Kentucky
Backyard Apple
Integrated Pest Management

Manual

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January 1994

This manual is provided by the Kentucky Integrated Pest Management Program.

I. INTRODUCTION

Homeowners plant apple trees for a variety of reasons: for the benefit of fresh fruit, for control over what types of pesticides and fertilizers are applied, to save money, as a learning experience for their children, to grow different or exotic varieties, or simply for the enjoyment of raising their own produce. Despite the diversity of reasons for raising apples, home gardeners want to produce quality fruit.

Home gardeners are troubled by a number of pests attacking apples. Many do not understand the biology of the pests and the importance of good cultural practices and appropriate timing of pesticide applications. Often pesticides are applied when they will do little good, leading the gardener to use them more often or at higher concentrations. Frequently the wrong pesticide is used to control a particular pest. Some are left wondering whether the fruit is safe to eat. Gardeners, especially those trying to raise fruit with little or no pesticides often end up with unacceptable fruit due to disease and insect damage. Many give up trying to grow apples when their expectations are not met.

In general, the public is becoming more concerned about the environment, pesticides, and the food we eat. Recent surveys indicate that over 80% of consumers are concerned about pesticide residues in food. Additoinally, the use of pesticides in the urban environment is a major concern among many homeowners. While home fruit growers have fewer chemical alternatives available than do commercial growers, the greatest pesticide use occurs in the urban setting. Home fruit growers able to produce quality fruit with reduced pesticide usage are pleased that they are consuming a healthy food and contributing to a safer environment.

Participants in this program should expect to alter pesticide use patterns and application timing while maintaining an acceptable level of quality. There is a greater reliance on a number of other strategies rather than sole reliance on chemical control. However, while there is less chemical input, there is probably as much or more time involved. Those growing fruit will have the opportunity to develop a better understanding of trees and pest biology. This is a valuable learning experience.

A. INTEGRATED PEST MANAGEMENT

Home fruit spray guides are often developed around a calendar schedule that will prevent losses from all pests known to occur in a region throughout the growing season. These guidelines, when followed properly, will provide the gardeners with a maximum amount of high quality fruit at the end of the season. However, most home plantings do not need to be protected against all pests throughout the whole growing season. Experience in Kentucky has shown us that pest problems are usually sporadic and site specific. For any particular situation, some pesticide applications are not necessary.

An integrated pest management (IPM) program for apples has been developed to provide home gardeners with guidelines to raise quality fruit with a minimum level of pesticide use. Integrated pest management is a production system which uses information about hosts, pests, and the environment to determine the potential for pest injury and select appropriate cultural, biological, or chemical tools in light of economic, social and environmental concerns. Pesticides are used only as a last resort, after the appropriate preventative cultural and biological practices have been used. This system results in less pesticide usage than conventional production systems. However, urban apple IPM is not simply a "recipe" to follow. There are various types of management options available. Selecting the type of IPM program to be

Table 1. Sequence of steps involved in making pest management decisions	
Step	Description
Prevention	Orchard pest management begins with using appropriate cultural practices that will prevent, reduce, or delay pests from reaching damaging levels.
Detection	Pest need to be detected and monitored early, before serious losses occur. This is best accomplished through regular and frequent examinations of the trees and fruit.
Identification	Pests and/or the damage they cause must be properly identified. The different stages of the pest should be recognized. Without proper identification, pests cannot be managed properly.
Evaluation of Pest Significance	Once the pest is identified, its potential impact (significance) needs to be determined. This involves recognizing the type of damage it will cause (foliar, fruit, or to the tree itself), and evaluating the pest level. Often a serious pest at low numbers is unimportant, while a minor pest at high numbers can cause serious damage.
Selection of Management Options	If a pest is at levels which require management, the most appropriate management option needs to be selected from the available alternatives. Stage of the pest and crop, other pests present, effect on beneficial organisms (pollinators and natural enemies of pests), cost of control, level of control expected, as well as potential social and environmental impacts need to be evaluated when making this selection.
Evaluation of Control	After a control action has been made, the level of control needs to be evaluated. Has the pest level returned to acceptable levels? Was the expected level of control obtained? Use this information in the future when selecting management options.

implemented will depend on the expectations of the gardener, the site-specific pest problems, and the amount of time and resources he/she is willing to commit.

The home gardener is not bound by market quality standards or economic justification of certain cultural practices. Thus, there is greater flexibility in the use of apple IPM. IPM in the urban setting relies much more heavily on cultural control of pests. These are preventive in nature and are often referred to as "good farming practices" in commercial agriculture. Good cultural practices include the use of disease resistant cultivars and proper site selection when establishing new plantings, hand thinning of fruit, timely sanitation of prunings and fruit drops, fertility management, pest mating disruption through mass trapping, adequate tree pruning, and use of physical barriers around the trees and fruit.

Pest predictors are available for apple scab, fire blight, codling moth, and San Jose scale. These allow you to monitor these pests accurately and treat only when they are at levels which may cause significant damage, and when they are most vulnerable. These predictors will allow you to eliminate, reduce or improve timing of pesticide use for some of the most damaging apple pests. These predictive systems do require that the gardener maintain weather records including minimum and maximum temperature and rainfall. Insect traps are

available to monitor for the presence of some of the damaging insect pests.

B. DETERMINING WHAT ARE ACCEPTABLE LOSSES AND THE NEED FOR ACTION

With IPM, the objective is not to completely eliminate the pests. Elimination of a pest is an unrealistic objective that commonly leads to additional problems including excessive pesticide use, pest resistance, and outbreaks of secondary pests. Rather the idea is to keep them below a level at which they will not cause sufficient damage to require control. In fact, a few individuals of a particular pest are often desirable. These help to maintain beneficial organisms that serve to regulate pests. With home apple production, as long as the gardener is a able to harvest enough apples at the quality desired it shouldn't matter if a few are lost to pest damage. Several apple pests cause only surface blemishes on the fruit which do not affect the flavor or nutritional quality of the fruit. For some gardeners, 50% of a crop is enough, others may want 90% or more acceptable fruit. It is important to decide what level of damage you are willing to accept before developing an IPM program. Those willing to accept slightly higher levels of fruit damage will be able to reduce pesticide usage considerably. Before beginning this program you will need to decide what types and levels of pest damage you are willing to accept; we ask you to share your objectives with us in the participant's questionnaire.

The level at which we try to keep pests below is often referred to as the ***Economic Threshold.*** When a pest exceeds the economic threshold and is left uncontrolled, it will cause unacceptable levels of damage. Below the economic threshold, pests may cause minor but tolerable levels of damage. Economic thresholds presented in this manual are conservative, designed to provide 90 to 95% acceptable fruit. Growers are encouraged to modify these values to meet their specific expectations.

C. WHAT TO EXPECT FROM THE UK APPLE IPM PROGRAM

You, the grower, are in charge. This program will provide information and guidelines for your use. But the decisions will be yours. There will be an IPM expert at the county extension office or a volunteer in your community to distribute IPM information and answer questions. The University of Kentucky Cooperative Extension Service will provide the technical support, training (field days and demonstrations), and training materials (this manual) for this program.

This program is new. We encourage your comments and suggestions that will improve this program to better serve your needs and expectations.

II. HORTICULTURAL MANAGEMENT

Management of many of the key pests that attack apples begins long before the pests reach damaging levels. In fact, some factors that may predispose apples to pest losses need to be considered before the young trees are purchased and planted. Cultural practices listed below have the potential to greatly delay, reduce or avoid damage from some pests. It is important to maintain an environment which is unfavorable to these pests. These non-chemical practices are the foundation of an integrated pest management program and are critically important in managing home apple plantings.

A. BEFORE PLANTING

Site Selection

Many pests and diseases are more serious in moist, shady locations. Plant new trees in a sunny well, drained locations. North or east facing slopes make good sites because they have good air drainage and they are cooler in the spring, thus are less apt to have frost or freeze injury during bloom. If soil is constantly wet, improve soil drainage by ditching or tiling. Apple scab, powdery mildew and fruit rot diseases are more serious in moist, shaded locations. Many pests that attack apple have wild and cultivated hosts on which they develop. Avoid planting apples near a forest, near wild brambles, or cedar trees. These plants harbor disease organisms and insects that attack apples.

Landscaping With Fruit

In choosing fruit to plant at home, you want to consider not only how it tastes but what it will look like. While commercial fruit growers try to attain maximum yields, the homeowner has multiple goals and should be willing to sacrifice a percentage of the harvest for some aesthetic effect. In this situation, increased competition among plants will cause some decrease in production, but you can still have plenty of fruit.

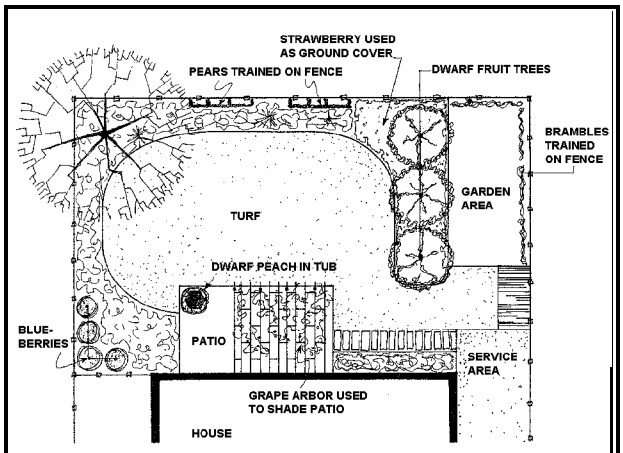


Figure 1. Fruit can be used in a small backyard to combine elegance with function

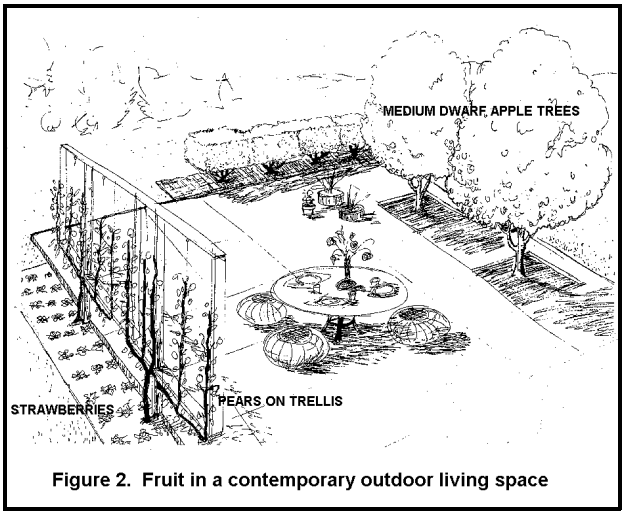


Figure 2. Fruit in a contemporary outdoor living space

Planning Varieties for the Landscape

You need a comprehensive plan for your landscape. Explore the UK Cooperative Extension Service recommendations to decide what varieties of ornamental and edible plants to grow. As you plan your landscape, feel free to mix edible and ornamental plants for a pleasing effect but be sure to consider maintenance requirements of each plant. You may wish to keep edible plants in groups or to mix them with ornamentals not requiring special pest management.

Cultivar Selection

Apple cultivars differ in their susceptibility to some pests. A number of cultivars are available which are resistant to apple scab, cedar apple rust, fire blight, and powdery mildew. Certain cultivars are more susceptible to rosy apple aphid and European red mites. Resistant and susceptible cultivars are listed under the respective pests. Generally, cultivars that mature early in the season escape much of the pest damage and are recommended for the urban growers. Early maturing cultivars are generally sprayed less and harvested before serious pest problems develop. Only apple cultivars that are suited to a particular area should be chosen. Dwarf or semi-dwarf trees are attractive to home fruit growers because they are easier to spray, prune and harvest. The smaller trees allow more cultivars in the same space. Cultivar selection is based on the following:

Quality

Select only high quality varieties that have proven their merit through the test of time. Remember that many varieties not suited for commercial production may be very good in the home garden. See Table 1 of ID-21. To prolong your harvest, you may want to plant several varieties that mature at different times. Fresh tasting apples may be had almost all year if you plant the right varieties and store them properly.

Disease Resistance

Select apples resistant to diseases so that fewer losses occur and so that fewer sprays are needed. See ID-21, included in the appendix, for a list of the recommended varieties and their resistance to the common diseases. In addition to the disease resistant varieties listed in ID-21, 'Gold Rush' and 'Enterprise' have exceptional fruit quality and disease resistance.

Dwarf Fruit

The advent of dwarfed fruit trees has opened the way for successful tree fruit growing by the urban homeowner. Dwarfed trees produce the same quality fruit as larger standard trees.

ADVANTAGES OF DWARF TREES:

✓ They fruit much sooner.

✓ They bear less fruit per tree. With several trees and varieties you will have enough fruit of each, but not so much that it becomes a problem, as often happens with standard trees.

✓ Fruit is usually larger and more highly-colored than in the same variety on standard rootstocks.

✓ You can reach all parts of the tree easily. Therefore, all operations may be performed from the ground or from a small stepladder.

✓ Smaller, less expensive spray equipment is needed.

✓ Dwarf fruit trees are easier to prune, train or espalier than standard trees because they are slower growing.

Apples are dwarfed principally by grafting the desired variety onto special clonal rootstocks. However, apples may also be dwarfed by grafting dwarfing interstems into the trunk above ground. The most important dwarfing clonal rootstocks in use today were developed in England and are designated as either M. (for “East Malling” or MM. (for “Malling Merton”). While many exist, only 5 having value forthe home landscape will be mentioned here. Figure 3 illustrates size reduction of apple trees using dwarfing rootstocks. Table 2 lists important factors to consider prior to choosing a dwarfing rootsotck.

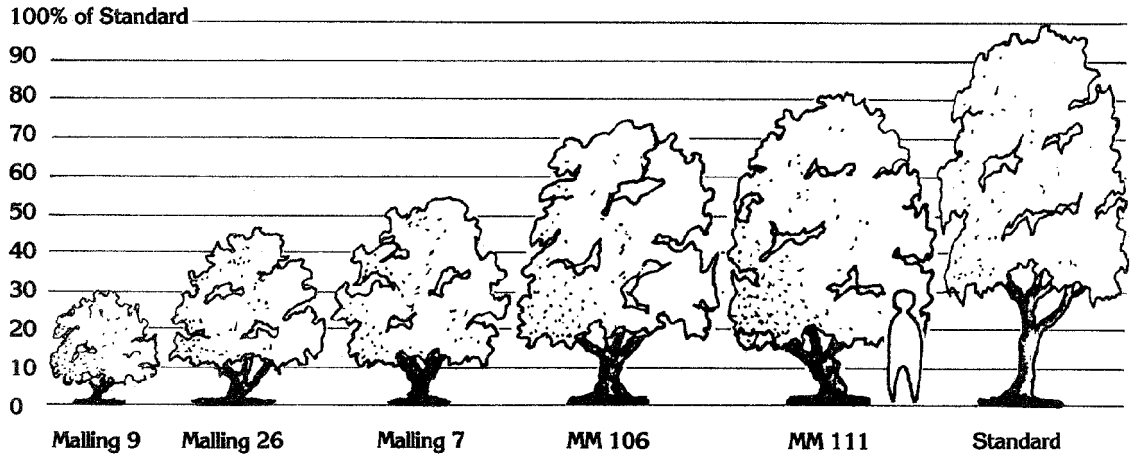


Figure 3. Comparative Dwarfing by Rootstocks for Apple

In many cases you will only be able to purchase a tree on a dwarf, semidwarf or seedling rootstock and will not be told the specific rootstock used by the nursery. However, with some nurseries a choice of specific rootstocks is possible.

