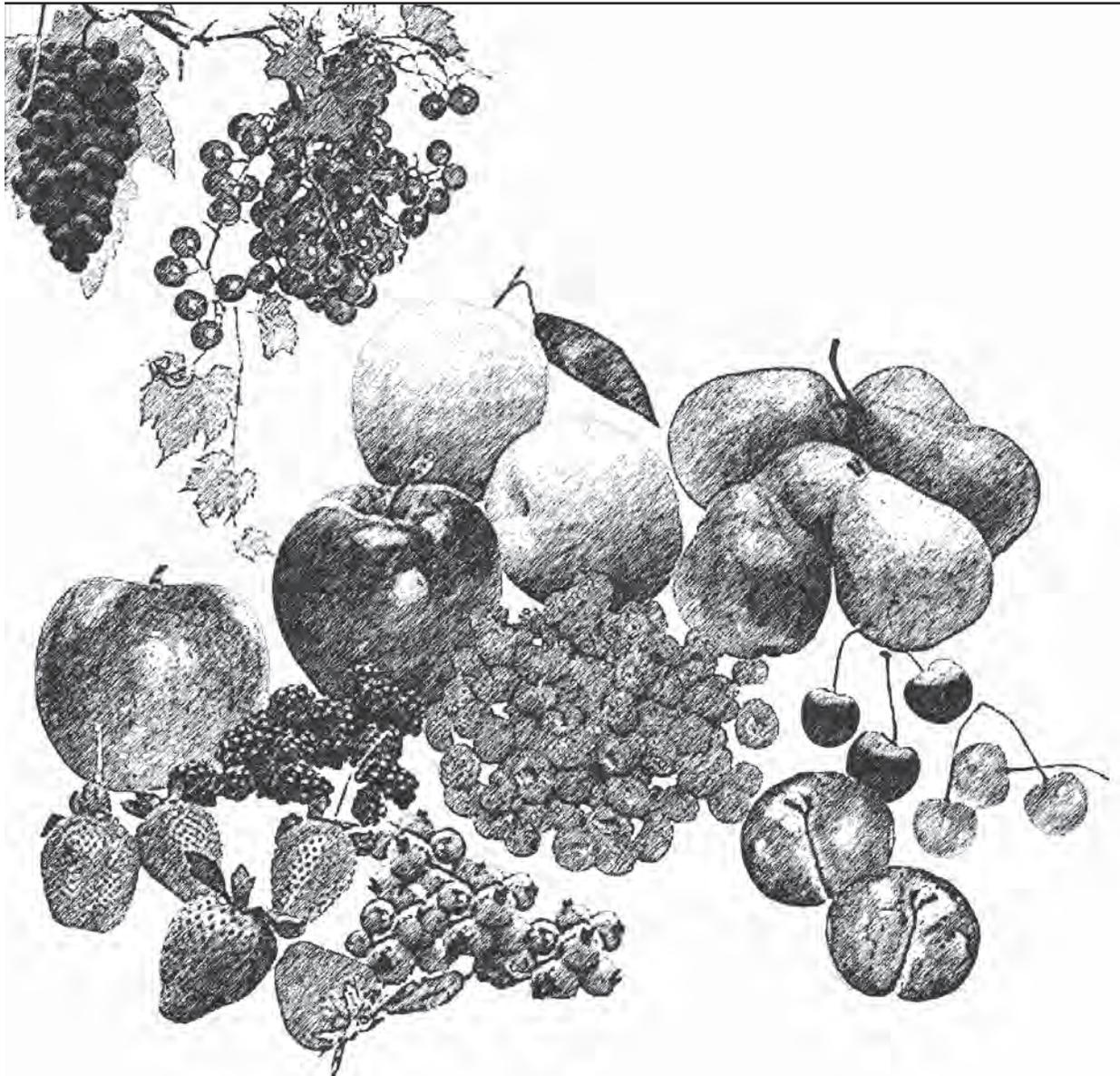


Fruit Production for the Home Gardener

A C O M P R E H E N S I V E G U I D E



PENNSTATE



COLLEGE OF AGRICULTURAL SCIENCES

Fruit Production for the Home Gardener has been developed as a resource for people who wish to produce fruit on a small scale (one acre or less) and who are not legally licensed to use pesticides. Production guides for commercial growers are also available from Penn State Cooperative Extension.

This guide emphasizes the most recently developed production methods that use alternative pest control strategies such as integrated pest management (IPM) to reduce pesticide use. To use such systems, the grower needs to have a complete understanding of the fruit planting as an entire system.

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USEFUL WEIGHTS AND MEASURES

<p>1 acre = 0.405 hectare</p> <p>1 hectare = 2.47 acres</p> <p>1 acre = 43,560 square feet</p> <p>1 acre = 4,840 square yards</p> <hr/> <p>1 bushel (dry) = 1.244 cubic feet</p> <p>1 bushel (dry) = 2,150 cubic inches</p> <p>1 bushel (dry) = 35.24 liters</p> <p>1 bushel (dry) = 4 pecks</p> <p>1 bushel (dry) = 32 quarts</p> <hr/> <p>1 cubic foot = 0.804 bushel</p> <p>1 cubic foot = 25.714 quarts (dry)</p> <p>1 cubic foot = 29.922 quarts (liquid)</p> <p>1 cubic foot = 1,728 cubic inches</p> <p>1 cubic foot = 7.81 gallons</p> <p>1 cubic inch = 16.39 cubic centimeters</p> <p>1 cubic inch = 0.554 ounces (fluid)</p> <p>1 cubic yard = 27 cubic feet</p> <p>1 cubic yard = 46,656 cubic inches</p> <p>1 cubic yard = 202 gallons</p> <p>1 cubic yard = 764.5 liters</p> <p>1 gallon = 3,785 cubic centimeters</p> <p>1 gallon = 231 cubic inches</p>	<p>1 gallon = 0.1337 cubic feet</p> <p>1 gallon = 3.785 liters</p> <p>1 gallon = 128 fluid ounces</p> <hr/> <p>1 inch = 2.54 centimeters</p> <hr/> <p>1 kilogram = 35.274 ounces</p> <p>1 kilogram = 2,205 pounds</p> <hr/> <p>1 liter = 33.81 ounces (fluid)</p> <p>1 liter = 1.816 pints (dry)</p> <p>1 liter = 2.11 pints (liquid)</p> <p>1 liter = 61.025 cubic inches</p> <p>1 liter = 0.264 gallons</p> <hr/> <p>1 meter = 39.37 inches</p> <hr/> <p>1 mile = 5,280 feet</p> <p>1 mile = 1,760 yards</p> <p>1 mile/hour = 1.467 feet per second</p> <p>1 ounce (avoirdupois) = 28.349 grams</p> <p>1 ounce (fluid) = 29.574 cubic centimeters</p>	<p>1 ounce (fluid) = 1.805 cubic inches</p> <hr/> <p>1 pound = 453.59 grams</p> <p>1 pound = 16 ounces</p> <hr/> <p>1 quart (dry) = 67.20 cubic inches</p> <p>1 quart (liquid) = 57.75 cubic inches</p> <hr/> <p>1 rod = 16.5 feet</p> <p>1 rod = 5.029 meters</p> <p>1 rod = 5.5 yards</p> <hr/> <p>1 square foot = 144 square inches</p> <p>1 square yard = 9 square feet</p> <hr/> <p>1 ton (short) = 907.185 kilograms</p> <p>1 ton (short) = 2,000 pounds</p> <p>1 ton (long) = 2,240 pounds</p> <hr/> <p>1 yard = 91.440 centimeters</p> <p>1 yard = 3 feet</p>
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CONVERSION FACTORS FOR ENGLISH AND METRIC UNITS

To convert column 1 into column 2,

multiply by

	<i>Column 1</i>	<i>Column 2</i>	
1.609	mile, mi	kilometer, km	0.621
0.914	yard, yd	meter, m	1.094
2.540	inch, in	centimeter, cm	0.394
2.590	mile ² , mi ²	kilometer ² , km ²	0.386
0.00405	acre, A	kilometer ² , km ²	247.1
0.405	acre, A	hectare, ha (0.01 km ²)	2.471
102.8	acre-inch	meter ³ , m ³	0.00973
0.2852	cubic foot, ft ³	hectoliter, hl	3.532
0.352	bushel, bu	hectoliter, hl	2.838
0.946	quart (liquid), qt	liter, L	1.057
0.9072	ton (English), T	ton (metric), T	1.102
0.00454	pound, lb	quintal, q	220.5
0.454	pound, lb	kilogram, kg	2.205
2.242	ton (English)/acre	ton (metric)/hectare	0.446
1.121	lb/acre	kg/ha	0.892
1.121	hundredweight/acre	quintal/hectare	0.892
0.0703	lb/inch ² , psi	kg/cm ²	14.22
0.06895	lb/in ² , psi	bar	14.50
1.013	atmosphere, atm*	bar	0.9869
1.033	atmosphere, atm*	kg/cm ²	0.9678
0.06805	lb/in ² , psi	atmosphere, atm*	14.70
0.555 (F-32)	Fahrenheit, F	Celsius, C	1.80C + 32
10.764	foot-candle, ft-c	lux	0.0929

To convert column 2 into column 1,

multiply by

*An "atmosphere" may be specified in metric or English units.

The Home Fruit Planting: Getting Started

Home fruit gardening offers many benefits—exercise, enjoyment, a supply of delicious fruits, enhancement of the home landscape, and a truly educational experience. There is, however, more to growing fruit than simply planting the crop and harvesting the fruit. Backyard growers and hobbyists must consider cultural requirements and solve pest problems throughout the year.

Fruit Production for the Home Gardener was developed as a resource for people who wish to produce fruit on a small scale—on one acre or less—and who do not have a commercial pesticide applicators license. This guide emphasizes the most recently developed production methods that use alternative pest-control strategies, such as integrated pest management (IPM), to reduce pesticide use. Throughout the guide, the symbol ♦ will be used to indicate a method for reducing chemical inputs in fruit production. Some of these methods are as simple as choosing the right variety to plant, removing diseased fruit, or pruning the plants to allow better air circulation. To use such strategies, however, the grower must have a complete understanding of the fruit planting as an entire system. Information in this publication will help you prevent or minimize common cultural and pest problems and will enable you to harvest succulent, fresh fruit.

THE PLANTING SITE

Plenty of sunlight is a key to maximizing fruit production. While some fruit plants can survive in partial shade, most require direct sunlight to fuel the energy-intensive fruit-production process. Choose a planting area in your yard that will be in the sun most or all of the day. ♦ Rapid drying of the plant canopy reduces the need for fungicides and is important in preventing disease. The more quickly the plants dry off after rain or dew, the less chance they have of contracting disease. Early morning sunshine is particularly important for drying dew from the plants.

Choose an area that is large enough to permit adequate plant spacing within and between rows. Less crowded plants will dry more quickly.

Choose a location with good air and water drainage and some protection from prevailing winds. Northern exposures are less subject to late spring frosts and are likely to have the most snow cover, which protects plants from soil heaving caused by alternate freezing and thawing of the soil surface.

Avoid planting within the root zone of black walnut trees since these trees produce a natural herbicide (juglone) that inhibits the growth of other plants. Do not plant brambles or strawberries where any Solanaceous crop (tomatoes, peppers, eggplant, potatoes) has been grown for the last five years. A soil fungus called *Verticillium* can inhabit plant debris from Solanaceous crops. If strawberries or brambles are infected, the entire planting may be lost within one season.

Lack of space in full sunlight often discourages the home gardener from planting fruit in the backyard. Fruit plants can be planted in ways that do not require large areas. The following list provides some suggestions for planting in smaller spaces.

- Use dwarfing rootstocks for apple trees. These reduce the apple tree size by as much as 60 percent and are readily available from most nurseries. See Chapter 4 for further details.
- Use the fruit plants as a property screen or divider. Fruit trees, grapes, and brambles are ideal for this.
- Grow espaliered apple or pear trees or vining plants such as grapes or thornless blackberries on a fence or against a wall.
- Grow strawberries in pots or as a pyramid.
- Grow currants or gooseberries in partial shade. (These are the only fruit crops that will tolerate some shade.)

Good internal water drainage in the soil is a more important consideration than soil fertility. Avoid soils and sites that are not well drained. If water stands for more

than 24 hours after a spring rain, the soil is probably not drained well enough for fruit production. Wet soils result in oxygen-starved roots and a microenvironment conducive to disease development.

POLLINATION REQUIREMENTS FOR VARIOUS FRUITS: AN OVERVIEW

Before you order plants for your orchard or vineyard, you should determine whether you will have to plant more than one variety to provide for pollination. Generally, all fruit plants grown in Pennsylvania require pollination to produce fruit.

Pollination is the transfer of pollen from the male part (anther) of a flower to the female part (pistil) of the same flower or another flower of the same sort. A pollinizer is a plant that provides the pollen to the flowers of a different plant variety. In most instances, bees are the agents that transfer the pollen, thus referred to as the pollinators. Little or no pollination occurs as the result of wind movement. To be an effective pollinizer, a variety must:

- have a bloom period that overlaps that of the variety to be pollinated,
- have a diploid chromosome makeup,
- produce viable pollen, and
- be grown in close proximity to the variety to be pollinated.

Several environmental factors affect pollination. Temperatures below 55 to 60°F reduce bee flight and activity, as do windy conditions. Temperatures above 85 to 90°F dry the flower's stigmatic surface and prevent pollen grains from germinating. Because bees naturally seek out the best nectar-producing flowers, other blooming flowers in the area can attract bees away from fruit plants, which generally are poor nectar producers. In the early spring, dandelions in bloom can attract bees away from the flowers of fruit plants. Finally, applying insecticides during bloom can harm bees or other pollinating insects.

The best time to plan for pollination is when you order your plants. Most nurseries have charts or tables recommending varieties that will serve as pollinizers for each other. You should also be aware of your neighbors and what fruit plants they have. To be effective, a pollinizer does not have to be directly next to your plant. Also remember that some ornamental plants, such as crab apples, flowering pears, and plums, can be effective pollen sources if their bloom overlaps that of the planted fruit.

Pollination Situation

The pollination characteristics of several fruit crops are listed below. Those fruits listed as *self-fertile* will set fruit with their own pollen, and therefore require you to plant only one variety or plant. In general, however, all plants produce more fruit when two or more varieties are planted close to each other. You should also consider closely related ornamental plants as good pollinizers. For example, crab apples can pollinate apples, and the ornamental Bradford pear can pollinate pears. For fruits that require cross-pollination, refer to the individual chapters covering those fruits.

Apple: Cross-pollination is always needed to produce an adequate fruit crop.

Apricot: All varieties are self-fertile, but cross-pollination is helpful.

Blackberry: Most are self-fertile, but a few require cross-pollination.

Blueberry: Fruit set and crop size are improved by cross-pollination.

Cherry, Sweet: Most older varieties are self-unfruitful. Recently, however, a number of new self-fertile varieties have been developed.

Cherry, Red Tart: The commercial varieties are self-fertile.

Currants: Self-fertile.

Gooseberry: Most varieties are self-fertile.

Grape: A variety of flower types (perfect, male only, and female only) exist. To assure good crops, consult an extension specialist to determine the proper variety mix to assure fruit set.

Nectarine: Self-fertile.

Peach: All commercial varieties, except J. H. Hale, are self-fertile.

Pear: Some varieties are partially self-fertile, but planting at least two varieties is best to ensure cross-pollination.

Plum: A wide diversity occurs in the plums; about half of the varieties are self-fertile and half are not. To be on the safe side, provide pollinizers.

Quince: All varieties are self-fertile.

Raspberry, Black: Most are self-fertile.

Raspberry, Purple: Self-fertile.

Raspberry, Red: Most are self-fertile, but crop size is improved by cross-pollination.

Strawberry: Some known varieties produce imperfect flowers, but most are self-fertile.

PLANT QUALITY

Purchase well-grown, heavily rooted, one-year-old plants of all fruits except blueberries and brambles. Two-year-old blueberry plants are recommended. Nursery plants listed as “certified” (true to name) and “virus tested” or “virus indexed” are recommended. Brambles and stone fruit trees (peaches, nectarines, plums, cherries) are especially prone to virus infection in the nursery. Infected plants are not very vigorous and may produce little fruit, so it is worth the additional cost to buy virus-tested plants. Micropropagated (“tissue-cultured”) brambles should be multiplied and grown in a greenhouse in steam-sterilized soil. Any bramble plant that has been grown outside in a nursery may be infected with several diseases, all of which will result in poor plant growth and yield.

SPRING FRUIT TREE PLANTING TIPS

The following suggestions will help you to successfully plant fruit trees.

- *Time of planting:* Dormant fruit trees can be planted in the spring as soon as the ground can be worked without fear of damaging the soil structure. In most parts of Pennsylvania this can occur anytime from March through mid-May. The later the trees are planted, however, the slower they will begin to grow.
- *Handling the trees:* As soon as the plants arrive, open the package. Report any signs of damage or poor handling to the nursery immediately.
- *Holding the trees until planted:* Trees to be held for several days should be *heeled-in*, or placed in cold storage with the roots covered with moist soil, sawdust, or sand. *Never* permit the roots to become dry.
- *On the day before planting,* place the trees in water so that all of the roots are covered. Allow the trees to absorb water for up to 4 hours.
- *The hole* in which each tree is to be planted should be wide enough to accommodate all of the tree’s root system without excessive bending or bunching of the roots. It should be deep enough so that the bud union will be no more than 2 to 3 inches above the ground after the soil settles. Grafted or budded trees should always be planted so their union is above the soil line.
- *Clonal rootstock trees:* Observe which side of the root system has the most roots. Set the tree so that the side of the root system with the most roots is pointed *into* the direction from which the prevailing winds come. This will afford added anchorage.
- *Planting the tree:* Add 4 to 6 inches of soil to the hole, while at the same time gently jiggling the tree up and down. This will cut down on the possibility of air pockets and help the soil to surround all of the roots.
- *Fill the hole* to within 3 to 4 inches of the ground line. Tramp the soil firmly, then add the remaining soil up to the ground line.
- *Apply 5 gallons of water* to each tree after planting. It is important to use at least 5 gallons to ensure complete wetting of all soil and roots in the hole.
- In the absence of a *soil test*, a reliable rule of thumb is to use the equivalent of ½ pound of 10-10-10 fertilizer per tree *except for pears*, in which case ¼ pound per tree will be adequate. Sprinkle the fertilizer in a 12-inch-wide band. Keep the fertilizer at least 6 inches away from the tree trunk. Do *not* apply any dry granular fertilizer near the tree until after the ground has settled and no cracks in the soil are evident.
- After the water has moved into the soil, add a *tree guard*. A 15-by-18-inch piece of ¾-inch hardware cloth (formed into a circle using the 18-inch dimension as the circumference) makes an excellent guard. Bury the bottom of the guard 1 to 2 inches into the soil or into finely crushed stone, which helps to reduce weeds and rodent damage when it is spread around the base of the tree.
- When planting *bare-root trees*, remember that approximately one-quarter of the root system was removed when the tree was dug. To compensate, remove about one-quarter of the top part of the plant to reestablish a 1:1 shoot-to-root ratio. Trees that come *balled and burlapped* do not need as much pruning; remove only broken or low-hanging branches.
- *Watering* the young tree in late June may be desirable depending on the rainfall up to that time.
- If less than 4 to 5 inches of rain have fallen since the trees were planted, apply 5 gallons around the base of each tree. You might have to hoe a small ridge of soil around each tree to prevent the water from running off.

SOIL FERTILITY AND pH

The soil in which our plants grow is a complex material. Its consistency and makeup have a marked influence upon plants. Soil provides support for the plant and is also the storehouse for plant nutrients, water, and oxygen for root growth.

Not all soils have the same ability to produce plant growth. The productive capacity of a soil must be considered in terms of both its fertility and physical condition. Even if the correct nutrients are present, they must be released in a form readily available to the plant. Soil fertility should then be considered as the soil's nutrient-supplying capacity, and not strictly as the amount of any one nutrient. Therefore, maintaining soil fertility involves adjusting the supply of available nutrients to levels conducive to the desired growth.

To determine the fertility of your soil, collect samples on which to have a soil test performed. Obtain a soil test kit from your county extension office. There is a small cost for the kit, which includes soil analysis and fertilizer/lime recommendations for your particular soil. When you submit the soil for analysis, be sure to specify the crop that you intend to grow since nutritional and pH requirements vary somewhat among fruit types.

You will receive a soil test report back from the laboratory. The Penn State report shows phosphate, potassium (also called potash), magnesium, and calcium levels, as well as soil pH. Suggested fertilizer application rates are provided along with the levels. The report has three sections. First, the pH adjustment shows the amount of calcitic limestone (0 to 3 percent Mg) needed to raise the soil pH to the desired level for your particular crop. Second, the magnesium and calcium section shows the amount of Epsom salts (magnesium sulfate) and gypsum (calcium sulfate) needed by the crop. Finally, the plant nutrient needs section indicates the amount of other fertilizer materials to be used. Before planting, fertilize and lime the soil (or acidify it for blueberries) according to the soil test results.

Fertilization and Fertilizers

Although the total amount of nutrients in the soil is important, the balance among them can be even more critical. Too much of a nutrient can be just as bad as too little. Excess magnesium may lead to calcium deficiencies, for example. Fertilization, or the addition of nutrients to the soil and plant, is the main method of adjusting the available nutrients. The degree of fertilization will depend upon the type of growth desired. Fertilization

often is thought of in terms of greatest response, which might not always be the optimum response. Generally, in commercial crops, when the cost of fertilization is equal to or greater than the value of increased growth, there is little reason for continued fertilization.

When a fertilizer material contains nitrogen, phosphorus, and potassium, it is known as a complete fertilizer. The fertilizer analysis is the percent by weight of these three elements in the final preparation. For historical reasons, the nitrogen is expressed as elemental, phosphorus as P_2O_5 and potassium as K_2O . A fertilizer analysis makes it easy to determine the exact amount of each element in a given quantity of complete fertilizer.

Since the needs of various crops differ, the plant requirements are expressed as a specific fertilizer ratio. If a plant needs twice the amount of phosphorus as it does nitrogen and potassium, using a material with a 5-10-5 analysis would be advisable since this fertilizer would have the needed 1-2-1 ratio. According to the analysis, 5 percent of the material by weight is nitrogen, 10 percent is phosphorus, and 5 percent is potassium. Therefore, when you apply 1 pound of the material to the soil you are applying 0.05 pounds of nitrogen, 0.10 pounds of phosphorus (as P_2O_5), and 0.05 pounds of potassium (as K_2O).

Gardeners have the option of using two major groups of fertilizers: natural organic and synthetic chemical. Natural organics include dried blood, manure, fish scraps, and cottonseed meal. These compounds are derived from living organisms. The nutrients in most organic fertilizers generally undergo gradual chemical transformations into plant-available forms after they have been applied to the soil; thus nutrients from them are more slowly available to the plant than from chemical fertilizer sources. When applying most organic fertilizers to the soil, timing must be adjusted to account for the slower release of nutrients. For example, June-bearing strawberries have a high nutrient demand in the fall as they produce flower buds for the crop the following season. When using compost, it may need to be applied in the late summer so it will have sufficient time to decompose and release nutrients in time to meet plant needs in the fall. Chemical fertilizers such as ammonium sulfate or superphosphate are prepared from inorganic minerals. The nutrients in most of the natural organic fertilizers generally undergo gradual chemical transformations into available forms after they have been applied to the soil. Most chemical preparations, on the other hand, are available for the plant as soon as they are applied to soils containing adequate moisture levels.

For this publication, organic gardening is defined as gardening based on the production practices in the National Organic Standard (NOS) and pursued by noncommercial growers. If you plan on selling what you grow as organic, you must strictly adhere to the National Organic Standard, which can be viewed in English, Spanish, Japanese, and French at <http://www.ams.usda.gov/nop/NOP/standards.html>. Information for commercial fruit production can be found in the *Tree Fruit Production Guide* or the *Mid-Atlantic Berry Guide*, which are guides produced for commercial growers.

Nutrients from most chemical fertilizers are available to the plant as soon as they are applied to soils containing adequate moisture levels. Various combinations of organic and chemical fertilizers can be prepared depending upon your needs. With such a mixture, some nutrients are available to the plant immediately while the remainder is released slowly to meet the extended needs of the plant. When opting to use chemical or organic fertilizers, make sure that adequate nutrients are

being applied. Table 1.1 lists the nutrient analyses of some fertilizers.

Chemical and organic fertilizers can be purchased at local garden centers or through gardening catalogs. To locate organic fertilizers in garden centers, ask personnel which products are used in organic production. Gardening catalogs will typically identify a product as allowable in organic production.

Composts can be obtained through various sources. Many local municipalities have composting facilities where composts can be obtained for a nominal fee or, in some locations, for free. Composts can also be purchased from garden centers. Making your own compost is a great option because you control what the compost is made from in addition to reducing the amount of waste sent to landfills.

The nutrient content in compost varies depending on what materials make up the compost and on the composting protocols used. Therefore, it is recommended that composts are tested, particularly those that you

Table 1.1. Fertilizer equivalents.

Ammonium nitrate fertilizer usually is available. If not, the materials listed below may be used instead. Use the table to determine the equivalent amount of each material.

Fertilizer Material	Chemical Breakdown			Approximate Amount Needed to Equal the Recommended Ammonium Nitrate Rate Per 100 Square Feet ^a		
	%N	%P ₂ O ₅	%K ₂ O	0.10 lb	0.50 lb	1.00 lb
Anhydrous ammonia	82	0	0	0.05	0.20	0.40
Urea 45	0	0	0.10	0.40	0.75	
Ammonium nitrate	32.5	0	0	0.10	0.50	1.00
Ammonium sulfate	21	0	0	0.15	0.80	1.50
Diammonium phosphate ^b	18	46	0	0.15	0.80	1.50
Sodium nitrate	16	0	0	0.20	1.10	2.00
Calcium nitrate	15	0	0	0.20	1.10	2.00
Potassium nitrate ^b	13	0	44	0.25	1.25	2.50
Monoammonium phosphate ^b	11	48	0	0.30	1.50	3.00
Dried blood	10	0	0	0.33	1.70	3.25
Cottonseed meal	7	2.5	1.5	0.50	2.50	4.75
Animal tankage	5	5	0	0.70	3.30	6.70
Steamed bonemeal ^b	2	25	0	1.75	8.25	16.60
Complete fertilizers: ^b						
10-10-10	10	10	10	0.33	1.70	3.25
10-6-4	10	6	4	0.33	1.70	3.25
5-10-10	5	10	10	0.70	3.30	6.75
5-10-5	5	10	5	0.70	3.30	6.75

a. Example: 0.50 lb of cottonseed meal contains as much nitrogen as 0.10 lb of ammonium nitrate.

b. Caution: Be sure to check for the amount(s) of either P₂O₅ or K₂O that these materials might carry. Do not overfertilize. Use only the amounts recommended.

Table 1.2. Monthly maintenance for home fruit gardeners.

Your schedule may vary from the one below by as much as 2 weeks (earlier or later) depending on the region of Pennsylvania in which you are located.

Throughout the season, scout to identify insects and diseases in the orchard. Apply fungicides and insecticides (see pesticide recommendations in each chapter) according to your scouting and the schedule below.

	Apples	Stone Fruits
January	Check for mice, deer, and rabbit damage. Collect scions for grafting. Cut and burn dead or diseased fruitwood. Cut out fire blight. overwintering.	Check for mice, deer, and rabbit damage. Cut and burn dead or diseased fruitwood. Remove all mummified fruit from peach trees to keep the brown rot fungus from
February	Begin pruning all fruits except peaches. Collect scion wood for grafting. Collect and burn all mummified fruit in trees or dispose of in sealed plastic bags. Check pesticide stock.	Prune and burn all black knot infections on plums and cherries.
March	Finish pruning. Begin grafting. Fertilize when ground thaws. Calibrate sprayers. Check for mite and aphid eggs.	Fertilize when ground thaws. Calibrate sprayers.
April	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Remove tent caterpillars. Spray for gypsy moths. Apply a delayed dormant oil spray for mite and aphid eggs. Hang pheromone traps. Continue grafting. Start scab sprays when green tissue appears.* Apply insecticide at 1/2 inch green if rosy apple aphids were a problem.	Scout for insects and diseases. Apply fungicides and insecticides according to scouting and schedule. Begin pruning when buds swell. Hang OFM pheromone traps. Apply leaf curl spray before buds swell if leaf curl was a problem last year. At bloom, begin controlling brown rot on peach.
May	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Place bees for pollination. Take soil samples for nematode analysis. Take soil samples for mineral analysis. Watch for fire blight at bloom. Watch for plum curculio damage on fruit. If codling moth has been a pest, monitor with traps.	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Cut out cytospora canker. Take soil samples for nematode analysis. Take soil samples for mineral analysis. At petal fall, watch for plum curculio damage on fruit. Pick up leaf curl leaves that have fallen.
June	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Cut or pull suckers. Apply calcium sprays if bitter pit is a problem. If fruit rots have been a problem, begin spraying. Thin fruit and look for plum curculio and codling moth damage. Dispose of thinned fruit and drops. Mow, cultivate, keep weeds away from trunk.	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Cut out cytospora canker. Check interval between last application and harvest. Dispose of thinned fruit and drops. Thin fruit and look for plum curculio damage. Mow, cultivate, keep weeds away from trunk.
July	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Summer prune lightly. Pull suckers. Budding. Remove fallen fruit. Watch out for codling moth second generation. Watch out for Japanese beetle damage. Maintain fruit rot sprays if rots are still a problem. Check for borers.	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Summer prune. Remove fallen fruit. Check for borers. Order trees needed in two years.

* Not necessary with scab-resistant apple varieties.

Table 1.2. Monthly maintenance for home fruit gardeners (continued).

August	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Budding. Remove fallen fruit. Take leaf samples before Aug. 15 for nutritional analysis. Harvest early fruit and chill immediately.	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Complete summer pruning. Remove fallen fruit. Take leaf samples before Aug. 15 for nutritional analysis. Control peachtree borer. Budding.
September	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Obey PHI periods. Test for nematodes if not yet tested. Remove fallen fruit. Harvest and identify disease and insect pests to aid in next year's control strategies.	Scout for insects and diseases. Apply fungicides and insecticides according to scouting. Test for nematodes if not yet tested. Nematode test for new plantings. Control peach tree borer. Remove fallen fruit.
October	Clean and store sprayer. Mow close for mouse control. Rake and dispose of leaves. Pick up fallen fruit and dispose.	Control peachtree borer (late Sept.). Clean and store sprayer. Remove fallen leaves and fruit and dispose.
November	Mow orchard. Winterize equipment. Rake and dispose of leaves. Paint tree trunks white.	Paint tree trunks white. Apply leaf curl spray. Rake and dispose of leaves.
December	Check and renew deer repellents. Clean up orchard floor.	Clean up orchard floor.
	Strawberries	Brambles
January–February	Don't fertilize.	Prune. Remove brush. Fertilize. Remove borer-infested tips.
March	Don't fertilize.	Prune. Remove brush. Fertilize. Remove borer-infested tips.
April	Remove mulch from over plants.	Apply lime sulfur spray. Place mulch between rows. Don't fertilize.
May	Apply bloom fungicide spray. Scout for insects and diseases.	Apply bloom fungicide spray. Scout for insects and diseases.
June	Keep fruit off of the ground. Pick damaged fruit and discard. Scout for insects and diseases. Apply fungicide and insecticide if necessary.	Scout for insects and diseases. Apply fungicide and insecticide if necessary. Pinch growing tips on black and purple raspberries and blackberries.
July	Renovate planting. Narrow bed width and reduce plant density to improve next season's disease control. Fertilize.	Scout for insects and diseases. Apply fungicide and insecticide if necessary. Pick ripe and overripe fruit. Continue to pinch black and purple raspberry and blackberry tips.
August	Water if necessary. Begin day-neutral harvest.	Remove old fruiting canes. Begin primocane-bearing harvest.
September–October		Mow closely next to rows to reduce mouse and vole injury.
November–December	Cover plants with straw. Blueberries	Grapes
January–March	Remove dead and scale-infested wood and mummified fruit. Prune. Remove brush. Fertilize.	Remove dead wood and mummified fruit. Prune. Remove brush. Fertilize.
April	Rake soil below the plants just before bloom. Mulch.	
May	Apply bloom fungicide spray. Scout for insects and diseases.	Apply bloom fungicide spray. Scout for insects and diseases.
June	Scout for insects and diseases. Apply fungicide and insecticide if necessary.	Scout for insects and diseases. Apply fungicide and insecticide if necessary. If not extensive, remove diseased fruit and leaves.

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Table 1.2. Monthly maintenance for home fruit gardeners (continued).

