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Organic Apple Production Guide for Atlantic Canada

Edited by: G. Braun and B. Craig

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Organic Apple Production Guide for Atlantic Canada

Edited by

Gordon Braun, Tree Fruit Pathologist
Agriculture and Agri-Food Canada
Atlantic Food and Horticulture Research Centre
32 Main Street, Kentville, Nova Scotia B4N 1J5

Bill Craig, Horticulturalist
AgraPoint International Inc.
10 Webster St., Suite 210, Town Square
Kentville, Nova Scotia B4N 1H7

Contributors

Robert F. Smith, Entomologist
John M. Hardman, Entomologist
Charles G. Embree, Plant Physiologist
Agriculture and Agri-Food Canada
Atlantic Food and Horticulture Research Centre

Graphic design and page layout

Erin Cadieu, Graphic Designer
Agriculture and Agri-Food Canada
Science Publishing and Creative Services
Science Strategy and Outreach
Saskatoon, Saskatchewan

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Organic Apple Production Guide for Atlantic Canada

This third edition of the guide is designed to assist growers who wish to experiment with organic apple production. The material in this guide has been collected from numerous different sources and different countries. Many of the suggested management strategies have not been tested outside of their area of origin. Growers are cautioned to attempt this strategy on a small orchard block before attempting to use this strategy in a large scale system. Producers wishing to become certified growers will need to review the Canadian Organic Production Systems Standards to determine what practices and products fit within a certification program. These standards can be obtained from the Organic Agricultural Centre of Canada (www.organicagcentre.ca/std_canadian.html).

As mentioned in the previous paragraph this guide recommends an entire system of apple production management. It must be recognized that every factor has an effect on all other factors in a living system. It is impossible to predict with any certainty what effect a change in one factor may have on all the others. However, it is logical to assume that a dramatic reduction in pesticide (insecticide, fungicide, herbicide) use will change the kinds and numbers of organisms and their inter-relationships in the orchard. This means that insect predators and parasites may increase in number and become more effective but it also means that insects and diseases which were only minor problems before may become more serious. The recommendations are made on the best information available to the authors at the time of writing. It may take several years for a stable new orchard ecosystem to develop and because the orchard ecosystem is so complex each grower's orchard could respond differently to the same management practices. Therefore, it may require some ingenuity or imagination on the part of the grower to alter their management strategies to suit their particular situation.

One of the most significant changes in this systems approach to organic apple production is that it will require an increased involvement of the grower or the hiring of an outside business to monitor pest and disease levels. This guide like the guides for Integrated Pest Management (IPM) or Integrated Fruit Production (IFP) recommends pest control practices only in response to a threat which has a significant economic or environmental impact.

While the main body of this guide provides the specific information required for a management strategy Appendices have been included which may provide help on how to carry out some of the suggested practices. There are also a large number of Federal and Provincial publications which are directly useful or can be adapted for use in an organic management system. Please consult the appropriate agricultural resource centres in your province for apple production recommendations specific to your province.

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Organic Production and Management Suggestions

Plant Diseases

There are only a few diseases in Atlantic Canada that could be considered major disease problems. Apple scab is the most serious threat to economic viability. The cool wet spring climate in Atlantic Canada is ideal for this disease and left untreated can cause a total loss of marketable fruit. Apple replant disease is a less severe threat, however, when old orchards are replanted this soil borne disease complex can cause lost productivity for the first five or more years of its life. With the high cost of orchard establishment it is essential for growers to begin receiving a return on their investment in the second or third year of growth. Trees that are stunted and unproductive because of apple replant disease may recover but never catch up to healthy trees. Fire blight has not been a significant problem in the past, however, it is spreading rapidly and poses a real threat if average spring temperatures should increase.

The remaining diseases are of a lesser concern for various reasons. Apple trees can tolerate moderate levels of powdery mildew without significant crop loss. The humid, hot conditions in which mildew thrives have not been common in Atlantic Canada in the past. However, if average temperatures increase powdery mildew may one day become a serious disease. Cankers tend to grow slowly leaving time to deal with the problem before losses occur. Some of the fruit rot and foliar disease developing in the summer may not have been a problem in conventional orchards because broad-spectrum fungicides maintained control of these diseases. As organic growers attempt to reduce or eliminate copper and sulfur sprays for apple scab control these secondary disease may become a greater problem.

Major Diseases

Apple Replant Disease

Replant affected tree (right)

Replant affected roots (right)

Biology

Apple replant disease is characterized by very slow growth of apple trees planted in the same spot where apple trees had previously grown. The disease is particularly severe in light sandy soils. The cause of this disease is still under investigation but the primary causes appear to be several fungi, Cylindrocarpon species, Pythium species, and possibly Rhizoctonia. Parasitic nematodes and nutritional factors may also play a part in this complex disease. These fungi cause the decay of the outer covering (cortex) of fine feeder roots that are required to absorb nutrients from the soil. Replant affected trees grow poorly and produce few fruit and may have a purple hue to their foliage which is a symptom of phosphorus deficiency. Trees rarely die from replant disease and frequently recover after 5 or 6 years, however, they never catch up in size or productivity to trees planted in the same location that do not have apple replant disease.

Control

When replanting an old orchard site, take the time to carefully prepare the soil. Remove the old tree stumps and as many roots as possible. Adjust the soil pH and nutrient levels to those recommended for apple production. Plant a green manure crop to increase soil organic matter content and to smother weeds. If at all possible plant the rows of new trees midway between the old tree rows.

When replanting individual trees in old tree sites, remove the old soil from the planting hole and replace it with fresh soil high in organic matter, compost or peat moss. This has been shown to be effective in some locations.

Apple Scab *(Venturia inaequalis)*

Apple scab on fruit

Apple scab on leaves

Biology

Apple scab is a fungal disease that is the greatest challenge to apple production in Eastern Canada. Apple scab has two different life stages, a sexual reproduction stage and an asexual stage. The sexual stage takes place in the spring on fallen apple leaves that were infected with scab the previous year. Sexual spores, called ascospores are produced in microscopic fungal fruiting bodies on last year's apple leaves. Once mature, ascospores are forcibly ejected into the air whenever sufficient rainfall (0.25 mm or 1/100 of an inch) wets the old leaves on the orchard floor. The majority of spores are released in the daylight. Spores ejected into the air are picked up by wind currents and can be carried several kilometers, however, 90% or more of the ascospores will remain in the orchard where they were produced. Ascospores are usually mature by the time apple buds reach the green tip stage and continue to be produced until calyx. Ascospores are not produced in equal numbers throughout this period. The first spore releases in early spring generally yield fewer spores with the numbers increasing as the season approaches bloom after which the numbers begin to drop-off. This pattern of ascospore production very nearly follows the same trend in susceptible foliage production and risk of infection. Early in the season fewer ascospores are produced and there is little surface area of susceptible green tissue exposed thus limiting the risk of an ascospore infection. However, as the season approaches bloom the trees are producing the greatest amount of new susceptible green tissue and the apple scab fungus is producing the largest numbers of ascospores, thus dramatically increasing the risk of infection between tight cluster and petal fall.

In order for ascospores to successfully infect apple tissues they require the presence of water, suitable temperatures and sufficient time to infect. The warmer the temperatures the shorter the wet period required for infection. The relationship between temperature and wetness is given in Appendix A. Ascospores that land on opening buds or young leaves will germinate and grow into the new green tissue to begin the second or asexual part of its life cycle. The length of time required for ascospores to infect, grow and produce mature asexual spores or conidiospores (conidia) ranges from 7 to 19 days and depends primarily on the temperature. Again, warmer temperatures require fewer days for disease development.

The conidia are produced in lesions that develop on the leaves and fruit. The first symptoms of scab lesion development are slightly darker green spots developing on leaves often easiest seen from below with the sunlight passing through the leaf from above. Eventually the lesions become olive-brown to brown in colour with an indistinct margin. The surface may appear velvety. This is the result of the thousands of spores produced on the surface of each scab lesion. The spores remain firmly attached to the leaf until they are released by rain. The spores can then drip down on to fresh leaves or developing fruit or be splashed by rain drops to more distant leaves and fruit. As with ascospores these asexual spores require a specific temperature and length of wet period to cause infection. Ascospore and conidiospore infection conditions are nearly identical and the table in Appendix A can be used to predict the occurrence of asexual infections as well. But unlike ascospores, conidiospores can be released both day and night. Fresh conidiospores are continually produced from these lesions throughout the summer resulting in the release of thousands of spores from every lesion. If conidia are not controlled, they greatly magnify the amount of scab in an orchard in a very short period of time. Scab lesions on young fruit will cause the fruit to become misshapen and even cracked. The surface

becomes black and corky giving the scab like appearance after which the disease was named. The 'scabs' also produce large numbers of conidiospores. Infections on the fruit occurring later in the season develop small 'pinpoint' scab lesions often appearing after the fruit have been in storage for a number of months. Scab lesions reduce the quality of the fruit and too much scab may make the fruit not saleable even for juice. Scabby leaves fall to the ground and it is in these leaves that the disease survives the winter to produce ascospores in the following spring, thus completing the fungus' life cycle.

Control

Successful organic apple production with scab susceptible apple cultivars is difficult. There are few control strategies in an organic production system that can provide adequate disease control in years when conditions are conducive to severe disease attacks. The best defense against apple scab is scab resistant apple cultivars. The use of scab resistant apple varieties in a reduced pesticide management or organic system has been tried here in Nova Scotia for more than 10 years. For a partial list of scab resistant cultivars and their qualities see Appendix B and C. However, scab resistant cultivars may be more difficult to market because they are not familiar to consumers. Conventional cultivars such as Honeycrisp, Idared, Northern Spy and Red Delicious are less susceptible to scab than McIntosh and may be considered for planting in areas where scab is not severe.

The first line of defense for scab susceptible cultivars should be reducing sources of over wintering disease. Since the scab fungus survives the winter in fallen leaves, practices that remove or decompose fallen leaves will reduce the source of ascospores in the spring. Mowing the orchard floor with flail mowers after leaf drop has been shown to speed up the breakdown of fallen leaves. Mowers must be able to reach under and around trees as well as along the boundaries of the orchard where wind blown leaves catch in the long grass. Removing wild apple trees from the borders of the orchard is one step that would reduce scab spore levels and will help with insect pest control. Earthworms will also consume fallen apple leaves by first dragging them down their burrows from where the leaves no longer pose a threat of scab. Increasing the soil organic matter will encourage earthworm activity. The second line of defense is keeping the amount of scab on leaves as low as possible. Scab susceptible cultivars may require the application of spray material acceptable to the *Canadian Organic Production Systems General Principles and Management Standards* (CAN\CGSB-32.310-2006) and the *Organic Production Systems Permitted Substances Lists* (CAN\CGSB-32.311-2006) and newer versions as they are updated over time. At the time of writing this publication only sulfur, lime sulfur and copper were effective and permitted, with some restrictions, for use against apple scab. These fungicide applications should be targeted to control apple scab during the ascospore phase of the disease with special attention given to the period of highest risk of infection, tight cluster to petal fall. Spray equipment must be properly calibrated and set up to give complete coverage of all the foliage and particularly the center top of larger trees. Scab lesions in the tops of trees can become established out of view of the grower and shower spores down on all the foliage and fruit in the tree with each rainfall. If excellent scab control is obtained during the ascospore phase of the disease no further control of scab may be required in the secondary scab phase of the season. However, if scab lesions are evident on leaves, fungicide applications to protect the fruit from infection will be required whenever wet weather threatens.

