
Odonata			Blackheaded fireworm
Neuroptera			Lepidoptera
PRINCIPAL BENEFICIAL MICROORGANISMS			
Group		**Species**	**Pest targeted**
Bacteria		*Bacillus thuringiensis*	Lepidoptera
Viruses			Cranberry girdler, spanworm moth, tussock moth
Fungi		*Beauveria bassiana*	Cranberry girdler, spanworm, tussock moth, Sparganothis fruitworm
Nematodes		*Steinernema carpocapsae* *Heterorhabditis bacteriophora*	Cranberry girdler and weevil Root weevil
OTHER BENEFICIAL ANIMALS			
Group		**Example of species**	**Pests targeted**
Spiders			Cranberry girdler, tussock moth, blackheaded fireworm
Birds		Crows, swallows and various others	Lepidoptera
Mammals		Bats	Lepidoptera

POLLINATORS		
Order	**Family**	**Species**
Hymenoptera	Apidae	*Apis mellifera* *Bombus affinis* *Bombus bimaculatus* *Bombus borealis* *Bombus fervidus* *Bombus griseoocollis* *Bombus impatiens* *Bombus perplexus* *Bombus rufocintus* *Bombus ternarius* *Bombus terricola* *Bombus vagans vagans*
	Andrenidae	*Andrena vicina* *Andrena crataegi*
	Anthophoridae	*Ceratina dupla*
	Halictidae	*Dialictus admirandus* *Lasioglossum coriaceum*
	Megachilidae	*Heriades* sp. *Hoplitis* sp. *Megachile* sp. *Osmia atriventris*
	Melittidae	*Melitta near americana*

APPENDIX C: PLANTS THAT ATTRACT BENEFICIAL INSECTS

English name	Latin name	Flowering	Insects attracted
Umbelliferae			
Fennel	*Foeniculum vulgare*	Summer	Ichneumonidae and ladybugs
Wild carrot	*Daucus carota*	Summer	*Itoplectis conquisitor*
Wild parsnip	*Pastinaca sativa*	Summer	*Itoplectis conquisitor*
Compositae			Lacewing larvae
Anthemis	*Anthemis tinctoria*	Summer	Parasitic wasps and flies
Black-eyed Susan	*Rudbeckia hirta*	Summer	Predators and parasites in general
Cosmos	*Cosmos bipinnatus*	Summer-Fall	Predators in general and spiders
Fleabane	*Erigeron spp.*	Depends on species	Ichneumonidae
Goldenrod	*Solidago spp.*	Summer-Fall	Ichneumonidae
Ox-eye daisy	*Chrysanthemum leucanthemum*	Summer	Predators and parasites in general
Tansy	*Tanacetum vulgare*	Summer	Ladybugs
White aster	*Aster ptarmicoides*	Summer-Fall	Ichneumonidae
Yarrow	*Achillea spp.*	Summer	Predators and parasites in general
Caryophyllaceae			*Itoplectis conquisitor*
Leguminosae			Predatory bugs and parasitic wasps
White clover	*Trifolium repens*	Summer	Soil predators
White sweet-clover	*Melilotus alba*	Summer	*Itoplectis conquisitor*
Cruciferae			
Sweet alyssum	*Lobularia maritima*	Summer	Predators and parasites in general
Wild mustard	*Brassica kaber*	Summer	*Itoplectis conquisitor*
Other plant species			
Buckwheat	*Polygonum fagopyron*	Summer	Syrphid flies
Field bindweed	*Convolvulus arvensis*	Summer	*Itoplectis conquisitor*
Milkweed	*Asclépias spp.*	Summer	*Itoplectis conquisitor*
Mint	*Mentha spicata*	Summer	Diptera and hymenoptera
Phacelia	*Phacelia tanacetifolium*	Summer	Carabes, syrphides et trichogrammes