July	Water if necessary. Harvest.	Scout for insects and diseases. Apply fungicide and insecticide if necessary. If not extensive, remove diseased fruit and leaves.
August	Water if necessary. Harvest.	If not extensive, remove diseased fruit and leaves.
September	Harvest late varieties.	If not extensive, remove diseased fruit and leaves.
October		Mow closely next to rows to reduce mouse and vole injury.
November– December		Rake up leaves and discard

make or obtain from local municipalities, to determine the amount of nutrients they contain (kits for doing this are available through local extension offices). Finished compost typically contains 0.5 to 2.5 percent total nitrogen. As a general rule, about 10 percent of the nitrogen will be available to the plant each year. Compost generally contains very little phosphorus for plant use, so phosphorus from alternate sources is typically needed to meet plant requirements. Potassium in composts is in a form that is readily available for plant use, but this form is also water soluble and, therefore, can leach out of compost piles. Placing a cover over a compost pile can help reduce the amount of potassium lost to leaching. In addition to determining the nutrient content of compost, the pH of the compost should be measured because it can be unsuitably high for fruit production, particularly for blueberries, which grow optimally in low-pH soils. When using compost to fertilize brambles, be aware that primocanes have difficulty emerging through large clumps; therefore, breaking up large clumps is necessary when applying compost.

The type and amount of fertilizer to use in a given situation has been the topic of study for many years. Present recommendations are based upon correlations between plant response and chemical tests on the soil or plant tissue itself. The nutrient availability is not a direct function of the total nutrient content of the soil. The available nutrients are related to the exchangeable cations, soil pH, and organic nature of the given soil. Over the years, quick tests have been attempted, but most are inaccurate.

HARVEST

One of the great benefits of growing fruit in the home garden is the ability to harvest the fruit according to

individual taste. One grower might consider a fruit to be ripe, whereas another believes it to be immature. The time to harvest is when it tastes good! As the fruits enlarge, change color, or simply begin to look ripe, try one—if it suits your taste, it’s ready to be harvested. It’s best, however, to be a little discriminating—don’t pick too soon. Immature fruit spoils quickly and never develops full flavor. Pears should be picked at a green-ripe stage and “ripened” at a temperature of 72°F for approximately one week. A particularly effective way to ripen fruit is to place it in a brown paper bag on top of your counter at room temperature. The bag helps to seal in some of the naturally occurring ripening volatiles to promote faster ripening. In some instances this process can be enhanced by including a ripe banana in the bag.

Fruit should be harvested regularly throughout the harvest season. Most fruits will rot in the garden when overripe. In addition to causing the loss of the rotten fruit, the rots can spread to unripe fruit before it is harvested. Regular harvesting can be used to reduce the buildup of insects and disease organisms that cause fruit loss through molds and rots.

In addition to eating fruit fresh, you also can preserve it in one of several ways. Recipes and processing directions are available through your county extension office. Plans for constructing and maintaining fruit storage cellars and drying equipment, as well as methods for bird control in fruit plantings are also available from the extension offices.

SOURCES OF NURSERY STOCK

Lists of tree and small fruit nurseries appear in Appendices A and B. They are not intended as an endorsement of any nursery, but are provided as a convenience for those wishing to purchase fruit plants.

Pests and Pesticides in the Home Fruit Garden

Can fruit crops be grown in the home garden without pesticides? The answer is yes, but fruit quantity and quality may decrease, especially in years when environmental conditions encourage disease and/or insect proliferation. Quality fruit, similar to what is available in the supermarket, cannot easily be grown without pesticides. If you do not wish to use pesticides, you can employ many other tactics to reduce pest numbers in your fruit plantings. These are discussed in detail in the following sections. You should be aware, however, of the possibility that you will lose a significant portion of your crop to insects and disease.

A *pest* is any organism that compromises the production and/or quality of the crop being grown. For the purpose of this manual, we are referring to organisms that harm fruit crops by directly injuring either the fruit or the leaves. Pests might not seem to cause appreciable damage to plants, but they might weaken the plant and reduce its ability to survive. Many backyard fruit producers have lost fruit trees to “winter injury,” when in fact the real cause was the general weakening of the plant from pest assault. Pests generally are classified as either insects, diseases, weeds, nematodes, or vertebrates (rodents or deer, for example), and will be discussed in this manual. For example, Chapter 3 deals specifically with controlling fruit damage caused by wildlife.

The first step in managing pests is careful observation. Develop a habit of observing your plants regularly, and daily if possible. Look at the blossoms, fruit, upper and lower surfaces of the leaves, new shoot growth, and general color and angle of the leaves. Also be aware that if you see changes in the plant, they may not be due to pests. The plant’s nutrition can cause poor leaf color or unusual growth patterns, and humans can also cause damage to plants. Careful observation of the biological system that surrounds your crop plants is one of the most educational and challenging aspects of fruit production.

The conditions for insect and disease development vary from year to year and among crops. In some years,

a no-pesticide strategy may work well to control pests, and there will be very little loss of yield or fruit quality. In other years, the entire harvest might be unusable due to pest damage. The following sections will explain the circumstances required for insect outbreaks and disease epidemics, as well as ways to limit their impact on harvestable fruit through both no-pesticide and pesticide control strategies.

IPM: INTEGRATED PEST MANAGEMENT

The modern approach to managing pests is referred to as integrated pest management (IPM). IPM involves compiling detailed, timely information about a crop and its pests (insects, weeds, and diseases) to ensure that pest-management decisions are economically, environmentally, and socially sound. In addition, IPM advocates integrating as many suitable pest-management tactics as possible, including biological control—using one organism to control another by predation, parasitism, or competition; cultural control; horticultural practices; specialized pruning; orchard sanitation; planting scab-resistant varieties; insect behavior modification such as mating disruption; and the judicious use of pesticides. Successful IPM requires knowledge about pests and the vulnerable stages of the crop. Our goal in publishing this guide is to give you the tools needed to implement a successful IPM program.

WEEDS

Weeds, or “plants out of place,” compete with fruit crops for nutrients and water, provide a moist environment for disease organisms, and often harbor insects and small animals such as rabbits and mice. Nearly every fruit grower who attempts to grow plants around his or her property is faced at one time or another with some form of weed problem. Each type of growing situation has its own type of weed problem: lawns might contain plants other than desirable grasses; the vegetable garden is a constant source of weed growth; and landscape plantings and garden areas devoted to fruit-bearing plant

production often are trouble spots. Competition between weeds and fruit plants for resources (nutrients and water) is of particular concern during the full-bloom period, when nothing should be allowed to interfere with the blossoming and subsequent fruit-setting processes.

Types of Weeds

To adequately control weeds in the small-scale orchard, you should learn proper weed identification. Weeds usually can be divided into two groups: broadleaved weeds and grassy weeds. These names are descriptive of their appearance. This grouping is not specific enough, however, if you anticipate selecting chemical herbicides for weed control. A number of reliable sources of information can assist you in properly identifying weed species. Many of the larger book stores and garden supply dealers have a garden book section containing publications on weed identification.

In addition to knowing what weed(s) you are attempting to control, you should also try to learn something about the specific weed(s) involved. By understanding the growth cycle of the weed, you will be able to plan a more effective control program against its most susceptible phase of growth. The type of control program used on annual plants, for example, will differ from that selected for biennial or perennial plants.

Annual plants are those that complete their entire life cycle in less than a full year. These plants grow from seed, develop into a mature plant, set flowers and seeds, and finally die after the seeds are shed. There are two types of annual plants: summer and winter annuals. Summer annuals germinate from seeds in the spring, live through the summer, and set seeds in the fall. Winter annuals germinate from seeds in the fall, live over the winter months, and set seeds the following spring. Annuals, therefore, maintain their populations through the production of seeds with each generation. Any program to control annual weeds should be designed to either eliminate the young seedlings or at least prevent the development of seeds.

Biennial plants require two growing seasons to complete their life cycle. These plants enter a nonflowering stage during the first season after germination of the seed. The root system on the young plant stores food and overwinters. During the second season, a new plant grows from the root and develops flowers that set seed to reproduce the plant. These types of weeds are best controlled in the young growing stages of the first-year plant.

Perennial plants are able to live for two years or more. Each year they are able to flower and set seed. In

addition to producing seeds, some perennial plants reproduce and persist by vegetative structures such as bulbs, tubers, budding roots, rhizomes, and stolons. These multiple reproductive mechanisms make perennial plants especially difficult to control. In addition to destroying the top growth, which will prevent seed development, you must also eliminate the underground vegetative portions to assure any degree of success in reducing their population.

Weed Control Methods

Weed control can be accomplished chemically or mechanically. Depending on the situation, each method has its advantages and disadvantages. Chemical weed control relies on an herbicide formulation that is toxic to plant growth. Mechanical control relies on a physical means of destroying the existing growth or preventing it from developing.

Several factors make weed control in a home planting different from the control of identical weeds in a field situation, even with the same crop plants. In a small-scale fruit planting, several types of fruit are usually being cultivated in a given area. The use of herbicides in this situation is often severely limited by specific plant tolerances to certain chemicals.

The various soil conditions in different locations can also have a direct bearing on the effectiveness of herbicide materials in plantings. Under field conditions in which the exact soil situation can be determined, adjustments can be made in the application of an herbicide.

There are advantages to using chemical herbicides in areas where their application can be made uniformly and safely around the desirable plants. Their safe use can result in reduced labor, improved plant quality, and less competition between the plants and weeds for water and nutrients.

In light of the above considerations, many small-scale fruit growers will find it more satisfactory, in the long run, to rely on a nonchemical form of weed control for most of their areas. Fruit growers should consider, when possible, a weed control program that uses a combination of methods to combat the problem. Generally, an approach that encourages the desirable plants while discouraging the undesirable ones will result in an effective program.

Weed control is much like other problems we encounter. Preventing weed growth in a fruit planting is much easier than eliminating it once the weeds are well established. A number of steps can be taken to prevent initial weed growth:

- Avoid using manures or compost containing viable seeds that might germinate into weeds.
- Keep all weed growth in surrounding areas under control to prevent seeds from blowing onto the property.
- Remove seeds and vegetative parts from your tools and equipment before working in a clean area of the property.
- Check nursery stock for weed seeds or vegetative parts of perennial weeds before you set new plants on the property.

Cultivating the soil and/or mowing are two effective weed-control practices that either destroy the entire plant or prevent the development of seed for the following generation. Hand weeding, however, still might be the most practical method of weed control available to the individual.

Existing weed growth or other conditions in the home fruit planting might prohibit mechanical methods from being the sole means of weed control. Where hand weeding or cultivation will not produce the desired results, you will have to decide whether to use a chemical form of control. If you choose chemicals, you might also have to make certain adjustments in your cultural operations or use of that plot for a given season. Sometimes it becomes practical to take a section of ground “out of production” until a weed problem has cleared up. Once an area has been cleared of weeds, most mechanical or nonchemical weed-control methods, such as mulching, are very effective.

Mulches for Weed Control

A mulch is any kind of material applied to the soil surface for protection or improvement of the area covered. The value of any mulch material is measured in how well it improves crop quality. The most common reason for using a mulch is to eliminate weeds or at least retard their growth. Where a mulch layer is sufficiently deep, few weeds will grow. In addition to controlling weeds, mulches also aid the optimum development of the plants that grow in the mulched areas. Other advantages include the following:

- By retarding the amount of soil-water evaporation, mulches conserve moisture, which is particularly important during droughty periods of the growing season.
- Mulches help maintain a uniform soil temperature. They act as insulation to keep the soil warmer during

cool spells and cooler during the warm months of the year. By maintaining uniform soil temperatures, they retard freeze-thaw cycles during winter and reduce heaving of perennial plants. Strawberries, for example, should always be mulched in the winter to help them survive the extreme cold temperatures. In the spring, the straw used to cover the plant can be pulled back between the rows to serve as an additional mulch to facilitate harvesting.

- As mulch materials gradually become mixed with the soil, they increase the water-holding capacity of light sandy soils and increase the aeration of heavy clay soils.
- Organic mulches serve as “food” for many microorganisms in the soil. During decomposition of the organic material, soil microorganisms secrete a sticky material that promotes the granulation of the soil. The mulch also maintains more stable temperatures, so the activity of the microorganisms can prevail at an even rate.

Although the advantages of properly used mulches far outweigh the few disadvantages, several inherent problems might occur when mulch materials are used as a form of weed control around plants. Once some of the following limitations are understood, mulches can be adapted to most situations.

- Mulch materials such as hay, straw, and strawy manure might introduce additional weed seeds into the planting area. Hulls or corn cobs might contain grain or seed that could germinate in the mulch layer.
- Several materials used for mulching, including wood chips, fresh sawdust, crushed corncobs, straw, and shredded bark, require the addition of fertilizer to reduce the chance of nitrogen deficiency in the growing plants. Yellowing of the plant foliage during the growing season can indicate the need for additional fertilizer.
- Some organic mulches, especially the fresh types that have not been composted or decomposed, can heat up quickly when damp. This heat, created by the decomposition process within the mulch layer, can “cook” the bark or stem of a plant if it comes into direct contact with the mulch.
- In the late part of the growing season, mulch can also cause the problem of improper hardening-off of the trunk at ground level. To harden off, fruit tree stems must be subjected to gradual temperature changes as the days become colder in the fall. When mulch material covers the base of the stem or trunk

of a tree, the covered portion is not able to respond to the seasonal temperature change. The covered part remains in the same condition as it was during the summer growing season, and when the air temperature drops to the freezing point, this plant tissue is not ready for winter and can be injured or killed.

- Plastic films used as mulches are quite effective, but also have some limitations. Problems can occur with plastics when very large areas are mulched. Under these conditions, the amount of water that actually enters the soil as rainfall or irrigation might be reduced. It is important to punch small holes every few yards in large areas of a plastic mulch layer to ensure that moisture penetrates into the soil. Weeds generally will not grow through these openings.
- It also is important to properly grade areas to be mulched with plastic films, in order to prevent excess surface water from collecting in one location and flooding or saturating the soil in that area.
- Mulches around fruit trees provide an ideal haven for voles, which can eat the bark at the base of a tree. If mulch is being used around apple and pear trees, it should be pulled away from the base of the trees in late October.

One final possible problem with mulches involves the area of soil rather than the material itself. Mulching is not recommended around plants in soils that tend to remain too wet. A mulch will only aggravate the waterlogged soil by preventing evaporation of the excess water.

Application of Mulches

Since most mulch materials are applied for weed control, it is important that they be in place before weeds have emerged from the soil. If, however, the application is delayed until weeds are observed, effective weed control is still possible. Delaying application of mulch also allows the soil to warm slightly, which aids in active root development. If the mulch is applied too early in the spring, soil temperatures will remain cool and root growth will be slow.

The settled depth of the mulch layer is also an important factor in its effectiveness around plants. To function properly, a mulch layer should be from 2 to 3 inches deep. This depth will easily smother young weed seedlings, prevent evaporation of soil water, and allow water penetration to the soil below. Thinner layers will not be adequate. Thicker layers tend to waste mulch and are no more effective in most cases.

Mulch material applied to the proper depth can work to a plant's advantage, but it must not contact the stem or trunk of the plant. Organic mulch materials absorb water, and when moist mulch comes in contact with a plant's stem, it creates conditions favorable for the decomposition of the bark on the plant. The bark on most woody plants must be dry or at least able to dry off rapidly after it becomes wet. Continued moisture on the trunk can be fatal to the plant.

Types of Herbicides

Herbicides have played a perennially important role in the production of food and fiber around the world. When possible, the fruit grower can take advantage of herbicides to reduce much of the labor involved in gardening; however, the effectiveness of herbicides is largely dependent upon the user. Understanding these materials will help you use them more effectively and safely.

A chemical must be toxic to plants before it can be effective as an herbicide. An herbicide that is effective against most kinds of plants is called a nonselective chemical. Such chemicals are useful in areas where complete control of vegetation is needed. On the other hand, herbicides that are more toxic to some plants than others are called selective chemicals. Most herbicides for use on lawns and crops are selective; using the proper rate of these herbicides can remove susceptible weeds from tolerant plants. If excessive rates are used, however, the tolerance may be exceeded, resulting in injury to desired plants. Each kind of flower, fruit, and vegetable varies in its tolerance to a specific herbicide. In the small orchard, this means that not all herbicides can be used around all plants and that many plants do not have tolerances for any of the herbicides available on the market. A limited number of selective herbicides can be used in the home garden and around the home grounds.

Selecting Herbicides

Before selecting an herbicide, the fruit grower should consider the available weed-control alternatives. The weed should be identified and its growth habit—annual, biennial, or perennial—should be determined. Additional consideration should be given to the location of the weeds and the intended use of the area after the weeds are removed. In a noncrop area, a certain herbicide might be very practical and effective, but in a crop area, that same material might not be suitable for controlling the same weed species. The potential problem of drift, or contamination of adjacent plants, is always pres-

ent when using herbicides in small areas. In addition, contamination of adjacent properties might also result in legal problems for the applicator.

The formulation of the herbicide also should be considered in relation to the crop and area being treated and the type of equipment available. Herbicides come in different forms and are prepared for the following:

- Mixing with a liquid carrier—usually water—and applying with a sprayer. These herbicides include wettable powders, water-soluble liquids, emulsifiable concentrates, and water-dispersible liquids.
- Distribution with mechanical spreaders or by hand. These herbicides include granules or pellets that are applied dry.
- Injecting into the soil for vaporization or fumigation. These include liquids, liquefied gases, and granules. They usually require specialized equipment available only to individuals who have a commercial pesticide applicators license.

The area to be treated, the crops, the type of weeds, and the availability of application equipment all affect the selection of a suitable herbicide.

In light of changing government regulations concerning pesticide use, it is very difficult to make specific recommendations about the control of weeds on an individual's property. Far too many variables exist within a given property, not to mention among different properties, to safely recommend herbicides with a safety range wide enough to meet an individual's needs. In addition, each type of fruit varies in its tolerance to a specific herbicide, further compounding the difficulty of selecting the optimum material for a given situation.

Even with today's restrictions and limitations on pesticide use, the interested individual can take several routes to obtain assistance in selecting suitable weed control. Once you have studied the site conditions and determined your needs, you will be able to select an herbicide that satisfies those needs without exceeding the limitations of the site or crop.

Herbicide Application

Herbicides generally are applied at different times, depending upon the emergence time of the weeds and upon the type of fruit plants. Herbicides that are applied at specific times include the following:

- *Preplant herbicides* are used before the crop is planted to control germinating weed seeds, and are usually mixed into the top 2 to 3 inches of soil. No preplant herbicides are labeled for fruit plants.

- *Preemergence herbicides* are used after the crop has been planted, but before the weeds or crop emerges. Restrictions on the age of plants to be treated must be followed.
- *Postemergence herbicides* are used after the crop and/or weeds have emerged from the soil surface and are growing. The most common of these is Round-Up®, which can be purchased without a pesticide license.

Herbicides usually are more effective when temperatures before application have favored uniform germination and rapid weed growth. Rapidly growing weeds are easiest to kill. High temperatures at the time of application also tend to increase the activity of the herbicide but also increase the possibility of crop injury. Moderate temperatures between 70 and 85°F are the most favorable for spraying.

Wind can also be a factor in herbicide application. It can cause improper distribution over the weeds, reducing herbicide effectiveness while increasing the danger of drift onto desirable plants. Fewer problems occur if sprays are used when the wind velocity is low and the wind is blowing away from desirable plants.

The activity of herbicides applied to the *soil* is improved by moderate rain or irrigation shortly after application. The water helps to move the chemical into the weed zone and aids in the germination of the weed seeds. When herbicides are applied to the *foliage*, rain or irrigation should not occur until several hours after the material has been applied. After this time, most herbicides will have been taken into the foliage of the plant where they are not affected by rainfall.

Soil Herbicides

Soil-applied herbicides are effective against germinating seeds or young seedlings. To function, they must persist in the soil during the time when the weed seeds are germinating. After this point, they will have little effect on the plant.

As long as growing conditions are favorable for weed growth, you should expect good control with soil-applied herbicides. Herbicide activity in the soil is influenced by the soil texture, organic matter content, acidity, and moisture conditions, all of which are also factors necessary for optimum plant growth. High temperatures and moist soils also favor the decomposition of herbicides in the soil. Microorganisms and chemical reactions in the soil also aid in the decomposition process, which prevents herbicide buildup in the soil.

Some chemicals used for long-term weed control,

however, may last for two or more years in the soil. When seasonal weed control is needed among desirable plants, chemicals that remain in the soil only a few days to a few weeks can be used. Some chemicals, however, may remain in the soil in sufficient amounts to affect susceptible crops the following season.

Foliar Herbicides

To be effective, herbicides applied to foliage must remain on the foliage long enough to penetrate into the leaf, move within the plant to an active site, and cause a toxic effect. Foliar herbicides can either kill or burn the foliage on contact, or be translocated within the plant to its growing points. The nontranslocated herbicides may not completely eliminate the weed problem but will kill any aboveground parts. The translocated chemicals are effective in killing both aboveground and belowground parts of the plants. Such translocated herbicides are effective against many of the perennial weeds with vegetative reproductive parts below the soil surface.

Weed response to selective herbicides depends upon the retention, uptake, or translocation of the chemical through the plant's foliage, as well as upon the reactions of the herbicide within the plant. The selectivity of an herbicide can result from slight differences in the plant's structure, the quality of the foliage, the depth of the root system, or the location of the growing points.

Substantial time, effort, and money have been invested in the development of pesticides designed to do a specific job. Each pesticide label must specify the intended use of the product, as well as the pests controlled and on which plants it can be applied safely. Chemical weed control, in its simplest form, involves matching a specific problem with the herbicide that will safely solve that problem.

For more information on the use of hand sprayers in applying herbicides, see the "Fungicides, Herbicides, and Insecticides" section of this chapter.

NEMATODES: THE UNSEEN ENEMY

Nematodes undoubtedly are the most numerous multicellular animals in the world. You can pick up a handful of soil almost anywhere and extract nematodes from it. Most kinds of nematodes escape notice, however, because they are so small that they cannot be seen without the aid of a microscope. Most soil-dwelling nematodes are of no concern to the gardener and are, in fact, a normal component of fertile soil. These innocuous nematodes feed on bacteria, fungi, algae, and even other nematodes. Some nematodes are parasitic on insects and higher animals. Others, however, are parasitic on higher

plants and can present a serious problem in the home fruit garden. Because nematodes are out of sight and gradually multiply to damaging population levels, they have been referred to as the unseen enemy in agriculture.

Nematodes are threadlike roundworms that move about in the thin film of moisture surrounding soil particles and root surfaces. Although each species of nematode is unique and can be identified under the microscope on the basis of size, shape, and certain morphological characteristics, all plant-parasitic nematodes share one distinguishing feature: a stylet. The stylet is essentially a hollow spear, like a hypodermic needle, that the nematode uses to puncture cells and feed.

The symptoms of nematode infection are commonly those of root impairment, such as growth reduction, increased wilting, mineral deficiency symptoms, decreased winter hardiness, and dieback in perennials. Since many of these symptoms are not necessarily diagnostic of nematode disease, they might be confused for other biotic or abiotic problems. In some cases, additional fertilizer and/or water may temporarily mask the problem. In small plantings, nematode problems initially might escape notice unless a similar healthy plant is nearby for comparison. Nematodes contribute to a number of other disease problems as well.

Problems Caused by Plant-Parasitic Nematodes

Loss of Vigor and Yield

Plant-parasitic nematodes vary in their feeding habits; each species causes a slightly different type of damage to the root. These differences are important because they affect the physiology and growth of the plant in different ways. One basic feature of nematode attack, however, is that nutrients and metabolic activities are diverted from normal, healthy growth and fruit production into sustaining the nematode population and repairing the wounds they cause. This is a chronic problem that continues throughout the growing season. All plants tolerate minor attacks by pathogens without a significant impact on vigor, but nematodes become a problem when the population level surpasses the damage threshold; at this point damage is measurable. Because of different feeding habits, reproductive potential, and other factors, the damage threshold is different for different species of nematode. The threshold for damage also will vary according to other variables such as plant age, size, nutritional status, moisture stress, and other disease problems.

Nematodes as Predisposing Agents

Research to determine the precise role of nematodes in plant decline has shown that feeding may have diverse effects on plant physiology. For example, it is clear that some nematodes may predispose fruit trees to other disease problems. Although very little is understood about how nematodes do this, some examples are well documented. Feeding by the ring nematode on peaches, for example, has been linked to increased susceptibility to bacterial canker, reduced winter hardiness, and the development of peach tree short life disease. Other research has shown that nematodes can make plants more susceptible to certain fungal pathogens such as verticillium wilt. The basis for predisposition presumably lies in the disruption of the normal hormonal balance of the root. More research is needed to understand the nature of this interaction.

Nematode-Related Replant Problems

Replanted fruit trees frequently have problems with reestablishment. The cause of these replant problems has been extremely difficult to pinpoint because of the abundance of microorganisms that have been isolated from replant sites. The available evidence indicates that replant disease results from an interaction between nematodes and various microflora. The nematode most frequently associated with this problem is the lesion nematode. The lesion nematode is very destructive; it burrows through the root as it feeds, leaving a trail of dead cells that appear as dark lesions. These wounds allow bacteria and fungi to enter the root. In older, well-established trees, a balance exists between new root growth and the activities of nematodes and microorganisms. When old trees are replaced with seedling trees, however, the balance is upset and the young trees cannot compete with the high populations of pathogens present.

Nematodes as Virus Vectors

Perhaps the most serious nematode-related problem with fruit production in the Cumberland-Shenandoah region is the transmission of plant viruses. The tomato ringspot virus (TmRSV) and tobacco ringspot virus (TbRSV) are both vectored by common species of dagger nematodes

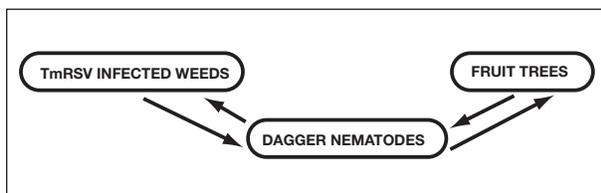


Figure 2.1. Tomato ringspot virus (TmRSV) transmission.

(*Xiphinema* sp.). The nematode acquires the virus when it feeds on an infected plant, then transmits the virus when it feeds on a healthy plant. Figure 2.1 illustrates this exchange. Feeding by dagger nematodes is the only natural means of infection for these viruses. In the absence of dagger nematodes, the virus does not spread naturally from plant to plant. Because dagger nematodes transmit TmRSV, their damage threshold is much lower than that of a parasite that causes damage only by feeding.

TmRSV causes serious disease problems in a number of different fruit crops, including peach, apple, plum, cherry, grape, raspberry, and blueberry. TmRSV infects many different plants, including most of the common broadleaf weeds. Good broadleaf weed control may be the most effective way of avoiding these virus problems. TmRSV can be spread in the seed of some weeds such as wind-blown dandelion seed.

Considerations Basic to Nematode Control

The first step in diagnosing a crop-production problem in which nematodes may be a factor is to collect and identify the nematodes that are present in the involved soil or plant material. Accurate species identification is essential because of differences in nematode life habits, host ranges, and pathogenic effects on various host plants. Distribution data are also important for determining whether the nematodes are associated or coincident with the disease problem. Since nematode control is difficult in an established planting (this is especially true for perennial crops), the best approach is to assay for potential nematode problems before planting. If a potential problem exists, control measures will be easier to execute. The biology of the nematode, its ecological relationships, its methods of spread, the value of the host crop, and the cultural practices used in the particular area are important factors that must be considered in developing control measures.

Prevention of Spread

Plant-parasitic nematodes move only relatively short distances under their own power; therefore, the most usual means of nematode spread is the transportation of infested soil and infected plant parts by humans. Sanitation and good cultural practices are the best preventive measures against nematodes. Obtain plants from reputable nurseries and wash soil from tools and machinery before using them at a new location. Nematodes also might be carried by wind, water, and animals. These methods of spread can be important under certain situations such as when water runs from an infested site.

Establishment in a new area occurs only when sufficient numbers of viable nematodes are transported to a location where susceptible hosts are subsequently planted and where the environment is suitable for reproduction of the nematode species.

Control of Nematode Populations

Although several chemicals that effectively control plant-parasitic nematodes are available, the chemical approach is generally not satisfactory for the home fruit grower. Chemical nematicides and fumigants are relatively expensive and require specialized equipment for application. In most cases, the cost and labor of application cannot be justified for a non-commercial planting. Instead, growers may use some of the control strategies given below.

Fallow ♦

Fallow may be used as a preplant nematode control when nematode assay reports indicate a potential problem in the intended planting site. Fallow is the practice of keeping land free of all vegetation for varying periods of time by frequent disking, plowing, or harrowing of the soil, or by applying herbicides to prevent plant growth. At least two principles of nematode control are represented by fallow. The first principle, and perhaps the most important, is starvation of the nematode. Plant-parasitic nematodes are obligate parasites, which depend on living hosts for the food necessary to develop, mature, and reproduce. Therefore, in the absence of a host plant, the nematode will die after the stored food in its body has been depleted. Most plant-parasitic nematodes probably do not survive for more than 12 to 18 months, and many do not survive the first 6 months.

The second principle involved in fallow is death through desiccation and heat. With some exceptions, most species of nematodes will die if exposed to the drying action of the sun and wind. Sometimes, the term *fallow* is used to mean letting the plot go without a crop, but allowing a weed cover to develop to minimize soil erosion. This practice is not suitable for reducing nematode populations since the weeds may serve as hosts for the nematodes.

Cover Crops ♦

Although no single crop will act as a “magic bullet” against all nematodes, specific problems may be controlled successfully in preplant situations by planting certain cover crops. Cover crops work for different reasons, depending upon the specific nematode-crop combination. In some cases, the cover crop may be a nonhost for the

nematode. Since nematodes do not feed on plants outside of their host range, such plants will starve out the population with the same effect as fallow cultivation. Other plants are known to be susceptible to nematode invasion but prevent the development of larvae into adults. Such plants are referred to as “trap crops.” *Crotalaria*, for example, has been used successfully in this way to reduce populations of root-knot nematodes. Still other “antagonistic” plant species have been found to naturally exude chemicals toxic to nematodes. French marigolds and asparagus are examples of such crops. While antagonistic and trap crops have been used successfully to control nematodes, little is understood about the principles involved. Clearly, this is an area in which more research is needed.

Crop Rotation ♦

The use of crop rotation to reduce nematode populations is a very effective and widely used land-management practice. This practice was used by growers long before its significance as a means of nematode control was recognized. To be an effective control practice, crops that are unfavorable, or nonhosts, for nematodes must be included in the rotation sequence. Although many people think of crop rotation as a short-term strategy against nematodes, some long-term crop rotations can be very effective for fruit production. For example, rotations of asparagus, raspberries, and Christmas trees might be an option.

Organic Manuring and Soil Amendments

In some instances, adding large amounts of organic materials to soil results in reduced populations of plant-parasitic nematodes and higher crop yields. The reduction in nematodes is thought to be caused, at least in part, by an increase in natural enemies of nematodes. In addition, the presence of decomposing organic materials in the soil apparently provides host plants with some tolerance to nematode attack. Decomposition products of organic matter and plant residues may also be detrimental, directly or indirectly, to plant-parasitic nematodes, as demonstrated by the butyric acid released by the decomposition of cover crops such as rye and timothy. Other examples of green manure crops and soil amendments reportedly effective for reducing plant-parasitic nematodes include ground sesame stalks and crabmeal. Some research suggests that ammonia released by decomposition of these soil amendments might be the active killing agent. This theory has been supported by reduced nematode populations after incorporation of agricultural-grade urea in the soil.

Nutrition and General Care of the Host

The deleterious effects of nematode damage to certain crops can be offset to some degree by proper nutrition, moisture, and protection from adverse conditions such as cold that place plants under stress. Practices that tend to offset the damage caused by nematode attack include irrigation, conservation of moisture by mulching, fertilization, protection of plants on cold nights, and control of root and foliar diseases caused by other pathogens. It should be pointed out, however, that these are only delaying tactics, and if susceptible crops are grown continuously, the nematode population will reach proportions that will cause serious damage. The rapidity of disease development and the magnitude of the damage will depend on the host and nematode species involved, the resistance or tolerance of the host, and various factors in the environment that favor or deter development of the disease.

Some research has shown that soil population levels of several nematode species may be changed by host nutrition and, similarly, that disease development and severity are more pronounced in infected plants that are deficient in one or more essential nutrients. Nematode infection also has been found to cause an increase or decrease in the concentration of one or more minerals in leaf or root tissue. The interactions among host, parasite, and nutrition are complex, and the application of such information to fertilization programs designed to minimize crop plant nematode damage is just beginning.

Sanitation and Nematode-Free Planting Stock

The land-management and cultural practices discussed above reduce nematode populations in plots to varying degrees. Most of these measures have limitations; the degree of control is erratic; and sometimes those factors actually responsible for the reduction in nematode populations are not fully understood. Sanitation and the use of nematode-free planting stock, however, are sure and effective means of nematode control. The cost of these practices is small, yet many growers continue to use nematode-infected transplants. Although pathogenic nematodes are already widespread, indiscriminate use of nematode-infected plants and plant parts introduces new species into many fields and consequently complicates control measures. Furthermore, nematodes introduced in this manner are in a favorable position for survival since they are already in or close to host plant tissues.

Sampling for Plant-Parasitic Nematodes

Determination of nematode species and population levels can be accomplished only with a nematode assay. To be of any value, the soil sample must be representative of the site to be checked; therefore, great care should go into taking samples. Since the results of the assay are affected by the condition of the nematodes, it is also very important that samples be handled properly until they are shipped or brought to the lab. In general, the more samples that are taken from a site, the more accurate the assay will be. Large parcels of land should be divided and each unit sampled separately.

Nematode assay packets may be obtained from county extension offices or from the Penn State Fruit Research and Extension Center (FREC).