Sulfur

If scab was prevalent on leaves last year, sulfur applications may be required at weekly intervals beginning at bud break when the first green tissues appear until calyx. Sulfur is a protectant fungicide and must be present on susceptible tissue before the arrival of the scab spores. It is re-distributed to some extent and therefore good coverage of tree tops may permit movement of sulfur to new emerging tissues or expanding leaves between applications. Heavy rainfalls (>2.5 cm) may wash off much of the sulfur requiring immediate re-application. It is important to monitor infection periods using a thermometer and the modified Mills Table provided in Appendix A. If an infection is predicted by the Mills Table to occur before the rain stops or before the foliage is dry it may be necessary to spray in the rain or on wet foliage. Do not apply sulfur in bright sunlight, when temperatures exceed 27°C and the relative humidity is expected to remain high, before a night frost or within 30 days of a dormant oil or a Bordeaux spray application that contained oil. Under these conditions sulfur may cause a toxic response on leaves or fruit. Be certain to read the label on the sulfur package carefully and follow the directions. Also, some people develop an allergic skin reaction to sulfur. Sulfur should be used only when necessary to maintain disease control. Sulfur will also provide powdery mildew, cedar (juniper) apple rust and some fruit rot control.

Lime-Sulfur

Lime-sulfur is reported to have some post-infection activity. If lime-sulfur at the rate of 20 L/1000 L water

is applied to dry foliage within 60 - 70 hours of the beginning of an infection period, scab lesions may be prevented from developing. However, there is a serious possibility that injury to the fruit and/or foliage may result. McIntosh is especially sensitive to injury by applications of lime-sulfur around petal-fall. If scab lesions do develop they may be prevented from producing conidia by another application of lime-sulfur. Only those sporulating lesions that are coated with lime-sulfur will be eradicated. As a protectant fungicide lime-sulfur is not superior to sulfur. Lime-sulfur may also have some activity against powdery mildew. For mildew control apply sprays at early pink, calyx and first cover. To avoid burning the foliage, do not apply lime-sulfur on wet foliage. Lime sulfur applied during the bloom period can have thinning activity that could be of benefit when the trees have a full bloom.

Copper or Bordeaux Mixture

Copper formulations are an effective control for apple scab and can be used for this purpose if this usage appears on the label. Copper persists on plant tissues for a long time even following rain. However, copper applied during bloom or later can cause russeting of the fruit finish. Fruit russeting reduces the quality and increases moisture loss of apples in storage. If applied near bloom, fruit russeting by copper can be limited by applying only when rapid drying conditions prevail. A Bordeaux mixture of 10 kg copper sulfate, 10 kg of lime and 1000 L of water plus 20 L of Superior oil® (70 second) may be applied as a dormant spray up to 1 cm green tissue for early scab and European red mite control. Hydrated lime is difficult to get into solution without forming lumps that will plug up a sprayer. Hydrated lime should be added to the spray tank by washing it through a screen with plenty of water. Sprayer agitation is required to keep the lime in suspension. If applications of copper (2 kg copper sulphate, 5 kg hydrated lime, 1000 litres of water per hectare) are made after 1 cm green they should not include oil since it is incompatible with sulfur which may be applied later for disease control. Also, some evidence exists suggesting that copper may be toxic to earthworms and therefore copper applications should be used wisely.

Copper induced russet

Fire Blight *(Erwinia amylovora)*

Shepherd's crook

Fire blight canker

Biology

Fire blight is a bacterial disease of the blossoms and tender new shoots of apple and pear. Fire blight usually appears in late June or early July in eastern Canada. The bacteria survive the winter in bark cankers that can develop on everything from small twigs to older scaffold limbs. As the temperatures warm in spring the bacteria in cankers become active and can occasionally be seen as a milky or orange coloured ooze coming from the canker margins. The fire blight bacteria also move within the cankered branch or limb infecting nearby shoots that may also produce bacterial ooze. This fluid is filled with bacteria and is attractive to flies and ants. Flies and ants feeding on the ooze picking up the bacteria on their feet and mouth parts and can transmit the bacteria to open flowers if they next feed on nectar or pollen. While cool spring temperatures in much of eastern Canada may inhibit blossom infections during the peak of bloom, blossoms that appear after the main flush of flowers (rat tail bloom) or from extended bloom periods caused by cool weather may be at risk of infection. The early symptoms of blossom infection are a water soaked appearance and the discharge of a milky or orange colored ooze on the blossom or the blossom stem. Bees and other insects visiting blossoms can transmit the bacteria to other blossoms

spreading the disease throughout the orchard. Insects that feed by stinging plant tissues such as the White Apple Leafhopper (WALH) and the Tarnished Plant Bug (TPB) also transport bacteria on their mouthparts and can infect flowers or tender green terminals. In addition, wind storms or hail can cause cracks and wounds in leaves and fruit that are readily infected by the fire blight bacteria. The early symptoms of shoot infection are the wilting of branch terminals and leaves. The ends of the branches bend over like a shepherd's crook and the leaves turn brown beginning at the petiole up to the tip but remain firmly attached to the terminal. Eventually the shoot terminal becomes brown to black in colour, shriveled and dry. Young fruitlets on infected terminals may become infected through the stem and turn brown, shrivel and remain firmly attached to the tree. Bacterial ooze is best observed in the morning before the dew on the leaves has dried. Severe infections may result in large limb cankers that may serve as a source of bacteria for several years if not removed.

Control

Fire blight cankers are preferably removed during the dormant period. Cankers can be removed by cutting branches or limbs 10 cm below the edge of the canker in late winter or 30 cm below the canker in summer. Winter pruning for fire blight cankers will require several passes through the orchard because it is impossible to spot all the cankers the first time. A dormant application of 10 kg copper sulfate, 10 kg hydrated lime and 1000 L water plus 20 L of Superior oil (70 second), called a Bordeaux mixture, made before the one-half inch (1.27 cm) green stage may reduce fire blight bacterial populations.

Summer pruning can be done if branch tip wilting or black scorched leaf symptoms appear. Prune out infected branches as soon as the symptoms are seen to prevent the bacteria from becoming established in cankers and also becoming a source of more bacteria for additional spread of the disease. Pruning during the growing season should always be done when the foliage is dry to prevent spreading bacterial ooze while remove the infected plant material. Also, remove suckers or watersprouts because they are very susceptible to infection. Prune during dry weather to reduce the risk of spreading the disease. Disinfect pruning tools periodically during the day, prior to moving into a new orchard block and at the end of each day. Dip pruning tools into a solution of household bleach (1 part bleach, 9 parts water) or into 70% alcohol and soak for several minutes. These solutions are corrosive, thus pruning tools should be oiled on a regular bases to protect them. It has been suggested that when pruning out fire blight in the growing season it is best to a leave a stub and not make a flush cut with older wood. Then during winter pruning these stubs can be cut-off flush. This is insurance against shears that were not sterile or the wound becoming re-infected. The re-infected stub can then be cut away when the bacteria are inactive. Pruning shears used to remove fire blight cankers should be thoroughly scrubbed with disinfectant before being used for other purposes.

Biological control agents such as BloomTime® and BlightBan C9-1® have recently been registered for use in Canada. These biological control bacteria compete with the fire blight bacteria for nutrients and space on susceptible blossoms. Therefore, they must be applied 3 to 4 days before fire blight infections occur. They are recommended to be applied at 20 percent bloom and then again at 80 to100 percent bloom for maximum effectiveness. In addition there are products being tested that stimulate the tree's natural defense mechanisms. Consult the *Organic Production Systems Permitted Substances Lists* (CAN\CGSB-32.311-2006) and its updated versions periodically for the latest developments in control products. In addition there are at least two popular fire blight prediction programs which have been widely used for a number of years, MaryBlyt© developed by Paul Steiner and Gary Lightner at the University of Maryland and Cougarblight developed by Timothy Smith at Washington State University. Both can assist growers in determining the risks of fire blight infection. This information may be useful in deciding when to apply a biological control agent to protect blossoms from infection. Fire blight prediction models are available from various sources that can be determined by an internet search.

It is also important to avoid the production of excessive green succulent growth due to heavy pruning or excessive nitrogen application. Green succulent growth is favoured by stinging insects that may carry fire blight bacteria and the succulent growth is also very susceptible to fire blight infection. However, excessive nitrogen applications and excessive tree vigor are rarely a problem in organic orchards.

Minor Diseases

Bitter Rot, Ripe Spot and Bull's-eye Rot

Gloeosporium bull's-eye rot

Biology

These fungal fruit rots are caused by spores from Gloeosporium or Glomerella cankers or infected apple fruit. Infections on fruit produce circular, sunken brown lesions. Within these brown lesions circular rings of tan-coloured fruiting bodies form giving a bull's-eye appearance. These fruiting bodies sometimes exude masses of creamy, pink to salmon-coloured spores. Cutting through the lesion shows that the rot penetrates into the flesh in a "V" shaped cone towards the core. Most infected fruit will fall to the ground. However, some fruit remain attached to the tree and form a "mummy" which can be a source of disease next year. Fruit infections occurring late in the season may not develop until the fruit has been in storage or even until after the fruit is removed from storage and held at room temperature for several days.

Control

The disease can be managed by removing fallen apples twice a week, surgically removing cankers and removing mummified fruit while pruning in the winter and early spring. The collection of fallen apples is also recommended for maggot control (see Insect Pests).

Blossom-end Rot *(Sclerotinia sclerotiorum)*

Biology

Blossom-end rot is caused by fungal infection of the calyx end of apples around the time of petal fall. The ascospores originate from tiny funnel shape mushrooms (apothecia) produced from hard black fungal survival structures (sclerotia) on the orchard floor. These sclerotia were likely produced from fungus infected weeds such as dandelion or clover or from fallen infected apples from the previous year. These apothecia are produced in response to temperatures of 11-15°C and several days of wet soil around bloom time. Infections occur at the time of flowering and are centered on the blossom end of the apple. Infected fruit develop brown watery rots at the calyx end of the fruit just a few weeks before harvest and may drop to the orchard floor before harvest.

Control

It is not known if sulfur applied at bloom will prevent infection. In some crops it has been shown that dandelions are a source of Sclerotinia diseases. Good weed control and orchard floor management and the removal of infected fruit from the orchard may have some impact on the severity of the disease.