Dwarfing characteristics of rootstocks are shown in line 1 of Table 2. These indicate that a Redfree variety on a M.7 rootstock will be 55% the size of a Redfree tree on a seedling rootstock at any time during its life. Remember that trees are not like people-they don't stop growing when they reach a particular height. Rather, they will continue to grow in size throughout their life and a dwarf tree can become quite tall. Size of a tree is regulated by the rootstock, amount of annual pruning, variety of apple selected and how well the tree crops.

Dwarfing characteristics are not the only aspect that should be considered in selecting a rootstock. If you have selected a variety that is susceptible to fireblight disease, Table 2 indicates that you would not want to put it on rootstock that is susceptible to fireblight such as M.9 or M.26. If you have very heavy clay soil that tends to be slightly wet, semidwarf MM.111 rootstock would be your best choice, but does not produce fruit as early as on a smaller semidwarf or dwarf rootstock.

In Kentucky, the M.7 and MM.111 rootstocks have performed well. The expected fruit yield for dwarf apple trees, is 1 bushel per tree in the fifth year and 4 bushels per tree in the 9th year.

Choosing Nursery Stock

Order plants only from reputable nurseries to insurance that they will be true to name, well-grown, free from insects and disease, and packed and shipped correctly.

Size and Age

Buy only vigorous trees. One-year old stock, if well grown, is usually the best- not because it costs less, but because trees establish themselves sooner, survive better, and can be shaped by the grower with a minimum of cutting.

When to Order

Get plant orders in early so they will be filled as specified. If ordering is delayed, supply of some cultivars may be exhausted, only second grade material may be left, or the order may arrive too late for the best planting time. Specify on the order blank the time of shipment preferred. Apples may be planted in spring or fall. For fall planting, order plants from a northern nursery.

TABLE 2. IMPORTANT CONSIDERATIONS IN SELECTION OF ROOTSTOCKS

Factor to Consider	Clonal Stocks					Seedling
	M.9	M.26	M.7	MM.106	MM.111	
Tree size as % of standard or seedling stock	30	45	55	75	80	100
Support Needed	Yes	May	May	No	No	No
Yields						
a. Early	++	+	+	+	-	-
b. Heavy	++	+	+	+	+	-
Adaptability						
a. Wet soil	-	-	-	-	+	?
b. Dry soil	+	+	+	+	+	+
c. Heavy soil	-	+	-	-	+	+
d. Light soil	+	+	+	+	+	+
e. Cold temperature	?	+	-	-	+	+
f. Hot temperature	+	+	+	+	+	+
Disease Resistance						
a. Collar rot	?	?	+	-	+	+
b. Fireblight	-	-	+	?	+	+
Spacing in Feet Between Trees for Spur Type (add 2' between each tree for nonspur type trees) Use smallest spacing for poor soils and largest spacing for excellent soils.	8'-12'	10'-14'	10'-16'	12'-16'	14-18'	16'-20'

Care of Stock

Inspect your stock as soon as it to see if proper varieties and numbers were sent. Also, check on sizes, development and condition. They should arrive in a damp material, such as sphagnum moss, peat moss or wood shavings. If you can't plant them in 2 or 3 days, you can spray plants with water and store them in the package in a cool, sheltered place. If planting is delayed, plants should be heeled in.

Heeling In

✓ Select a well-drained place and dig a trench of sufficient size to contain roots of the plants.

✓ If plants are tied in bundles, separate them to fan out roots so that soil can be packed around them. This method eliminates air pockets.

✓ Slant trees to the southwest so the sun will not shine directly on exposed trunks and cause sunburn.

✓ Firm soil well and mound it around the plants to furnish good drainage.

✓ If the soil is dry at heeling-in time, water plants before mounding. Stock will keep in good condition for an indefinite period of time when properly heeled in.

B. PLANTING APPLES

Mapping Locations

It will be helpful to have a planting plan showing where different varieties will be planted. Different varieties may need to be managed in different ways depending on time of ripening and susceptibility to pests. If you do not write it down, you will probably forget what is planted where. You can put the plan in a notebook and use it for making records of

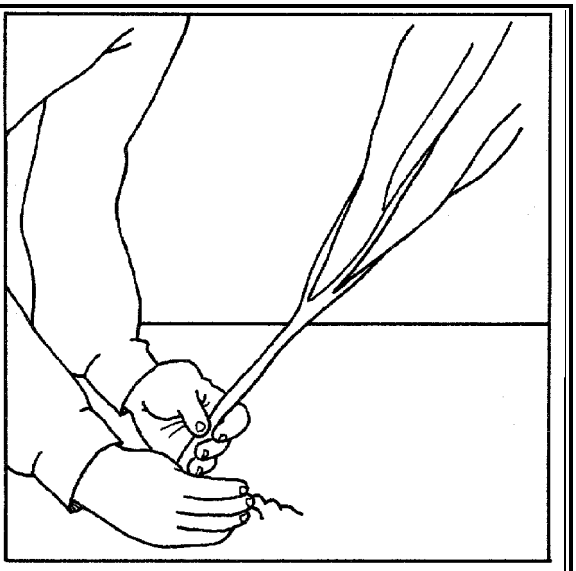


Figure 4. If planting must be delayed more than 3 days, nursery stock should be "heeled in."

various things to be done. After the paper plan is completed, put stakes in the ground where plants will be set.

Planting

✓ **Keep tree roots moist** and protected from the drying effects of the air at all times during planting. Roots may be kept in water or covered with burlap or straw. Perhaps the best way is to lay each tree near the planting site and cover the roots with moist soil.

✓ **Make the planting hole large enough** for roots to fan out without crowding, and deep enough so that roots are properly covered.

✓ **Cut off all broken roots**. Use a slanting cut on the underside so that the root will shed water better and heal more quickly. Separate roots that are twisted together even if you must remove one.

✓ **Set** standard-size fruit trees **at the same level** or slightly deeper than they were in the nursery. In planting dwarf trees, take care that the graft union is above ground. If it is below ground, the part above the union will develop roots and destroy the dwarfing effect of the rootstock.

✓ **Incline the tree slightly** in the direction of the prevailing wind so it will not blow over.

✓ Free-standing, **dwarf apple trees should be supported** for the first 4 to 5 years, especially M.9 and M.26.

✓ After the tree is at the proper depth and roots are fanned out, **cover roots with top soil**. Pack the soil so that no air pockets are left near the roots to dry them out. After the soil has settled for 2 to 4 months, additional soil may be needed to level the hole.

✓ **In spring, mound soil slightly** on the edge of the planting hole creating a saucer to allow

C. AFTER PLANTING

Site Modification

Site modification is used to create an apple growing environment that is less favorable for disease development and insect attacks. Site modifications are discussed in more detail in the sections related to specific pests and diseases.

Sanitation

Proper sanitation is fundamental to a sound integrated pest management program in apples. Sanitation is not limited to a specific time of year, rather it is a year round activity. Prematurely dropped fruit, fallen leaves, and pruning trash provide food and shelter for some insect pests and can be sources of innocluum for diseases.

Home owners should routinely pick up and destroy fallen fruit, particularly during May and June. Fruit that are infested with either codling moth or plum curculio usually larvae drop prematurely with the larvae still in them. This fruit should be picked up daily and disposed of in such a manner that the larvae do not have a chance to complete their life cycle. This will help to reduce damage later in the season.

Apple scab overwinters in the apple leaves that had fallen around the base of the tree the previous fall. Removal or destruction of these leaves will limit the amount of primary innoculum the following spring. Composting or shredding of the leaves in the late fall or early winter are effective methods of removing leaves.

Debris around the base of the tree and loosened bark provide protection for codling moth during the winter and during pupation. Debris such as piles of leaves and prunings should be removed during the winter and not allowed to accumulate. Sanitation is discussed in more detail under the sections related to specific pests and diseases.

Exclusion

Some diseases, especially soil-borne and root diseases, may be brought into the planting on transplants. Buy nursery stock from reputable growers. Inspect all purchases for galls, root decay, stem cankers, or insect pests and exclude all diseased or insect-infested plants from the home fruit planting.

Exclusionary devices are available to prevent injury and/or establishment by certain pests of trees and fruit. Devices, such as paper sacks when placed around fruit, can protect fruit from feeding and egg laying by plum curculio. Paper sacks have been found to provide season long control of codling moth in commercial plantings in California. Paper sacks are secured around the fruit prior to pest activity and removed at harvest. This has not been demonstrated in Kentucky, but should be very effective particularly for plum curculio which is only active for a short period of time in the spring.

Dormant Sprays

Dormant oil applications are very important for IPM of apple insects and mites. Dormant oils help to manage many of these pests that overwinter as eggs on the tree. The mode of action of dormant oils is suffocation of the eggs. Failure to use a dormant oil application may require additional inseason treatments. These inseason treatments are usually more expensive and disrupt beneficial insects that control secondary pests.

High volume and thorough coverage is essential to getting good control with dormant oils. Trees should be pruned properly to allow for spray penetration and good coverage. Typically a dormant oil application made during January is more effective against San Jose scale than the delayed dormant application recommended for European red mites and apple aphids. A mid-winter oil application is recommended over a delayed dormant application in trees where scale has been a serious problem. Oil appications are more

effective against European red mites when timed to coincide with egg hatch. Therefore, a delayed-dormant oil application when buds show 1/4 inch green is recommended where European red mite or rosy apple aphids have been a problem.

Dormant sprays are applied during the winter or early spring, before apple buds begin to swell. Their use is described in more detail in the sections dealing with specific disease and insect problems.

D. PRUNING

Pruning and training are two of the most important and time-consuming practices involved in growing fruit trees. Pruning should begin the spring that a tree is set out. Removing small branches early in the tree's life is much easier and causes fewer adverse effects than doing extensive corrective pruning when the tree is much larger. Since no two individuals will prune a tree exactly the same way, and no two trees look exactly the same, understanding basic principles of pruning is necessary to do a good job. Please note the Pruning Terminology information, which is at the end of this section.

Equipment For Pruning and Training

If you have only one or two trees, you may only need a pair of hand shears and a small firewood saw. **Hand shears** come in basically two types. **Anvil pruners** are the best choice if you want an inexpensive pair of pruners. Their sharpened blade cuts up against a brass or aluminum plate and will slightly crush the tip of the cut branch. The **shear type** of pruners are best if they contain high quality steel. Blades on an inexpensive pair will become splayed after some use and then won't do an adequate job of cleanly cutting a branch.

Long-handled pruning shears or **loppers** cut intermediate sized limbs up to about 1 inch in diameter. They can be found in many shapes and forms. If you buy loppers, get a pair with a rubber shock absorber, which makes

Reasons for pruning include:

✓ **Containing tree size.** Since pruning is a dwarfing process, it helps to keep trees more manageable and facilitates basic maintenance and harvest. However, excessive pruning will delay fruitfulness and encourage vegetative growth at the expense of fruiting.

✓ **Controlling tree shape.** Pruning helps develop a strong tree structure that will support a large fruit crop without breaking. It also helps you avoid having to prop weak limbs. If too many scaffold limbs are left in the tree, they will be weak and will bend too much or will break under a heavy crop load. In addition, removing scaffold limbs with narrow crotch angles will help reduce winter injury to the trees.

✓ **Controlling flowering and fruiting.** It helps balance the tree's fruit load and reduce alternate-year-bearing problems of some tree fruits.

✓ **Repairing injury.** Pruning removes broken, dead and diseased limbs, which helps reduce spread of disease within the tree, reduce fruit rot diseases and improve tree survival.

✓ **Increasing light penetration,** which promotes fruit bud initiation within the tree. Light also improves fruit coloration and sugar content.

✓ **Improving air movement,** which reduces disease-favorable humidity and moisture conditions.

✓ **Improving penetration of spray material,** which helps to produce blemish-free fruit and reduces tree insect and disease problems.

extensive pruning less tiring.

A small firewood saw can remove

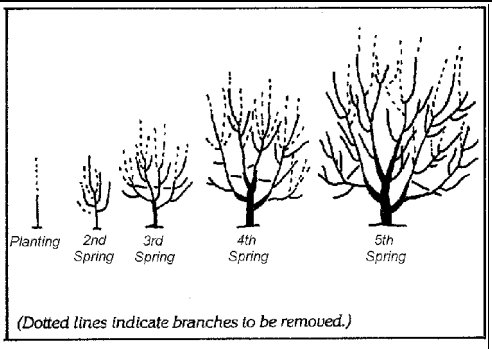


Figure 7. A modified central leader sometimes used for apples.

larger limbs; however, it occasionally won't fit where several branches are clustered together. **A small lightweight pruning saw** is ideal for getting into tight places. They generally have a wooden handle with an 8 to 15 inch curved saw blade. Teeth are wide set with about 6 teeth per inch to enable you to cut green wood without clogging with sawdust. Some models can be folded and carried in a back pocket. **A pole pruner** and/or saw can help you prune limbs that are out of reach and can reduce the amount of time you use a ladder.

Hydraulic or pneumatic pruners and saws work well in reducing pruning time and in reducing pruning costs in large fruit plantings.

Tree spreaders are indispensable in helping develop a strong tree structure. While heavy toothpicks, clothespins and sharpened wires may be used on small branches, use wooden spreaders on larger branches. **Wooden spreaders** are made in varying lengths and have nails driven into both ends with the heads cut off at an angle. In a home situation with children around, these nails can be dangerous. Instead, make spreaders from lath strips with a V-notch in each end.

General Principles of Pruning

Types of Pruning Cuts

Basically only two types of pruning cuts are made in pruning, the heading-back cut and the thinning-out cut. **The heading-back cut** involves removing the terminal portion of a shoot. It promotes branching in a 10-inch area below the cut. The uppermost remaining bud then grows to become the new leader and usually 2 to 4 other lateral buds below the terminal bud also grow out. Heading-back is used primarily on young trees to induce branching where you want to strengthen scaffold limbs and to develop tree structure.

On bearing trees, very light heading preserves flower spurs below. With increasingly severe heading, more shoots are produced and the number of flower spurs that are developed is reduced. Heading-back is the most drastic of the two types of cuts and effects of the cut are confined to a very localized area. The use of the heading-back cut in older trees should be minimized, since it tends to reduce spur formation and fruiting.

The thinning-out cut involves removing a shoot at its origin. This type of cut helps to keep the tree from becoming too bushy and causes the tree's existing framework to grow. It is used on young trees to favor the development of certain limbs and shoots and is almost always used on older bearing trees that need light penetration into their interior, and no additional branching.

