ORGANIC APPLE PRODUCTION

GUIDE

FOR

NOVA SCOTIA

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ORGANIC APPLE PRODUCTION GUIDE

INTRODUCTION

This guide is designed to provide suggestions to 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 in Nova Scotia. To the best knowledge of the authors the use of scab resistant apple varieties in a reduced pesticide management system has not been tried anywhere before but will begin here in Nova Scotia in 1991. Growers are cautioned to attempt this strategy on a small block (~ 1/2 ha) before attempting to use this strategy in a large scale system.

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 a change in one factor may have on all the others. It is, however, logical to assume that a dramatic reduction in fungicide 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 be that it will take several years for a new stable orchard ecosystem to develop and because the orchard ecosystem is so complex every 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) recommends pest control practices only in response to a threat which has a significant economic or environmental effect.

While the main body of this guide provides the specific information required for a management strategy an Appendix has 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.

ORGANIC PRODUCTION AND MANAGEMENT SUGGESTIONS

PLANT DISEASES

Apple Scab (*Venturia inaequalis*):

Successful organic apple production with conventional apple varieties is virtually impossible. Scab control would require numerous applications of sulfur, lime-sulfur, or Bordeaux mixture. This would put an un-natural amount of these chemicals into the orchard environment. Copper in Bordeaux is toxic to earthworms and should be used sparingly. Both copper and sulfur are toxic to the apple trees and can cause burning of the leaves and russetting of the fruit. Also many people develop an allergic skin reaction to sulfur. Numerous trips through the orchard with a tractor and sprayer particularly in wet weather may increase soil compaction. It also increases labour, equipment depreciation, gasoline consumption and air

pollution. The solution to these problems is to grow scab resistant apple varieties. There are more than 20 varieties available. For a description of some of these varieties consult the APPLE CULTIVARS publication Agdex 211/30 publication No. ACC-1205 available from the Nova Scotia Department of Agriculture and Marketing (NSDAM).

No fungicide sprays are required for scab control if scab resistant cultivars are used. It is recommended that, to be certain that the resistance is not overcome, all sources of scab such as unsprayed apple trees, wild apple trees or root suckers be removed from the orchard and hedge rows.

If you are determined to use standard apple varieties the following are some guidelines of scab control.

Avoid growing extremely scab susceptible varieties such as McIntosh or Cortland. Northern Spy, Idared and Red Delicious may be more suitable.

There are presently three fungicides available for scab control under the Organic Crop Improvement Association (OCIA) guidelines, sulfur, lime-sulfur and Bordeaux mixture.

Sulfur

Apply at weekly intervals beginning at bud break. Sulfur is re-distributed to some extent and therefore good coverage of the tops of trees is very important. Repeat applications after heavy rainfalls which may wash off much of the sulfur. It is important to monitor infection periods using a thermometer and the modified Mill's Table provided in Appendix A. If infection will occur before the rain stops or the foliage is dry it may be necessary to spray in the rain. If the rain is heavy and it is possible the sulfur will be washed off before it is effective, apply the sulfur as a dust or in a higher concentration. Do not use sulfur in bright sunlight, when temperatures exceed 27^0C and the relative humidity is expected to remain high, before a night frost or within 30 days of a dormant oil spray. Be certain to read the label on the sulfur package carefully and follow the directions. Sulfur is a chemical fungicide and should be treated with care. Sulfur will also provide powdery mildew, 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 2 L/100 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. There is however a serious possibility that injury to the fruit and/or foliage may result. McIntosh is especially sensitive to injury at petal-fall. If lesions do develop they may be prevented from producing conidia by another application of lime-sulfur. Only those sporulating lesions which 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 and anthracnose. 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.

Bordeaux Mixture

A Bordeaux mixture of 1 kg copper sulfate, 2 kg of lime and 385 L of water plus 7.6 L of superior oil may be applied as a dormant spray up to 1 cm green tissue for early scab and European Red Mite control. Bordeaux mixture used after this growth stage may cause russetting. Also the copper in Bordeaux mixtures is toxic to earthworms. Bordeaux applications may reduce the incidence of fire blight.

Cultural Control

Dead apple leaves on the ground in the fall or spring may be burned or raked up. Raked leaves may be burned, buried or preferably composted for one year under a layer of soil to prevent the escape of spores. This technique may be very difficult because leaves can blow into hedge rows where they are inaccessible. Encourage, through good soil management, earthworm activity and numbers because they will drag into their burrows and consume large quantities of apple leaves.

