Best Management Practices for Nova Scotia Apple Production

Edited By B. Craig, Perennia

2010
Table of Content

Introduction

Section 1 Orchard Site Selection & Preparation .................................................................1
   Site Selection
   Field Preparation
   Sequence of events for good site preparation

Section 2 Orchard Design ....................................................................................................5
   Rootstocks
   Cultivars
   Pollination
   Planting System

Section 3 Orchard Fertility Management ........................................................................13
   Nutrition Levels

Section 4 Ground Cover and Soil Moisture Management .................................................18
   Permanent sod, with herbicide strip
   Permanent sod cover over 100% of the orchard floor
   Mulching
   Cultivation
   Moisture Management

Section 5 Tree Training & Pruning ....................................................................................22
   When to Prune and Objectives

Section 6 Crop Load Management ....................................................................................26

Section 7 Insect and Disease Management .....................................................................29
   Major Diseases
      Apple Scab
      Fire Blight
Apple Replant

Secondary Diseases

Powdery Mildew
Nectria and Gloeosporium Cankers
Collar and Crown Rot
Bitter Rot, Ripe Rot and Bull’s-eye Rot
Blossom-end Rot
Sooty Blotch, Fly Speck
Frog-eye Leaf Spot
Cedar Apple Rust

Key Insect Pest

Apple Maggot
Codling Moth
Winter Moth

Secondary Pest

Aphids
Green Pug Moth
Eye-spotted Bud Moth
Pale Apple Leafroller
Fruit Tree Leafroller
Obliquebanded Leafroller
White Apple Leafhopper
Spotted Tentiform Leafminer
Apple Brown, Mullein and Tarnished Plant Bugs
Fall Webworm and eastern Tent Caterpillar
Apple Thorn Leaf Skeletonizer

Section 8 .......................................................................................................................................................67

Pesticide Handling and Application
Indices for determining apple maturity

Harvesting

Postharvest Management

Orchard Management

Harvest management

Sanitation in the orchard, storage and packinghouse

Storage and marketing practices
Introduction

The concept of best management practices is not a new concept for Nova Scotia apple growers. They were some of the first growers in North America to follow IPM guidelines for controlling orchard best. The industry was also developing IFP guides in advance of the CHC guide lines produced for Canadian apple growers. Growers have had excess to various fact sheets produced by NSDA, NSFA, AAFC and AgraPoint which promote best practices. This publication brings the information from these sources together in one publication. The publication will be a living document in that as management practices change so will the document.
Section 1 - Orchard Site Selection & Preparation

Site Selection

1) Location:

The preferred orchard site is on gently sloping land which allows for good air drainage and greater protection against frost and winter injury. When given the choice of slope direction, south sloping land is preferred over other direction because of its greater exposure to sunlight. Planting on flat land in low lying areas should be avoided because these sites are more prone to spring and fall frosts. Spring frost can kill and/or damage fruit buds thereby reducing yield and fruit quality. Fall frost can damage fruit tissue and depending upon the severity of the frost, storage life and fruit quality may be reduced and fruit may be down grade to a juice apple. Wind can have an adverse effect on tree growth, bee activity for pollination, pesticide application, fruit quality and yields. If the site is exposed to strong winds, windbreaks should be planted keeping in mind not to plant them in locations where they will create frost pockets or increase snow load in the orchard. A properly designed windbreak can limit wind induced fruit bruising and fruit drops. Increase bees and other insect activity during bloom and thus fruitfulness. They can raise the air temperature by up to 1°C which can provide some spring frost protection. In Europe where there is extensive use of wind breaks, single row deciduous trees that provide 50% obstruction are recommended. Conifers are not recommended because they do not grow rapidly enough and are too dense (over 80% obstruction).

2) Soil:

Trees grown on soil that permits deep extensive rooting will produce up to twice the tonnage compared to trees of similar age cultivar and care, growing in soil with a restricted root zone. Orchard should be located on soils that are well drained and allow for root penetration to 80 cm and greater. Soils with hardpans, compact wet subsoil and plow pans should be avoided when possible because these are barriers to good root penetration.

Poor drainage will restrict root development which can contribute to inadequate yields. Areas that are poorly drained due to ponding, compact sub-soils, seepage from up slopes and high water table, likewise should be improved prior to planting, or avoided. If choice of site is limited to soils with one or more of these problems then attempts should be made to improve the soil prior to planting. When the problem cannot be corrected the site should be avoided.

Orchard on light sandy soils with low water holding capacity may require irrigation particularly when dwarfing rootstocks are used. Irrigation is an added cost of production which can be avoided with the selection of soil type. Soils with very good water holding capacity and good open structure that will allow deep root penetration should meet all the demands of the tree.

When considering land as a possible orchard site consult “Soils of the Annapolis Valley Area of Nova Scotia” Report No. 22 Nova Scotia Soil Survey for its soil classification. The report will provide general information on the suitability of the site for orchard production. The soil should be investigated as to its potential for orchard production. The best way to find out is to conduct a proper investigation of the soil and site at least two full years before planting. This will most often require someone who has experience in soil-related aspects of orchard establishment. A thorough soil investigation normally requires the examination of a least 4 soil profile exposures per hectare, dug on a 50m x 50m grid. Test pits need to be a least 1 meter in depth and are easily dug and refilled with a backhoe. If the soil is highly variable and more than 4 exposures are required, the additional pits can be dug in locally depressed or crested topographical positions. The nature of the terrain (slope and aspect) and the limitations within each soil
profile should be recorded and the individual soil units classified and representatively sampled on a layer basis for fertility adjustments.

3) Fertility:

Soil samples for nutrient analysis should be collected at least two years prior to planting to allow for any required amendments prior to planting. When sampling restrict the area sampled to no more than two hectares of a uniform soil type. Areas within the planting site that have different soil types, soil texture, drainage conditions or depth to impecious layers or of different fertilizer history should be sampled separately. At the time of planting the soil nutrients should be within the desired ranges. Sampling the topsoil and subsoil separately will provide a more accurate reading of the soil fertility. The topsoil will reflect recent fertilizer applications while the subsoil may indicate either inherent soil fertility or the effects of long-term fertilizer and lime applications. It is more convenient to collect soil samples with an auger, however, a spade can be used if an auger is not available. When sampling scrape away the top 2.5 cm of soil and collect a soil core from the 2.5 to 20.0 cm depth. Collect a separate sample from the 20 to 40 cm depth. Collect soil from a minimum of 10 to 20 locations from a two hectare site. Thoroughly mix the soil collected from the 2.5 to 20 cm depth and fill the sampling box. The soil from the 20 to 40 cm range should be mixed and placed in a separate soil box and sent to a soil lab for analysis.

The soil pH and nutrients that are deficient should be raised to within the recommended ranges. It is much quicker and easier to raise nutrient levels prior to planting than after the site has been planted. Failure to correct nutrient levels can have an adverse effect on tree growth, and effect productivity and fruit quality in future years. For detailed information on nutrients see the section on fertility and refer to ACC 1201 Orchard Fertility (http://www.extensioncentral.com/eng/index.php?option=com_docman&task=cat_view&gid=142&Itemid=32).

4) Apple Replant Disease:

Young orchard planted on an old apple site may suffer from apple replant disease which is primarily caused by soil pathogens in Nova Scotia. In Eastern Canada the primary means of correcting soils with apple replant disease is to fumigate the soil prior to planting. Soil fumigation does not fit well into the IFP concept. Planting orchard on soil that had not previously been planted to apple will avoid a replant problem. When planting on an old orchard site the soil should be checked for a potential replant problem by means of a pot test. If a replant problem exist and an alternative site or viable alternatives are not available then the site should be chemically sterilized (fumigated) the fall prior to planting. Trials are ongoing to find alternative means to fumigation for apple replant disease control. These controls will be compatible with IFP guidelines.

Refer to ACFC 1209 *Planting and Care of the Young Apple Orchard*.

Field Preparation

Preparation of an orchard soil should start several years prior to planting. Collect Soil samples for analysis to determine organic matter, soil acidity and nutrient levels. According to the results of the test report, the pH and soil nutrient level should be adjusted to fit within the optimal levels for apples, through the application of limestone and fertilizer prior to planting. Efforts should be made to increase the organic matter of the soil, since organic matter improves the physical condition and allows improved moisture and nutrient capacity, aeration, and microbial activity. The application of livestock manures, compost and the growing of cover crops will increase the organic matter. The application of composted manures is preferable to fresh manure to reduce the risk of nitrate leeching into ground water. For general
information on soil fertility, see ACC publication No. 1201 Orchard Fertility. Excess moisture in the root zone impacts negatively on root activity by restricting gas exchange in and out of the soil, keeping spring soil temperatures low, contributing to frost heaving, forcing new roots to grow just below or even on the soil surface, making the root system more susceptible to attack by soil pathogens and contributing to the tree leaning.

The choice, design and capacity of a drainage system should be related the soil type, terrain, slope and most importantly, the degree of water logging in a wet year. How many sub-surface drainage systems are there in orchards in your area that do not remove excess water in the root zone rapidly and effectively enough? A very effective way of estimating the depth and duration of water logging is to install a number of simple well points on the land 2 or 3 years before planting. Rigid, perforated drainage pipe works well. Measure the rise in the water table during the growing season in relation to the amount of precipitation that has fallen in the preceding months. Then use historical rainfall data to find out if the measured water table levels are below or above average. Subsurface drainage systems are often deployed ineffectively on sloping and undulating land when the design incorporates fixed-interval drain spacing, ignoring the fact that some areas are wetter than others.

Refer to ACFC 1209 *Planting and care of the young apple orchard* for options to correct excessive moisture problems.

Some form of deep soil manipulation is often required and is used to: 1) break up restricting subsoil layers, 2) loosen and mix top- and subsoil and 3) mix in any required lime and fertilizers to the desired depth. To ensure effectiveness and permanence of the action, it is important that this be done at optimum soil moisture content. Soil moisture content just below field water capacity, when the soil is most friable, is often required. However, structured clay subsoil and hardpans often need to be slightly drier to ensure the maximum amount of fragmentation and loosening. Only a visual, physical inspection of the soil profile will reveal this. Sub-soiling a wet soil is a waste of time and money and can negatively affect the potential of the soil as a growing medium. If soil investigation has revealed that the soil is too shallow and cannot be deepened by sub-soiling, the only alternative is too ridge. Refer to ACFC 1209 *Planting and care of the young apple orchards* and Atlantic Food and Horticulture Research Centre technical report 00-05 *Improved orchard performance through soil modification* for details on soil manipulation, soil surface modification and their benefits.
Sequence of events for good site preparation

1. Soil investigation; plan for soil prep & orchard layout: Summer of year 1
2. Order rootstocks/cultivar: Summer of year 1
3. Install deep subsurface drainage, if required: Summer/fall year 1
4. Clear land of any trees; erosion control: Fall of year 1
5. Soil samples: Spring year 2
6. Remove sod, soil surface in friable condition: Early summer year 2
7. Broadcast lime and fertilizers: Early summer year 2
8. Soil manipulation: Summer year 2
9. Cut-off drainage above orchard, if required: Summer year 2
10. No traffic after soil prep; mark out rows: Summer year 2
11. Ridging, berming, if required: Summer year 2
12. Fumigation (if required): Summer/fall year 2
13. Establish cover crop in drive alley: Summer/fall year 2
14. Planting: Spring year 2

If a considerable number of acres are planned, give yourself 3 to 4 years of planning time. It always pays to invest at the front end and lay a solid foundation!
Section 2 - Orchard Design

1) Rootstocks

Of the many factors which influence the success of the orchard enterprise, the selection of good cultivars and the best rootstock are fundamental. While cultivars can be changed by grafting, the wrong rootstock must either be tolerated with a lower level of profitability or the orchard removed. Selection of the rootstock is governed by the intensity of management, financial considerations, climate, orchard site and soil, and cultivar. Obviously, then with this many variables, there is no one best rootstock, and the orchard manager must select those which give most promise for his needs.

When selecting rootstocks for new orchard planting the following characteristics need to be taken into consideration:

- **Vigour.** Rootstocks can provide a complete range in tree size control. Once the orchard is planted it cannot be changed so selecting the best rootstock is a very important decision. Unfortunately designing an orchard with a specific tree size is not as simple as picking a certain rootstock. The ultimate tree size for an orchard is strongly influenced by many factors including; cultivar, soil type, climate, and training system. It should also be clearly recognized that early, consistent and heavy cropping will exert a major effect in control of tree size.

- **Precocity.** This is defined as the time it takes a tree to come into production. It is strongly influenced by the cultivar and rootstock. Many stocks have been promoted because of their ability to induce the cultivar to bear fruit within a year or two after planting. Although early production is desirable it may not necessarily always be an advantage. Capacities for early production are important but, not if it is at the expense of tree development and the failure of the mature trees to fully utilize its allotted space in the orchard.

- **Production-Efficiency.** Precocity in the young tree and productivity of the same tree when mature are not necessarily correlated. Trees on size controlling stocks do tend to crop heavily for their size and therefore appear to be very efficient in converting the incoming light energy into fruit. With many trees per hectare, full yields are soon reached.

- **Site and soil requirements.** Soil type can have as much influence on vigour as the rootstock. Growers may sometimes need to use more than one rootstock within the same orchard site in order to compensate for changing soil types. Generally more vigorous stocks should be used on light, weaker soils and weaker stocks on stronger soils. Keep in mind that certain conditions like cold and wet or hot and dry may make a given rootstock the best choice even though it may not fit the exact size range originally envisioned. Since our soils tend to be rather variable, one should consider the use of several stocks with each matched according to the vigour mosaic of the field. e.g. A dry knoll would have a more vigorous stock for that part of each row. Soil compaction and drainage must be attended to prior to planting. Hilling (ridging) along each row before planting will considerably assist where soils are week or less well drained.

- **Hardiness.** The three periods when so-called winter injury can occur are late fall, mid winter, and early spring. In the Maritimes, lack of hardening in the late fall and/or loss of hardening in the early spring followed by a cold dip are the major cause of winter injury. While most stocks in themselves are hardy enough, they can affect the amount of cold injury suffered by the scion cultivar to a marked degree. In areas where winter temperatures often dip below -25°C the frame should always be of a hardy cultivar or framestock. Serious damage can occur when soil temperatures throughout the root zone fall below - 8°C.
Anchorage. Dwarfing rootstocks are not usually well anchored. Roots on these stocks tend to have fewer fibres and a high portion of bark to wood; they are therefore rather brittle. In other stocks there are many fine roots. A tree support system is therefore required for dwarf stocks. Shallow rooting and rooting from one side of the stock is also a problem which may require tree support for stocks that are not even in the dwarf classification.

Root suckering. This is usually a factor that is prevented by the plant breeder. However, some stocks recommended because of certain special traits may have a greater tendency to produce root suckers around the base of the tree. Root suckers, may develop more profusely when a dwarfing stem-piece is inserted between the cultivar and roots. Such trees should be planted with half of the interstem buried below ground as this helps reduce suckering. When given the choice it is best to avoid using rootstock that produce root suckers as these can harbour insects and disease.

Incompatibility. Occasionally a scion and stock will not grow together properly. The union may be easily broken especially when early heavy crops are present during a fall wind storm, e.g. Northern Spy on M.26. In other cases the scion is actually unthrifty.

Susceptibility to disease and pests.

Collar rot (Phytophthora cactorum) is a soil born fungal disease that affects apple trees usually just after the orchard has produced its first heavy crop. Infections occur at or near the soil line. The best control is to use resistant stocks like the Cornell-Geneva Series, especially on seasonally water-logged soils. Under maritime conditions MM.106 is noted for its susceptibility to this disease.

Fire blight (Erwinia amylovora) is a bacterial disease that is more commonly found in warmer climates, but has been appearing regularly in Nova Scotia. Burr knots, bark cracks and root suckers may provide a point of entry for the pathogen which can result in tree mortality or diminished productivity. It is usually more adept at entering through the blossom. The stock EMLA 26 and EMLA 9 are noted for their sensitivity and susceptibility to fire blight.

Woolly apple aphid, a major problem in the Southern Hemisphere, is not usually a consideration for this region. The MM. series were bred for resistance to woolly aphid.

Dogwood borer, along with other bores have been found in burrknots and can reduce tree vigour. Rootstocks such as M.26 and MM.111 which are prone to produce burrknots are most often infected. This insect is presently not a problem in our region.

Longevity. There is no reason to think that "old age" is a factor for any stock. This does not mean that some stocks will not have more tree losses than others; but if cared for and not affected by injury or disease, all live equally long. Although orchards on dwarf rootstock have been known to live a long time (up to 40 years) they reach the senescence spur bound condition much quicker than the more vigours rootstocks. The life expectancy of a dwarf may be as short as 15 years because of economic and management reasons.

Fruit quality. It has been observed that rootstocks influence fruit size. Some dwarf rootstocks like M.9 increase fruit size while others like M.27 the size is reduced. Since dwarf rootstocks have fewer shoots to spur ratios the apples produced on them generally have more colour.

Virus status. There are a number of viruses that may be present in apple and pear rootstocks and cultivars. Many of these do not show visual symptoms. They can, however, alter or reduce
performance of the orchard. A scion virus can interact with a rootstock virus and cause incompatibilities at the graft union. While viruses do not necessarily reduce tree efficiency, attempts to control tree size by means of introduced mild viruses do not show promise. Many of the older rootstock selections carry viruses; for example, M. 9 and M. 7. These were exposed to a heat treatment process which eliminated most of the viruses to give the stock designation M. 9a and M. 7a. A further clean up of these stock result in the EMLA series, M. 9 EMLA, M. 7 EMLA, etc. The best practice is to use only virus free material.

Table 1: North America Apple Rootstock Classification

<table>
<thead>
<tr>
<th>Size classification</th>
<th>Tree size comparison to seedling</th>
<th>Rootstock designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigorous</td>
<td>100%</td>
<td>Seedling</td>
</tr>
<tr>
<td>Semi-vigorous</td>
<td>75-85%</td>
<td>Alnarp 2, BA, EMLA 111, Bud 118</td>
</tr>
<tr>
<td>Semi-dwarf</td>
<td>55-75%</td>
<td>M4, MM104, MM 106, Bud 490, EMLA 7, CG 30</td>
</tr>
<tr>
<td>Dwarf</td>
<td>35-50%</td>
<td>EMLA 26, EMLA 9, B9, G.16</td>
</tr>
<tr>
<td>Sub dwarf</td>
<td>25-35%</td>
<td>EMLA 27</td>
</tr>
</tbody>
</table>

2) Cultivars:

When selecting cultivars for a new orchard only those cultivars that offer a good prospect for economic success should be considered. Cultivar selection will depend upon the marketing outlet, fresh or processing and therefore it is important to consult with the processors and packing houses as to what their demands are for particular cultivars. Producers that are direct marketing will have more leeway when it comes to the selection of cultivars. Cultivars that can be produced with a minimal use of agricultural chemicals fit best into the IFP concept however at this time disease resistant cultivars are not as well recognized as the non resistant selections in the everyday market place. The susceptibility of standard apple to disease vary and are given in table 1. Other factors that need to be considered when selecting cultivars are cultivar strains, harvest season and storage life.

Table 2: Susceptibility of certain cultivar to apple scab and powdery mildew

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Scab</th>
<th>Powdery Mildew</th>
<th>Cultivar</th>
<th>Scab</th>
<th>Powdery Mildew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortland</td>
<td>VS</td>
<td>VS</td>
<td>Idared</td>
<td>S</td>
<td>VS</td>
</tr>
<tr>
<td>Crispin(Mutsu)</td>
<td>VS</td>
<td>MS</td>
<td>Jerseymac</td>
<td>VS</td>
<td>S</td>
</tr>
<tr>
<td>Red Delicious</td>
<td>S</td>
<td>R</td>
<td>Jonagold</td>
<td>VS</td>
<td>MS</td>
</tr>
<tr>
<td>Empire</td>
<td>S</td>
<td>S</td>
<td>Mcintosh</td>
<td>VS</td>
<td>S</td>
</tr>
<tr>
<td>Gala</td>
<td>S</td>
<td>S</td>
<td>Northern Spy</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Golden Delicious</td>
<td>S</td>
<td>MS</td>
<td>Paulared</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Gravenstein</td>
<td>S</td>
<td>S</td>
<td>Spartan</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>Honeycrisp</td>
<td>S</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There are now over 150 strains of the cultivar Red Delicious with the strains primarily varying in fruit spur growth and colour development. Spur type trees tend to be more compact than non spur types thus this need to be considered when designing the orchard. Strains can vary with regards to the intensity of colour; shades and percent of fruit covered with colour (stripe vs solid blush) and thus can have a significant influence on the grade out of fruit. Strains can vary in maturity by up to a week or more and growers can make use of this trait to spread out the harvest season of a particular cultivar or allow the fruit to be placed on the market earlier. New strains of cultivars are introduced on an annual bases and producers would be well advised to contact and consult with their marketing outlets to determine what strains of a particular cultivar are in demand.