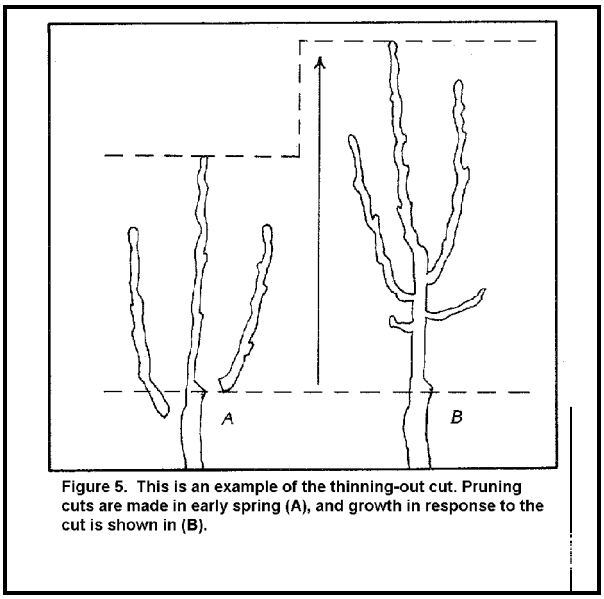


Figure 5. This is an example of the thinning-out cut. Pruning cuts are made in early spring (A), and growth in response to the cut is shown in (B).

When to Prune

Prune all fruit trees annually. Only through annual pruning can we properly train a tree to develop and produce maximum crops of quality fruit. Most pruning is done during the dormant season after danger of winter injury is over, usually from February until just before full bloom. Prune as late as possible, since pruning causes limbs to deharden and makes the tree more subject to cold injury. Young trees (approximately 5 years or less) are much more subject to winter injury, so save these for last. Start pruning oldest trees first in February.

Also by waiting until late winter or early spring to prune you can determine the amount of winter injury and prune accordingly. If a large percentage of fruit buds have been killed, the tree may need only very light pruning. If most buds survived, pruning should be heavier. A tree that shows severe winter injury to woody portions of its trunk and/or branches should be pruned very lightly or not at all in spring. Dead wood is then removed from these trees in summer when the injury can be clearly assessed.

Pruning in fall is not recommended. It delays development of winter hardiness and can

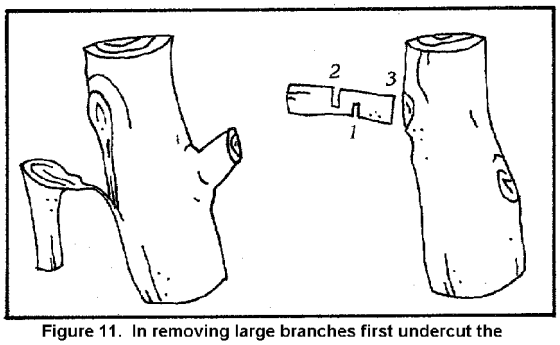


Figure 11. In removing large branches first undercut the branch a foot or two from the trunk.

lead to severe winter injury, particularly on young trees if an early winter freeze occurs. Summer pruning is an extremely dwarfing and devitalizing process and is restricted primarily to removing watersprouts and suckers.

Pruning at Planting

At planting no matter what training system is used, the central leader of the tree is headed back to a height of about 30 inches on one year old trees. This heading back cut will force vigorous wide angled scaffold limbs to form within an area about 10 inches below the cut. This leaves enough room below the lowest scaffold limb for an 18 inch rodent guard.

Large trees may have lateral branches along their trunks. Some of these should be removed completely, but others in desirable locations for scaffold limbs should be headed back leaving 2 to 4 inch stubs containing one or two lateral buds each. The central leader should be headed back at the same height as for smaller trees.

In a back yard planting the central leader may be headed somewhat higher if this makes the lower scaffold limbs too close to the ground for mowing. Heading young trees when they are planted in the spring is extremely important.

Training During the First Growing Season

Increased growth of the most desirable scaffold limbs can be obtained by pinching back less desirable branches and removing suckers during the first summer's growth. This process is usually done two or three times during the summer.

A Central Leader Tree - is shaped just like a Christmas tree. It consists of a central leader trunk with scaffold limbs symmetrically arranged on it and radiating outward. A central leader tree has a maximum of strong horizontal fruiting wood and a minimum of heavy upright structural wood. Scaffold limbs are well-balanced around the central leader and allow maximum interception of sunlight, as well as fruit production along their entire length. A tree may have as many as 11 to 14 scaffold branches, and they should be stout enough to support a fruit load without propping.

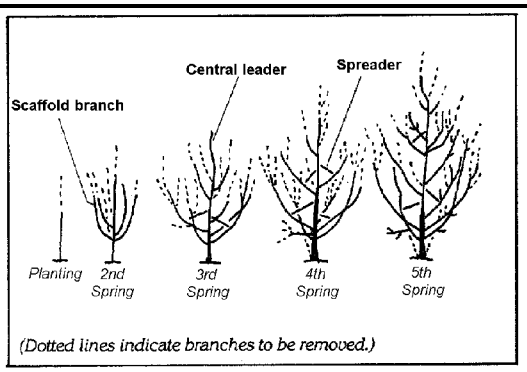


Figure 6. A central leader tree showing the pruning cuts that need to be made. Note the spreaders to obtain strong, wide branch angles.

Ultimately on a mature apple tree we would like to have a whorl of 4 scaffold limbs about 28 inches from the ground, 4 more scaffold limbs 3.5 to 4 ft above the first whorl, and then a whorl of 3 scaffold limbs about 3.5 ft above the second whorl. A young tree would be developed with scaffold limbs between these whorls and these intermediate limbs would be gradually taken out over a period of years as the tree gets larger and more sunlight needs to reach the interior.

A Modified Central Leader or Multiple Leader Tree - is developed with scaffold limbs radiating out from the trunk and then at some point, depending on the fruit variety, the central leader is cut out to open up the center of the tree. This form is sometimes used to train apples, although the central leader form is preferred.

In this type of training system, scaffold limbs should be spaced evenly around the tree beginning at about 28 inches from the ground. Leave about 8 to 12 inches of vertical distance between scaffold limbs.

Getting the desired number of scaffold limbs may take 3 or 4 years. As the tree gets older, the upper center of the tree is kept pruned out to allow sunlight to reach the interior of the tree.

In the dormant season remove pinched back branches and all lateral branches on scaffold limbs within 18 inches of the trunk. The ball of pinched back foliage in the center of the tree may be removed at this time if scaffold limbs are well spread and the tree has made good growth the first season. If not, leave the ball of foliage and remove it during the next dormant season. Remove any branches growing across the center of the tree, toward the ground or straight up toward the sky.

Hereafter, until the tree reaches the desired height remove branches each spring that form on the trunk or grow across the center of the tree. Work on developing a series of secondary scaffold limbs off the main scaffold limbs. Shorten limbs that tend to grow more rapidly than others.

When the tree reaches the desired size (7-8 ft high), cut all branches over 7-8 ft back to an outwardly growing lateral branch to keep the tree height down. Thin out 10 to 20% of one-year-old fruiting wood.

Pruning Objectives

Eliminate weak crotch angles. Narrow crotch angles tend to be weak because bark from both branches prevents the two branches from knitting together well. These branches are ones that split off under the weight of a heavy fruit load or in an ice storm. Wide crotch angles are much stronger since bark does not accumulate between the two branches. Thus, thinning-out cuts should be used to eliminate narrow crotch angles before branches get large.

Leave the swollen branch collar. Always cut a branch at its base at the outer edge of branch bark ridge and the branch collar. These points designate the edge of the tree's natural barrier to decay. Cutting the branch flush with the tree opens up this barrier making the wound larger and more difficult for the tree to exclude decay.

While leaving the swollen branch collar to avoid a flush cut, do not leave a stub. If you leave a stub, it will either produce watersprouts or die back to the next point of branching. A stub must rot out before the tree can grow to seal over the wound. This rot often causes additional decay in the tree, which may also

infect fruit, resulting in storage decay.

When your remove a large limb, first undercut the limb and then saw it off past the undercut portion, to avoid tearing bark when the limb drops off. When the limb falls off, bark will tear to the point of the undercut. Then saw off the stub to make a smooth cut that will heal rapidly.

✓ **Let the sun bleach and dry out areas** where limbs have been removed. Painting cut areas or applying wound dressings actually increases decay. Trees do not heal wounds, but compartmentalize the diseased area and grow over it.

✓ **When selecting framework branches, never select one that is directly over another** unless it is at least 24 inches above the lower branch. Upper branches compete with lower branches for sunlight and shade them out. With closer spacings, the top branch will receive more sunlight and will grow faster. The lower branch will be shaded, grow slower and produce lower quality and fewer fruit.

✓ **After the tree has been shaped by early pruning, the job consists mainly of pruning to keep it within bounds,** removing broken and diseased limbs, occasionally removing limbs to let more light into the tree interior, removing watersprouts and suckers and removing limbs that rub together.

Pruning Terminology

Branch bark ridge: The ridge at the base of a limb's upper side, caused by bark phellogen forced to the surface. It indicates a natural barrier to decay on that side of a limb.

Branch collar: The raised area at the base of a limb's lower side, caused by clumping of vascular tissue. This designates the edge of the tree's natural barrier to decay, on that side of the branch.

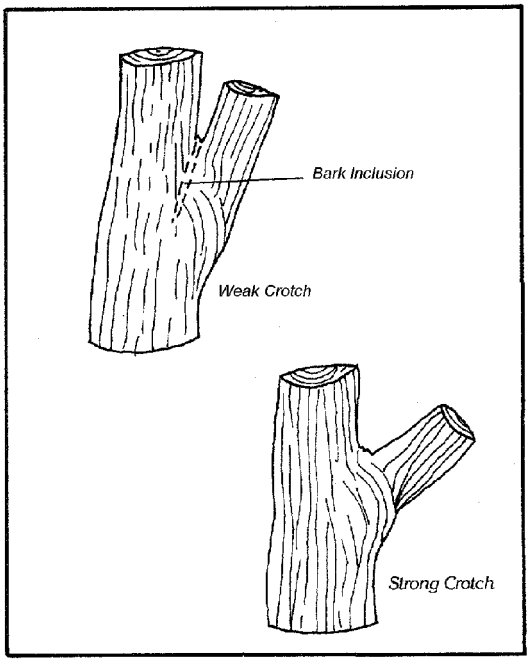


Figure 9. Narrow (weak)-angled and wide (strong)-angled branch crotches. The accumulation of old bark in the narrow angled crotches weakens the branch, often resulting in breakage at this point. Branches with weak crotches should be removed when the tree is small.

Central leader: The central trunk in a central leader pruning system, which extends from the root to the top of the tree.

Crotch: The point at which two branches join.

Framework: Major limbs that make up a tree's structure and support its fruiting branches.

Graft union: The point at which the rootstock is joined to the desired fruit variety.

Heading back: Cutting back a branch or limb, but not completely removing it.

Lateral branch: A small limb growing from a larger limb. Often used for fruit wood.

Leader: A dominant upright branch.

Primary scaffold limb: One of the major limbs arising from the trunk.

Rootstock: The original plant that is now the root system upon which the desired fruiting variety has been budded or grafted.

Secondary scaffold limb: A framework limb that arises from a primary scaffold limb.

Shoot: Current season's or one year old growth, with or without leaves.

Spur: A short shoot that is the primary fruiting structure on apples, pears, plums and cherries.

Stub: A protruding branch left after pruning, which is the result of careless pruning. A branch should be removed at the outer edge of the branch bark ridge and the branch collar for maximum decay prevention.

Sucker: A vigorous shoot that arises below the bud union from the rootstock roots.

Terminal: The apex of a shoot or limb.

Thinning out: Complete removal of a branch or limb at its point of origin.

Watersprout: A vigorous, usually undesirable, shoot arising from the trunk or scaffold limbs.

E. SUMMER CARE

Soil Management

An apple tree is long-lived, so give special attention to soil management before and after establishing the planting. Soil tests taken the season before planting will indicate fertilizer, lime or sulfur requirements on the planting site.

Apples are often grown in a grassy area and mulch is used at the base of the plant to improve appearance and keep the tree healthy. For the home gardener, mulching is an excellent way to reduce weeds and to keep lawnmowers away from the trees. Mulch should extend as far from the trunk as the limbs and should be 2-4 inches deep. Mulch conserves moisture, keeps soil cool, and adds organic matter. However, it may be a hiding place for mice, and special care should be taken to combat this pest. When you first use mulch, increase the amount of nitrogen fertilizer by 50% (see section on fertilizing). Organic mulches may also be used advantageously with any of the other soil management systems. Grass clippings, hay, straw, strawy manure, sawdust, corncobs, etc. are all good mulch materials.

Fruit trees may be planted in permanent sod with cultivation around the trees. The cultivated area may extend slightly beyond the ends of branches. Cultivation must be very shallow to avoid damaging tree roots. The cultivated area will dry out quickly and additional water may be necessary during dry periods.

Fertilization

Because apples are perennials, they require a different fertility program from that of annual plants. In perennials, fertilizer applied during the current season affects winter-hardiness and production the following year. In most fruit plants, nitrogen should be at its highest level during spring and summer and low in the fall to slow growth and reduce winter injury.

Adjust soil acidity to pH 6-6.5 before planting. Base adjustments before planting on recommendations for establishing fruit plantings given in U.K. Extension publication AGR-1, "Lime and Fertilizer Recommendations." Work fertilizer into the soil before planting rather than placing it in the hole at planting. Roots that directly contact undissolved fertilizer may be burned.

During subsequent seasons, base fertilizer applications on plant growth rate and condition. If average new terminal growth is less than 12 to 15" for mature trees or 24 to 30" for 1 to 3 year old trees apply 1/4 lb ammonium nitrate (½ lb granular fertilizer is equal to approximately 1 cup) per tree per year of age in

February. If terminal growth exceeds the amount listed, reduce the nitrogen.

Fruit crops grown in the lawn often receive enough nutrients from the lawn's fertilizer. In this case, determine if additional fertilizer is needed based on terminal growth.

F. THINNING FRUITS ON TREES

Why?

Apple trees often set more fruit than they can mature to a desirable size. This situation can be remedied by hand-thinning or pulling excess fruit. Nutrients are then utilized to produce fewer but larger, higher quality fruit. The total usable production of a properly thinned tree will be almost as great as an unthinned one. Apples spaced an average of 6 to 8 inches apart on a limb will have enough leaves needed to properly size the fruit. Apple fruits need to be thinned almost every year. Some apple varieties get into an alternate bearing cycle. In these instances, a lot of fruit would be removed during the heavy bearing year and no thinning would be done during the light production year.

How Much?

Don't be alarmed if you must remove as much as two thirds of the immature apples from a tree. The important thing is the number you leave on the tree, not the number you remove. The general recommendation for fruits per branch length is 1 fruit per 6-8 inches of branch. If a branch measures 18 inches, 2-3 fruit should be left on it. If a branch measures 60 inches, 8-10 fruit should be left on it.

How?

When thinning, try to pull off damaged fruit, break up clusters and space the load as uniformly as possible over the tree. Reduce clusters to one fruit and space these uniformly over the tree. Don't shake apple branches to thin the fruit, because you will remove the largest fruit and bruise what is left.

When?

There has been much discussion about when to thin a fruit crop. Apples have 3 periods when some immature fruit drops from the tree. June drop is the last one and many growers feel that thinning should follow this drop. However, if a heavy bloom has coincided with good weather so that bees worked the blooms, chances are that relatively few fruit will drop from the tree. In this situation, heavy thinning is required in June. Early varieties should be thinned earlier. Because early varieties mature over a short time, early thinning gives them a better chance for sizing by reducing nutrient competition.