Fireblight (*Erwinia amylovora*)

Fireblight is a bacterial disease which appears, in Nova Scotia, as a terminal twig blight several weeks after bloom. The bacteria become active when the temperatures are between 18ºC and 35ºC and a relative humidity above 80 per cent. The early symptoms are the wilting of terminal branches and leaves. The end of the branch bends over like a shepherd's crook and the leaves begin to turn brown from the petiole up to the tip but remain firmly attached to the terminal. Young fruitlets on infected terminals may become infected through the stem and turn brown, shrivel and remain firmly attached to the tree. During hot humid weather bacterial ooze will appear on the branch, petiole, leaf or fruit as a milky droplet at first but then turn brown and become hard as it dries. This ooze is the source of bacteria for other infections. The ooze forms fine threads if the droplets drip and these threads are carried by the wind. The bacteria are also spread by rain and by insects, including bees. Severe infections may move down the branch into larger limbs causing cankers with sunken surfaces and cracked margins which also serve as a source of bacteria for several years. A dormant application of a 4.5 Kg : 4.5 Kg : 385 L (copper sulfate:lime:water) Bordeaux mixture plus 2% miscible oil before bud-break will reduce fireblight bacterial populations. This should be done in conjunction with the removal of fireblight cankers during the dormant period. Cankers can be removed by cutting branches or limbs 10 cm below the edge of the canker in winter, preferably, or 30 cm below the canker in summer. This wood must be burned immediately. It is also important to avoid the production of excessive green succulent growth due to heavy pruning or excessive nitrogen application. Also remove suckers or watersprouts because they are very sensitive to infection. If branch tip wilting or black scorched leaf symptoms appear; prune out infected branches as soon as the symptoms are seen and burn the cuttings. The pruning tools used to remove fireblight infected materials must be sterilized or disinfected between each cut by dipping into a solution of household bleach (1 part bleach, 9 parts water) or into alcohol and scrubbed with disinfectant before being used for other purposes. Fireblight usually appears in late June or early July in Nova Scotia.

Anthracnose Canker (*Glomerella cingulata or Colletotrichum gloeosporioides*)

Early canker infections appear as purple blotches on small twigs and branches. They may also appear on the trunk and larger limbs of young trees. Young McIntosh trees are particularly susceptible, although not all of the purple blotches will develop into cankers, those which do may girdle and kill small branches. Control is possible where infections are light by pruning out cankered twigs and branches. Pruning should be done late in the dormant period to avoid wound infection. Spores produced by untreated cankers can cause a fruit rot just like Gloeosporium fruit rot. In orchard blocks where anthracnose is particularly severe post-harvest sprays of copper sulfate plus lime (81.5 kg/ha applied dilute) or Fixed Copper 53% WP (5.1 kg /ha) may be helpful. Large amounts of copper should be used with caution because of potential toxicity to trees and earthworms. Cankers which do develop should be surgically removed. All the diseased bark of the canker should be removed down to the wood. Large wounds should be painted with latex paint or tree dressing to prevent infection by other canker organisms.

Nectria (*Nectria galligena*) **and Gloeosporium Canker** *(Gloeosporium malicorticus or Neofabraea malicorticus*)

Nectria cankers produce a typical bull's-eye appearance when several years of concentric

rings of wound tissue have developed. Gloeosporium cankers develop with strands of wood or bark still stretched across the canker to give the "fiddle string" appearance. Both of these canker types can be controlled by routine annual inspection of the trees for cankers which can be surgically removed with a knife or chain saw attachment. Cut away all the diseased bark and soft tissues around a canker down to the hard wood and healthy bark. The best time to prune these cankers is when the trees are most actively growing and the wounds will heal quickly. Gloeosporium cankers often develop at the sites of wooly aphid feeding. Control of the wooly aphid, as described further on, is advised. Untreated Gloeosporium cankers can produce spores which cause a fruit rot. Tight fitting mouse guards may also keep the bark wet longer and provide a favourable environment for infection and canker development. For more information on Nectria canker control consult ACC publication 1223, European Canker of Apples.