Apple cultivars are broken down into early, mid and late season when it comes to fruit maturity and harvesting. Early season cultivars are those that are harvested mature from early August to early September, mid season cultivars such as McIntosh are harvested from early September to early October and late season cultivars such as Northern Spy from early October to late October. Having a mixture of cultivars that extend the harvesting and marketing season will provide more efficient use of harvest labour and machinery. Once again the marketing outlet will determine the percentage of fruit produced in the three harvest periods. The present trend is for the majority of fruit to be produced in the mid to late season period as these fruit tend to have longer storage and shelf life than early season cultivars.

The storage life of apple cultivars will vary from as short as a one to two week period to over a year depending upon the type of storage and the stage of maturity when the fruit was placed in storage. This again points out the importance of knowing the market potential for a cultivar and the marketing policy of the packing house. The marketing season of an apple that can be stored for 10 to 12 months is much longer than that of an early season cultivar thus allowing for a greater volume of fruit to be produced. The drawback is the added cost of storing the fruit thus the need for a higher rate of return to offset this cost. Certain cultivars perform better in long term storage than others being less prone to storage disorders such as scald and senescent breakdown.

3) Pollination:

In order to obtain fruit, pollination and fertilization of the flower have to take place. The apple blossom has five sepals, which persist at the "bloom end" of the fruit; five petals which are soon shed; twenty to twenty-five stamens each with an anther containing pollen surmounting the filament; they surround the five stigmas, which unite in a common style that leads to the ovary, and together constitute the pistil of the flower. The stamens and pistils are the essential organs of the flower representing the male and female parts.

Pollination is the transfer of the pollen from the anther to the stigma and is usually accomplished by insect activity primarily honey bees with seed number being directly correlated to this activity. The transfer of pollen from the anther of one flower to a stigma of the same cultivar is known as self-pollination. The transfer of pollen to the stigma of the flower of another cultivar is cross-pollination. In some cases, the stigma becomes receptive shortly before the anther dehisces (sheds ripe pollen) and makes it difficult for pollen from the flower to reach the stigma of the same flower. Therefore, this flower would need pollen from another flower on the same tree (self-pollination) which sometimes happens or from another cultivar (cross-pollination). Following pollination with the pollen of a suitable cultivar, the pollen tube develops, growing down the style through the tissue and finally reaches the ovary, where it releases the sperm which then unites with the egg cell, thus accomplishing fertilization. This process usually results in the formation of seeds. This initiates the growth and development of the fruit and is needed for fruit to set. The ovary is divided into five compartments each containing two eggs cells (three in Golden delicious, four in Northern Spy). Where the ovules are not fertilized, or where for
any reason development is checked, the blossoms are soon shed.

It is not necessary for the entire complement of seeds to be produced in order for normal apples to develop but, the higher the number of seeds that do develop in a fruit, the better the set. Fruit with only one to three seed may tend to be smaller than those with a full complement of seeds (10), may be miss shaped, have a greater tendency for premature drop and may not be has highly coloured at harvest. The calcium content of fruit has been shown to be enhanced by the number of seeds. Apples with one or more compartments devoid of seeds are more likely to be one-sided or otherwise abnormal in shape.

Most apple cultivars are considered to be self-unfruitful, which means that the pollen of one flower will not fertilize an egg of the same cultivar. Strain of a cultivar will not pollinate the parent cultivar (ie; Marshal McIntosh will not pollinate Summerland McIntosh). There are few apple cultivars primarily triploid cultivars, such as Graventstien, Jonagold and Crispen (Mutsu), which produce non viable pollen and should not be considered as pollenizing cultivar. A third cultivar that produces viable pollen is therefore required when triploid cultivars are used in the orchard design. Cultivars that have a biennial bearing tendency are not reliable pollinators as in their off year they will produce no or very few blooms. A third pollen source is suggested when cultivars with a biennial bearing habit are planted and crop load management should be conducted to reduce the severity of biannual bearing. Thus, in an orchard there is a need for a number of apple or crab apple cultivars to be planted to ensure that each cultivar's pollination requirement is met in order to set a commercial crop of apples.

One of the important factors to be considered in pollination is the weather conditions during the bloom period. Temperature has an important role in fertilization as the rate of growth of the pollen tube is dependent on temperature. There is little bee activity when temperatures drop below 10°C and pollen the germination of pollen is hindered at temperatures below 4.5°C. Studies on pollen tube growth have shown that at temperatures below 13°C the growth rate is very slow. From 13°C to 24°C there was maximum growth of the pollen tube. The fastest growth rates were at temperatures over 27°C. Pollen from some cultivars has faster pollen tube growth the others. It has been observed that as the number of pollen tubes increase, there is an increased chance of pollination. The average is 30-50 pollen tubes per style but there have been reports of up to 100 pollen tubes per style. Insect activity and pollination are temperature dependent. The use of wind breaks can improve temperatures by reducing wind speed which will also improve insect activity.

Two vital weather effects are:
1) At lower temperatures bee activity is decreased which leads to reduced pollination.
2) Rain will also stop bee activity and destroy all ripe pollen from the anthers, thus rendering it useless for pollination.

Apparently, during a hot bloom period, the pollen tube can reach the egg before it degenerates while under cooler conditions the egg will degenerate before it can be fertilized. Excessively hot weather, especially if accompanied by dry winds and cold soil, may also be detrimental to good fruit set.

When designing and an orchard the provision for good cross pollination is the number one priority. The objective is to have a large volume of compatible pollen available when the cultivars to be pollinated are in bloom. Distance between the cultivar to be pollinator and the pollinating cultivar, overlap of bloom periods, viability of pollen, and the commercial acceptance of the pollinating cultivar need to be taken into consideration to obtain this objective. The best means to ensure for adequate cross pollination is to design the orchard so that a suitable pollinator is within 15 m of each tree. It is suggested that there ought to be a minimum of 20 to 25% pollenizer trees in any orchard. To facilitate orchard picking operation blocks of up to four rows of a single cultivar can be used with blocks of one two rows of a suitable pollinator. When growers wish to set out solid plantings of a cultivar for economic and management
reason provision for cross pollination is obtained through the planting of a suitable pollinator at regular intervals throughout the orchard and or the use of inter plants of crab apples. Growers should also consider using a ratio of 9 to 1 when determining the number of pollinators required. This ratio becomes more important when inter plants of crab apples are used as the source of pollen. Orchard nutrition also plays a role in fruit set. Nutrient deficiencies will adversely affect, vegetative growth, flowering, fruit set, fruit yield and fruit quality. Trees deficient in nitrogen may have reduced fruit set, increased June-drop and be more sensitive to chemical thinners. A phosphorus deficiency could result in reduced flower numbers and flowering maybe delayed in the spring. The micro nutrients boron and zinc are also known to play a role in fruit set. A boron deficiency can result in reduced flowering, reduction in pollen tube development and germination thus severely reduced fruit set. A Zinc deficiency can result in a reduction of flowering and fruit set.

Table 3: Bloom Periods

<table>
<thead>
<tr>
<th>Bloom period for selected crab apples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Blooming</td>
</tr>
<tr>
<td>Dolgo</td>
</tr>
<tr>
<td>Manchurian</td>
</tr>
<tr>
<td>Rosedale</td>
</tr>
<tr>
<td>Chestnut</td>
</tr>
<tr>
<td>Crimson Gold</td>
</tr>
<tr>
<td>Simpson 10-43 Malus aldenhamensis</td>
</tr>
</tbody>
</table>

Bloom period for selected apple cultivars

| Idared | Cortland | Ambosia |
| Paulared | Empire | Golden delicious |
| Gravenstein | Honeycrisp | Northern Spy |
| Jerseymac | Red Delicious |
| McIntosh | Jonagold |
| Gala |

4) Planting System:

Planting systems that guarantee good light for the fruit during the entire growing season for the production of high quality fruit while allowing for early and sustained yields fit best within the IFP protocol. Single row planting systems are preferred over multiple row systems because they require less plant protection products (especially reduced herbicides). Systems that contain mature tree size to within four metres or less should allow growers to meet the IFP objectives. Any one of the following four systems would lend its self to the criteria of IFP
Spindle Bush

Basically this training system is similar to that used in the 155 system in that a central leader training method is used to develop a cone shaped tree supported by a post or wire support system. The training form is suitable for medium to medium high density planting with tree height varying from to 2 to 3 meters in height and spread. This tree spacing necessitates the development of a permanent set of scaffold limbs in the bottom third of the tree canopy. Early cropping is desirable were good growth is being obtained in order to control tree vigor and retain the mature tree size to planting space.

Slender Spindle

The difference between a slender spindle and a spindle bush tree is that lateral limb growth is limited by either partial removal or cutting them back to the central leader to develop a renewal shoot. The slender spindle has more of a conical shape than the pyramidal shape of the central leader or spindle bush tree. Limb development is trained to or below the horizontal position to control tree vigour and induce early fruit production. The slender spindle system lends itself to high density planting on dwarf rootstocks with a tree height of 2 m or less. Tree density can vary from 2000 to 5000 trees per hectare, depending upon the use of single row or multiple row bed plantings.

Supper Spindle

The super spindle is characterized by very high tree densities of 3000 to 5000 tree per hectare and close in row spacing at less than 1 meter. Structural wood is not allowed to develop on the trees and from planting onwards, this type of limb development wood tree is pruned off from the main axis. When pruning the 50% rule is closely adhered to. The tree shape has a very narrow columnar look. The advantage of this system is reduced labour inputs and slight earlier fruit production.

French Axe (Central Axis)

The French Axe training system was developed in France by J. M. Lespinasse and is a modified central leader training style with a narrow pyramid shape. This system takes advantage of the natural growth habits of the cultivar to develop a proper balance between vegetative growth and fruiting and allows for early cropping, reduced pruning and training time, improved light distribution within the canopy thus increasing fruit size and colour. The natural growth habit and balance between fruiting and growth is used to control fruit size instead of pruning and thus minimal pruning is a key element of this system. Trees trained to the French Axe are generally planted in single rows to form a fruit wall at maturity. A support system is generally used with this system as it allows for a more rapid development of the leader to the desired height. A trellis system consisting of 1 to 3 wires ranging in height up to 4.3 m depending upon the rootstock cultivar combinations is used to support and train the leader. Where a one wire trellis is used the leader is support by bamboo or conduit piping attached to the single wire at the top of the trellis by a clip. Tree planting densities used for this training method vary from 650 to 2,700 per hectare with in row spacing of 1.2 to 3 m and between row spacing of 3.6 to 4.6 m.

Formal Trellis Systems

There are a number of formal trellis systems and they all have merit under certain growing and financial conditions. The Tatura and the Y trellis system have been the most widely used trellis system in North America in recent years. These systems develop a V-shaped canopy with all limbs being in the same fruiting plane. The advantages of the system are that it is productive, produces high quality fruit and dwarf rootstocks are not required. The draw backs are that the trellises are elaborate and expensive, and meticulous tree training is required.
The height of these systems depends upon the rootstock and cultivar combination but generally do not surpass 3.25 m in height with 60 degree trellis fame. A slightly sharper angle can be used were more tree vigour is desired. The distance between the upper tips of the trellis posts in adjacent rows must be at least 1.8 m. The spacing of trees in the row varies between 0.9 to 1.8 m (depending upon scion/rootstock vigour and soil type) and 4.3 to 5.8 m between rows. Tree density per hectare ranges from 944 to 2,562 trees. The Tatura uses up to 15 wires depending on the height of the trellis while the Y trellis uses 4 to 10 wires. The wires are attached to the post at intervals of 60 cm with the upper two wires spaced closer at 45 cm.

Steps on training and pruning apple trees can be found in AFCC 1208 Pruning and training apple trees.

**Virus Certified Trees**

Most apple virus can effect growth and productivity and some viruses can also reduce fruit size and colour. Virus can occur in the rootstock as well as the cultivar (scion). Only of virus free certified nursery trees or utilising virus free material when propagating should be used when setting out new orchard.

**Putting It All Together**

The success orchard design will be one where the producers is able to match the rootstock cultivar combination with the training system and soil type, which may vary within the orchard site. Being able to do this will provide a tree canopy that is able to optimize light capture, have the potential to produce high quality fruit and facilitate the control of insect and diseases following IPM guide lines.
Section 3 Orchard Fertility Management

Annual fertilizer requirements are determined by leaf analysis, soil analysis, and observation of tree growth and fruit quality. If available pre-harvest fruit analysis should be used to indicate long-term storage potential of the fruit. Fertilizer applications should be based upon these reports and observations.

Leaf samples for tissue analysis are collected once terminal growth has stopped which may occur as early as the last week of July. Sampling can be conducted into mid-August. Soil sample can collected at the time of sampling leaf tissue. Long term fertilization must be made through the soil with foliar nutrients addressing short term deficiencies.

The desired soil nutrient ranges for tree fruit are as follow:

Nutrition Levels

Soil pH Desired range for tree fruits 5.5 to 6.5.

The desired pH range for tree fruit is 5.5 to 6.6 and when the pH gets above or below these levels nutrient disorders can occur. Problems associated with low pH (below 5.5) include: bark measles (manganese or aluminum toxicity), calcium and magnesium deficiency, restricted root growth or regeneration, reduced availability of phosphorus; reduced efficiency of nitrogen and potassium use and poor response to applications of nitrogen and potassium application. Soils in the Atlantic region are naturally acidic however excessive use of lime can result in the pH rising above 6.5. Higher soil pH (above 6.3) may reduce the availability of micronutrients such as manganese copper, zinc and boron. In general, apply limestone (calcite or dolomite) when soil pH drops below 6.0. The type of lime applied should be based upon the soil levels of calcium and magnesium. The ratio of calcium to magnesium in the soil should be 10:1 with dolomitic being used only when soil pH and magnesium levels need to be raised.

Nitrogen - N Desired range for leaf tissue 1.9 to 2.2%.

Nitrogen requirement vary with cultivar, type and extent of pruning, ground cover management and soil type. For example, Red Delicious usually need’s twice as much nitrogen as McIntosh but spur-pruned Red Delicious needs no more nitrogen than McIntosh pruned by scaffold renewal. Unusually heavy pruning or increasing the area that is sprayed with herbicide will decrease need for nitrogen fertilizer. Excessive levels of nitrogen can decrease yield, fruit colour, fruit quality, and storage life. Leeching of nitrates into the ground water is also of concern. Nitrogen deficiency can result in low tree vigour which are more susceptible to winter injury and have a greater biannual bearing tendency. The foliage is light green or yellowish while the fruit is smaller, highly coloured and more prone to premature drop.

The desired leaf tissue level for apples will vary with tree age and cultivar. In young non bearing trees the desired level is 2.4 to 2.6 % while the level for mature bearing trees is 1.9% to 2.4%. The desired level for red fresh fruit cultivars such as McIntosh and Cortland is 1.9 to 2.0% while that for Red Delicious and Northern Spy would be 2.2 to 2.4%.

Phosphorus - P Desired range: Soil 472 to 650 kg/ha; Leaf tissue 0.15 to 0.26%.

The requirement of mature apple trees for phosphorus is relatively low and there is no need to apply any phosphorus if a soil test shows P2O5 to be adequate. The over application of phosphorus can contribute to zinc and copper deficiency and present a risk for water pollution through surface runoff.

Potassium - K Desired Range: Soil 381 to 490 kg/ha; Leaf tissue 1.2 to 1.6%.
Potassium deficiency in apple trees is evidenced by a grey or dull brown cast near the leaf margins which spreads inwards toward the midrib as marginal scorch develops. These symptoms first appear on leaves of fruiting spurs and basal leaves of extension shoots in late July and August. Temporary shortage of water can cause very similar symptoms. Fruit set on deficient trees may be normal, but the fruit is smaller than normal, has poor, dull colour and lacks acidity. The trees are more susceptible to winter cold injury and spring frost injury to flower buds.

Annual applications of potassium to mature trees are generally not required, however on lighter soils soil and tissue levels drop below the desired ranges requiring the application of a potassium containing fertilizer from time to time. As with phosphorus, the needs for potash fertilization are greatest with young trees and fertilization may be discontinued once the tree is well established, or after initial potash shortage in the soil is corrected. Excessive potash fertilization will induce magnesium deficiency and increase calcium deficiency disorders such as bitter pit.

Potash is often perched (trapped) in the upper soil layers. In such cases mulching will increase uptake of potash. Dry weather, which reduces root activity near the soil surface; or excessive water, which decreases soil aeration, will decrease potash uptake. Potash levels will also decrease in years when a full crop is born by the trees.

**Magnesium – Mg** Desired range: Soil 336 to 446 kg/ha; Leaf tissue 0.20 to 0.28%.

The typical symptoms of Mg deficiency in apple trees are yellow or brown patches between the main veins of older leaves, early shedding of leaves and premature drop of fruit. These yellow or brown patches (foliar symptoms) usually develop first near the midrib and spread outward, between the main veins, toward the leaf margin. Leaves of fruiting spurs and basal leaves of extension shoots are usually the first affected. Slight development of these foliar symptoms of Mg deficiency is more or less normal and not indicative of a real deficiency that should be corrected. Excessive pre-harvest fruit drop is associated with moderate Mg deficiency. Tree growth and yield are likely to be decreased if foliar symptoms are severe (more than 20% of leaves affected by late summer).

Measures to prevent or correct magnesium deficiency include: use of dolomitic limestone of high magnesium content (40% magnesium carbonate), potassium-magnesium sulphate (Sul-Po-Mag or K-Mag), Epsom salts foliar sprays and decrease in potash fertilization.

Dolomitic limestone is the most economical way to supply Mg but is slow acting if applied to the surface and not tilled in. By using soil and leaf analysis it is possible to anticipate Mg deficiency. Correct it long before it becomes a real problem, and avoid overcorrecting it, i.e. **avoid applying too much Mg.** Excessive Mg can cause Ca deficiency problems and dolomitic limestone should be used on orchard soils only if a definite need to increase soil Mg. Epsom salts foliar sprays will correct magnesium deficiency. There is no carry-over from year to year thus annual applications may be required until the soil nutrients can be corrected.

Potash fertilization is a key factor in magnesium and calcium nutrition. Potash fertilization should be reduced to the minimum that will avoid potassium deficiency where Mg or Ca deficiency is present or anticipated.

Magnesium deficiency may vary from year to year depending upon weather conditions and the cropping pattern of the trees. Unusually wet or dry soil conditions and high temperatures intensify Mg deficiency. The relationship between Mg deficiency and cropping pattern is complex and more or less unpredictable. In irregular bearing trees the Mg content of leaf tissue tends to be higher in on-crop years. On the other hand, there is an opposing tendency for foliar deficiency symptoms (at a given Mg concentration in leaf
tissue) to increase as crop load increases. In practice, this year to year variation simply means that leaf analysis and observation of symptoms over a period of several years may be required in order to get a reasonably accurate measure of Mg status.

**Calcium – Ca** Desired range: Soil 2,001 to 3,351 kg/ha; Leaf tissue 1.0 to 1.6%.

Calcium is recognized as the most important mineral in relation to storage quality of apples. Low calcium concentrations in apple fruit causes physiological disorders such as bitter pit, water core, lenticel blotch pit and senescent breakdown. Cultivar and cultural practices will have an influence on the level of calcium in the fruit. In the Atlantic Region cultivars that produce large apples are more likely to show signs of fruit disorders than those that produce moderate size fruit. Jonagold, Northern Spy, Honey Crisp and Cortland have a greater tendency to show signs of bitter pit than McIntosh. Cultivars can also vary in the concentration of calcium required for satisfactory storage quality. Soil conditions such as excessive or deficient soil moisture can contribute to calcium disorders. Poor soil conditions resulting in low soil pH, low soil calcium and magnesium levels may result in low levels of fruit Ca. Maintaining a balanced nutrition program is critical, excessive nitrogen, potassium and Magnesium levels and deficient levels of Ca, Boron and Zinc contribute to calcium disorders. Vegetative growth competes with the fruit for calcium therefore cultural practice that allows for moderate growth should be followed. Avoid excessive pruning, high nitrogen levels and light crop loads as these will promote excessive vegetative growth. Light crop loads result in larger apples which are normally lower in calcium on a weight bases and more prone to calcium disorder than medium or smaller sized apples.