Cedar (Juniper) Apple Rust *(Gymnosporangium juniperi-virginianae)*

Biology

This is another unusual fungal disease of apple not common in Nova Scotia but found in other provinces in eastern Canada where *Juniperus* species (eastern red cedar) are still found. This fungus has four different phases and requires two different hosts to complete its life cycle. Two spore phases occur on cedar and the other two on apple, hawthorn, mountain ash or other rosaceous species of plants. The fungus overwinters on *Juniperus* species and produces galls in the spring. These galls exude jelly like horns in wet weather that produce one kind of spore (teliospore). The spores germinate to produce a second spore type (basidiospore) which are carried by the wind and are responsible for infecting apple and related plant species. Young leaves and blossoms around petal fall are most susceptible to infection. After several weeks, yellow lesions appear on the upper sides of leaves and on fruit containing fruiting bodies bearing small spores (pycniospores). One to two months later spore bearing, cup-like structures (aecia) are formed on the undersides of infected leaves or on apples. These spores (aeciospores) infect red cedar twigs in the fall completing the life cycle of this unusual organism.

Control

The effect of sulfur or copper on this fungus is not known. However, Delicious, McIntosh and Liberty are resistant to cedar apple rust while Golden Delicious, Jonathan, Rome Beauty and Prima are very susceptible to this fungus. Removal of *Juniperus* species in the vicinity of apple orchards will reduce the amount of spores reaching an orchard.

Collar and Crown Rots *(Phytophthora cactorum)*

Biology

The Phytophthoras are not like traditional fungi because they have spores that swim. Rotting of the bark and girdling of trees at the soil line and the upper parts of the roots is called crown rot while rotting of the bark above the graft union is called collar rot and both can be caused by *Phytophthora cactorum*. The disease is most common in orchards with poorly drained soils. Infected trees are slow growing with sparse foliage. Additional symptoms of crown and collar rot are purpling of the foliage in late summer and soft, rotting bark between the scaffold limbs and the roots where they attach to the crown. Rotting bark is loose and when removed reveals an orange to brown coloured inner bark. Infected trees generally decline slowly over several years and eventually die though in very wet seasons some trees may collapse and die in one season.

Control

Draining wet soils before planting should be the first consideration, or at a minimum planting on soil ridges high enough to keep the crown and upper roots of the tree out of the wet soils. Drain areas where water pools in the spring and after heavy rains. Wet soil can be removed from around the trunk and upper roots of infected trees and all the diseased bark cut away and the planting hole backfilled with gravel to improve water drainage. Trees planted in wet soil should not have mulch placed close to the trunk as it may prevent the bark from drying. Plant trees that have collar rot resistant rootstocks and avoid the use of susceptible rootstocks such as MM 106. Carefully control nitrogen applications to avoid soft and luxuriant growth. Remove tight fitting mouse guards from trees in the spring to prevent the bark behind guards from remaining wet for long periods of time. Recent research has shown that phosphite fungicides have been shown to prevent diseases caused by this family of fungi and may soon be registered for use in Canada. Periodically check updates to the *Canadian Organic Production Systems General Principles and Management Standards* (CAN\CGSB-32.310-2006) and the *Organic Production Systems Permitted Substances Lists* (CAN\CGSB-32.311-2006) for newly registered products.

Frog-eye Leaf Spot *(Physalospora obtusa)*

Frog-eye leaf spot on leaves and on fruit

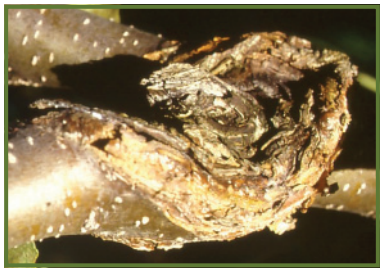
Biology

Frog-eye leaf spot, a fungal disease, is recognized by the distinctive spots occurring on leaves a few weeks after petal fall. The spots are initially purple but as they enlarge the center becomes tan coloured with a red to purple halo giving the frog-eye appearance. Leaves with multiple infections may turn yellow and drop prematurely. In severe disease situations, frog-eye leaf spot has been known to completely defoliate a tree by mid-summer, though this is rare in eastern Canada. Fruit infections and cankers also occur but are hard to distinguish from other fruit rots and bark cankers. Fruit infections appear as red or purple flecks that do not enlarge until the fruit ripens. Expanding lesions develop alternating circles of black and brown. The rotten spots remain firm and some fruit become mummified and remain attached to the tree over winter. Fire blighted twigs and fire blight cankers can be invaded by this pathogen resulting in elongated bark cankers of 0.5 meters or more.

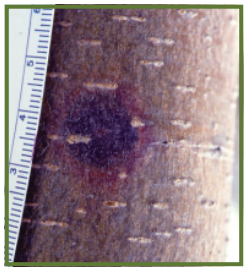
Control

The impact of copper and sulfur sprays on frog-eye leaf spot is not known. The removal of mummified fruit and fire blight cankers as well as other cankers in the winter may help decrease sources of spores in the spring.

Nectria or European Canker *(Nectria galligena)* and Gloeosporium Canker *(Gloeosporium album* or *Neofabraea alba)*



Nectria canker



Gloeosporium canker in early spring

Year old Gloeosporium canker

Biology

Nectria canker is a fungal disease of the bark of apple trees. Both sexual (ascosopores) and asexual spores (conidiospores) are produce on the bark at the margins of the canker. Ascospores are produced in spring and early summer and are forcibly ejected from red fruiting bodies on the cankered bark in response to rain. Conidia are produced in a gelatinous matrix from small cushion-like fruiting bodies on cankered bark and spread by rain splashes. Infections most often occur in the crotches of limbs which remain wet longer after rains than the remainder of the tree. Infections are also common at pruning cuts, broken twigs and leaf scars. Young cankers appear as small sunken areas of bark frequently darker in colour than surrounding bark. If left untreated the cankers continue to expand and the tree responds by producing callus tissue around the margin of the canker in an attempt to stop its progress. In the spring the fungus again begins to grow and enlarges the canker outside of the callus ring. The sunken bark in the center of the canker loosens and falls off. After several years of this repeating pattern of growth, concentric rings of callus tissue produce a bull's-eye appearance in the cankered wood. Nectria cankers, if not treated, will eventually girdle the limb or trunk of a tree causing its death. A number of common native tree species are also infected by *Nectria galligena*; maple, aspen, birch and beech.

Gloeosporium is also a fungal pathogen of apple and can infect healthy bark on the trunk and scaffolds of young trees. Gloeosporium canker infections first appear as purple blotches on the smooth bark of scaffold limbs and the central leader in early spring, although not all of the purple blotches will develop into active cankers. The severity of infection can range from a few scattered lesions to hundreds of lesions on larger limbs and trunks. In the spring and summer, developing cankers become sunken as the soft cambium tissues beneath the bark decay. By fall or the following spring, remnants of bark may still be attached to fibrous strands stretched across the canker to give a "fiddle string" appearance to this disease. Gloeosporium cankers only grow for one year and then stop but the bark attached to these cankers can be a source of spores until it falls away. Cankers can produce spores all year long that are spread by rain, rain splashes and wind driven rain to uninfected trees. Individual cankers are too small to girdle most branches, however, large numbers of cankers can grow together to girdle and kill a limb. Severely infected trees may lose their leaves and appear very weak and sickly. However, these trees can recover if the following years are not suitable for further severe canker infections. Young McIntosh trees are particularly susceptible.

Control

Control of both Nectria and Gloeosporium cankers is possible where infections are light. Individual cankers can be removed or cankered twigs and branches pruned out if it will not permanently disfigure the structure of the tree. Pruning should be done late in the dormant period to avoid wound infection or when the trees are most actively growing and wounds heal quickly. Both of these canker types can be controlled by routine annual inspection of the trees for cankers that can be surgically removed with a knife or specialized chainsaw attachment. Cut away all the

diseased bark and soft tissue around a canker down to the wood and healthy bark. Tight fitting mouse guards may also keep the bark wet longer and provide a favourable environment for Nectria infection and canker development. Spores produced from untreated cankers and spread to fruit can cause fruit rot. Gloeosporium spores cause a fruit rot that develops concentric ring patterns on the sides of the fruit giving it a bull's-eye appearance. For more information on Nectria canker control consult ACC publication 1223, European Canker of Apples.

Powdery Mildew *(Podosphaera leucotricha)*

Mildew on terminal

Biology

Powdery mildew is a fungal disease attacking the foliage and fruit of apple trees. It is an unusual fungus in that it only survives on living apple tissue. The fungus survives the winter in infected buds. Infected buds are more susceptible to freezing temperatures than healthy buds. This may account for buds that do not open in spring after a cold winter. The mildew in some buds may be killed by temperatures below -12°C. Mildew infected buds have a tendency to open later than healthy buds, around tight cluster, and the leaves have an elongated strap like appearance. The mildew spores produced on infected buds will have abundant fresh plant material to infect at this time of the year. Leaves and flower buds only remain susceptible to infection for a few days after they emerge. The peak period for powdery mildew infections is three weeks before to three weeks after bloom. Mildew developing on the young tender terminal leaves appears as a white powdery dust on the surface of the leaves. The white dust is the spores that are easily carried by the wind to newly emerging leaves, starting the disease cycle all over again. Mildew growth is favoured by the hot, humid weather of summer. Infected terminals have leaves that are curled back and from a distance look as if they are being blown by the wind and are quite conspicuous on a calm day. While trees can tolerate some mildew, treatments are necessary if ten or more infected terminals, on average, are found per tree. Infections on fruit produce a net-like russet over the surface of the apple. Developing buds are infected before the bud scales harden and are the source of the disease in the following year.

Control

The primary period to treat trees for powdery mildew infections is from tight cluster until the terminal buds are set. Where mildew is a severe problem, sulfur 90 - 95% WP can be applied at 10 kg/ha at weekly intervals. Follow the directions on the sulfur label carefully. In areas where mildew is an annual problem it is best to avoid growing very susceptible varieties such as Jonathan, Cortland, Idared, and Rome Beauty. The mildew susceptibility of scab resistant apple cultivars may not be known but indications are that Britegold, Freedom, Jonafree, Liberty, Murray, Nova Easygro, Prima, Priscilla, Redfree and Sir Prize are resistant to mildew while Macfree, Novamac and Trent are moderately susceptible and Moira is susceptible (see Appendix B & C). For mildew control with lime-sulfur, reduced spray rates applied at early pink, calyx and first cover may be effective. High rates of lime sulfur at bloom may cause thinning. Follow the label directions carefully. Sodium and potassium carbonate have been demonstrated to provide some control of powdery mildew in other crops and may be registered for use in apple at some point. Consult the *Organic Production Systems Permitted Substances Lists* (CAN\CGSB-32.311-2006) or its updated versions periodically for newly approved substances.

Sooty Blotch *(Gloeodes pomigena)* and Fly Speck *(Microthyriella rubi* or *Zygophiala jamaicensis)*

Sooty blotch

Biology

There is a complex of at least two or more fungal organisms that may become a problem in organic apple orchards that have rarely been a significant problem in

conventionally sprayed orchards. They are sooty blotch (*Gloeodes pomigena*) and fly speck (*Microthyriella rubi* or *Zygophiala jamaicensis*). Since they are rarely a problem in orchards sprayed with traditional fungicides there is little to no experience in managing these diseases. The fungi grow superficially on the waxy cuticle of the fruit. They are primarily an aesthetic problem with apple fruit. Sooty blotch, as its name implies appears as an irregular grey to black spot on the surface of fruit near harvest time and resembles a spot of soot. Sooty mould is known to grow on the sugary exudates of aphids and on leafhopper droppings. Flyspeck appears as generally round patches of varying size containing a few to many tiny shiny black specks resembling fly droppings from which it takes its name. Fly speck is believed to survive on wild raspberries and blackberries frequently found in and around apple orchards in eastern Canada.