APPENDIX D: PLANTS THAT ATTRACT POLLINATORS

Family	Genus	Species	Common name	Flowering
Apocynaceae	*Apocynum*	*androsaemifolium* L.	Spreading dogbane	Summer
Aquifoliaceae	*Ilex*	*verticullata* L.	Winterberry	Spring
Balsaminaceae	*Impatiens*	*capensis* M.	Spotted jewelweed	Summer
Berberidaceae	*Berberis*	*vulgaris* L.	Common barberry	Spring
Boraginaceae	*Borago*	*officinalis* L.	Borage	August to first frosts
	Symphytum	*officinale* L.	Comfrey	Summer
Campanulaceae	*Campanula*	spp.	Bellflower	Generally summer
Caprifoliaceae	*Viburnum*	spp.	Viburnum	Spring
Compositae	*Achillea*	spp.	Achillea	Mid-July to September
	Artemesia	*vulgaris* L.	Mugwort	Summer
	Aster	*novae-angliae* L.	New England aster	Fall
	Centaurea	*montana* L.	Mountain bluet	Summer
	Chrysanthemum	spp.	Chrysanthemum	Summer
	Eupatorium	*maculatum* L.	Spotted Joe-Pye weed	Summer
	Helianthus	spp.	Sunflower	Summer
	Hieracium	spp.	Hawkweed	Summer
	Senecio	spp.	Groundsel	Generally summer
	Solidago	*altissima* L.	Tall goldenrod	Summer-fall
		canadensis L.	Canada goldenrod	Summer-fall
		uliginosa N.	Bog goldenrod	Fall
	Silybum	*marianum* L.	Milk thistle	Summer
	Taraxacum	*officinale* W.	Dandelion	Spring
Crassulaceae	*Sedum*	spp.	Stonecrop	Spring, summer or fall
Cruciferae	*Raphanus*	*sativus* L.	Radish	Summer
	Brassica	*juncea* C.	Indian mustard	Summer
		rapa L.	Kohlrabi	Summer
	Lepidium	*densiflorum* S.	Peppergrass	Spring
Ericaceae	*Andromeda*	*glaucophylla* L.	Bog rosemary	Spring
	Chamaedephne	*calyculata* L.	Leatherleaf	Spring
	Erica	*carnea*	Spring heath	Spring
		cinerea	Twisted heath	June-September
		X darleyensis	Darley heath	Spring
	Gaylussacia	*baccata* W.	Black huckleberry	Spring
	Kalmia	*angustifolia* L.	Sheep laurel	Summer
		polifolia W.	Bog laurel	Summer
	Ledum	*groenlandicum* R.	Labrador tea	Spring
	Rhododendron	spp.	Rhododendron	Spring
	Vaccinium	*Corymbosum* L.	Highbush blueberry	Spring
		oxycoccus L.	Small cranberry	Summer
Euphorbiaceae	*Euphorbium*	*spp.*	Spurge	Generally summer
Geraniaceae	*Geranium*	*spp.*	Geranium	Spring-summer
Hydrophyllaceae	*Phacelia*	*tanacetifolia*	Phacelia	8 weeks after emergence
Iridaceae	*Iris*	*versicolor* L.	Blue iris	Spring
Labiatae	*Agastache*	*foeniculum* K.	Giant hyssop	July-September
		ruposa	Korean mint	July-August
	Ocimum	*basilicum*	Basil	Summer

Family	Genus	Species	Common name	Flowering
	Mentha	*spp.*	Mint	Summer
	Monarda	*fistulosa* L.	Wild bergamot	Summer
	Nepeta	*cataria* L.	Catnip	Summer
	Origanum	*vulgare* L.	Oregano	Summer
	Prunella	*vulgaris* L.	Heal-all	Summer
	Salvia	spp.	Sage	Summer
	Satureja	hortensis	Summer savory	Summer
	Scutellaria	*epilobiifolia* A.	Common skullcap	Summer
Leguminosae	*Lathyrus*	*latifolius* L.	Everlasting pea	Summer
	Lotus	*corniculatus* L.	Birdsfoot trefoil	July-August
	Lupinus	spp.	Lupine	Summer
	Medicago	*lupulina* L.	Black medick	Summer
	Melilotus	*alba* D.	White sweet-clover	Late spring until snow
	Robinia	*pseudo-acacia* L.	Black locust	Spring
	Trifolium	*hybridum* L.	Alsike clover	Summer
		pratense L.	Red clover	Summer
		repens L.	White clover	Summer
	Vicia	*craCca* L.	Tufted vetch	All summer
Oleaceae	*Syringa*	*spp.*	Lilac	Spring-summer
Umbelliferae	*Anthriscus*	*cerefolium* L.	Chervil	Spring
	Daucus	*carota* L.	Wild carrot	Summer
Orchidaceae	*Calopogon*	*pulchellus* R.	Grass-pink orchid	Summer
	Pogonia	*ophioglossoides* L.	Rose pogonia	Summer
Polygonaceae	*Polygonum*	*fagopyrum* L.	Buckwheat	Summer
	Rumex	*acetosella* L.	Sheep sorrel	Summer
Pontederiaceae	*Pontederia*	*cordata* L.	Pickerelweed	Summer
Primulaceae	*Primula*	*spp.*	Primrose	Summer
Ranunculaceae	*Aquilegia*	*spp.*	Columbine	Spring
Rhamnaceae	*Ceanothus*	spp.	Ceanothus	Spring
Rosaceae	*Amelanchier*	spp.	Serviceberry	Spring
	Aronia	*melanocarpa* M.	Black chokeberry	Spring
	Malus	spp.	Apple	Spring
	Potentilla	*palustris* L.	Marsh cinquefoil	Summer
	Prunus	spp.	Plum	Spring
	Rosa	*blanda* A.	Meadow rose	Spring
		palustris M.	Swamp rose	Summer
	Rubus	spp.	Bramble	Summer
	Spiraea	*latifolia* A.	Broad-leaved meadowsweet	Spring
		tomontosa L.	Hardhack	Spring
Rubiaceae	*Cephalanthus*	*occidentalis* L.	Buttonbush	Summer
Rutaceae	*Ruta*	*graveolens* L.	Rue	Fall
Salicaceae	*Salix*	*discolor* M.	Pussy willow	Spring
Saxifragaceae	*Ribes*	spp.	Currant and gooseberry	Spring
Scrophulariaceae	*Digitalis*	spp.	Foxglove	Spring
	Veronica	*spicata* L.	Spike speedwell	Fall
	Chelone	*glabra* L.	Turtlehead	Summer
Valerianaceae	*Valeriana*	*officinalis* L.	Common valerian	Summer