Methods, within the fertilizer program, to minimize Ca problems include: use of calcitic limestone, sprays of Ca salts, application of gypsum and avoidance of excessive of K, Mg and N. However, optimum soil management will have relatively little effect unless other conditions are also favorable. Fortunately most of these conditions which are conducive to good fruit Ca, such as good pollination and low leaf to fruit ratio are conditions which are desired in any case. An outstanding exception is the common desire to increase fruit size. If fruit size is increased excessively, especially if this is done by increasing cell size as opposed to increasing cell number, then it may be at the expense of poor fruit Ca, poor shelf life, poor quality and lost markets.

Foliar applications of calcium can eliminate or reduced fruit calcium disorders and may increase storage life when a sufficient volume of calcium is applied. Two to four applications of calcium should correct most minor calcium deficiencies which occur in the Atlantic Region however four to six applications may be need to correct problems in young vigorous orchards producing large fruit of cultivars more prone to bitter pit. Applying four to five kilograms per hectare of actual calcium should correct minor problems while it will require nine to fourteen kilograms to improve storage quality. The timing of sprays will depend upon the number of applications to be applied and are made at two week intervals. The calcium has to land on the fruit to be absorbed into the tissue and the larger the apple the more uptake of calcium. If only two sprays are to be applied they would be best timed to start one month prior to harvest. The more applications required the further they are backup from the start of harvest on a two week bases.

Pre-harvest fruit analysis can be used to indicate long-term storage potential of apples provided Ca-related disorders do not predominate. Leaf Ca cannot be used for this purpose because leaf Ca and fruit Ca are not well correlated.
Management practices that influence fruit calcium are:

- Excessive nitrogen can promote larger fruit which are more prone to calcium related disorders. If leaf tissue nitrogen levels are above the desired range then eliminate or reduce nitrogen fertilizer for one or more seasons.

- Dormant pruning practices that promote excessive vigour will result in higher nitrogen levels and larger apples. When trees are severely pruned, reduce or eliminate nitrogen fertilizer for one or more seasons.

- Summer pruning reduces the number of vegetative growing points which can reduce the movement of calcium from the fruit to vegetative growing points.

- Avoid over thinning as light crop load will promote increased fruit size and vegetative growth thus increasing the likely hood of fruit calcium disorders.

- Avoid excessive levels of potassium and magnesium as they decrease the supply of calcium while increasing the demand for calcium.

- Low soil pH decreases calcium uptake. When applying lime use calcitic limestone when the ratio of calcium to magnesium in the soil is less than 10 to 1.

- Mulch will even out soil moisture fluctuations increasing the availability and uptake of calcium.
Boron - B Desired range: Leaf tissue 20 to 40 ppm.

Internal browning or dry corky tissue around the seed cavity is the most common symptom of boron deficiency in the Atlantic region. Fruit with a boron deficiency may also show symptoms of external cracking, the fruit surface may develop a pebbly appearance and matures early and drops. In addition there may be die-back of wood, or poor fruit set, Boron deficiency is aggravated by dry soil conditions and heavy crop loads and tends to be more pronounced on coarse textured soil. Fruit set may be reduced resulting from a reduction in pollen development and germination. Low boron supply may accentuate deficiencies of other nutrients such as calcium. The best method for preventing boron disorders is the use of boron in mixed fertilizer at a nitrogen to boron ratio of about 50:1 (e.g. 10:0.2 or 17:0.3), by application of about 2 kg/ha (2 lb/acre) boron every third year. The foliar application of boron, by the use of products such as Solubor will provide temporary correction. Excessive liming can cause boron deficiency. Such lime-induced deficiency can be corrected by applying more than the usual amount of boron.

Zinc - Zn Desired range: Leaf tissue 15 to 40 ppm.

Visual symptoms of zinc deficiency are ware in the in the Atlantic Provinces. Symptoms suggestive of zinc deficiency include: poor shoot growth, failure of lateral buds to develop or open (seen as sparse branching, few spurs and growth only from the several buds nearest the tip of last year's growth), delayed opening of buds, slow leaf development, pale or yellowish leaf color early in the year, small and narrow leaves, and die-back or abnormal current growth, small apples and poor fruit color. Abnormal development of pollen tubes resulting in poor fruit set may occur as well as the tree and flowers are more susceptible to freezing temperatures.

Mild zinc deficiencies can be corrected with one to two applications of a zinc containing fungicide during the growing season or a foliar application of zinc sulphate at the low rate being bested time prior to bloom. More serious cases of zinc deficiency may require dormant applications of zinc sulphate and summer application of zinc chelates or other zinc containing materials.

Manures

Fresh animal manure can be a source of e-coli bacteria as well as other bacteria, thus there is a food safety issue with regards to their use in the orchard. Manures are applied to the soil surface which creates a risk of water pollution from surface water runoff. This risk is related to the time of year the manure is applied and proximity of water courses. Manures are a source of N-P-K nutrients however, it is difficult to be precise with the rate of nitrogen being applied thus there is a risk of oversupply or under supplying nitrogen. For these two reasons fresh animal manures do not fit within the guideline of IFP as it is not environmentally sustainable. Composted manures on the other hand do fit within the guidelines and is discussed under mulch in the Ground Cover Management section.

Biosolids

Biosloids are the byproduct of domestic and commercial sewage and wastewater treatment. It is not permissable to apply biosloids to orchards under the Canada GAP (CHC On-Farm Food Safety Program).
Section 4 Ground Cover and Soil Moisture Management

Ground cover management is the manipulation of vegetation within the orchard to maximize its benefit while minimizing its drawbacks. There are many benefits to be gained by managing the ground cover in orchard blocks including more rapid tree growth and earlier bearing, greater response to fertilizer, reduced tree stress during periods of dry weather, increased fruit size and yield, reduced insect injury, minimizing the potential for mouse injury, erosion and insulation against deep cold (frost) penetration.

While total ground cover control will eliminate competition for water and nutrients, it does, have it drawbacks with regards to erosion, dust, frost penetration, and equipment mobility during periods of wet soil conditions. By today’s environmental standards, total vegetation control is not environmentally sustainable under our conditions and doesn’t fit in the IFP concept. Ground cover management in the orchard should make use of grass alleyways and some form of vegetation control under the tree canopy. Year round bare ground is not an environmentally sustainable option. Vegetation control under the tree canopy can included the use of mulch, herbicides, mowing or a combination of these options.

Weed competition in early summer (before mid-July) will decrease shoot growth, tree vigor and fruit bud formation. To get a maximum yield response from managing ground cover, control should start as soon as there is significant new weed growth. Some weed growth in late summer and fall may not affect yield, and re-establishment of weeds under the trees at this time has some advantages. Therefore, under bearing trees a weed control program should aim for enough control to prevent significant weed competition, but enough re-growth during late summer and fall to avoid certain detrimental effects of bare ground.

Weed growth in late summer can be controlled, if necessary, by mowing or the application of glufosinate-ammonium (Ignite). In dry years, extending the period of weed control may increase yields.

When using a herbicide program some re-growth of ground cover, starting about mid-July for bearing trees, has the following advantages over year-long bare ground:

1. There is less chance of excessive nitrogen uptake in late summer and fall by trees. If weather conditions cause an unusually large release of N from soil organic matter, the re-growth will compete with the trees for it. Excessive N late in the summer or fall will cause poor fruit colour, shorten fruit storage life and decrease winter hardiness of the tree.

2. Weed cover will decrease the chance of early frost penetration into the tree root zone before roots are hardened off. This is particularly true on light soils. Weed growth within the row will tend to trap leaves and snow, whereas bare ground is more likely to be swept clean. This will decrease frost penetration into the soil that can injure or kill trees.

3. In the early spring when the soil is very wet there is less chance of loosening and leaning of trees. This problem is generally observed on trees on dwarf rootstocks, especially on soils with poor drainage. The roots of a living ground cover help to bind the soil together and hold the tree against wind action.

4. Soil erosion is minimized. Erosion of bare ground can be extensive, even on soils with a very slight slope, during rapid snow-melt and heavy rains. Vegetation will generally improve soil structure and penetration of water.

5. There is less loss of nutrients by leaching and less soil acidification if vegetation is present during fall, winter and early spring.

6. Decaying organic matter will maintain or increase the soil organic matter and humus (complex mixture
of decayed plant tissue). Humus is a major source of nitrogen, phosphorous, and sulfur and can form chelates with micro-nutrients such as copper, zinc, manganese, etc. These chelated micro-nutrients are held against leaching from the soil, and under the right conditions, are available to be taken up by roots. Cation exchange is improved which, in turns, reduces the leaching of nutrients.

**Permanent sod, with herbicide strip**

This method requires mowing in the alleyways and the use of herbicides in the tree row. It offers the benefits of sod cover with regards to erosion, orchard equipment operation, etc while reducing weed competition in the tree root zone. The reduction in competition will depend upon the width of the herbicide strip. The strip may only be wide enough to allow for safe mowing or may be extended to cover the full width of the tree canopy to promote tree growth. The width of the strip can be adjusted from year to year to compensate for drought conditions. The negative aspect of a weed free-strip is the potential for erosion and frost penetration. The selection of herbicides that allow for late season vegetation growth will help to offset these negative aspects. This method of orchard vegetation management is presently the most commonly used.

**Permanent sod cover over 100% of the orchard floor**

While this option eliminates the undesirable characteristic of bare ground, trees will still have to compete with the ground cover for nutrients and moisture. Mowing the orchard (alleyways and under trees) several times a year is required to keep this competition at a minimum. This option should only be considered for mature orchards, once the trees have filled their allotted space. Rootstock and soil type also should be taken into consideration when selecting this option as dwarf rootstocks are influenced more by competition and light soils have less nutrient and soil moisture retention. When utilizing a permanent sod cover growers should consider the use of grasses and grass mixtures such as Canada and Kentucky Blue grass that are dwarfing and need less frequent mowing. Mowing in the fall is a must to expose mice to predators.

**Mulching**

The use of mulches to control weeds in orchards is attracting more attention because of environmental issues with regards to the use of herbicides, the negative aspects of maintaining a clean herbicide strip and the benefits to be obtained from mulches. Mulched strips can be used in combination with mowing and herbicides to control ground cover. Prior to the application of mulch, it is beneficial to control weeds by means of suitable herbicides or cultivation. Spot spraying with an herbicide such as glyphosate may also be required to keep weeds out of the mulch. A number of materials can be used, (hay, straw, wood chips, wood bark, composted manure and composted organic waste etc.), with hay and straw presently being the most commonly used in Nova Scotia. Hay and straw mulch will increase soil organic matter and potassium.

Mulch can:

- Correct light soil that has poor holding capacity for water nutrients,
- Improve heavier soil with poor structure
- Open up soils that restrict deep rooting,
- Correct soils subject to heaving
- Improve soils low in potash and top soil subject to erosion,
- Insulate the roots and reduce root damage where sub freezing temperatures occur, particularly important were herbicide strips are maintained through winters without snow cover,
- Keep soils cooler during the summer months and help conserve soil moisture
- Depending upon the level of soil moisture, mulch may be just as effective as irrigation in reducing drought stress
The negative aspects of mulching are that it is labour intensive to apply, it can provide a shelter for mice and reduce the availability of nitrogen to fruit trees the year of application. When using mulch, potential mice and nutrient problems will need to be addressed.

Decaying organic matter will maintain or increase the soil organic matter and humus (complex mixture of decayed plant tissue). Humus can increase moisture-retaining ability of sandy soils as organic matter can hold up to 20 times its weight in water. Humus is a major source of nitrogen, phosphorous, and sulfur and can form chelates with micro-nutrients such as copper, zinc, manganese, etc. These chelated micro-nutrients are held against leaching from the soil, and under the right conditions, are available to be taken up by roots. Cation exchange is improved which, in turns, reduces the leaching of nutrients. It will bind soil mineral particles together to form aggregates. These provide a loose, open, granular condition that aids penetration of water, air, and roots and resists erosion. Humus has the ability to absorb many organic pesticides, holding them near the soil surface, where they are more likely to be degraded by biological activity and sunlight, rather than leaching to groundwater.

Organic mulches should be applied early in the growing season while the soil is still moist. Relatively sparse hay mulch (0.5-1 kg/m²; 0.1-0.2 lb/ft²) applied each spring, shortly after herbicide application, leads to year-round mulch cover and maximum benefit per unit of mulch. Deep mulch encourages mice, especially if applied late in the year, it decays more rapidly than sparse mulch because the lower portions are moist for longer periods and, if applied to dry soil, can temporarily decrease moisture availability by intercepting light summer rains. Decomposable organic mulches can reduce fertilizer needs and if rich enough, (e.g. hay from fertile land), can entirely replace mineral fertilizer.

**Cultivation**

In the past this was the most common method for weed management in orchards. While clean cultivation has the potential of eliminating weed competition in an orchard, the negative aspects of this method doesn’t make it a suitable option. Discing of the soil can cause root and bark injury to fruit trees. Without a ground cover, severe soil erosion can occur, and organic matter is broken down more quickly than with other forms of orchard floor management. Operation of orchard equipment can be hindered during periods of wet weather. Clean cultivation in the year of planting can be used to reduce the risk of herbicide damage to newly planted trees. In new plantings a sod cover should be established in the fall to reduce soil erosion.

**Moisture Management**

The first step in good moisture management is the selection of orchard soils that allows for deep rooting, good water and nutrient holding capacity. Apple trees on these sites, if well managed, will seldom suffer from prolonged periods of dry weather which periodically occur in the Atlantic Region. In our region excessive moisture presents more of a problem than lack of moisture.

Excess moisture in the root zone has a negative impact on root activity by restricting gas exchange in and out of the soil, keeping spring soil temperatures low, contributing to frost heaving, forcing new roots to grow just below or even on the soil surface, making the root system more susceptible to attack by soil pathogens and contributing to the old problem of tree leaning. The time to correct excessive moisture problems is during the site preparation period. Refer to AFCC 1209 *Planting and care of the young apple orchard* on options for controlling excessive soil moisture.

Apple trees grown in soil types that have limited soil-water retention can be subjected to periods of drought stress particularly in growing seasons with less than average rain fall. In years with average rain fall there still may periods of drought stress because of the lack of rain fall for one to two week periods or
Conserving soil moisture will help fruit to offset these periods of dry weather.

Steps to conserve soil moisture begin with site preparation. Cover crops grown on the orchard site can increase organic matter in the soil improving its ability to retain moisture. Once trees have been planted the best practice for soil conservation is the use of mulch under the tree canopy. The mulch will reduce moisture evaporation from the soil, minimize weed growth and competition for soil moisture and improve soil organic matter.

Reducing weed growth under the trees by means of herbicides will assist with water conservation as these weeds compete for soil moisture. Mulching is preferred over the use of herbicides for best management practices however the uses of certain herbicides are permitted. When using herbicides early season weed control is more beneficial than late season application for moisture conservation. The width of the herbicide strip can be increased when below average rain fall is experienced, particularly early on in the growing season.

Frequent orchard mowing of the alleyway and under the tree canopy where mulched or herbicides are not used will assist with soil conservation. Vegetative growth should be maintained at less than 20 cm in height. Controlling vegetative growth under the tree canopy by mowing is less effective than herbicides and mulching in improving fruit size but is still better than not mowing. The best practise is to use the combination of mowing with mulching.

On soils which have poor soil water retention irrigation may be required as the above options are not sufficient to overcome moisture deficiencies. Irrigation is costly and has only proven financially beneficial on certain soil types in our region. Growers should consult with a soil specialist to determine the soil type and water holding capacity to determine if irrigation is required. If it is determined that irrigation would be financially beneficial than an irrigation specialist should be consulted to design an irrigation system for the new planting. To obtain the full benefits of an irrigation system, particularly trickle irrigation systems, they should be installed and function at the time of planting.
Section 5 Tree Training & Pruning

Light is a major limiting factor in fruit production. It influences flower bud formation, productivity and fruit quality. The productivity of an orchard is directly related to the amount of light intercepted by the orchard. One of the main goals of pruning and training apple trees should be to maximize light capture and distribution within the tree canopy to increase flower bud development, fruit set and fruit quality.

Tree form and size along with tree density will determine the percentage of light captured for fruit production. In general the effective light penetration into the tree canopy is approximately 1 meter and based upon this, the tree canopy can be broken down into tree zones according to light penetration. Zone one located in the top portion of the tree receives 100 to 60% full sunlight, zone two receives 59 to 30% full sunlight and zone three receiving less than 30% full sunlight. Once light levels drop below 30% of full sunlight, flower-bud formation is reduced, spur vigor is lost and fruit that are produced in this zone are small and of poor quality. Fruit production will decline in this area as a result of fruit spurs death. Zone 3 is a non productive zone and the size of this zone is influenced by size tree, tree form and pruning.

Tree size has a significant influence on the area of zone three within the tree canopy. This area of inadequate light can vary as much as 25% in a large central leader tree to as little as 1.6% in a dwarf central leader tree. The smaller area of nonproductive zone is one of the reasons why dwarf trees can be more productive than large trees. Consideration also needs to be given to shading by adjacent trees. With increasing tree height there is a greater tendency for the top of the tree to shade the bottom, the bottom of adjacent trees or the bottoms of adjacent rows. In free standing trees, the height should not exceed the spread of the branches. In tree walls and trellis systems, the height should not be greater than the distance between rows. A tree height that does not exceed four meters will lend itself best to IFP.

Tree shape also affects light distribution within the tree canopy and the areas of the three zones. A conic or pyramidal shape such as a central leader tree produces a much more favorable light distribution than that of the globular form which was typical of standard trees and is well suited for IFP. The most common tree forms that apple trees are trained to are as follow: 1) Globular which is characteristic of large open centered tree were the most productive portion of the tree is top third, were the fruit is less accessible. 2) Conical or pyramidal this would be
characteristic of Christmas tree shape with an open framework. The top of the tree does not shade the bottom branches and a major part of the bearing surface is close to the ground. The open framework will allow light to penetrate well into the canopy. Central leader and spindle bush tree are good examples of this shape. 3) Vertical tree wall were the spread of the limbs across the row is limited to about 2 m. The restricted limb spread allows for effective light penetration. The central axe tree is an example of this form. 4) Horizontal canopy: were the thickness of the canopy is limited to about 1 m which allows for effective light penetration to the full canopy. The Lincoln canopy is good example of this tree form. 5) Y or V form which allow for maximum light penetration while providing growth control and influencing productivity. The Tatura V trellis and the New York Y trellis are examples of this form. The conic, vertical tree wall and Y or V trellises shapes lend themselves best to fruit production in the Atlantic Region.

**When to Prune and Objectives**

There are two preferred times - when the tree is dormant and in the summer when terminal shoot buds have been formed. In N.S. and N.B. climatic conditions dictate the dormant pruning period as pruning can contribute to winter kill or damage. The safe period for dormant pruning is usually from early March to the end of April. Late fall or early winter pruning is especially risky as the trees have not yet fully prepared for maximum cold and pruning will delay this process, especially so if many cuts are made. Growers that cannot wait until early March to begin pruning should at least wait until the end of January and only prune blocks that are due for removal in the near future, those that bore light crops, trees which require only light pruning or hardier cultivars. If necessary growers can continue dormant type pruning up until bloom but once growth has started the growth response to pruning cuts will not be same as when the tree is fully dormant. In Nova Scotia and New Brunswick summer pruning may be done the last of July into early August once the terminal bud has been set. Summer pruning prior to this can result in weak shoot growth which is prone to winter kill.