Collar Rot (*Phytophthora cactorum*)

Rotting of the bark and girdling of trees at the soil line can be caused by this fungus in poorly drained soils. Symptoms of collar rot are purpling of the foliage in late summer and soft, rotting bark at the soil. Draining wet soils before planting should be the first consideration or at least planting on ridges large enough to keep the crown and upper roots of the tree out of the wet soil. Wet soil can be removed from around the trunk and upper roots and all diseased bark cut away and the hole backfilled with gravel. Also, on wet soils do not place mulch close around the trunk which may keep this area wet longer than is desireable. Avoid using collar rot susceptible rootstocks like MM 106. Carefully control nitrogen applications to avoid soft and luxuriant growth.

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

These fruit rots are caused by spores from the Gloeosporium and Glomerella cankers and other bitter rot infected apples. Infections on fruit produce circular, sunken brown lesions. Within these brown lesions circular rings of tan-coloured fruiting bodies form giving the spot 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 after the fruit is removed from storage and is held at room temperature for several days. The disease can be managed by removing fallen apples twice a week, surgically removing cankers and removing mummified fruit during pruning in winter. Apple collection is also used for maggot control (see Insect Pests).

Blossom-end Rot (*Sclerotinia sclerotiorum*)

Infections occur at the time of blossoming and are centered on the blossom end of the apple. It is not known if sulfur applied at blossoming 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 may have some impact on the severity of the disease.

Apple Replant Disease

The cause of this disease is largely unknown. Fungi, bacteria, nematodes and nutritional factors may all play a part in this complex disease. The disease is characterized by very slow growth of apple trees planted in the same spot where apple trees grew previously. The disease is particularly severe in light sandy soils. Removal of the old soil from the planting hole and replacement with fresh soil high in organic matter or peat moss has been shown to be effective in some locations. If at all possible plant the new trees between the sites where the old trees grew.

Powdery Mildew (*Podosphaera leucotricha*)

Powdery mildew develops on the young tender terminal leaves and appears as a white

powdery dust on the surface of the leaves. Infected terminals have leaves which are curled back and from a distance look as if they are being blown back by the wind and are quite conspicuous on a calm day. Mildew infections on apples produce a net-like russet over the surface of the apple. Where mildew is a severe problem, sulfur 90 - 95% WP can be applied at 10 kg/ha at weekly intervals from bud burst to terminal bud formation. Do not use sulfur on Delicious. Follow the directions on the sulfur label carefully to avoid russetting the fruit. In areas where mildew is an annual problem it is best to avoid growing very susceptible varieties such as Jonathan, Cortland, Idared, Tolman Sweet, Monroe, Rome Beauty, and Baldwin. The mildew susceptibility of most scab resistant apple cultivars is not known at this time 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.

Sooty Blotch (*Gloeodes pomigena*), **Fly Speck** (*Microthyriella rubi or Zygophiala jamaicensis*)and **Frog-eye-spot** (*Physalospora obtusa*)

There are at least three other diseases which may become a problem in an organic apple orchard which have rarely been a significant problem before. They are Sooty Blotch (*Gloeodes pomigena*), Fly Speck (*Microthyriella rubi or Zygophiala jamaicensis*)and Frog-eye-spot (*Physalospora obtusa*). Since they are rarely a problem in orchards sprayed with traditional fungicides there is little to no experience in managing these diseases. Sooty Mould is known to grow on sugary exudates of aphids and on leafhopper droppings. Therefore, a serious problem with sooty mould may be avoided with careful management of the aphids and leafhoppers both of which are economically important pests of apple. Adequate tree spacing and summer pruning which reduces humidity in the tree canopy and rapid drying of fruit after wet periods may reduce the incidence of infection. Sulfur applied on a 14 schedule will provide some protection from sooty blotch and fly speck. Copper is effective against sooty blotch and fly speck on red coloured apples but causes fruited discolouration of yellow apples. However, copper is currently only registered for use on apples for fire blight control and only Bordeaux is registered for use after silver tip and up to 1 day before harvest.

INSECT PESTS

INTRODUCTION

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. Direct pests cause direct injury to the fruit. Indirect pests attack other organs of the plant such as leaves, shoots or roots, indirectly 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 occasional problems because they are sometimes effectively controlled by natural enemies or adverse weather or they only attack certain restricted varieties of apple or they were controlled by treatments applied for other pests. Thus these pests only require control in certain years. Secondary pests are those that would normally be effectively controlled by natural enemies where pesticides are not used. Natural control of these organisms is very important since it is most often the secondary insect pests which have several generations per season and produce large numbers of off-spring and thus are much more likely to become resistant to pesticides.