Control

A serious problem with sooty blotch may be avoided with careful management of the aphids and leafhoppers both of which are economically important pests of apple. Fly speck severity may be reduced by eliminating brambles from the orchard and surrounding property. Adequate tree spacing and summer pruning that reduces humidity in the tree canopy and promotes rapid drying of fruit after wet periods may reduce the incidence of infection. Sulfur applied on a 14 day schedule will provide some protection from sooty blotch and fly speck. Bordeaux is effective against sooty blotch and fly speck and is registered for use after silver tip and up to 1 day before harvest. However, copper applied at flowering and on developing fruit can cause severe russeting of the fruit finish and discolouration of yellow apples. To minimize russeting and discolouration, only apply Bordeaux to nearly mature red fruit under rapid drying conditions.

Insect and Mite Pests

Insect pests may be classified according to the type of injury they do to the crop, as direct or indirect pests, and to the necessity for control, as key pests, occasional pests, or secondary pests (see Appendix D). Direct pests cause damage to the fruit while indirect pests attack other organs of the plant such as leaves, shoots or roots reducing yield and fruit quality. Key pests are those found in most orchards each year, are not effectively controlled by natural enemies (predators, parasites and diseases), and must be regularly monitored and controlled to prevent significant economic losses. These are also the most difficult to control in an organic management system. Occasional pests are those that rarely cause problems because they are controlled by natural predators, or treatments applied for other pests. Thus these pests only require control in certain years. Secondary pests are those that would be effectively controlled by natural enemies if pesticides were not used. Natural control of these organisms is very important since it is most often the secondary insect pests that have several generations per season and produce large numbers of off-spring and thus are more likely to become resistant to pesticides.

Key Pests

Apple Maggot *(Rhagoletis pomonella)*

Adult flies

Symptoms on fruit

Fruit damage

Biology

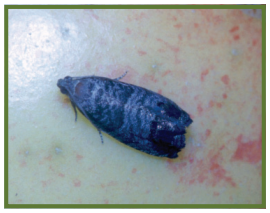
The apple maggot is probably the most serious apple pest because it is very difficult to control particularly for the organic grower. The adult fly is about the size of a house fly with a dark body, red eyes and a white spot in the middle of its back. The dark bands on the wings form an

identifiable "F". The adults emerge in early July from the soil where they overwinter as pupae. About 10 to 14 days later they begin to lay eggs. The eggs are laid just under the skin of the apple fruit and the larvae hatch and mine the fruit often causing it to drop prematurely. The larvae leave the fruit and enter the soil where they pupate to survive the winter. All the pupae do not hatch in the first spring; some remain in the soil until the second or third spring. This is why it may take several years to reduce the effects of a single year with a very large population. The flies are attracted to early sweet apple varieties such as Bough Sweet and Wealthy. Cortland, Gravenstein and Delicious apples are also attractive to apple maggot and these varieties should not be used in the organic orchard. Apple maggots also breed on hawthorn, crabapples and wild apples which should be removed from the vicinity of the orchard if possible. Crabapple cultivars are not desirable for pollinators unless they are maggot resistant.

Control

Apple maggot should be monitored with yellow sticky boards including protein baits or apple volatile lures or with glossy red or black sticky spheres about 7.5 cm in diameter and apple volatile lures. One trap per hectare of orchard should be hung in the trees in early July. A control strategy must be applied when one fly is caught per sticky board or sphere with a protein bait or 5 flies with an apple volatile lure. The registration of Surround®, a kaolin clay based product, provides organic growers with a viable option for controlling codling moth. Surround provides a protective coating on the fruit and foliage which discourages egg laying by adult female maggot flies. Apply Surround WP at a rate of 25 - 50 kg/ha starting in mid July with 3 to 4 applications during the growing season. The higher rate should be used at the start and reduced once a coating has been built up. The amount of rain and wash-off will determine how often Surround needs to be re-applied. Surround may also provide some control of the following orchard pest, tarnished plant bug, obliquebanded leafroller, leafhopper, plum curculio and codling moth. Orchard sanitation is another option that should be practiced even where Surround is used. Conduct a very thorough pick up of all fallen fruit from the orchard twice a week. Fallen fruit should be buried deep, processed or put into cold storage immediately to prevent the maggot from completing its life cycle. Intensive trapping has reduced maggot populations at some locations but can be very costly and time consuming. Between one sticky ball per tree to one sticky ball per every 100 apples may be necessary depending on the size of local maggot populations. If the orchard itself is kept clean it may be possible to limit traps only to the perimeter of the orchard to intercept flies coming into the orchard from outside. Apple maggots do have some natural enemies but complete control with these parasites and predators has not been demonstrated. Among observed parasites are *Opius melleus*, *Patasson conotracheli*, and *Boisteres rhagoletis*. There is also a spider, *Dendryphantes militaris* the common jumping spider, in Nova Scotia which captures flies as they rest on leaves. As the pesticide load in orchards is reduced the presence and efficacy of parasites and predators may improve. In the future there may be scab resistant apple varieties which are also resistant to apple maggot.

Codling Moth *(Cydia pomonella)*



Adult moth

Larval stage

Fruit damage

Biology

This is one of the two most serious insect pests of apple. Codling moths will also feed on pears, crabapples, quince, hawthorn, and walnut. The adult moth is nearly 8 mm long with a wing span of almost 18 mm. When it is not flying the wings are folded along the body. The forewings are grey brown with wavy crossbands of lighter gray and areas of deep gold and bronze. The moth overwinters as

a larva in a cocoon under rough bark on the tree trunk near the ground. The first adults appear at about petal fall (early June) and continue to emerge over several weeks. Eggs are laid between sundown and about 2200 hours when the temperature is above 16°C. The eggs hatch after several weeks and the larvae burrow into the developing apple. Damage to apples consists of stings, the result of shallow feeding which causes a pit in the fruit surface, or deep feeding, which is a tunnel to the core and is distinguished by the large amount of brown frass (insect excrement) at the entrance.

Control

Using pheromone traps (wing type traps only) is essential for good codling moth control. Sex-pheromone traps with lures (1 mg pheromone) should be placed on the windward side of the orchard with at least 1 trap per 1 ha block. This allows the pheromone to be wafted through the orchard block by prevailing winds. Traps should be hung at eye-level on the inside of the tree and captured moths should be counted twice a week and the traps cleaned. A total count (cumulative count) of 40 moths per trap means economic injury will occur if controls are not applied (see Appendix E for thresholds). The use of pheromone for mating disruption is a viable option for controlling low to moderate populations of codling moth. Pheromone twist ties (Isomate-plus) should be placed in the orchard following the first moth capture in pheromone traps. Place ties in the upper third of the tree canopy at a rate of 500 to 1,000 ties per hectare. The number of ties per hectare should be based upon pest pressure with in the orchards.

One of the natural parasites of the codling moth are wasps. *Trichogramma* minutum is a wasp which parasitizes codling moth eggs and it is probably the most important parasite. It can be purchased and should be released about 1 week after the first capture of an adult moth in a pheromone trap. If 20 adults have been captured in the trap before the wasps are released it is possible to release other predators such as *Ascogaster quadridentata*, *Macrocentrus ancylivorus*, *M. delicatus* or *Itoplectis conquisitor*. The easiest to apply and least expensive control practice would be the use of *Bacillus thuringiensis* (*B.t.*, Dipel®). It should be applied as soon as 40 male moths are captured and reapplied every 5 days for 4 sprays. Adding skim milk powder to the spray has been shown to enhance larval feeding. A second generation of codling moth, very rare in Nova Scotia, may appear 5 to 6 weeks after egg-laying. Monitoring with fresh lures and additional sprays may be required to avoid second generation damage. To reduce second generation and overwintering codling moths the trunk of the tree can be wrapped with burlap coated with Tanglefoot® or with corrugated cardboard which presents ideal spots for cocoon spinning. The cardboard strips can be burned before the adults emerge (about 2 weeks after the first larvae spin cocoons). Research has shown that woodpeckers can consume a considerable number of overwintering cocoons. Woodpeckers can be encouraged to feed in the orchard by placing a bit of suet on a string suspended from a pole above a couple of trees in the orchard. It is also possible to remove cocoon spinning sites on the trunk by using a piece of chicken wire like a bath towel to remove loose scaly bark. Codling moth control can be significantly improved by removing all wild hosts of codling moth as well as wild or neglected apple trees within 100 meters of the organic orchard.

Winter Moth *(Operophtera brumata)*

Adult wingless female

Larva

Fruit damage

Biology

Mature winter moth larvae are 25 mm long and green with a brown head. They are much more difficult to identify when they are very small because the colours are not well developed and can be confused with pug moth larvae. It is however distinguished from most other caterpillar pests of apple because it is of the "inch-worm or

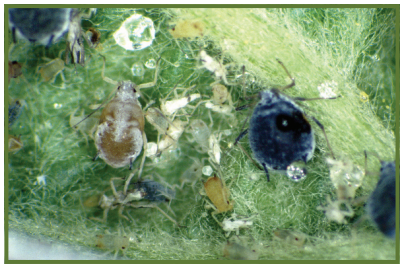
measuring-worm" type. They are difficult to find because they burrow into buds and leaf clusters and feed inside during the day but may feed on the outside of leaves at night. The male moths have light brown to gray wings with a wingspan of 25 mm while the female has virtually no wings and is flightless. This pest overwinters on the tree as an egg which hatches at bud-break and the small larvae feed on the developing leaves. At calyx they will feed on leaves and the surface of the fruit. The larvae descend from the trees in June to pupate and the moths appear in October and November to lay eggs on the trunk and lower scaffold branches of the tree.

Control

Since the females are flightless they must climb the tree to lay eggs. Therefore, some control of ascending females is possible with burlap bands covered with Tanglefoot wrapped around the trunk in October and November. Also spring sprays of *B.t.* (Dipel) to which powdered skim milk has been added as a feeding attractant should provide reasonably good control of light to moderate winter moth populations if applied early, 6 mm (1/4 in.) green (green tip) to tight cluster. It is important to monitor pest populations in the orchard and only apply control measures if necessary (see Appendix E for thresholds).

Secondary Pests

Rosy Apple Aphid *(Dysaphis plantaginea)*, Apple Aphid *(Aphis pomi)*, Woolly Apple Aphid *(Eriosoma lanigerum)* and Grain Apple Aphid *(Rhopalosiphum fitchii)*



Rosy apple aphids

Rosy apple aphid damages

Grain apple aphid

Adults and nymphs

Late season damage

Woolly aphid

Woolly aphid colony

Biology

There are four types of aphids that are common on apple in Nova Scotia. They are the rosy apple aphid, the apple aphid, the woolly apple aphid and the grain apple aphid. Aphids are about 4 mm in length and wingless for most of the season.