APPENDIX E: FOR MORE INFORMATION

Chapter 1: Concepts of Integrated Pest Control

Integrated pest control specialists

Quebec

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Prince Edward Island

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Charlottetown, PEI C1A 8B9
Telephone: (902) 566-2733
Facsimile: (902) 566-5637
E-mail: peihort@isn.net

New Brunswick

Department of Agriculture, Fisheries and Aquaculture
P.O. Box 6000
Fredericton, NB E3B 5H1
Telephone: (506) 453-2108 or (506) 453-2214

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Web sites

Integrated Pest Management for Cranberries in Western Canada

http://res2.agr.ca/parc-crapac/english/lagassiz/ipm/fitzpatrick/pages/electpubs.html

Chapter 2: Insect Pest Monitoring

Pest monitoring equipment suppliers

Great Lakes IPM
10220 Church Road NE
Vestaburg, MI 48891
Telephone: (517) 268-5693
Facsimile: (517) 268-5311
Web site: http://www.greatlakesipm.com/

Solida
480 rang St-Antoine
St-Férréol-les-Neiges, QC G0A 3RO
Telephone: (418) 826-0900
Facsimile: (418) 826-0901
E-mail: solida@clic.net

Phero Tech Inc.
7572 Progress Way
Delta, BC V4G 1E9
Telephone: (604) 940-9944 or 1-800-665-0076
Facsimile: (604) 940-9433
E-mail: Pherotech@mindlink.bc.ca
Web site: www.pherotech.com

Cooper Mill Ltd.
R.R. No. 3
Madoc, ON K0K 2K0
Telephone: (613) 473-4847
Facsimile: (613) 473-5080
E-mail: ipm@coopermill.com
Web site: www.coopermill.com

Web sites

Pheromones - 3M Canada http://www.mmm.com/ca/ag

Pest Monitoring Equipment Suppliers (partial list) http://www.gov.on.ca/omafra/english/crops/resource/pestmonitor_equip.htm

Chapter 3: Insect Pests

List of pesticides registered for use on cranberries in Canada

Cranberry Institute
266 Main Street
Wareham, MA 02571
Telephone : Jere Downing, Executive Director (508) 759-6855

References

Insectes ravageurs de la canneberge au Québec – Guide d'identification (Landry et al., 2000)

Club d'encadrement technique Atocas Québec
898 Principale
Notre-Dame-de-Lourdes, QC G0S 1T0
Telephone: (819) 385-1053 Facsimile: (819) 385-1054
Attn: Edith Leclerc

Cranberry Insects of the Northeast (Averill and Sylvia, 1998)

UMass Cranberry Experiment Station
P.O. Box 569
East Wareham, MA 02538
Attn: Martha Sylvia
Telephone: (508) 295-2212 Facsimile: (508) 295-6387

Integrated Pest Management for Cranberries in Western Canada (Maurice et al., 2000)

Agriculture and Agri-Food Canada
Pacific Agri-Food Research Centre
P.O. Box 1000
Agassiz, BC V0M 1A0
Attn: Dr S. M. Fitzpatrick

Régie de culture : le contrôle des insectes. Bulletin technique, production de canneberge, 1997, 42–45 + appendices.