The objectives of pruning will vary with tree age, cultivar, rootstock, training system, tree vigour and may included the following:

- Improve the fruit bearing surface to light exposure thereby increase or maintain fruitfulness and improve fruit quality.
- To control tree size, height and limb spread, alleviate crowding and permit efficient orchard operations.
- Stimulate growth or vigour in the whole tree or portions of the tree.
- To remove broken, diseased (cankers), or insect-infested (borers) branches.
- To remove weak bearing wood that is marginally productive (i.e. producing poor quality fruit).
- To remove excessively vigorous, unproductive wood that creates undesirable shading and restricts spray penetration.
- To renew areas of declining fruit production.
- To open the tree to effective spray penetration to improve disease and insect control.
It is best to conduct dormant pruning of apple trees on annual bases to keep fruit and vegetative growth in balance thus reducing the need to carry out heavy pruning which upset the balance between fruit and growth. Maintaining uniform vigour is important in obtaining proper light penetration throughout the tree and thus fruitfulness. Pruning that promotes excessive tree vigour often results in reduced yields, fruit quality and storage life. Summer pruning may not be required on an annual base and is often cultivar dependent; it may be used for the following three reasons:

- To improve fruit colour and in some situations improve fruit calcium content. Summer pruning may have a negative impact on fruit size yield and soluble solids particularly when extensive pruning is conducted. Production should be monitored to determine if summer pruning is having the desired results.

- To control vegetative growth and tree vigour. Summer pruning to control excessive vigour is a two edge sword in that the amount of growth removed to achieve the desired results often results in the reduction of fruit size, yield and soluble solids. Summer pruning to alleviate a crowding problem may not require as much growth removal as that of vigour control and thus may not impact fruit quality. Trees that have moderate or low vigour should not be summer pruned.

- To reduce pest and disease problems. Removing succulent shoots will reduce woolly aphid habitat and open trees to better spray penetration and air movement. Improved air movement will decrease humidity and drying time, which will help to control summer diseases such as fly speck and sooty mould.

When pruning and training apple trees some of the principals that need to be followed are:

- Pruning can never make a tree larger, parts of the tree are removed and thus it is a dwarfing process.

- Pruning encourages shoot growth; there are fewer buds (shoots) to compete with each other, so each grows somewhat more.

- Pruning is more dwarfing and less invigorating when done after growth has started compared to dormant pruning.

- Removal of large branches removes more reserves, is less stimulating and is more dwarfing, than is the removal of many small branches having an equivalent number of growing points (buds).

- Pruning must be integrated with other factors such as fertilization, irrigation, rootstock, cropping, spraying, etc. according to economic conditions for best results.

- Young trees should be trained not pruned; it is better to prevent undesirable shoots from developing than to waste the tree energy in producing twigs which must be cut off before they have fruited.

- A single strongly growing dominant terminal shoot will induce wide angles on any basipetal lateral shots. It will also tend to inhibit the initiation and development of lateral shoots.

- Correct pruning becomes more critical as the tree becomes crowded; in modern intensive plantings, training and pruning must be carefully planned and executed.
• Train and prune so that a bearing surface will develop and can be maintained where you want it. Ideally each leaf should receive the equivalent of at least 50 percent full sun skylight every day. This means the canopy should not be over 2 leaves equivalent in thickness and well spread over the orchard area. While such an arrangement is not fully attainable in practice it is well to know that this is the goal towards which one should be striving for.

• Cuts should be close to the branch or limb; do not leave sticks or snags which will die back, heal slowly and leave a point of entry for disease. Wound dressings, such as the asphalt emulsions may be applied to large cuts (5 cm or larger in diameter). This generally are not required if the trees are in good vigor and correct pruning cuts made.

The specifics for pruning will be influenced by the local climate; intended market, cultivar; strains of cultivar, rootstock; tree density and management system, local expertise and the individuals philosophy and expertise. For these reasons pruning practices will change from orchard to orchard and farm to farm; however by following the basic objectives of pruning, and combining pruning the proper nutrient and crop load management, will ensure for good yields of high quality fruit.

Additional information on pruning can be found in AFCC 1208 Pruning and training apple trees while an excellent reference book on pruning is Training and pruning apple and pear trees by C.G. Forshey, D. C. Elfving and R. L. Stebbins and published by the American Society for Horticultural Science.

Training refers to the development of the structural framework of the trees. While some training may be necessary after the tree comes into production, this activity is largely confined to the nonbearing years. The objective of the training program is to develop a frame work that effectively displays a large surface area of the tree canopy to full sunlight and will support heavy crop loads. Pruning is part of the training program. Detail steps on tree training are provide in the publication AFCC 1208 Pruning and training apple trees for the central leader, central axe and the Y and V trellis systems.
Section 6 Crop Load Management

Given today's economic situation growers cannot afford to have fruit trees in a biannual bearing habit or producing under sized fruit. Thinning of the fruit will improve fruit size, quality and regulate cropping. In most situations growers will need to make use of registered chemical thinners followed up with hand thinning. Chemicals thinners vary in their impact on the environment and growers should use those products that have minimal impact on beneficial insect, human health and the environment while being economical.

Advantages of chemical thinners are:
- Increased fruit size and quality
- Reduced biennial bearing
- Increased fruit yield

There are a number of factors and variables that can affect the outcome of chemical thinners and these need to be taken into account to maximize the benefits of thinning.

Weather conditions

- Cool, wet weather preceding application may precondition leaves, causing more thinning than usual.
- Trees subject to frost or low temperatures at "pink" or "bloom" are easier to thin.
- Slow drying conditions following spray application increases the thinning effect of hormone type products.
- Low temperatures (≤10°C) during spray application decrease the thinning effect.
- Low humidity causes rapid drying of the spray and decreased absorption occurs before and after spraying decreases the thinning effect.
- Prolonged cloudy periods reduce photosynthesis before or after application and will increase the thinning effect.
- Fruit that has set under good pollination conditions is more difficult to thin.

Tree Conditions

- Any stress on the tree makes it easier to thin.
- Trees with a heavy bloom and/or fruit set are thinned more readily than those with a light bloom and/or fruit set.
- Trees that bore a heavy crop or were under stress in the previous season are somewhat easier to thin.
- Trees that are weak, suffering from lack of nutrition, have root damage or have been mouse girdled will be easily over thinned.
• Young trees are easier to thin than are mature trees.

• Fruit on spurs in well-lighted areas of a tree (topes and outer periphery) are more difficult to thin then fruit on spurs on the lower, shaded inside branches are easier to thin.

Cultivar Response

• Cultivars respond differently to chemical thinners:

• Spur-type trees mature faster and show biennial bearing characteristics earlier than do non spur-type trees. Spur-type trees should be thinned to induce annual bearing. Heavy setting spur-type trees are more difficult to thin.

Table 5: Easy of thinning

<table>
<thead>
<tr>
<th>Easy</th>
<th>Moderately difficult</th>
<th>Difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idared</td>
<td>Corrtland</td>
<td>Golden Delicious</td>
</tr>
<tr>
<td>Non-spur Red Delicious</td>
<td>McIntosh</td>
<td>Gravenstein</td>
</tr>
<tr>
<td>Jonagold</td>
<td>Spy</td>
<td>Spartan</td>
</tr>
<tr>
<td></td>
<td>Empire</td>
<td>Vista Bella</td>
</tr>
<tr>
<td></td>
<td>Honeycrisp</td>
<td>Gala</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paulared</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spur-type Red Delicious</td>
</tr>
</tbody>
</table>

Other

• Addition of a wetting agent (surfactant) will enhance the effectiveness of the thinning agent.

• Trees treated with the growth regulator Promalin during the bloom period are easier to thin.

• The application of Apogee for vegetative growth control may increase the strength of fruit set there by making it more difficult to thin.

When these factors are taken into consideration, growers have been very successful seldom having variable results.
Steps in Successful Thinning

The first step in a successful thinning program is maximizing good pollination conditions. It is important for growers to be able to predict a heavy set. There are a number of essentials that contribute to a good set. These are:

- Adequate bloom of having vigour.
- Sufficient fresh, ripe pollen from other diploid cultivars such as McIntosh, Cortland, Red and Golden Delicious, Spartan and Idared.
- Honey bee and other pollinating insect activity to carry pollen to the stigma of the flower.
- Warm $\geq 18^\circ$C temperatures, bright light, and relatively calm conditions all encourage pollen maturity and bee activity. Assessment of these conditions often determines the success or failure of the thinning program.

Details on specific thinners and rates of thinners for various apple cultivars are given in ACC 1215 *Thinners and growth regulators for fruit trees.*
Section 7 Insect and Disease Management

It is best to follow a progressive ‘Integrated Pest Management’ (IPM) program that embraces new advancements in pests control to manage diseases and insects. Since the early 1600s Maritime farmers have had to control the dozen or so species of insects & mites that threaten the economic viability of fruit production. ‘Harmonized Pest Management’ as championed by the late A.D. Pickett, is the foundation of today’s Maritime IPM. It was a great revelation to both orchardists and the scientific community when, in the early 1900s, Nova Scotia researchers resolved the broad, negative impact of sulphur-based fungicides on key beneficial parasites that suppressed pest populations. This opened the door to the realization that there are far-reaching consequences and interactions not only among pesticides used, but also horticultural practices that impact the several thousand different kinds of organisms living in the orchard habitat.

Seventy-five percent of the pesticides used in an orchard are fungicides directed against apple scab and secondary plant pathogens. As discussed elsewhere in the manual, growers must select a fungicide program that will have the least impact on other orchard pests. A sound knowledge of pest biology is essential if orchardists are to optimize the pest management tools available while minimizing crop losses. In addition to the ‘Nova Scotia Tree Fruit Production Guide’, a copy of the ‘Nova Scotia Orchard Pest Management Fact Sheets’ is a vital tool.

Historically growers have accepted up to 5.0% loss from all pests (not more than 1.0% from any single pest). Fundamental to IPM, within IFP, is the reality that eradication of a pest is unlikely, if not impossible and it is not cost efficient to apply precautionary insecticides. Mere detection (with rare exceptions) does not necessarily mean there is a need to apply a pesticide. Monitoring for pathogens, insects and mites requires specific methods & tools as discussed in this and associated documents. These tools and techniques include examination of fruit spur leaf clusters, use of sex pheromone lure-baited traps and limb tapping into collection trays. In order to find and identify pests the orchard manager must have a good quality 10 or 20x magnification hand lens. A worthwhile investment is a ‘student grade’ dissecting scope that will further expand your capability to quickly identify small insects.

Pathogens  Apple scab is the ‘key’ organism that drives pest management programs, and accounts for most of the precautionary control measures. Orchards that are not treated for this pathogen will most certainly have a complete crop loss. Other fungal pathogens include powdery mildew, blossom end rot, nectari or European canker, Gloeosporium canker Crown and Collar rot, Sooty blotch, fly speck and frog eye leaf spot. Most serious among bacterial agents is fire blight, which, although present in the Maritimes, has not spread beyond our ability to manage it. Fruit trees replanted into previous orchard land sometimes encounter a ‘replant’ complex of fungal/bacterial/nematode pests, especially if the orchard is planted on sandy loam soils.

Phytophagous mites  European red mite, two spotted spider mite and apple rust mite are the prominent species of plant-attacking acarids. Although not directly damaging to the fruit, these mites in all their motile life stages can drain the nutrients from the trees and dramatically degrade fruit quality. Fortunately there is an array of predatory mite species that can, if properly managed, keep these pests from reaching economically damaging levels.

Insects  About one dozen insect species can inflict significant direct damage to fruit, while another eight species indirectly feed on leaves, shoot terminals or trunk scaffolding. Growers need to use control measures in nine years out of ten for apple maggot, codling moth and winter moth. Minor or sporadic pests are often kept in check by a diverse array of predatory or parasitic insects collectively called ‘beneficials’ because they offer some measure of pest control. Flair up of minor pests often can be traced to the application of a pesticide during a vulnerable life stage of the beneficial.
Reviewing individual orchard farm operations will reveal tailored opportunities that best fit an orchardist’s circumstances. Horticultural practices impact pest abundance. Well pruned trees allow optimum air flow and spray penetration that prevents apple scab outbreaks. Fall mowing that keeps orchard vegetation short, coupled with gathering of drop apples, and discourages rodent populations from taking up over wintering living quarters in a block. Elimination of wild apple and hawthorn from the borders surrounding orchards prevents both pathogens & insects from invading commercial crops. Avoiding broad spectrum highly disruptive products ((e.g. Organophosphates (Imidan, Gethion,Diazinon Zolone), Pyrethoids (Pounce, Ripcord, Matador,Decis) Thiodan, sulphur-based fungicides) encourages biological control of pests to play a larger role in their management. This minimizes the flare ups of secondary pests (e.g. leafminers, woolly apple aphids and leafrollers).

In the past, common farming practices have led us to believe that unless we took action against disease, animal and insect problems they would never go away. Now we are beginning to understand that given the chance, Mother Nature will lend us a hand. Natural predators such as foxes, coyotes and hawks will work full time keeping our orchards free of rabbits, mice and voles. Swallows will consume thousands of moths and other flying insects.

As part of the IFP program, growers should encourage predators by maintaining suitable habitat on the property to promote foxes that feed on voles, mice and rabbits. That means that the farmer avoids disturbing the dens of these beneficial.

For avian predators such as kestrels, owls and hawks, a few nesting boxes erected near the orchards can make them welcome. They can contribute significantly in keeping the rodent population under control.

The first and most important component of any IPM program is a monitoring system for insects, mites, and diseases. Regular monitoring for pest and beneficial species provides the essential information needed to make the important management decisions that save money. Without good information, decisions on the need for sprays, which chemicals to use and how often can be made only very crudely. In this day-and-age, with the technology and expertise available, there is no reason for making uninformed management decisions.

The skills required to get the best results from monitoring include the following.

- Experience to efficiently find and accurately identify the economically important pests
- An understanding of the interactions between the plants, insects, mites, and diseases in the system
- Knowledge to interpret observations and integrate the results into a management decision
- Ability to recognize and evaluate the pest potential of unfamiliar, or introduced, organisms

**Fungal and Bacterial Pathogen**

**Apple Scab** (*Venturia inaequalis)*:

**Biology**

Apple scab is the fungal disease that presents the greatest disease 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 these 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**

The best defense against apple scab is to grow scab resistant apple cultivars however the demand for these cultivars in the market place is very low and not presently financially sustainable for the overall industry. Fruit quality, public acceptance and competition for other apple growing regions are the major factors
preventing the adoption of disease resistant cultivars. As plant breeders continue to improve the quality of scab resistant they should become a viable alternative to the susceptible cultivars. For a partial list of scab resistant cultivars and their qualities see Appendix B and C.

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 enhance the decomposition of 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 may need to be modified with leaf rakes to be able to reach under and around trees as well as along the boundaries of the orchard where windblown leaves catch in the long grass. The application of urea in the fall or spring to the fallen leaves in some growing regions has speed up the breakdown of the leaves and reduced ascospore numbers. 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. Removal of wild apple trees from the borders of the orchard will also reduce scab spore levels and will also help with insect pest suppression.

The second line of defense is a fungicide program that controls primary and secondary scab infections with the least number of fungicide applications. The timing of fungicide applications should be based upon ascospore production, the risk of infection (wetness duration and temperature), development of leaf tissue and the efficacy of the previous fungicide treatment. New leaves that develop after a fungicide application are unprotected and leaf growth causes a ‘fungicide dilution’ which may be insufficient to provide protection. A protectant fungicide is considered to be washed off by 25 mm or more of rain fall. The efficacy of a fungicide declines with time and 7 to 10 days following treatment the efficacy level is very low. The timing of fungicide should take these factors into consideration. Conditions may be such that the spray interval may only be 4-5 days apart while at other times it may span 10-14 days apart.

The control of primary infections will lessen the need for fungicide applications to control secondary infections. 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, 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. A close examination of orchard blocks in mid June should determine the need for control of secondary infections.

Registered fungicides to control apple scab are provided in appendix C along with information on their toxicity and impact on beneficial insects. When possible it is best to use a fungicide that has the least impact on beneficial orchard insects. Resistance management is also very important when using certain classes of fungicide. Growers should not use more than two back to back sprays of fungicides from one of the following groups1, M2, 3 or11 fungicides and not more than 4 times during the growing season. Repeated use of a fungicide within one of these groupings will lead to resistance development and loss of efficacy.

**Fire Blight** (*Erwinia amylovora*)
**Biology**

Fire blight is a bacterial disease of the blossoms and tender new shoots of apples and pears. 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. While feeding on the ooze flies and ants pick 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**

Streptomycin presently is the most effective product registered in Canada for fire blight control. Repeated applications of streptomycin could lead to the development of strains of fire blight bacteria that are resistant thus the need to limit its application to no more than 3 during the growing season. BloomTime®, BlightBan C9-1®, BlightBan A506 and Serenade MAX have recently been registered for use in Canada. These products will provide suppression but may not provide 100% control when used by themselves. These biological control bacteria compete with the fire blight bacteria for nutrients and space on susceptible blossoms. Therefore, these products 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 to 100 percent bloom for maximum effectiveness. 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 and timing of streptomycin applications. The best control approach to the blossom blight stage of fire blight is to use a prediction model to determine the need for streptomycin applications and the use of biological controls to provide protection during the early to mid bloom period.

Fire blight cankers are best 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 removing the infected plant material. Also, remove suckers or water sprouts 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 basis to protect them. It has been suggested that when pruning out fire blight in the growing season it is best to 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.

It is also essential to avoid the production of excessive green succulent growth due to heavy pruning or excessive nitrogen application. Green succulent growth is favored 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. The application of the growth regulator Apogee® will reduce vegetative growth and the incidents of shoot infections.

Apple Replant Disease

Apple replant disease is characterized by very slow growth of apple trees planted in the same ground 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 compared to trees planted in the same location that does not have apple replant disease. Failure to control replant disease can lead to lost productivity and returns.
Control

If available set out new orchard on land that had not previously been planted to apple orchard. On old sites soil fumigation is presently the most effective means to overcome apple replant disease. Alternative to the present soil fumigates are being investigated because of their impact on the environment. 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.

Secondary Diseases

Powdery Mildew (*Podosphaera leucotricha*)

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 overwinters 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, 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 prior to bloom and three weeks post 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 was a moderate to severe problem during the previous growing season, fungicides applications on regular bases from tight cluster to calyx should provide adequate control. A number of fungicides control both powdery mildew and apple scab. When selecting a fungicide program resistance management should be taken into consideration. Do not use more than two back to back sprays...
of fungicides from within groups 1,3and11.

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

**Biology**

Nectria canker is a fungal disease of the apple tree bark. Both sexual (ascospores) 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 apples and can infect healthy bark on the trunk and scaffolds of young trees. 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.

**Crown and Collar 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*

Proper site preparation and rootstock selection are the best means to control *Phytophthora cactorum*. 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. The fungicides Ridomil Gold 480 SL and Aliette WDG are registered as drench treatment on non bearing apple trees while Aliette WDG can be applied as a foliar spray to bearing apple trees as a control.
**Bitter Rot, Ripe Spot and Bull's-eye Rot**

![Image of a fruit with a brown lesion and bull's-eye appearance]

**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 the 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). Fungicide application that control apple scab will generally control these secondary diseases.

**Blossom-end Rot** *(Sclerotinia sclerotiorum)*

![Image of apples with blossom-end rot]

**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, 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

In some crops it has been shown that dandelions are a source of Sclerotinia diseases. Good weed control, orchard floor management and the removal of infected fruit from the orchard may have some impact on the severity of the disease. Some of the fungicides applied to control apple scab may provide some protection.

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

![Sooty Blotch and Fly Speck](image)

**Biology**

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 too 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. Fungicide programs for apple scab control will control these diseases in most situations. Growers can occasionally run into problems with these diseases when they terminated scab control programs too early in the growing season or use a fungicide that does not control these secondary diseases.

**Frog-eye Leaf Spot** (*Physalospora obtusa*)

![Frog-eye Leaf Spot](image)

**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 blight twigs and fire blight cankers can be invaded by this pathogen resulting in elongated bark cankers of 0.5 meters or more.

**Control**

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. Remove current seasons pruning’s from the orchard or chop with a flail mower. Do not pile prunings on the perimeter of the orchard as they can act as a source of inoculum. The DMI fungicides used for scab control will not control this disease while Captan or Maestro will.