Rosy aphids are dark purple to rosy or pink in colour and have two long tubercles (also called cornicles), or tubules projecting from the abdomen from which honeydew is excreted. They suck juices from leaves and this loss of plant energy can damage fruit which is nearby. The rosy apple aphid can be a serious problem particularly on Cortland, Gravenstein and Idared cultivars where they can cause fruit to be small and distorted (see Appendix E for thresholds). The economic threshold for rosy aphids is calculated by counting all the colonies on a tree and dividing by the tree height measured in meters.

The apple aphid is light-green with short cornicles. It feeds mostly on the tender young terminal leaves and fruit by piercing the epidermis and sucking the juices which results in curled and twisted leaves and deformed fruits. The apple aphid may cause severe damage to young non-bearing trees. Young aphid infested trees grow more slowly and make it difficult to develop good tree structure. The apple aphid can be present on the tree throughout the growing season but the populations normally increase during July and August. The economic threshold is determined by counting the number of infested terminals out of a sample of 100 terminals. If 10 or more terminals are infested, treatment should be considered.

The grain apple aphid is dark green with very short cornicles and it attacks the buds and immature foliage in early spring and usually vacates the apple tree before bloom.

Woolly apple aphids are blue-black but are often concealed by a woolly white substance (waxy secretion). They survive the winter on twigs around the bud scales or in cracks in the bark.

Control

Aphids are readily preyed upon by predatory gall midges that live on wild cherry and lupines. Unfortunately, they prefer warm weather and often appear too late in the season to provide satisfactory control. Lacewing adults and larvae (aphidlions), ladybird beetle larvae, and syrphid fly maggots, are aphid predators. A chalcid wasp (*Aphelinus mali*) and braconid wasp (*Aphidius testaceipes*) are effective aphid parasites. Some of these are commercially available. Natural populations of syrphids can be encouraged by growing buckwheat as part of the cover crop. If control with predators is unsuccessful spot treatments with insecticidal soaps may be necessary. They are difficult to apply effectively since they require complete coverage of the foliage and branches and do not work in hard water. Partial control of some aphids is obtained with dormant or delayed-dormant sprays of 2% oil emulsion. The use of Rotenone has been advocated by some, however, it is undesirable because of its mammalian toxicity. Aphid infestation can be reduced by careful nitrogen application to avoid excessive lush green growth. It is also important to remove all watersprouts or suckers from the roots and scaffold branches. Since woolly apple aphids are protected by a mass of waxy wool they are more difficult to control. Large colonies on suckers can be pruned out and burned. Woolly apple aphids also infest tree wounds and can increase the occurrence of cankers. Therefore, if woolly apple aphids are a problem in your area, large pruning wounds should be painted with a latex paint.

European Apple Sucker *(Cacopsylla mali)*

Adult

Nymph

Biology

European apple suckers, which are an occasional pest in conventional orchards, may become a yearly pest in an orchard under organic production as a result of reduced pesticide usage. The adult suckers are 2.5 to 3 mm long and have four transparent wings. Early in the year, the insects are yellowish green, but as the season progresses, the body colour changes to black and red. The adults appear during mid June and are present until late October. During the summer, they are very active, and fly readily if disturbed. Mating occurs during August and Septem-

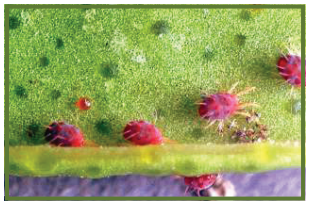
ber, and eggs are laid until the adults are killed by cold temperatures. The eggs hatch the following spring around bud break. The nymphs are green and have red eyes and a flattened oval body. The nymphs enter opening buds and blossoms to feed. They are quite sluggish and secrete a shiny, white thread-like substance and droplets of honey dew. Development is completed in about 34 days. Feeding by these nymphs can reduce tree vigour and fruit set can be reduced by high populations of this pest. The adults, by flying in the face of pickers when disturbed, can be a real nuisance during harvest.

Control

Where populations of this pest are high, application of insecticidal soap with a high volume of water should provide some control of the soft-bodied nymphs.

European Red Mite *(Panonychus ulmi)* and Two-spotted Spider Mite *(Tetranychus urticae)*

ERM eggs



ERM adults

Two-spotted spider mite

Mites and webbing

Tree bronzing symptoms

Biology

Mites are classified as a secondary pest because normally they would be controlled by predators unless the predators were harmed by pesticides such as sulfur or various synthetic pesticides. Mites lacerate the outer cells of leaves causing excessive moisture loss and interruption in photosynthesis. Mites suck the juices of the leaves and in large numbers can cause the leaves to discolour (bronze) and drop prematurely. This in turn can increase premature fruit drop and reduced fruit quality; apples are smaller, poorly coloured, softer, have lower acidity and sugar content and do not store well. Mites are particularly active during hot dry weather when new generations are produced every 14 days.

European red mites (ERM) overwinter as orange to red coloured eggs which are laid around folds or rough bark at the base of twigs or branches. Newly hatched mites are velvety red, less than 0.5 mm long, have six legs (but eventually grow two more), and no wings. They turn rust coloured as they mature. Numerous patches of red eggs indicate the need to apply a mite management strategy.

Two-spotted spider mites (TSSM) are similar to ERM. They are about 0.5 mm long, oval and change in colour from orange in the spring to green, and finally brown as they age, with two dark spots on their backs and two red eyes. They overwinter on ground cover plants and plant debris or under tree bark scales. They emerge in spring as temperatures rise and begin feeding on broadleaf plants on the orchard floor. They move into the tree canopy in midsummer in response to succulent root suckers or after cultivation or mowing disturbs the ground cover. They begin by colonizing the centers and tops of trees and move out to the ends of terminals as the summer progresses. They produce silk webbing similar to spiders and can be observed moving about on the webbing from leaf to leaf. They frequently appear in high numbers in a few trees called hot spots before spreading out over the orchard.

Control

In an organic system the use of sulfur to control apple scab and some summer diseases is a contentious issue.

The use of sulfur is toxic to mites including the predatory mites that provide natural control of plant feeding mites. Therefore, avoiding the use of sulfur, if possible, will make it possible to establish populations of natural mite predators. However, season long use of sulfur may also provide control of European and spider mites throughout the summer.

A dormant oil spray applied at 5 to 10 mm of green tissue in spring will suppress ERM population but can only be used when sulfur will not be applied within 30 days such as on a scab resistant apple cultivar. Organic growers of traditional varieties may have to apply oil sprays much earlier in the spring when they are less effective. Oil should be used in a minimum of 845 L/ha of water, or more, to give thorough coverage which is critical to good control. Dormant oils (recommended rate, 65 L/ha) are likely to perform better than oil concentrates (recommended rate, 17 L/ha). There are also several natural predators of mites. *Typhlodromus pyri* and *Zetzellia mali* are mites which prey on the European red mite and can be very effective in orchards where traditional fungicides and sulfur are not used. There are also predaceous thrips and several species of mirids (plant bugs) that prey on mites. If natural enemy populations are low in your orchard it may take some time for them to increase. If predation is low in your orchard you may consider purchasing lacewings as a predator until natural predatory mite populations are restored. Predatory mites also require other sources of food such as rust mites when ERM populations are low, therefore, some rust mites should be tolerated. If mite populations get out of hand, spot treatments with insecticidal soaps may be necessary.

Two-spotted mites can also be reduced by growing a solid grass ground cover in the orchard. However, this practice goes against the philosophy of increasing plant diversity in an organic system. It is possible to compromise by growing a continuously flowering ground cover around and between orchard blocks to provide a haven for predatory insects in close proximity to the apple trees. For more information see the ground cover and weed control section.

Occasionnal Pests

Apple Brown Bug *(Atractotomus mali)*, Mullein Bug *(Campylomma verbasci)*, Red Apple Bug *(Lygidea mendax)* and Tarnished Plant Bug *(Lygus lineolaris)* or mirid bug complex

Brown bug adult

Apple brown bug nymph

Mullein bug adult

Nymph

Mullein bug damage

Tarnished plant bug adult and nymph

Tarnished plant bug damage

Biology

The apple brown bug nymph is small, about 3 mm long, and pale yellow in colour turning first orange, then brick red, as it matures. The mullein bug is also about 3 mm and bluish-green in colour. The red apple bug is bright red in colour and turns orange-red with darker markings as it matures. The tarnished plant bug is about 6 mm long and brown to tan with rusty markings as an adult and yellow to green as a nymph and commonly attacks apple blossoms, buds and fruits. Clover, alfalfa or other legume crops near by may increase tarnished plant bug populations. All except the tarnished plant bug survive the winter as eggs which hatch in the spring (late May to early June). Tarnished plant bugs survive the winter as adults and lay eggs on twigs and fruit buds. These mirid bugs are typically sap feeders and while they may feed on the juices of leaves the most serious damage is done by feeding on the developing fruit. Feeding on the blossoms may cause the blossoms to drop. Feeding puncture sites on the fruit of sensitive cultivars may cause a corky wound or malformation of the fruit. Northern Spy, Red Delicious and Spartan are considered sensitive and should be monitored.

Control

Populations of these mirid bugs are monitored at calyx and again 5 to 7 days later by holding a square white tray (50 X 50 cm) under a limb and tapping the limb with a stick with rubber tubing slipped over the end to prevent damaging the bark. A total of 8 mirid bug nymphs per 20 tapping sites (4 per tree depending on size) indicates that a treatment to reduce populations is warranted to prevent significant crop loss. The only control available to organic growers is high-pressure washes with insecticidal soap applied while the insects are still soft bodied nymphs. Burlap bands coated with Tanglefoot® should be placed around the trunks before spraying to prevent nymphs which drop to the ground from returning to the tree. While they are rarely captured on the Tanglefoot they do refuse to attempt to cross it. With careful monitoring, spot sprays applied at the right nymphal stage may suppress populations enough to restrict yield lost due to poor quality.

Apple Thorn Leaf Skeletonizer
(Choreutis pariana)

Adult moth

Larva

Biology

This small moth is gray to reddish brown in colour. The larvae or caterpillars are yellowish-green in colour with a pale brown head. They fold a leaf together with webbing and feed on the upper leaf surface leaving only the veins and lower leaf surface intact.

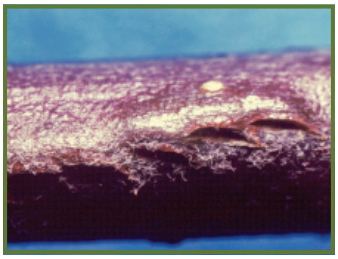
Control

The larvae are difficult to target with *B.t.* (Dipel) because they are protected within the webbed together leaf. Insecticidal soap has been suggested as a possible control, however, applying the product to the target may be difficult.

Buffalo Treehopper *(Stictocephala bisonia)*

Adult

Nymph



Buffalo tree hopper damage

Biology

The greenish to brown 6 mm long adults have a hood over the head which gives them a buffalo-like appearance. The nymphs are light green and spiny. The buffalo treehopper causes damage to apple when it lays its eggs in slits in the bark. The trees tend to become stunted and have scaly bark. The adults prefer to lay their eggs in alfalfa stems and nymphs feed on the plant juices. Orchards that have a legume cover crop or are next to a field of legumes are most often hardest hit.