Web sites

Black vine weevil http://www.colostate.edu/depts/CoopExt/tra/plants/blakvine.html

Cranberry fruitworm http://www.bio.umassd.edu/biodept/res-instut/cranberries/cranberries.htm

Cranberry tipworm http://www.nemaine.com/rc&d/tipworm.htm

Gypsy moth management http://gypsy.fsl.wvu.edu/gmoth/manag

Major cranberry pest identification key http://pupuxl.env.gov.bc.ca/~ipmis/docs/cranmjr.html

UMass Integrated Pest Management www.umass.edu/umext/programs/agro/ipm

Chapter 4: Pollination

Bumblebee hive suppliers

Halifax Seed Co. Inc.
P.O. Box 8026, Station A
Halifax, NS B3K 5L8
Telephone: (902) 454-7456

P.O. Box 2021
Saint. John, NB E2L 3T5
Telephone: (506) 633-2032

Styrofoam (polystyrene) hives. Specify type 'B' for fields.

Koppert Canada
3 Pullman Court
Scarborough, ON M1X 1E4
Telephone: (416) 291-0040

Hives for fields available, sold in groups of four with plywood boxes. Average recommended: 4 hives/hectare (2.5 acres).

Apipol s.e.n.c.
1131 Belleville
Laval, QC H7C 2C8
Jacques Gervais
Telephone: (450) 661-1894
Facsimile: (450) 661-5377

Waxed, waterproof boxes, sold separately or in groups.

Beehive suppliers

Contact an advisor.

Web sites

The Bumblebee page http://www.mearns.org.uk/mrssmith/bees/bees.htm

General beekeeping and plans for a bumblebee nest http://www.members.aol.com/beetools/index.htm

Plants that bumblebees forage and pollinate in the bog ecosystem http://www.cae.wisc.bumblebees

Solitary bees http://www.uidaho.edu/pses/strickler/solitarybees/solitary.htm

Bumble bee nest box (construction) http://www.anet-chi.com/~manytimes/page40.htm

Chapter 5: Biological Control Agents

Suppliers

Great Lakes IPM
10220 Church Road NE
Vestaburg, MI 48891
Telephone: (517) 268-5693
Facsimile: (517) 268-5311
Web site: http://www.greatlakesipm.com/

Insecterra
2300 Sherbrooke East, Suite 4
Montreal, QC H2K 1E5
Telephone: (514) 524-2433
Facsimile: (514) 528-6849
E-mail: ffournier@insecterra.com

E.S. Cropconsult Ltd.
3041 West 33rd
Vancouver, BC V6N 2G6
Telephone: (604) 266-6560
E-mail: debhend@axion.net

Web sites

List of nematode suppliers http://www.nysaes.cornell.edu/ent/biocontrol/pathogens/nematodes.html

Beneficial insects of British Columbia cranberry bogs http://www.direct.ca/pestpage/ben3.html

Nematodes http://www.oardc.ohio-state.edu/nematodes/biologyecology.htm

Nematode information related to cranberry http://www2.oardc.ohio-state.edu/nematodes/cranberry_fact_sheet.htm

List of beneficial insects and mites suppliers http://www.gov.on.ca/omafra/english/crops/resource/beneficial.htm

Chapter 6: Diseases

References

Compendium of Blueberry and Cranberry Diseases. F. L. Caruso and D. C. Ramsdell, Eds. American Phytopathological Society Press, St. Paul, MN, 1995, 87 pp.

Web sites

Fruit pathology http://www.plantpath.wisc.edu/fpath/frames.htm

University of Wisconsin, Plant pathology http://www1.uwex.edu/ces/pubs/showpubs.cfm?theid=17

Chapter 7: Weeds

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Guide d'identification des mauvaises herbes. C. J. Bouchard et R. Néron. 1998. Centre ARICO. Direction des sevices technologiques. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, 253 pp.

Flore laurentienne. Frère Marie-Victorin. 5e édition. Les Presses de l'Université de Montréal, 1964, 925 pp.

A Field Guide to Common Weeds of Cranberries in Southeastern Massachusetts. H. A. Sandler and M.J. Else. UMass Cranberry Station Extension Publication, 1995, 16 pp.

An Illustrated Guide to the Weeds of Cranberry Bogs in Southeastern New England. J. R. Sears, J. Dunn and B. Harrison. UMass-Dartmouth Publication, 1996, 90 pp.