Irrigation of Fruits

Irrigation, especially for small fruits, will increase production of large, high quality fruits more than any other practice. You can get excellent results with an ordinary lawn sprinkler or soaker hose. In general, if rainfall is less than one inch per week, add the amount of irrigation water required to bring the total to one inch. Trickle or drip irrigation is also very effective.

G. WINTERIZING FRUIT TREES

Examine the soil around the base of the trees for depressions, which can trap water in the root zone. In addition, ice in depressions adjacent to the trunk or roots can physically damage the plant. The ideal topography is soil sloping away from the trunk so that water will drain off.

Remove any vegetation within 12 to 14 inches from the trunk to discourage rodents such as voles and mice from nesting and feeding on the trunk. Put commercial or homemade treeguards (cylinders of 1/2 inch hardware cloth) around the trunk to prevent rodents from damaging it. Tree guards should be large enough in diameter to allow for growth and should be 18 inches high to discourage rabbits. Push the treeguard an inch or so into the ground to discourage tunneling voles. Treeguards are

even more important when mulch is used near the base of the plant.

A common winter problem on young apple trees is sunscald injury or injury to the southwest side of the trunk. This winter injury occurs because of rapid fluctuations in temperature, as on cold days when the sun heats the southwest side of the tree and then passes behind a cloud or is blocked abruptly. Subsequent rapid temperature drops cause the bark to split and separate from the tree.

This injury can be reduced by painting the tree trunk from the ground to a height of 36 inches or so. Interior white latex paint reflects the sun's heat and is least damaging to the tree. Painting is usually done after frost and before onset of extremely cold temperatures.

While we can do little to control the weather's effect on hardening or dehardening, we can alter the plants environment to avoid direct injury from cold, and we can avoid cultural practices known to delay or reduce the level of hardening. One method that alters the plant's environment is mulching. It helps protect plants from winter injury in two ways: it protects shallow-rooted plants from extremely cold temperatures; and it avoids fluctuating moisture levels in the soil that can predispose the plant to injury from future cold stress. Mulch also slows soil warming in spring, preventing dehardening and reducing damage from occasional sudden drops in temperature. The plants which bloom earliest suffer most from late spring frosts.

Cultural practices that affect the plant's capacity to survive winter include pruning, fertilization and watering. Anything that promotes excessive growth will normally decrease a plant's capacity to survive winter stresses. Avoid any cultural practice that overstimulates the plant so that it keeps growing in the fall; avoid over fertilizing, excessive watering and early fall pruning. Ideally, the plant should grow slower in late summer and early fall. Twig dieback and bark cracking will be worse on trees that continue to grow.

While too much watering can cause winter injury, adequate water is needed to prevent injury from dying caused by cold temperatures and winter winds. If you can water your plants, water them when needed, especially during summer, September and October, which are dry periods.

A healthy fruit planting will be able to survive winter stress better than a neglected or overly-vigorous one. Late fall is a pleasant time to be out in the yard doing tasks necessary to help your plants get through the winter. While in the yard, observe and correct any potential problems.

Winter damage can usually be attributed to:

✓ too much or too little moisture;

✓ colder mid-winter temperatures than the plant can withstand;

✓ fluctuating temperatures, especially in late fall and early spring, that reduce plant

III. DISEASE MANAGEMENT

In a general way, apple growers need to be aware that apple diseases are only possible when susceptible apples are exposed to virulent pathogens (usually microbes) under environmental conditions favorable for infection and disease development. Knowledge of how these three factors interact are helpful for growers attempting to understand and control apple diseases.

A. APPLE SCAB

Apple scab is the most consistently serious disease of apples in Kentucky. This disease has the potential to cause serious fruit losses and to seriously weaken trees through defoliation every year, and should, therefore, be monitored closely.

SYMPTOMS: Scab infections are most prominent on the leaves and the fruit. On the leaves, early infections appear velvety, olive-green and become puckered with time. Severely diseased leaves may become distorted or turn yellow and fall from the tree. Spots initially appear on the underside of leaves, so be sure to look there; later, spots also appear on the upper leaf surface, where they are somewhat easier to detect. (See Apple Disease I picture sheet, plate #8.)

Fruit spots resemble leaf spots when young, but eventually become brown or black, develop a corky ("scabby") appearance, and frequently become cracked. Infections may be more prevalent near the blossom end.

DISEASE CYCLE: The scab fungus overwinters in diseased leaf litter on the ground. In spring, the fungus produces windblown spores, which can be carried to susceptible apple tissue and cause an initial (primary) infection, given the proper temperature and moisture conditions. If primary infection occurs, new spores are produced; this is the velvety growth on leaf and fruit spots. These new spores can then be splashed by raindrops to nearby tissues and cause repeating (secondary) infections the rest of the season when the weather is conducive. The cycle is completed when diseased leaves eventually fall to the ground.

As can be seen from the accompanying chart, called Mills' table, infection and incubation periods are predictable, being based upon average temperatures and the number of hours that leaf surfaces remain wet. Consequently, a knowledge of recent weather will indicate when new scab infections might be observed. Also, note that secondary infections cannot develop unless primary infections occur first, during the early season.

Disease prediction instruments such as the Envirocaster, or Metos predictor when placed in the orchard, use Mills' Table to compute the disease prediction. Such instruments offer the grower and IPM scout a precise means of managing apple scab diseases. The advance of new fungicides capable of "eradicating" already progressing infections up to 4 days after a wetting event makes apple scab management using predictive instruments a practical activity for commercial growers.

SCOUTING: Lesions (spots) can first appear about 10-14 days after bud break. Early infections are most likely to be noticed on the flower bud leaves (sepals). Recall also that the undersurface of leaves may become spotted before the top surface. Examine 20 leaves on each of 5 limbs per tree and record the number of leaves showing any scab lesions. After fruit has set, make leaf observations, and also examine 20 fruit on each tree showing any scab lesions

Table 3. MILLS' TABLE

Approximate number of hours of wetting required for primary apple scab infection at different air temperatures and the length of time required for secondary spore development.

Ave Temp °F	Degree of Infection (hrs)[a] Light	Moderate	Heavy	Days Incubation[b]
78. . . .	.13	17	26	
77. . . .	.11	14	21	
76. . . .	9.5	12	19	
63-75. . . .	9	12	18	9
62. . . .	9	12	19	10
61. . . .	9	13	20	10
60. . . .	9.5	13	20	11
59. . . .	.10	13	21	12
58. . . .	.10	14	21	12
57. . . .	.10	14	22	13
56. . . .	.11	15	22	13
55. . . .	.11	16	24	14
54. . . .	.11.5	16	24	14
53. . . .	.12	17	25	15
52. . . .	.12	18	26	15
51. . . .	.13	18	27	16
50. . . .	.14	19	29	16
49. . . .	.14.5	20	30	17
48. . . .	.15	20	30	17
47. . . .	.17	23	35	[c]
46. . . .	.19	25	38	
45. . . .	.20	27	41	
44. . . .	.22	30	45	
43. . . .	.25	34	51	
42. . . .	.30	40	60	

[a]The infection period is considered to start at the beginning of rain.

[b]Approx. no days required for secondary spore development after primary infection.

[c]Data are incomplete at low temperatures.

[*]From W. D. Mills, Cornell University.

SCAB MANAGEMENT:

✓ Plant Scab-immune trees.

✓ Remove nearby landscape trees or tree branches which shade the apple tree.

✓ Thin apple tree branches during the dormant pruning operation and remove suckers during summer pruning.

✓ Rake up and destroy all fallen leaves from the previous season.

✓ If a protectant fungicide is used, apply only at green tip, tight cluster, pink, petal fall, and ten days later.

✓ Use temperatures and leaf wetness with Mills' Table to determine when infections have occurred.

✓ If a systemic fungicide is available, apply only after a leaf wetness and infection event.

✓ Construct a clear plastic canopy over the tree to prevent leaves from becoming wet from bud break to ten days after bloom.

B. FIRE BLIGHT

Although not a serious problem every year, fire blight is a disease which can "explode" with devastating consequences under the proper conditions. Consequently, fire blight should be monitored closely.

SYMPTOMS: Infection first occurs around bloom. Infected blossoms appear water-soaked and turn brown or black. The infections may then spread through the blossom-bearing stem (pedicel), turning it black, and into the spur or main branch to form a canker. As young shoots begin to develop, they may also become infected. This "twig blight" phase of the disease begins at the succulent growing tip and moves downward. Infected twigs turn dark brown and become hook-shaped, like the top of a cane. The leaves on infected twigs or spurs then turn brown and die and appear as though they have been scorched by a fire, but remain attached. (See Apple Disease II picture sheet, plate #7.)

If the fire blight bacteria spread into the main branches, they may cause a canker to develop. Such cankers often appear outlined by cracks in the bark at their margins. Fruit may occasionally become infected; these generally turn brown to black at the site of infections, and exude droplets of milky or amber ooze. In fact, the presence of ooze on the surface of any diseased tissue, especially during humid weather, is a good diagnostic sign for fire blight.

DISEASE CYCLE: The fire blight bacteria, which overwinter in the margins of limb and trunk cankers formed the previous season, begin to multiply rapidly as temperatures warm in the spring to about 60^0F or higher. As the bacterial population increases, oozing sticky droplets will be formed on the surfaces of cankers. The bacteria from these droplets are then spread to open blossoms by insects, where they may cause infections and continue to multiply and ooze. Further spread to additional blossoms or twigs is accomplished by insects and splashing or windblown rain.

SCOUTING: Be especially alert for the blossom blight and spur blight phase of this disease when the weather is warm ($65\text{-}80^0$F), humid, and rainy during the bloom period; similarly, be especially alert for the twig blight phase if these conditions prevail while active shoot growth is occurring. All apple varieties are at least partially susceptible to fire blight; however, the following varieties are highly susceptible and should be watched closely: Beacon, Fuji, Gala, Idared, Jonathan, Lodi, Paulared, Rome, Tydemans Red, Wealthy, Yellow Transparent and York.

During the bloom period, examine 20

blossom clusters on each of 5 limbs per tree and record the number of fire blight strikes. After the bloom period, similarly note the number of strikes per 100 spurs and 100 terminal shoots on each tree examined. Continue monitoring until the terminal shoot buds have set. When scouting for fire blight, be sure to check for the presence of blighted suckers arising from the rootstock. Blighted suckers can quickly lead to the death of the tree.

USING THE MARYBLYT COMPUTER PROGRAM TO AID IN APPLE FIRE BLIGHT CONTROL: An approach to understanding and thereby attaining better control of fire blight is presented in a computer program called MARYBLYT developed by Paul Steiner at the University of Maryland and Gary Lightner of the USDA/AFRS, Kearnysville, WV. MARYBLYT can be run in a DOS compatible home or office computer. When using MARYBLYT in an IPM program, growers are required to record daily high and low temperatures, rainfall, hail, frost, and tree development stage to be entered into a computer program file for their orchard. The computer calculates when fire blight infections have occurred, when they are likely to occur, based on weather forecasts, and furthermore, predicts when visible symptoms would appear in the days following infection.

MARYBLYT predicts four distinct types of fire blight: blossom, canker, shoot and trauma blight. Disease development is monitored using current weather and phenological (seasonal tree development) information to operate three cumulative time-temperature "clocks". There is an "apple clock," a "disease clock" and a "pathogen clock" which keep track of tree, canker disease, and pathogen development to make predictions about fire blight disease.

Blossom blight involves direct infections of open flowers and killing of the spur. The source of inoculum is overwintering cankers in and around the orchard. Early symptoms often show ooze droplets or browning of blossom pedicels. The infection of a single flower in a cluster usually kills the entire spur. In later stages bacteria invade the supporting twig, causing a canker that girdles the twig, resulting in the loss of other nearby spurs.

Canker blight involves the renewal of infection activity at the margins of overwintering fire blight cankers. Some cankers may expand laterally to girdle limbs, causing their sudden death.

Shoot blight, or twig blight, is the most visible and damaging phase of fire blight. Primary shoot blight involves direct infections of vegetative shoot tips. The top 3 leaves of growing shoots are most susceptible. Inoculum for shoot blight comes from earlier blossom or canker blight infections. If these sources are nearby, early shoot blight can usually be forecast. Early shoot blight symptoms show a slight wilt of the shoot tip, sometimes with ooze droplets visible on the stem. This is soon followed by leaf and shoot browning and death which proceeds down the shoot. Infections of short shoots are more likely to lead to canker development on the supporting limb.

Trauma blight is the sudden, widespread occurrence of fire blight on many tissues following hail, severe wind or late frost damage when the populations of the bacteria on the foliage are high.

The MARYBLYT screen display shows risks of infection (low to high) and decisions on whether to spray for blossom blight are based on these risks. A "predictions" option uses forecasted weather information to determine risks for one or more days in advance. Growers could use the MARYBLYT risk warning to determine whether or not to spray.

Table 4. MARYBLYT

DATE	PH	HI	LO	WET	T	S	NOTE	AVG	EIP	BHWTR	BBS	CBS	SBS	TBS
3/31	D	46.0	40.0	0.00				43.0	0		0	0	0	0
4/ 1	GT	59.0	42.0	0.00				50.5	0		0	0	0	0
4/ 2	GT	67.0	38.0	0.50				52.5	0		0	0	0	0
4/ 3	GT	71.0	49.0	0.00				60.0	0		0	13	0	0
4/ 4	GT	75.0	58.0	0.00				66.5	0		0	42	0	0
4/ 5	TC	70.0	49.0	0.00				59.5	0		0	55	0	0
4/ 6	TC	76.0	42.0	0.00				59.0	0		0	65	0	0
4/ 7	TC	73.0	50.0	0.20				61.5	0		0	81	0	0
4/ 8	TC	75.0	48.0	0.35				61.5	0		0	CMI	0	0
4/ 9	PK	77.0	50.0	0.00				63.5	0		0	38	0	0
4/10	PK	81.0	48.0	0.00				64.5	0		0	45	0	0
4/11	B	78.0	49.0	0.00				63.5	39	+--+M	0	52	0	0
4/12	B	84.0	55.0	0.00			X	69.5	124	++-+H	0	64	0	0
4/13	B	70.0	60.0	0.55				65.0	139	++++I	0	72	0	0

A - ADD DATA M - MODIFY DATA G - GRAPH DATA
P - PRINT DATA H - HELP X - PREDICTIONS
V - VIEW DATA T - MODIFY THRESHOLDS E - EXIT

CHOICE =

In years with low disease pressure, growers have saved one or more streptomycin sprays by following the MARYBLYT recommendations.

The MARYBLYT program also informs the grower when an infection has occurred. By continuing to enter weather data, the program also predicts or alerts the grower when certain symptoms such as blossom blight or shoot blight are going to occur. If infected spurs are removed immediately when symptoms just begin to appear, further spread of the disease can be stopped, and this reduces later infections of twigs and branches. Growers with labor available could use this feature of MARYBLYT for timely pruning.