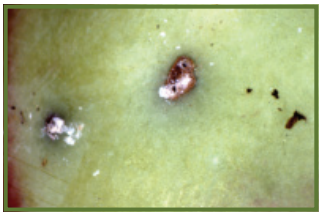
Control

There are some natural predators of the buffalo treehopper. The only other practical control suggestion available is to grow only a small percentage of legume in the orchard cover to provide some nitrogen fixation, good soil structure and preferred egg laying sites for the treehopper without permitting large populations to build. It is also wise not to plant legume crops near apple orchard blocks.

Eye-spotted Bud Moth *(Spilonota ocellana)*

Adult

Larva



Fruit damage

Biology

Mature bud moth larvae are about 12 mm long, brown with a black head. The larvae survive the winter in cocoons which they spin at the base of spurs or in crevices on larger branches. As the buds swell in spring the larvae become active and begin feeding inside buds or leaves which are webbed together. These leaves turn brown and curl up. This is a diagnostic feature of the eye-spotted bud moth and makes it easy to monitor. In early summer the larvae web leaves together and form a cocoon. By mid June the adults emerge and lay eggs on the leaves to begin the second generation. In late July or early August the larvae emerge and once again feed on the foliage and sometimes the fruit in contact with their webbed leaf shelters.

Control

Feeding larvae are difficult to treat because they are protected by their rolled leaf shelters. Applications of *B.t.* (Dipel) mixed with skim milk powder or Spinosad (Entrust® 80 W) applied as the leaves emerge in the spring and in late July or early August will reduce the numbers of newly emerged larvae and the damage they cause.

Bud moths appear in a cyclic fashion because they are killed by temperatures below -29°C and by a nuclear polyhedrosis virus disease and are preyed upon by many natural predators. Therefore, it is important to only treat for this pest when it is present in large numbers.

Fall Webworm *(Hyphantria cunea)*, Eastern Tent Caterpillar *(Malacosoma americanum)*

Fall webworm tent

Biology

The fall webworm moth is white and occasionally has black spots on the fore wings. The caterpillars are yellow or greenish in colour with a dark stripe down the back. Long whitish hairs arise from black and orange tubercles on its sides and they have a black head capsule. The adults emerge from pupal cases in the ground, on leaf litter or under bark scales in early summer. The moth lays it eggs in a row along the underside of leaves. The caterpillars hatch and construct a web tent surrounding the leaves they are feeding on. The tent, generally on the ends of branches, is extended as they continue to feed. Young caterpillars tend to eat the leaf blade leaving the veins untouched but mature larvae eat the entire leaf. They mature in about 6 weeks after which they drop to the ground to pupate and overwinter.

The eastern tent caterpillar overwinters as a dark coloured egg mass of 150 to 400 eggs deposited around a branch or in a branch crotch and covered with a varnish like material. The eggs hatch as the leaves begin to emerge. The caterpillars are hairy with a black and a white stripe down the middle of the back and a brown and yellow stripe down each side. There are also a row of blue dots down each side of the caterpillar. The caterpillars from one egg mass stay together and make a protected tent of webbing in the crotches of trees. They emerge from the tent to feed on the foliage in the mornings and early evenings. When they reach 5 to 6 cm in length they leave the tent to spin cocoons. Adult moths emerge about three weeks later and begin to lay the eggs for next year. The adult is rust-brown with two off-white stripes placed diagonally on the fore wings.

Control

Both caterpillars have a number or parasites and parasitoids including, ichneumonids, braconids, and chalcids. Also, egg masses of the eastern tent caterpillar can be destroyed when observed during pruning. Tents can be destroyed by rolling them up on a stick and birds will prey on the caterpillars. In addition, *Bacillus thuringiensis* var. *kurstaki* is effective when applied to the foliage while they are feeding. This may be more difficult for the fall webworm because it feeds within the protection of the tent.

Fruit Tree Leafroller *(Archips argyrospilus)*

Biology

Oval masses of 100 or more gray eggs are laid on the bark of twigs and branches. The eggs hatch at the time of bud break and the larvae begin feeding on the buds and developing leaves, blossoms and fruits. Serious damage to the fruit occurs when leaves are webbed to the side of the fruit and the larvae feed on the surface of the fruit under the leaf. The larvae are light green with a black head and reach 18 mm in length when full grown. In mid June they form a cocoon within the rolled leaves and 2 weeks later emerge as moths which lay eggs for the next year.

Control

Natural enemies of the Fruit Tree Leafroller do exist but may not be sufficient for complete control. Applications of *B.t.* (Dipel®) plus skim milk powder or Spinosad (Entrust® 80 W), which is derived through the fermentation of a naturally occurring organism, may be effective on feeding larvae if they come out of the rolled leaves at night like winter moth. An application in early spring at bud break may be somewhat effective.

Green Pug Moth *(Chloroclystis rectangulata)*

Adult green pug moth

Green pug moth larva

Biology

The adult moth is small, about 10 mm long with a 20 mm wingspan. It is a geometrid with a distinctive greenish tinge over the entire body and wings. The larvae are small

stout caterpillars easily confused with winter moth larvae. They are pale green with a distinctive reddish or dark green stripe down the back and reddish ring divisions. The reddish stripe may not be evident in the first two instars and in some cases does not develop at all. The overwintered eggs hatch in late April to mid-May and the larvae feed in the leaf and blossom clusters like winter moth larvae. In June the larvae drop to the orchard floor and pupate. The adults emerge in late June or early July and overwintering eggs are probably laid in August.

Control

These larvae can be managed just like winter moth with *B.t.* (Dipel) and skim milk powder except that they are not thought to feed on the fruit and therefore have a higher economic threshold than winter moth. That is to say, the tree can withstand much higher numbers of green pug moth larvae than winter moth larvae without a significant yield loss. With the high cost of management techniques, treatments for winter moth which were initiated because of misidentified pug moth larvae could be a costly error.

Obliquebanded Leafroller *(Choristoneura rosaceana)*

Adult moth

Larva

Damage

Biology

The obliquebanded leafroller (OBLR) is rarely a serious pest in Nova Scotia. The overwintered larvae are light green with black heads. They emerge in spring and feed on the leaves at first and then as they grow larger they web leaves together to feed inside. In June the larvae pupate and adults emerge soon afterwards to lay eggs for the next generation. Some locations may have two generations a year.

Control

The damage and life cycle are much like those of the eye-spotted bud moth as are the control recommendations and list of natural predators. Spinosad (Entrust® 80 W) can be used to control this pest and is OMRI approved.

Pale Apple Leafroller *(Pseudexentera mali)*

Adult

Larva

Fruit damage

Biology

The small green larvae hatch in late May and feed on the growing tips of terminal buds. As the leaves develop the larvae will web a leaf to the side of an apple or fruit cluster and chew a vertical strip down the side of the apple. This is another leaf-feeder which is sheltered within rolled up leaves and difficult to treat. This pest causes its greatest damage when it feeds on the terminal buds of young non-bearing trees. It can significantly stunt or deform the tree and make good tree structure difficult to develop.

Control

Early spring applications of *B.t.* (Dipel) as for winter moth may be successful (see Appendix E for threshold).

Spotted Tentiform Leafminer *(Phyllonorycter blancardella)*

Leafminer damage

Biology

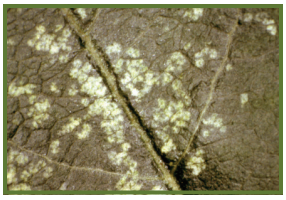
Adults emerge from cocoons on the orchard floor at the time of bud break and lay eggs on the underside of new leaves. The first few stages of the larvae are spent sucking plant juices but then they begin to mine the leaf tissues between the top and bottom epidermal layers. The mines are webbed inside and as they dry the leaf is folded into a tent shape.

Control

Treatment is warranted if one or more active mines per leaf are found on average. There are enough natural predators present in Nova Scotia so that external controls are seldom needed.

White Apple Leafhopper *(Typhlocyba pomaria)*

WALH nymph



Leaf damage

Biology

The young nymphs are pale white with dull red eyes, 1-1.5 mm long. The eyes change to white and finally creamy white in the adult which may reach 3 mm in length. The adults hold their wings folded over their backs and move very quickly. White apple leafhopper overwinters as eggs beneath the bark of twigs. The eggs hatch at early pink and adults appear in June. A second generation appears in August. These insects suck plant juices causing numerous white flecks on the leaves reducing photosynthesis and producing small, poor quality fruit that are often soiled with excrement.

Control

Natural enemies of leafhoppers include lacewings and spiders. Averages of 1 nymph per leaf during the first generation and 2-5 nymphs per leaf during the second generation are the economic thresholds (see Appendix E for thresholds). Spot treatments with high pressure washes of insecticidal soap may be necessary.

Horticultural Practices

Orchard Site Selection

Orchard sites should preferably be on a gently sloping hillside with good air drainage in order to provide some protection against frost and freezing injury. Wind can have an adverse effect on tree growth and yield; therefore, if the site is exposed to strong winds, wind-breaks should be planted. However, wind-breaks should not be planted in locations where they will create frost pockets, that is, prevent cold air drainage downhill. Also, windbreaks should be made of non-competitive tree species and definitely not poplar which is very competitive for water, nutrients and light.

Trees grown in soil that permits deep and extensive rooting (at least 1 meter) will produce up to twice the yield obtained from trees of similar age, cultivar and with similar care, but growing in soil that restricts deep rooting. Prior to planting the orchard, several soil profiles should be checked to determine potential root depth and if rooting restrictions can be corrected. Soil structure below plow depth is very important. Orchard soils with problems such as hardpans, compact wet subsoil and plowpans should be avoided if possible. If there are no other sites available, attempts should be made to improve the soil prior to planting. Deep tillage, when the soil is relatively dry, by subsoiling or ripping to a depth of at

least 70 cm beneath the site of the new tree row will, in certain situations, improve root penetration and drainage in soils with hardpans or plowpans.

Areas that are poorly drained due to ponding, compact subsoils, seepage from upslope and high water table, should be improved prior to planting, or avoided. Fields with minor areas which are slow to drain can sometimes be improved through the use of drainage tile. Ponding may be eliminated by grading the field surface and providing broad grassed drainage channels for controlled water run-off. In some fields tile underdrainage may be desirable below these channels. Some heavier soils would benefit, in many instances, from raising the area where the trees are to be planted. These ridges should slope gently down toward the open space between the tree rows providing up to an additional 30 cm of well drained soil for rooting.

Land previously used for crops other than apples is the most suitable on which to begin an organic orchard. Planting apple trees on an old apple orchard can result in poor tree growth due to apple replant disease. This soil borne disease which attacks the tree's roots can reduce vegetative growth and the productivity of the orchard. This particular disease appears to be more of a problem on lighter, sandy soils. If suitable new orchard land is not available then the following procedures can help to reduce the impact of replant disease. Plan the planting design so that as many of the new trees as possible are planted between the old tree rows and/or tree sites. Replace the soil removed from the planting hole with new top soil from land that was not previously planted with apple trees. Use a more vigorous rootstock but make sure that the tree spacing is adequate for this rootstock when the trees grow out of the replant diseased soil and continue normal growth, after about 5 years.