Web sites

Weed Identification Guide http://www.gov.ns.ca/nsaf/elibrary/archive/ipm/weeds/990019.htm

Chapter 8: Pesticides

Pesticide information

Pest Management Regulatory Agency (PMRA)
Health Canada
2720 Riverside Drive
A.L. 6606D2
Ottawa, ON K1A 0K9

Pesticide Management Information Service
(5 days a week)
Telephone: 1-800-267-6315 or (613) 736-3799
Facilmile: (613) 736-3798
Web site: http:/www.hc-sc.gc.ca/pmra-arla
E-mail: pmra_infoserv@hc-sc.gc.ca

Regional Offices of the Pest Management Regulatory Agency

Atlantic

PMRA
Regional Director
1081 Main Street
P.O. Box 6088
Moncton, NB E1C 8R2
Telephone: (506) 851-2689
E-mail: mctiernann@em.agr.ca

Quebec

ARLA
Regional Director
2001 University, 7th Floor
Montreal, QC H3A 3N2
Telephone: (514) 283-8888
Facsimile: (514) 283-1919
E-mail: lafortunej@em.agr.ca

Ontario

PMRA
Director General
174 Stone Road West
Guelph, ON N1Q 4S9
Telephone: (519) 837-9400
Facsimile: (519) 837-9773
E-mail: Pettigrewr@em.agr.ca

Regional Offices of the Canadian Food Inspection Agency

Atlantic Area Office

1081 Main Street
P.O. Box 6088
Moncton NB E1C 8R2
Pierrette Savoie
Secretary, Executive Director
Telephone: (506) 851-7670
E-mail: savoiepm@inspection.gc.ca

Newfoundland Regional Office – St. John's

10 Barter's Hill
St. John's, NF
Sharon Myler, Administrative Assistant
Telephone: (709) 772-6070
Facsimile: (709) 772-2282
E-mail: mylers@inspection.gc.ca

Prince Edward Island Regional Office – Charlottetown

690 University Avenue
Charlottetown, PEI C1E 1E3
Kirsten Johnson, Administrative Assistant
Telephone: (902) 566-7449
Facsimile: (902) 566-7334
E-mail: johnsonkl@inspection.gc.ca

Nova Scotia Regional Office

1992 Agency Drive
P.O. Box 1060
Dartmouth, NS B2Y 3Z7
Deborah Forsythe, Administrative Assistant
Telephone: (902) 679-5740
Facsimile: (902) 679-5565
E-mail: forsythed@inspection.gc.ca

New Brunswick Regional Office – Fredericton

850 Lincoln Road
P.O. Box 2222
Fredericton, NB E3B 5G4
Wanda Alexander
Program Officer, Plant Protection
Telephone: (506) 452-4890
Facsimile: (506) 452-3923
E-mail: alexanderw@inspection.gc.ca

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Je passe à l'action, je règle mon pulvérisateur à rampe. Institut de technologie agroalimentaire de La Pocatière, Stratégie phytosanitaire – St. Lawrence Vision 2000. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, 2002.

Web sites

Pesticides http://www.eddenet.ca

Texts of Canadian legislation http://laws.justice.gc.ca/en/index.html

Canada Wildlife Act http://www.cws-scf.ec.gc.ca/laws_e.cfm

APPENDIX F : RE-ENTRY INTERVALS

The following table provides the re-entry intervals for all pesticides registered for use on cranberries for the 2002 season, as recommended by the Quebec Toxicology Centre [Centre de toxicologie du Québec]. The list is subject to change and certain intervals may be modified. It is important to know the re-entry interval of newly registered pesticides.

Re-entry intervals for pesticides

Pesticide type	Commercial name	Re-entry interval
Herbicides	Casoron	24 hours
	Devrinol	12 hours
	Round Up, Touchdown	12 hours
	Poast Ultra	12 hours
	Lontrel	12 hours
	Herbicide oil	12 hours
	2,4-D	24 hours
Insecticides	Dipel, Bioprotec CAF	12 hours
	Diazinon	Between 12 and 24 hours*
	Sevin	24 hours
	Guthion	48 hours
	Malathion	24 hours
	Imidan	24 hours
	Orthene	24 hours**
Fungicides	Bravo	48 hours***
	Topas (propiconazole base)	24 hours****
	Copper oxychloride	24 hours
	Ferbam	24 hours
	Funginex	12 hours
	Folpan	24 hours