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

**Biology**

This is another unusual fungal disease of apples 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**

Removal of *Juniperus* species in the vicinity of apple orchards will reduce the amount of spores reaching an orchard.
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 (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. 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*)

Biology

The apple maggot is the only orchard pest that is regulated in Nova Scotia so that export restriction can be met. 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 overwintered 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 flies do not emerge from the pupae the first summer pupae; some remain in the soil until the second or third. 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 cultivars such as Bough Sweet. Cortland, Gravenstein, Delicious and Honeycrisp apples are also attractive to apple maggot. Other hosts for apple maggots are hawthorn, crabapples and wild apples which should be removed from the vicinity of the orchard.

What to Look For:

- Become familiar with what the adult apple maggot fly looks like by referring to some of the many pictures available in print and on the Internet.
- The male and female are very similar in appearance except that the male is slightly smaller, and has a shorter abdomen with a rounded tip. To the trained eye, there are three transverse white stripes on the abdomen of the male versus four on the female. The ability to sex the flies is not critical for the purposes of monitoring.
How to sample:

- The best method is to trap the adult flies using yellow sticky traps with an apple volatile lure as an attractant.
- Place these traps in orchards the first week of July.
- Use at least three traps per four-hectare block.
- Hang the traps at eye level in the outer canopy, on the sunny side of a susceptible cultivar such as Gravenstein, Bow Sweet, or other early cultivars.
- Try to choose locations in the orchard block that have historically been prone to apple maggot infestations. For example, on a border with a known source such as wild host trees.
- Check the traps at least weekly starting one week after placement, and continue checking weekly until at least mid-August.
- Clean the traps when needed (or replace if necessary), but at least remove all apple maggot flies after they are counted and recorded.

Interpretation of observations:

- The problem with apple maggot is that the immature stages, or larvae, inhabit the fruit. Often, infested fruit can remain on the trees until picking time, and actually get harvested along with the non-infested fruit. Infested fruit that gets processed can spoil a lot of product because of the undesirable appearance that the larval tunnels create in the apple. Also, no one likes biting into fresh fruit only to discover maggot trails, or the maggots themselves. Therefore, the threshold is generally accepted to be one fly per orchard block.
- If your crop is potentially for export, then the threshold is one fly per block. **There is simply no tolerance for apple maggots in fruit that will be exported. If infested fruit is discovered in a shipment, the whole shipment is rejected.**
- Apple maggot larvae in fruit that is destined for pack out or processing is unacceptable because it makes grading more expensive and missed infested fruit can negatively impact packer reputation, and may result in litigation. Therefore, the threshold is, again, one apple maggot fly per orchard block.
- For smaller operations that sell at the farm gate or for juice, the threshold can be raised slightly to 2-3 apple maggot flies per block.
- Traps should be inspected and cleaned immediately prior to a treatment.
- If additional apple maggot flies are captured 10-14 days after treatment, then another treatment is warranted. In most cases where flies occur, two treatments give adequate control for the season. For main season cultivars sprays after mid-August are seldom required despite maggot fly flight that extends into September.

**Control**

A control strategy must be applied when one fly is caught per sticky board. Choose a suitable insecticide from those listed in the most current edition of the Nova Scotia ‘Orchard Management Schedule’. 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.

**Codling Moth** (*Cydia pomonella*)
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 approximately 10 days later depending upon temperature 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.

What to Look For:

- Become familiar with what the adult male codling moth looks like by referring to some of the many pictures available in print and on the Internet.
- The female is very similar in appearance except for the hind wing markings. Growers will seldom ever see, or know they have seen an adult female codling moth.
- The adult male is the only stage you need to be able to recognize for monitoring purposes.

How to Sample:

- Use pheromone traps. These traps are called wing traps because of the appearance. The top forms a roof over the bottom to deflect rainwater and spray blasts. The bottom is a similar shape, but is notched on either end to provide entrances for the male moths. There is also a sticky trapping surface on the inside of the bottom. A pheromone lure is placed in the middle of the bottom. A wire hanger holds the trap together.
- Traps should be placed in orchards shortly after the first emergence of adult male codling moths. In Nova Scotia traps go up late May or early June.
- Hang the traps on high, or rising, ground on the windward side of an orchard.
- Use 1-2 traps for every 4 hectares of orchard.
- Check traps weekly and record the number of captures since the previous count. The easiest way to keep track of what to count is to remove all counted moths at the end of each visit.
- Record the count of moths and add the number to the previous counts.

Interpretation of observations:

- Compare the cumulative total count to the thresholds in the following table. Be sure to take into consideration the estimated crop load because lighter crops can be subject to a higher percentage of fruit damage.
- Be sure to do a moth count and clean the trap out immediately prior to a treatment.
- After the first threshold has been reached and a treatment applied, continue monitoring the traps. If an additional 10 moths are captured, before the end of July, a second treatment should be considered.
### Table 6: Codling moth decision table

<table>
<thead>
<tr>
<th>Cumulative trap count</th>
<th>&lt;20</th>
<th>21-50</th>
<th>51-80</th>
<th>&gt;80</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-19</td>
<td>X</td>
<td>¼</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>20-39</td>
<td>X</td>
<td>⅓</td>
<td>⅓</td>
<td>X</td>
</tr>
<tr>
<td>40-99</td>
<td>⅓</td>
<td>⅔</td>
<td>⅔</td>
<td>⅔</td>
</tr>
<tr>
<td>100-199</td>
<td>⅔</td>
<td>⅔</td>
<td>⅔</td>
<td>⅔</td>
</tr>
<tr>
<td>200+</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

X = no treatment, ¼ = ⅓ label rate, ⅔ = ½ label rate, 1 = full label rate

### Control

A total count (cumulative count) of 40 moths per trap means economic injury will occur if controls are not applied (see above table for thresholds). Current pesticides controls for codling moth can be found in the most recent edition of the Nova Scotia “Orchard Management Schedule.” 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 within 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 ancyivorius, M. delicatus* or *Itoplectis conquisitor*.

### Winter Moth (*Operophtera brumata*)

![Winter moth](Image)

### 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.

### What to Look For:

At the tight cluster stage of bud development, the presence of caterpillar feeding on buds will appear as pinholes in the new leaflets and bud heads. The presence of tiny black specks (frass) can also tip the observer off to which buds have larvae present.
The larvae are very tiny at this stage and feeding damage may not be easily noticeable yet. Therefore, even buds with no visible damage should be examined.

Once a larva is found, it needs to be identified. A winter moth larva at the tight cluster stage of bud development will be 10 mm or less in length with a light green body and a darkish head. Depending on the season, some larvae may be in the second instar. This stage does not have a dark head. As the larva matures, the body will develop several fine creamy colored longitudinal stripes, including a dark green stripe along the back. The mature larva is the stage that is most easily identified, but this stage does not occur until after the optimal treatment period. The key is to know what the immature larva looks like, as opposed to the mature larva, because this is the stage that needs to be identified for the purposes of making a management decision.

There may be larvae of several species encountered during the search for winter moth larvae. They may all look very similar so here are some additional characteristics of a winter moth larva.

- Three pairs of jointed legs near the head end.
- Two pairs of fleshy legs at the rear end.
- No legs in the middle.
- Moves slowly
- To travel from point A to point B it "inches" along by arching its back as it moves the hind end forward and then straightens out as the front end is moved forward.

The other "inchworm" that is most likely to be encountered at the tight cluster stage of bud development is the green pug moth. Refer to the next section for distinguishing characteristics.

**How to Sample:**

- Collect 20 clusters at random from each of at least three standard trees. On small trees, collect 5 or 10 clusters from each tree and group the buds in samples of 20. You need a minimum of 60 buds in total.
- Empty a sample of 20 buds onto a table and examine them by teasing the leaves apart with a fine tipped knife or noodle probe. Inspect the bud carefully with a hand lens or microscope as you tease it apart.
- Record the number of larvae found and what kind they are (i.e. winter moth, green pug moth, eye-spotted bud moth, leaf roller, fruit worm, or other).
- When you are finished, you should have a record for each orchard block of how many trees were sampled (a sample of 20 buds is considered a tree), and how many winter moth larvae were found.
- NOTE: The buds do not have to be collected; they can be examined on the trees. However, it is easy to overlook the small larvae, and this method can actually be more time consuming.

**How to Interpret What You Observe:**

Winter moth larvae can be tolerated at low abundance. Therefore, using the sampling technique described above, an action threshold of a light-moderate population has been established.

Use the table to determine if a treatment is required. You should note that if the number of winter moth larvae is low, you may need to sample more trees before you are confident enough to make a decision.

The optimal treatment period is at bud separation (the point when the flower buds are starting to separate from one another).
Table 7: Winter moth decision table

<table>
<thead>
<tr>
<th>Number of trees examined (20 buds/tree)</th>
<th>Total number of winter moth larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treat</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td>3</td>
<td>&gt;4</td>
</tr>
<tr>
<td>4</td>
<td>&gt;5</td>
</tr>
<tr>
<td>5</td>
<td>&gt;6</td>
</tr>
<tr>
<td>6</td>
<td>&gt;7</td>
</tr>
</tbody>
</table>

Control

It is important to monitor pest populations in the orchard and only apply control measures if necessary (see APPENDIX E for thresholds). Current pesticide controls for winter moth can be found in the most recent addition of the Nova Scotia ‘Orchard Management Schedule’.

Secondary Pest

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

Biology

There are four types of aphids that are common on apples in Nova Scotia. They are the rosy apple aphid, the green 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. 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.

What to Look For:
- Individual or clusters of puckered, curled leaves in the inner canopy.
- A rosy aphid colony starts from a single individual, therefore, even one rosy aphid is considered to be a colony.
- All stages can be present in the clusters at this time.
- The young stages are pale yellow or pinkish. As they mature, they can be pink to dark bluish gray in color. Also, adult rosy aphids have a waxy outer layer that is a translucent whitish-gray giving the appearance of a powdery coating.
How to Sample:

- Carefully inspect at least three trees of susceptible cultivars such as Cortland, or Gravenstein. Scan the trees from top to bottom, inside the canopy and out to the terminals.
- Your search image should be for small leaves or clusters of leaves that are curled or show signs of starting to curl.
- Carefully pry open every curled leaf to determine if aphids are present and what kind they are. Also, look for the presence of parasites and predators of the aphids.
- Count all infested clusters on each tree.

How to Interpret What You Observe:

- An infested cluster is a cluster of leaves that originate from the same bud and at least one leaf in the group has at least one rosy aphid.
- If parasites and predators have killed the aphid colony, or apparently will kill the colony in short order, do not count the cluster as being infested.
- After counting all infested clusters on three trees, add the counts together and divide this number by the cumulative height in metres of all three trees (e.g. tree 1 = 3.0 m, tree 2 = 3.0 m, tree 3 = 2.0 m; cumulative tree height = 8.0 m).
- Compare the result to the following table. If the result is greater than the threshold, then a treatment is warranted (e.g. 10 infested clusters / 8.0 m = 1.25 aphid colonies per metre of tree height).

<table>
<thead>
<tr>
<th>Phenology</th>
<th>Colonies per metre of tree height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pink</td>
<td>0.5</td>
</tr>
<tr>
<td>Calyx</td>
<td>1.0</td>
</tr>
<tr>
<td>Calyx + 1 week</td>
<td>1.0</td>
</tr>
<tr>
<td>Calyx + 2 weeks</td>
<td>1.5</td>
</tr>
<tr>
<td>Calyx + 3 weeks</td>
<td>1.5</td>
</tr>
<tr>
<td>Calyx + 4 weeks</td>
<td>2.0</td>
</tr>
</tbody>
</table>

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. 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.

Current pesticide controls for aphids can be found in the most recent edition of the Nova Scotia ‘Orchard Management Schedule’.

**Green Pug Moth (Chloroclystis rectangulata)**

![Green Pug Moth](image)

**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 laid in August.

**What to Look For:**

Green pug moth larvae at the tight cluster stage of bud development can be very difficult to distinguish from winter moth larvae. It is important to make the distinction, however, because a greater number of green pug moth larvae can be tolerated.

As with winter moth larvae, the caterpillars will make pinholes in the new leaflets and bud heads. The presence of tiny black specks (frass) can also tip the observer off to which buds have larvae present. The larvae are very tiny at this stage and feeding damage may not be easily noticeable yet. Therefore, even buds with no visible damage should be examined.

**TIP:** Green pug moth larvae tend to prefer feeding on flower parts in blossom buds. Therefore, they frequently can be found hidden away inside the tightly closed blossom buds with no external indication of larval presence. Winter moth larvae can also be found in blossoms, however they move into the blossoms later and show less of a preference for them.

Once a larva is found, it needs to be identified. A green pug moth larva at the tight cluster stage of bud development will be 10 mm or less in length with a light green body and a darkish head. Depending on the season, some larvae may be in the second instar. This stage does not have a dark head. As the larva matures, the body will develop a dark reddish brown colored longitudinal stripe, or partial stripe, on its back. This stripe starts to develop at about the time that is considered to be optimal for treatment. If stripe development is slow, then it may be worth delaying a treatment decision a day or two in hopes that the stripe will appear and the larvae can then be positively identified. The mature larva is the stage that is most easily identified, but this stage
does not occur until after the optimal treatment period. The key is to know what the immature larva looks like, as opposed to the mature larva, because this is the stage that needs to be identified for the purposes of making a management decision.

There may be larvae of several other species encountered during the search for green pug moth larvae. They may all look very similar so here are some additional characteristics of a green pug moth larva.

- Three pairs of jointed legs near the head end.
- Two pairs of fleshy legs at the rear end.
- No legs in the middle.
- Moves slowly

To travel from point A to point B it "inches" along by arching its back as it moves the hind end forward and then straightens out as the front end is moved forward. The other "inchworm" that is most likely to be encountered at the tight cluster stage of bud development is the winter moth. Refer to the section on winter moth for distinguishing characteristics.

**How to Sample:**
- Same as for winter moth. You can do both species at the same time.
- Collect 20 clusters at random from each of at least 3 standard trees. On small trees, collect 5 or 10 clusters from each tree and group the buds in samples of 20. You need a minimum of 60 buds in total.
- Empty a sample of 20 buds onto a table and examine them by teasing the leaves apart with a fine tipped knife or noodle probe. Inspect the bud carefully with a hand lens or microscope as you tease it apart.
- Record the number of larvae found and what kind they are (i.e. winter moth, green pug moth, eyespotted bud moth, leaf roller, fruit worm, or other).
- When you are finished, you should have a record for each orchard block of how many trees were sampled (a sample of 20 buds is considered a tree), and how many green pug moth larvae were found.
- **NOTE:** The buds do not have to be collected; they can be examined on the trees. However, it is easy to overlook the small larvae, and can actually be more time consuming.

**How to Interpret What You Observe:**
The reason for this increased tolerance is the fact that green pug moth larvae mature before the calyx period and therefore are not on the trees to feed on the fruitlets as they start to develop. The worst case is if green pug moth larvae are so numerous that they over-thin the crop by feeding on too many blossom buds.

Green pug moth larvae can be tolerated at greater abundance than winter moth larvae. Therefore, using the sampling technique described above, an action threshold of a moderate-high population is generally employed.

Use the table below to determine if a treatment is required. You should note that if the number of green pug moth larvae falls within the “continue sampling” column, you should sample more trees before making a treatment decision.

<table>
<thead>
<tr>
<th>Number of trees examined (20 buds/tree)</th>
<th>Total number of winter moth larvae</th>
<th>Treat</th>
<th>Continue</th>
<th>No treat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>M-H</td>
<td>M</td>
<td>L-M</td>
</tr>
<tr>
<td>3</td>
<td>&gt;4</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>&gt;5</td>
<td>5</td>
<td>3-4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>&gt;6</td>
<td>6</td>
<td>4-5</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>&gt;7</td>
<td>6-7</td>
<td>4-5</td>
<td>3</td>
</tr>
</tbody>
</table>
The optimal treatment period is bud separation (the point when the flower buds are starting to separate from one another).

Control

Pug moth tend not to feed on the fruit dropping from the flower clusters around petal fall 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. Current pesticide controls for pug moth can be found in the most recent addition of the Nova Scotia ‘Orchard Management Schedule’.

Speckled Green Fruit Worm (Orthosia hibisci)

Speckled green fruit worm larvae emerge from eggs starting just before the tight cluster stage of bud development. Emergence tends to span a longer period than for winter moth and green pug moth larvae. Therefore, there can be greater variability in size differences of fruit worm larvae. The first instar speckled green fruit worm larva is difficult to distinguish from either the winter moth or green pug moth larva. The most significant difference is that there is one pair of fleshy legs on the tail end and four pairs in the middle region of the body. Because the larvae are very small at this time, a hand lens or microscope is essential to for viewing this characteristic.

As with winter moth larvae, the presence of caterpillars feeding on buds will be revealed by pinholes in the new leaflets and bud heads. The presence of tiny black specks (frass) can also tip the observer off to which buds have larvae present.

The larvae are very tiny at this stage and feeding damage may not be easily noticeable yet, therefore, even buds with no visible damage should be examined.

TIP: Speckled green fruit worm larvae tend to curl up when disturbed. This behavior may tip the observer to the possible identity of the larva even before the number of pairs of legs is examined for confirmation.

Once a larva is found, it needs to be identified. A speckled green fruit worm larva at the tight cluster stage of bud development will be 10 mm or less in length with a light green body and a darkish head. As the larva matures, the body takes a similar coloration to that of the winter moth larva. However, a mature fruit worm larva is about twice the length of a mature winter moth larva. The key distinguishing characteristic of the immature larva is the number of pairs and position of fleshy legs.

There may be larvae of several other species encountered during the search for speckled green fruit worm moth larvae. They may all look very similar, so here is a summary of the characteristics.

- Three pairs of jointed legs near the head end.
- One pair of fleshy legs at the rear end.
- Four pairs of fleshy legs in the middle body region.
- Moves slowly
- Tends to curl
• Does not "inch" along when it moves (does not arch its back).

**How to sample:**
• Same as for winter moth. You can do both species at the same time.
• Collect 20 clusters at random from each of at least three standard trees. On small trees, collect 5 or 10 clusters from each tree and group the buds in samples of 20. You need a minimum of 60 buds in total.
• Empty a sample of 20 buds onto a table and examine them by teasing the leaves apart with a fine tipped knife or noodle probe. Inspect the bud carefully with a hand lens or microscope as you tease it apart.
• Record the number of larvae found and what kind they are (winter moth, green pug moth, eye-spotted bud moth, leaf roller, fruit worm, or other).
• When you are finished, you should have a record for each orchard block of how many trees were sampled (a sample of 20 buds is considered a tree), and how many green pug moth larvae were found.
• NOTE: The buds do not have to be collected; they can be examined on the trees. However, it is easy to overlook the small larvae, and can actually be more time consuming.

**How to Interpret What You Observe:**
• There is no quantitative threshold established for speckled green fruit worm larvae. However, because each larva can damage many fruit, there is a tendency to consider 1-2 larvae in a three-tree sample (60 buds/clusters) as an indication of a need for a treatment.

**European Apple Sawfly (Hoplocampa testudinea)**

The European apple sawfly is a small clear-winged wasp-like insect that overwinters as a mature larva in an earthen cell just below the soil surface. The larvae pupate in the spring emerging around the pink stage of fruit bud development. The mature female lays eggs just after the opening of the king flower bud. The eggs are deposited singly at the base of the flower. Egg hatch occurs in eight to ten days with the larvae burrowing into the apple feeding on the tissue just below the surface of the skin. The larva gradually feeds it way towards the seed cavity feeding on one or two seeds and then proceeds to another nearby apple. The larva will mature in four to six weeks leaving the fruit and returning to the soil to form a cocoon in preparation for pupation.

**What to look for:**
• A heavy russeted winding scar that spirals from the calyx end
• Large crewed out cavities on the fruitlets with wet black frass
• Several fruit in a cluster may be damaged
• Growers can confuse the damage with that of codling moth
• Fruit with chewed out cavities will often drop before harvesting while those with the ribbon like scar with be present at harvest.

**How to sample:**
• Place three-dimensional UV white sticky board traps in trees between tight cluster and pink. Monitor twice weekly until two weeks after petal fall.
• Place traps on the south side of the tree at eye level and along edges of the orchard bordering wood lots or fence rows.

How to Interpret What You Observe:

• Threshold for treatment is 6 sawflies per trap for a pre bloom insecticide and 3 sawfly per trap if no pre-bloom insecticide has been applied.