Using the MARYBLYT computer program. Using MARYBLYT from your hard drive or a floppy disk, activate the file MB.EXE and continue past the title screen as directed. From this point, procedures and features will vary depending on the version of MARYBLYT used. A file menu and directory screen presents choices, the most important of which are to start a new file, to get an existing file (to add to or review), and to exit. Other choices might include an explanation of fire blight and MARYBLYT, and various file operations including deleting, adding, changing the name, and printing a list of files. The screen might look like this:

MARYBLYT, Version 2.1
[Copyright 1989, All Rights Reserved]

A. Fire Blight control and the MARYBLYT Program

B. Start a New File

C. Retrieve a File

D. Exit

At this stage it would be wise for the user to explore one or more of the demonstration files provided with the MARYBLYT program. They may be listed as a numbered file on this menu screen, or as a number in the list of files on the diskette or computer subdirectory. After some practice, the user can begin to create files relating to their own orchard or orchard blocks.

When a grower creates a new file, it will be given a short name and in some cases the variety, orchard name, and year. The program

immediately calls for a beginning date, usually sometime in March near the end of the dormant season, the high and low temperatures for that date, and the rainfall or other weather events for that day. Once this data is entered, a file for the orchard or block in the orchard is begun and a new chart appears on the screen (Table 4).

This chart is divided; the left portion is data entered by the grower relating to date, tree growth stage, high and low temperature, rainfall, trauma events, sprays, and other notes. The user then follows directions from a lower section of this chart to add, modify, graph, view, and make predictions from data. The right portion of the screen presents the computer calculations of average temperature, epiphytic inoculum potential, risk factors and potential, blossom blight symptoms, canker blight symptoms, shoot blight symptoms, and trauma blight symptoms. The chart on the computer screen might appear as follows:

It is important for the grower to begin taking records while the trees are still dormant. Temperatures leading up to bloom help determine growth of the fire blight bacteria in the old cankers and how many bacteria are available for infection. The most vulnerable stage for the apples is the bloom period. This is also the only time chemical control can be used to reduce infection. Growers could enter data weekly from dormant to tight cluster stages, but beginning with pink, data should be entered daily to track fire blight progress.

In this example, the (+) and (-) designations appear at bloom. The heading BHWTR stands for bloom, heat (accumulated), wetness, temperature (for that day), and risk (+ = low, ++ = medium, +++ = high, and ++++ = infection). On April 11, in this example, the risk was medium because only two of the four criteria needed for infection were met: the trees were in bloom, and the temperature that day was suitable for infection. On April 12, accumulated heat had built up so that bacterial inoculum (EIP) crossed a threshold of 100, and the risk was high, but still no infection occurred because the rain or heavy dew needed to wash the surface bacteria into the base of the blooms did not occur. On that day, the X appearing in the left part of the chart told the grower to look at the weather forecast and if rain was predicted, to spray if needed. On April 13, the rain provided the fourth risk factor and infection occurred.

As data are added to the chart after bloom, growers will be alerted to the date of first appearance of fire blight symptoms in the blossoms and the shoots. Careful pruning of infected fruit clusters can reduce further spread of the disease. Additional details about MARYBLYT can be found in the help menu of

FIRE BLIGHT MANAGEMENT:

✓ Select fire blight disease-tolerant varieties and rootstocks.

✓ Sanitation - this involves pruning out last year's infections and any dead wood in the winter. Prunings must be removed from the apple planting and destroyed.

✓ Faithfully record temperatures, rain, and tree growth stage in the spring.

✓ Use MARYBLYT to determine when symptoms will appear.

✓ Eradication - this means plucking out all infected fruit spurs when symptoms first appear on the one or more of the faded flowers or fruitlets in the spur.

✓ Although commercial growers use the antibiotic streptomycin, it is probably not a good idea for urban situations.

✓ Use MARYBLYT to determine when to spray, if sprays are used.

✓ Construct a clear plastic canopy over the tree during bloom to prevent movement of bacteria into the flowers by rain.

the program.

C. POWDERY MILDEW

SYMPTOMS: The most obvious sign of powdery mildew is the presence of a whitish, powdery or felt-like growth on the leaves, first along the margins and lower surfaces, and eventually over the entire leaf surface. Infected leaves are distorted, becoming narrow, cupped towards the middle, and brittle. Fruit on heavily infected trees may become severely russeted.

DISEASE CYCLE: The powdery mildew fungus survives the winter within buds which became diseased the previous summer. When these buds open in the spring, the fungus resumes growth in the newly expanding leaves and produces the white, powdery spores which give the disease its name. These spores are then blown by the wind to emerging tissue and produces secondary infections until tree growth stops or temperatures become limiting. (See Apple Disease II picture sheet, plate #4.)

Disease development, although rapid between 60-80^{0}F, is slow both between 40-50^{0}F, and at temperatures above 90^{0}F. High relative humidities favor disease development; however, rain and dew are not required for spore movement or for infection to take place.

SCOUTING: Powdery mildew is most likely to be a problem on highly susceptible varieties, including Jonathan, Rome, Cortland, Baldwin, and Idared. Disease pressure is also likely to be higher in seasons following a mild winter where fungal survival is greatest.

Record the number of terminal shoots showing powdery mildew infections out of 100 observed on each tree (20 per limb x 5 limbs). Begin monitoring at shoot emergence, and continue until terminal growth has ceased.

POWDERY MILDEW MANAGEMENT:

✓ Sanitation - this could involve pruning out badly infected shoots.

✓ Fungicide sprays can be used for powdery mildew control.

✓ Thin branches of the apple tree during the dormant pruning operation, remove suckers during the summer.

✓ Remove nearby landscape trees or tree

D. RUST DISEASES

Three different rust diseases can occur on apple. However, it is not necessary to distinguish the subtle differences between these rusts for the purposes of scouting, since the disease cycles and control programs are similar for each.

SYMPTOMS: Small pale yellow spots appear on the upper surface of infected leaves shortly after bloom. These spots gradually enlarge up to 1/4" in diameter, depending upon the apple variety and the number of spots per leaf, and become bright yellow-orange in color. By early or mid-summer, yellow spots will also be present on the lower leaf surface; from these come small, orange-yellow tubular fruiting bodies which eventually project downwards. As the tubes mature, they split towards the base into narrow strips and curl back on themselves to form cup-like structures. Within these structures a mass of light brown spores can normally be seen with a hand lens (10x). Heavily infected leaves may fall off the tree. (See Apple Disease I picture sheet, plate #10.)

Fruit spots usually appear near the blossom end, and may be of two types: 1) spots that are similar in color to the leaf spots, but larger (up to 3/4" in diameter), which may be

outlined by a dark green border; 2) spots that are dark green and sunken. Fruits with the latter infection usually become puckered at the blossom end while the fruit is still an inch or less in diameter.

DISEASE CYCLE: Spores produced in the cup-like structures on the lower surface of infected apple leaves become wind-dispersed, and infect nearby cedar or juniper trees during the summer and fall. The rust fungus then grows and survives two succeeding winters in galls which are formed on infected cedars. When apple buds are in the pink to early bloom stage, the fungus produces spores upon the cedar galls, and these spores are blown to apple tissue, where they infect and complete the disease cycle two years after it began. The infection period for apple usually ends about 30 days after bloom. Unlike apple scab or fire blight there is no apple-to-apple (secondary cycle) spread of disease.

SCOUTING: Apple varieties vary greatly in their susceptibility to rust. Be alert for leaf and fruit infections on Prima, Sir Prize, Lodi, Jonathan, Rome, Wealthy, and York Imperial. Also, look for fruit infections on Cortland, Golden Delicious, McIntosh, Red Delicious, Stayman, and Winesap.

For each tree record the number of infected leaves per 100 observed (20 per limb x 5 limbs). Also, examine 100 fruit per tree and record the number with at least one rust spot.

If you can see cedar trees near the orchard, look for the presence of the orange cedar galls from pink bud to 30 days after bloom. Note your findings on the scouting form.

CEDAR APPLE RUST MANAGEMENT:

✓ If there are no cedars or junipers within 200 yards of the apples, rust disease will not be a serious problem.

✓ Remove and destroy susceptible cedars and junipers if you can.

✓ Remove and destroy galls on susceptible cedars and junipers.

E. FROGEYE LEAF SPOT

The fungus which causes frogeye leaf spot also causes a canker disease on limbs and twigs, and "black rot" on the fruit later in the season. These diseases are more likely to be a problem on old trees than on young trees.

SYMPTOMS: Small purple specks typically appear 1-3 weeks after petal fall. These specks then enlarge to 1/8" - 1/4" in diameter and become brown with a purple margin. Older spots become irregularly shaped or lobed, retain their purple margin, and appear brown with a light colored center. Small black dots may appear in the light centers of older spots on the upper leaf surface. Heavily infected leaves may turn yellow and fall off, especially on the variety Jonathan. (See Apple Disease I picture sheet, plate #4.)

DISEASE CYCLE: The fungus overwinters in dead bark and mummified fruit. Spores are primarily dispersed in splashing rain; this commonly results in the development of cone-shaped zones of infected leaves beneath the source of spores (e.g., fruit mummies hanging in the tree, or dead twigs and branches). Although spores may be released during rainy periods throughout the season, leaf infections occur primarily around the time of petal fall. Warm temperatures (minimum 60^0 F, optimum $75\text{-}80^0$ F) and adequate moisture are necessary for infection to occur.

SCOUTING: Examine 100 leaves from each tree scouted (20 leaves per 5 limbs) and record the number showing at least 1 spot. On your

scouting form, note the presence of fruit mummies and dead wood above zones of infection. Black rot cankers often form in branches that were infected with fire blight the previous season. From records or from the grower, note whether or not fire blight was serious the previous season. Note leaf yellowing and leaf drop if it occurs.

FROGEYE LEAF SPOT MANAGEMENT:

✓ Prune out all cankers and dead wood during the dormant pruning operation.

✓ Remove and destroy mummies (shriveled

F. COLLAR ROT

Collar rot caused by various species of Phytophthora is impossible to positively diagnose without laboratory culturing. However, the grower can identify trees which may be infected, and deliver appropriate samples to the County Extension Office.

SYMPTOMS: The symptoms of collar rot are often similar to those caused by any agent which interferes with part or all of the tree's root or trunk system (rodents, soil compaction, mechanical injury, canker diseases, fire blight, etc.). Affected trees may exhibit poor terminal growth; have small, chlorotic leaves; and/or wilt and eventually die. Trees collapsing as a result of collar rot will be largely or completely girdled by a zone of dead inner bark just beneath the soil line. Bark discoloration sometimes extends above the soil line as well. Collar rot is most common on MM.104 and MM.106 clonal rootstocks, although all rootstocks are at least partially susceptible. (See Apple Disease II picture sheet, plate #5.)

DISEASE CYCLE: The collar rot fungus persists for long periods in diseased host tissue or as resting spores in the soil. When the soil becomes saturated with water, the fungus produces small swimming spores (zoospores), which are chemically attracted to plant roots. Spores may also be carried by water as it drains down a slope and through the soil profile. Upon contacting a root or the trunk, the spores may germinate and infect. Both of these processes depend upon the susceptibility of the rootstock, and how long the soil remains excessively wet. Spore production and infection is most common in the spring and the fall.

SCOUTING: Observe and note the location of any weakly-growing or collapsing trees. Note these trees especially if they appear to be growing in a low-lying or poorly-drained area. Gently dig the dirt away from a portion of the crown (trunk/root area) and check to see if the inner bark is still alive. If so, it will appear green and the wood just inside the bark will be firm and white with no discoloration being evident.

To collect a sample, dig a shallow hole within the drip line of the tree, and put some moist soil and segments of roots into a plastic bag. If the crown or lower trunk appears infected, remove a few pieces of inner bark from near the margin of the infected region, and place them in a plastic bag with moist soil. It is important to keep samples cool and avoid placing bags in direct sunlight before they are delivered.

COLLAR ROT MANAGEMENT:

✓ Provide good drainage. Underground tiling will help improve internal drainage of heavy soils.

G. FUNGAL TWIG AND LIMB CANKERS

In addition to fire blight (caused by a bacterium), twig and limb cankers are caused by several different fungi. It will not be necessary to determine the actual cause of cankers other than fire blight; however, it is important to note the occurrence of cankered limbs when they are observed.

SYMPTOMS: Generally, cankers will appear as small to large sunken areas on twigs, limbs and/or tree trunks. Depending upon the cause of the cankers, the sunken areas may exude a liquid or develop sporulating structures which in turn exude a gelatinous material laden with fungal spores. This is especially true during humid, rainy weather. Cankers may become cracked or appear to blister in a way which is not characteristic of "normal" apple bark. Many times cankers will be associated with lenticels or tree wounds, especially those resulting from improper pruning techniques. Additionally, healthy wood bordering cankered tissue will often be swollen with callous tissue as the tree attempts to "heal" cankered wood. (See Apple Disease I picture sheet, plate #11 and Apple Disease II picture sheet, plate #1.)

DISEASE CYCLE: Canker-causing fungi normally overwinter in diseased or dead wood on the tree, and produce and disseminate spores during rainy periods in the growing season. New infection sites then become sources of additional spore production. Weakened or poorly-growing trees are especially susceptible to fungal canker diseases.

SCOUTING: A quantitative assessment of these diseases is not required; rather, be on the lookout for twig and limb cankers as you scout for leaf and fruit diseases, and record their occurrence in the comments section of your scout form.

SUMMER FRUIT ROTS

Several different rots can occur on apple fruits, especially as they approach maturity. The following are the most common and important "summer rots" which occur in Kentucky.

APPLE CANKER MANAGEMENT:

✓ Prune out and destroy all cankers and dead wood from the tree.

✓ Remove prunings from the area and

H. BLACK ROT

SYMPTOMS: Infections are usually not apparent until fruit begin to ripen. The disease may first be noticed as a brown to black spot at the blossom end of the fruit, or around a worm hole or some other wound. Usually, only ONE spot appears per fruit. This is a characteristic which helps distinguish black rot from some other fruit rots.

As the infected area enlarges, a series of brown or black concentric rings sometimes develops, producing an alternating "bulls-eye" or target-shaped pattern. Small black dots will frequently be seen within older rotted areas. The infected tissue remains firm as the rotted area expands throughout the entire fruit. At this point the whole fruit typically turns black. Such fruit will eventually shrivel and harden into mummies which remain attached to the tree and become a source of spores for future infection. (See Apple Disease I picture sheet, plate #4.)

DISEASE CYCLE: Same as "Frogeye Leaf Spot", discussed previously.

SCOUTING: For each tree observed record the number of fruits with black rot per 100 examined (20 fruit per 5 limbs). Note the

presence of mummified fruit in the tree in the comments section of the form. This disease is more likely to occur in old and in poorly pruned trees that have poor air and light penetration than in young trees.

I. BITTER ROT

SYMPTOMS: One to several small brown circular spots may first appear any time after fruit are half grown. These spots expand rapidly in warm weather, becoming dark brown or black and somewhat sunken in the center (saucer-shaped). After the spot has enlarged to about 3/4" in diameter, a number of slightly raised dark "cushions" appear near the centers. As the spots continue to enlarge, these cushions frequently radiate outward in rings to give target-shaped appearance. In warm, humid weather, masses of slimy salmon-pink spores may be seen oozing from the cushions. If warm, moist weather prevails, several spots may expand and fuse together to rot the entire fruit, (see Apple Disease I picture sheet, plate #2.)