Sampling Procedure

When taking samples, follow these steps:

- If the soil in the area to be sampled is fairly uniform and the area is not very large, one composite sample will suffice. If the field is large, divide it into two or more blocks of approximately equal size and take one composite sample from each block. The sample area should not be more than one acre in size.
- In each field to be assayed, take a sample from each area that has a common cropping history and that will be planted to a single crop. For example, if a one-acre field is to be planted to peaches next year and if one-half of the field was in apples last season and the remainder in woods, collect a sample from each of the areas.
- If the soil in the area to be sampled is variable, such as having a heavy clay soil in one portion and a sandy soil in another portion, take one composite sample from each soil type.
- Preferably using a 1-by-12-inch sampling tube (or a trowel, small shovel, or similar tool, if a sampling tube is unavailable), take at least 20 cores of soil from each sampling area. Samples should be taken to a depth of 9 to 12 inches.
- Take soil samples from the area in which the roots were growing. Feeder roots, found at varying depths, usually are most abundant in soil at the dripline, directly below the outer leaf canopy. Do not sample from dead or nearly dead plants; rather, sample from adjacent plants.

Since nematodes generally are not uniformly distributed in a field, a carefully prescribed sampling procedure must be followed to obtain root and soil samples

representative of the area surveyed. Furthermore, the samples must be properly handled and shipped to assure that they remain alive until they are processed in the laboratory. Samples can be taken any time from May to November, as long as the soil is moist and the temperature is above 40°F. If there has been a prolonged dry spell or if the soil has been saturated with water for an extended period, wait for 4 to 6 weeks of normal soil moisture conditions before sampling.

Handling Samples

- Make certain that all information requested is included on the nematode assay form that you will receive with the assay packet. This information is needed to identify the sample and to aid in interpreting assay data. If you collect more than one sample, you must assign a field number to each area sampled and place that number in the appropriate area of the form. Each plastic bag should be sealed tightly by tying it with the twist tie found in the bag. A separate assay packet must be used for each composite sample.
- Keep the samples out of direct sunlight to avoid overheating. The samples may also be damaged by heat if they are stored in the trunk of a car or other hot location. Use a Styrofoam cooler to keep the samples cool. Heat kills nematodes, and dead nematodes are unsuitable for identification.
- After completely filling out the assay forms and sealing the plastic bags, place the samples in a suitable container and send or bring them promptly to:

Penn State Nematode Diagnostic Service
FRUIT RESEARCH AND EXTENSION CENTER
P.O. BOX 309, 290 UNIVERSITY DRIVE
BIGLERVILLE, PA 17307
PHONE: 717-677-6116
- A \$15.00 fee is charged for each sample sent to the lab. Payment in full by check must accompany each sample. Cash cannot be accepted, and there will be no billing. Please make all checks payable to *The Pennsylvania State University*.

An assay report will be returned for each submitted sample, stating the numbers and kinds of important plant-parasitic nematodes that were detected. The report will also comment on the need for nematode control.

INSECTS AND MITES IN FRUIT

Many species of insects and mites attack various fruit crops (see Table 2.1). Fortunately, only a few are considered serious enough to prevent a good yield and high fruit quality. These pests can be divided into two groups: those that affect the fruit (direct pests) and those that affect parts of the plant other than the fruit (indirect pests). In most instances, direct pests are far more serious since they can damage or infest the harvested part of the crop. Very few of these pests can be tolerated. Moreover, in many cases by the time an infestation is noticed, extensive damage has already been done. For this reason some pest controls (such as pesticide sprays) must be applied before fruit damage is observed. These sprays are usually applied to correspond with some stage of crop development such as pink bud or petal fall. Indirect pests, on the other hand, can be tolerated to a certain degree because a healthy plant is able to withstand some feeding damage, and the fruit are not being affected directly. Fruit growers can wait until they notice that an indirect pest is present in damaging numbers before applying a control.

The keys to successful pest management in fruit crops are close observation of the plants, the ability to distinguish the few pest species from the myriad of innocuous or beneficial insects that may be present on the plant, an awareness of when pest numbers are threatening the growth of the tree or the crop, and the ability to choose the best control option when control of a pest is necessary. Some of these techniques are discussed below.

Fruit crop plants undergo a sequence of growth stages every year. Apple trees, for example, proceed from green tip (bud break) to tight cluster (flower buds visible) to pink (flower buds showing pink) to bloom (flowers open) to petal fall, etc. The rate at which this process progresses is largely due to environmental conditions such as temperature. Likewise, pests respond similarly to these environmental cues, usually appearing in concert with some developmental stage of the plant. Therefore, the plant's developmental stage can help determine when pests (especially direct pests) should be controlled.

Not all insects are bad! In fact, many are beneficial because they feed on the pest insects. For some indirect pests, beneficial insects may obviate the need for a pesticide spray or two. In addition, these beneficial insects might be killed by the pesticide sprays. Therefore, the detrimental as well as the beneficial impact of a pesticide spray must be considered. For example, syrphid fly

Table 2.1. Important insects and mites.

Insect or Mite	Apple	Peach	Pear	Cherry	Strawberry	Bramble	Blueberry
Apple maggot	D						
Black cherry aphid				I			
Blueberry maggot							D
Cane borer						I	
Cherry fruit fly				D			
Codling moth	D		D				
Cranberry & cherry fruitworms	D	D		D			D
European red mite	I	I	I	I			
Green apple aphid	I	I	I				
Green peach aphid		I		I			
Japanese beetle	I	I + D				I + D	
Oriental fruit moth	D	D	D				
Peachtree borer		I		I			
Pear psylla			I				
Plum curculio	D	D		D			D
Potato leafhopper	I					I	
Raspberry aphid						I	
Root weevil					I		
Rosy apple aphid	I		I				
San Jose scale & others	I	I	I	I			I
Sap beetle					D		
Slug					D		
Spittlebug					I		
Stink bug	D	D	D	D	D	D	D
Strawberry bud weevil					D		
Tarnished plant bug	D	D	D	D	D	D	D
Two-spotted spider mite	I	I	I	I	I	I	I
White apple leafhopper	I						
White grub					I		

D = primarily a direct pest

I = primarily an indirect pest

larvae might be feeding on pest green apple aphids and control the aphids without the use of a pesticide. However, it might be the time of the year to protect the fruit from apple maggots, which have plagued the trees in the past. The fruit grower might decide that protecting the fruit from maggots is more important and might apply a pesticide that also kills many of the syrphid flies.

How many pests are too many? As stated earlier, very few direct pests (those that attack the fruit) can be tolerated, and protective sprays are often applied prophylactically. Populations of indirect pests, however, can be tolerated without harming the tree or crop. On apples,

for example, an average of five or six mites per leaf can be tolerated. Only if the mite numbers exceed this threshold are sprays recommended.

Other insects also are considered beneficial in the fruit planting. Bees are beneficial since they pollinate most fruit crops. Insecticides should *never* be sprayed when the crop is in bloom. Also, avoid the drift of insecticides onto other blooming plants when fruit crops are being sprayed.

As mentioned above, many types of flies are predators or are parasitic on fruit pests. Syrphid fly larvae are typically maggot-shaped and legless, with a head

end that is narrower than the tail end. These flies may be found foraging among colonies of aphids on the undersides of leaves.

Beetles, particularly ladybird beetles (“ladybugs”) can be very beneficial. Several species of ladybird beetle are voracious predators in both the larval and adult stages. The larvae are elongate with distinct legs and are usually black with orange markings. These larvae often are found feeding on aphid colonies. The black ladybird beetle is a mite predator. This species is discussed in the European red mite section in Chapter 4. Other predators and parasites include lacewings, predatory mites, and many parasitic wasp species.

Monitoring

Monitoring fruit plantings frequently and on a regular basis is the key to a successful IPM program. Monitoring can take several forms, and is accomplished by using various types of traps and by weekly scouting. Pheromone traps lure male moths onto a sticky panel by means of a synthetic sex-attractant chemical. Counting the number of male moths in these traps weekly allows the gardener to better time insecticide treatments. Other insect traps are apple maggot spheres and white sticky panels for trapping European apple sawflies and tarnished plant bugs.

Scouting is the most useful technique for monitoring most pests. It should be done weekly during the growing season, and involves inspecting a sample of fruit plants to determine the presence and severity of various pests. During the dormant season, scouting should be performed at least once to determine levels of overwintering forms of some pests such as mite and aphid eggs and of San Jose scale. Invest enough time to make reliable assessments of pest and tree conditions.

PEST MANAGEMENT

Pest-management techniques for specific crops are discussed in Chapters 4 through 12. Many plant diseases and insect pests survive the winter on woody plant parts, in the soil, or on weed hosts. They can live in a dormant state in dead wood, infected buds, limbs, trunks, bark on twigs, mummified fruit, decaying plant parts, leaf litter, and plant debris. When weather conditions become favorable in the spring, these insects and diseases become active again. The fungal and bacterial diseases begin to multiply, sporulate, and are carried by wind and rain to susceptible plant parts. This begins a new disease cycle. Knowing how these diseases and insect pests overwinter and spread is crucial in their control. This is why cultural

methods such as sanitation, pruning and using disease-resistant plants are so important. Pruning removes the source of the overwintered pathogen or insect pest. Some pruning guidelines are listed below.

Pruning

- Prune out and destroy dead, diseased, or insect-infested twigs and branches.
- Prune branches that rub against each other.
- Try not to leave a stub when pruning; remove the whole branch if possible.
- Do not prune in fall or early winter. This will make trees more susceptible to winter injury.
- Prune to “open” trees, which will facilitate disease control. Pruning promotes better air circulation and light penetration, facilitates the drying of plant surfaces, and enhances spray distribution.
- Prune out cankers in stone fruit to discourage borers.
- Prune out fire blight cankers and all other cankers caused by disease organisms.

Sanitation

- Remove leaves and other plant parts containing insect egg masses.
- Remove and destroy decayed, injured, and mummified fruit left in the tree or on the ground.
- Pick up, burn, bury, or destroy fallen fruit.
- Rake and burn leaves and other litter under the tree to destroy overwintering disease and insect habitats.
- Eliminate weed hosts. Many insects and diseases overwinter in weeds.
- Avoid excessive nitrogen fertilization.
- Avoid wounding plant parts and fruit during the season. Wounds are excellent entry points for insects and diseases.

FUNGICIDES, HERBICIDES, AND INSECTICIDES

In some cases, pesticides are the only alternative in controlling pests. The pesticides cited here have moderately low mammalian toxicity and degrade soon after application. Little or no toxic residues remain either on the fruit or in the environment if the pesticide is used according to label instructions.

A number of general-purpose products (GP-Products) are available at retail outlets. A GP-Product usually includes one or more insecticides and fungicides. It may

or may not include a miticide. This type of mixture will afford adequate control of insect and disease problems, provided the amount used, the method of application, and the time of application are correct. These products allow you to buy one package of material instead of several individual pesticides that must then be mixed. Some mixtures are available in ready-to-use premeasured packets. Always follow the directions on the container package when mixing and applying pesticides.

Hand Sprayers

Homeowners and hobbyists with small plantings need effective, low-cost spraying equipment. Hand sprayers fill this need. Several choices of hand sprayers can provide adequate coverage on trees. If you plan to apply herbicides underneath or around your fruit plants, you will need to have two sprayers—one for the application of herbicides and one for fungicides, insecticides, or foliar nutrients. The popular types are described below.

Knapsack Sprayers

A knapsack sprayer is suitable for small plantings up to an acre in size. This sprayer is entirely manual and is carried on an operator's back. Also called a backpack sprayer, the knapsack sprayer is designed to be as light as practical. A typical empty weight is about 12 pounds. With 4 gallons of water, the weight is approximately 45 pounds. The parts of the knapsack sprayer are the same as those found on most sprayers: a tank to hold the spray mix; a pump to produce pressure and flow; a regulator to control the flow; and at least one nozzle to atomize

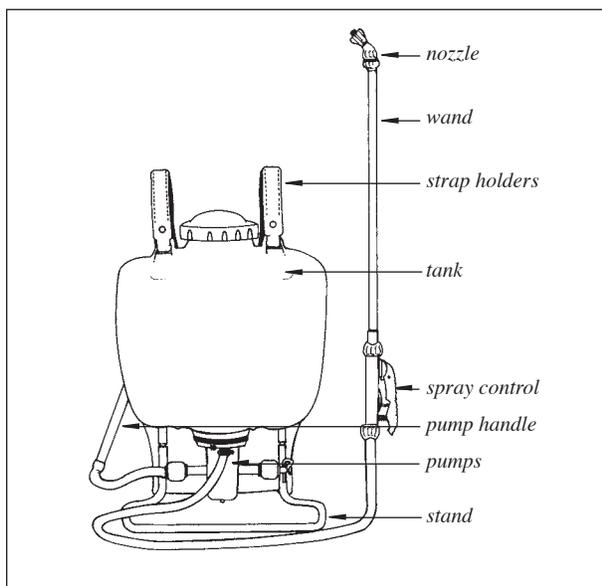


Figure 2.2. Knapsack sprayer.

the spray mix (Figure 2.2). Tanks on the knapsack sprayer typically are made of plastic or steel and hold three to five gallons. Some knapsack sprayers have a mechanical agitator that moves when the pump is used. Others have jet agitation. Before spraying, shake the entire sprayer to ensure a uniform mix.

The sprayers have a built-in piston or diaphragm pump that is operated by hand. Some models can be adapted to either right- or left-hand pumping; the other hand is needed to operate the flow-control valve and the wand. The pumps are capable of relatively high pressures (80 to 180 psi). Some backpack sprayers are equipped with pressure gauges as well as pressure regulators. The chamber that pressurizes the chemical liquid is very small, so the operator must pump while walking and spraying. At least one company manufactures a knapsack sprayer with an engine-powered pump. This eliminates hand pumping but increases the empty weight of the sprayer by about 50 percent.

The distribution system includes an on-off valve, usually with a pistol-grip handle, and one or more nozzles on a wand. The nozzle is often mounted at an angle on a 16- to 20-inch-long wand to aid spray placement on the trees. Some designs allow for interchangeable nozzle tips so that the nozzle can be better matched to the job. Others use an adjustable nozzle that can be varied from a wide discharge angle to a solid stream. Although the solid stream setting will throw the liquid farther, it should not be used on fruit trees because there is little or no atomization. Poor coverage and pest control results.

The time and energy needed to use a knapsack sprayer on fruit trees limits the device to small plantings. When labor is of minimal consideration, such as with homeowners and hobbyists, the knapsack sprayer can be effective. Its size, however, is not practical for applying high rates of water per acre. Considerable practice is required to obtain thorough coverage of trees without overspraying, which creates wasteful runoff and may increase the risk of phytotoxicity.

A great deal of skill is needed to obtain a uniform application. The rate of spray will be less reliable by hand than if a tractor sprayer is used. Application rates, walking speeds, and coverages also will vary with operator fatigue caused by temperature conditions, the time of day, the slope of the terrain, and the walking surface. In addition, the risk of overspraying and underspraying is increased because the knapsack sprayer uses a small volume of water. Extra care should be given to coverage and uniformity.

Knapsack Mistblower Sprayers

The powered knapsack sprayer, also called a mistblower, has a small engine and fan. It is actually a small, back-carried air-blast sprayer.

Powered knapsack sprayers are equipped with two-stroke-cycle, three- to five-horsepower engines. These relatively lightweight engines require that oil be mixed with the fuel. They operate at 5,800 to 8,000 revolutions per minute and are rather noisy; operators should wear ear protection. The sprayers weigh between 17 and 25 pounds when empty and are much heavier than the manual models (Figure 2.3).

The engine propels a centrifugal fan that delivers 200 to 450 cubic feet of air per minute (cfm) at a discharge velocity higher than 200 mph. With this high velocity, air shear nozzles are sometimes used. Hydraulic orifice and rotary nozzles also are popular because they can easily form and inject droplets into the airstream. The air from the fan is fed through a flexible tube with an air nozzle on the end that the operator directs to deliver the spray. Because of the high discharge velocity, the air nozzle should be kept at least 6 feet from the trees. The airstream should be aimed downwind so that air currents can assist in carrying the droplets away from the operator. Mistblowers should not be used to apply herbicides.

Powered knapsack sprayers can spray trees much faster than the manual sprayers. The airstream will assist in delivery and coverage even at lower application rates. The number of trees that can be sprayed, however, is

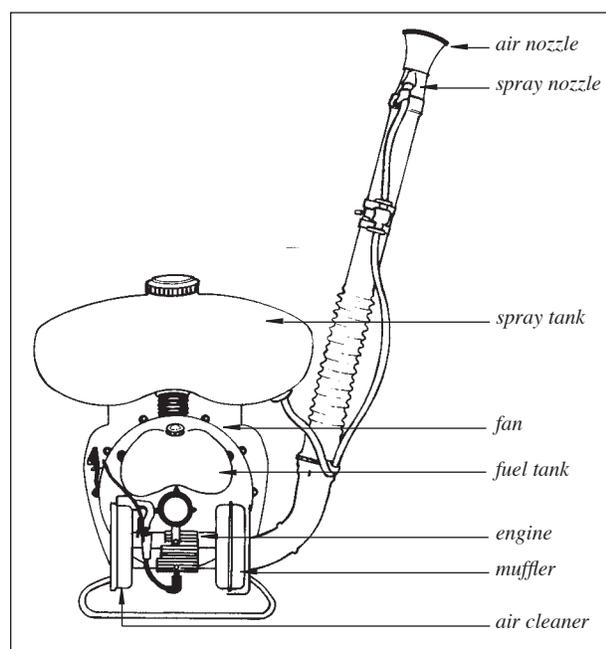


Figure 2.3. Powered knapsack sprayer.

still limited because the sprayer tanks are small. Because a tankful will cover only a relatively small area or a few trees, refilling and measuring the chemicals is time consuming.

Handgun Sprayers

Handguns are basically hand sprayers with an engine-powered pump. Hydraulic handheld gun sprayers might be equipped with more than one nozzle. The multiple-nozzle guns are, in effect, very small handheld boom sprayers. A handgun is connected by a hose to a powered pump. Two or more handguns can be used on one pump if its capacity is sufficient. Piston or diaphragm pumps are usually needed to provide the required high pressure. Because the pump and tank are carried or towed by tractors or other vehicles, their tanks can be much larger than is feasible with the knapsack sprayers. This permits using more water and fewer refills.

As with any hydraulic nozzle, the handgun sprayers use pressure to atomize the spray liquid into droplets. The droplets' velocity when discharged from the nozzle must carry the spray to the target. The farther the tree is from the handgun, the higher the pressure must be to adequately deliver the droplets. Handguns with pistol grip-handled valves are preferred for spraying fruit trees because the operator can turn off the spray easily when going from one tree to the next.

Because the operator controls the travel speed, or time at each tree, variation in application rates similar to those of the knapsack sprayer can be expected. Long and heavy hoses contribute to operator fatigue and result in less uniformity. Some people build platforms on the sprayer or tractor on which the handgun operator can ride. This provides comfort but limits maneuverability. If you do build a platform, be sure that guards and railings are adequate to protect the operator.

Two or more people often are used in handgun spraying—one (or more) operates the handgun(s) and one drives the tractor through the plantation. This increases the number of people involved in comparison to knapsack spraying but allows treatment of many more trees in a given time period.

Hand Sprayer Calibration

Calibrating a sprayer means making trial runs to determine the application rate. Calibration requires only a few minutes and is worth the time spent for several reasons. For one, the right amount of chemical must be applied to be safe, effective, and economical. Using more chemical than is needed is wasteful and may pollute the environment; not applying enough chemical also is

uneconomical because the treatment is less effective.

Hand sprayers must be calibrated to ensure accurate application rates. The person who will make the application should do the calibration. The operator needs to know the application rate so that the percentage of an acre covered by a tankful can be determined. By multiplying this percentage by the recommended application rate per acre, the operator can find the amount of chemical required for each tankful. Before calibration is begun, operate the sprayer with water only to ensure that all parts are operating properly. Knapsack sprayers, handguns, and other hand sprayers can be calibrated with the following methods.

Per-Acre Rates for Broadcast or Band Herbicide Applications

For broadcast or band spraying of herbicides, or for continuous “down-the-row” tree spraying, follow these steps:

1. Select a plot to measure and then mark the calibration distance appropriate for your nozzle spacing for broadcast spraying (width covered by a single nozzle) or your band width for applying a band. The proper course size should be selected from Table 2.2 (see also Figure 2.4). Caution: The pattern width depends on the nozzle-to-target distance. You might need to practice with water on a paved surface until you determine the proper nozzle height to obtain the desired pattern width.
2. Fill the sprayer tank with water only and spray the calibration plot at the desired pressure and walking speed. Measure the number of seconds required to

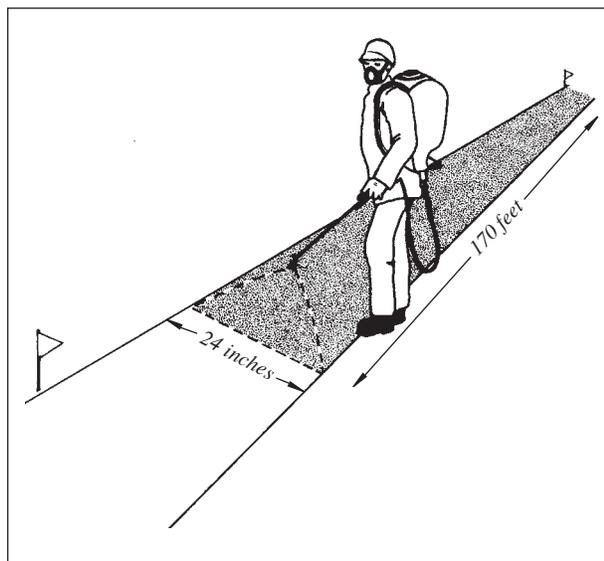


Figure 2.4. Calibration course.

spray the calibration course while walking and pumping at a comfortable, steady speed. You might want to practice with only water on a paved surface to establish your walking speed and to check for uniformity by observing the drying pattern.

3. With the sprayer in place and while pumping to maintain the selected application pressure (not applicable to powered pumps), collect the spray output from one nozzle for the same number of seconds measured in step 2. Be sure to collect all the spray output from the nozzle under test for exactly the same time period. The water in the container will be the same amount applied to the calibration course. The number of fluid ounces collected equals the gallons per acre (gpa).

Example: With a 24-inch band, if it took 38 seconds to cover the 170-foot course, collect the spray output for 38 seconds. If you collect 16 fluid ounces, the application rate is 16 gallons per acre and a 4-gallon tankful will cover 0.25 acre.

Rates for Application on a Per-Tree Basis

Calibrating a sprayer to treat trees is similar to doing it for a plot, except the application rate per tree is determined rather than the rate per acre. Follow these steps:

1. Select the desired application rate per acre and divide by the number of trees planted per acre. This will give the amount of spray to apply to each tree.

Example: The trees are planted on a 6-by-6-foot spacing and it is desired to spray at the rate of 100 gallons per acre. The number of trees per acre is the area (43,560 square feet per acre) divided by the space

Table 2.2. Sprayer calibration distances.

Nozzle Spacing or Band Width (inches)	Calibration Distance (feet)
10	408
12	340
14	292
16	255
18	227
20	204
24	170
28	146
32	127
36	113
40	102

occupied by each tree (6 feet by 6 feet = 36 square feet) or 1,210 trees per acre. Divide the desired application rate per acre (100 gallons per acre) by the number of trees (1,210) and determine the amount for each tree (0.08 gallon per tree).

- Determine the output of the sprayer (gallons per minute) by spraying into a container for a period of time such as 5 minutes.

Example: Spraying into a bucket for 5 minutes produces 6 quarts or 1.5 gallons. Dividing by the number of minutes gives a throughput rate of 0.30 gallons per minute.

- Determine the length of time to spray each tree by dividing the gallons per tree by the throughput rate.

Example: Given the information above, divide 0.08 gallons per tree by 0.30 gallons per minute to get 0.26 minutes or 16 seconds per tree. Spray each tree for about 16 seconds.

- Practice spraying with water while someone times you until you can consistently come close to spraying each tree for the proper amount of time and, thus, apply the proper amount of chemical. Recheck your timing an hour later.

Determining the Amount of Chemical

The main reason for calibrating a sprayer is to determine the amount of formulated chemical to add to a tankful of water. The following must be known:

- The calibrated output of the sprayer.
- The measured capacity of the sprayer tank.
- The recommended rate of application.

The operator needs to know the application rate so the area per tankful can be calculated. With a knapsack sprayer, the area likely will be less than an acre. Check the capacity of the sprayer tank; decals or molded marks often are in error, and foreign-manufactured tanks may be marked in metric units. The operator must know the percentage of an acre covered by a tankful. By multiplying this percentage by the recommended application rate per acre, the operator can find the amount of chemical required for each tankful.

With a handgun, a tankful may cover several acres with an herbicide; perhaps less with insecticides and fungicides.

Example: If a knapsack sprayer has a 4-gallon tank and is applying 16 gallons per acre, then a tankful will cover 0.25 acre. If an herbicide is recommended at 3 pounds per acre, then 0.75 pound should be added to each tankful of water.

Operation of Hand Sprayers

Although most hand sprayers are limited to small plantings, the handgun can supply a high application rate because the pump is powered and the spray mix is portable. Be sure, however, to practice with water while gaining application competence.

Hand sprayers place the operator near the nozzles and discharge point of the sprayer. Therefore, all operators should wear a hat, a long-sleeve shirt, and trousers, or a spray suit. Depending on the toxicity of the chemical, other protective wear such as a respirator, goggles, waterproof gloves, and waterproof boots might be required. The spray should be discharged when there is little or no wind, so drift is minimized and the chemical is not blown on the operator. Always follow the instructions on the pesticide label attached to the container.

Drift from a hand sprayer can be dangerous, especially when the spray mix is concentrated. The best solution is to spray only when winds are less than 5 mph, which is a very mild breeze. Operators should also use as low a pressure and as large a nozzle orifice as is practical to minimize the number of small droplets. Herbicides should be applied at 15 to 40 psi, depending on nozzle design. A drift control agent added to the spray mix might also help.

Thoroughly spraying the entire plant is necessary for satisfactory pest control. Amounts of spray material per plant for various fruits are listed in Table 2.3. Pesticide suggestions are based on the need for pest control under average conditions. Applying reduced amounts of pesticide is practical under relatively ideal conditions, which include using highly effective chemicals and efficient sprayers, as well as having a fruit planting with no special pest problems. Conditions can change rapidly, especially during periods of unusually moist weather. The fruit grower must be prepared to adjust the amount and frequency of pesticide applications to handle such situations in accordance with label limitations.

Pesticides have specific ranges of activity. In other words, a particular insecticide might kill one type of insect but not another type. Some insecticides have a very broad spectrum of activity, killing a wide variety of pests. Other insecticides have a narrow spectrum, killing only a few kinds of pests.

Knowledge of the properties of insecticides is just as important as knowledge of the biology of the pest. In addition, some insecticides might be harmful to the plant in some situations. An insecticide that successfully controls insects on apples might cause all of the leaves to fall off a raspberry plant. It pays to read the label on

Table 2.3. Pesticide application amounts.

Types of Fruit	Amounts
Apples (12 to 15 ft)	5 to 7 gal/plant
Peaches (7 to 9 ft)	3 to 4 gal/plant
Cherries, Tart	5 to 7 gal/plant
Cherries, Sweet	5 to 7 gal/plant
Plums	4 to 6 gal/plant
Blueberries	2.5 gal/436 sq ft
Brambles	2.5 gal/436 sq ft
Strawberries	varies depending on pesticide
Grapes	1 pt/plant
Currants	2.5 gal/436 sq ft
Gooseberries	2.5 gal/436 sq ft

the pesticide container and pay attention to the recommendations, cautions, and warnings in this guide to avoid disastrous results from the misuse of pesticides.

Days to Harvest Restrictions

Pesticide residues on plants degrade to harmless by-products over time. Toxicity varies among pesticide products, however, as does the amount of time necessary for degradation. The toxicity of pesticide residues has been tested and, in some cases, restrictions have been placed on the use of a product. The restrictions are usually labeled “Days to Harvest Intervals” (DHIs) or “Preharvest Interval” (PHI). The DHI or PHI is a period of time that must pass before fruit can be harvested after the application of a particular pesticide. If DHIs or PHIs have been established, they can be found on the pesticide label.

Pesticide Types

Several examples of pesticides available for backyard plantings are described below. Since various suppliers provide the same active ingredient under various trade names, the compounds below are listed using their common chemical name. Not all insects or diseases appear on all labels for all crops. Always consult the label before making pesticide applications. Labels vary greatly between commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides.

AZADIRACHTIN. This azadirachtin-based biological insecticide, repellent, antifeedant, and insect growth regulator is used mostly in soft, organic insect-control programs. It controls pests on contact and ingestion. Azadirachtin can be applied using standard spraying equipment up to the day of harvest. This pesticide is toxic to fish and aquatic invertebrates.

BACILLUS THURINGIENSIS (Bt—many products) is a selective microbial insecticide formulation using a byproduct of the naturally occurring bacterium *Bacillus thuringiensis* as its active ingredient. This bacterium is able to exist as a spore until temperature, moisture, and available nutrients are conducive to the reinitiation of the life cycle. Bt exhibits a unique insecticidal activity when eaten by susceptible larvae, specifically those of the insect order Lepidoptera (moths and butterflies).

Bt does not have any of the hazards sometimes associated with chemical insecticides. It has been shown to be incompatible, however, with mixtures with a high pH such as Bordeaux mixtures. In orchards, Bt should provide excellent control of variegated leafroller, tufted apple bud moth, red-banded leafroller, oblique-banded leafroller, green fruitworm, and most forest-orchard species (gypsy moth, tent caterpillar, webworm). If mixing Bt with other products, always add Bt first. Good mechanical agitation is important to quickly mix Bt.

BORDEAUX—See COPPER COMPOUNDS

Bt—See BACILLUS THURINGIENSIS

CAPTAN is a fungicide with protective and curative action. Many of the general purpose product mixes contain captan (see Table 2.4). Captan is effective against scab, black rot, white rot, bitter rot, Brooks spot, and blossom end rot on apples. It is effective against sooty blotch and flyspeck if the last spray application is not more than 30 to 40 days before harvest. It is not effective against the rusts, fire blight, or powdery mildew.

Where the early season apple scab control program fails and scab becomes established in the trees, captan at low rates cannot be expected to provide control. This fungicide is highly effective, however, in reducing spore germination. Use at least 4 to 5 T per 2.5 gal applied at intervals of no more than 10 to 14 days.

On stone fruits, captan is a good fungicide for the control of brown rot and scab when adequate spray schedules are followed. Captan plus wettable sulfur can be used on peaches when brown rot, scab, and mildew are present. Captan is effective against cherry leaf spot and brown rot on tart cherries if the diseases are at a low level and the spray intervals do not exceed 2 weeks.

Captan has caused a necrotic spotting, yellowing, and dropping of leaves when used under poor drying conditions or in combination with sulfur, especially on Delicious, Stayman, Baldwin, and King apple varieties. Foliage of d’Anjou pears has been stunted and cupped. Necrotic spots on fruit and foliage have occurred on both plums and prunes where captan was used from petal fall until the fruit begins to ripen. Its use usually

results in acceptable fruit finish on apples, peaches, and nectarines. Captan residues on peaches at harvest may cause increased skin discoloration from abrasions that occur during picking and packing. The leaves of some sweet cherry varieties may be injured by repeated captan applications. A full-season program of captan may require the use of miticides or close adherence to a pest management program. Captan is not registered on pears.

Captan has few spray incompatibilities, but it should not be used with oil, lime, or other alkaline materials. Using captan within a week either before or after an oil application may result in leaf injury on apple trees. Combinations with sulfur might result in increased injury under high temperatures and high relative humidity. The preharvest interval for captan is 0 days. Please remember to check the label for rates and application times for best disease control.

CARBARYL (Sevin) is a relatively safe, carbamate insecticide. It is highly toxic to bees and should not be used near bloom. When applied 2 to 3 weeks after bloom, carbaryl acts as a fruit thinner on many varieties. Mite populations usually build up rapidly following carbaryl applications because of its toxicity to mite predators. Thus, it is not recommended for most applications where mites are a threat.

CHLOROTHALONIL (Bravo). Chlorothalonil formulations are nonsystemic foliar fungicides with protective action registered for the control of brown rot blossom blight; leaf curl of stone fruits; scab on peaches, nectarines and apricots; and cherry leaf spot. There are many formulations of chlorothalonil available to the home gardener (see Table 2.4). Please remember to check the label for rates and application times for best disease control

COPPER COMPOUNDS are widely sold as fungicides for orchard and garden use. Copper is a foliar fungicide with protective action. These compounds can be highly phytotoxic to many fruit crops and must be used with extreme care. Check the label for type of copper and any cautions that accompany its use. Please remember to also check the label for rates and application times for best disease control. Many formulations of copper are available to the home gardener (see Table 2.4).

Copper was first used in the mid-1800s in grape vineyards in France to discourage theft of the grapes. Copper sulfate and lime were mixed in a slurry and spread over the grape vines. In 1882 a French scientist observed that this antitheft treatment was effective in reducing a disease called downy mildew. This observation was made near the town of Bordeaux, so the mixture of copper sulfate and lime became known as Bordeaux mixture.