The insects and mites may be classified as follows:

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
European red mite	indirect	secondary
Twospotted 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.

Codling Moth (*Cydia pomonella*)

This is one of the two most serious insect pests of apple. Codling moths will also feed on pears, crab-apples, 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 with 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 2200 h when the temperature is above 16ºC. 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.

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 Table 1. for thresholds).

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 (See Appendix) 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)*. B.t. 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. The organic grower may experiment with B.t. plus natural pyrethrum with the hopes of increased efficacy. A second generation of codling moths, 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.

Table 1. Thresholds and expected optimal period for treatment of several apple pests.

Pest	Expected optimal treatment period	Threshold
Winter moth	bud separation	2-3 larvae/20 clusters per tree averaged over 5 trees
Rosy apple aphid	early calyx-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 gen.)
Apple maggot	mid July - mid August	1 adult/orchard (protein bait + yellow card)
Codling moth	early July, mid July	40,10 males/trap
Spotted tentiform leafminer	mid-late July	1 live mine/leaf
European red mite	mid June, mid July, mid August	20, 10, 15 mites/leaf

Apple Maggot (*Rhagoletis pomonella*)

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 10-14 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. The flies are attracted to early sweet apple varieties such as Bough Sweet and Wealthy. Cortland 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.

Apple maggot should be monitored with yellow sticky boards with protein baits or apple volatile lures or glossy red or black sticky spheres about 7.5 cm in diameter with an apple volatile lure. One trap per 1 ha of orchard should be hung in the trees in early July. If one fly is caught per ball or sticky yellow board plus protein bait or 5 flies with an apple volatile lure a control strategy must be applied. For the organic grower there is very little that can be done except to be very thorough and pick up 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.

Mites

Mites are classified as a secondary pest because normally they would be controlled by predators unless the predators are 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. 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, and European Red Mites (ERM), (*Panonychus ulmi*) in particular can cause an unsuspected large loss of fruit to early drops and poor quality. They are particularly active during hot dry weather when new generations are produced every 14 days. Mites suck the juices of the leaves and in large numbers can cause the leaves to discolour, bronze, and drop prematurely. They can weaken a tree to the point of reduced fruit size and premature fruit drop.

Mites overwinter as orange-red 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 and have six legs (but eventually grow two more) and they have no wings. They turn rusty coloured as they mature. Numerous patches of red eggs indicate the need to apply a mite management strategy. 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 used 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 at 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 mirid (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.

Aphids

There are four types of aphids which are common on apple in Nova Scotia. They are the rosy apple aphid (*Dysaphis plantaginea*), the apple aphid (*Aphis pomi*), the woolly apple aphid (*Eriosoma lanigerum)* and the grain apple aphid (*Rhopalosiphum fitchii*). 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 long tubercles (also called cornicles, 2 tubular projections from the abdomen from which honeydew is excreted). They suck juices from leaves and this loss of plant energy can damage fruit which is near-by. 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 Table 1 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 trees grow more slowly and make it difficult to develop a 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 apple grain aphid is dark green with very short cornicles and it attacks the buds and young leaves in early spring and usually leaves apple 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 cracks in the bark.

Aphids are readily preyed upon by predatory gall midges which live on wild cherry and lupines but they prefer warmer 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 aphid parasites which are also effective and some of these can be purchased commercially. 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. Some control of some aphids is also 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. Because 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.

Winter Moth (*Operophtera brumata*)

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 the 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 as an egg on the tree 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 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. Since the females are flightless they must climb the tree to lay eggs. Therefore some control of ascending females should be possible with burlap bands covered with Tanglefoot® wrapped around the trunk in October and November. Also spring sprays of B.t. to which skim milk has been added as a feeding attractant and possibly the addition of natural pyrethrum to improve efficacy should provide reasonably good control of light to moderate winter moth populations if applied early, 6 mm (1/4 in.) green to tight cluster. Again it is important to monitor pest populations in the orchard and only apply control measures if necessary (See Table 1 for thresholds).

Pug Moth *(Chloroclystis rectangulata)*

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. These larvae can be managed just like winter moth with B.t., natural pyrethrum and skim milk 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 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.