* It is recommended to wait 24 hours before re-entry

** Possibly carcinogenic

*** Risk of dermatitis and severe irritation

**** Possible teratogenic effects

APPENDIX G: UNITS OF MEASUREMENT AND EQUIVALENTS

Length					
1 inch	(in.)	…..	2.54	centimetres	(cm)
1 foot	(ft)	…..	30.48	centimetres	(cm)
1 yard	(yd)	…..	91.44	centimetres	(cm)
1 mile	(m)	…..	1.609	kilometre	(km)
1 arpent		…..	58.52	metres	(m)
1 centimetre	(cm)	…..	0.3937	inches	(in.)
1 metre	(m)	…..	3.2808	feet	(ft)
1 kilometre	(km)	…..	0.6215	miles	(mi)
1 arpent			192	feet	(ft)

Weight					
1 ounce	(oz)	…..	28.349	grams	(g)
1 pound	(lb)	…..	453.592	grams	(g)
1 tonne	(t)	…..	1 000	kilograms	(kg)
1 gram	(g)	…..	0.0353	ounces	(oz)
1 kilogram	(kg)	…..	2.2046	pounds	(lb)

Area					
1 square inch	(in^2)	…..	6.45	square centimetres	(cm^2)
1 square foot	(ft^2)	…..	0.093	square centimetres	(cm^2)
1 square yard	(yd^2)	…..	0.836	square metres	(m^2)
1 acre	(ac)	…..	0.404686	hectare	(ha)
1 hectare	(ha)	…..	10 000	square metres	(m^2)
1 square centimetre	(cm^2)	…..	0.155	square inch	(in^2)
1 square metre	(m^2)	…..	10.752	square feet	(ft^2)
1 acre	(ac)	…..	43 560	square feet	(ft^2)
1 hectare	(ha)	…..	107 593.20	square feet	(ft^2)
1 hectare	(ha)	…..	2.47105	acres	(ac)
1 square metre	(m^2)	…..	1.196	square yards	(yd^2)
1 acre	(ac)	…..	4 840	square yards	(yd^2)
1 hectare	(ha)	…..	11 959.88	square yards	(yd^2)

Temperature (t)					
1 degree Fahrenheit	(°F)	…..	5/9 (t-32)	degees Celsius	
1 degree Celsius	(°C)	…..	t (9/5) +32	degrees Fahrenheit	
Velocity					
1 mile per hour	(mi/h)	…..	1.609	kilometres per hour	(km/h)
1 kilometre per hour	(km/h)	…..	0.621	mile per hour	(m/h)
Volume					
1 fluid ounce	(fl oz)	…..	28.41	millilitres	(mL)
1 US fluid ounce	(US fl oz)	…..	29.57	millilitres	(mL)
1 cup	(c)	…..	250	millilitres	(mL)
1 US pint	(US pt)	…..	0.473	litre	(L)
1 imperial pint	(pt)	…..	0.568	litre	(L)
1 US gallon	(US gal)	…..	3.785	litres	(L)
1 imperial gallon	(gal)	…..	4.546	litres	(L)
1 US barrel	(bbl)	…..	158.98	litres	(L)
1 millilitre	(mL)	…..	0.0352	ounce	(oz)
1 litre	(L)	…..	0.22	gallon	(gal)
1 cup	(L)	…..	8	ounces	(oz)
1 cubic centimetre	(cm³)	…..	1	millilitre	(mL)
1 cubic metre	(m³)	…..	1,000	litres	(L)
1 US gallon	(US gal)	…..	8	US pints	(US pt)
1 imperial gallon	(gal)	…..	8	imperial pints	(pt)
Units of volume per area					
1 ounce per acre	(oz/ac)	…..	0.0702	litre per hectare	(L/ha)
1 pound per acre	(lb/ac)	…..	1.12	kilograms per hectare	(kg/ha)
1 gallon per acre	(gal/ac)	…..	11.23	litres per hectare	(L/ha)
1 litre per hectare	(L/ha)	…..	14.25	ounces per acre	(oz/ac)
1 kilogram per hectare	(kg/ha)	…..	0.893	pound per acre	(lb/ac)
1 litre per hectare	(L/ha)	…..	0.089	gallon per acre	(gal/ac)