Copper sulfate is readily soluble in water. This high degree of solubility is the fundamental cause of the toxicity problems, which copper sulfate can cause to all fruit crops. Fixed coppers have been developed that are relatively insoluble and therefore less toxic to plants; however, fixed coppers can also result in phytotoxicity under certain conditions. Fixed coppers include basic copper sulfate, basic copper chloride, copper oxides, and copper hydroxide.

The fungicidal activity of copper is based on its ability to destroy proteins in plants. This is true for all plants, fungi, and fruit plants. When lime is combined with copper compounds, it reacts with the copper, making it more stable. Thus, copper compounds in the presence of lime would generally produce lower, more uniform concentrations of free copper, which in turn would be less apt to injure plant tissues than if no lime were used. Because copper has the ability to kill all types of plant tissues, the use of copper fungicides carries with it the risk of causing injury to fruit plants. Ideally, copper on the leaf or fruit surface should be in high enough concentration to kill the fungus or bacteria but low enough not to cause injury to the plant. Factors that can promote injury include failure to use enough lime; cold, wet weather conditions that apparently increase copper's solubility, allowing more into the plant and resulting in toxicity; and application of excessive rates of copper. Even when no injury is evident on the plant, subtle effects of the copper on the plant may be occurring. In addition, to reduce growth and yields, it has been shown that the use of copper fungicides can reduce the maturity of the fruit as well as that of the shoots. Copper fungicides can have subtle, chronic negative impacts on fruit plants.

Copper will provide low to moderate control of many of the diseases. Bordeaux may be used on pears during bloom for fire blight control when temperatures are above 70°F and drying conditions are rapid. Fixed coppers, plus lime, are safer than Bordeaux. They may be used for leaf curl control on stone fruits and pre- and postharvest leaf spot control on tart cherries. These compounds are useful in plant nutrition since they supply copper to the plant. Strawberries are very sensitive to copper. Never apply copper to strawberries because severe phytotoxicity will result under almost any conditions.

Do not apply any of the copper compounds without adding lime. Lime should be used at a rate one to two times that of the copper. If a copper material is applied without lime and yellowing and leaf drop occur, an application of lime within 2 to 3 weeks of the copper application may prevent further yellowing and leaf drop. Again, check the label of the product you intend to use

to see if lime has already been added in the formulation or if it is advised to add lime and at what rates. Do not use copper in cool wet weather. Do not use immediately before or after using ferbam. Most insecticides are not compatible with lime.

ESFENVALERATE is a broad-spectrum pyrethroid insecticide with contact and stomach action. Esfenvalerate is very toxic to fish and other aquatic organisms. Esfenvalerate is also highly toxic to bees exposed to direct treatment and residues on plants. Use recommendations are generally limited to before bloom in Pennsylvania to conserve *Stethorus* and other predators of European red mite. Do not feed pomace to livestock.

FERBAM (Carbamate) is effective on apples for rust and scab control, on stone fruits for leaf curl, on cherries and plums for clear spots and black knot, and on pears for leaf and fruit spot control. Do not use with lime. Ferbam may produce unsightly residues on leaves and fruit. On Golden Delicious, Jonathan, and other varieties that russet easily, injury may result from using ferbam, especially if it is applied in the pink through mid-June. The best time to use it is in the prepink period or in later summer sprays after mid-June.

GARLIC (Guardian). A 10 percent formulation of garlic is registered on apples and a number of apple pests are on the label. However, during the 1995 studies conducted at the Cornell University, no efficacy was observed when the compound was applied to control fruit pests listed on the label.

GENERAL PURPOSE PRODUCTS vary depending upon the manufacturer. Generally, the products will contain both a fungicide and an insecticide mixed in appropriate ratios for general control of most diseases and insects (see Table 2.4).

GLYPHOSATE (Roundup) is registered for use on apples and pears up to 14 days before harvest and in stone fruit orchards up to 28 days before harvest. It is effective in controlling many emerged annual and perennial grasses and broadleaved weeds. Best results occur when it is applied as a 2 percent solution. It is labeled as a directed spray on apples and pears. In stone fruits it must be applied through a wick applicator. Glyphosate has no preemergence activity; therefore, it should be combined with a preemergent material for residual activity.

Caution: Avoid all contact with tree foliage. The chemical is not readily metabolized by plants, and accidental coverage could cause injury the following year. Glyphosate should not be stored or applied in galvanized steel or unlined steel (except stainless) containers

or tanks. It can react with these containers to produce highly combustible hydrogen gas mixtures.

GRANULOSIS VIRUS (Cyd-X, Carpovirusine). The naturally occurring codling moth granulovirus belongs to the subclass B of the baculoviridae. Infection with granulosis virus is an acute insect disease with a short, rapid course. Incubation is rapid and death occurs 4 to 6 days after ingestion of virus particles. However, as with other baculovirus infections, the length of the incubation periods is influenced by temperature. As the disease progresses the dorsum of the integument turns intense pink; larvae become swollen and flaccid; shortly before or soon after death the integument ruptures. The applied virus is not very persistent in the environment and frequent applications may be necessary to achieve effective control of codling moth.

IMIDACLOPRID is a systemic, synthetic insecticide with contact and stomach action. Its mode of action is similar to that of nicotine. Imidacloprid is used postbloom in apples for control of leafhoppers, leafminers, and aphids. For first-generation spotted tentiform leafminer, imidacloprid should be applied while the larvae are still in the sap-feeding stage, or within about 5 days after pollination is complete. For second and succeeding generations, apply 2 weeks after peak of pheromone trap catch for each generation. A second application may be required if severe pressure continues or if generations are overlapping. For white apple leafhopper, target nymphs of the first and, if necessary, the second generation. Imidacloprid is toxic to bees. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area.

KAOLIN CLAY—See SURROUND

LAST CALL CM—See MATING DISRUPTION

LAST CALL OFM—See MATING DISRUPTION

LIME SULFUR is good for prebloom powdery mildew control on apples and for leaf curl control on peaches and nectarines during the dormant season. High rates will also control scale insects on stone fruit trees. Several formulations are available. Lime sulfur is incompatible with most pesticide formulations and should be used alone (see Table 2.4).

MALATHION is the most widely used home-planting insecticide because of its broad range of activities and safety for mammals. It is effective, however, for only 2 to 3 days. It is effective against aphids and moderately effective against mites, leafhoppers, and scale crawlers. It is available in wettable powder and liquid forms. The

liquid form, however, may be injurious to the foliage of sensitive plants, such as raspberries. Phytotoxicity has been reported on McIntosh and Cortland apples, sweet cherries, European grapes, and Bosc pears.

MANCOZEB has a protective effect for controlling black rot, downy mildew, and phomopsis cane and leaf spot of grape (see Table 2.4).

MANEB has a protective effect for the control of black rot, downy mildew, and phomopsis cane and leaf spot of grape (see Table 2.4).

MYCLOBUTANIL (Nova) is a systemic fungicide with protective and curative action for many of the diseases of fruit.

METHOXYCHLOR is a chlorinated hydrocarbon insecticide with fairly long residual activity. It is relatively safe to use since it is not very toxic to mammals and is not known to be phytotoxic. It can be purchased separately but is commonly an ingredient in orchard general purpose mixes.

MATING DISRUPTION. Insect sex pheromone-based mating disruption is widely adapted by commercial fruit growers to prevent male and female moths from mating and therefore from producing viable eggs. Since mating disruption does not kill insects, it needs to be applied on large areas (minimum 5 acres) in order for it to be effective. For smaller growers, a different kind of mating-disruption technology called “attract and kill” is recommended. A formulation of insect sex pheromone and insecticide sold under the name of Last Call OFM or Last Call CM proved to be effective in controlling Oriental fruit moth or codling moth in small orchards. Multiple droplets of insecticide/pheromone solution need to be applied to the tree branches and trunk before the flight of each generation of Oriental fruit moth/codling to provide effective control. It is important to remember that mating-disruption technology, in contrast to most insecticides, is effective only against the target insect species and will not control other species of insects. In order to control both Oriental fruit moth and codling moth, separate applications of Last Call OFM and Last Call CM need to be applied.

PERMETHRIN is a nonsystemic, broad-spectrum synthetic pyrethroid insecticide with contact and stomach action, having a slight repellent effect. The compound is active against: leafrollers, plum curculio, plant bugs, rosy apple aphid, and leafhoppers. Permethrin is not recommended after bloom to prevent outbreaks of European red mite.

PYRETHRUM is a natural insecticide produced by several species of *Chrysanthemum* sp. and is the precursor of the synthetic pyrethroid insecticides. Pyrethrum is available as an emulsifiable concentrate, in combination with rotenone, or alone as a wettable powder. Pyrethrum is labeled against a large number of pests: grape leafhopper, potato leafhopper, leaf curl plum aphid, blueberry flea beetle, blueberry thrips, and blueberry sawfly. Pyrethrum is quickly broken down in the environment and may be used up to and including the day of harvest.

ROTENONE is derived from the root of various plants of the *Derris* or *Lonchocarpus* species from Southeast Asia and Central and South America. Rotenone is a broad spectrum botanical insecticide with expected activity against a broad range of pests: codling moth, plum curculio, European apple sawfly, apple maggot, pear psylla, European red mite and two-spotted spider mite, Japanese beetle, and tarnished plant bug. Rotenone is nontoxic to syrphid flies that feed on aphids, and to honeybees. Due to the fact that rotenone is rapidly degraded by sunlight it needs to be reapplied frequently (every week or less). Rotenone is also highly toxic to fish and birds.

ROUNDUP—See GLYPHOSATE

RYANIA is a botanical insecticide made from the ground stems of *Ryania speciosa*, a plant native to tropical America. Ryania is toxic to moth pests such as codling moth.

SAFER INSECTICIDAL SOAP is a “natural” pesticide for insect and mite control on fruit trees. This soap-like material, consisting of long-chain fatty acids, is thought to disrupt the cellular metabolism of insects and mites. It has been used to control a variety of insects on various crop and noncrop plants. Safer insecticidal soap is effective only in the liquid state as it contacts the insect or mite. Once dried, it is not toxic to the pest. In certain situations, this pesticide can be an effective alternative to traditionally used insecticides. Moreover, it is extremely safe for humans and other animals. There are no reentry restrictions, and sprays can be applied up to the day of harvest. There is a lingering concern, however, about fruit russetting associated with the product, especially in dilute applications. Moreover, it may be toxic to *Stethorus*, the black ladybird beetle used as a mite predator. Therefore, we currently recommend Safer insecticidal soap only for *nonbearing* apple and pear trees and other fruit crops.

On apples, Safer insecticidal soap has proven effective against motile stages of mites and white apple leafhoppers. Apply one part Safer insecticidal soap

concentrate and 50 parts soft water to foliage. Be aware that agitation in the spray tank can cause excessive foaming and require the use of defoamer (see label on Safer insecticidal soap container).

On pears, Safer insecticidal soap is effective against pear psylla and mites in postbloom applications at the same rate recommended for apples. However, it is not effective against many other pear pests during post-bloom. It can be mixed with a one-half rate of another insecticide to provide a broader range of effectiveness.

SEVIN—See CARBARYL

SPINOSAD ♦ is a member of the new Naturalyte class of insecticides labeled for apples in 1998. Spinosad is recommended for control of leafrollers and thrips on peaches, plums, cherries, nectarines, prunes, and apricots. The compounds also possess some activity against Oriental fruit moth and codling moth. It is formulated as a suspension concentrate. This product, with both contact and ingestion activity, provides about 7 to 8 days of residual activity on the tree. Natural enemy toxicity is low. Spinosad can be used to manage various lepidoptera pests and also has activity against apple maggot. Control of spotted tentiform leafminer is very good with one application per brood. Excellent control can be achieved for tufted apple bud moth and oblique-banded leafroller with two applications per generation. Spinosad under the trade name Entrust is registered for use by organic fruit growers.

STREPTOMYCIN is used for the control of fire blight on apples and pears. Bloom sprays are most effective when applied at night. See discussion of bloom sprays in apple and pear spray programs for amounts and timing.

SULFUR is very effective against powdery mildew of apples and cherries and scab on peaches and nectarines. Some varieties are easily injured by sulfur applications. Jonathan and Cortland are more tolerant than Stayman and Delicious. Rome Beauty is intermediate. Allow at least 7 days between oil and sulfur applications. Some of the newer sulfur formulations can be used in seasonal programs on apples without injury. Read the labels on these products for rates (see Table 2.4).

SUMMER HORTICULTURAL OILS are horticultural “superior oils” with a narrow 10 to 90 percent distillation range that permits relatively safe use on apple foliage during the summer months. In orchards under an effective prebloom mite-control program, a summer oil can effectively suppress mite and aphid populations when applied at petal fall timing and subsequently at 2 and 4 weeks after petal fall. Using oil at a concentrate rate

higher than 1 percent solution increases the likelihood of phytotoxicity and is therefore not recommended. Apple variety and spray drying conditions should be taken into account to minimize any possible effects on fruit finish. The slow drying conditions and extremes of cool or hot conditions should be avoided when applying horticultural mineral oils. Treatment with other materials is generally not recommended.

SUPERIOR OIL with a 60- or 70-second viscosity is recommended as a control measure for preventing San Jose scale, European red mite, and aphids. The 60- or 70-second oil is not a dormant-type oil. It is lighter and more volatile than the original superior oil used as a dormant spray. The main advantage of the lighter 60- or 70-second oil is the reduced possibility of plant injury. It is safer because it is more volatile, resulting in less persistence on the tree. It remains on the tree long enough to kill the pest, but not long enough to interfere with vital plant processes or oil-incompatible pesticides that may be applied later. Because of this safety factor, the 60- or 70-second oil can be applied up to the prepink stage of apple tree development. Oil applied during silver tip to ¼-inch green is not nearly as effective on mites as it is when applied between ½-inch green and full pink.

SURROUND ♦ (kaolin clay) is a novel, nontoxic material that forms a mechanical barrier film to protect fruit against insect and solar damage. Surround is registered for use on pears, apples, and stone fruit. Surround suppresses insects by creating a protective white particle barrier on plant surfaces, which repels and irritates insects. For best results, the material should be first used before expected insect appearance and reapplied every 7 to 14 days throughout the season. Uniform and consistent coverage is essential for effective insect suppression and control. Special washing may be required at harvest to remove residue from fruit.

2,4-D (various names) is a broadleaf contact herbicide that will not control grasses. It is particularly useful for controlling perennial weeds. It should not be applied to bare ground or under hot dry conditions. **DO NOT** use ester formulations of 2,4-D because they are extremely volatile and could vaporize and damage surrounding nontarget vegetation. Use with extreme caution if grapes or solanaceous vegetable crops are in the immediate vicinity. Not recommended if the area to be treated contains a domestic well field.

Table 2.4. Pesticides available for home garden use on various fruit crops (continued).

Active Ingredients Contained in Products	Examples of Products Containing Listed Ingredient	Company	Apples	Pears	Peaches	Nectarines	Plums	Apricots	Cherries	Grapes	Strawberries	Raspberries	Blackberries	Blueberries	Gooseberries	Currants	Elderberries	Hardy Kiwi
	Fungicide 3 Concentrate	Garden Safe	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Oil: Petroleum/Paraffinic ^b	Ultrafine Year-Round Pesticidal Oil <i>Note: Labeled on many crops, but as fungicide only on grapes</i>	Sun-spray (Sunoco)	Y	Y	Y				Y	Y	Y			Y				
	Horticultural Spray Oil	Dragon	Y	Y	Y	Y	Y	Y	Y	Y								
	Oil and Lime Sulphur Spray	Bonide	Y	Y	Y	Y	Y		Y	Y		Y			Y	Y		
Sulfur (Sulphur) ^b	Sulfur Plant Fungicide	Bonide	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y		Y	Y		
	Wettable or Dusting Garden Sulphur	Dragon Chem. Corp.	Y	Y	Y		Y		Y	Y								
	Dusting Wettable Sulfur	Hi-Yield	Y	Y	Y		Y		Y									
	Garden Fungicide for Flowers, Fruit, and Vegetables	Safer	Y	Y							Y	Y						
Bactericides																		
Streptomycetes sulfate ^b	Fire Blight Spray	Bonide	Y	Y														

a. This table includes examples of products available to home gardeners for use on various fruit crops in Pennsylvania. This list was current as of April 14, 2005. Other formulations exist with the same active ingredient as some of the products listed above that may or may not be labeled for the same uses. Always consult the label before making pesticide applications.

b. Certain formulations of these active ingredients exist that are suitable for organic production. They may be listed with the Organic Material Review Institute (OMRI), and their classification may be acceptable or restricted. For specific information, check the Web sites www.omri.org or www.paorganic.org.

c. Sour cherries only.

USING PESTICIDES SAFELY

General Guidelines for Pesticide Safety

Always Read the Label!

Only use pesticides when necessary. Before using any pesticide product, always read the label, as it is a legal document. The label provides information on which pests can be controlled, on which crops the pesticide product can be used, and the recommended rates and times of application. Any “off-label” use is a violation of both federal and state laws. Correct use of pesticides is essential to protect human, animal, and plant health as well as to protect the environment. Additionally, proper use will ensure chemical residues on crops and animals do not exceed legal limits (tolerances).

- Before using any pesticide, read the label.
- Become familiar with current federal and state pesticide laws and regulations.

- Follow all safety precautions on the label.
- Wear protective clothing and use protective equipment (both are referred to as PPE) according to instructions on the pesticide label.
- Minimum clothing requires long pants, long-sleeved shirt, socks, and shoes. In addition, one should ideally wear chemical-resistant gloves (nitrile, butyl, or neoprene) and unlined rubber boots.
- Be careful when handling pesticide materials to avoid spilling on skin or clothing.
- Never eat, drink, smoke, or use tobacco products while applying pesticides.
- When selecting pesticides, consider type of formulation and the application equipment required.
- Avoid drift to nontarget areas, which may endanger other plants or animals. Dusts drift more than sprays and airblast sprayers create more drift than boom sprayers.

- For record-keeping requirements, record the date, time, location, amount of each pesticide used, and any other required information as soon as possible.
- Bathe or shower in hot, soapy water after applying pesticides.
- Wash clothing worn while applying pesticides separate from other laundry, in hot, soapy water. Contaminated clothing must be handled with the same precautions as the pesticide itself.

Parts of the Pesticide Label

You should always read and understand the label before using any pesticide product. An EPA Registration Number (as indicated by the letter “A” in the figure below) indicates that the product has been registered and its label was approved by the Environmental Protection Agency (EPA). The active ingredient, the chemical(s) responsible for controlling the pest, is listed on the product label along with its concentration (indicated by the letter “B”). All pesticide labels have a signal word (indicated by the letter “C”) to indicate the relative acute toxicity of the product to humans and animals. If two products will

control the same pest, signal words can help you choose the least toxic chemical to control the pest. (Signal words will be discussed later in more detail.)

The directions for use section on the label (indicated by the letter “D”) tell you how to properly use a product to get the best results without harming yourself, others, and the environment. Remember, it is a violation of federal law to use any pesticide in a manner inconsistent with its labeling. Items included in this section include which pests the product is registered to control, where the product can be used (plants, animals, locations), how to apply the product, how much product to use, when the product should be applied, how often to apply the product, how soon the crop can be used or eaten after an application, and when people and animals can reenter a treated area after application.

Precautionary statements provide information about possible hazards of using the product. The Statement of Practical Treatment or First Aid (indicated by the letter “E”) describes what you should do if you are exposed or accidentally poisoned by a product. Also, emergency telephone numbers may be listed.

I. I. Icide, Inc.
Specimen Label for Educational Purposes Only.

Weed Eliminator

Concentrate

HERBICIDE Kills Lawn Weeds

(dandelion, clover, thistle, and other listed broadleaf weeds)

B Active Ingredients:

Mecoprop, dimethylamine salt	10.60%
2, 4-D, dimethylamine salt	3.05%
Dicamba, dimethylamine salt	1.30%
Inert Ingredients:	85.05%
TOTAL 100.00%	

C **KEEP OUT OF REACH OF CHILDREN**
CAUTION
See back label for additional precautionary statements.

A EPA Reg. No.: 123-114-16802
EPA Est. No.: 50263-PA-A
Net Contents 32 fl oz
(1 qt) 946ml

I. I. Icide, Inc.
123 Pesticide Safety Lane
Your Town, PA 19104
(215) 555-0000
www.icide.com

D **STOP! Read the entire label first.**
Observe all precaution and follow directions carefully.

Directions For Use
It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Weeds Controlled:
Black medic, broadleaf plantain, buckhorn, chicory, chickweed, curly dock, dandelion, knotweed, purslane, south thistle, speedwell, white clover.

Amount to Use:
1 fl oz (2 Tbs) per gallon of water for each 400 sq ft.
Spray evenly over 1,000 sq ft until sprayer is empty.

Measure:
To treat entire lawn (broadcast application): Use a tank or hose-end sprayer. Measure lawn. Calculate square feet by multiplying length times width.

To spot treat individual weeds in lawns:
Use a tank sprayer.

Mow:
Do not mow for 1 to 2 days before or after application.

Water:
If soil is dry, water 1 to 2 days before application. Rain or watering 6 hours after application will not wash away effectiveness.

Spray when:
Weeds are small and actively growing, temperature is below 90 degrees F, and air is calm to avoid spray drift onto landscape plants as contact with foliage may injure flowers, shrubs, trees, and other desirable plants.

Reapplication can be made in 2 to 3 weeks if necessary. Newly seeded lawn can be sprayed after first mowing. Bare spots can be planted with grass seed 1 week after application.

Important:
If an ornamental shrub or tree is in the lawn, keep spray off foliage and exposed roots.

Do not spray carpetgrass, dichondra, or desirable clovers. Do not use on or around fruits, vegetables, or flowers. The maximum number of broadcast applications per treatment site is 2 per year. Do not exceed specified dosages for any area.

Do not allow people (other than applicator) or pets on treatment area during application. Do not enter treatment area until spray has dried.

Storage and Disposal

Storage:
Store in original container in a locked storage area inaccessible to children or pets. Avoid temperature extremes.

Disposal:
Triple-rinse and puncture container. Then offer for recycling or dispose of in sanitary landfill, or by other procedures approved by local and state authorities. If burning is allowed, stay out of smoke.

Precautionary Statements

Hazards to Humans and Domestic Animals:

Caution:
Harmful if swallowed. Avoid contact with eyes, skin, and clothing. Wear face shield or goggles when mixing, loading, or applying this product. When using this product, wear long-sleeved shirt, long pants, socks, shoes, and rubber gloves.

Personal Hygiene:
After using this product, rinse gloves before removing. Remove clothing and launder separately before reuse. Promptly and thoroughly wash hands and exposed skin with soap and water.

Environmental Hazards:
Do not apply when weather conditions favor drift. This product is toxic to aquatic invertebrates. Drift or runoff may adversely affect aquatic invertebrates.

E **First Aid**
Always have the label available when seeking medical attention.
If in eyes: Immediately flush eyes with plenty of water. Get medical attention if irritation persists.
If on skin: Wash with plenty of soap and water. Get medical attention.
If swallowed: Call a Poison Center immediately. Do not induce vomiting.
Note to Physicians: Emergency information call 215-555-0000.

Pesticide Toxicity

For all pesticides to be effective against the pests they are intended to control, they must be biologically active, or toxic. Because pesticides are toxic, they are also potentially hazardous to humans and animals. Any pesticide can be poisonous or toxic if absorbed in excessive amounts. Pesticides can cause skin or eye damage (topical effects) and can also induce allergic responses. However, if used according to label directions and with the proper personal protective equipment (PPE), pesticides can be used safely. For this reason, people who use pesticides or regularly come in contact with them must understand the relative toxicity and the potential health effects of the products they use. The risk of exposure to pesticides can be illustrated with the following simple equation:

Hazard of Pesticide Use = Toxicity x Actual Exposure

Toxicity is a measure of the ability of a pesticide to cause injury, which is a property of the chemical itself. Pesticide toxicity is determined by exposing test animals to different dosages of the active ingredient. Tests are also done with each different formulation of the product (for example, liquids, dusts, and granulars). By understanding the difference in toxicity levels of pesticides, a user can minimize the potential hazard by selecting the pesticide with the lowest toxicity that will control the pest.

Applicators may have little or no control over the availability of low-toxicity products or the toxicity of specific formulated products. However, exposure can be significantly reduced or nearly eliminated by using PPE. For example, over 90 percent of all pesticide exposure comes from dermal exposure, primarily to the hands and forearms. By wearing a pair of chemical-resistant gloves, this exposure can be reduced at least 90 percent. Therefore, by wearing the correct PPE, the hazard of pesticide use can be reduced to an insignificant level for the applicator.

Acute Toxicity and Acute Effects

Acute toxicity of a pesticide refers to the chemical's ability to cause injury to a person or animal from a single exposure, generally of short duration. The four routes of exposure are dermal (skin), inhalation (lungs), oral (mouth), and eyes. Acute toxicity is determined by examining the dermal toxicity, inhalation toxicity, and oral toxicity of test animals. In addition, eye and skin irritation is also examined.

Acute toxicity is usually expressed as LD₅₀ (lethal dose 50) or LC₅₀ (lethal concentration 50). This is the

amount or concentration of a toxicant required to kill 50 percent of a test population of animals under a standard set of conditions. LD₅₀ values of pesticides are recorded in milligrams of pesticide per kilogram of body weight of the test animal (mg/kg) or in parts per million (ppm). LC₅₀ values of pesticides are recorded in milligrams of pesticide per volume of air or water (ppm). To put these units into perspective, 1 ppm is analogous to 1 inch in 16 miles or 1 minute in 2 years.

The LD₅₀ and LC₅₀ values are found in the product's Material Safety Data Sheet (MSDS), which is available from the supplier or product manufacturer where pesticide products are purchased. Most are also available from various online sources including the manufacturer's Web site or through various search engines as listed on our Web site at <http://www.pested.psu.edu/resources/web/labels.shtml>. For many reasons, especially in an emergency situation, maintaining a file with copies of the label and MSDS for each pesticide product used is highly recommended.

The LD₅₀ and LC₅₀ values are useful in comparing the toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD₅₀ value of a pesticide, the less it takes to kill 50 percent of the test population, and, therefore, the greater the acute toxicity of the chemical. Pesticides with high LD₅₀ values are considered the least acutely toxic to humans when used according to the directions on the product label.

Signal Words

Acute toxicities are the basis for assigning pesticides to a toxicity category and selecting the appropriate signal word for the product label. Pesticides that are classified as "highly toxic" on the basis of either oral, dermal, or inhalation toxicity must have the signal words DANGER and POISON (in red letters) and a graphic of a skull and crossbones prominently displayed on the package label. PELIGRO, the Spanish word for danger, must also appear on the label of highly toxic chemicals. Acute oral LD₅₀ values for pesticide products in this group range from a trace amount to 50 mg/kg. An exposure of a few drops of a highly toxic material taken orally could be fatal to a 150-pound person.

Some pesticide products are labeled with the signal word DANGER without the skull and crossbones symbol. A DANGER signal word does not provide information about the LD₅₀ value of the chemical. Instead, this signal word alerts the user of potentially more severe skin or eye effects from the product (caused by its irritant or corrosive properties).

Pesticide products considered “moderately toxic” must have the signal words WARNING and AVISO (Spanish) displayed on the label. Acute oral LD₅₀ values range from 50 to 500 mg/kg. An exposure of 1 teaspoon to 1 ounce could be fatal to a 150-pound person.

Pesticide products classified as either “slightly toxic or relatively nontoxic” are required to have the signal word CAUTION on the pesticide label. Acute oral LD₅₀ values are greater than 500 mg/kg.

Chronic Toxicity and Chronic Effects

Any harmful effects that occur from repeated small doses over a period of time are called chronic effects. The chronic toxicity of a pesticide is determined by observing symptoms of test animals, which result from long-term exposure to the active ingredient.

Some of the suspected chronic effects from exposure to certain pesticides include birth defects (teratogenesis); fetal toxicity (fetotoxic effects); production of tumors (oncogenesis), either benign (noncancerous) or malignant (cancerous/carcinogenesis); genetic changes (mutagenesis); blood disorders (hemotoxic effects); nerve disorders (neurotoxic effects); and reproductive effects. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than is acute toxicity. The product’s MSDS also contains information regarding chronic symptoms of pesticide exposure.

Symptoms of Pesticide Poisoning

The symptoms of pesticide poisoning can range from a mild skin irritation to coma or even death. Different classes or families of chemicals cause different types of symptoms. Individuals also vary in their sensitivity to different levels of these chemicals. Some people may show no reaction to an exposure that may cause severe illness in others. Because of potential health concerns, pesticide users and handlers must recognize the common signs and symptoms of pesticide poisoning.

The effects, or symptoms, of pesticide poisoning can be broadly defined as either topical or systemic. Topical effects generally develop at the site of pesticide contact and are a result of either the pesticide’s irritant properties (either the active and/or inert ingredient) or an allergic response by the victim.

Dermatitis, or inflammation of the skin, is accepted as the most commonly reported topical effect associated with pesticide exposure. Symptoms of dermatitis range from reddening of the skin to rashes and/or blisters. Some individuals exhibit allergic reactions when using

pesticides or when these materials are applied in or around their homes or places of work. Symptoms of allergic reactions range from reddening and itching of the skin and eyes to respiratory discomfort often resembling an asthmatic condition.

Systemic effects are quite different from topical effects. They often occur away from the original point of contact as a result of the pesticide being absorbed into and distributed throughout the body. Systemic effects often include nausea, vomiting, fatigue, headache, and intestinal disorders.

Seeking prompt medical attention is important; however the development of certain symptoms is not always the result of exposure to a pesticide. Common illnesses such as the flu, heat exhaustion or heat stroke, pneumonia, asthma, respiratory and intestinal infections, and even a hangover can cause symptoms similar to pesticide exposure. Carefully consider all possible causes of your symptoms.

Responding to Pesticide Poisoning Symptoms

Be alert for the early symptoms of pesticide poisoning. Responding immediately and appropriately when pesticide exposure is suspected will help minimize the effects of exposure and, in extreme cases, may save a life. If you are having symptoms but are unsure if they are pesticide related, at least notify someone in case your symptoms become worse. At this time, call the **National Poison Center at 1-800-222-1222** for guidance on the proper response to your symptoms. This number will direct your call to the nearest poison center, which is staffed on a 24-hour basis.

If safe to do so, take the pesticide container to the telephone. (However, if the pesticide container is contaminated, write down the product name and percentage of active ingredients to take to the phone.) The product label provides medical personnel information such as active ingredients, an antidote, and an emergency contact number for the manufacturer of the product. If you must go to the hospital or doctor’s office, take the entire container, including the label, with you. In order to avoid inhaling fumes or spilling the contents, make sure the container is tightly sealed and never put it in the enclosed passenger section of a vehicle.

If the MSDS is available, also take it with you because it frequently contains additional information for medical personnel. In addition to posting emergency numbers or having them readily available by a telephone, keep these numbers in all service vehicles

involved in transporting pesticides. Additional pesticide information can also be obtained by contacting the National Pesticide Information Center (NPIC) located at Oregon State University at 1-800-858-7378. The NPIC provides a variety of unbiased information about pesticides to anyone in the United States. (Medical professionals and government agencies can call NPIC at 1-800-858-7377.)

First Aid for Pesticide Poisoning

Reviewed by J. Ward Donavon, medical director of PinnacleHealth Toxicology Center, Harrisburg Hospital

Immediate and appropriate action, such as providing first aid, may be necessary to prevent serious injury to a victim of pesticide poisoning. The situation can be a life-or-death matter. The product label should be one of the first sources of information in a pesticide exposure emergency, in addition to calling the National Poison Center (1-800-222-1222) and 911. First aid is only the “first response” and is not a substitute for professional medical help.

General First Aid Instructions

- Most important, be sure to protect yourself by wearing appropriate protective clothing and equipment if there is a likelihood of being directly exposed to a pesticide while administering first aid or removing the victim from an enclosed area.
- Have current labels and Material Safety Data Sheets (MSDS) available.
- Have emergency response telephone numbers readily available.
- Assemble a first aid kit with necessary supplies.
- Always have a source of clean water available. In an extreme emergency, even water from a farm pond, clean water irrigation system, or watering trough could be used to dilute the pesticide.
- If oral or dermal exposure has occurred, the first objective is usually to dilute the pesticide and prevent absorption.
- If inhalation exposure occurs, first protect yourself, and then get the victim to fresh air immediately.
- Never give anything orally to an unconscious person.
- Become familiar with the proper techniques of artificial respiration; it may be necessary if a person’s breathing has stopped or become impaired.

Specific First Aid Instructions

If the victim is NOT breathing:

First—Evaluate the surroundings of the victim. Protect yourself from pesticide exposure prior to and while giving assistance.

Second—Administer artificial respiration and call 911.

Third—Call the National Poison Center (1-800-222-1222).

Fourth—Decontaminate the victim immediately; wash thoroughly and quickly. Speed is essential.

If the victim IS breathing:

First—Evaluate the surroundings of the victim. Protect yourself from pesticide exposure prior to and while giving assistance.

Second—Decontaminate the victim immediately; wash thoroughly and quickly. Speed is essential.