DISEASE CYCLE: The bitter rot fungus persists between crops in partially mummified fruit on or beneath the tree, or in dead wood. Initial infection can occur anytime that warm (about 70^0 F or higher), rainy weather occurs. The salmon-pink spores are then produced as the fruits approach maturity and the infected regions expand. These spores are subsequently splashed onto healthy fruits by raindrops, and can cause a rapid secondary spread of disease under warm, humid conditions. Pruning, tree shape and weed control will effect the degree of severity.

SCOUTING: Record the number of fruits with bitter rot per 100 examined from each tree. This disease can be distinguished from black rot by the slimy salmon-pink spores oozing from cushions (use a hand lens to see), as well as the appearance of saucer-shaped depression towards the center of each spot. The presence of more than one spot per fruit, and their lack of consistent association with the blossom end or wounds are other characteristics which may distinguish bitter rot lesions from those of black rot. In addition, bitter rotted tissue can be cleanly separated from healthy tissue using a knife to give the appearance of an inward cone. This is not possible in fruit with black rot.

J. SOOTY BLOTCH/FLYSPECK

Sooty blotch and flyspeck are two distinct diseases, caused by different fungi. However, because both diseases usually occur together, and because their disease cycles and control procedures are similar, the two diseases are frequently "lumped" into a single disease complex.

SYMPTOMS: Sooty blotch, as its name implies, appears as sooty brown or black blotches on the surface of nearly-mature apples. Blotches vary greatly in size, but may be 1/4" in diameter or larger. Several blotches may coalesce to cover relatively large areas of the fruit.

Flyspeck appears as a group of tiny, distinctly defined black dots, with several to 50 or more individual dots making up a single cluster. A number of different clusters may be found on a single fruit. (See Apple Disease I picture sheet, plate #5.)

DISEASE CYCLE: Both fungi overwinter on the twigs and branches of many wild woody plants, in addition to apple. Spores are produced and blown or splashed onto fruit during rainy periods from May onwards; however, the diseases develop most rapidly during relatively cool, humid weather. Practically no fungus growth occurs at temperatures above 85^0F; consequently, infections which are initiated in late spring may not become evident until the weather turns cool in the fall when fungi resume growth. Disease outbreaks are most likely to be severe when cool wet springs are coupled with

later summer rains and cool weather prior to harvest.

SCOUTING: From each tree observed record the number of fruits per 100 examined which are infected with sooty blotch/flyspeck. Of those infected, rate the average or typical disease severity as light (< 5 % of the apple surface blemished), moderate (5-20% blemished), or severe (> 20% blemished).

K. WHITE ROT

White rot is also referred to as Bot rot or Botryosphaeria rot.

SYMPTOMS: Fruit lesions begin as small, often circular, slightly sunken tan spots, which may be surrounded by a red or dark purple halo. As lesions expand, the rotten area extends in a cylindrical manner toward the core. Under warm conditions, the rotted areas are usually sort, watery, and clear to tan in color. Scattered clumps of dark fungus dots develop on the fruit surface. The decay may progress until the entire fruit is rotted at which time the fruit may drop or hang on the tree as a mummy. The white rot fungus may also cause twig and branch cankers.

DISEASE CYCLE: Similar to black rot, the white rot fungus overwinters in dead bark, twigs, fruit mummies, and cankers in the tree. Spores produced during the growing season are washed onto the new fruit during rainy periods. Fruit infections occur primarily through wounds throughout the season, but decay symptoms often do not appear until fruit begin to mature.

SCOUTING: Record the number of fruits with white rot per 100 examined from each tree. This disease can be distinguished from black rot and bitter rot by the tan color and cylindrical pattern of the decay from the skin to the core, and by the red or purple surface halo.

SUMMER FRUIT ROT MANAGEMENT:

✓ Prune out cankers and dead wood in the tree and destroy the prunings.

✓ Remove and destroy all mummies and infected fruit.

✓ Summer pruning by removing water sprouts will help improve air movement and reduce disease.

✓ Remove and destroy weeds, undergrowth and brush from near the orchard; these plants may harbor pathogenic microbes.

✓ Protectant fungicides can be used.

✓ Fruit covers such as paper or plastic bags may help in disease control by excluding fungal inoculum. Fruit covers are an untried practice and may or may not work.

L. APPLE DISEASE CONTROL STRATEGIES AND THE SIGNIFICANCE OF DISEASE SCOUTING

To effectively control the major apple diseases in Kentucky, growers must develop control strategies based upon a variety of factors. These include, the age, cultivars, general condition, and topography of the orchard; current and projected weather conditions, knowledge of past histories of disease incidence, and present disease conditions as determined by scouting.

Cultural Control Strategies

Resistant cultivars. Where disease resistant apples fit the taste and preference of the

gardener, they provide an economical way to control diseases. Even cultivars that are partly resistant, or at least not highly susceptible to diseases will be easier to manage. There are many apple cultivars that are resistant to scab; many are also less susceptible to fire blight, cedar rust, and powdery mildew. Use these cultivars if possible. Plant rootstocks that tolerate collar rot and fire blight diseases.

Sanitation. Disease-causing fungi and bacteria often survive from one year to the next on diseased leaves, fruit, and branches. Reduce the activity of the apple scab fungus by raking up or chopping fallen leaves into tiny pieces with a power mower in fall and winter. Remove and destroy fruit "mummies" and cut out dead and diseased twigs and branches during annual tree pruning. Remove and destroy any abandoned and unsprayed apple or pear trees near the orchard.

Exclusion. Use only disease free nursery stock when planting a new block of trees. Try to use physical barriers to block microbes from contact with apples. The apple grower needs to be aware that some disease-causing microbes can be kept out of the orchard, or can be kept from spreading to a tree or block from one nearby. Soil contaminated with the collar rot fungus should not be moved about, and pruning tools contaminated with fire blight bacteria should be disinfested before using in the next tree, especially during summer.

Environmental modification. Prune with the objective of improving air and light penetration into the trees to reduce disease enhancing humidity and moisture. Improve soil drainage where needed. You may want to consider constructing canopies to keep leaves and flowers dry.

Eradication. Remove and destroy nearby cedar trees to break the cycle of cedar rusts on apple. Remove and destroy newly infected fruit spurs using MARYBLYT for timing.

Chemical Control

If cultural control strategies are effeciently and completely applied, and if some low level of disease can be tolerated, chemical controls may not be necessary.

Although chemical control strategies may vary for each disease, they are generally classified as being protective, or reactive (where the control measure employed is in reaction to the development of a problem), or a combination of the two.

Protective strategies are based primarily upon prior disease histories and the likelihood that a disease will show up year after year. Protective strategies are also used for diseases such as fire blight because of its erratic, yet potentially devastating nature. With the more predictable diseases such as apple scab, rust, and the "summer diseases", as well as fire blight, control measures are generally in place prior to known periods of infection. The primary role of scouting in these instances is to provide insight into where a control program can be adjusted to provide for more effective disease control in subsequent seasons.

Scouting also allows reactive control strategies to be implemented into protective programs. That is, scouting may detect lapses in the effectiveness of the protective program due to one reason or another. These lapses may indicate ways to correct a problem before it gets out of hand. This is especially true of diseases such as apple scab and fire blight where the development of secondary inoculum, if left unchecked, can soon result in poor disease control.

When properly implemented, a protective spray program will effectively control most of the apple diseases encountered on a yearly basis. However, many of the chemicals used in a protective program require that they be present on the plant surfaces prior to the arrival of the disease organism. Unfortunately, this is not always possible because of the unpredictability of the weather in Kentucky. Many times it is simply impossible to apply

spray materials prior to periods of infection. Fortunately, the development of a new breed of fungicides, and a modified method of application provide us with means to circumvent this problem.

Chemicals are now available which show substantial "kick back" action against certain diseases. These chemicals have the ability to stop disease activity after infection has taken place. This is very desirable in situations where plant tissue is left unprotected during periods of infection, because of rapid growth and/or lengthened spray intervals. Sometimes they are included early in the season to assure the grower of eradicating infections that might have escaped protectant fungicides. Consequently, these chemicals add a certain degree of flexibility to a spray schedule and ease the demands of a strictly protective spray schedule. In most cases, growers having orchards with a history of diseases are best served with a strict protective spray schedule.

In orchards where apple scab has been kept under control, growers can reduce early season fungicide use. Scab infections, determined using Mill's Table as explained earlier, can be controlled using "eradicating" or "kick back" fungicides. Scab fungicide use can also be reduced by using a four spray schedule at tight-cluster, pink, petal- fall, and first cover. An eradicating fungicide such as myclobutanil (Nova), used in the four-spray schedule, will also control cedar rust and powdery mildew. Beginning at first cover, traditional calendar sprays are then used.

Although the above discussion is very general in nature, it should assist in the development of control strategies based upon individual needs. It is also meant to tie together the role of scouting in the development and implementation of an effective spray schedule. For more specific information concerning diseases and control recommendations for Kentucky, please consult the current guide for control of diseases and insects in home fruit plantings (ID-21). The Commercial Tree Fruit Spray Guide (ID-92) or the Midwest Tree Fruit Handbook (ID-93) are also useful additional references.

More detailed information about symptoms, causal organisms, disease cycle and epidemiology, and control can be found in the *Compendium of Apple and Pear Diseases*. This book is available from The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, MN 55121.

IV. INSECT MANAGEMENT

A. CODLING MOTH

The codling moth larva is one of the very destructive pests introduced from Europe by settlers. The larva of this insect is the "worm in the apple," and tunnels in the fruit to the core. This insect pest, left unmanaged, can cause near complete loss of yield in some areas of the country.

Female moths lay the scale-like eggs singly on developing fruit or adjacent leaves or stems just after sundown each night. The eggs are very difficult to spot. Upon hatching the larva enters into the calyx end or side of the fruit then tunnel to the center where they feed and develop. Brown frass is often noticed near the calyx end of the developing fruit. The larva is pinkish to white in color with a brown head and shield on the first segment behind the head. Larvae can reach 3/4 inch when full grown. Larval development is completed in 3 to 5 weeks. Larvae pupate in a thick silken cocoon on the bark or other protected areas. The fully developed larva is the overwintering stage. Pupation occurs in spring beginning at about bloom with adults first active in late April or early May. In Kentucky, there are three generations each year. The adult is about 3/8 inch, gray, with distinctive bronze areas on the bottom 1/3 of the wing.

There are a number of alternatives for control of codling moth for the home owner. These alternatives include intensive monitoring of codling moth activity and development to accurately time insecticide applications, bagging of the fruit to exclude codling moth, trapping of male moths to prevent mating, and banding of the scaffold limb to capture codling moth pupae.

PHEROMONE TRAPPING

Pheromone trapping uses chemical lures to attract male moths. These chemical lures are synthetic copies of chemicals female moths release and are used by males to locate females for mating. A trap consists of plastic top and bottom held together by a wire hanger with the lure placed inside. The inner surface of the bottom is coated with a sticky material to hold the insects once they land in the trap. Traps are hung in the southeast quadrant of the tree at eye level. It is important to distinguish codling moths from other moths captured in the traps. Codling moths can be recognized by the bronze areas on the bottom 1/3 of the wings (See Common Fruit Insects picture sheet, figure 1).

Traps should be put out at the pink stage of bud development. Every month, pheromone lures need to be replaced. Codling moths can be distinguished from other insects in the traps by their bronze wing tips. For a list of the sources of various type of pheromone traps, see ENT-54, Vendors of Microbial and Botanical Insecticides and Insect Monitoring Devices.

IPM MANAGEMENT OPTIONS

Pheromone Trapping & Degree Day Accumulation (intensive IPM)

Control of codling moth with intensive IPM relies on the three tools; regular examination of the trees and fruit (termed monitoring), pheromone trapping to determine the need for insecticides and accurately time their application, and the use of weather recording and degree day models. Trees should be examined on a weekly basis for insects and mites beginning at the half-inch green stage in the early spring and continued throughout the summer. By mid summer, every other trip may be omitted such that examinations are about two weeks apart.

Table 5. Predicting Codling Moth Development	
DD Target	Action taken when target reached
250	Egg hatch begins. An insecticide spray is recommended. If codling moth are abundant (more than 10 per trap per week), a second spray may be necessary 7 to 10 days later.
1000	When 1st generation moth begin to fly. Use their emergence as the next biofix.
1300	About when 2nd generation egg hatch begins. An insecticide spray is recommended. If codling moth are abundant, a second spray may be necessary 7 to 10 days later.

Initial trap catches in the early spring are termed biofixes. This information will be used to predict when egg hatch will occur and synchronize insecticide sprays. In commercial IPM orchards, inclusion of an insecticide in the cover sprays is recommended as long as pheromone trap catches exceed an average of five moths per trap per week.

The biofix for the codling moth is the starting date of the first sustained flight of male moths captured in pheromone traps. Generally, this is when the fifth moth has been captured in the trap. A few moths often emerge very early in the spring ahead of the rest. Using the fifth moth as the biofix better represents when the majority of the codling moths begin to emerge. This usually occurs just after petal fall. Codling moth traps need to be examined daily in order to know exactly when the biofix occurs. After the biofix has occurred, degree days are calculated on a daily basis and a running total is kept. The codling moth has a 50°F threshold temperature. These degree day accumulations are compared with the target values in the table above.

Codling moth trap catch records need to be maintained throughout the summer to monitor additional generations. However, after the initial biofix it is only necessary to examine the traps twice a week. A threshold of five moths per trap per week is used to determine if there are sufficient levels of moths to warrant an insecticide application. Imidan and Diazinon provide good control of codling moth and are less toxic to beneficial insects and mites than the most of the other available materials. *Bacillus thuringiensis* can provide effective control of codling moth when applied at three to four day intervals during egg hatch. *Bacillus thuringiensis* is available as an organic alternative.

Trunk Banding (Organic alternative)

Another tactic that can be used by home owners is the use of cardboard bands placed around the trunk of the trees to serve as pupation sites for the wandering larvae. A four to six inch band encircling the trunk or scaffold limbs will attract the larvae. Bands should be in place before larvae begin to leave the apples in search of pupation sites and removed and destroyed before moth emergence begins. This technique will not be effective if bands are not placed on the tree and removed at the proper time. Bands should be placed on trees in August to capture overwintering pupae and removed and destroyed in December. Bands can also be used in the summer to capture pupae from the summer generations, but timing is more difficult. If degree day records are kept, bands should be placed on the tree about 450 degree days after eggs are laid and removed 725 degree days after egg lay. Trunk banding is usually more effective on smooth bark apple varieties that do not have as many alternative pupation sites. Banding

typically only controls a small proportion of the codling moth as some drop to the ground or find other roughened areas in the bark to pupate.

Sanitation

The value of good sanitation cannot be over emphasized! Home owners should routinely pick up and destroy fallen fruit, particularly during May and June. Fruit that are infested with either codling moth or plum curculio usually larvae drop prematurely with the larvae still in them. This fruit should be picked up daily and disposed of in such a manner that the larvae do not have a chance to complete their life cycle. This will help to reduce damage later in the season. Debris around the base of the tree and loosened bark provide protection for codling moth during the winter and during pupation. Debris should be removed during the winter.