Eye-spotted Bud Moth (*Spilonota ocellana*)

**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**

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.

Feeding larvae are difficult to treat because they are protected by their rolled leaf shelters. Pesticide applications can be 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. Current pesticide controls for eye-spotted bud moth can be found in the most recent edition of the Nova Scotia ‘Orchard Management Schedule’.

Pale Apple Leafroller (*Pseudexentera mali*)

**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.

**What to Look For:**
- Larvae emerge from eggs during bloom and seek shelter in new furled leaves.
- Upon emerging a larva is cream colored with a black head. As it grows, the head becomes a light brown color. At calyx, both color phases may be present.
- Pale apple leaf roller larvae are smaller than most other larvae found on apple at this time, around 5-8 mm in length.
- The larvae are not very active, and even if provoked, they do not move fast.
- Resembles the early stage of winter moth and green pug moth, however, is not an "inchworm". Under magnified inspection (10-20X), four pairs of fleshy legs can be observed in the middle underside of the body.

**How to Sample:**
- Inspect terminal leaves that have not unfurled.
- A pointed probe is useful for separating the leaves and a hand lens is essential for confirming the presence and identification of the tiny larvae.

**How to Interpret What You observe**
- Because the greatest percentage of the population is present on terminal leaves and therefore do not cause direct fruit damage, a moderately high population can be tolerated.
- The main concerns are on young trees, which can experience stunting of tip growth and on any sized trees when the population is high enough that larvae can be found on leaves in contact with fruit.
- As a rule of thumb, the **threshold is considered to be about 50% of terminals infested**. On young trees, where tree training may be affected, the tolerance level may be less, and on older trees where the larvae are not affecting the fruit, the tolerance may be higher.
- If you determine that a treatment is warranted, keep in mind that the larvae are feeding in well-protected sites and will be difficult to control. Selection of a control product should be done with compatibility with IPM in mind.

**Control**

Current pesticide controls for pale apple leafroller can be found in the most recent edition of the Nova Scotia ‘Orchard Management Schedule’.

**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**

Current pesticide controls for fruit tree leafroller can be found in the most recent edition of the Nova Scotia ‘Orchard Management Schedule’.

**Obliquebanded Leafroller** (*Choristoneura rosaceana*)

![Obliquebanded Leafroller](image)

**Biology**

The obliquebanded leafroller (OBLR) in the past was rarely a serious pest in Nova Scotia however in recent years its population has been building and increasing the number of orchard block that have treatable populations. 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. Current pesticide controls for obliquebanded leafroller can be found in the most recent edition of the Nova Scotia ‘Orchard Management Schedule’ published by the Nova Fruit Growers’ Association.

**White Apple Leafhopper** (*Typhlocyba pomaria*)

![White Apple Leafhopper](image)

**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. Sevin applied for chemical thinning purpose generally controls the spring population of this pest on bearing fruit trees. Current pesticide controls for white apple leafhopper can be found in the most recent edition of the Nova Scotia ‘Orchard Management Schedule’.

**Spotted Tentiform Leafminer** *(Phyllonorycter blancardella)*

![Spotted Tentiform Leafminer](image)

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

**Apple Brown Bug** *(Atractotomus mali)*, **Mullein Bug** *(Campylomma verbasci)*, **Red Apple Bug** *(Lygidea mendax)* and **Tarnished Plant Bug** *(Lygus lineolaris)* or **Mirid Bug Complex**.

**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 nearby 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.

**What to Look For: Apple Brown Bug**

- Over winter as eggs. Depending on the year, the eggs start hatching anywhere from pink to early calyx. Therefore, a search image has to be developed for very small nymphs.
- While the adults are about 3-4 mm in length and a dark brown to blackish color, the nymphs are 1-2 mm and vary from light reddish-brown initially, to dark brown for the front half of the body and red for the back half.
- In addition to the body coloration, a key identifying feature is the distinctly swollen second segment of each antenna.
• On tapping trays, the nymphs will hide in the debris or along the edges of the tray. When they do move it is in short bursts. They can be difficult to spot because they remain hidden and do not move continuously.
• On buds and in clusters, they may be seen trying to hide among the various cluster parts.

How to Sample:
• Examining buds is an ineffective method of monitoring that is only useful for verifying a high population. Therefore, this method is not recommended as a general monitoring technique.
• The most effective monitoring method is to use a tapping tray and beating stick. The tray is held under a branch and the stick is used to strike the branch sharply several times above the tray. This dislodges any apple brown bugs present and they fall into the tray where they can be counted.
• Because there is a varietal difference in sensitivity to feeding damage, it is recommended that the more sensitive cultivars be preferentially sampled. The most sensitive cultivars are Red Delicious, Spartan, and Northern Spy.
• Twenty limb taps is roughly equivalent to tapping a whole "standard" apple tree. If an orchard consists of only small trees, it is still possible to tap twenty limbs. Adding together all brown bugs in the twenty limb taps gives a relative number that can be compared to a threshold. Counting brown bugs can be difficult if a lot of debris falls into the tray. Therefore, it is often wise to tap fewer than twenty limbs, count the brown bugs, record the number, empty the tray, tap some more limbs up to twenty, and then add the counts together to get the total number of apple brown bugs per twenty limb taps.

How to Interpret What You Observe:
• The threshold for apple brown bug is eight per 20 limb taps. However, if mullein bugs are also present, they have to be included in the count (e.g. 4 apple brown bugs + 4 mullein bugs = 8, therefore the threshold is reached and a treatment is warranted). If several sets of limb taps have been done in the same orchard, the highest count should be used to compare to the threshold.

What to Look For: Mullen Bug
• Depending on the year, the eggs start hatching anywhere from pink to early calyx.
• The adults are about 3 mm in length and grayish-green to orange-yellow in color. For comparison sake, the nymphs are even smaller than apple brown bug nymphs and are a pale-blue-green in color.
• The nymphs are fast moving, but when not moving, they blend into the background very effectively. Therefore, it is necessary to literally stare at the tapping tray for some time so as to spot them during short bursts of movement and to give your search image time to register with what is on the tray.
• In addition to the body coloration, mullein bugs can be identified by the black spots and spines on the legs, and touches of black on the body, as well as white hairs. For those with little experience identifying mullein bug nymphs, magnification is vital to confirm these characteristics.
• There are numerous other mirid species that may be present in orchards and most of them are highly beneficial. Therefore, care should be taken to not include the beneficial species in the count of pest species.

How to Sample:
• Examining buds for mullein bugs is not recommended as a general monitoring technique for this insect.
• The most effective monitoring method is to use a tapping tray and a beating stick. The tray is held under a branch and the stick is used to strike the branch sharply several times above the tray. This dislodges any mullein bugs present and they fall into the tray where they can be counted.
• Because there is a varietal difference in sensitivity to the feeding damage caused by mullein bug, it is recommended that the more sensitive cultivars be preferentially sampled. The most sensitive cultivars are Red Delicious, Spartan, and Northern Spy.

• Twenty limb taps is roughly equivalent to tapping a whole "standard" apple tree. If an orchard consists of only small trees, it is still possible to tap twenty limbs. Adding together all mullein bugs in the twenty limb taps gives a relative number that can be compared to a threshold. Counting mullein bugs can be difficult if a lot of debris falls into the tray. Therefore, it is often wise to tap fewer than twenty limbs, count the mullein bugs, record the number, empty the tray, tap some more limbs up to twenty, and then add the counts together to get the total number of mullein bugs per twenty limb taps.

**How to Interpret What You Observe:**

- The threshold for mullein bug is 8 per twenty limb taps. However, if apple brown bugs are also present, they have to be included in the count (e.g. 4 apple brown bugs + 4 mullein bugs = 8, therefore the threshold is reached and a treatment is warranted). If several sets of limb taps have been done in the same orchard, the highest count should be used to compare to the threshold.

**Control**

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) indicates that a treatment to reduce populations is warranted to prevent significant crop loss.

**What to Look For: Tarnished Plant Bug**

- Over winter as adults. They are active insects that will fly when disturbed. About 5-6 mm in length, reddish-brown with flashes of yellow.
- Feed on a wide cultivar of plants. They have piercing-sucking mouthparts. On apple they can be seen sucking plant juices from buds. Damaged buds will ooze a droplet of sap for a short time after the injury is inflicted.

**How to Sample:**

- Visually inspect buds several times from 15 mm green tip through to calyx. Pick nice days when the insects would be most likely to be actively feeding.
- Alternatively, or in addition to, white sticky traps can be attached to stakes at about knee level within the rows at 3-6 locations in orchard blocks up to 4 hectares in size.

**How to Interpret What You Observe:**

- Tarnished plant bug damage caused prior to the pink stage has a thinning affect on buds. However, feeding that occurs from pink through to calyx can result in fruit with funnel shaped dimples or corky scar tissue.
- One school of thought suggests that damage from tarnished plant bug is more severe in warm early seasons or seasons that have a delayed start. The reasoning is that such conditions produce compressed development of both plants and insects, however, insect development becomes more advanced relative to bud development. Therefore, the buds and developing fruit are more likely to be attacked and are more prone to damage.
- No threshold for visual inspections has been established. However, during the pre-bloom period, a good rule of thumb is 20% of buds with tarnished plant buds present or evidence of feeding damage.
At calyx, if this insect is present or there is damage on 5% of calyxes, then management action should be considered.

- The provisional threshold used for sticky traps is 2-4 per trap in any given week.

**Fall Web Worm** (*Hyphantria cunea*) ~ **Eastern Tent Caterpillar** (*Malacosoma americanum*)

### Biology

The fall web worm 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 its 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 of 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 web worm because it feeds within the protection of the tent.

**Apple Thorn Leaf Skeletonizer** (*Choreutis pariana*)

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 a control product because they are protected within the webbed together leaf.
Phytophagous mite management

J. M. Hardman and J. L. Franklin,

The predator mite *Typhlodromus pyri*, which is a pyrethroid resistant strain of “typh”, is becoming more readily available to growers. New miticides are on the market too, offering better mite control, but mites still remain a challenge. Mites damage leaves and reduce the rate of photosynthesis, causing the apple tree to run short of essential carbohydrates. This resource shortage leads to excessive fruit drop, reduced fruit size and lower quality. The apples are soft, have low sugar and acid content and do not store well.

The problem is worse in a drought year because the mites are more numerous and trees are less able to withstand injury. To solve this problem many rely exclusively on miticides. The newer ones are more effective, but also more expensive. Exclusive reliance on chemical controls requires continuing vigilance. The miticide needs to be applied to at the proper time to avoid economic losses. On the other hand you do not want to use an expensive spray unless it is really needed.

Beginning in the 1990’s in the Annapolis Valley, the two-spotted spider mite has become a consistently serious problem. Individually, two-spotted mites are more destructive than red mites, and they can appear more suddenly. Massive numbers can crawl up a tree from the ground vegetation or drift in on air currents. Also, two-spotted mites have considerably higher rates of egg production and develop more rapidly than red mites. So it is essential that we take full advantage of our new opportunities for chemical and biological control.

To reduce problems with mites you must use a fully integrated pest management IPM program that includes the following elements:

- Monitor mite and insect populations so treatments are well timed and applied only when necessary.
- Use dormant oils and selective (predator-friendly) miticides when these are needed. Several new products are now available.
- Use a Modified Spray Program to conserve beneficial predators.
- Follow appropriate mowing and herbicide practices.
- Release the New Zealand strain of pyrethroid/organophosphate/Sevin-resistant *T. pyri* (typhs) into your orchard. Once they are established, spread them to other parts of your orchard.

Steps to Solve Your Mite Problems

1. **Monitor the orchard**
   This will ensure you can put on mite sprays when these are really needed, while avoiding unnecessary treatments. Leaf samples for mites taken in June, July and August will tell you if calyx or summer miticides should be applied. In general if there are more than 15 eggs and active stages of red mites per leaf (plate counts) you should spray. Where typhs (beneficial predators) are present you should spray if red mites outnumber typhs by more than 10 to 1. There is value in sampling red mite winter eggs in April or very early May, particularly in blocks where you had moderate to high numbers of red mites the previous season. In these cases the April count will warn you of impending trouble and help you decide which pre-blossom or calyx treatment to use: a dormant oil alone, a miticide alone, or an oil followed by a miticide.

2. **Spray oil and miticides**
   Both dormant oil and selective miticides will control harmful mites yet permit survival of typhs.
Superior oil 70 is used before bloom when winter egg counts are just above the economic threshold. Alternatively if you have very high egg counts, it may be wise to apply oil in May followed by a miticide in June to prevent early-season damage and to maintain full season mite control. Oil should not be used if there is a risk of frost. Also the recommended interval between an oil and a Captan or Maestro application is 10 days. Using an EBDC fungicide such as Polyram before bloom will have minimal impact on typhs at that time. Oil use is fully compatible with typhs and will not interfere with biological control of mites. Registered miticides are listed in the Orchard Management Schedule select the miticide that best fits the mite complex within the orchard while paying attention to resistance management.

3. Modify horticultural practices
Mulches under the tree seem to reduce the two-spotted spider mites in the tree canopy provided the trees have well-established populations of typhs but do not seem to help so much where typhs are not present. Possibly mulch slows down TSSM migration up the tree trunk into the tree so that typhs can rapidly annihilate most of the smaller number of TSSM entering the canopy. Using Ignite, an herbicide that is highly toxic to two-spotted spider mites, in the herbicide strip can reduce the number of spider mites climbing up tree trunks from the ground cover. Moderating use of nitrogen fertilizers can also be helpful. Mites lay more eggs and their populations increase more rapidly on leaves with higher nitrogen content. With mature, well established trees avoid excessively wide herbicide strips. Our research has shown that wider herbicide strips cause higher leaf nitrogen in apple trees and may allow more weed growth in summer. Both of these factors can promote two-spotted spider mites in the tree canopy, unless they are well suppressed by T. pyri. Our research also suggests that use of the plant growth regulator, Apogee, will assist mite control. Because Apogee reduces shoot growth and leads to fewer leaves, there are more T. pyri per leaf, which tends to enhance biological mite control. Use of selective herbicides to convert alleyways to grasses thereby eliminating broadleaf alternate hosts of spider mites is under research investigation. While this approach has reduced tarnished plant bug injury to fruit it has not been as effective in reducing TSSM numbers in the tree canopy. Further investigations are in progress.

4. Use biological controls
Use the New Zealand strain of T. pyri for biological control. This is the most decisive step you can take to improve mite management in the long term. Below we describe the benefits of this approach and the steps you must take for biological control to work.

Biological Control of Mites

*Typhlodromus pyri* (typhs)
New Zealand *T. pyri* (typhs) are highly effective against European red mites and rust mites and offer distinct advantages over chemical controls. Once typhs are established on trees there will be a gradual reduction in the need for miticides. Usually within two or three years, miticides or dormant oil are seldom needed for those two mites. When you follow the Modified Spray Program and avoid repeated use of insecticides or fungicides toxic to *T. pyri*, the likelihood of mite resurgence will be minimal. Typhs are normally effective against two-spotted spider mites unless several risk factors are involved. These include applications of pesticides that suppress typh populations, wide herbicide strips that extend to the drip line or further, mite-infested weedy growth under trees, prolonged hot, dry weather, and overuse of nitrogen fertilizer. Under these conditions you may have to use a properly-timed application of typh-compatible miticide such as Agri-Mek, Apollo, Acramite, or Kanemite to supplement predator activity, reduce the risk of economic damage and restore a favourable

There will also be advantages on the production side. Both growers and members of our research team
have noticed larger, greener leaves, and larger, tastier fruit on trees occupied by *T. pyri*. Best of all, these beneficial typhs are always on the job, looking for mites because that is their favorite food. If you rely only on chemical controls, then you must be constantly vigilant to detect damaging mite populations and apply miticides at the right time to prevent economic injury. In practice, chemical treatments do not always get applied at the best time, nor are they always fully effective. Typhs, however, are always monitoring and controlling mites in your orchard. In the long run, biological control is a better approach to mite infestation. But this approach requires work on your part.

**First year of typh release**

Before releasing the New Zealand typhs into your orchard, you must spray to eliminate native typhs. If the New Zealand typhs cross breed with Canadian typhs their offspring will lose resistance to pyrethroids (Ripcord, Cymbush) and will likely have reduced resistance to other insecticides like Guthion, Malathion, Imidan, Sevin and Zolone A Dipel-Ripcord or Dipel-Cymbush mixture should be applied in the release block to reduce the population of native typhs in preparation for a release of the resistant strain.

**The years after release**

Once typhs are in the block you need to use only Dipel/pyrethroid mixtures when these are needed for winter moth, pale apple leaf roller or other insect pests. Your typhs and your fruit will do better if you use Sevin for thinning. You should arrange for monitoring of typhs and of mites in your release row and the rest of the block. You will know if you need to apply dormant oil or a selective miticide (Agri-Mek, Apollo, Acramite or Kanemite ). By monitoring, you will also know if you have enough typhs to spread them by moving prunings or shoots to other parts of that block or to other orchard blocks. We have found that within one to three years after release, if you follow the Modified Spray Program, inoculated trees and adjacent trees in your original release row will have enough typhs to inoculate many more trees in the orchard. That is when you will be able to transfer enough foliage to inoculate many new trees with 50-100 typhs. Cut a 50-leaf shoot as a standard. Then, depending on your typh count, you will need to place one, two or more of these shoots on recipient trees. You should inoculate every second or third tree within each row in a release zone, because *T. pyri* are slow to disperse between rows. Within a few years you will be able to scale up from a few rows to whole blocks and then to your whole orchard.

**Amblyseius fallacis**

This mite, a specialist predator of the two-spotted spider mite (TSSM), is found in the ground cover vegetation and on tree trunks in most orchards, but occurs only in trace numbers on apple foliage in orchards where *T. pyri* is present. While *A. fallacis* undoubtedly reduces the number of TSSM that would otherwise climb up trees from the ground cover, *T. pyri* does most of the work in controlling TSSM in the tree, and nearly all of the work in controlling European red mites and apple rust mites. Hence *A. fallacis* only performs an auxiliary role in biological control in most orchards.

**Mites**

**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.

Apple rust mites are minute orange-brown mites. Adult females measure about 0.17 mm in length, while adult males are 0.15 mm long. The deutogyne (winter female) overwinter under loose bark, lichens or in other protected areas. Emergence occurs at ‘bud break’, and deutogynes invade opening buds to feed on developing flowers and leaf tissue. These give rise to first generation primary (summer) females and males in mid-June. These mites mate and deposit eggs, which give rise to second generation protogynes and males in July. The second generation mites deposit eggs, and deutogynes (the third generation) hatch during late July and early August then move to overwintering sites.

**European Red Mite** (*Panonychus ulmi*)

**What to look for:**

- **WARNING:** Identifying and assessing mites, in general, requires a fairly high degree of skill. It is necessary to study identification guides in detail to become competent at determining what species and stages are being observed. The size of mites, and the complexity of species and identification characteristics can make early detection and assessment a time consuming and labor intensive task.
- During the first half of June, there is very little overlap of generations. Also, most mites will be synchronized to a uniform life-stage. In early June, look for tiny, red eggs on the underside of leaves.
- It is important to pinpoint the start of egg hatch in June. Newly hatched European red mites are even smaller than adult mites and are light orange in color. A hand lens or microscope is very helpful for spotting immature mites.
- By mid-July, there is substantial overlap of generations. Therefore, all life-stages of mites will be present.
- In August, the overlap of generations is very dramatic and there is absolutely no synchronicity in life-stages.
Thresholds for the presence/absence monitoring technique for European red mite at three critical sampling periods. This table is a simplified summary of 3 sequential sampling plan charts published in the Cornell Cooperative Extension IPM publication #215 (Breth, Nyrop, Kovach, 1998).

<table>
<thead>
<tr>
<th>Number of Leaves examined</th>
<th>Sample period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mid-June</td>
</tr>
<tr>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>40</td>
<td>29</td>
</tr>
<tr>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>60</td>
<td>41</td>
</tr>
<tr>
<td>70</td>
<td>47</td>
</tr>
<tr>
<td>80</td>
<td>53</td>
</tr>
<tr>
<td>90</td>
<td>58</td>
</tr>
<tr>
<td>100</td>
<td>58</td>
</tr>
</tbody>
</table>

How to sample:
- There are two methods for assessing and quantifying European red mite populations.
- The most accurate method involves using a specialized machine for brushing the mites off the leaves onto plates. A microscope is used to count the mites within grids on the plate. This method is best performed by researchers and monitoring specialists because it is a highly specialized and tedious task.
- The method most feasible for producers is to determine presence or absence of active stages of mites on leaves. Examine both the upper and lower surfaces of 5 leaves on each of 4 trees per block. Select intermediate aged leaves from the middle of clusters from just inside the canopy. When mite populations are low or borderline threshold, it is recommended to increase the sample size by 2 to 5 times.