Third—Call 911 if the victim has ill effects from the exposure.

Fourth—Call the National Poison Center (1-800-222-1222).

If the pesticide has been spilled on the skin or clothing, remove any contaminated clothing immediately and thoroughly wash the skin with soap and water. Avoid harsh scrubbing since it enhances pesticide absorption. Rinse the affected area with water, wash again, and rinse. Gently dry the affected area and wrap it in a loose cloth or blanket, if necessary. If chemical burns of the skin have occurred, cover the area loosely with a clean, soft cloth. Avoid the use of ointments, greases, powders, and other medications unless instructed by medical personnel.

Heavily contaminated clothing should be disposed of properly. If clothing is not heavily soiled, wash all contaminated clothing separately from any other laundry in hot water, at a high water level, and with a heavy duty liquid detergent. Run the washer through a complete cycle with detergent and no clothes to remove pesticide residue before another wash. Store washed protective clothing separately from other clothes. (Also, do not store protective clothing and equipment in pesticide storage areas.)

If the pesticide has entered into the eyes, hold the eyelid open and immediately begin gently washing the eye with clean running water. Do not use chemicals or drugs in the eye wash water. Continue washing for 15 minutes. If only one eye is involved, avoid contaminating the other one. Flush under the eyelids with water to remove debris. Cover the eye with a clean piece of cloth and seek medical attention immediately. If contact lenses are worn, remove and discard the contacts, then wash the eyes as described above.

If the pesticide has been inhaled, get the victim to fresh air immediately. However, do not attempt to rescue someone who is in an enclosed area unless you are wearing appropriate protective equipment. Have the victim lie down and loosen their clothing. Keep the victim warm and quiet. If the victim is convulsing, watch their breathing and protect their head. Keep the chin up to keep air passages free for breathing. If breathing stops, administer artificial respiration and call 911. Call the National Poison Center (1-800-222-1222) after the victim is stabilized for further advice.

If the pesticide has been swallowed, contact the National Poison Center (1-800-222-1222) and provide them with the name and approximate amount of material that was ingested. Call 911 immediately if the victim has symptoms from the exposure. If the pesticide has entered the mouth but has not been swallowed, rinse the mouth with large amounts of water.

Inducing vomiting is rarely advised for any poisoning, including pesticide poisonings.

If a petroleum product (kerosene, gasoline, oil, lighter fluid, EC pesticides) has been swallowed, call the National Poison Center (1-800-222-1222) and 911 immediately for further instruction.

If a corrosive poison (a strong acid or alkali) has been swallowed, dilute with water or milk immediately. Consult the National Poison Center (1-800-222-1222) and 911 immediately. The victim may experience severe pain and have extensive mouth and throat burns. Fortunately, most commonly used pesticides are not corrosive, but some household disinfectants and germicides fall into this category.

Safe Storage of Pesticides

- Read the label for specific storage instructions and precautions.
- Store pesticides in a clean, cool, dry, and well-ventilated building. Always lock the area to prevent entry by children and untrained persons. Mark the storage facility with an appropriate warning sign.
- Maintain proper temperature control. For example, if emulsion-type materials freeze, the emulsion may be destroyed, resulting in loss of effectiveness and possible serious plant injury.
- To avoid the danger of cross-contamination, do not store herbicides with other pesticides.
- Keep dry materials above liquid materials.

- Do not store pesticides where food, water, feed, seeds, fertilizers, or personal protective clothing and equipment (such as respirators) can become contaminated.
- Store pesticides in their original containers. Never store pesticides in any food or drink containers.
- Do not remove the labels.
- Keep lids tightly closed.
- Check containers frequently for leaks.
- Clean up spilled chemicals promptly and properly. Dispose of broken or damaged containers and any pesticide waste in an approved and safe manner as directed on the product label.
- Keep an inventory of all chemicals. Mark each container with the year of purchase.
- Inform your local fire department of any chemicals (including fertilizers) stored in large quantity.

Safe Disposal of Pesticides

- Read the pesticide label for specific disposal instructions.
- Avoid disposal problems by purchasing only the amount of material needed for one growing season. Do not stockpile.
- Use proper personal protective clothing and equipment when you dispose of pesticide wastes and containers.
- Mix only the amount of pesticide required for a particular application. If you mix too much, use the surplus by applying the material at the recommended rate to one of the crops listed on the label.
- Do not dump pesticides or pesticide rinsates on the ground or pour them down sinks, toilets, or other drains, including storm sewers.
- Pressure rinse or triple rinse empty pesticide containers with water and pour the rinse water into the spray tank. Drain the containers for 30 seconds each time.
- After rinsing metal, plastic, or glass containers, puncture, break, crush, or in some way render unusable. Recycle plastic containers through the Plastic Pesticide Container Recycling Program sponsored by the Pennsylvania Department of Agriculture (PDA). Contact your regional PDA office for further information. Disposal in a sanitary landfill is desirable if conducted in accordance with local regulations.

- If stated on the label and permitted by local ordinances, combustible containers can be burned. However, do not burn pesticide containers near residential areas or where the smoke can contact humans. Avoid exposure to the smoke; it may contain toxic vapors. Bury the ashes, since they also may be toxic.
- Send large metal drums to a reconditioning company.
- Before disposing of pesticide concentrates, check with PDA's CHEMSWEEP Program, which provides disposal options for unwanted and outdated pesticide concentrates free of charge.
- Do not reuse empty pesticide containers for any purpose.
- Clean up thoroughly after handling and disposing of pesticides.

Current Status of Restricted-Use Pesticides In Pennsylvania

Under the authority of the amended Pennsylvania Pesticide Control Act of 1973 and the amended Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), applicators who apply restricted-use pesticides (RUP) in the production of an agricultural crop must be certified as a private applicator or must work under the direct supervision of a certified applicator. Furthermore, only certified applicators can purchase restricted-use pesticides. The pesticide dealer is required by law to record the name, address, and certification number of the purchaser of RUPs, as well as the identity of the product, amount sold, and date of purchase. Commercial and public pesticide applicators must be certified to use both general and restricted use pesticide products.

The official list of Pennsylvania's RUPs includes all pesticide products designated as restricted-use by the U.S. Environmental Protection Agency, and, in the interest of the public health and welfare of the citizens of the Commonwealth, any other product designated for restricted-use by the Secretary of Agriculture, Commonwealth of Pennsylvania. If a pesticide is restricted use, it will be clearly marked on the label.

Poison Control Centers

1-800-222-1222

Calling the toll-free National Poison Center hotline will connect you to the nearest poison center. Pennsylvania residents are served by the Pittsburgh Poison Center and the Poison Control Center in Philadelphia.

Controlling Wildlife Damage in the Home Fruit Garden

To the passing robin or deer, your fruit garden appears to be a grocery store. In most cases, growers can tolerate a little damage from wildlife, but sometimes losses can become excessive if measures are not taken to control wildlife damage. In general, fruit-eating birds such as robins and starlings and browsing mammals such as deer, voles, and rabbits are the most common wildlife problems in the home fruit garden.

Effective management begins by anticipating the extent of damage and responding with the appropriate control. Before deciding on a control method, if any, you should consider the cost and benefits of the control program. Economic costs are not the only costs that should be taken into consideration. Time constraints and the impacts of the control methods on other nontarget wildlife should be considered. In many instances, an integrated pest management (IPM) plan is the best approach.

BIRDS

On many farms or orchards, bird damage is minimal and growers choose to ignore the problem or just take the loss from birds into account as a management cost. For others, problems from birds can be substantial, resulting in the consumption of or damage to large portions of the fruit crop.

The type and amount of damage caused, effective control methods, and legal protection vary among bird species. As a result, it is very important for a grower to be able to identify the birds causing damage. A number of field guides for identifying birds are available at bookstores or libraries. Listed below are the species that most often cause damage to fruit, along with a brief description of each bird and the type of damage it causes.

Species of Birds

Crows

The American crow, *Corvus brachyrhynchos*, is a problem primarily for apples. It pecks deep triangular holes in the apples, often destroying the fruit or leaving it susceptible to disease.

Grackle

The common grackle, *Quiscalus quisula*, has a black body, an iridescent head, and a keel-shaped tail. Grackles consume small fruit such as blueberries whole. They often slash large fruit such as cherries and apples and leave it damaged.

House Finch

The house finch, *Carpodacus mexicanus*, is a relative newcomer to the eastern United States—its historic range is in the western part of the country. In the 1940s, it was released on Long Island, New York, and has been spreading in numbers and distribution since that time. The house finch has brown streaks and looks like a sparrow. The male has patches of orange or red under its chin and on its sides.

The house finch starts at the top of a blueberry bush and pecks berries in rapid succession. Many are left damaged. It also pecks grapes open and feeds on the juice and pulp within. It leaves small irregular nicks on apples, which often make the fruit susceptible to disease. The house finch causes extensive damage to fruit in the western United States. In the eastern United States, it is not a major problem but might become one in the future.

House Sparrows

The house sparrow, *Passer domesticus*, is also an exotic species introduced from Europe. The male can be recognized by his black bib and white cheeks. The female is drab brown. House sparrows damage grapes, cherries, and other small fruit, generally by pecking holes. The house sparrow is not protected by law.

Robin

The American robin, *Turdus migratorius*, is a common and well-known bird. It is probably the species most frequently reported as consuming small fruits and cherries. Robins consume whole cherries, grapes, blueberries, and other small fruit and frequently cause substantial damage.

Starling

The European starling, *Sturnus vulgaris*, is an exotic (nonnative) species introduced into North America from Europe. It has a black-speckled appearance, short tail, and wings that appear triangular when the bird is in flight. Starlings are not protected by law. They can cause extensive damage to fruit because they often descend on orchards in huge flocks. Starlings eat small fruit such as grapes whole, and slash large fruit such as cherries. They peck holes in apples, consume the inside of the fruit, and leave the apple hollowed out.

Others

A number of other species might cause problems, depending on the time of year and the habitat surrounding the orchard or garden. Species include the cedar wax-wing (*Bombycilla cedrorum*), gray catbird (*Dumetella carolinensis*), northern mockingbird (*Mimus polyglottos*), and Baltimore oriole (*Icterus galbula*).

Damage

Damage to fruit does not occur randomly. By being familiar with patterns of damage, a grower may be able to reduce damage or the cost of control by concentrating control methods in particular areas and at times of the season when damage is most severe.

Although all farms and orchards are susceptible to damage, it usually is greatest on farms in close proximity to town environments where birds such as robins and starlings are abundant. Damage is generally higher in orchards isolated from other orchards. In large areas of orchards, so much fruit is available that the amount of damage on any one site is fairly low. The size of the orchard also influences the amount of damage. As a pattern, small orchards generally experience a greater degree of damage than large orchards because they have fewer trees. Thus, damage can be an important problem for those who produce fruit on a small scale.

The time at which the fruit matures appears to influence the amount of damage. For apples, bird damage is highest on early maturing varieties. Late varieties that experience damage are primarily ones that turn red early in the season. These patterns suggest that birds are

responding to the color change in apples. Bird damage to cherries and grapes is also greatest to early ripening varieties. Early ripening fruit might be damaged more frequently because it matures at a time when other fruits are not available.

Legal Status

Federal law protects all species of birds except starlings, house sparrows, and pigeons. All other species are protected and cannot be trapped or shot without a permit. The only exceptions to this rule are blackbirds, cowbirds, crows, and grackles, which may be killed without a permit when they are observed committing or about to commit damage. When controlling birds through lethal methods, use extreme care in identifying the species causing damage.

Damage Control

The type of control you choose will depend on a number of factors. Use your knowledge of damage patterns and species behavior to decide when and where to use control methods and the types of control methods to use. A listing of product suppliers can be found in Appendix D.

Netting

For many types of fruit, netting is the most effective way to reduce bird damage. Cover, cage, or surround trees, vines, and bushes with nylon or plastic mesh, closely woven wire, or cheesecloth before the fruit begins to ripen and throughout the harvest period.

In most cases, netting is placed directly over the plants or bushes, but for some fruits such as high-bush blueberry, a framework is built and the netting is suspended over the frame. The major disadvantages of netting include the high initial cost, the time necessary to apply it, and the inconvenience of working around it. Although netting is expensive, it can be reused for a number of years if it is removed carefully and stored over winter. When deciding whether to use netting, growers should consider the costs of purchasing and installing it relative to the losses from bird damage. Although netting is the most effective means of bird control for small fruits and isolated trees, other methods are available.

Scare Tactics and Noise Devices

Many growers use visual scare devices and noisemakers to frighten birds away from fruit crops. Visual scare devices include streamers, spinners, aluminum pie tins, plastic owl and snake models, and scare-eyes (large balloons with eyes painted on them). They are most

effective when used in conjunction with sound devices. Because birds learn quickly that visual scare devices are harmless, they should be used only during short damage periods and should be changed regularly. Varying locations, colors, and types of scare devices enhances their effectiveness.

A number of noise devices are available. Cannons, exploders, sirens, and other noisemakers work best when the sound is presented at irregular intervals and the sound source is moved frequently. Taped distress calls are more effective, but the calls are usually species specific, so a grower must obtain a tape of the distress calls of the type of bird causing the damage. A problem with both visual and scare tactics is that birds become accustomed to them over time.

Chemical Repellents

One chemical repellent, methyl anthranilate (MA), currently is registered for use on small fruits in Pennsylvania. In the past, the repellent methiocarb (Mesurol) was registered for use on cherries and blueberries; however, this product is no longer registered in Pennsylvania.

Methyl anthranilate is a colorless to pale-yellow liquid with a grape-like odor. It has been used as a food and drug flavoring for humans for years. In preliminary tests, fruit treated with MA were consumed significantly less than untreated fruit. In addition, human consumers could not detect a difference in taste between fruit that had been treated earlier in the season and fruit that had not been treated. MA should not be applied to blueberry plants, however, because it has been known to cause foliar burns in field studies and has not been cost effective. Methyl anthranilate is currently registered for use on fruits and turf.

Summary

For best results in reducing bird damage, growers should use a variety of simultaneous techniques and start the control program before birds have established a habit of feeding on the fruit. Control is much more difficult after feeding patterns have become established. Growers also should keep records of attempted control methods and their success rates. The methods listed above are only suggestions.

MAMMALS

Various mammal species can cause damage to fruit trees and shrubs. Rabbits and rodents such as mice and voles will damage the twigs, bark, and roots of plants if given the opportunity. Deer will browse on foliage and twigs and can damage the bark.

Voles

Voles are small rodents with short legs, stocky bodies, small eyes and ears, and short tails. Two species, the meadow vole (*Microtus pennsylvanicus*) and the pine vole (*Microtus pinetorum*), might damage fruit trees and become serious pests in orchards. The meadow vole is approximately 5.5 to 7.5 inches long. It has brown fur mixed with black, and its tail is approximately twice the length of its hind foot. The meadow vole is also called the meadow mouse. The pine vole is Pennsylvania's smallest vole. It is 4 to 5 inches long and has chestnut or auburn fur and a short tail approximately as long as the hind foot.

Voles are vegetarians, feeding on grasses, tubers, and seeds. They also consume the bark of young trees. Unlike many other small mammals, voles do not hibernate. Instead, they are active throughout the year, both day and night, with peak activity at dawn and dusk.

Meadow voles create surface runways in the grass; in winter, they are active in these runways beneath the snow. Pine voles build underground tunnels in loose, crumbly soil. As they build the tunnels, they push out dirt, producing small conical piles of soil on the ground surface. Both types of voles build large globular nests of dry grasses and leaves. The nests are located close to tree trunks, in tussocks of grass, and at the end of burrows.

Voles are extremely prolific. Their peak breeding activity occurs between March and October, but when winters are mild, voles may breed all year long. A female meadow vole could potentially produce over 70 young in a year, and the young voles become sexually mature at the age of 1 month. As a result, under ideal conditions vole populations can reach densities as high as 270 voles per acre. Scientists have found that voles exhibit regular population fluctuations at approximately 4-year intervals. Populations apparently crash to levels as low as 10 voles per acre after peak years and then begin to build up again. Voles can cause extensive damage to orchards, particularly during peak population years.

Damage

Voles can cause extensive damage to fruit trees and orchards by girdling seedlings and trees and damaging roots. Damage occurs primarily during winter when other types of food are scarce. The most common form of tree injury caused by meadow voles is trunk girdling at or near the ground surface. Since voles burrow in the snow, they might damage tree trunks as high as the accumulated snow. Young trees are especially susceptible to attack. Occasionally, meadow voles will burrow in

the soil and damage roots, resulting in weak, unhealthy trees.

Damage from pine voles is harder to detect because it occurs underground as voles consume small roots, girdle large roots, and eat bark from the base of trees. By the time growers note weak, unhealthy trees, the damage already is extensive.

Signs of Voles

The most easily identified sign of meadow vole presence is a system of surface runways in the grass. Meadow voles create these runways by their feeding activities and keep them free of vegetation. The runways are generally about 1.5 inches wide. Bits of freshly cut vegetation and accumulations of vole droppings (brown or green in color and shaped like rice grains) in the runway are positive evidence they are being used. Vegetation, small roots, or mold in the runways indicate that the voles are no longer using them. Pine voles do not use surface runways, so their presence is much harder to detect. In apple orchards, tiny, elongated tooth marks on apples on the ground are signs of both meadow voles and pine voles.

Legal Status

Voles are classified as nongame mammals and can be controlled when causing damage.

Damage Control

NATURAL CONTROLS. Hawks, owls, snakes, weasels, raccoons, foxes, opossums, and house cats all feed on voles. These predators are beneficial in orchards because they help keep vole populations under control. Whenever possible, growers should encourage these predators, or at least not harass or kill them.

When natural controls are inadequate, artificial methods must be used to control vole populations. The fall is the best time for initiating control programs. A number of different control methods are listed below. The greatest success is usually achieved by using a variety of techniques at once.

HABITAT MODIFICATION. In orchards, the major food sources for voles are normally not the fruit trees, but roots and stems of grasses and other groundcover. As a result, habitat modification (e.g., reducing or eliminating grasses and cover) is one of the best long-term methods of controlling voles. Repeated mowings that maintain groundcover at a height of 3 to 6 inches serve to limit both food and cover and expose voles to predators. Where possible, mow both between trees in a row as well as along tree rows. Delays between mowings result

in excessive vegetation, which, when cut (especially with a sickle-bar mower) forms a thatch layer that protects voles. A flail or rotary mower is preferred to reduce thatch.

Establishing vegetation-free zones that extend at least 2 feet from tree trunks will discourage voles from living near the bases of trees, where they cause the most damage. Vegetation-free zones can be established by mowing, applying herbicides, cultivating, or placing a layer of crushed stone or gravel 1 to 2 inches deep extending 15 to 18 inches from the trunk. Do not allow mulch, prunings, or decaying vegetation to accumulate around the bases of trees or in tree rows.

EXCLUSION. Hardware cloth barriers can be used to keep voles from girdling small trees. Wrap a strip of 0.25-inch or smaller mesh hardware cloth around the base of each small tree. The hardware cloth should be set 4 to 6 inches into the ground and be approximately 18 to 24 inches high. Use higher guards where snow might be deep. Tree guards should be large enough to allow for 5 years of growth. This method is very effective but extremely labor intensive and expensive when a large number of trees need protection.

REPELLANTS. Several repellants are registered for voles. The primary active ingredient in these products is capsaicin (the “hot” in hot peppers). It is not clear how effective these products are at deterring voles. If you need to protect a large number of plants, repellants could become too expensive. As with most repellants, they should be applied before damage is significant, and always follow label directions.

TRAPPING. Trapping is not an efficient way of controlling voles in large orchards, but it is an effective and safe control method in small orchards or around selected trees. Use standard wooden-base snap traps (mouse size) and bait them with peanut butter, oatmeal, or apple slices. For meadow voles, place the traps in runways, flush with the ground and perpendicular to the runway. Place the trigger end directly in the runway. For pine voles, locate a tunnel and place the trap within the tunnel and perpendicular to it.

SUMMARY. Keep the grass mowed as if it were your front lawn. This is an excellent way to control rodents. Rodents require lots of cover to keep their natural predators—hawks and cats—from finding them. If the cover is removed, voles won’t stay in the area. Use snap traps to help maintain populations at low levels.

Cottontail Rabbits

Cottontails are active year round and can be seen at dawn and dusk. They tend to concentrate in favorable habitat such as brushy fence rows or field edges, brush piles, or landscaped backyards where food and cover are suitable. They need cover such as burrows or brush piles to escape predators. Cottontails are rarely found in thick shrubbery or dense forests; they generally spend their entire lives in a 10-acre or smaller area. Lack of food or cover usually is the motivation for a rabbit to relocate. Population density varies with habitat quality, but an average of three to five rabbits per acre is reasonable.

Description of Damage

Rabbits can feed on plants in your orchard year-round. Rabbits damage woody plants by gnawing bark or clipping off branches, stems, and buds. In winter, when the ground is covered with snow for long periods, rabbits can severely damage trees and shrubs. Some young plants are clipped off at snow height, and larger trees and shrubs can be completely girdled.

In addition, the character of the bark on woody plants influences rabbit browsing. Most young trees have smooth, thin bark with green food material just beneath it. Such bark provides an easy food source for rabbits. The thick, rough bark of older trees often discourages gnawing. Even on the same plant, rabbits avoid the rough bark but girdle the young sprouts that have smooth bark.

Damage Identification

Rabbit damage can be identified by the characteristic appearance of gnawing on older woody growth and the clean-cut, angled clipping of young stems. Damage occurs primarily within 2.5 feet of the ground. The clipping of small twigs and buds appears as a knifelike slanting cut with no apparent tooth marks. When rabbits gnaw bark, they gnaw in patches. The average width of a cottontail's incisor is 0.1 inch and the average width of the tooth mark is 0.08 inch. Squirrels and voles also gnaw bark, but their tooth marks are much narrower. Distinctive round droppings or rabbit tracks in the immediate area also are good signs of their presence.

Legal Status

In Pennsylvania, rabbits are classified as game animals and are protected as such. The Pennsylvania Game Commission grants exceptions to property owners, allowing them to trap or shoot rabbits outside the normal hunting season on their own property if damage is occurring.

Damage Control

Many methods can be used to control damage by cottontail rabbits. Exclusion techniques, such as fences and tree wraps, are among the most effective ways to control damage. Such techniques are the only methods to control damage in areas where rabbit populations are high. In areas with moderate damage, repellents have been used to successfully reduce damage. Because of the cottontail's high reproductive potential, trapping and other lethal techniques are not effective over long time periods.

EXCLUSION. One of the best ways to protect a berry patch is to put up a fence. A fence of 2- to 4-foot chicken wire, with the bottom tight to the ground or buried a few inches, is sufficient to prevent young rabbits from getting through. The lower 1.5 to 2 feet should be covered with small mesh wire. A fence might seem costly, but with proper care it will last many years and reduce damage caused by rabbits and other animals.

Cylinders of 0.25-inch wire hardware cloth will protect young orchard trees. The cylinders should be placed 1 to 2 inches out from the tree trunk and should extend higher than a rabbit's reach when it stands on the expected snow depth. Rabbits commonly damage vegetation at a height of 2 to 3 feet, depending upon the snow depth in winter. You can use larger mesh sizes, 0.5 to 0.75 inch, to reduce cost, but be sure the cylinder stands far enough away from the tree trunk that rabbits cannot eat through the holes. Commercial tree guards or tree wrap are another alternative. When rabbits are abundant and food is in short supply, only hardware cloth will guarantee protection. Small-mesh (0.25-inch) hardware cloth also protects against vole damage.

REPELLENTS. Several chemical repellents discourage rabbit browsing. For best results, use repellents and other damage-control methods at the first sign of damage. Always follow the application directions exactly. Since pesticide registrations change frequently, check with your local cooperative extension office for information on repellents or other new products available for use in your area. Remember that some repellents are poisonous and require safe storage and use.

Most rabbit repellents are contact or taste repellents that render the treated plant parts distasteful. Taste repellents protect only the parts of the plant they contact; new growth that emerges after application is not protected, and heavy rains may necessitate reapplication. Odor repellents protect plants within a limited area and do not need to be touching the plant. The degree of efficacy is highly variable, depending on the behavior, and number of rabbits, and the availability of alternative food

sources. When rabbits are abundant, use other control techniques along with chemical repellents.

Hinder and Deer-off are available for use on consumable plants such as fruits. Hinder consists of ammonium soaps of higher fatty acids. It is an odor repellent that may be sprayed or painted on the foliage. Hinder has been found to be effective in repelling rabbits and deer from crops and ornamental plants. Deer-off consists of garlic oil, capsaicin, and putrescent whole egg solids. It is an odor and taste repellent that can be applied to foliage, but edible fruits should be cleansed prior to consuming. Hot Sauce Animal Repellent, by Millers, which contains capsaicin (the heat source in hot sauce), can also be applied to fruit trees; however, it must be applied either before the fruit is on the plant or after it has been removed. Capsaicin is a taste repellent. The warm sensation it leaves in the throat of the animal is believed to cause the animal to avoid eating that plant again. The effectiveness of capsaicin-containing repellents varies depending on the availability of other food sources.

TRAPPING. Trapping can be used to remove rabbits from problem areas. Several excellent styles of commercial live traps are available from garden centers, hardware stores, and seed catalogs. Most commercial traps are made of wire and last indefinitely with proper care. Live traps often can be rented from animal control offices or pest control companies.

Dry corn and dried apples make very good year-round bait. Dried leafy alfalfa and clover are good cold-weather baits. Apples, carrots, cabbage, and other fresh green vegetables are good baits in warmer weather, but these soft baits become mushy and ineffective once frozen. For best results, use baits similar to the fruit on which the target rabbits are feeding. Position the bait at the rear of the trap. Placing a trap involves a few easy steps:

- Place traps where you know rabbits feed or rest. Check for runways along the edge of cover. To locate an active runway, look for rabbit droppings and clipped twigs. Place sticks in the ground in front of the trap to guide the rabbit into the trap.
- In winter, face traps away from prevailing winds to keep snow and dry leaves from interfering with the door.
- Move traps if they fail to make a catch within a week.

Check traps twice a day to replenish bait or remove the catch. Legally, in Pennsylvania, traps must be checked every 36 hours, but they should be checked every 12

hours, particularly in suburban areas where neighborhood pets might be caught.

A commercial wire trap can be made more effective by covering it with canvas or some other dark material. This will cause the trap to resemble a safe, secure environment. Be sure that the covering does not interfere with the trap's mechanism.

HABITAT MODIFICATION. Although frequently overlooked, removing brush piles, weed patches, dumps, and other debris near fruit gardens can be a useful way to manage rabbits. Keeping your grass mowed will remove potential cover that might attract cottontails to your garden. Filling old woodchuck or skunk burrows will remove their potential as rabbit homes. Encouraging the rabbit's natural enemies—or at least not interfering with them—may aid in reducing rabbit damage. Hawks, owls, foxes, mink, weasels, and snakes all help control rabbits.

SUMMARY. The most effective method of reducing rabbit damage to your garden or orchard is fencing or other forms of exclusion along with habitat modification. If numbers of rabbits are low and alternative food sources are available, repellents also might be useful in reducing damage.

White-Tailed Deer

Deer are most active during early morning and evening hours. They can have a home range of several square miles, but this varies with season, habitat, sex, and even individual characteristics. Whitetails are creatures of habit—most use the same home range year after year. They also tend to establish one part of their home range for feeding and another part for resting. For instance, if deer establish an orchard as a source of food, they will habitually move into the area a little before sunset to feed, and move back to the woods before dawn to rest.

The natural food habits of deer depend on the time of year and the plant species available. During the winter months, deer consume evergreen and dry leaves, as well as dormant buds. In the spring and summer, they eat new growth on woody and herbaceous plants. From late summer to early winter, fruits and nuts comprise a large part of a deer's diet.

Damage

Deer cause damage to fruit plants year round, but the most serious damage occurs in the winter months when the availability of natural foods is limited. Dwarf, semidwarf, and young standard fruit trees are the most susceptible, because most of the tree is within reach of

the deer. In winter, browsing on dormant terminal buds may lead to stunted or misshapen growth in standard fruit trees less than 3 years old. Browsing on fruit buds of dwarf and semidwarf trees may lower fruit production. In either case, severe winter browsing can reduce tree vitality and even cause death.

During the spring and summer, natural sources of forage are readily available to whitetails; however, they still might browse new growth on fruit trees and eat ripening fruit. In autumn, deer might continue to browse and eat fruit within the planting. Additionally, bucks can cause severe damage by rubbing their antlers on trees, which can result in broken limbs and girdling of the trunk if the deer removes enough bark.

Monitoring

The extent of deer damage can be monitored through direct and indirect observation. Deer might be “caught in the act” during their active periods in the evening and early morning. Indirect observation involves recognizing signs that deer leave behind.

Lacking upper incisor teeth, deer characteristically tear off vegetation, leaving jagged edges that identify browsed trees. In comparison, browsing by rodents and rabbits leaves a clean-cut surface. The height of the damage, however, might be the only factor necessary to eliminate any mammal other than deer. Another method for determining the source of damage is to search for tracks. Deer leave a distinctive split-hoofed track that can easily be seen in damp soil or snow. Monitoring your fruit plantings for damage is an important, ongoing process and the first step in a successful management plan.

Legal Status

White-tailed deer are classified by the Pennsylvania Game Commission as a game mammal. As such, they are protected. Deer may be harassed throughout the year, but harming deer is prohibited outside of the legal hunting season, unless your livelihood comes from growing crops or fruit.

Damage Control

HUNTING. In Pennsylvania, the white-tailed deer is a protected game species. The game commission is authorized to manage the size of the deer herd through regulated hunting of antlered and antlerless deer. As a landowner, you should encourage hunting in your area, especially if your fruit plantings are subject to heavy deer damage. Posted areas serve as refuges for deer during the hunting season and might compound the damage to an orchard by concentrating the deer popula-

tion. Before opening the area to hunters, make sure the orchard is a safe area for hunting. Consult your local wildlife conservation officer for information on opening your land to hunters, or on eligibility requirements for hunting.

REPELLENTS. Repellents are most effective when integrated into a damage-control program that includes fencing, hunting, and several types of repellents. Apply repellents at the first sign of damage to prevent deer from establishing a feeding pattern at the site. Area repellents include tankage (putrefied meat scraps), ammonium soaps, bone tar oil, blood meal, and human hair. Contact repellents work by taste and must be applied directly to the plant. These repellents work best if you apply them in the dormant season on dry days when temperatures are above freezing. Examples of contact repellents are putrescent egg solids, thiram, and hot pepper sauce (capsaicin). Remember that whenever you apply a commercial repellent, you are required by law to comply strictly with the label. Home remedies often have limited success.

Human hair can be obtained from a local barber shop and placed in small bags (cloth or plastic—if plastic is used, punch three to four holes in the bottom). Tie up the tops and hang them around the garden or individually in trees. Soap bars can be placed in individual trees. Blood meal and tankage can be hung around the perimeter of the planting, initially 20 feet apart and then closer together if needed. Place these items about 30 inches off the ground, about the average height of a deer. Remember, success depends upon early preventative monitoring, as well as on alternation of materials.

Repellents containing denatonium saccharide, such as Ro-Pel, have been found to be less effective. There is little evidence to suggest that the bittering agent, denatonium saccharide, works as a mammal repellent. These products are taste repellents that may only be applied to plants during the dormant season. Because they are taste repellents, the new growth in the spring is not protected. Denatonium saccharide, including Ro-Pel, is not approved for rabbits. However, it is an approved deer repellent.

Repellents have variable results—what works for one grower might not work for another, and success differs from year to year. Some repellents do not weather well and require repeated applications during the season. Also, if deer are very hungry and the area lacks other more palatable food resources, they might ignore the repellents. Success must be measured by how much the damage has been reduced since it is rarely eliminated.

In areas where deer density is low and damage is light, repellents may be a cost-effective part of your IPM strategy.

FENCING. Fencing deer out of the orchard is the most efficient way to reduce damage when deer density is high and damage is extensive. The conventional 8-foot woven-wire fence effectively excludes deer by forming a barrier around the orchard. The fence consists of two widths of 4-foot woven wire and 12-foot posts. To prevent deer from crawling under the fence, keep the wire close to ground level. Unfortunately, deer-proof fencing is expensive, but it is effective, long lasting, and requires little maintenance.

An alternative to barrier fencing is an electric fence. This type of fence is designed to change the deer's behavior. Although deer can easily jump an electric fence, they will instead try to go through or under it. An electric fence takes advantage of this behavior and successfully trains the deer to stay 3 to 4 feet away from the wires.

Researchers at Penn State have developed a low-cost, five-wire electric fence. Through tests conducted statewide, the design has shown to be an adequate means of deer control. The fence incorporates high-tensile steel wire; in-line wire strainers; and high-voltage, low-impedance energizers. High-tensile fence can absorb the impact of deer and tree limbs, thereby eliminating some of the problems associated with soft-wire fences. In addition to Penn State's five-wire fence, other high-tensile electric fence designs are available.

The disadvantages of electric fences include required high maintenance and regular inspections. You must maintain a 6- to 8-foot-wide mowed strip along the fence perimeter to discourage deer from jumping and to decrease the weed load on the fence. You must also regularly check the electric current to ensure that the shocking power is sufficient for turning the deer. The advantages include a relatively low cost and, when properly maintained, a long life.