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Barrette, Evelyne	Ministère de l'Environnement, Québec, Que.
Bernier, Danielle	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec, Que.
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Coady, Juanita	Department of Forest Resources and Agrifoods, Corner Brook, Nfld.
Coombes, Janet	Agriculture and Agri-Food Canada, St. John's, Nfld.
Delbridge, Rick	Delbridge Disease Management, Kentville, N.S.
Desjardins, France	Ministère de l'Environnement, Québec, Que.
Desrosiers, Richard	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec, Que.
Dittl, Tim	Ocean Spray Cranberries Inc., Babcock, WI
Dixon, Peggy	Agriculture and Agri-Food Canada, St. John's, Nfld.
Drolet, Jacques	Health Canada – Pest Management Regulatory Agency, Ottawa, Ont.
Duval, Mélissa	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec, Que.
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Fréchette, Mario	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec, Que.
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Gobeil, Jacques	Canneberges Bieler Inc., Manseau, Que.
Guay, Louise	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec, Que.
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Henderson, Deborah	E.S. Cropconsult Ltd., Vancouver, B.C.
Iraqi, Driss	Canadian Food Inspection Agency, Que.
Johnston, Blake	Nova Scotia Cranberry Growers Association, Laurencetown, N.S.
Jordan, Chris	Agriculture and Forestry, Montague, P.E.I.
Lacroix, Michel	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Sainte-Foy, Que.
Letendre, Michel	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Sainte-Foy, Que.
Lynch, Kelvin	Agriculture, Fisheries and Aquaculture, Fredericton, N.B.
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Mahr, Daniel	University of Wisconsin, Madison, WI
Maund, Chris	Agriculture, Fisheries and Aquaculture, Fredericton, N.B.
McCully, Kevin	Agriculture, Fisheries and Aquaculture, Fredericton, N.B.
McNeil, Jeremy	Laval University, Québec, Que.

Parrot, Marc	Maison des insectes, Québec, Que.
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Roy, Michèle	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec, Que.
Ryan, Karen	Department of Environment and Labour, Nfld.
Sandler, Hilary	Cranberry Experiment Station, Univ. of Massachusetts, East Wareham, MA
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GLOSSARY

n. = noun **vb = verb** **adj. = adjective**

Annual: (n. and adj.) a plant that completes its life cycle in a single year.

Anther: (n.) terminal pollen-bearing portion of the stamen, the male organ of flowers.

Ascospore: (n.) sexual spore borne in an ascus.

Ascus: (n.) in some fungi, sexual reproduction organ in which spores are produced.

Asymptomatic: (adj.) said of a disease that exhibits no symptoms.

Bacterium: (n.) unicellular micro-organism, generally without chlorophyll, which reproduces by simple division.

Bee bread: (n.) food of worker bee larvae over three days old, composed of honey, pollen and secretions.

Biennial: (n. and adj.) a plant with a two-year development cycle.

Biodegradation: (n.) relatively rapid decomposition of certain substances (e.g., organic matter) due to the action of live organisms.

Biopesticide: (n.) pesticide of bacterial origin used to destroy certain insects and poses no risk to the environment.

Broad spectrum: (adj.) said of a non-selective pesticide that can be used against a large number of species.

Carpophore: (n.) fungal reproductive organ or aerial part in fungi.

Caste: (n.) a segment of an animal population (e.g., bees), generally asexual, that carry out specialized functions (supply, defence, etc.).

Chlorophyll: (n.) complex organic substance that gives plants their green colour and which plays a major role in photosynthesis.

Collar: (n.) transition between the root and stem in vascular plants.

Conidium: (n.) small asexual fungal spore.

Cotyledon: (n.) first leaf of the embryonic plant within the seed.

Cuticle: (n.) thin resistant layer secreted by the epidermal cells of plants.

Dicotyledon: (n.) plant whose seeds contain an embryonic plant with two cotyledons.

Drone: (n.) male bee.

Earwig: (n.) insect.

Economic threshold (n.) population level at which an organism becomes a pest and the use of pesticides becomes cost-effective.

Elytron: (n.) hard, rigid front wing of certain insects that are not used in flight but serve only to protect the membranous posterior wing when the insect is at rest.

Entomopathogenic: (adj.) producing disease in insects.

Entomophagous: (adj.) feeding on insects.

Flower bud: (n.) plant organ containing a flower.

Fungus: (n.) cryptogamous plant without flowers and chlorophyll.

Grass: (n.) monocotyledonous herbaceous plant, with minuscule flowers in spikes, and fruit in the form of seeds.

Hermaphroditism: (n.) presence of male and female sexual organs in one organism.

Honeydew: (n.) a sweet substance excreted by some plant parasites, such as aphids and gathered by bees to make honey.

Host: (n.) a plant or animal affording subsistence or lodgement to a parasite.

Inflorescence: (n.) arrangement of flowers on the plant.

Leaf blade: (n.) broad part of a leaf, sepal or petal.

Ligule: (n.) in grasses, a small membranous extension arising from the junction of the sheath with the leaf blade.