Eye-spotted Bud Moth (*Spilonota ocellana*)

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. Feeding larvae are difficult to treat because they are protected by their rolled leaf shelters. Applications of B.t. (Dipel) mixed with skim milk and possibly natural pyrethrum 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.

Pale Apple Leafroller (*Pseudexentera mali*)

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 it difficult to develop good tree structure. Again early spring applications of B.t. as for Winter Moth may be successful (See Table 1 for threshold).

Fruit Tree Leafroller (*Archips argyrospilus*)

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. 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 and natural pyrethrum may be effective on feeding larvae if they come out of the rolled leaves at night like winter moth do. An application in early spring at bud break may be somewhat effective.

Obliquebanded Leafroller (*Choristoneura rosaceana*)

The 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 bigger 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. 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.

White Apple Leafhopper (*Typhlocyba pomaria*)

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. The WALH 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 and cause numerous white flecks on the leaves which reduces photosynthesis and produces small poor quality fruit which is often soiled with excrement. 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 Table 1 for thresholds). Spot treatments with a high pressure spray of insecticidal soap may be necessary.

Spotted Tentiform Leafminer (*Phyllonorycter blancardella*)

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. 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 need.

Buffalo Treehopper (*Stictocephala bisonia*)

The greenish to brown 6 mm long adults have a hood over the head which gives them somewhat the appearance of a buffalo. The nymphs are light green and spiny. The Buffalo Treehopper causes damage to the 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 and orchards which have a legume cover crop or are next to a field of legumes are most often hardest hit. There are some natural predators of the Buffalo Tree Hopper and the only other practical control suggestions available are to keep only a small amount 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 population buildups. It would also be wise not to plant legume crops near apple orchard blocks.

Apple Brown Bug, Mullein Bug, and Tarnished Plant Bug (Mirid bug complex)

The apple brown bug (*Atractotomus mali*) nymph is small, about 3 mm long, and pale yellow in colour turning first orange, then brick red, as it matures. The mullein bug (*Campylomma verbasci*) is also about 3 mm and bluish-green in colour. The red apple bug (*Lygidea mendax*) is bright red in colour and turns orange-red with darker markings as it matures. The tarnished plant bug (*Lygus lineolaris*), about 6 mm long and brown to tan with rusty markings as an adult and yellow to green as a nymph, 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.

Populations of these mirid bugs are monitored at calyx and again 5 to 7 days later by holding a square white tray 50 cm 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) would indicate 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 those 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.

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.

Trees grown in soil that permits deep and extensive rooting (at least 1 meter) will produce up to twice the tonnage 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 root depth and if rooting restriction 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 and, sloping gently down toward the open space between the tree rows. These ridges can provide 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 specific 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 the lighter soil types. 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 as possible of the new trees 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 which 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 micro nutrients 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 an optimum. 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 Provincial Agricultural Extension office 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 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. It increases the availability of phosphorus and molybdenum from the soil. 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. If soil magnesium content is adequate use Calcite to raise the soil pH. 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 a positive response to liming is noted. In new orchard plantings the pH should be brought up to the optimal range by broadcast spreader application and working the limestone into the soil.

Soil Organic Matter Content

Soil organic matter consists of humus which is somewhat 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. Orchard soil should have an organic matter level in excess of 3 per cent. 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. The ground should not be left bare for any length of time because this will encourage soil erosion and the loss of nutrient 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 - 30 kg of compost per tree every year in early spring will be adequate, but soil, leaf and compost analysis will provide the best recommendation for organic apple production.

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 which have broken dormancy, if otherwise well, 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.

Trees should be planted as soon as received or dug into the ground in a sheltered area. Trees can be held for 24 hours in a cool location that is protected from wind, frost and sun. A pond or brook is generally suitable for holding trees. If roots are on the dry side, soak in water for 12 hours before planting.

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.

The boron content of apple trees is very important to the establishment of good fruit set. Foliar applications of boron if required by a leaf analysis can be made with a soluble boron source such as solubor as a stop-gap measure, but watch rates carefully because an excessive amount of boron can burn foliage.