SCARE TACTICS. Another method of deer control in orchards is the use of guard dogs. Deer quickly learn the extent of a dog's range if it is chained. But free-ranging dogs can deter deer from feeding in any part

of the orchard. An electronic containment fence can be buried or placed on an existing fence. This will keep the dogs in the orchard but allow them free access to all areas. Most dogs will patrol the edge of their territory; therefore, a closely mowed strip along the fence line will enable them to patrol the entire area. Herding breeds are the most effective because of their natural tendencies to chase animals. Long-haired breeds may be more apt to patrol in colder weather and therefore come in contact with deer in more conditions than the shorter-haired breeds. Place dog houses and feeders near established deer trails if they exist in your orchard. This will increase the likelihood that the deer will come in contact with the dog. Place dogs in the containment approximately one month before damage is anticipated. This will allow the dogs to get used to the containment system and the area.

SUMMARY. Deer damage management is a complicated issue with many alternatives that depend upon financial considerations and the amount of damage that can be tolerated. A combination of control methods such as fencing and repellents is most effective. If possible, opening your orchard to hunters after considering safety and zoning regulations is a good way to reduce the deer herd on your property.

CONCLUSION

Wildlife damage can be reduced and maintained at a tolerable level if the species causing damage is properly identified and control methods are implemented before a damage pattern is established. Anticipation of potential problems is the key to effective damage control. The use of a variety of control techniques is essential because the offending species can become accustomed to a single method.

Wildlife damage to fruit and fruit trees is a seasonal problem. In many instances, damage will occur only over a short time period of days or weeks. Control methods might be necessary only during those short time periods. Observation of damage and damage trends can reduce the time and money allocated to damage-control techniques.

Pome Fruits: Apples and Pears

Apples and pears, botanically referred to as pomes, are excellent candidates for the home garden, as long as you are committed to the attention to detail and pest management that the crops require. Advantages of homegrown pome fruit are numerous. You can grow varieties that are not readily available in grocery stores, control the level of pesticides used, and gain a greater understanding of the processes of nature that interact with the tree to produce these wonderful fruits. Remember, however, that producing high-quality apple and pear fruit requires careful observation as well as knowledge of how to respond to various pest problems that you may encounter.

Because apples and pears have many insect and disease pests, growing quality fruit in Pennsylvania is difficult without some pesticide use. Home gardeners are encouraged, however, to purchase disease-resistant varieties if they are available. Although these varieties are not resistant to all diseases that occur in Pennsylvania, they are resistant to the major ones. Pesticides still might be required, particularly in wet seasons, but their application rates can be reduced greatly. Under normal conditions, a home gardener might have to apply pesticides six to ten times to produce fruit of reasonable quality. If scab-resistant apples are planted, a gardener might need only two to three pesticide applications to produce quality apples.

VARIETY SELECTION

Scab-Resistant Apple Varieties ◆

Scab-resistant apple varieties are varieties that are not susceptible to apple scab, the most important disease in the Northeast. These varieties have been bred genetically for immunity to this pathogen. As a result, fungicides are not needed to control apple scab throughout the growing season. Scab-resistant apple varieties are, however, susceptible to the summer fruit diseases, including black rot, white rot, bitter rot, sooty blotch, and flyspeck, and they vary in susceptibility to cedar apple rust, powdery mildew, fire blight, and leaf spots.

In certain regions and summers, sooty blotch and flyspeck can cause extensive fruit blemishing. These blemishes are only superficial and can be partially rubbed off. They cause the fruit to look unsightly but do not affect taste. These two diseases can be minimized by training and pruning the trees to increase air circulation and reduce humidity in the canopy. ◆

None of the scab-resistant apple varieties are completely immune to cedar apple rust. Even those rated as rust resistant will need fungicide protection from rust if they are planted adjacent to cedar trees that harbor this pathogen. It is advisable to remove the cedar trees if possible. To ensure high fruit quality, fungicides still will be required on scab-resistant varieties; however, fewer will be needed than on highly scab-susceptible varieties such as Empire, McIntosh, and Red Delicious. The number of fungicides applied on scab-resistant varieties also will depend on the particular season, especially if it is extremely wet.

Scab-resistant apple varieties are excellent choices for the home garden and backyard farmer. The fruit are of reasonable quality and can be produced with only a few pesticide applications each year. These varieties make harvesting fresh apples from late July through October possible (Table 4.1).

Standard Apple Varieties

Traditional apple varieties (Table 4.2) also can be grown in the home orchard. The varieties listed in the table were selected for their popularity and availability. Some of the newer varieties such as Gala, Fuji, or Jonagold are especially valued because of their fruit quality. When choosing these varieties, the orchardist should be aware that a more intensive pesticide program must be followed to obtain marketable fruit.

Some apple varieties such as Red Delicious and Golden Delicious also are available in various strains. A strain is a mutation of a certain variety that has been selected and propagated for an improved characteristic. A strain might differ in fruit characteristics, growth char-

Text continued on page 54.

Table 4.1. Scab-resistant apple varieties recommended for home planting in Pennsylvania (listed in order of ripening).

Variety	Characteristics	Ripening Period	Disease Rating ^b		
			CAR ^a	PM	FB
Pristine	Very early, medium-sized yellow apple, pleasant tart flavor with a smooth, attractive finish.	Late July to early August	M	R	M
Williams Pride	Early, dark red-purple apple. Large fruited. Semi-tart flavor. Sometimes shows water-core or bitter pit.	Mid-August	R	M	R-M
Redfree^d	An early, red-skinned, sweet summer apple. Crisp. Does not have a long storage life.	Late August to mid-September	R	R-M	R-M
Crimson Crisp^c	Rich flavor with moderately acidic and a spicy aftertaste. Bright red fruit with cream-colored flesh	Early September	M	M	S
Liberty^d	Mid-season, high-quality dessert apple. Most disease resistant. Flavor improves after storage.	Mid- to late September	R	R	R
Freedom	Mid-season, large fruit, spicy flavor. Rough external appearance. Fruit quality varies. Susceptible to black rot.	Mid- to late September	R	R	R-M
Jonafree	Mid-season, firm, red apple, slightly tart. Flavor improves after storage. Similar to Jonathan.	Mid- to late September	S	R	M
Scarlet O'Hara^c	Large round fruit with medium red to orange color. Rich, pleasant, slightly spicy flavor.	Early to mid-October	R	M	S
Sundance^c	Medium-sized fruit with a sweet, tart flavor. Yellow fruit with some russet.	Mid-October	R	M	R
Enterprise^d	Good-quality, late-season, smooth, glossy red apple similar to McIntosh. Stores well. Susceptible to a fruit spotting disorder.	Mid-October	R	M	R
Goldrush^d	Excellent quality fruit, good storage apple. Very late maturing Golden Delicious type. Fruit may russet.	Late October	S	R	M

Notes

a. CAR = cedar apple rust; PM = powdery mildew; FB = fire blight

b. R = resistant; M = moderate; S = susceptible

c. A newly released scab-resistant variety

d. Has performed well in taste tests

Table 4.2. Apple varieties not resistant to apple scab but recommended for home planting in Pennsylvania (listed in order of ripening).

Variety	Characteristics	Ripening Period
Jerseymac	Early McIntosh type. Crisp, red apple of excellent quality. Good for eating, sauce, and pies.	Late July to early August
Zestar!	Medium to large, red-over-yellow fruit. Flavor is well balanced. Slightly sweeter than tart. Flesh is crisp and medium to coarse. Good for fresh eating and sauce.	Early to mid-August
Ginger Gold	Golden-type apple ripening in mid- to late August. High-quality, russet-free fruit. Good for eating fresh and pies.	Mid-August
Gala	Orange-red fruit, sweet and hard with high quality. Developed in New Zealand. Good for eating fresh and sauce.	Late August to September
McIntosh	Old-time favorite. Purchase new high-coloring strains. Available as a spur type. Good for fresh eating, pies, and sauce.	Early September
Honeycrisp	Large, explosively crisp, and juicy fruit. Fruit color is red-over-green ground color. Weak-growing tree. Fruit may show bitter pit when the trees are young.	Mid-September
Delicious	Most popular commercially grown variety. Available in spur and nonspur strains. Good for fresh eating.	Early to mid-October
Empire	Dark-red apple of excellent dessert quality. An all-purpose apple that keeps well. Good for fresh eating, pies, and sauce.	Mid- to late September
Golden Delicious	Excellent all-purpose apple. Heavy producer. Avoid spur strains because they tend to russet more than nonspur strains.	Late September to early October
Idared	Popular older variety. Produces large, mildly tart, red fruit that keeps well. Good for all uses.	Early to mid-October
Jonagold	Developed in New York as a cross between Jonathan and Golden Delicious. High-quality fruit. Develops a red blush over yellow skin. It is a triploid and produces sterile pollen (see section on pollination). Good for fresh eating, sauce, and baking.	Early to mid-October
Mutsu	Cross between Golden Delicious and Indo. Very large, light-green to yellow fruit. It is a triploid and produces sterile pollen. Good for fresh eating, pies, sauce.	Mid-October
SunCrisp	Golden-type apple that can develop a red or orange cheek in cooler years. Unusual cinnamon spice-flavored fruit. Tastes better after a period of storage. Good for fresh eating, sauce, and pies.	Mid- to late October
Fuji	Developed in Japan. Late-ripening apple. People located above Interstate 80 might have difficulty in maturing the fruit each year. There are, however, some early maturing strains available, such as Daybreak and September Wonder. Very firm, red-over-green fruit that is sweet. Stores extremely well in regular refrigeration. Good for fresh eating and pies.	Late October
Braeburn	Newer apple variety that ripens in late October. Red-over-green fruit that is semi-tart but very firm. Good for fresh eating and sauce. Do not plant if you live north of Interstate 80.	Late October

acteristics, or both. Some varieties have many strains; for example, approximately 250 different strains of Red Delicious have been described and cultivated.

The most common strain difference that the backyard grower should be concerned about is spur strains versus nonspur strains. Spur-type growth is more compact since fruit spurs and leaf buds are closer than those on nonspur trees. On spur types, two-year-old wood will usually form fruit buds rather than develop side shoots. As a general rule of thumb, spur strains of a given variety will result in trees only about 60 to 70 percent as large as the nonspur types of that variety. Because of their compact form of growth, spur types are ideally suited for home gardeners with limited space.

Pear Production

Pears were once the dominant fruit grown in North America. Early colonial settlements would often have pear trees. The earliest known pear orchard was reported in 1630 in Massachusetts. Pears are easily adaptable to nearly all of Pennsylvania because they tolerate a wide range of climatic conditions. The one major limiting factor for pear production is the bacterial disease known as fire blight (*Erwinia amylovora* (Burril)). Humid conditions favor development of this disease, which can kill pear trees.

Two types of pears are commonly grown in Pennsylvania, the traditional European types (*Pyrus communis*) and the Asian pears (*Pyrus serotina*). Both types are susceptible to fire blight. Pears, like apples, require cross-pollination to set fruit. Therefore, you must plant at least two different varieties. Asian and European pears have compatible pollen, but they often do not have sufficient overlap of bloom periods to supply pollen for one another.

Pear trees usually bloom 7 to 10 days before apples and their flowers may be killed by spring frosts. Temperatures below 28°F can severely reduce the fruit set by killing the flowers. Therefore, be sure to place pear trees in a sheltered area of the yard.

Pear Rootstocks

Pears do not root easily, so they are propagated by budding or grafting onto a rootstock. Unlike apples no viable commercially available rootstocks that consistently control tree size exist yet. The most common rootstock used is seedling. You may occasionally find pears grafted onto hybrid rootstocks developed from crossing Old Home and Farmingdale varieties. These selections were developed because of their moderate resistance to fire blight. The nursery catalogs will list

them as OHxF. Pears are also sometimes propagated on selections of Quince (*Cydonia oblonga*). However, some varieties like Bartlett and Bosc are not compatible with Quince. Asian pears are, by nature, weak-growing trees and, therefore, should be grafted onto more vigorous rootstocks such as seedling.

Pear Varieties

The following is a list of common pear varieties.

ANJOU: Fruit is average to large in size. Skin ripens to a creamy greenish color and occasionally develops a red cheek. Flesh is mild to rather sweet and fine textured. Excellent late pear for all uses. Fairly good pollinator. Harvest 3 to 3.5 weeks after Bartlett.

BARTLETT: The most widely grown of all pears—it is the standard against which all others are judged. Fruit ripens to a yellow color and a medium to large size. Tree is of average size and is productive. Pick third to last week in August in most areas of Pennsylvania. Red sports are available and can be expected to perform the same as standard nonred strains.

BOSC: Large, long-necked fruit that ripens to a greenish yellow, usually completely overlaid with a cinnamon-colored russet. Fruit quality is excellent for all uses. Good pollinizer for Bartlett. Harvest 3 to 4 weeks after Bartlett.

GORHAM: Similar to Bartlett in size, shape, and color. Fruit has a shorter neck than Bartlett. Always has russetting around stem end. Sometimes develops a blushed cheek. Flesh is firm, juicy, and sweet. Good for both canning and fresh use. Pick 12 to 14 days after Bartlett.

KEIFFER: Fruit is small to average in size. Ripens to a creamy yellow color with many conspicuous brown lenticels. Only use is as a canning pear. Harvest 5 to 6 weeks after Bartlett.

MAGNESS: Medium-size fruit with excellent quality. Pollen is sterile; therefore, you will need two additional varieties for pollination. This variety has some fire blight resistance.

MOONGLOW: Medium to large, dull-green fruit sometimes having a pink blush. The fruit flesh is smooth and fine with excellent quality. This variety has some fire blight resistance.

SECKEL: Small fruit. Tree is small, very productive, and fairly resistant to fire blight. Fruit ripens to deep yellowish brown and is very sweet. Excellent for canning and for fresh use. Poor pollen producer. Harvest approximately 3 weeks after Bartlett. Seckel and Bartlett are

incompatible and should not be planted together for pollination.

Ripening European Pears

Compared to other fruits, pears are unique because they are resistant to ripening right after harvest and will not ripen evenly until they have had a period of chilling. Without some post harvest chilling, a mature fruit will simply shrivel and decompose without ripening. Bartlett pears need to be refrigerated for only a day or two, whereas winter pears such as D'anjou, Bosc, and Comice require 2 to 6 weeks of refrigeration. Pears purchased in the supermarket have already had their chilling requirement. Pears should be ripened at 65 to 75°F and high humidity. The length of time required for ripening differs with variety: 5 days for Bartlett, 7 days for Bosc and Comice and 9 days for D'Anjou. Pears are ready to eat when the fruit flesh just below the stem yields slightly to pressure when squeezed.

Asian or Oriental Pears

The Asian or oriental pear has been in this country since the late 1800s but has not been planted regularly until the last 10 years. These pears, sometimes referred to as oriental pears, Chinese pears, or Japanese pears, are considerably different from the old, hard, homegrown varieties like Keiffer and Seckel. Asian pears have a distinct but pear-like taste and a crisp texture, much like a good apple. Many Asian pear varieties also have an apple-like shape, and this combination of taste, texture, and shape causes many people to refer to them as “apple pears.” They are sometimes also called “salad pears” or “sand pears.” Their flesh is crisp, sometimes gritty, and always very sweet. They do not have the buttery flesh of European pears. Their skin is often russeted.

Harvesting Asian Pears

Asian pears, unlike European pears, ripen on the tree. They do not need a cold storage period. Asian pears are ready for harvest when you easily remove them from the spur or branch by slightly lifting and twisting them. Use the taste test—they're ready when they taste good. Asian pears should be crisp and crunchy when eaten.

The biggest problem with the adaptation of Asian pears has been fire blight, which attacks pears and apples and can kill blooms, young tender shoots, and sometimes major limbs and whole trees. Plant at least two Asian pear varieties to assure cross-pollination and good fruit set. Do not rely on common pear varieties to pollinate Asian pears. Pear trees should be trained and pruned in

a similar fashion as apples. Asian pears tend to overproduce and need to be thinned shortly after bloom. Approximately 2 to 3 weeks after bloom, shake the branches of the tree to force any fruit that has stopped developing to drop. Starting at the end of a branch, cut off all but one fruit per cluster and space the clusters about 8 inches apart. This may mean totally removing some clusters. Be sure to remove the fruit with pruning shears; do not pull or twist the fruit off. Pulling the fruit off may damage the fruit spur and prevent flowering next year.

The Shinseiki variety tends to be self-fruitful, but it still benefits from cross-pollination. Other cultural methods used on regular pears should be followed for Asian pears. Many varieties are being tried, but to date the following are the best as measured by overall grower and consumer preferences.

HOSUI: Large, yellowish-brown, russet fruit with prominent lenticels and excellent quality. Many prefer the taste of this variety. Fruit must be thinned to obtain adequate size. Fruit matures mid- to late August.

KOSUI: Apple-shaped, small- to medium-sized fruit. Skin is brown and fruit mature in mid- to late August.

OLYMPIC: Variously known as A-Ri-Rang, Korean Giant, or Olympic Giant and is a new variety developed in Korea. Fruits are large, late, round, and have an attractive golden russeted skin. Reportedly, this pear's bloom period overlaps with Bartlett, and the two make compatible pollinizers. Olympic has the longest storage life of the Asian pears

SHINSEIKI (NEW CENTURY): Yellow-green to yellow-skinned type, medium-sized, good- to excellent-flavored fruit that ripens early. Flesh is creamy white with a very sweet taste. Fruit is round to oblong. Fruit matures in early to mid-August.

TWENTIETH CENTURY (NIJISSEIKI): Yellow-skinned type that is the most popular variety worldwide. It has very good medium to large fruit. One of the most susceptible to fire blight.

Nursery Stock Selection

The old adage “you get what you pay for” is an important consideration when buying fruit trees. Bargain plants might not be healthy or might be a variety not adapted to your area. Buy only trees of recommended varieties from a reliable source. Keep in mind the following points when purchasing fruit trees:

- A healthy one-year-old whip, approximately 4 to 6 feet tall, with a 0.5-inch caliper and a good root system, is preferred.

- A smaller tree with a good root system is more desirable than a large tree with a poor root system.
- Trees that are 2 years old or older are often not as good as one-year-old trees. The older trees frequently do not have enough buds on the lower portion of the trunk to develop a good framework.
- Trees that appear stunted, poorly grown, diseased, or insect injured should not be purchased.
- Check the label closely to make sure that you are getting the variety and rootstock that you desire.

Standard Trees versus Dwarf Trees

Trees on dwarf and semidwarf rootstocks are ideally suited for home fruit production. Although more expensive, the smaller trees are easier to prune, spray, and harvest; they also begin to produce fruit at an earlier age than full-sized trees. The two most dominating influences on tree size are the rootstock and the type of strain used (spur or nonspur). Other factors influencing ultimate tree size include general care, variety, soil type, earliness of fruiting, and time and severity of pruning.

Apple tree size as influenced by rootstocks is generally divided into three categories: standard (also called seedling), semidwarf, and dwarf. Standard trees are propagated on seedling rootstock and produce large trees that can grow to be 30 feet tall. Semidwarf trees are propagated on one of several clonal (vegetatively propagated) rootstocks that produce trees that will be about three-quarters the size of standard trees grown under similar circumstances.

True dwarf trees will be about 30 to 40 percent as large as standard trees and require support by either a trellis or a post. The two most common dwarf rootstocks are Malling 9 and Budagovsky 9 (commonly abbreviated as M.9 and Bud.9, respectively). Trees grown on M.9 are the smaller of the two. The most common semidwarf rootstocks used for apples are M.26, M.7 or M.7a, Malling Merton 106 (commonly abbreviated as MM.106, and MM.111. Trees on M.26 will produce the smallest trees while MM.106 will produce the earliest bearing trees. The MM.106 and MM.111 will produce the largest of the semidwarf trees.

Dwarf fruit trees often require fewer pesticides. Since the trees are smaller than standard-sized trees, air circulates better inside them and they dry off more quickly. Most diseases develop under wet conditions. Small trees that dry off quickly have a reduced potential for disease development and therefore require fewer pesticide applications to control disease. In addition, when pesticides are necessary, obtaining a uniform application is

much easier on small trees. Uniform pesticide deposits are necessary for disease and insect control.

The interstem tree is another category of rootstock that might be available. It has a small stem section of M.9 grafted between an understock such as MM.111 or MM.106 and the variety. These trees are slightly larger than dwarf trees but smaller than the semidwarf. Because of the extra propagation needed, interstem trees are the most expensive. Current recommendations suggest planting these trees so that a portion of the M.9 piece is below the soil line.

Table 4.3 lists the space requirements and probable yields for fruit trees grown on different types of rootstocks. The spacings listed are minimum distances; wider spacings can be used.

PLANTING

The soil should be prepared thoroughly by deep cultivation either by hand or with a rototiller before planting. The soil pH should be maintained between 6.0 and 6.5. Have a soil test taken and make the recommended adjustments before planting. You can get information on soil testing from your county extension office.

In the absence of a soil test, lime a 10-by-10-foot area where each tree will be planted. Dig each planting hole wide enough to accommodate all of the root system without bending or bunching it, and deep enough so that the bud union of grafted plants will be no more than 2 inches above the ground line after the soil settles.

Keep root pruning to a minimum, but cut off all broken or mutilated root parts with pruning shears. Set the plants with the graft or bud union no more than 2 inches above the soil line (Figure 4.1). Work the soil in and around the roots. When the hole is half full, firm the soil with your feet before filling the rest of the hole. When the hole is full, pack the soil firmly. Do not leave



Figure 4.1. Two-piece apple or pear tree with circle around the bud union.

Table 4.3. Apple and pear tree spacings and probable yields on various rootstocks.

Rootstock	Approximate Size (% Seedling)	Suggested Spacing (ft)	Average Yields for Trees at Least 10 Years Old (Bushels)
Apple:			
Malling 27	15–20	5 x 13	1 to 1.5
Budagovsky 9	30	6 x 14	1 to 2
Malling 9	35	8 x 16	1 to 2
Mark	35	7 x 15	2 to 3
Malling 26	40	8 x 16	3 to 4
Malling 7 or 7A	60	12 x 20	10 to 12
Interstem trees ^a	40	12 x 20	10 to 12
Malling Merton 111 ^b	70	18 x 26	20 to 25
Seedling	100	20 x 28	25 or more
Pear:			
Interstem trees		10 x 18	5 to 10
Seedling		20 x 28	15 or more

a. Apple interstem trees are composed of either Seedling MM. 106 or MM. 111 roots, a 6- to 8-inch stempiece of M. 9 or M. 27, and the scion variety on top. Pear interstem trees are composed of Quince root, a 6- to 8-inch piece of Old Home trunk, plus the desired scion.

b. Malling Merton trees require extremely well-drained soils to perform as advertised. Do not plant them where drainage is slow or the soil is heavy clay.

a depression around the tree. *Also, do not place fertilizer in the planting hole or fertilize the soil immediately after planting.* Fertilize only after the soil has been settled by a drenching rain.

After planting, apply sufficient water to thoroughly soak the soil around the tree roots. This watering will help to bring the soil into closer contact with all sides of the roots and eliminate air pockets around the roots. Remember that approximately one-quarter of the root system was removed when the tree was dug. To compensate, remove the top quarter of the plant to reestablish the plant's previous shoot-to-root ratio.

On branched trees, remove poorly spaced and narrow-angled branches. Leave branches that are wide angled and arranged spirally about 6 to 9 inches apart up the leader (trunk). Branches left on the tree should be reduced by up to one-half of their length, and the leader should be cut about 12 to 15 inches above the top limb. Cut the leaders on nonbranched whips back to three-quarters of their original lengths.

NUTRITIONAL REQUIREMENTS

Generally, apple trees need fertilizing each year. Nitrogen is the most important essential nutrient. Two other nutrients, phosphorus and potassium, are needed in relatively large amounts when the tree is young; however, after it reaches maturity, it usually requires only nitrogen.

Broadcast 8 ounces of 10-10-10 over a 2-foot circle about 1 month after planting. Keep the fertilizer 6 inches away from the trunk and broadcast it evenly over the

recommended area. *Do not put any fertilizer in the hole before planting.* In June following the planting, broadcast another 8 ounces of 10-10-10 around the tree. Increase the amount of 10-10-10 applied by 0.25 pound per year to 2.5 pounds per tree for a dwarf tree, 5 pounds per tree for a semidwarf, and 10 pounds per tree for a standard tree. Maintain pH at 6.0 to 6.5. (See Chapter 1 for more information on fertility and fertilizers.)

WATERING IN THE FIRST YEAR

Watering the young tree in late June might be desirable, depending on the rainfall up to that time. If less than 4 to 5 inches of rain have fallen since the trees were planted, pour 5 gallons of water around the base of each tree.

FLOWERING HABITS OF APPLES AND PEARS

Recognizing where the flowers and fruit develop on the different types of tree fruits is important. Their location as well as the fruit species will determine how the different species are pruned and trained. Tree fruit have two types of buds, terminal and lateral buds. Apples and pears flower and fruit primarily on terminal buds. A terminal, sometimes called the apical bud, is one located at the tip of a shoot. A lateral bud develops along the developing shoot at the base of the leaf blade.

The flower/fruit buds in apples and pears can be terminal on long shoots (greater than 4 inches) or more commonly on short shoots called spurs. A spur is a short shoot (4 inches or less) that only grows a very small amount each year. Spurs usually take 2 years to develop;

that is, in the first year the bud is formed as either a lateral or terminal bud. If the bud is terminal, it may flower the next year or it may not. Lateral buds formed the first year may produce a flower, but the fruit that develops is small and of poor quality. More often, the lateral bud may thicken and grow only a small amount and develop as a spur, which may flower in the subsequent years.

The spur and terminal flower buds can have both vegetative and flower components. The buds usually produce about five to eight flowers and a similar number of leaves. Occasionally, a new vegetative shoot will develop after the flowers set fruit.

Pruning and training as described below will affect the amount and type of buds formed by apples and pears. Trees that are very vigorous, whether due to pruning or over-fertilization, form fewer flowers.

PRUNING

Generally, fruit trees are pruned to develop a desired tree shape, to maintain the tree at a desired size, to make spraying easier, to improve fruit quality, to improve tree strength and induce branching, and to improve air circulation within the tree, which will reduce the potential for disease. Excessive pruning encourages excessive shoot growth and reduces the quality of fruit on young trees. Older trees (25 years and older) will produce higher-quality fruit following a vigorous pruning.

Regardless of the type of tree you are pruning, there are only two types of pruning cuts. The first is a *heading cut*. This type of cut involves shortening a limb or shoot by removing a portion off the end. Heading cuts remove the terminal buds that normally inhibit shoot develop-



Figure 4.2. Effects of differential amount of heading on regrowth. The dotted lines separate the different wood age. Adapted from *Training and Pruning Apple Trees* by C. G. Forshey.

ment from buds below the terminal or end of the shoot. A heading cut results in several shoots developing just below the location of the cut. The number of shoots that develop and the vigor of the growth will depend on the severity of the heading cut. Heading cuts result in a thicker and denser canopy and reduce light levels within the tree.

The second is a *thinning cut*. A thinning cut is the removal of an entire shoot back to its point of origin. Thinning cuts do not induce excessive vigorous regrowth and open the tree's canopy to allow more sunlight into the interior. Figure 4.2 illustrates the growth that occurs when a dormant shoot (A) is not headed, (B) is headed one-third of its length; (C) is headed two-thirds of its length, or (D) is headed to remove all of the previous year's growth. Note the increase in vigor and reduction in fruiting wood the more severe the cut.

Prune young trees (up to 10 years of age) lightly. Prune older trees more vigorously. Be sure to remove all dead and broken limbs when you prune. Remove sucker growth from the interior of the tree and around the base of the trunk annually. *Thinning-out cutting* (removing an entire limb or shoot) is associated with increased apple flower bud production. *Heading-back cutting* (shortening the ends of branches) encourages shoot growth. Remove pruned brush from the orchard area. Dead wood will harbor disease organisms that can spread back into the tree. Burning or burying the prunings is the best practice.

Pruning and Training to a Central Leader

The day you plant your trees is the day you should begin to prune and train for future production. Too often,

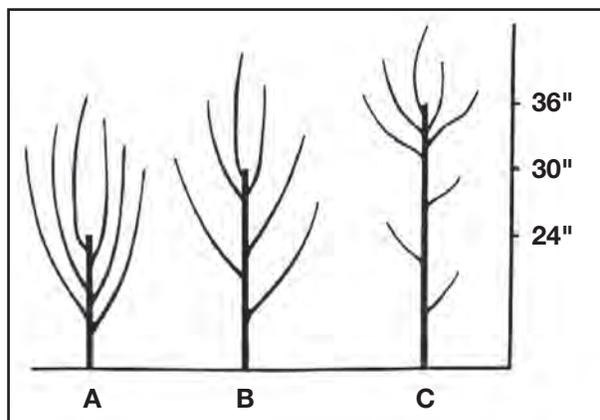


Figure 4.3. Response of trees to different heading heights: (A) the cut is too low; (B) the cut is at the proper height of 30 inches; and (C) the cut is too high.

backyard growers plant apple and pear trees and leave them untended for several years. This neglect results in poor growth and delayed fruiting.

The purpose of pruning a young tree is to control its shape by developing a strong, well-balanced framework of scaffold branches. Unwanted branches should be removed or cut back early to avoid the necessity of large cuts in later years. Currently, the preferred method of pruning and training nontrellised trees is the central leader system.

Pruning should be done in late winter. Winter pruning of apple trees consists of removing undesirable limbs and tipping terminals to encourage branching. Summer training is most beneficial if done in early June and early August.

First Growing Season

Figure 4.3 (B) shows the proper height, 30 inches, at which to cut back the tree at planting. Heading back the tree to this height will bring the top and roots back into balance and cause buds just below the cut to grow and form scaffold branches. Cutting lower, 24 inches (A) will result in excessive vegetative growth. Cutting too high, 36 inches (C) will result in weak growth in the top of the tree as well as in lower areas.

After a few weeks, trees that are headed may appear as in Figure 4.4A. The shoots are vigorous and upright growing with very narrow crotch angles. To prevent this, you need to force the new shoots to a more horizontal growth pattern. When 2 to 3 inches of growth have occurred, position wooden spring-type clothespins between the main trunk or branch and the new succulent growth (4.4B). The clothespins will force the new

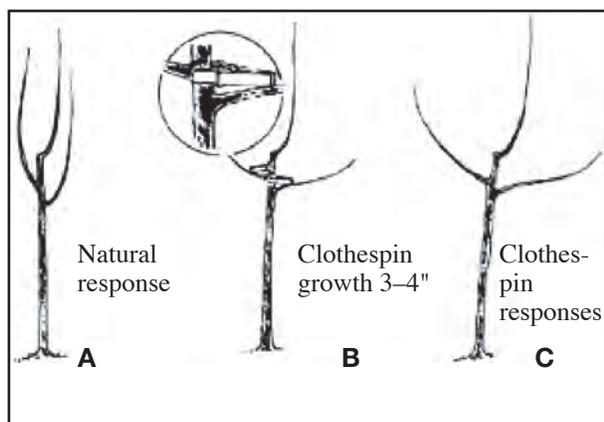


Figure 4.4. Natural tree growth (A); placement of clothespins (B); and tree response at end of the growing season (C).

growth outward and upward and form the strong crotch angles needed to support the fruit load in years to come. Allow the most vigorous upright branch to remain growing straight up—this will become the central leader. You should plan to keep approximately four to six of the developing shoots with the goal of having them separated equally around the trunk and arranged vertically within a 4- to 10-inch distance. Looking downward on the tree the arrangement would appear as in Figure 4.5.

It is important that the limbs are spread when they are young. If a limb is not spread as in the picture above, a bark inclusion can develop. This occurs when the bark of the trunk and the branch have been pressed together. This structure weakens the branch and serves as an entry point for pathogens. The wide-angled branch on the right, however, allows for growth and expansion of both the trunk and the branch and produces a much stronger branch that can withstand future heavy crop loads.

One Year Old

A number of branches should have developed after the first growing season; if they were clothes pinned, they should have good crotch angles. The objective now is to develop a strong central leader and framework of two to three sets of scaffold branches. Remove any broken limbs or limbs growing vertically. Head the central leader about one-third the length of the shoot that grew the first year. Several shoots should develop just below the heading cut. If the first set of scaffolds is vigorous and begins to grow too upright they should be spread through the use of wooden spreaders, weights, or string. Tie or spread the limbs down to a 45- to 60-degree angle.

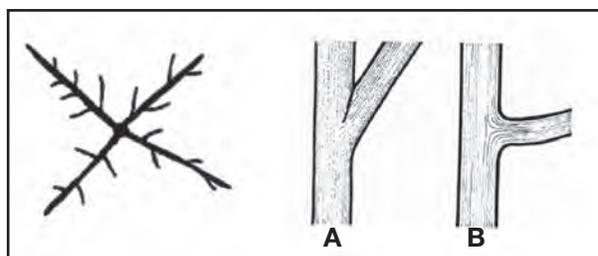


Figure 4.5. View looking down on an apple or pear tree and effects of spreading the tree limbs.

Second Growing Season

During the second growing season, develop a second layer of scaffolds 24 to 36 inches above the scaffolds you established the year before. Be sure to clothespin the second level to develop wide crotch angles. Remove any undesirable shoots that are too vigorous or in competition with the central leader during the growing season.