Bagging Fruit (Organic alternative)

Bagging of the individual fruit has been used experimentally with some success for codling moth control in commercial apples in California. To control codling moths, bags should be placed around fruit at thinning (earlier if used for plum curculio control) to prevent egg laying. A 2-inch slit is made in the bottom of a small brown paper bag. This opening is slipped over individual fruit and stapled shut to form a good seal. This is still experimental in Kentucky, but worth investigating.

Mass Trapping of Male Moths (Organic alternative)

Home owners can use pheromone traps to time insecticide sprays as discussed above, or to "trap out" all the male moths. This involves using enough pheromone traps such that all of the male moths in an area are captured in the traps before the female moths mate. Female moths are then not able to lay fertilized eggs. Unfertilized eggs that are laid will not develop and hatch. Typically, 2 to 4 traps per tree are required for this to be successful. Larger trees require more traps than smaller trees. This is less effective if there are additional sources of mated females, such as other unmanaged trees in the neighborhood or wild hosts for codling moths in nearby wooded areas.

Mating Disruption (Not advised for homeowners)

This relies on saturating an area with enough of the female pheromone to confuse male moths such that they are not able to locate females. Unlike trapping of male moths, no traps are involved, just pheromone dispensers. The moths are not killed and the fruit have no chemical or physical protection. Typically a rate of 400 dispensers per acre is used. This method is only effective where there are large continuous acreages (5 acres or more) of apples, and not recommended for small acreages or in urban areas where mated female moths may immigrate from surrounding areas. Mating disruption is also being used for pests grapes and peaches commercially on in some regions.

B. PLUM CURCULIO

Plum curculio is a native pest of North America that has caused considerable problems in orchards throughout Kentucky. Like the codling moth, this is a direct pest of apples as both the larva and adult feed on the fruit. While it has only a single generation in Kentucky, it can cause serious early season fruit damage to apple, pears, peaches and other stone fruits often resulting in 60% or greater losses in unmanaged trees.

The adult is a typical snout beetle, 1/4 inch long, dark brown in color with patches of white or gray (See Common Fruit insects Picture sheet, figure 8). There are four prominent humps on the wing covers. The snout is 1/4 the length of the body, with mouth parts located at the end. Plum curculio overwinters in the adult stage in ground litter or soil usually outside the orchard. Adults migrate into the orchards each spring. Often border rows near woods are the first to show injury.

The adult curculio becomes active in the

early spring where it flies to trees and feeds on buds, flowers and newly set fruit over a five to six week period. This results in cat-facing of the fruit because of plum curculio feeding and egg-laying injuries. The female adult cuts a hole in the fruit with her mouthparts and hollows out a small cavity then turns and deposits an egg in the cavity. She then cuts a crescent-shaped silt which extends beneath the egg so as to leave the egg in a flap of flesh. Injury appears as a 1/8 inch crescent-shaped cut on the fruit. This prevents the egg from being crushed by the rapidly developing fruit. After about five days, the larvae hatch and burrow into the fruit. The larva is a leg-less grayish white grub with a brown head. Its length will be about 1/3 inch when full grown.

When the larvae are fully developed, they leave the fruit through clean-out holes. No frass or webbing will be evident. Frass is usually found around the calyx end on codling moth damaged fruit.

Surface feeding and egg-laying by the overwintering adults can scar or misshape the fruit by harvest, while feeding by the larvae causes premature drop of the fruit. In peaches, gummy material can often be seen at the location of the wound. **These insects are active primarily at night and serious damage may appear in orchards that have been scouted rigorously even though the adults were not detected. Currently there are no methods to accurately predict when plum curculio damage will occur**.

Newly emerging adults in the late summer will feed on apples for a short period of time. They cause round, cylindrical feeding wounds in the side of the fruit that penetrate about 1/4 inch often lead to localized rots on the fruits.

IPM MANAGEMENT OPTIONS

Petal-fall Control

There is no effective method to monitor for plum curculio adults or predict when and to what extent damage may occur. Adult control is accomplished by insecticide applications timed at petal-fall stage for apples. Serious plum curculio damage is usually restricted to trees that do not use this insecticide application. Developing fruit should be monitored carefully for the characteristic crescent-shaped plum curculio laying scars. If these are seen on the fruit, a second insecticide application 10 to 14 days after the first may be needed.

Sanitation

Home gardeners can help reduce future problems by picking up these damaged apples as they fall off the tree and destroying them before the larvae emerge to go into the ground to pupate. In apples, the larvae will only complete development in fruit drops. Fruit need to picked up daily and the fruit destroyed in such a manner that the larvae inside cannot complete development. This will help to reduce additional damage later in the season.

Bagging Fruit (Organic alternative)

Bagging of the individual fruit has been used experimentally with some success for codling moth control in commercial apples in California. To control plum curculio, bags should be placed around fruit after petal fall to prevent egg laying. A 2-inch slit is made in the bottom of a small brown paper bag. This opening is slipped over individual fruit and stapled shut to form a good seal. Bags can be removed one month after petal fall. Bags should be kept on the fruit for a longer period if used for codling moth control.*Bags must be removed 3-4 weeks before harvest to allow fruit to color*. Bagging fruit on the tree is still experimental in Kentucky, but worth investigating.

C. SAN JOSE SCALE

San Jose scale is an extremely important indirect pest of apples, pears, peaches, and plums. It is a sucking inject that injects a toxin into the plant as it feeds causing localized discolorations. The presence of reddish

blemishes on fruit at harvest indicates potentially damaging numbers on the trees (See Common Tree Fruit Insect picture sheet, figure 6). Left uncontrolled, San Jose scale can kill the entire tree in a couple years. If such damage is noted, inspect trees for scale, especially one year-old wood. Purplish-red halos on young bark are indications of scale infestation. Often this very small insect goes unnoticed until large populations have developed.

San Jose Scale overwinter as immature scales. In the spring, the tiny winged males emerge and mate with the wingless females, and about one month after the beginning of the male flight, the first crawlers can be seen. Eggs are not seen because females give birth to live crawlers. These tiny yellow insects move around randomly on bark and foliage before settling down permanently. A few days after settling down, crawlers will secrete a waxy covering over their body that will protect them from pesticides. From this point on female scales will not move. Males will remain in one location until maturity, at which time the winged males will seek out females and the cycle will begin again.

DETECTING CRAWLER MOVEMENT

Crawler movement begins sometime between mid-May and mid-June. Dark double sided sticky tape should be used to monitor for emerging crawlers. A small amount of tape is applied tightly to around a scaffold limb after removing surface debris with sandpaper. A limb with a known infestation should be selected. Crawlers will appear as extremely small flattened yellowish insects which can be seen with a hand lens on the tape (especially around the edges). Within two days, the crawlers will find a permanent resting spot where they will feed and begin to secrete a protective waxy covering. There are two generations each year.

IPM MANAGEMENT OPTIONS

Dormant Oil

Effective control of San Jose Scale in apples is obtained with a dormant oil spray to control the overwintering nymphs. High volume and thorough coverage is essential to getting good control with dormant oils. Trees should be pruned properly to allow for spray penetration and good coverage. Typically an application made during January is more effective against scale than the delayed dormant application recommended for European red mites and apple aphids. A mid-winter oil application is recommended over a delayed dormant application in trees where scale has been a serious problem. Failure to use a dormant oil application may require additional inseason treatments. These inseason treatments are usually more expensive and disrupt beneficial insects that control secondary pests.

Pheromone Trapping & Degree Day Accumulation (intensive IPM)

Pheromone trapping involves the use of chemical lures to attract male scales. These chemical lures are synthetic copies of the chemicals female scale use to attract the male for mating. A trap consists of a lure suspended between the two sticky sides of a tent-like trap. Pheromone traps for this insect should be placed in scale infested trees either prior to or during bloom. For a list of the sources of various types of pheromone traps see ENT-54,

Table 6. Predicting San Jose Scale Development	
San Jose Scale DD targets	Action taken when target reached
300	Place a piece of black tape, with sticky side out on an infested scaffold limb. Begin examining tape at least twice a week for minute scale crawlers.
380-400	Crawler emergence should begin.
600-700	Maximum crawler movement. This is the best time for an insecticide spray.

Vendors of Microbial and Botanical Insecticides and Insect Monitoring Devices. Lures need to be replaced monthly.

Male scales are extremely small gnat-like insects, so traps need to examined carefully. Scales appear as a fine dust on the trap, usually concentrated on the sticky surface near the pheromone lure. Trapping of scale is used to indicate when the activity of the male scales begins. The date that the first males are caught in the trap is termed the biofix date. Male flight usually occurs after petal fall (mid to late April). Pheromone traps need to be examined daily in order to know when biofix occurs. After the biofix has occurred, degree days are calculated on a daily basis and a running total kept. San Jose scale has a 51°F threshold temperature. These degree day accumulations are compared with the target values in the following table.

Insecticide applications for San Jose scale control should be aimed at the immature, crawler, stage. Sprays directed against crawlers also protect fruit from infestation. Sprays should be timed about one week after the first crawlers are seen. If populations are heavy, a second application two weeks after the first should be used. These applications aimed at the crawlers have little effect on the adult scales. Because San Jose Scale occur on all parts of the tree, spray coverage as well as are very critical to effective control. Although there is a second generation later in the summer, crawlers emerge over an extended period of time making insecticidal control of this generation impractical.

Summer Horticultural Oil and Insecticidal Soap (Organic alternatives)

Monitor for San Jose scale crawlers and apply a 1 to 2% horticultural oil or 1 to 2% insecticidal soap application at peak crawler movement. These have no residual activity against scale that may emerge after the application was made. An additional application may be necessary to control scale if crawlers are emerging over a prolonged period. Horticultural oils and insecticidal soaps provide alternatives to traditional synthetic insecticides and are less toxic to the applicator. Horticultural oil is effective at controlling crawlers and settled first instar scale, while insecticidal soap can provide excellent control of crawlers. While effective control can be obtained with a 1 to 2% summer horticultural oil treatments, caution is advised as these may be incompatible with some other pesticides (particularly sulfur containing products), may be phytotoxic at higher temperatures (above 100°F and high humidity) and concentrations greater than 2%, and may affect fruit finish on some varieties.

D. EUROPEAN RED MITES

The European red mite is another introduced pest in the US. It is a pest of nut,

pome and stone fruits, and some berries. This pest damages leaves and causes fruit russetting. European red mites can have 6 to 8 generations per year, depending on the temperature. Summer generations may develop in as little as 14 days.

The adult female mites are brick red with white spots at the base of six to eight hairs on their back. The male mite is more slender, lighter in color than the female, and has a more pointed abdomen. Overwintering eggs are red, globular and somewhat flattened (onion shaped) with a slender stalk on the upper side. European red mites overwinters as eggs laid in roughened bark around the bases of buds and spurs on small branches. During the summer eggs are spherical and laid on the underside of leaves. Egg hatch in the spring is closely correlated with bud development and begins close to the tight cluster stage. During the summer, eggs require 7 to 14 days to hatch.

All active stages of the European red mite injure the foliage by feeding with piercing mouthparts and removing cell contents, including chlorophyll. Moderate to high numbers of mites can cause the leaves to initially turn pale and with continued feeding the leaves turn bronze. Heavy mite feeding early in the season can reduce tree growth, yield, and also effect fruit bud formation for the following year. Some apple cultivars, such as 'Red Delicious' and 'Braeburn', are more prone to mite buildup and injury.

European red mites are rarely a problem on backyard apple trees. Predatory mites, ladybird beetles and the six-spotted thrips help to maintain European red mite at nondamaging levels. This mite is considered a secondary pest, it typically only builds to damaging levels after its natural enemies have been depleted by insecticide applications used to control codling moth or other pests. Minimizing insecticide usage and selecting insecticides that are least toxic to beneficial organisms will help to minimize problems with this mite.

IPM MANAGEMENT ALTERNATIVES

Dormant Oil

Overwintering mite eggs should be controlled through the use of a delayed-dormant oil treatment, anytime between bud swell and half inch green. Control with dormant oil improves the closer to egg hatch. High volume and thorough spray coverage are necessary to provide effective control of the eggs. Dormant oils are effective at controlling eggs of a number of insect pests. Failure to use a properly timed delayed dormant oil application may require additional inseason treatments. These inseason treatments are usually more expensive and disrupt beneficial insects that control secondary pests.

Monitoring and Economic Thresholds

To monitor for mites, examine 5 hardened-off leaves from each of four scaffold limbs per tree. Certain varieties, such as Red Delicious, are more likely to develop large numbers of mites. Using a hand lens, count all active stages of pest and predatory mites. Predatory mites are more active and are tear-drop shaped. Determine the average number of European red mites per leaf. The economic threshold for the mites varies with the time of year. Control is recommended early in the year (until April 1) if numbers of active mites exceed an average of 5 per leaf, during April and May when mite numbers exceed 10 per leaf, or the rest of the season if mite numbers exceed 15 per leaf. Vendex and Kelthane are general use miticides for apples, but these are not available in most areas. Diazinon will suppress mites but is not considered a miticide.

Summer Horticultural Oil Insecticidal Soap

(Organic alternatives)

Management of mites during the growing season is based on monitoring, economic thresholds, and the use of summer oil or insecticidal soap treatments as needed. Often when heavy summer infestations exist, a second treatment may be required 10 to 14 days later. Horticultural oils provide an alternative to traditional synthetic miticides, are able to kill all mite life stages, and are less toxic to the

applicator. While effective control can be obtained with a 1 to 2% summer horticultural oil treatments, caution is advised as these may be incompatible with some other pesticides (particularly sulfur containing products), are phytotoxic at higher temperatures (above 100°F and high humidity) and higher concentrations (> 2%), and may affect fruit finish on some varieties. Although less effective than summer oil treatments, insecticidal soap can provide some control of European red mites. Use the economic thresholds and repeat applications if necessary.

E. JAPANESE BEETLES

Japanese beetle was accidently introduced into the United States in 1916. In the early 60's, Japanese beetles spread into Kentucky from surrounding states. Japanese beetles feed on the leaves of more than 300 species of plants, including apple foliage and damaged fruit. Kentucky provides a favorable climate, abundant pasture areas for grub development, and few natural enemies of the beetles. Fruit trees that may be severely defoliated include apple, cherry, black cherry, peach, and plum.

The adult beetles feed on leaves of a wide variety of trees and shrubs. Adults feed on the upper surface of foliage, chewing out tissue between the veins, leaving a lace-like skeleton of the leaf. They usually feed in groups, starting at the top of a plant and working downward. The beetles are most active on warm, sunny days, and prefer plants that are in direct sunlight. A single beetle does not eat much; it is group feeding by many beetles that results in severe damage. Trees that have been severely injured appear to have been scorched by fire.

Adult Japanese beetles are 3/8-inch long metallic green beetles with copper-brown wing covers. A row of white tufts of hair project from under the wing covers on each side of the body. Japanese beetles overwinter underground in the grub stage, and pupate near the soil surface in the spring. Grubs spend 10 months in the soil where they feed on roots of grasses and can be serious pests. Adults emerge from the ground and begin feeding on various plants in June. Activity is most intense over a 4 to 6 week period beginning in late June. By mid-July, numbers of beetles gradually diminish. Individual beetles live about 30 to 45 days. There is a single generation per year.