How to interpret what you saw:
- Because the tolerance for mites increases as the season progresses, three sampling periods are used. These periods are approximately mid-June, mid-July, and early-mid August.
- If plate counts are done, the thresholds are 5, 10, 15 mites per leaf, respectively.
- If the presence/absence technique is used, the thresholds vary with the number of leaves examined. The table above summarizes the thresholds for each sample period and for increased sampling intensities.

In a hot, dry season, mites can double in numbers in 7-10 days. Therefore, more frequent monitoring may be necessary, especially if there are no predator mites in the orchard.
Two Spotted Spider Mite (*Tetranychus urticae*)

What to look for:
- Adult, immature, and egg stages of two-spotted spider mite can be present anytime from prebloom into the fall. July and August are the months when problems are most likely to occur.
- Adults are pale green or yellowish and have two distinct dark spots on the back. The immature stages resemble the adults. The eggs are smaller than the eggs of the European red mite, and are clear or white with a glistening sheen.
- Part of the TSSM population overwinters as adult females on ground cover vegetation or in plant debris under the tree. These females in spring begin laying eggs and feeding on broadleaf plants on the orchard floor. Starting in spring, small numbers begin to move up into the tree canopy. Mass migrations can occur when hot, dry weather desiccates the ground cover vegetation, when mite-repellent herbicides are applied or when mite movement is triggered by cultivation or mowing. However, our recent studies suggest that most of the TSSM in trees are descendants of adult female mites that overwintered in the tree, usually under bark scales, or in other crevices. Thus, mites climbing into the tree probably contribute less to canopy populations than those overwintering in the tree. Can be found on the leaves.

How to sample:
- Same as for European red mite.

How to interpret what you observe:
- When the leaf brushing technique is used, the count of two-spotted mites should be combined with the count for European red mite and the total compared to the threshold for the period when the sample was taken.
- If the presence/absence monitoring method is used for European red mite, then consider the active stages of two-spotted spider mite on a leaf; the leaf should be counted as one with mites.
- In a hot, dry season, mites can double in numbers in 7-10 days. Therefore, more frequent monitoring may be necessary, especially if there are no predator mites in the orchard.

Apple Rust Mite (*Aculus schlechtendali*)

What to look for:
- The adult stage of this mite species is 0.15-0.17 mm in length. Obviously this mite is not visible to the unaided eye, and in fact, is barely visible to a trained eye using a hand lens. Essentially, a microscope is necessary to see this mite.
- Under a microscope this mite is yellowish-brown in color and teardrop shaped.
• The first generation is produced from over wintered females. It is the second generation that occurs in July that can be numerous enough to cause leaf damage.

**How to sample:**

• In July, arrange for a professional to monitor for this mite, or collect a twenty-leaf sample, as explained in the European red mite section, from each block.
• Examine the underside of the leaves under a microscope at a minimum of 20x magnification.

**How to interpret what you observe:**

• Apple rust mite is an excellent food source for beneficial mites. Also, trees can tolerate high numbers without serious damage.

Because there is no definitive threshold established, it is important to rely on experienced observation to determine if a treatment is warranted. For the inexperienced, it may be helpful to suggest that individual leaves can tolerate several hundred mites. Using this information as a guide, try to classify apple rust mite abundance on a six-point scale as detailed in the next table. The threshold that has been used traditionally is a moderate-high population.

| Assessment categories for estimating abundance of apple rust mites |
|-----------------------|-----------------|
| Assessment            | Average abundance per leaf |
| VL (Very low)         | 0                |
| L (Low)               | 1-19             |
| L-M (Low-moderate)    | 20-49            |
| M (Moderate)          | 50-99            |
| M-H (Moderate-high)   | 100-200          |
| H (High)              | > 200 mites      |

**Control**

There are 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 predacious 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. Two-spotted mites can also be reduced by growing a solid grass ground cover in the orchard.

When treatment thresholds are met select an appropriate miticide from those listed in the most current Orchard Management Schedule.
Section 8 Pesticide Handling and Application

Pesticides have been the main defense against orchard pest, be they man made of naturally occurring, for hundreds of years. Guidelines and fact sheets have been developed under the Nova Scotia Environmental Farm Program for the best means to store handle and apply pesticides. Factsheets that are available with regards to pesticide application and storage from NS Federation web site (http://www.nsfa-fane.ca/factsheets) are:

- On-farm Pesticide Use
- Pesticide Storage and Handling
- Air-Blast Sprayer Calibration for Orchard and Vineyards
- Tree-Row Volume Concept, Calculations and Application

The CHC CanadaGap on-farm-food safety manual for Tree and Vine Fruit provides procedures and guidelines with regard to the safe handling, storage and record keeping for tree fruit pesticides and fertilizers usage. Following good environmental stewardship and food safety programs are a important components of best management practice fort fruit production.
Section 9 Fruit Maturity & Harvesting

Choosing the best time to harvest is the most critical consideration of the harvest procedure. Fruit picked at the correct stage of maturity will ripen and develop the full flavour and attributes characteristic of the particular cultivar. Non-bruised, properly coloured fruit of this quality is in high demand and will bring higher returns.

The market and time of year the fruit is to be marketed will determine at what maturity the fruit should be harvested. Harvesting apples at the proper maturity affect both the quality and storage success. Fruit that is harvest for long-term controlled atmosphere (CA) and low oxygen storage is harvested at an earlier stage of maturity than fruit that will be placed in short term cold storage. Picking fruit to early has its penalties.

- Fruit size can be sacrificed as fruit can continue to grow as it matures. A 1/4 inch increase in size that is going from 2 3/8 to 2 5/8 can translate into a 35% increase in fruit volume. It takes just as long to pick one large (88 count) apple as it does to pick one small apple (160 count). But it will take half as long to make up a bushel of larger apple than the smaller, 160 count apple. So picking cost and time required are less for larger fruit.
- Fruit colour can be lost and thus reducing pack out.
- Immature fruit bruises easily and is subject to scald and extreme shriveling in storage.
- Immature fruit may be of poor eating and culinary quality.

Picking over mature has its problems:

- There is an added risk of water core and the fruit will be softer.
- It will be more prone to senescent or old age breakdown as well as other storage problems.
- There is an increased chance of pre-harvest drop.
- In the case of late season cultivars there can be an increased chance of frost damage to the fruit.

There is a period of time for the harvesting of each cultivar and maturity has to be monitored closely and harvesting will need to be adjusted to obtain the maximum amount of quality fruit at peak perfection.

Indices for determining apple maturity

- **Starch content**: The starch content of apples gradually decreases as the apple matures. The starch level of apples can be measured using the starch iodine test with the results of the test being used to determine the stage of maturity. A universal chart or charts for specific cultivars which depict starch patterns based upon maturity are available.

- **Soluble solids**: The sugar content of apples increases as the fruit matures. The soluble solid level which is highly correlated with sugar content is measured using a hand refractometer. Soluble solid levels will vary from year to year depending upon crop load (leaf to fruit ratio) and growing conditions (heat units).
• **Fruit firmness**: The flesh of apples becomes softer as the fruit matures. Firmness is determined using a penetrometer with optimum pressure varying with cultivar. The type of storage the fruit will be held in will determine at what firmness the fruit should be harvested. If the fruit is to be placed in long term storage than the higher firmness range should be used while fruit for immediate shipping or use the lower range is more desirable. The firmness of a cultivar will vary from year to year and is influenced by factors such as fruit size, nutrition and location on the tree. Fruit on the outside of the tree may be firmer than those from the inner canopy.

• **Development of red colour**: The development and intensify of red colour can be used for red and bicoloured apples. Grower experience is needed when using this index as some cultivars or strains of cultivars may be fully coloured well before the optimum harvest date. The McIntosh strain Redmax7 can develop full colour before it is mature and there can be a tendency to harvest this strain at the immature stage. Seasonal climate conditions, nutrient and cultural practice can all influence colour which complicates the accuracy of using this index.

• **Ground colour change**: The underlying green or yellow colour of apples is referred to as the ground colour and is an indication of the amount of green chlorophyll in the skin of the apple. The shade of green varies with cultivar and can be influenced by nitrogen levels and the growing season. The back ground colour changes from green to yellow as the fruit matures. Ground colour is used more for bicoloured apples such as Honeycrisp, Jonagold and Gala to assist with determining maturity.

• **Ease of picking**: Many apple cultivars will easily separate from the spur without breaking the stem when the fruit is lifted with or without a slight rotation. Growing conditions and nutrient levels can influence the tendency for the fruit to cline to spurs.

• **Seed colour**: Seed turn brown to dark brown as they mature in the fruit. The change in colour often varies from year to year. An average rating can be made using the seed colour ratings.

• **Days from full bloom**: The period from full bloom to harvest is fairly constant for any given cultivar and some growing regions have developed periods for specific cultivars. These ranges have not been developed for the Atlantic regions as we have tended to rely upon the starch test for determining the maturity of the most commonly grown cultivar.

All of the above can be used to help determine fruit maturity. Presently the best practices that individual growers can use to determine fruit maturity is the starch iodine test. Growers can also contact their packing house at too when to harvest fruit.

**Harvesting**

Picking apples entails more than just removing the fruit from the tree. It also involves the proper choice and use of picking, equipment, training and managing the picking crew, sorting the fruit all the while taking steps to avoid bruising. Finally, record keeping is an essential task for determining block and picker performance.

In general picking bags are more efficient to use and if properly handled are less likely to cause bruising than baskets. The bags are either metal or plastic, side lined with canvas or vinyl drop bottom bags.
Some bags have foam linings for added protection against bruising. All picking bags are adjusted to fit the picker. The picker can pick with both hands and gently set the fruit in the bag. When the bag is full it can be carefully emptied through the bottom into the bin, setting the newly picked fruit gently on top.

The use of ladders increases picking cost by decreasing picker efficiency (by 105 for each step taken above the third rung). In orchards where ladders must be used the trees should be pruned in such a way as to have openings to effectively place a ladder. This will reduce the amount of bruising by the placement of ladders in the tree and increase picking efficiency. The best practice is to design orchards where ladders are not required or when minimal harvesting is required with the use of short step ladders (not more than 3 steps).

Apple bruising is one of the most common reasons for culling fruit. Bruised fruit will store poorly, and often decay will spread to previously undamaged apples. Training pickers properly in the picking and emptying of bags into the bin along with good supervision will help to reduce bruising by the harvesting crew. Bruising does not start and end with the harvesting crew, as the bulk handling of full bins by forklift and truck can be a major source of bruising. The flexing of full bins disturbs the fruit and pressures the adjacent fruit. The more times the bin is moved during filling and placement in storage the greater the incidence of bruising. Placement of bins on uneven ground and the transportation of full bins over uneven orchard alleyway and roads will increase bruising. Only the best quality bins should be used for fresh fruit while saving the poorer quality for juice apples. Bruising of fruit can occur very easily when the apple has been subjected to frost. Apples should not be harvested until the frost has left the apple. Apples may withstand several minor freezing’s on the tree, but once harvested the fruit is much more prone to damage and breakdown.

Stem punctures provide a site for pathogen to enter the fruit resulting in losses on the grading line and to storage rots. This tends to be more of a problem with cultivars that are thin skin and have long stems. Honeycrisp is a cultivar that is prone to stem punctures and storage rot. Clipping the stem of susceptible cultivars at the time of harvest will help to prevent the loss to grading and storage rot.

Postharvest Management

Postharvest diseases and disorders do occasionally cause major losses of fruit during storage and transit. Many of the problems are controlled by chemicals which help to preserve quality and prevent decay. The concept of IFP is to reduce the usage of chemicals and, when they are necessary, to use products that have less of an impact on the environment and human health. Steps can be taken to reduce or eliminate the need for postharvest fungicides at the grower level and in the packinghouse. Effective control of storage diseases and disorders requires careful attention to all of the following:

- **Decay**: cultivars differ in their susceptibility decay. Avoid planting cultivars that are known to be prone to storage decay.

- **Scald**: Select cultivars that are susceptible to scald or can be harvested and stored in a manner where a scald inhibitor will not be required. When a scald treatment is required the drench accumulates fungal spores and carries inoculums to wounds on the fruit. When given the choice avoid cultivars that are prone to scald.

- **Nutritional disorders**: disorders such as bitter pit can increase susceptibility to decay and decrease storability. Nutritional disorders can be corrected in the field and knowing the nutritional disorders of the cultivar will assist in preventing problems. Growers may wish to avoid planting cultivars where nutritional disorders cannot be remedied easily.
Moldy core: cultivars that have an open calyx sinus are more prone to moldy core in the field and occasionally in postharvest drenches. Red Delicious, Glouster and Cortland are three cultivars where moldy core has been observed however there have not been reports of significant losses to this disorder in the Atlantic Region.

Optimum harvest maturity: over mature fruit will be more prone to decay problems, physiological disorders and breakdown during storage and shipping.

Harvest dates: having a mix of cultivars with varying maturity dates will help to insure that the fruit is picked at the optimum maturity.

Orchard Management

Crop management in the field is an essential part of producing healthy fruit with maximum natural resistance to postharvest diseases and disorders. This encompasses nutrient, water, crop load, disease, summer pruning and dormant management.

Harvest management

Harvesting fruit at the appropriate maturity, minimizing bruising, and cooling fruit as rapidly as possible will help reduce disorders. Bruised and/or overly mature fruit are more prone to physiological and decay problems in storage. Proper supervision of harvest labour, forklift operators, smooth orchard floors and road ways will all help to reduce bruising. Using the starch index or other maturity test will help to harvest fruit at the optimum maturity. Placing the fruit in storage and cooling it as quickly as possible will help to preserve fruit firmness and quality and also slow development of decay.

Sanitation in the orchard, storage and packinghouse

If the industry is to move away from the use of chemicals and pesticides to control postharvest disorders sanitation within the orchard, storage and packinghouse will become increasingly more important. The following sanitation steps can be taken to minimize disease problems:

- Keep fruit and bins from contacting soil. The soil harbours many decay organisms and bins will pick up soil on the bottom skip boards when set directly on the soil. When possible keep bins on sod to reduce contact with the soil. Pushing bins over the sod can or picking up sod with the bin can be a cause of contamination.

- Keep the solutions as clean as possible if postharvest drenches or water flumes are used. Keep soil out of drench solutions and change or filter solutions when dirty post harvest treatments.

- Disinfect badly contaminated bins before they are re-used. Concentrate on bins that contained badly decayed fruit (cull bins) and bins with visible fungal growth on wood.

- Remove decayed culls and leaf debris from packing sheds daily.

- Keeping packing houses clean.

- Pick up drops in the orchard. Drops that decay provide a nutrient source for decay fungi in the soil.
**Storage and marketing practices**

A good knowledge of storage, packing and marketing practices will go a long way in avoiding damaging fruit during storage and to assure that fruit with poor keeping quality is marketed first.
References

1) **Pruning and Training Apple Trees**
   Revised in January 2006 by AgraPoint International Inc.
   Originally Prepared by the Atlantic Committee on Fruit Crops
   Publication ACC 1208 Agdex: 211

2) **Planting and Care of The Young Apple Orchard**
   Revised in October 2005 by AgraPoint International Inc.
   Originally Prepared by the Atlantic Committee on Fruit Crops
   Publication ACC 1209 Agdex: 211

3) **Orchard Fertility**
   Revised in March 2006 by AgraPoint International Inc.
   Originally Prepared by the Atlantic Committee on Fruit Crops
   Publication ACC 1201 Agdex: 211/541

4) **Apple and Pear Rootstocks For Atlantic Canada**
   Revised September 2009 by AgraPoint International Inc.
   Originally Prepared by the Atlantic Committee on Fruit Crops
   Publication ACC 1202 Agdex 211/24

5) **Thinners and Growth Regulators for Fruit Trees**
   Revised December 2009 by AgraPoint International Inc.
   Originally Prepared by the Atlantic Committee on Fruit Crops
   Publication ACC 1215 Agdex 210/24

6) **Organic Apple Production Guide for Atlantic Canada**
   Published by Agriculture Agri-Food Canada 2007
   Edited by G. Braun and B. Craig

7) **Orchard Management Schedule 2009/2010:** A guide to insect, mite, and disease management in apple and pear orchards in Nova Scotia
   Agdex 211/605
   Prepared by AgraPoint International Inc.
   Published by Nova Scotia Fruit Growers’ Association

8) **Integrated Fruit Production Guide:** For the Apple Growers of Atlantic Canada
   Copyright 2001; Dr Rob Smith AAFC Kentville NS
   Printed by AgraPoint International Inc

**Insect and Disease Photos**

http://www.ipm.msu.edu/fruit.htm
http://www.caf.wvu.edu/kearneysville/wyufarm8.html
http://postharvest.tfrec.wsu.edu/market_diseases.html
http://jenny.tfrec.wsu.edu/opm/
APPENDIX A

Minimum number of hours of leaf wetness required for primary and secondary apple scab infections at various temperatures

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Severity of Primary Scab Infections (Ascospore)</th>
<th>Secondary Scab Infections (Condia)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Light</td>
<td>Moderate</td>
</tr>
<tr>
<td>25.5</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>25.0</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>24-25</td>
<td>6.5</td>
<td>9</td>
</tr>
<tr>
<td>16-24</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>15.5</td>
<td>6.5</td>
<td>10</td>
</tr>
<tr>
<td>14-15</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>12-13</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>21</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>52</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>69</td>
</tr>
<tr>
<td>1</td>
<td>41</td>
<td>69</td>
</tr>
</tbody>
</table>

Table from Carisse O. 2006. Apple Scab: Improving Understanding for Better Management. AAFC Pub. 10203E
### APPENDIX B

Disease resistant cultivars

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Apple Scab</th>
<th>Powdery Mildew</th>
<th>Fire Blight</th>
<th>Harvest Season</th>
<th>Storage (Months)</th>
<th>Best Use</th>
<th>Tested at Kentville</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belmac</td>
<td>R*</td>
<td>MR</td>
<td>U</td>
<td>Early Oct</td>
<td>3-4</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Britegold</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>Late Sept</td>
<td>12</td>
<td>dessert</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Dayton</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Mid Sept</td>
<td>1</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Enterprise</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>Early Nov</td>
<td>6</td>
<td>dessert</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Freedom</td>
<td>R</td>
<td>MR</td>
<td>R</td>
<td>Early Oct</td>
<td>\1-2</td>
<td>\dual</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Florina (Querina®)</td>
<td>R</td>
<td>U</td>
<td>MR</td>
<td>Late Oct</td>
<td>3</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Goldrush</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Late Oct</td>
<td>7</td>
<td>dessert</td>
<td>N</td>
<td>?</td>
</tr>
<tr>
<td>Jonafree</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Mid Oct</td>
<td>2.5</td>
<td>dessert</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Liberty</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>Early Oct</td>
<td>2</td>
<td>dessert</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Macfree</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Early Oct</td>
<td>3-4</td>
<td>dessert</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>McShay</td>
<td>R</td>
<td>S</td>
<td>U</td>
<td>Early Oct</td>
<td>2-3</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Moira</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>Early Oct</td>
<td>2-3</td>
<td>dual</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Murray</td>
<td>R</td>
<td>R</td>
<td>MR</td>
<td>Early Sept</td>
<td>&lt;1</td>
<td>dessert</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Nova Easygro</td>
<td>R</td>
<td>R</td>
<td>MR</td>
<td>Late Sept</td>
<td>2-3</td>
<td>dessert</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Novamac</td>
<td>R</td>
<td>MR</td>
<td>R</td>
<td>Mid Sept</td>
<td>2-4</td>
<td>dessert</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Novaspy</td>
<td>R</td>
<td>MR</td>
<td>U</td>
<td>Mid Oct</td>
<td>4-5</td>
<td>dual</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Priam</td>
<td>R</td>
<td>MR</td>
<td>U</td>
<td>Mid Oct</td>
<td>3</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Prima</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Mid Sept</td>
<td>1-2</td>
<td>dual</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Primevere</td>
<td>R</td>
<td>U</td>
<td>U</td>
<td>Mid Oct</td>
<td>6</td>
<td>dessert</td>
<td>N</td>
<td>?</td>
</tr>
<tr>
<td>Priscilla</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>Early Oct</td>
<td>2-3</td>
<td>dessert</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Pristine™</td>
<td>R</td>
<td>R</td>
<td>MR</td>
<td>Late Aug</td>
<td>1-1.5</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Redfree</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Early Sept</td>
<td>12</td>
<td>dessert</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Richelieu</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Late Sept</td>
<td>3</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Rouville</td>
<td>R</td>
<td>U</td>
<td>U</td>
<td>Early Sept</td>
<td>2</td>
<td>dessert</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Scarlett O’Hara</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>Early Oct</td>
<td>6</td>
<td>dessert</td>
<td>N</td>
<td>?</td>
</tr>
<tr>
<td>Sir Prize</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Mid Oct</td>
<td>2-3</td>
<td>dual</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Trent</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Late Oct</td>
<td>6</td>
<td>dual</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>William’s Pride</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td>Early Sept</td>
<td>1.5</td>
<td>dessert</td>
<td>N</td>
<td>?</td>
</tr>
</tbody>
</table>