Two Years Old

Limb spreaders can aid in bringing about earlier fruit production, improved tree shape, strong crotch angles, and improved fruit color. Spreaders can be either short pieces of wood with sharpened nails driven into each end or sharpened metal rods. Always spread the tree before pruning, which consists of entirely removing undesirable upright limbs and reducing the length of new shoot growth by one-quarter. Limbs should not be spread below a 60-degree angle from the main trunk. Limbs spread wider tend to produce vigorous suckers along the top of the branch and might have reduced terminal growth. The spreaders should remain in place for 1 to 2 years until the branch “stiffens up.”

Figure 4.6 is an illustration of what the tree might look like after a couple of years. The objective is to try to leave only four to six main scaffold branches spaced around the tree. A second set of branches above the first is then developed the following year. Always make sure that the ends of the scaffold branches are below the end of the central leader after they have been pruned back.

At maturity the overall appearance of the tree should be a pyramid with the largest and longest branches in the lowest and first set of scaffolds followed by 2 to 3

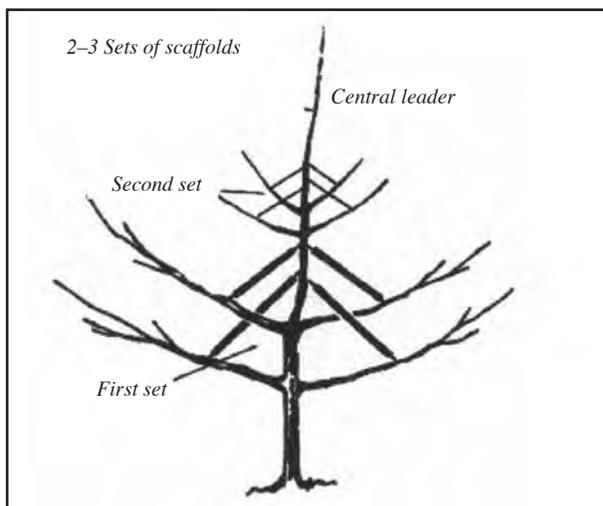


Figure 4.6. An apple or pear tree trained to a central leader system after three growing seasons.

additional sets that are progressively smaller in diameter and shorter in length.

Three to Four Years Old

Continue to head back the new terminal growth by one-quarter each year and remove any upright limbs. Any broken or diseased limbs also should be removed. Always maintain the central leader as the highest point on the tree. The ends of the primary and secondary scaffolds should be kept below the top of the tree. Prune the trees every year in late winter (February or March). Keep the leader dominant by shortening competing branches. Remove branches that form narrow crotch angles. Remove weak, twiggy growth.

Succeeding Years

Once the trees begin to bear fruit and no later than when they reach their fifth winter, discontinue heading back the new terminals. Pruning for the rest of the life of the tree will be done to maintain the conical structure. Remove vigorous upright or downward-growing shoots. A good image to guide your pruning is to try to create two-dimensional scaffold branches. This means the branches will have a single terminal point and will spread out in a triangle back into the center of the tree but will not have any shoots growing up or down (Figure 4.7). Try to retain only shoots that are horizontal. Periodically thin out the branching structure to allow adequate light to penetrate the interior and lower portions of the tree.

Always maintain the central leader as the highest point on the tree. The ends of the primary and secondary scaffolds should be kept below the top of the tree. Prune the trees every year in late winter (February or March).

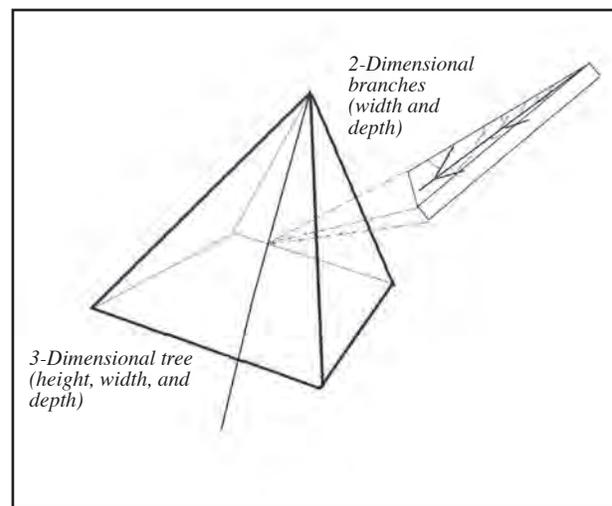


Figure 4.7. Maintaining a three-dimensional Christmas tree form and a two-dimensional branch form.

You can view a copy of the slide set Pruning and Training Fruit Trees at <http://tfpg.cas.psu.edu/pruning/slide1.htm> to help assist you in your pruning.

Pruning and Training to a Trellis

Trellising is a means of supporting dwarf apple and pear trees to increase their bearing surface and hence their production. The trellis consists of a series of wires supported by posts (Figure 4.8). Limbs and branches are positioned on this wire fence to encourage fruit production. Varieties on M.27, Bud.9, M.9, or M.26, as well as pears on Quince C rootstock, can be trained to a trellis.

Constructing the Trellis

The trellis should be in place before the trees are planted. In the home orchard, 8-foot posts are driven 2 feet into the ground and spaced every 15 to 20 feet apart depending on the amount of space available and the number of trees to be planted. Four wires spaced 18 inches apart, or three wires (no. 9 galvanized wire or stronger) spaced 24 inches apart are strung across the posts. The wire can be fastened to the posts by fence staples, or 1/4-inch holes can be drilled through the posts and the wire passed through the holes. The top wire can be either stapled to the top of the post or strung through a hole drilled 1 inch below the top. End posts will need additional anchoring using a deadman such as that used on telephone poles.

To train trees to a trellis, start by planting the trees 6 to 7 feet apart between the supporting posts (see Figure 4.8). Plant the first tree 4 feet from the end post. Remember to keep the graft union above the ground.

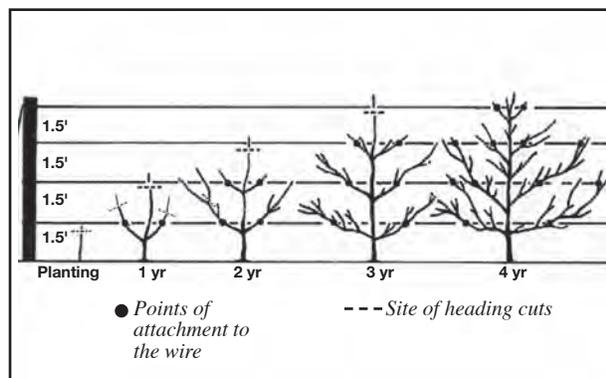


Figure 4.8. Pruning and training apple or pear trees to a four-wire trellis.

Head the tree off just below the bottom wire and loosely tie it to the same wire. Allow young shoots to develop and loosely tie them to the trellis wire in the spring and early summer. Some shoots will develop that are not in the plane of the trellis (projecting away from the wire). These shoots should be pruned off or bent and tied to the wire so they fit the plane. The shoots should be tied to the trellis so they form a 45-degree angle from the main trunk. Allow one shoot to grow straight up. This will be used to develop succeeding levels of branches.

After the first growing season, prune back the terminals of the tied limbs as well as the central trunk. Remove undesirable limbs. Pruning after the second growing season should be similar to that done after the first season. Your goal should be to fill up the trellis area with limbs before heavy fruiting begins. Remove all fruit during the first 2 years following planting to encourage tree growth. The onset of fruiting will reduce the amount of pruning necessary.

Periodically, limbs get old and production decreases. If a limb starts declining, prune it out by cutting it back to a stub close to the main trunk, and train a new one to take its place.

Girdling can result where the limbs and trunk are tied to the wires. Periodically check these ties to make sure that they are still loose and not binding.

Pruning—A Special Case—Renovating Old Fruit Trees

Many people move to new homes where the previous owners had planted fruit trees. If the owner did not properly care for the trees, the results are large ungainly giants that are completely out of control and are an unsightly mess. In other instances, people move into old farmhouses where trees were planted 30 or 40 years ago. These, too, if they have been neglected, are large and difficult to maintain. In many cases, these old trees can be brought back to a more manageable state. The primary means of renovating older trees is through judicious and properly selected pruning cuts. Apple and pear trees are most easily renovated. Cherries also can be renovated, but to a lesser degree and with less success. Peaches and nectarines are not recommended for renovation, and are not considered here. It is easier to cut a peach tree down and plant a new tree.

Several questions should be answered before an attempt is made to rejuvenate an old tree. Is the tree worth saving? Did it formerly bear unique fruit that was exceptionally good for fresh eating or canning? Is the tree structurally sound—do the trunk and main limbs

seem capable of bearing a heavy load of fruit, or would they simply break when heavily laden? Is the tree in a suitable location or does it shade the garden or interfere with lawn mowing? Is it full of insects and diseases? These are among the most important issues one should consider before proceeding.

The first step is to examine the trunk and butt ends of the major branches. They should be reasonably sound and free from large areas of dead wood on which the bark has died. Although much of the trunk and parts of the major limbs are nonfunctioning, they do provide structural strength to the entire tree. If the trunk and parts of the major limbs are hollow, efforts to save the tree will most likely be unsuccessful. Areas of branches and the trunk that appear orangish-brown and scaly also are an indication of poor health. A thin green line, visible when the bark is peeled back gently with a pocket-knife, indicates a healthy branch and tissue.

If this examination reveals serious structural and health problems, you might be better off vegetatively propagating the tree or ordering a new one of the same variety for planting. Your county extension office has a bulletin titled *Grafting and Propagating Fruit Trees* that explains how to vegetatively save the tree.

If you decide to rejuvenate the tree, prune out all broken and dead branches and cut away the sucker growth around the bottom of the trunk. Once the dead and broken material has been removed, the general form of the healthy portions of the tree can be seen.

The second step is to decide how big you want the tree to be. Realize, however, that you can never make a seedling tree into a dwarf size no matter how much you prune. A true dwarf tree can be maintained at about 6 to 10 feet tall, a semidwarf at about 10 to 16 feet and a standard at about 16 to 20 feet tall. Trees that have not been pruned in many years should not be reduced to the desired height in a single pruning. To prevent excessive growth and excessive sunburn on previously shaded portions of the tree, you should plan on reducing tree height over a period of 3 years by removing no more than one-third of the tree in one season. If, for example, the tree is currently 23 feet tall and you want to bring it back to about 14 feet, lower the overall height by 3 feet per year.

To reduce tree height, selectively cut to branches growing more horizontal to the ground. Thin out excessive branches as well. Do not indiscriminately cut all the shoots in half. Do not “dehorn” the tree, as some people mistakenly do with large shade trees to reduce their height. After the desired height and limb spread

have been decided, look closely at the major branches to determine where they could be cut to bring the tree into conformity.

It is important that no nitrogen be applied immediately after the initial heavy cutting. Nitrogen should not be applied because the root system under the tree is large enough to provide water, oxygen, and stored food reserves to all of the aboveground portions of the tree *before* any cutting was done. In effect, the first year’s pruning means that the same amount of root system is supplying fewer growing points. Adding more nitrogen fertilizer would stimulate excessive vegetative growth that would further complicate next year’s pruning.

The remaining portion of the tree should be protected from insects and diseases to ensure that the fruit produced will be usable and that the tree will form flower buds for next year’s crop. Unfortunately, on tall, large trees it is often difficult to reach the tops. Most small hand sprayers can reach at best 10 to 12 feet up into a tree. It will be difficult, therefore, to control diseases and insects in the larger trees until they have been lowered.

During the summer after the first winter pruning, remove the numerous water sprouts that will grow on the heavily pruned tree. Water sprouts are rapidly growing vegetative shoots that develop around pruning cuts. The method of removal is important. If you use a pruning shears, you can never quite remove the entire shoot. Instead, pull the shoots off the trunk in mid-June when they are about 10 to 12 inches long. Keep pulling these shoots off throughout the season on the major scaffolds. The shoots can be pulled off safely as long as their bases remain tender and green. Stop when the base of the shoot becomes woody and does not easily pull off. Also during this time, or from late May to early June, thin the fruit down to 1 fruit per cluster and space the clusters about 6 to 10 inches apart. This practice will ensure that the remaining fruit will attain the largest possible size.

In the late winter or early spring of the following year, before growth begins, prune the tree again. This time, however, limit the pruning to thinning out the bearing wood. Take time to look carefully at the tree. Notice where the 1- to 4-year-old wood pieces are located. This is important because the best fruit grows only on spurs that are 2 to 3 years old. To promote better flower formation and good light penetration into the tree, separate these bearing surfaces by about 18 to 24 vertical inches from any other layers.

Another way to visualize this type of pruning is to imagine the removal of 65 to 70 percent of the bearing

surface. This is accomplished primarily through thinning-out cuts—removing branches back to their point of origin.

Following the last year of rejuvenation pruning, apply a light application of fertilizer. A good rule of thumb is to apply 0.5 pound of 5-10-10 for each inch of trunk diameter, measured 18 to 24 inches above the soil line. Apply fertilizer at any time from December until April. Scatter it under the entire limb spread of the tree, but keep it at least 6 inches away from the trunk.

FRUIT THINNING

The practice of fruit thinning apples, pears, and stone fruits is much discussed but little understood. Thinning is done for two reasons. First, a certain portion of the fruit is removed so that the remainder will develop adequate size and quality. Second, the thinning process serves to increase the plant's ability to form flower buds for the next year—provided the thinning is done early enough. Thinning also reduces the total load on the branches and reduces breakage. Thinning is necessary for apples, nectarines, pears, plums, and peaches.

Hand thinning is the easiest and safest way to remove excess fruit. Hand thin fruit when the fruits are the size of the end of your little finger—about ½ inch in diameter. Simply start at one end of a branch and systematically remove fruit, leaving one fruit every 6 to 10 inches. It is best to cut the fruit off rather than pulling the fruit. Cutting the fruit will lessen the chance of damaging the spur. Be sure to leave only one fruit at a given site. Where doubles or triples are left, insects and disease will be difficult to control. Keep in mind that only 7 or 8 percent of the tree's flowers are needed to set a full crop of fruit.

An alternative to hand thinning is foliar application of the insecticide Sevin (carbaryl). This method might be necessary on large trees that are difficult to reach. Disadvantages of chemical thinning include the inability to selectively position fruit, the danger of removing too many or too few fruit, and the potential to increase mite populations.

Sevin as a 50WP should be mixed at a rate of 2 to 4 tablespoons per gallon of water and applied in a foliar spray to thoroughly wet the leaves. Apply 10 to 14 days after bloom. Wait for 7 days, then assess the number of remaining fruit. If too many fruit remain to be hand thinned easily, then a second application of Sevin can be applied at the same rate.

INSECT AND MITE PESTS

Information on specific insect, mite, and disease problems of pome fruits follows.

Apple Maggot

The apple maggot, *Rhagoletis pomonella*, is a serious apple pest that often damages homeowners' fruit. Careful management, however, including treating with insecticides and trapping adults before they lay eggs can reduce the chance of injury.

The adult fly is black with three or four white stripes across the body and a prominent white spot in the middle of the back. The wings are clear and have four black bands shaped somewhat like the letter "F." The maggot is white and legless, and can be ¼ inch long when fully grown. Apple maggot fruit damage is characterized by egg-laying scars that cause pitting and dimpling on the apple surface and brown, winding, bacteria-laden trails under the apple's skin caused by the maggot's tunneling and excrement. The apple maggot is sometimes called the "railroad worm" because of the speed at which the maggots dig through the apple and the tunnels they create.

Adult flies start to emerge in mid-June, and most have emerged by the end of August. Peak emergence can occur in mid- to late July. The adults spend a feeding period of 1 to 2 weeks before the female begins to lay her 300 eggs over her 30-day life span. The female lays eggs singly in small holes cut in the apple skin. Each egg hatches in 2 to 10 days, and the young maggot starts to feed, working its way through the fruit. The most severe infestations occur in early maturing and thin-skinned apples.

After the infested apple has dropped to the ground, the mature maggots leave the fruit and burrow up to 2 inches into the soil. The maggots pupate and remain in the soil until the following summer. Only one generation occurs each year in Pennsylvania, although a small percentage of the pupae do not emerge for 2 or more years.

Insecticide treatments based on trap thresholds are one method of controlling the apple maggot. Two or three sticky red spheres baited with an apple volatile are hung in the edge of each orchard block and monitored twice a week. The grower should apply an insecticide treatment when the average number of flies per trap reaches five. After the insecticide residue has declined, captures in the trap are accumulated until the threshold is exceeded again. This method can prevent unnecessary insecticide sprays if maggot density is too low to result in significant injury. Effective control in the absence of trap monitoring can require spray coverage during July, August, and early September. If pesticide treatments are

necessary, products containing broad-spectrum insecticide (e.g., spinosad, pyrethroids, or carbaryl) can be applied.

◆ Trapping alone also can serve as a control measure for apple maggots in small plantings. Baited red spheres hung at a rate of 1 per 100 to 150 fruit are used to “trap out” females before they have a chance to lay eggs. These traps should be placed in mid-June. Other cultural control measures include frequently picking up dropped fruit and removing nearby abandoned trees.

Codling Moth

The codling moth, *Cydia pomonella*, is a constant threat to apple production in Pennsylvania. This species, along with another internal fruit feeder, oriental fruit moth, *Grapholita molesta*, and lesser appleworm, *G. prunivora*, has been known to infest the majority of fruit in untreated orchards. Despite similarities in the way the larvae damage fruit, each species require a special set of treatments at different times during the season. Proper identification of the problem is a crucial to effectively control the pest.

The adult codling moth is approximately $\frac{3}{8}$ inch long and grayish in color. The wing is generally a darker shade of gray near the base, with a dark patch containing coppery scales near the inside wing tip. The larvae have a cream to pinkish body and a brown head with dark speckles on the prothoracic shield (the collar behind the head). When fully grown, larvae are from $\frac{1}{2}$ to $\frac{5}{8}$ inch long. Larvae of the other two species are smaller but otherwise closely resemble the codling moth. The eggs, laid singly, appear as flat, slightly ovoid, discs.

The codling moth overwinters as a full-grown larva within a cocoon under leaf litter, loose bark scales, or any other sheltered place it might encounter. Pupation occurs at about first pink bud, with first flight occurring about the first week of May (full bloom), and peak flight occurring approximately 2 weeks after full bloom. First-generation eggs are laid on leaves near the fruit or on the fruit itself and develop in about 8 to 14 days (first cover spray, about 2 weeks after petal fall on apples). The newly hatched larvae bore through the fruit surface, generally at the blossom or calyx end, and feed near the surface for a time before boring to the core. Here the larvae feed on the seeds and surrounding flesh until they are fully grown in 3 to 4 weeks. Then, they exit the fruit, seek shelter, spin a cocoon, and may or may not pupate. Some first-generation larvae that do pupate emerge as adults in 2 to 3 weeks (fourth or fifth cover spray, July 15 to August 1) and produce a second generation.

The majority of the second generation overwinters as mature larvae.

First-generation larvae that do not pupate enter a quiet phase, overwinter as larvae, and pupate and emerge as adults in the spring. Individuals of the second generation may also pupate and attempt to produce a third generation (seventh or eighth cover spray, September 1 to 15). This generation, which does not survive the winter, is termed a suicide generation. Individuals can, however, inflict additional late-season fruit injury.

Codling moth damage to apples can appear as tunnels or “stings.” Tunnels originate in the calyx or, particularly in the later generations, from the side of the apple and extend to the core. Codling moth larvae that feed on the core characteristically leave frass (excrement) exuding from the point of entry. Stings result from limited feeding and are often small, shallow holes the size of pinpricks with a little dead tissue on the cavity walls. They are caused by early instar larvae that have been poisoned and die shortly after puncturing the apple skin. Oriental fruit moth larvae are less likely to feed on the seeds than are the larvae of codling moth; lesser apple worm larvae feeding is limited to just beneath the skin, either on the side of the fruit or in the calyx.

Controlling the codling moth requires careful monitoring and timing of insecticidal applications, which must coincide with the hatching of larvae. If insecticides are applied too late, the larvae will have had time to tunnel into the fruit and will be sheltered from the effects of any treatments. Applications should begin at late petal fall. To protect pollinators, spraying should not be done during full bloom. Following the petal fall application, cover sprays are necessary to protect the fruit from recently hatched larvae. Controls might be necessary with the hatching of the second and possibly the third generations, depending on conditions in the orchard. Fruit should be examined in mid- to late June for evidence of frass and to determine the need for control of the second generation. Some level of codling moth reduction can be achieved by maintaining good orchard sanitation and removing loose bark from old trees. It might help to place corrugated cardboard bands around apple trunks in September to trap larvae, which should be removed and destroyed in December. If pesticide applications are necessary, the broad-spectrum insecticides (e.g., carbaryl, compounds from the pyrethroid group, rotenone) are recommended. The attract-and-kill material Last Call CM mating disruption can also be successfully used to control this pest as well. In or-

chards where excellent spray coverage can be achieved, the natural product codling moth granulosis virus can be applied to reduce the codling moth population.

European Apple Sawfly

Since 1985, European apple sawfly (*Hoplocampa testudinea*) has extended its range from the northeastern portion of Pennsylvania to the Maryland border. Now this pest is common throughout fruit orchards located in all fruit-growing areas of Pennsylvania.

European apple sawfly adults are about $\frac{5}{16}$ inch long and wasp like, but with a broad attachment of the thorax and abdomen. Sawfly larvae resemble caterpillars but have prolegs on each abdominal segment. Sawflies overwinter as larvae in the soil and have only one generation per year. Adults emerge during late pink and early bloom. Eggs are laid on the calyx end of developing fruit. Young larvae feed along the surface of the fruit and leave a winding feeding scar on the surface. These apples usually remain on the tree, and the presence of the scars can reduce fruit value. Older larvae bore deeply into one or more fruit, usually causing mid-season fruit abortion.

White sticky rectangle traps should be placed at one per 3 to 5 acres along the orchard periphery at pink on the south sides of trees at 5 to 6 feet above the ground. Treatment thresholds are 5.5 flies per trap by petal fall if no prebloom insecticide has been applied or 4.7 flies per trap with a prebloom insecticide.

An application of a broad-spectrum insecticide as soon as pollination is complete is the best control tactic for orchards with a history of this sawfly.

European Red Mite

The European red mite, *Panonychus ulmi*, a major tree fruit pest that attacks apples, stone fruits, and pears, is considered to be one of the most important indirect apple pests in Pennsylvania. The eight-legged female is $\frac{1}{20}$ inch long, bright red, and has four rows of white hairs on her back. The male mite is smaller, lighter in color, and has a pointed abdomen. The overwintering egg is round, bright red, and has a small stalk approximately the length of the diameter of the egg arising from the top. Summer eggs are pale and translucent. Six-legged nymphs hatch from the eggs, molt to eight-legged protonymphs, then become deutonymphs, and finally adults.

The rate at which mites develop is primarily temperature dependent. Hot, dry weather favors development, while cool, wet weather delays mite activities. Over-

wintering eggs are laid in groups on roughened bark, in crevices and cracks, and around bud scales on twigs and branches. Eggs begin to hatch at prepink bud stages and continue throughout bloom. Young mites move to newly opened leaves where they feed, mature, and reproduce. The first generation requires approximately 3 weeks to develop; summer generations are completed in 10 to 18 days. Each female is capable of laying 35 eggs during her average life span of 18 days. Eight to ten generations occur during the year.

Mites feeding on leaves cause injury to the tree by removing nutrients. The most serious injury occurs in early summer when trees are producing fruit buds for the following season. Moderately to heavily infested trees produce fewer and less vigorous fruit buds. Mites feeding on leaves also reduce the ability of leaves to manufacture enough food for desirable sizing of fruit. A characteristic brown foliage that, in severe cases, becomes bronze results from heavy mite feeding.

In general, on apple trees in the dormant period up to prepink, overwintering mite eggs can be evaluated with a hand lens. Pay particular attention to the bases of twigs and spurs. Look for clusters of tiny (less than $\frac{1}{50}$ inch), red spheres. If overwintering eggs are easily visible, especially to the unaided eye, then an early season oil application should be made.

Through June, European red mite populations should be kept low; after July 1, mite populations can be allowed to rise. Close watch must be kept on populations at this time of year. If weather conditions are favorable and predator response is low, a miticide should be applied to suppress mites and allow predator populations to increase. In general, an average of one to three mites per leaf is tolerable through May, five to seven mites per leaf in June and July, and seven to twelve mites per leaf for the rest of the growing season. An exception concerns pears, which are badly damaged even by small mite populations. On pears, a miticide should be applied at the first sign of mites.

◆ Several predators can help control mites and reduce the use of pesticides. These include other predatory mites and other insect species. Of these, the most important in Pennsylvania is the black ladybird beetle, *Stethorus punctum*. This black beetle is small—the size of a pin head—and can be seen walking over the leaves. If disturbed, it quickly falls to the ground. If an average of less than five mites per leaf is present and *Stethorus* is also present, wait a few days to see if the mite population is rising or falling. If the mite population is rising, a pesticide may be necessary. If the mite population is

stabilized or decreasing, the predators might be eating enough mites to control it, and no pesticide should be applied. Also, other mite predators such as *Zetzellia mali*, *Amblyseius fallacis*, or *Typhlodromus pyri* should provide excellent mite control. The applications of pyrethroid insecticides and carbaryl, used for the control of various other pests, are very detrimental to natural mite predators and are known to flare mite populations on fruit trees.

Green Aphids

Green aphids include two species that are very difficult to distinguish, the apple aphid, *Aphis pomi*, and the spirea aphid, *A. spiraecola*. Recently, the spirea aphid was found to have become the most common species on tree fruits and is thought to have adapted to a host range similar to that of the apple aphid. Hosts of green aphids include apple, pear, quince, and hawthorn trees. The aphids are abundant during June and July on young trees, water sprouts, and vigorously growing terminal branches. They curl the foliage and cover it with honeydew, upon which grows a black fungus that smuts both the fruit and leaves and causes considerable discoloration, especially of early apples.

Eggs are small, shiny, and black. Most are laid on bark or on buds in the fall by the wingless female. The eggs hatch in spring about silver tip. They hatch into stem mothers—wingless females that are pear shaped and bright green. These give birth to a generation of green viviparous aphids, about three-quarters of which develop into winged females. The rest remain wingless. The winged forms spread the species to other parts of the tree or other trees. About half of the second generation and some of the later generations develop wings and migrate.

Unlike rosy apple aphids, green aphids live on the apple tree all year, breeding continuously during the summer. In August and during the autumn months, they are found almost exclusively on water sprouts or terminal branches of young trees that are still growing, and such locations are where the male and female sexual forms are produced.

Immature stages of the green aphids can be distinguished readily from early stages of the rosy apple aphid by the length of the cornicles (“exhaust pipes”). Rosy apple aphids have well-developed cornicles, while those of the green aphids are scarcely developed. Also, the rosy apple aphid has a longer antenna than the green aphids.

Since the overwintering eggs are indistinguishable

from rosy apple aphid eggs, early season scouting and management for both species are identical. Since these aphids do not migrate to alternate hosts as rosy apple aphids do, however, they must be scouted for and managed until the terminals harden off. Beginning in early June, randomly select 10 growing shoots (not water sprouts). On each shoot, determine the number of leaves that have aphids. If an average of more than 4.2 leaves per shoot is aphid infested, an insecticide application is recommended. If pesticide applications are necessary, a single spray of product containing imidacloprid will provide excellent control of aphids. Applications of summer horticultural oils will also provide good control of various aphid species. In many years, green aphids will be controlled by naturally occurring predators, including fly and lacewing larvae and ladybird beetles.

Gypsy Moth

The gypsy moth, *Lymantria dispar*, might attack fruit trees, especially apple trees, causing leaf damage. Damage can be severe on young trees, where defoliation can stunt or kill the plant.

Egg masses are deposited in July on trees, rocks, and other surfaces, where they overwinter. Eggs hatch from late April through early June, with most hatching by mid-May. Young larvae might stay near where they hatch or, by forming a long silk thread, be picked up by the wind and carried great distances. This is when orchards are invaded. The black, hairy caterpillars feed on leaves until mid-June, then pupate, molt to adults, and lay eggs.

Trees should be inspected in early June. If gypsy moths are found, they can be removed by hand and destroyed, or killed with an insecticide. Bt (*Bacillus thuringiensis*) or spinosad are very effective choices and least toxic to other animals.

Oriental Fruit Moth

Oriental fruit moth, *Grapholita molesta*, is a pest of most stone and pome fruits. In pome fruits, its appearance and injury is similar to that of the codling moth and lesser appleworm.

Adults are gray, with a wing spread of ¼ inch; the wings are gray with brown markings. Eggs are single, flat, whitish ovals on twigs or the undersides of leaves. Larvae are grayish white with a black head and reach ½ inch at maturity. Larvae are distinguished from codling moth by the presence of a black anal comb on the top of the last body segment.

Oriental fruit moths have four to five generations per

year in Pennsylvania, with the first and last two generations being the most numerous. They overwinter as larvae in silken cocoons on the tree or on the ground, and they pupate and begin to emerge as adults during April, shortly before peach trees bloom. These females lay up to 200 eggs, primarily during May. The succeeding overlapping generations extend into September and October.

The earliest indication of injury is a dying back of the new growth of twigs in spring. A first-generation larva enters at a leaf axil near the tip of a shoot and bores down the central core for several inches, causing the terminal to wilt, or “flag.” Later-generation larvae may enter the fruit near the stem end and make feeding burrows that usually extend to the pit or to the core. The mature larva exits the fruit from the side leaving a large gumming hole with much frass. In apples, oriental fruit moth larvae may feed around, but not in, the core.

Insecticide spray timing can be aided by using pheromone traps. The sex pheromone traps should be placed in stone fruit and/or apple orchards in early April and checked at least once per week. Broad-spectrum insecticide spray should be applied about 7 days after the beginning of the generation(s) and repeated 7 to 10 days later for each generation. Orchard sanitation also helps—remove dropped fruit and other ground litter that may serve as development and overwintering sites.

Mating disruption (e.g., attract-and-kill Last Call OFM) can be used to manage this pest. Pheromone and insecticide solution droplets should be placed in the mid to upper level of the tree canopy at the label rate at pink stage of apples and again at about every 45 days. The droplets remain effective for at least 6 to 7 weeks. Moreover, monitoring should proceed as usual to check the effectiveness of disruption.

Pear Psylla

Pear psylla adults, *Cacopsylla pyricola*, look like small cicadas. They are about 1/10 inch long and are dark reddish brown. The adults, which overwinter on trees or other sheltered places, become active any time the temperature is above 40°F. Females begin laying tiny, pear-shaped, yellowish eggs in cracks in the bark and around the buds in late March and continue through the white bud stage. The peak of egg laying is green tip to green cluster bud. Eggs hatch in 2 to 4 weeks, and the yellowish, wingless nymphs move to succulent stems and developing leaves to feed. Nymphs are flattened, covered with honeydew, have sucking mouth parts, and feed on plant sap. Four to five generations are born each year.

The pear psylla secretes large amounts of honeydew, which runs down over foliage and fruit and in which a sooty fungus grows. This causes the skin of the fruit to become blackened and scarred and the foliage to develop brown spots. Heavy infestations can cause partial to complete defoliation of trees, reducing vitality and preventing the formation of fruit buds.

Orchards with a history of severe psylla infestations should receive an intensive insecticide program beginning in the dormant period. To prevent egg laying, oil should be applied in mid-March to early April, depending on the location in the state. At green cluster bud, a treatment of oil plus a pyrethroid compound should be applied. If psylla are still present at petal fall, begin kaolin clay (Surround) applications at about 10-day to 2-week intervals. Shorten spray intervals if psylla persist. Good spray coverage is essential to controlling this difficult pest.

Plum Curculio

Pennsylvania weather is variable during May and June, frequently changing from periods of cold wind and rain to stretches of abnormally high temperatures. These climatic irregularities govern the activities of the plum curculio, *Conotrachelus nenuphar*, a pest injurious to pome and stone fruits throughout the state.

Adult plum curculios first appear in apple orchards during bloom. The beetle is 1/4 inch long, dark brown with whitish patches, and has four humps on its back. The adult has a long snout (one-third its body length) projecting forward and downward from its head. Most beetle activity occurs during the first warm period after petal fall, when the maximum temperature is 70°F or higher. Periods of cool, rainy weather with maximum temperatures below 70°F are not suitable for curculio activity. The plum curculio is usually more abundant on fruit trees adjacent to woods, fence rows, and trashy fields. Adults can be found in orchards for 5 to 7 weeks.

Small, pearly white eggs are laid singly in a small cavity underneath the fruit skin during the first warm periods after petal fall; eggs hatch in 7 days. Slight feeding occurs on petals, buds, and blossoms, but little injury occurs until the fruit is available. When the fruit is approximately 1/2 inch in diameter, it provides abundant food and a suitable place for egg laying. Early blooming varieties are the first to provide suitable locations for feeding and depositing eggs.

The yellowish-white larva has a brown head and is 1/4 inch long when fully grown. It burrows into the fruit's center, where it makes large irregular cavities, feed-

ing for 16 days before maturing. Larvae then leave the fruit and enter the soil, where they transform into adult curculios that emerge during August and feed for a short time before seeking winter quarters.