IPM MANAGEMENT OPTIONS

Monitoring and Insecticidal Control

Look for the presence of Japanese beetles in the trees. Note the presence of live Japanese beetles on the scouting form. If present, try to estimate the approximate number of beetles per tree. There are few threshold guidelines relative to when apples need to be treated for Japanese beetles. Carbaryl is the most effective insecticide used in managing Japanese beetles. **However, because carbaryl can greatly increase problems with European red mites, other insecticides are recommended to manage low to moderate Japanese beetle populations in apples.** Repeated insecticide applications may be necessary at 7-10 day intervals to prevent reinfestation during the adult flight period, or after heavy rains. Botanical insecticides such as pyrethrin provide an organic alternative to synthetic insecticides for Japanese beetle control.

Japanese Beetle Traps (not advised)

Many garden supply outlets have been marketing Japanese beetle traps for a number of years. These traps are very effective at attracting and trapping large numbers of Japanese beetles. However, more beetles are usually attracted to the trap than are actually captured. Research conducted at UK has indicated that damage by Japanese beetles is usually more severe when Japanese beetle traps are used. Placement of traps at various distances and directions from the plants to be protected has not been shown to be effective at reducing damage.

F. APPLE APHIDS

Generally four species of aphids - the **green apple aphid, rosy apple aphid, apple-grain aphid and woolly apple aphid** - attack apples in Kentucky. Three of these aphids, the green apple aphid, rosy apple aphid and the apple-grain aphid are very similar in appearance. Damage is primarily on new foliage and fruit by feeding on plant sap using their piercing-sucking mouthparts.

Green apple aphid and **apple-grain aphid** are small pear to tear-drop shaped insects. Color varies from light to dark green. Generally a pair of projections (cornicles) are present on the fifth or sixth segment. Mouthparts are piercing-sucking. Generally these aphids are in colonies. The life cycle of these aphids begin with the egg, which is the overwintering stage. Overwintering eggs generally are found on twigs, around buds or in crevices in the bark. Eggs will generally begin hatching in early spring about green tip stage. The first generation of nymphs are all wingless females, called stem mothers. These females give birth to live young, and a generation is completed about every fourteen days. In early summer some winged young are produced, these fly to new host plants and start new colonies. During late summer and early fall, both male and female forms will be produced, mate and lay overwintering eggs. When first laid, these eggs are green but soon turn shiny black as they mature. Large number of aphids can stunt new growth and cause sooty mold to develop on fruit and leaves.

The **rosy apple aphid** injects a toxin with its saliva that causes the leaf to curl. While all apple varieties are attacked, 'Cortland', 'Ida Red', and 'Golden Delicious' are particularly susceptible. Feeding on the leaves of fruit clusters often results in stunting and malformation of the fruit. For this reason, rosy apple aphids are the most serious aphids attacking apples. Honeydew produced by the aphids promotes the growth of sooty mold as well. This becomes more noticeable as the fruit develops. Problems usually begin to appear after petal fall and by mid summer the aphids move to alternate hosts.

The aphid overwinters on apple trees as eggs laid on twigs, bud axils, or in bark crevices. The black eggs are 1/2 mm long and football shaped. Shortly after silver tip the eggs hatch. The nymphs color changes from dark green to purple as they grow (See Common Fruit Insects picture sheet, figure 5). The aphids continue to reproduce on apple until summer, then winged forms are produced which migrate to other hosts such as dock and narrow-leaved plantain.

Apple growers should monitor their trees carefully for rosy apple aphids, a few colonies can rapidly infest the entire tree. Because these infestations will curl the leaves, early control is important. Once the leaves are tightly curled, adequate spray coverage and control is more difficult. There are a number of predators that often control rosy apple aphid, so distorted leaves should be open to determine if the aphids or predators are still present before making control decisions.

The **woolly apple aphid** differs from other apple aphids in appearance, life cycle, and the type of damage inflicted. A colony appears as a cottony mass generally clustered in wounds and pruning scars on the trunk and branches of the tree. The aphids themselves are purplish in color surrounded by white, cottony, thread-like secretions. Egg-laying wounds by the periodical cicada are ideal sites for infestation.

The life cycle of woolly apple aphid is very complex. The winter may be passed in two forms, the egg or immature nymph. Nymphs hibernate underground on roots of apple. Wherever apples and elms are close together, overwintering eggs are be deposited in cracks or protected places on the elm. During spring, eggs will hatch into wingless nymphs which feed on elm buds and leaves. In early June, a winged form is produced which migrates to apple and other hosts. These individuals feed on wounds in the branches and trunk, and as the number of aphids on the above ground portion of the tree increase, many work their way down to the roots and trunk below ground surface. It is the feeding on the roots that produces the greatest damage. Young trees are often injured the most by this pest. Rootstocks vary in susceptibility to woolly apple aphid and susceptible rootstocks will form galls around the infestation sites. Use M111 or M106 if woolly apple aphid is a serious problem. Control of these aphids is very difficult when they attack the roots.

During the summer, repeated woolly apple aphids generations of wingless individuals are produced. In the fall, winged individuals are produced which fly back to elm and lay overwintering eggs, while some wingless forms may remain on both above and below ground parts of apple throughout the winter.

IPM MANAGEMENT OPTIONS

Delayed Dormant Oil

The green apple aphid, apple-grain aphid and rosy apple aphid overwinter as eggs on twigs and bark crevices of apple trees. A delated dormant oil application between green-tip and half-inch green controls newly hatched aphids. Failure to use a properly timed delayed dormant oil application may require additional inseason treatments. These inseason treatments are usually more expensive and disrupt beneficial insects that control secondary pests.

Monitoring and Economic Thresholds

Examine four leaf terminals on each of 5 scaffold limbs on each tree for active aphid colonies. When monitoring for woolly apple aphid, examine four pruning scars on each of 5 scaffold limbs per tree. Record the total number of aphid infestations per 20 leaf terminals, fruit clusters or pruning scars by species. Carefully examine woolly apple aphid colonies to determine if live aphids are present. Predators can completely destroy the colony but the waxy residue will remain. If a leaf terminal has ANY live aphids on any of the leaves, it is considered infested. Treatments are recommended when 5% of the terminals are found to have rosy apple aphid infestations. Other aphids such as the green apple aphid and the apple grain aphid do not curl leaves and have higher action thresholds. Treatments are not recommended for these aphids until 50% of the terminals are infested. Treatments for woolly apple aphid are recommended when 50% of the pruning scars are infested with live colonies. Diazinon or malathion can provide effective control of these pests.

Insecticidal Soap and Summer Horticultural Oil (Organic alternatives)

A 1 to 2 % application of insecticidal soap or summer horticultural oil can provide effective control of these aphids. Use the monitoring and economic thresholds and apply these as necessary. Neither of these will provide any residual control, so thorough coverage is essential. Control of rosy apple aphid after the leaves have curled may be difficult. While effective control can be obtained with a 1 to 2% summer horticultural oil treatments, caution is advised as these may be incompatible with some other pesticides (particularly sulfur containing products), are phytotoxic at higher temperatures (above 100°F and high humidity) and at high concentrations (> 2%), and may affect fruit finish on some varieties.

G. LEAFROLLERS

There are several different species of Lepidoptera commonly known as leafrollers.

The most common of these insects are the **Fruit-Tree leafroller, Oblique-Banded leafroller, Omnivorous leafroller and the Red-Banded leafroller.** Leafrollers commonly web leaves together forming small pockets in which they can feed on leaf tissue inside while being protected from predators. Occasionally where leaves touch fruit, or two fruit are touching, leafrollers will feed on the surface of the fruit.

The **Fruit-Tree leafroller** is a native pest occurring in the northern half of the United States. The adult is a brown moth slightly larger than the codling moth. Thin light markings will appear in various patterns across the front wings. The larva is a slender worm, pale green in color. The head is black and a black spot will appear just behind the head. The larva may reach 3/4 inch in length.

The insect overwinters in the egg stage. Hatching will occur about the time buds begin to open. Larvae feed on buds, blooms, leaves and fruits. In June full grown larva transform into pupae, inside folded or rolled up leaves. Moths appear in about two weeks, lay their eggs, and die. Only one generation occurs each year.

The **Oblique-banded leafroller** is somewhat less important than the Fruit-tree leafroller. Adults are brown with three dark bands on the front wings. Wingspread is about one inch. Larva are small and green with black heads.

Overwintering occurs as partially grown larva inside tightly woven cases, on the host trees. During spring, larva emerge and continue feeding until late May. Pupation occurs and adults will emerge in June. One or two generations may occur. Damage is done by young larva mining the leaves, with larger larva feeding inside rolled up leaves.

The **Red-banded leafroller** is generally a problem north of the Ohio and east of the Mississippi Rivers. However, they are at times a problem in Kentucky. Adults are brown, about the size of the codling moth, and have broad reddish bands on each forewing. Larva are green, slender and will reach a length of about 2/3 inch (See Common Fruit Insects picture sheet, figure 3).

Winter is passed in the pupal stage. This pupa will generally be found in a silken cocoon, in detritus at the base of host trees. Moths emerge in the early spring, and lay their eggs in clusters on the bark of host trees. The first generation larva will emerge and begin feeding at about petal-fall. Up to four generations may occur each season.

IPM MANAGEMENT OPTIONS

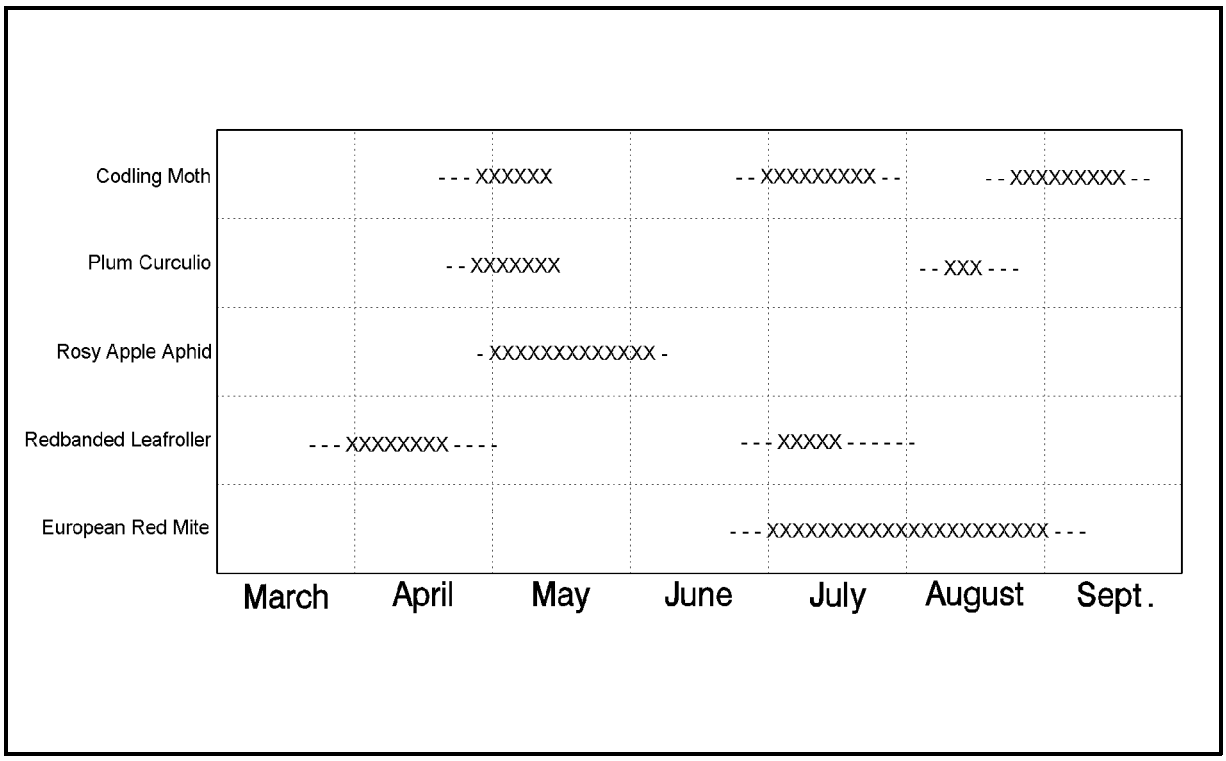
Monitoring and Economic Thresholds (Organic)

Leafroller populations are by regular tree examinations. Examine 10 leaves on each of five scaffold limbs per tree. Look carefully for leaf mining injury and folded leaves. Record the number of live leafroller larvae per 50 leaves. An average of 2 larvae per 50 leaves justifies control. Sprays containing *Bacillus thuringiensis* provide excellent control of leafrollers.

H. INSECT CALANDER

- = Pest may be present at low levels.

X = Pest frequently found a economically damaging levels during these periods.



V. PESTICIDE USE & SAFETY

Using Pesticides

Pesticides should only be used as a last resort to kill insects and disease pathogens. While many home fruit growers may opt to use pesticides, there are several safety issues that need to be addressed before using them. Handle these chemicals carefully to prevent injury to yourself, other people or pets. Although the pesticides suggested for home use are the least hazardous available, certain precautions are still necessary. **For more information on using pesticides, spray equipment for home fruit growers, how to spray fruit trees, harvest restrictions, storage of pesticides, and notes on specific pesticides, see ID-21 in the appendix of this manual.**

Multi-Purpose or All-Purpose Fruit Sprays

Insecticides and fungicides are often needed at the same time on a plant to protect it against attack by both insects and diseases. There are all-purpose fruit sprays on the market which contain a mixture of insecticides and fungicides that give adequate control for most common problems and are easy to use. If a mixture containing Sevin is used, apply this only three to four weeks after petal fall on apples and pears. Sevin thins or causes fruit to drop if applied before this date. Sevin may also cause buildup of pest mites.

These commercially prepared mixtures are convenient to use and reduce the number of pesticides the homeowner must store safely.

You can mix the all-purpose fruit spray with additional pesticides, but there are some limitations with which you should become familiar. If you are in doubt about spray combination injury, check the label. Apply the mixture to a small portion of the tree and wait to see what happens. Spray burn should show up in 24 to 48 hours. If burn results, do not apply the combination. If you plan to mix your own combination, it is advisable to use wettable powders to reduce the problem of plant injury.

SPRAY MIXTURE CONSIDERATIONS:

✓ None of these multipurpose mixtures controls all of the insects and diseases you are likely to encounter. Not realizing this, many users tend to apply mixtures more frequently and at higher rates trying, in vain, to control some pests.

✓ Multipurpose mixtures lack flexibility so that when only a fungicide is required (e.g. during bloom), an insecticide also is applied even though it is not needed and could be damaging.

✓ Most multipurpose mixtures are more expensive than those you prepare.

✓ Mixtures containing dicofol miticide may cause a problem because their continued use may lead to the development of dicofol

Where To Purchase Pesticides

Most garden centers or stores with yard and garden departments where pesticides are sold have the commonly recommended pesticides. Many agricultural supply or farmer co-op centers also carry them. Some pesticides are difficult to obtain in some parts of the state and can be ordered through the mail.