Soil Preparation

Plant health and nutrition are very important in preventing serious disease and insect problems. Excessive nitrogen can result in lush green growth that favours insect and disease attack while lack of nitrogen can result in weak vegetative growth which is more prone to low temperature injury. To obtain and retain healthy tree growth a proper balance of macro and micronutrients must be maintained. Therefore, soil analysis of the planting site should be done one to two years prior to planting. This will provide an opportunity to correct nutrient deficiencies before planting. Soil and leaf analysis should be done on a regular basis once the trees begin bearing so that soil and leaf nutrient levels may be kept at optimum levels. Provincial governments in the Atlantic Provinces provide a soil analysis service while Nova Scotia and New Brunswick also provide a leaf analysis service for fruit trees. Consult your local agricultural resource centres for instructions on collecting soil and leaf samples and submission for analysis.

Soil pH

Most agricultural soils in the Atlantic region are naturally acidic and liming is essential if they are to be productive. The desirable pH range for tree fruits is 5.5 to 6.5 with 6.5 being the optimum. At this level most nutrients are readily available for uptake by the roots. Very acidic soils (pH <5.0) contain soluble aluminum and manganese at toxic levels which can adversely affect tree growth. The application of agricultural limestone will raise the soil pH thereby reducing the availability of aluminum and manganese to the roots. Raising the soil pH towards 6.5 will also increase the availability of the following soil nutrients: nitrogen, phosphorus, potassium, magnesium, calcium, sulphur and molybdenum. Liming materials contain calcium and in the case of dolomitic limestone, calcium and magnesium. If the magnesium content of the soil is low then a dolomitic limestone should be used but excessive magnesium must be avoided because an imbalance of calcium and magnesium can result in bitter pit. Calcitic limestone contains primarily calcium carbonate and a small amount of magnesium and can be used to raise the soil pH when the soil magnesium level is adequate. Aim for a calcium to magnesium ratio of 10:1 in the soil. For more information on liming refer to the Atlantic Soils Committee publication 534-84, *Atlantic Soils Need Lime*.

Increasing the pH of soil to near 6.5 will also increase the activity of soil micro-organisms which can result in faster decomposition of added organic matter and increased availability of organic nitrogen, sulfur and phosphorus to the plants. Liming also improves soil structure by stabilizing soil aggregates, thus reducing soil erosion.

In established orchards, limestone will have to be broadcast on the orchard floor at a maximum rate of 6 to 8 metric tonnes per ha. It will take 1 to 3 years before it moves down through the soil profile and a positive response to liming is observed. In new orchard plantings the pH should be brought up to the optimal range by broadcast spreader application and then working the limestone into the soil profile.

Soil Organic Matter Content

Soil organic matter consists of humus which is resistant to further rapid decomposition and organic materials that are subject to fairly rapid decomposition. Organic matter acts as a storehouse of nutrients, increases exchange capacity, provides energy for micro-organism activity, releases carbon dioxide, stabilizes soil structure, improves tilth, provides surface protection from erosion and increases water infiltration and retention. Orchard soil should have an organic matter level in excess of 3%. Soil organic matter content can be increased by growing green manures such as Sudan grass, buckwheat, alfalfa, ryegrass etc. or by applying composted organic matter or manures prior to planting. The ground should not be left bare for any length of time because this will encourage soil erosion and the loss of nutrients by leaching. All applications of manure should be composted before application to prevent a potentially large release of nitrogen into ground water through leaching. Forty tonnes of composted manure per ha will increase the soil organic matter content by 1% and contains about 3 to 6 kg of nitrogen per tonne. Generally 25 to 30 kg of compost per tree every year in early spring will be adequate, but soil, leaf and compost analysis will provide the best recommendations for the amount of compost to apply.

Tree Selection

Nursery stock should be vigorous, one or two-year-old trees with lateral shoots (feathers). Trees should be dormant, free of frost or other injury and have never been subjected to drying conditions from time of digging to completion of planting. Good unfeathered one year or branched two year trees will be about a year later in coming into bearing. Poor trees are slower to develop and in many cases will never equal a good tree in growth or production. Trees that have broken dormancy, if otherwise healthy, may not suffer much unless warm dry weather follows soon after planting. Trees damaged by freezing or by drying out may take several years to recover and therefore should be examined carefully when received and rejected if damaged.

In the Atlantic Provinces fruit trees should be planted in the spring (April-May) as soon as the soil can be worked and planting doesn't place trees in water logged soil conditions. Trees are generally kept in cold storage until they are planted. Care should be taken to keep the tree roots from drying out before they are planted.

Plant Nutrient Applications

While composted organic matter and manures were discussed in a previous section there are occasions when the results of soil and leaf analysis or tree symptoms will require the addition of other nutrients. Liquid manure may be applied if the applications meet the requirements of CAN/CGSB-32.310-2006 section 5.5.

The rapid development of new leaves, blossoms and young fruit early in the year may cause nitrogen stress on the tree signified by a pale green colour of the foliage. Foliar applications of fish emulsion, 100 L in 3000 L of water per ha applied at early pink and 50 L in 3000 L water per ha at petal fall, should supply enough nitrogen to relieve the stress. Seaweed extracts have also been recommended for foliar application to relieve nutrient stress.

The boron content of apple trees is very important to the establishment of good fruit set. Foliar applications of boron, if required according to a leaf analysis can be made with a soluble boron source such as Solubor® as a stop-gap measure. Watch rates carefully because an excessive amount of boron can burn foliage. Soil boron levels can be improved through the application of borax to the soil.

The following are sources of other mineral nutrients acceptable to the CAN/CGSB-32.311 guidelines:

Rock Phosphate
a good source of phosphorus, particularly for young trees

Bone Meal
contains about 26% phosphorus

Potassium Sulfate
a good source of potassium contain 55% potassium and 18% sulfur

Sul-Po-Mag
contains 22% sulfur, 22% potash, and 11% magnesium

Wood ashes
contains about 6% potassium, 23% calcium, also contains traces of magnesium, manganese, zinc, boron and copper

Ground Covers and Weed Control

Weeds can reduce the growth of young apple trees by using up the available nutrients, water and light. To reduce weed competition in a new orchard a green manure such as Sudan grass grown for 2 years prior to planting will increase soil organic matter and choke out many of the unwanted weed species. A weed free strip 1.2 m wide

along the tree row or as circles around trees for the first 3 years is desirable. This can be accomplished with hand or mechanical cultivation but care must be taken to avoid damaging shallow roots.

Mulches around trees are preferred after the third year. Non-composted conifer or oak bark chips and wood chips applied 10 cm thick to a 1.2 m diameter circle around trees in the early spring, before weed seeds germinate, has been shown to provide good weed control in Europe and Nova Scotia. Straw mulch free of weed seeds has been tested here with encouraging results. In Europe mulches reduce nitrate leaching, improve soil organic matter content and stabilize pH, improving apple fruit quality with no negative effect on yield. Since mulches are applied to the surface of the soil and not worked in they cause very little nitrogen immobilization due to a high carbon to nitrogen ratio. Mouse guards may be necessary with mulch to prevent winter mouse damage but they must be used with care to avoid canker and collar rot problems. If mouse guards are used, find a type that does not fit snugly around the trunk and which provides good air movement to keep the trunk dry. On small farms in Europe they simply move the mulch away from around the base of the trees in the autumn.

The soil between the tree rows is most often planted with a grass. While this is a good practice to reduce soil erosion and increase soil organic matter it is too uniform to establish diverse populations of insect predators and parasites. A diverse population of plants in the ground cover will provide alternative sources of food for insect parasites and predators such as pollen and nectar when their prey is not plentiful on apple. Native plant species which produce pollen and nectar may encourage larger, stable populations of predatory insects. Some plants that should be encouraged are yarrow, wild carrot, dill, caraway, catnip, mustards, black-eyed susans, goldenrod, buckwheat, nasturtiums, clover, a bit of alfalfa, and other native flowering species. Alfalfa will help improve soil structure and will increase soil nitrogen levels. Too much alfalfa may encourage large populations of buffalo treehoppers that could cause injury to the trees. The addition of tall or red fescue as the grass component may help inhibit nematode populations especially in light sandy soils where nematodes can be a problem. Buckwheat is known to encourage Syrphid fly larvae populations which are important in biological control of aphids. A good ground cover should be diverse and able to withstand some traffic in the orchard as well as at least one mowing in the autumn before harvest, if not more often. An autumn mowing will make harvesting easier and will help owls and hawks capture mice and voles. Tall plants, however, may be a problem for pickers and broadleaf plants may provide a habitat for two-spotted spider mites. A reasonable compromise is to use straw mulch to keep weeds and tall plants from growing under trees. Alternatively, grass can be grown under the trees and between the tree rows while flowering plants that provide habitat for beneficial insects can be grown around the perimeter of orchards and between orchard blocks. This provides beneficial insects with a source of pollen and nectar for food when prey species are scarce while keeping them close enough to the orchard so they can attack orchard insect pests when their numbers increase.

Pollination

Apples for all intents and purposes are not self-pollinating or self-fruitful and need to be cross-pollinated to set fruit. This means that most apple cultivars require the pollen from another apple cultivar to pollinate its flowers in order to set fruit. When establishing new orchards particular attention should be given to the planned placement of cultivars within the rows to ensure a suitable mixture of cross-fruitful cultivars which bloom at the same time. Cross-fruitful cultivars should be within 15 meters of each other and therefore no more than 4 solid rows of a particular cultivar should be planted at a time. If a solid orchard planting of one cultivar is desired then a selection of cross-fruitful crab apple cultivars can be used as a pollen source. If at all possible the crabapple cultivar should be scab and apple maggot resistant.

While establishment of native flowering plants in the ground cover may increase populations of native pollinators such as the bumble bee it would be wise to use honey bee colonies as insurance for good pollination. Using two to three colonies (hives) per ha will ensure a good fruit set even under less than ideal conditions.

Fruit Thinning

Fruit thinning may be required in some years to ensure adequate fruit size and quality and to prevent biennial bearing. There are several techniques that may be attempted.

The preferred thinning practice is to remove extra blossoms because this will prevent the tree from putting energy into developing apples that are going to be removed during thinning, therefore wasting energy. In Europe, particularly with spur type cultivars, extra flower buds are removed by hand just as they are opening. In Atlantic Canada, spur pruning has been shown to be effective in managing crop load.

Hand thinning of fruit is very labour intensive but can be practical in small operations. Hand thinning makes it possible to remove exactly the right number of fruit allowing for proper size and spacing of the developing fruit. It is an opportunity to selectively remove small, deformed or insect injured fruit. Apples should be spaced about six inches apart on the branch unless they are abnormally large for that time of the year in which case the tree may be able to mature a larger number of fruits. Spacing of fruit would be much closer in spur type cultivars. Ideally, thinning should be done when the apples are 10 to 13 mm in diameter or 7 to 14 days after bloom.