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 following are sources of other mineral nutrients acceptable to the OCIA guidelines:

Rock Phosphate	- a good source of phosphorus, particularly for young trees.
Bone Meal	- contains about 26% phosphorus
Sul-Po-Mag	- contains 22% potash, 22% sulfur, and 11% magnesium
Wood ashes	- contains about 6% potassium, 23% calcium, alsocontains 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 cultivation but care must be taken to avoid damaging shallow roots.

Mulches around trees are preferred after the third year. Uncomposted conifer or oak bark chips and sawdust applied 10 cm thick to 1.2 m diameter circles around trees in the early spring, before weed seeds germinate, have been shown to provide good weed control in Europe and Nova Scotia. Straw mulch free of weed seeds have been tested here with some encouraging results. In Europe the mulches reduce nitrate leaching, improve soil organic matter content and stabilize the 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 which 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 moved the mulch away from around the base of the trees in the autumn.

The soil between the 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 which should be encouraged are yarrow, wild carrot, dill, carroway, catnip, mustards, blackeyed susans, goldenrod, buckwheat, nasturtiums, clover, a bit of alfalfa, and other native flowering species. Alfalfa will help improve soil structure and will increase the soil nitrogen levels. Too much alfalfa may encourage large populations of Buffalo Treehoppers which may 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 significant 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.

Pollination

Apples for all intents and purposes are not self-pollinating or self-fruitful and need to be cross pollinated 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 crab apple cultivar should be scab-resistant.

While the establishment of native flowering plants in the ground cover may increase the population of native pollinators such as the bumble bee it would be wise to use honey bee colonies as an insurance for good pollination. The use of 2 to 3 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 insure adequate fruit size and quality and to prevent biennial bearing. There are several techniques which may be attempted.

The preferred thinning practice would be to remove extra blossoms because this would prevent the tree from putting energy into developing apples which are going to be removed during thinning and that energy being wasted. In Europe, and particularly with spur type cultivars, extra flower buds are removed by hand just as they are opening.

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 to give the proper size and spacing to the developing fruit. It is also an opportunity to selectively remove small, deformed or insect injured fruit. These fruits can also be removed from the orchard to prevent them from becoming a source of disease or insect problems. 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 also be much closer if a spur type cultivar is being grown. Thinning should ideally be done when the apples are 10-13 mm in diameter or 7 to 14 days after bloom.

Chemical thinning with NAA (naphthalene acetic acid), a natural plant hormone, should be acceptable to the OCIA but check with your local association to be sure. Applications of 10 - 20 ppm to McIntosh apples when they are about 10 mm in diameter should produce acceptable results. Be sure to read and follow the package instructions carefully.

Experimental mechanical thinning is being researched in several places in North America. High pressure water jets from guns with four nozzles have been attempted with some success. Also large ropes hung from a metal bar extended over the tree row from a hydraulically operated front end loader on a tractor has be used to remove blossoms from peach trees in Virginia.

Summer Pruning

Summer pruning is important in improving fruit colour, quality and storage life. It involves primarily the removal of some of this years growth to open up the canopy to allow light penetration and to reduce crowding. Summer pruning may be initiated once the terminal bud development is evident.

APPENDIX A

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

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

[a] Table 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.

Atlantic Crops Committee Publications

Orchard Fertility	ACC 1201
Apple Cultivars	ACC 1205
Home Garden Production of Apples	ACC 1206
European Canker of Apples	ACC 1223
Specialized Juice Apple Production System	ACC 1225
Stocks for Apples	AHC 2
Harvesting Apples	AHC 3
Refrigerated Storage of Apples and Pears	AHC 4
Pruning and Training the Apple Orchard	AHC 8
Planting and Caring of the Young Orchard	AHC 9
Physiological Disorders	AHC 10
155 System	AHC 16
Preparing for the New Orchard	AGDEX 211

These publications and others are available from local Nova Scotia Department of Agriculture and Marketing offices and extension personnel.

Agriculture Canada Publications

Apple Growing in Eastern Canada	Publication No. 1975

Edited by: P. G. Braun, Tree Fruit Pathologist, Agriculture Canada Research Station, Kentville, Nova Scotia, 1991. Contributors: R.F. Smith, Entomologist, J.M. Hardman, Entomologist, and D.H. Webster, Soil Scientist, Agriculture Canada, Kentville; W. Craig, Tree Fruit Specialist, and R. Rogers, Entomologist/Apiculturist, Plant Industry Branch, Nova Scotia Department of Agriculture and Marketing, Kentville.
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