- R = resistant, MR = moderately resistant, S = susceptible, U = unknown, Y= yes, and N= no.
## Appendix C

### Characteristic Disease Resistant Cultivars

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Brief Description of Major Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belmac</td>
<td>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.</td>
</tr>
<tr>
<td>Britegold</td>
<td>Yellow, medium size, sweet, flesh creamy yellow, slightly coarse, tender, and juicy. Bruises easily. Home garden use.</td>
</tr>
<tr>
<td>Dayton</td>
<td>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.</td>
</tr>
<tr>
<td>Enterprise</td>
<td>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.</td>
</tr>
<tr>
<td>Freedom</td>
<td>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.</td>
</tr>
<tr>
<td>Florina (Querina®)</td>
<td>Fruit 50% red on yellow ground colour, firm, small to medium size, sweet flavour. Whitish-yellow flesh, very crisp, low acid. Deserves further evaluation.</td>
</tr>
<tr>
<td>Goldrush</td>
<td>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.</td>
</tr>
<tr>
<td>Jonafree</td>
<td>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.</td>
</tr>
<tr>
<td>Liberty</td>
<td>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.</td>
</tr>
<tr>
<td>Macfree</td>
<td>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.</td>
</tr>
<tr>
<td>McShay</td>
<td>70% dark red blush over a green background colour, similar to McIntosh. Flesh, moderately firm, fine texture, juicy, mild flavour and low acid.</td>
</tr>
<tr>
<td>Moira</td>
<td>McIntosh type, red, medium to small size, flesh creamy white with a green tinge. Medium eating quality.</td>
</tr>
<tr>
<td>Murray</td>
<td>Early McIntosh type, red, medium sized, flesh is soft, juicy, white and fine textured. Home garden use.</td>
</tr>
<tr>
<td>Nova Easygro</td>
<td>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.</td>
</tr>
<tr>
<td>Novamac</td>
<td>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.</td>
</tr>
<tr>
<td>Novaspy</td>
<td>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.</td>
</tr>
<tr>
<td>Prima</td>
<td>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.</td>
</tr>
<tr>
<td>Primevere</td>
<td>Fruit bright and glossy dark cardinal red, slightly conical. Flesh is moderately coarse grained, pale green to white, firm, crisp. Has commercial potential.</td>
</tr>
<tr>
<td>Priscilla</td>
<td>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.</td>
</tr>
<tr>
<td>Pristine™</td>
<td>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.</td>
</tr>
</tbody>
</table>
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, slightly coarse, and 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.

APPENDIX D

Insects and mites may be classified as follows:

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

The following publications may be available on the Perennia website www.perennia.ca and were referenced for this document:

**Pruning and Training Apple Trees**
Revised in January 2006 by AgraPoint International Inc.
Originally Prepared by the Atlantic Committee on Fruit Crops
Publication ACC 1208 Agdex: 211

**Planting and Care of The Young Apple Orchard**
Revised in October 2005 by AgraPoint International Inc.
Originally Prepared by the Atlantic Committee on Fruit Crops
Publication ACC 1209 Agdex: 211

**Orchard Fertility**
Revised in March 2006 by AgraPoint International Inc.
Originally Prepared by the Atlantic Committee on Fruit Crops
Publication ACC 1201 Agdex: 211/541

**Apple and Pear Rootstocks For Atlantic Canada**
Revised September 2009 by AgraPoint International Inc.
Originally Prepared by the Atlantic Committee on Fruit Crops
Publication ACC 1202 Agdex 211/24

**Thinners and Growth Regulators for Fruit Trees**
Revised December 2009 by AgraPoint International Inc.
Originally Prepared by the Atlantic Committee on Fruit Crops
Publication ACC  1215  Agdex 210/24

**Guide to Weed Management in Orchards**
Revised February 2010 by AgraPoint International Inc.
Originally Prepared by the Atlantic Committee on Fruit Crops
Publication ACC  1211  Agdex 210/641

**Organic Apple Production Guide for Atlantic Canada**
Published by Agriculture Agri-Food Canada 2007
Edited by G. Braun and B. Craig

**Orchard Management Schedule 2009/2010:** A guide to insect, mite, and disease management in apple and pear orchards in Nova Scotia  Agdex 211/605
Prepared by AgraPoint International Inc.
Published by Nova Scotia Fruit Growers’ Association
## APPENDIX F

### Pesticide Listed in NS Orchard Management Schedule

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Product</th>
<th>Chemical Family</th>
<th>MAMMAL ORAL</th>
<th>BEE SKIN</th>
<th>Relative Toxicity (1=least,5=most)</th>
<th>Days to Harvest</th>
<th>RE-ENTRY INTERVAL</th>
<th>Pests Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUNGICIDES/ANTIBIOTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captan</td>
<td>Captan Maestro</td>
<td>Phthalimide</td>
<td>M</td>
<td>1</td>
<td>1 1 1 1 -</td>
<td>7</td>
<td>48 hrs</td>
<td>Apple &amp; pear scab, black rot, fly speck, sooty blotch, storagerots (applied preharvest)</td>
</tr>
<tr>
<td>cyprodinil</td>
<td>Vangard</td>
<td>Anilinopyrimidine</td>
<td>9</td>
<td>1</td>
<td>1 - - -</td>
<td>72</td>
<td>72 hrs</td>
<td>Apple scab</td>
</tr>
<tr>
<td>Dodine</td>
<td>Equal/Sylit</td>
<td>Guanidine</td>
<td>M2</td>
<td>1</td>
<td>1 1 1 -</td>
<td>7</td>
<td>-</td>
<td>Apple &amp; pear scab</td>
</tr>
<tr>
<td>flusilazole</td>
<td>Nustar</td>
<td>Triazole</td>
<td>3</td>
<td>-</td>
<td>- 1 2 -</td>
<td>77</td>
<td>12 hrs</td>
<td>Apple scab, powdery mildew</td>
</tr>
<tr>
<td>fludioxonil</td>
<td>Scholar</td>
<td>Phenyl pyroles</td>
<td>12</td>
<td>1</td>
<td>1 - - -</td>
<td>-</td>
<td>-</td>
<td>Storage rots (blue and grey mold)</td>
</tr>
<tr>
<td>kresoxim-methyl</td>
<td>Sovran</td>
<td>Strobilurin</td>
<td>11</td>
<td>1</td>
<td>1 1 1 1</td>
<td>30</td>
<td>48 hrs</td>
<td>Apple &amp; pear scab, powdery mildew</td>
</tr>
<tr>
<td>mancozeb</td>
<td>Dithane Manzate Pennozeb</td>
<td>Dithiocarbamate</td>
<td>M</td>
<td>1</td>
<td>1 1 1 4</td>
<td>45</td>
<td>24 hrs</td>
<td>Apple scab, powdery mildew, cedar apple rust, fly speck, sooty blotch</td>
</tr>
<tr>
<td>mancozeb + dinocap</td>
<td>Dikar</td>
<td>Dithiocarbamate</td>
<td>M</td>
<td>1</td>
<td>1 1 1 4</td>
<td>45</td>
<td>48 hrs</td>
<td>Apple &amp; pear scab, powdery mildew, cedar apple rust, mites, fly speck, sooty blotch</td>
</tr>
<tr>
<td>metiram</td>
<td>Polyram</td>
<td>Dithiocarbamate</td>
<td>M</td>
<td>1</td>
<td>1 1 1 3</td>
<td>45</td>
<td>-</td>
<td>Apple scab, powdery mildew, cedar apple rust, fly speck, sooty blotch</td>
</tr>
<tr>
<td>thiabendazole</td>
<td>Mertect</td>
<td>Imidazole</td>
<td>1</td>
<td>1</td>
<td>1 - - -</td>
<td>-</td>
<td>-</td>
<td>Storage rots (blue and grey mold)</td>
</tr>
<tr>
<td>myclobutanil</td>
<td>Nova</td>
<td>Triazole</td>
<td>3</td>
<td>1</td>
<td>1 1 1 1</td>
<td>14</td>
<td>dry</td>
<td>Apple scab, powdery mildew, cedar apple rust</td>
</tr>
<tr>
<td>pyrimethanil</td>
<td>Scala</td>
<td>Anilinopyrimidine</td>
<td>9</td>
<td>1</td>
<td>1 - - -</td>
<td>72</td>
<td>24 hrs</td>
<td>Apple &amp; pear scab</td>
</tr>
<tr>
<td><strong>pantoea agglomerans strain C9-1</strong></td>
<td>Biopesticide</td>
<td>11</td>
<td>1</td>
<td>1 1 1 1 1 1 -</td>
<td>4 hrs</td>
<td>Suppression of fire blight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>streptomycin sulfate</td>
<td>Streptomycin</td>
<td>Antibiotic</td>
<td>18</td>
<td>1</td>
<td>1 - - -</td>
<td>50</td>
<td>24 hrs to 14 days</td>
<td>Fire blight</td>
</tr>
<tr>
<td>Active Ingredient</td>
<td>Product</td>
<td>Chemical Family</td>
<td>Relative Toxicity (1=least,5=most)</td>
<td>Relative Toxicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>-----------------------------------</td>
<td>-------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAMMAL ORAL SKIN BEES OTHER INSECTS</td>
<td>DAYS TO HARVEST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fungicides/antibiotics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulphur</td>
<td>Kumulus</td>
<td>Inorganic</td>
<td>M 1 1 1 3 3 1 -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microscopic Sulphur</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>thiophanate-methyl</td>
<td>Senator</td>
<td>MBC</td>
<td>1 1 1 1 1 -</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trifloxystrobin</td>
<td>Flint</td>
<td>Strobilurin</td>
<td>11 1 1 1 -</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>insecticide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>acetamiprid</td>
<td>Assail</td>
<td>Chloronicotines</td>
<td>4 1 1 4 -</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>amitraz</td>
<td>Mitac</td>
<td>Triazapentadiene</td>
<td>19 1 1 1 -</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>azinphos-methyl</td>
<td>Sniper/Guthion</td>
<td>Organophosphate</td>
<td>1B 4 2 5 1 5</td>
<td>14 day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bacillus thuringiensis</td>
<td>Dipel 2XDF/Bioprotec CAF</td>
<td>Bt Microbial</td>
<td>11 1 1 1 1 1 -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>carbaryl</td>
<td>Sevin</td>
<td>Carbamate</td>
<td>1 2 1 5 1 1 11 -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chlorantraniliprole</td>
<td>Altacor</td>
<td>Ryanodine receptors</td>
<td>28 2 1 3 3 4 14</td>
<td>12 hrs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cypermethrin</td>
<td>Ripcord</td>
<td>Pyrethroid</td>
<td>3 2 1 3 3 3 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lambda cyhalothrin</td>
<td>Matador/Warrior</td>
<td>Pyrethroid</td>
<td>3 2 1 3 3 4 7</td>
<td>24 hrs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>deltamethrin</td>
<td>Decis</td>
<td>Pyrethroid</td>
<td>3 2 1 5 5 5 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>imidacloprid</td>
<td>Admire/Alias</td>
<td>Neonicotinoid</td>
<td>4 1 1 - 1 3 7</td>
<td>24 hrs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>methoxyfenozide</td>
<td>Intrepid</td>
<td>Ecdysone Disrupter</td>
<td>18 1 1 1 1 1 14</td>
<td>dry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pests Controlled**

- Powdery mildew, apple & pear scab
- Apple & pear scab, powdery mildew
- Apple & pear scab, powdery mildew, sooty blotch, fly speck, cedar apple rust
- Winter moth, leafrollers
- White apple leafhopper, pear leaf blister mite
- Codling moth, obliquebanded leafroller, leaf miner
- Winter moth (NS), bud moth, pale apple leafroller, tarnished plant bug, pear psylla
- Winter moth, leafrollers, tarnished plant bug, pear psylla
- Leafrollers, winter moth, pear psylla
- Rosy and green apple aphid, white apple leafhopper, mullein bug
- Pale apple, obliquebanded, and three lined leafroller, pear psylla
<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Product</th>
<th>Chemical Family</th>
<th>Relative Toxicity (1=least,5=most)</th>
<th>Relative Toxicity</th>
<th>Days to Harvest</th>
<th>RE-ENTRY INTERVAL</th>
<th>Pests Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>novaluron</td>
<td>Rimon</td>
<td>IGR</td>
<td>GRO</td>
<td>15 1 1 1</td>
<td>14</td>
<td>12</td>
<td>Codling moth</td>
</tr>
<tr>
<td>pemethrin</td>
<td>Pounce</td>
<td>Pyrethroid</td>
<td>3M</td>
<td>3 2 2 5 5 5 5 7</td>
<td>-</td>
<td>Winter moth, fruitworm, bud moth, pear psylla</td>
<td></td>
</tr>
<tr>
<td>phosalone</td>
<td>Zolone</td>
<td>Organophosphate</td>
<td>1B</td>
<td>2 1 3 1 5</td>
<td>14 days</td>
<td>Tent caterpillars, leafrollers, fruitworm, green pug moth, eyespotted budmoth, plum curculio, codling moth, apple maggot, pear psylla</td>
<td></td>
</tr>
<tr>
<td>phosmet</td>
<td>Imidan</td>
<td>Organophosphate</td>
<td>1B</td>
<td>2 1 5 1 5</td>
<td>7 days</td>
<td>Tent caterpillar, leafrollers, fruitworm, green pug moth, eyespotted budmoth, plum curculio, codling moth, apple maggot, pear psylla</td>
<td></td>
</tr>
<tr>
<td>spinosad</td>
<td>Success</td>
<td>Naturalyte</td>
<td>5M</td>
<td>5 1 1 1</td>
<td>12 hrs</td>
<td>Obliquebanded, three lined, fruittree &amp; European leafroller, eyespotted budmoth</td>
<td></td>
</tr>
<tr>
<td>spinetoram</td>
<td>Delegate</td>
<td>Naturalyte</td>
<td>5M</td>
<td>5 1 1 1</td>
<td>12 hrs</td>
<td>Codling moth, obliquebanded, and three lined leafroller, spotted tentiform leafminer</td>
<td></td>
</tr>
<tr>
<td>spirotetramat</td>
<td>Movento</td>
<td>Tetronic Acid</td>
<td>23M</td>
<td>1 1 2 1 1</td>
<td>12 hrs</td>
<td>Rosy apple aphid, apple aphids, pear psylla</td>
<td></td>
</tr>
<tr>
<td>tebufenozide</td>
<td>Confirm</td>
<td>Ecdysone Disrupter</td>
<td>18M</td>
<td>1 1 1 1</td>
<td>14 hrs</td>
<td>Obliquebanded leafroller, coding moth, winter moth, green pug moth</td>
<td></td>
</tr>
<tr>
<td>thiacloprid</td>
<td>Calypso</td>
<td>Chloronicotines</td>
<td>4M</td>
<td>2 1 2</td>
<td>30 hrs</td>
<td>Codling moth, plum curculio, apple maggagot, mullein bug, leafhopper, spotted tentiform leafminer</td>
<td></td>
</tr>
<tr>
<td>thiamethoxam</td>
<td>Actara</td>
<td>Neonicotinoid</td>
<td>4M</td>
<td>1 1 3</td>
<td>60 hrs</td>
<td>Rosy apple aphid, mullein bug, spotted tentiform leafminer, plum curculio, pear psylla</td>
<td></td>
</tr>
<tr>
<td>kaolin</td>
<td>Surround</td>
<td>Kaolin</td>
<td>1M</td>
<td>1 1 1 1</td>
<td>-</td>
<td>Apple maggot, leaf rollers, leafhopper, plum curculio, tarnished plant bug, first generation coding moth</td>
<td></td>
</tr>
<tr>
<td>acequinocyl</td>
<td>Kanemite</td>
<td>Quinolinone</td>
<td>20M</td>
<td>1 1</td>
<td>14 hrs</td>
<td>European red, two spotted spider</td>
<td></td>
</tr>
<tr>
<td>bifenazate</td>
<td>Acramite</td>
<td>Carbazate</td>
<td>25M</td>
<td>1 1 3</td>
<td>7 12 hrs</td>
<td>Two spotted spider, McDaniel and European red mites</td>
<td></td>
</tr>
<tr>
<td>abamectin</td>
<td>Agri-Mek</td>
<td>Avermectin</td>
<td>6M</td>
<td>1 1 1 1 1</td>
<td>28 Dry</td>
<td>All mites, pear psylla</td>
<td></td>
</tr>
<tr>
<td>Active Ingredient</td>
<td>Product</td>
<td>Chemical Family</td>
<td>GROU</td>
<td>Relative Toxicity (1=least,5=most)</td>
<td>DAYS TO HARVEST</td>
<td>PESTS CONTROLLED</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------</td>
<td>-----------------</td>
<td>-----</td>
<td>-----------------------------------</td>
<td>-----------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>clofentezine</td>
<td>Apollo</td>
<td>Tetrazine</td>
<td>G</td>
<td>10 1 1 1 1 -</td>
<td>12</td>
<td>European red, two spotted spider and McDaniel mite</td>
<td></td>
</tr>
<tr>
<td>dicofol</td>
<td>Kelthane</td>
<td>Diphenylethane</td>
<td>M</td>
<td>3 1 5 4 1 7</td>
<td>Dry</td>
<td>All mites</td>
<td></td>
</tr>
<tr>
<td>formetanate</td>
<td>Carzol</td>
<td>Carbamate</td>
<td>M</td>
<td>1A 4 3 5 1 -</td>
<td>-</td>
<td>All mites, white apple leafhopper</td>
<td></td>
</tr>
<tr>
<td>petroleum oil</td>
<td>Superior oil</td>
<td>-</td>
<td>M</td>
<td>- 4 - - 2 1 1 -</td>
<td>-</td>
<td>Oystershell scale, all mites</td>
<td></td>
</tr>
<tr>
<td>pyridaben</td>
<td>Nexter</td>
<td>Pyridazinone</td>
<td>M</td>
<td>21 1 1 - 2 - 25</td>
<td>24 hrs</td>
<td>All mites</td>
<td></td>
</tr>
<tr>
<td>spirodiclofen</td>
<td>Envidor</td>
<td>Tetronic Acid</td>
<td>M</td>
<td>23 1 2 1 1 7 12 hrs</td>
<td>All mites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
<td></td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>diphenacnione</td>
<td>Ramik Brown</td>
<td>Indandione</td>
<td>O</td>
<td>- 5 - 1 1 1 -</td>
<td>-</td>
<td>Mice</td>
<td></td>
</tr>
<tr>
<td>chlorophacinone</td>
<td>Rozol Groundforce</td>
<td>Inadandione</td>
<td>O</td>
<td>- 5 5 - 1 1 1 -</td>
<td>-</td>
<td>Mice</td>
<td></td>
</tr>
<tr>
<td>zinc phosphide</td>
<td>Waxed Mouse Bait</td>
<td>Inorganic Phosphide</td>
<td>G</td>
<td>- 5 - 1 1 1 -</td>
<td>-</td>
<td>Mice</td>
<td></td>
</tr>
</tbody>
</table>