Maggot: (n.) the larva of various insects.

Mating flight: (n.) in bees, flight of the young queen during which she mates.

Monocotyledon: (n.) a plant whose seeds contain an embryonic plant with a single cotyledon.

Mycelium: (n.) underground portion of a fungus, generally composed of white microscopic filaments.

Naiad: (n.) nymph of certain groups of insects, found in rivers and streams.

Nectar: (n.) sweet watery secretion, more or less viscous, rich in sugars, produced by the nectaries of plants.

Nectary: (n.) gland at the base of various plant organs (leaf, ovary, stamen), secreting nectar.

Nematode: (n.) microscope cylindrical roundworm that lives in the soil; some species are parasites of animals or plants.

Overwinter: (vb) to spend the winter in a lethargic state, due to a drop in body temperature.

Ovipositor: (n.) in the females of some insect species, egg-laying structure located at the end of the abdomen.

Parasite: (n.) organism that lives in or on another living organism, called a host.

Parasitoid: (n.) organism that lives exclusively on another living organisms for only part of its existence.

Pathogen: (adj.) an agent capable of inducing disease.

Perennial: (n. and adj.) a plant that grows and flowers for several years.

Perithecium: (n.) in some fungi, flask-shaped organ containing asci.

Pest: (n.) animal causing damage to crops and forests.

Pesticide: (n.) substance or preparation used for control of plant or animal pests.

Pesticide formulation: (n.) ready-to-use liquid for spraying or soaking, which contains the pesticides to be applied.

pH: (n.) measure of the degree of acidity or alkalinity of a solution or soil.

Phenology: (n.) scientific study of the impact of time and climate on the animal or plant developmental stages.

Pheromone: (n.) chemical substance produced by animals which, when secreted in the environment, has an effect on the behaviour of other individuals of the same species.

Photosynthesis: (n.) in green plants and some bacteria, process of manufacturing organic matter from water and carbon dioxide from the atmosphere, using light as a source of energy, with simultaneous liberation of oxygen.

Phylogenesis: (n.) evolutionary history of a plant or animal species.

Pistil: (n.) female structure of a flower composed of stigma, style and ovary.

Pollen: (n.) mass of microspores, generally yellow in colour, produced by the anthers of stamens of a seed plant.

Pollen basket: (n.) in worker bees, organ for carrying pollen located on the outside of the tibiae of the third pair of legs.

Polyphagous: (adj.) organism that feeds of many different kinds of plants or animals.

Predator: (n.) organism that, throughout its life, kills and consumes animals, called prey.

Propolization: (n.) action of close up cracks in hives with a resinous material that bees collect from bark and buds.

Pteridophyte: (n.) a vascular plant that does not reproduce by means of flowers or seeds.

Pupa: (n.) in some insects, inactive resting stage between larval and adult stages.

Pycnidium: (n.) asexual fungal fruiting body that produce conidia.

Registration: (n.) action of officially recognizing something as being in compliance with the regulations.

Resistance: (n.) property of an organism to survive despite a generally effective treatment.

Rhizome: (n.) underground perennial stem that produces adventitious roots and aerial stems every year.

Royal jelly: (n.) a whitish liquid secreted by worker bees, used to feed the larvae and young queens.

Runner: (n.) Thin stem with nodes which arises from the base of a main stem, which runs along the surface of the soil and which roots at the nodes.

Sheath: (n.) widened base by which the petiole of a leaf is attached to the stem.

Spike: (n.) an inflorescence in which flowers without peduncles are sessile on a main axis.

Spikelet: (n.) secondary spike which, when packed close together, form a spike.

Spore: (n.) reproductive body produced by plants which, after dispersal, is capable of producing a new individual.

Stamen: (n.) male sexual organ of a flower, composed of the anther and filament.

Stigma: (n.) in botany, terminal portion of a pistil on which pollen grains germinate.

Style: (n.) a small cylindrical projection that bears the stigma.

Swarm: (n.) the aggregate of worker bees and queens that leaves the parent colony.

Terminal bud: (n.) bud located at the end of a stem.

Tetrad: (n.) group of four pollen grains derived from one pollen mother cell.

Tiller: (n.) shoot characteristic of grasses which, after development of the main stem, emerges at the axil of the leaves at the base of the plant.

Vein: (n.) any of the vascular bundles which form the framework of fibrous tissue of a leaf.

Virus: (n.) micro-organism parasitizing animal and plant cells.

Water table: (n.) a body of ground water filling the interstices of a porous and permeable zone (aquifer) and overlying an impermeable layer.

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