Blossom thinning trials being conducted by AAFC indicate that lime sulfur applied during bloom has some thinning activity. Five percent lime sulfur applied at full bloom improved fruit size and colour. Trials in the USA have demonstrated that the addition of fish oil with lime sulfur increased the thinning effect.

Experimental mechanical thinning is being researched in several places in North America and Europe. High pressure water jets from guns with four nozzles have been used with some success. In Virginia, blossoms have been removed from peach trees using large ropes hung from a metal bar extended over the tree row from the bucket of a front-end loader. In Europe, a rope flail has been tried with some success.

Summer Pruning

Summer pruning is important for improving fruit colour, quality and storage life. It involves the removal of some of the current year's growth to open up the canopy to allow for better light penetration and to reduce crowding. Summer pruning may be initiated once terminal bud development is evident, usually by early to mid August.

Appendix A Modified Mills Table

Minimum number of hours of leaf wetness required for infection of apple leaves by ascospores and conidia of *Venturia inaequalis

Temperature (°C)	Minimum no. of hours of leaf wetness required	
	Ascospores	Conidia
1	40.5	37.4
2	34.7	33.6
3	29.6	30.0
4	27.8	26.6
5	21.2	23.4
6	18.0	20.5
7	15.4	17.8
8	13.4	15.2
9	12.2	12.6
10	11.0	10.0
11	9.0	9.5
12	8.3	9.3
13	8.0	9.2
14	7.0	9.2
15	7.0	9.2
16	6.1	9.0
17	6.0	8.8
18	6.0	8.5
19	6.0	8.2
20	6.0	7.9
21	6.0	7.8
22	6.0	7.8
23	6.0	8.3
24	6.1	9.3
25	8.0	11.1
26	11.3	14.0

**Reprinted by permission from Stensvand, A., Gadoury, D. M., Amundsen, T., Semb, L., and Seem, R. C. 1997. Ascospore release and infection of apple leaves by conidia and ascospores of *Venturia inaequalis* at low temperatures. Phytopathology 87:1046-1053.

Appendix B Disease Resistant Cultivars

Cultivar	Apple Scab	Powdery Mildew	Fire Blight	Harvest Season	Storage (months)	Best Use	Tasted at Kentville	Recom-mended
Belmac	R	MR	U	Early Oct	3-4	dessert	N	?
Britegold	R	R	R	Late Sep	1-2	dessert	Y	Y
Dayton	R	MR	MR	Mid Sep	1	dessert	Y	?
Enterprise	R	MR	R	Early Nov	6	dessert	Y	N
Freedom	R	MR	R	Early Oct	1-2	dual	Y	N
Florina (Querina®)	R	U	MR	Late Oct	3	dessert	Y	?
Goldrush	R	MR	MR	Late Oct	7	dessert	N	?
Jonafree	R	MR	MR	Mid Oct	2.5	dessert	Y	N
Liberty	R	R	R	Early Oct	2	dessert	Y	Y
Macfree	R	MR	MR	Early Oct	3-4	dessert	Y	Y
McShay	R	S	U	Early Oct	2-3	dessert	Y	?
Moira	R	S	S	Early Oct	2-3	dual	Y	N
Murray	R	R	MR	Early Sep	<1	dessert	Y	N
Nova Easygro	R	R	MR	Late Sep	2-3	dessert	Y	N
Novamac	R	MR	R	Mid Sep	2-4	dessert	Y	Y
Novaspy	R	MR	U	Mid Oct	4-5	dual	Y	Y
Priam	R	MR	U	Mid Oct	3	dessert	Y	?
Prima	R	MR	MR	Mid Sep	1-2	dual	Y	Y
Primevere	R	U	U	Mid Oct	6	dessert	N	?
Priscilla	R	R	R	Early Oct	2-3	dessert	Y	N
Pristine™	R	R	MR	Late Aug	1-1.5	dessert	Y	?
Redfree	R	MR	MR	Early Sep	1-2	dessert	Y	Y
Richelieu	R	MR	MR	Late Sep	3	dessert	Y	?
Rouville	R	U	U	Early Sep	2	dessert	Y	?
Scarlett O'Hara	R	R	S	Early Oct	6	dessert	N	?
Sir Prize	R	MR	MR	Mid Oct	2-3	dual	Y	N
Trent	R	MR	MR	Late Oct	6	dual	Y	N
William's Pride	R	MR	MR	Early Sep	1.5	dessert	N	?

R = resistant, MR = moderately resistant, S = susceptible, U = unknown, Y = yes, N = no

Appendix C Cultivar Descriptions

Cultivar	Brief Description of Major Attributes
Belmac	Resembles McIntosh, skin smooth and glossy with up to 90% red, slightly striped over a green background colour. Flesh is white, medium to coarse texture, mild sub-acid. Cold hardy.
Britegold	Yellow, medium size, sweet, flesh creamy yellow, slightly coarse, tender, and juicy. Bruises easily. Home garden use.
Dayton	Medium fruit size, 80 - 90% attractive glossy red over yellow background colour. Flesh pale yellow, crisp, juicy, firm, fine grained, and moderately acid. Home garden use.
Enterprise	Medium fruit size, washed 80 - 100% medium red on a very bright and glossy green-yellow ground colour. Flesh is fine grained, pale yellow to cream coloured, firm, crisp, sub-acid. Has potential as a commercial cultivar.
Freedom	80% red stripes on a yellow background, medium-large size. Flesh is creamy, juicy, firm, medium fine grained, tender and moderately acid. Has potential as a commercial cultivar.
Florina (Querina®)	Fruit 50% red on yellow ground colour, firm, small to medium size, sweet flavour. Whitish-yellow flesh, very crisp, low acid. Deserves further evaluation.
Goldrush	Fruit medium size, greenish-yellow to red blush at harvest, becoming entirely deep yellow in storage. Flesh is medium coarse grained, firm, crisp, pale yellow and non-browning. Flavour is complex, spicy and slightly acid at harvest. Recommended in the USA for cider and juice.
Jonafree	90 - 95% red, medium-sized with pale yellow flesh. Crisp, juicy, very firm, fine grained, mildly acid and pleasant aroma. Has potential as a commercial cultivar.
Liberty	Fruit medium-large, 90% dark red with a yellowish background colour. Somewhat striped, moderately acid, flavour good. Flesh is yellowish, juicy, crisp, and fine textured. It has been very productive at the AAFC test site at Kentville, NS and has potential as a commercial cultivar.
Macfree	75% medium red over greenish-yellow background, medium to small size. Flesh is juicy, white with a slight green tinge. Firm, moderately coarse, pleasant, moderately acid. Medium eating quality.
McShay	70% dark red blush over a green background colour, similar to McIntosh. Flesh, moderately firm, fine texture, juicy, mild flavour and low acid.
Moira	McIntosh type, red, medium to small size, flesh creamy white with a green tinge. Medium eating quality.
Murray	Early McIntosh type, red, medium sized, flesh is soft, juicy, white and fine textured. Home garden use.
Nova Easygro	Striped or washed, medium red over a green-yellow background. Fruit medium sized, flesh is creamy white, moderately fine, firm, crisp, moderately juicy, and low acid. Home garden use.
Novamac	McIntosh type, fruit medium size, 50 - 90% blushed or striped medium red with a greenish-yellow background. Flesh is creamy white, fine, tender, moderately crisp, juicy, and moderately acid. Similar to McIntosh. Has potential as a commercial cultivar.
Novaspy	Similar to Northern Spy, greenish yellow striped or blushed with dark red. Flesh creamy yellow, fine, very firm, crisp, moderately tender, juicy and moderately acid. Has potential as a commercial cultivar to replace Northern Spy.
Prima	60 - 80% bright red blush over a yellow background. Flesh is moderately acid, medium grained, crisp, and juicy. Tree lacks winter hardiness. Home garden use.
Primevere	Fruit bright and glossy dark cardinal red, slightly conical. Flesh is moderately coarse grained, pale green to white, firm, crisp. Has commercial potential.
Priscilla	70 - 90% bright red blush over a light yellow background. Flesh is crisp, medium grained, juicy, mild flavour and low acid. Fruit size can be small. Home garden use.
Pristine™	Fruit medium size, pale green-yellow at harvest, maturing to deep yellow, with moderate orange blush. Flesh is pale yellow, crisp, medium to fine grained, medium acid to sweet.
Redfree	80 - 90% glossy medium red on a yellow background. Flesh is firm, light cream, medium grained, crisp, juicy, mild flavour, low acid. Uneven ripening. Has potential as a commercial cultivar for late August to early September.
Richelieu	Fruit 50 - 60% medium red, striped over green to light yellow ground colour, medium in size. Flesh white, tender, juicy, fine texture, mild to sub-acid.
Rouville	Fruit large, 75 - 80% medium red, lightly striped, over pale green to yellow ground colour. Flesh is white, tender, slightly coarse, and sub-acid.
Sir Prize	Yellow, can have a slight red blush, can russet. Large, bruises easily, flesh is juicy, crisp, and very tender. Poor pollenizer. Home garden use.
Trent	Red, medium to large in size. Flesh is firm, juicy, cream coloured with greenish tinge, and slightly coarse. Prone to bitter pit.
William's Pride	Moderately bright dark red on green-yellow or pale yellow background. Medium to large size, flesh is light cream, medium grained, mildly acid, very crisp and firm. Multiple pickings required. Home garden use.

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Appendix D Insect and Mite Classification

Pest	Type of Injury	Pest Status
Codling moth	direct	key
Apple maggot	direct	key
Winter moth	direct	key
Pug moth	direct/indirect	occasional
Pale apple leafroller	direct/indirect	occasional
Fruit tree leafroller	direct/indirect	occasional
Obliquebanded leafroller	direct/indirect	occasional
Apple brown bug	direct/indirect	occasional
Mullein bug	direct/indirect	occasional
Green apple bug	direct/indirect	occasional
Tarnished plant bug	direct/indirect	occasional
White apple leafhopper	indirect	occasional
Spotted tentiform leafminer	indirect	occasional
Buffalo treehopper	indirect	occasional
Rosy apple aphid	direct/indirect	secondary
Apple aphid	indirect	secondary
Grain apple aphid	indirect	secondary
Woolly aphid	indirect	secondary
Apple sucker	indirect	secondary
European red mite	indirect	secondary
Two-spotted spider mite	indirect	secondary
Apple rust mite	indirect	secondary

Note: This data was derived from studies of conventional orchard management systems and may change under an organic system.

Appendix E Insect Thresholds and Treatment Period

Pest	Expected Optimal Treatment Period	Threshold
Winter moth	bud separation	2-3 larvae\20 clusters per tree (average of 5 trees)
Rosy apple aphid	early calyx to end of June	1.0 colonies/m of tree height
Apple aphid	July to August	10% of terminals infested
Apple brown bug	early calyx	8\20 limb taps
White apple leafhopper	early calyx	1.0\leaf (1st generation) 2.0\ leaf (2nd generation)
Apple maggot	mid July to mid August	1 adult\orchard (protein bait + yellow card)
Codling moth	early July mid July	40 males\trap 10 males\trap
Spotted tentiform leafminer	mid-late July	1 live mine\leaf
European red mite	mid June mid July mid August	20 mites\leaf 10 mites\leaf 15 mites\leaf