Adults make both feeding punctures and egg punctures in the fruit. Feeding punctures are small, round holes extending $\frac{1}{8}$ inch into the fruit; egg punctures are distinguished by a characteristic crescent-shaped cut that partly surrounds the sunken egg. An adult averages more than 100 feeding and/or egg punctures during its normal life. Feeding punctures cause deformed fruit and contribute to premature drop.

The critical period for controlling plum curculio is during the first few days of warm weather following petal fall, when the maximum temperature remains approximately 75°F. Control is more difficult when feeding is greatly reduced by low temperatures and moderate rains because spray deposits are washed from fruit and foliage. However, low temperatures also extend the period during which curculio is active in orchards. It is advisable to spray perennial trees or trees adjacent to woods more frequently. The length of time between sprays is as important as the insecticide combination. Kaolin clay (Surround) can be used to reduce the plum curculio infestation.

In trees with a history of plum curculio injury, the following are important considerations: (1) shorten the interval between sprays during peak curculio activity (this might be necessary on outside rows only), (2) increase the insecticide rate during peak activity, and (3) select the most effective insecticides without sacrificing control of other pests or interfering with the integrated pest management program. On stone fruits, time sprays for the shuck split stage.

Rosy Apple Aphid

The rosy apple aphid, *Dysaphis plantaginea*, has been a major pest of apple trees, causing both direct and indirect injury since the end of the nineteenth century. The egg, laid on the bark of apple trees, is oval and about $\frac{1}{2}$ millimeter long. When first laid, it is bright yellow, but it gradually changes to greenish yellow and finally to a shiny jet black. The individuals that hatch from the eggs in spring are all viviparous (giving live birth) wingless females, which are called “stem mothers” when mature. The bodies of these aphids have a waxy coating and usually a slight purplish or rosy tinge, hence the name.

There are five instars, the last being that of the mature stem mother, which begins to parthenogenetically (without mating) bring forth living young shortly after the

fourth instar. These young are produced at an average of five to six per day. The nymphs of the second generation, all of which are females, reach maturity in 2 to 3 weeks; the great majority begins to reproduce on the apple, although a few might develop wings and migrate to the weed plantain. The third generation is produced in June and early July. The majority of this generation develops wings and migrates to another plant species—plantain.

Although apple trees are its preferred host, this species also feeds on pear and hawthorn trees. Untrimmed trees make conditions more favorable for aphids and greatly handicap methods of control. A cool, wet spring favors aphid development because it provides conditions unfavorable for parasites and predators of aphids.

The eggs usually hatch when buds are at the silver tip stage in spring. Egg hatch is complete by the $\frac{1}{2}$ -inch green stage. The young, as soon as they hatch, seek out the opening buds of the apple, seeming to prefer the fruit buds. They feed on the outside of the leaf bud and fruit bud clusters until the leaves begin to unfold. Then, they work their way down inside the clusters and begin sucking the sap from the stems and newly formed fruits. Their feeding causes the leaves to curl, affording the aphids protection from sprays and some natural enemies.

Aphids cause a decrease in tree vigor because of foliage loss and damage to the fruit through dwarfing, misshaping, and staining. The severe curling of foliage caused by this species is probably the most characteristic feature of its work. Another of this species' most characteristic features is the congregating of young aphids around the mother. Each stem mother or group of mothers will have hundreds of young massed about it so that infested leaves might soon be covered—in some cases, by more than one layer of aphids. This habit of congregating soon causes the death of the infested leaves and the consequent migration of the aphids.

In the fall, the winged females fly back to the apple trees. The males mate with the females, which then deposit eggs on the bark. Overwintering eggs are usually present sometime before silver tip. If eggs are found, delayed-dormant oil and insecticide sprays should be applied. Starting at early pink, trees should be routinely inspected. Pay particular attention to sensitive varieties such as Golden Delicious, Rome Beauty, Stayman, and York. For 3 minutes, count the number of fruit spurs showing curled leaves on each tree. If, on average, more than three-quarters of the clusters are aphid infested, a pink insecticide application of a product containing imidacloprid is recommended.

San Jose Scale

The San Jose scale, *Quadraspidiotus perniciosus*, is a pest of fruit trees; it also attacks many other trees, as well as shrubs. Once established, most scale insects are difficult and expensive to control.

Female scales are very prolific and can produce approximately 400 young over a 6-week period. The San Jose scale produces living young called “crawlers”; most other scales produce eggs. Crawlers move around for a short period in search of a suitable place to settle.

Two to three generations of the San Jose scale are born each year. The scale overwinters as immature “blackcaps”; adults mature during the bloom period. Males emerge and mate at apple petal fall. First-brood crawlers begin appearing in early June and continue for a month in southern areas of Pennsylvania. These crawlers develop into mature adults by late July. Second-brood adults appear from late July to early September; if a third brood occurs, it appears in late October to early November. The life cycle is completed in about 37 days. Crawlers usually can be found from early June until a hard frost in the fall.

Crawlers are lemon colored and very small ($\frac{1}{25}$ inch long). When they settle, they secrete a waxy substance that produces a grayish-yellow scale covering that becomes darker with age. The male scale is oblong, with a small black spot near one end, and is much smaller than the female. Color varies with age—very young females are round and nearly white but turn dark gray as they mature. A characteristic black spot appears in the center of the scale.

Scales on new vegetative growth and fruit produce deep purplish-red coloration in the tissue. When scales are removed from the fruit, a light-colored “bull’s eye” is evident. Additional injury to the tree is caused by loss of plant sap, which depletes vigor and decreases yield. Prolonged attack causes the wood to crack and split; if the scale is not controlled, the tree might die.

Scales are especially difficult to control on large trees with rough bark. The secret to successful control is thorough pesticide coverage. If scales are present, the trees will benefit from an oil spray at the dormant or delayed-dormant period. Later in the season, usually from early to mid-June, the crawlers can be targeted if the oil sprays were less than effective. To accurately time these sprays, locate infested branches and wrap black electrician’s tape around the branch at each end of the infestation. Coat the middle section of the tape with a very thin film of petroleum jelly. Check the tape often for the presence of crawlers trapped in the jelly. Apply an insecticide when the first crawler is observed.

DISEASE DESCRIPTIONS AND MANAGEMENT

See basic cultural guidelines for the control of plant diseases under “Pest Management,” discussed on page 24 in Chapter 2. A list of pesticides available on various fruit crops for the control of diseases can be found in Table 2.4. Pictures of fruit diseases can be found on the Fruit Pathology Fact Sheets at <http://fpath.cas.psu.edu/factsite.html>.

Apple Crown and Collar Rot

Crown rot continues to be a major cause of tree death in Pennsylvania orchards. It often is observed on 3- to 8-year-old trees. Certain rootstocks are more susceptible to the pathogen than others. The disease often occurs in low-lying areas of orchards with heavy, poorly drained soils. The incidence of this disease has increased with the introduction of more dwarfing rootstocks.

Symptoms

The first symptoms to appear in the spring are delayed bud break, leaf discoloration, and twig dieback. These symptoms indicate that crown infection is advanced. Although infected trees might survive the growing season, they show symptoms of leaf and bark discoloration and premature leaf drop in the fall.

The most obvious symptom found on affected trees is a partial or complete girdling of the trunk. Infected bark becomes brown and is often slimy when wet. Close examination of the roots often reveals reddish-brown, water-soaked areas of necrotic tissue located at the base of the root where it attaches to the rootstock. The entire underground portion of the stem is usually water soaked and brown, and the necrotic area usually extends upward to the graft union.

Disease Cycle

The disease is caused by fungi in the genus *Phytophthora*, which belongs to a group of fungi known as the water molds. The fungus survives in the soil for several years as spores that are resistant to drought and somewhat resistant to chemicals. The fungus requires high levels of moisture and cool temperatures for growth and reproduction, and grows best at temperatures around 56°F. Trees, therefore, are attacked at about blossom time (April) and during the onset of dormancy (September). The fungus can infect apple trees in the following ways: (1) collar rot—infection above the tree union, (2) crown rot—infection of the lower trunk and root bases, and (3) root rot—infection of the lateral and fibrous root system.

Disease Management

- ◆ The following techniques are useful in managing apple crown and collar rot:
 - Rootstock selection—Of the rootstocks preferred by growers, none is completely resistant to crown rot. The rootstocks M.7 and MM.106 have appeared to be the most susceptible. The most resistant rootstock is M.9.
 - Orchard site selection—Avoid planting orchards in heavy, poorly drained soils. These sites favor fungal growth and development. Crown rot prevention is difficult, and eradication almost impossible in low-lying, poorly drained sites.
 - Horticultural—If the tree has not been girdled completely, remove the soil from the base of the tree; scrape the surface of the discolored area and leave it exposed to dry. Drying often stops crown rot from progressing further.

Apple Scab

Apple scab is Pennsylvania's most important apple disease, attacking wild and cultivated apple and crabapple. Early season disease management is primarily directed at controlling apple scab.

Symptoms

The first infections often occur on the leaves surrounding flower buds. Dull, olive-green areas visible on the undersides of leaves are the first evidence of the disease. As the lesions (infected areas) become older, they assume a definite outline as olive-green or brown circular spots. Leaves are susceptible to infection for about 5 days after they unfold. Severe early leaf infection can result in dwarfed, twisted leaves, which might drop later in the season.

Early infection can occur on the calyx (blossom end of the fruit) or on the pedicel (fruit stem). Severe pedicel infection results in fruit drop. Fruit can become infected at any time in its development. Typical fruit lesions are distinct, almost circular, rough-surfaced, olive-green spots. Heavily infected fruits are usually misshapen and might crack and drop prematurely. When leaf infection is active just before harvest, the fruit might become infected. These spots do not show at harvest time, but develop slowly while the apples are in storage. This phase of apple scab disease is termed storage scab.

Disease Cycle

Apple scab is caused by the fungus *Venturia inaequalis*, which overwinters in infected leaves that have fallen

to the ground. Fruiting bodies are produced within the dead leaf tissue. As spring approaches, these begin to mature and produce spores (ascospores) that are discharged into air currents and carried to developing apple buds. The fruiting bodies in the fallen leaves must be wet for the spores to discharge. The ascospores are not all discharged with the first spring rains since they mature over a 4- to 6-week period.

If the spores remain wet for a few hours after landing on wet apple buds, leaves, or fruit, they germinate and grow into the apple tissue. The time required for germination and penetration depends on the temperature and the presence of a wet surface. After the fungus has penetrated, it continues to grow beneath the cuticle. After 8 to 18 days (development occurs most rapidly at high temperatures), a visible scab lesion is produced. On its surface appear more spores (conidia), which are easily dislodged when the lesions are wet. The spores are splashed around by rain and blown by wind to new leaf and fruit surfaces within the tree. They germinate on wet surfaces, infect the tissue, and produce a new lesion. In this manner, several secondary infection cycles can occur in the course of a growing season.

Disease Management

Scab infections may be prevented by applying fungicides at regular intervals throughout the growing season. The objective is to provide a protective coating that will inactivate any spores landing on the fruit and foliage. It is critical to control scab early in the season, from bud emergence through the second spray after blossom petals fall (second cover period). If scab infection can be prevented during the time all the ascospores are discharged from the fruiting bodies in the fallen leaves, the disease cycle is broken and no further source of infection remains for the rest of the season. If the cycle is not controlled, however, and leaf and fruit infection do occur, then conidia are produced on these lesions and scab will remain a constant threat all season whenever wet weather occurs.

◆ The proper selection of varieties can help reduce the need to control this disease. Scab-resistant apple varieties are available. A list of these varieties appears in Table 4.1 at the beginning of this chapter. Orchard sanitation is also important in the prevention and spread of this disease. Keeping the orchard floor free of leaf litter also aids in disease control.

Bitter Rot of Apple

Bitter rot, *Glomerella cingulata*, is an important disease in the southern states and infrequently occurs in Penn-

sylvania. Its hosts are apple and pear trees. On the fruit of nectarine, the same fungus causes a disease known as anthracnose; on grape, it causes ripe rot; and on chestnut, it causes blossom-end rot of green burrs. The discussion below is limited to the disease as it affects apple and pear trees.

Symptoms

Bitter rot occurs only on fruit. Cankers can form on twigs, but they are rare. The fungus is one of the few fruit rot organisms that can penetrate the unbroken skin of the fruit. The disease first appears during midsummer or later as a small, light-brown, circular spot. One or many spots might appear; if temperatures are high, they enlarge quite rapidly and soon change to a dark brown. By the time the spots are $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, they are distinctly sunken or saucer shaped. When they reach $\frac{1}{2}$ inch in diameter, small, black dots—the fruiting bodies of the fungus—appear in the sunken lesion. These might be arranged in concentric rings. Later, they ooze a gelatinous, salmon-pink mass of spores, which is washed by rains onto other fruit. Beneath the surface of the spot, the flesh is light brown and watery in a cone-shaped area, with the small end of the cone toward the fruit center. As the fruit ripens, it decays rapidly and finally shrivels into a mummy.

Disease Cycle

The fungus overwinters in mummified fruit and in cracks and crevices in the bark. Jagged ends of broken limbs are ideal sites. With the advent of warm weather, the fungus produces spores washed by rains onto developing fruit. Often, the first infections appear as a cone-shaped area within the tree and can be traced to a source of spores at the tip of the cone. The disease develops optimally in rainy conditions, with a relative humidity of 80 to 100 percent and a temperature of 85°F.

Disease Management

Routine fungicide sprays normally control bitter rot in Pennsylvania. Summer fungicide applications should not be extended beyond 14-day intervals. Sanitation practices, such as removing mummified fruit, are important in controlling this disease. ♦

Black Rot of Apple

The black rot fungus, *Botryosphaeria obtusa*, covers a wide geographical range and attacks the fruit, leaves, and bark of apple trees and other pomaceous plants. The fungus is a vigorous saprophyte and can colonize the dead tissue of many other hosts; however, its parasitic activities are confined mainly to pome fruits.

The disease can occur in three forms: as a fruit rot, leaf spot, or limb canker on apple trees, and as a fruit rot on pear or quince trees. In northern regions, losses from black rot principally result from the cankering of large limbs and the dieback of twigs and branches. Losses from fruit rot and defoliation resulting from leaf spot can be considerable, especially in warm, humid areas of southern and central fruit-growing regions of the eastern United States.

Symptoms

The first signs of black rot are small, purple spots appearing on the upper surfaces of leaves 1 to 3 weeks after petal fall. Leaf margins remain purple, while the centers turn brown, tan, or yellowish brown. After a few weeks, secondary enlargement of leaf spots occurs. Because this is not a uniform expansion, the spots become irregular or lobed in shape, at which time they assume a characteristic “frog-eye” appearance: a purple margin with a zone of dark brown surrounding the tan-to-gray center. Small, black pycnidia (pimple-like fruiting bodies of the fungus) might appear in the centers. Leaves that are heavily infected will drop from the tree.

Infected areas of branches and limbs are reddish brown and sunken slightly below the level of the surrounding healthy bark. These cankers might expand each year, with a few eventually reaching several feet in length. Pycnidia are produced abundantly on limb cankers.

Fruit rot usually appears at the calyx end of the fruit. It can originate at any wound that penetrates the epidermis, including insect injuries. Usually only one spot occurs per fruit—a characteristic that distinguishes black rot from bitter rot. Initially, the infected area becomes brown and stays brown or turns black as it increases in size. As the rotted area increases, a series of concentric rings often forms. The flesh of the decayed area remains firm and leathery. Eventually, the apple completely decays, dries, and shrivels into a mummy. Pycnidia that contain spores of the black rot fungus appear on the surface of the rotted tissue.

Disease Cycle

The fungus overwinters in dead bark, dead twigs, cankers, and mummified fruit. It can invade almost any dead, woody tissue and frequently is found in tissue killed by fire blight. Early leaf infections often are visible as a cone-shaped area on the tree, with a dead twig or mummified fruit at the apex.

In the spring, spores (conidia and ascospores) are released during rainfall throughout the season. Conidia

might continue to be produced during wet periods throughout the summer and can remain viable for long periods. Disseminated by splashing rains, wind, and insects, these spores can infect leaves, the calyxes of blossoms, tiny fruit, and wounds in twigs and limbs. Leaf infection develops during petal fall, at which time conidia attach, germinate, and penetrate through stomata or wounds. Infections of fruit and wood might not become visible for several weeks. Initial fruit infections occur during the bloom period but are not usually apparent until midsummer as the apple approaches maturity. Throughout the growing season, infections occur through wounds.

Disease Management

Cultural control strategies can affect the level of control achieved for black rot. Management programs based on sanitation to reduce inoculum levels in the orchard are the primary means of control.

- Carefully prune and dispose of dead wood. This should be an important component of both current-season and long-range management. ◆
- Prune and remove cankers; properly dispose of prunings by burial or burning. ◆
- Remove all mummified fruit. ◆
- Control fire blight by pruning out infected wood or controlling insect vectors. ◆

Blossom End Rot of Apple

Blossom end rot of apple is not a major problem in Pennsylvania orchards. Because it occurs only infrequently, very little is known about its disease cycle and control. The disease, caused primarily by the fungus *Botrytis cinerea*, attacks the blossom end of apple fruit. The infection is likely to occur during bloom, although it is not visible until several weeks later. The infected area appears as a small, 1/4- to 1/2-inch-diameter lesion next to or including part of the calyx. Usually brown, the spot is slightly sunken and often has a red border. A dry or corky shallow rot develops in the flesh beneath the spot.

Blossom end rot appears to be more common in seasons of prolonged cool, wet weather during and shortly after bloom. It has appeared most frequently on Delicious, McIntosh, and Rome Beauty, apples. On stored fruit, especially Delicious, blossom end rot often leads to a moldy core.

Blotch of Apple

Blotch is caused by the fungus *Phyllosticta solitaria*, which can infect the fruit, leaves, and twigs of apple and crabapple trees. Only occasionally seen in Pennsylvania fruit orchards, this disease does not pose a very large problem for apple producers here.

Symptoms

Two types of leaf spots appear as a result of blotch. The less frequent appears between the leaf veins as a small, light-gray spot with a dark dot in its center. The more common leaf spots occur on the veins, midribs, and petioles (leaf stems) as long, narrow, slightly sunken, light-colored lesions. These contain several dark dots—the fruiting structures (pycnidia) of the fungus. When petiole infections are numerous, leaves might drop off.

New shoot infections look similar to petiole infections at first, except that they are longer and more visible. They occur at the juncture of the petiole with the shoot (node) or between the nodes. Once the lesion is established, it might continue to enlarge for 3 or 4 years, becoming noticeably larger than the diameter of the normal limb. In this manner, the organism causing apple blotch establishes itself in the tree.

Fruit infections vary in size from small, dark spots to large blotches that can cover much of the fruit surface. Edges of the larger lesions are irregularly lobed with many radiating projections. Large lesions often cause the fruit to crack.

Disease Cycle

The fungus overwinters in twig and limb cankers. The first infections in spring occur at about petal fall on leaves, young fruit, and new shoot growth and are caused by spores oozing from the cankers. Secondary infections from spores produced in the pycnidia can occur until late summer. Frequent rains and temperatures above 75°F favor the disease.

Disease Management

Routine fungicide applications normally will control this disease in Pennsylvania. Summer fungicide applications should not be extended beyond 14-day intervals. Control also is achieved by planting disease-free nursery stock and resistant varieties such as Delicious. ◆

Blue Mold of Apple

Blue mold, a common rot of stored apples and pears, is caused by the fungus *Penicillium expansum*. Other names for the disease are “soft rot” and “Penicillium rot.” Soft rot is a disease of ripe fruit and develops

mostly on apples that are picked before they are mature. Firm fruit in the same container as decaying fruit might absorb a moldy odor and flavor.

Symptoms

Soft rot appears as soft, light-brown, watery spots that begin around injuries or lenticels on the outer surface of fruit. Rotted fruits have a characteristically moldy odor and flavor. When the relative humidity is high, grayish-blue masses of spores might appear on the fruit surface. Under favorable conditions, the entire fruit can rot in 2 weeks.

Disease Cycle

Spores of the soft rot fungus are present almost everywhere and can survive long periods of unfavorable conditions. Injuries to fruit, especially during picking and handling operations, are the primary points of entry. At ordinary temperatures, infected fruit can rot in 2 weeks or less.

Disease Management

◆ To control blue mold, it is important to prevent fruit from becoming bruised during picking and handling. Fruit should be harvested at optimum maturity. It is also essential to move harvested fruit into cold storage as rapidly as possible.

Brooks Fruit Spot of Apple

Caused by the fungus *Mycosphaerella pomi*, Brooks fruit spot is also known as Phoma fruit spot. The disease attacks apple and crabapple trees and rarely is found in well-sprayed orchards. When sprays are stopped too soon, or when trees are not well-pruned and sprayed, severe losses can occur. Varieties such as Grimes Golden, Jonathan, Rome Beauty, and Stayman are quite susceptible.

Symptoms

Brooks spot appears on immature fruit in late June and July. Spots on fruit are about 1/4 inch in diameter, irregular in shape, slightly sunken, and usually most numerous on the calyx end. On red-skinned varieties, lesions are dark red to purple. On light-skinned varieties, lesions remain dark green. Unless infected fruit is placed in cold storage immediately after harvest, the spots increase in size and become more sunken, thus more visible.

Disease Cycle

The fungus overwinters in apple leaves on the orchard floor. About the time of petal fall, ascospores are discharged from fallen leaves. How the fungus gets on the

leaves is not known since there is no evidence of the disease on leaves while they remain on the trees. Rain and high humidity favor spore discharge and infection of fruit. Infections continue until midsummer, although they decrease as the season progresses.

Disease Management

Routine fungicide applications normally control this disease in Pennsylvania. Summer fungicide applications should not be extended beyond 14-day intervals. Golden Delicious, Jonathan, Rome Beauty, and Stayman, are susceptible. Delicious is somewhat resistant.

Fire Blight of Apple and Pear

Fire blight is destructive to apple and quince trees and is the most serious pear disease in the eastern United States. In recent years, significant losses to the apple industry have resulted due to this disease. Caused by the bacterium *Erwinia amylovora*, the disease can attack some 75 species of plants of the rose family. Fire blight also occurs frequently on pyracantha, spirea, hawthorn, and mountain ash. In fruit trees, the disease can kill blossoms, fruit, shoots, limbs, and tree trunks. Certain varieties of apple are more susceptible than others. Susceptible varieties include Gala, Ginger Gold, Idared Jonathan, Rome Beauty, and Yellow Transparent.

Symptoms

Fire blight kills fruit-bearing spurs, branches, and entire trees. It can be distinguished from other disorders by droplets of red-brown, sticky, liquid, bacterial ooze that seeps from the surfaces of infected tissue. The disease gains entry to the tree through two main points—blossoms and new shoots—and often appears first in the spring as blossom, fruit spur, and new shoot blight. Infected blossoms wilt rapidly and turn light to dark brown. Bacteria might move through the pedicel to the fruit spur and out into the leaves, where they follow the midrib and main veins, which soon darken. The leaves wilt, turning brown on apple and quince, and dark brown to black on pear. The blighted leaves remain attached for much, if not all, of the growing season. Some remain even after normal leaf fall.

Fire blight's two main symptoms are shoot blight and cankers on limbs. Shoot blight begins with the infection of the young, succulent growing tip, which turns brown to black. This infection might occur at any time during the season while the shoots are still growing and when environmental conditions are most favorable for the disease. The leaves wilt rapidly, turn dark, and remain attached, as in the case of spur blight. A characteris-

tic symptom of shoot blight is the bending of terminal growth into the shape of a shepherd's crook. Pearly or amber-colored droplets of bacterial ooze are often present on diseased blossoms, fruit, and leaf stems, on succulent shoot stems, and on the exterior of infected fruits. Inside these droplets are millions of bacteria, which can cause new infections.

Fire blight bacteria can move from blighted spurs and shoots into larger limbs and tree trunks. Infected branches can be girdled, resulting in loss of the entire branch. Suckers at the base of trees often are invaded and can blight back to the trunk or rootstock, causing the loss of the entire tree in one season. This is true of susceptible pears, especially Bartlett, Bosc, and Clapp's Favorite, and certain clonal apple rootstocks, especially M.26 and M.9.

Cankers, slightly sunken areas of various sizes surrounded by irregular cracks, occur on small to large limbs, trunks, and even roots. They often begin at the bases of blighted spurs, shoots, and suckers. Active blight cankers are characterized by an amber or brown exudate on their surfaces or on the bark below.

The bacteria also can invade fruit, which becomes water soaked. Droplets of bacterial ooze appear on the surface. Later the fruit becomes leathery, turns brown on apples and black on pears and quinces, shrivels, and usually remains attached to the fruit spur.

Disease Cycle

Bacteria overwinter in the margins of cankers on branches and trunks. When the temperature reaches about 65°F, bacteria begin to multiply and appear on the outsides of the cankers in drops of clear to amber-colored ooze. The bacteria are spread to blossoms primarily by rain, with some transmission by flies and ants. Blossom-to-blossom transmission is carried out mainly by bees and other insects that visit the flowers. The spread of the bacteria from flower to flower by bees is rapid. Insects also transmit bacteria to growing shoots. If the temperature is 65°F or higher and relative humidity is at 60 percent or more, or if there is rain, new infections can occur. At 75°F, blossom blight and shoot blight will be evident in 4 to 5 days. Bacterial ooze appears on the new infections soon after the symptoms, providing additional sources of bacteria for new infections. In early to midsummer, during prolonged periods of muggy weather, blighted shoots and spurs, infected fruit, and new branch cankers all might have droplets of ooze on them.

The bacteria usually enter the flowers through natural openings such as stomates. Wounds also are important entry points to leaves, shoots, and fruit. Aphids, leafhop-

pers, lygus bugs, and other insects with piercing mouth parts can transfer fire blight bacteria directly into susceptible tissues. Wounds from hail and wind-driven rain often lead to a severe outbreak of fire blight. Any fresh wound can serve as an entry point.

Disease Management

Temperatures just before and during bloom will determine if fire blight becomes serious in early spring. Daily temperatures must average 65°F or higher during pink through petal fall for bacterial populations to grow enough to cause severe disease. The disease also occurs later in the season when bacteria enter late-opening blossoms or growing tips of new shoots.

Where this disease was present the previous year, we suggest the following management program:

- Prune out all cankers from limbs 1 inch or more in diameter. Cut apple limbs at least 8 inches below external evidence of the canker and cut pear limbs at least 12 inches below. Pruning tools do not need to be disinfected when temperatures are below 45°F.
- Where the disease was severe the previous year, apply a dilute Bordeaux spray plus miscible superior oil at silver tip. This spray is not warranted if only occasional infections occurred.
- When daily temperatures average 65°F or higher during pink through petal fall, make at least two applications of a streptomycin formulation. Apply the first streptomycin spray anytime after first blossoms open, when daily temperatures are above 65°F or are expected to be so within 24 hours. Repeat sprays at 5- to 7-day intervals through late bloom. A minimum of two applications is necessary to provide control. (Streptomycin formulations are much more effective when applied during slow drying conditions, such as at night.)
- When average daily temperatures fail to reach 65°F during pink through petal fall, delay the streptomycin application until the disease first appears. To detect the first appearance of fire blight, inspect trees at 5- to 7-day intervals beginning at petal fall. When the disease appears, prune out all new infections. Again, remove shoots 8 to 12 inches below the last signs of browning. Remember to disinfect pruning tools between cuts with a bleach solution or alcohol since contaminated tools can spread the disease.

We do not recommend cutting out blighted shoots after terminal growth has stopped. When growth stops, the spread of fire blight should also stop. The most important thing to do to control fire blight during the summer

is to control sucking insects like aphids and leafhoppers. Applying streptomycin sprays within 24 hours after hail to prevent new infections is also a good practice.

Proper fertilization practices can help reduce the potential for fire blight. Trees that are excessively vigorous due to high nitrogen applications can be more prone to fire blight. Variety selection also can help reduce the incidence of this disease. Many of the scab-resistant varieties are resistant to fire blight (see Table 4.1). Varieties such as Jonathan and Rome Beauty are more susceptible to fire blight. Resistant pear varieties include Magness and Moonglow. ♦

Nectria Twig Blight of Apple

Nectria twig blight, caused by the fungus *Nectria cinabarina*, is a minor disease that breaks out occasionally. Because its symptoms are similar to those of fire blight, growers need to be able to recognize it. The chemical controls used for fire blight would be wasted on Nectria twig blight.

Symptoms

In early summer, leaves and shoots of infected twigs wilt and turn brown. Close examination will show that a canker has girdled the twig at the point where shoots begin to grow. Most often, this spot is located at the base of the previous season's cluster bud. Rome Beauty and close relatives such as Gallia Beauty, characterized by enlarged cluster-bud bases, are very susceptible. In midsummer, a few pink or coral fruiting structures of the fungus might appear in the cankered area.

Disease Management

No control is necessary.

Fabraea Leaf and Fruit Spot of Pear

This disease should not be confused with the fire blight or leaf spot diseases of pears. Leaf blight and fruit spot are caused by the fungus *Fabraea maculata*, which infects the leaves, fruit, and shoots of pear and quince and the leaves of apple trees. The disease can build up rapidly, even in orchards where it has not been a problem. If conditions favor the disease and it is not controlled, pear trees can become defoliated in a few weeks.

Symptoms

Leaf spots first appear as small, purple dots on the leaves nearest the ground. They grow to circular spots and become purplish black or brown. A small, black pimple appears in the center of the spot. When the leaf is wet,

a gelatinous mass of spores oozes from the pimple and gives the spot a creamy, glistening appearance. Each lesion might have dozens of spots, resulting in extensive defoliation. Fruit lesions are much like those on leaves, but they are black and slightly sunken. They can be so numerous that they run together and make the fruit crack.

Lesions on twigs occur on current-season growth. They are purple to black with indefinite margins. The lesions can run together and form a superficial canker. Early defoliation leads to small fruit, weak bud formation, and fall blossoming. Infected fruit have no sale value and often are cracked and misshapen.

Disease Cycle

The sexual spore stage develops on fallen, overwintered leaves. Conidia—asexual spores—might also develop in the spots on overwintered leaves, or they can be produced in the previous season's shoot infections. Often the first infections do not occur until mid-June to the first of July. Secondary infections begin about 1 month later and reoccur throughout the season during periods of rain.

Disease Management

Routine fungicide sprays normally control this disease in Pennsylvania. In the northeastern states, fungicide applications in June and July generally will control this leaf spot; however, mid-August and September applications are advisable in wet seasons, especially on late varieties such as Bosc.

Pear Leaf Spot

The pear leaf spot fungus, *Mycosphaerella pyri*, infects the leaves of pear, quince, and occasionally apple trees. Numerous leaf spots can produce defoliation. Fortunately, this does not occur often before fall, except in nurseries.

Symptoms

Mature leaf spots are recognized easily by their grayish-white centers with sharply defined margins. Appearing first on upper leaf surfaces as small, brown lesions, they enlarge from 1/8 to 1/4 inch in diameter. The borders become dark brown, and small, black pimples appear in the centers.

Disease Cycle

Sexual spores are produced on overwintered, fallen leaves and are carried by air currents to newly formed leaves. About a month after infection, new spores are generated in the centers of the grayish-white leaf spots,

from which they are washed by rain to other leaves. These secondary infections usually peak in late summer or early fall.

Disease Management

Routine fungicide sprays normally control this disease in Pennsylvania. The control program for *Fabraea* leaf spot will usually control this leaf spot as well.

Pear Scab

Pear scab resembles apple scab in nearly all respects and is caused by the closely related fungus *Venturia pirina*. Although it is not particularly common, pear scab is very destructive when it does occur. Its symptoms and disease cycle are so similar to those of apple scab that they need not be repeated here. A major difference is the frequent appearance of pear scab on twigs, where it can overwinter and start new infections in spring. Infection of pear leaves is not as common as apple scab on apple leaves.

Disease Management

Routine fungicide sprays normally control this disease in Pennsylvania. The fungicides that control apple scab also will control pear scab; however, pear scab is never as severe a problem as apple scab.

Powdery Mildew of Apple

Powdery mildew, caused by the fungus *Podosphaera leucotricha*, attacks buds, blossoms, leaves, new shoots, and fruit of wild and cultivated apples and crabapples. It interferes with the proper functioning of leaves, reduces shoot growth and fruit set, and produces a netlike russet on the fruit of some varieties. It often is a serious problem in apple nurseries.

Symptoms

The first sign of powdery mildew in spring is a 3- to 4-day delay in the opening of infected buds. Leaves and blossoms of these buds soon become covered with a white to light-gray powder—the spores of the powdery mildew fungus. Flowers do not develop normally, are likely to be greenish white, and produce no fruit. On leaves of new shoot growth, symptoms of powdery mildew appear as felt-like, white patches on the margins and lower surfaces. Infected leaves curl upward and soon become covered with a powdery coating of spores. New infections of succulent leaves and growing shoots reduce the size of the entire shoot. By midsummer, leaves and shoots can turn brown.

Disease Cycle

The fungus overwinters as mycelium (the body of the fungus) inside infected buds. As these buds open in spring, all of their parts become covered with a powdery coating of spores. The spores are easily windblown and infect new leaves, fruit, and shoots. Fruit infection takes place during and shortly after the blossom period. Leaf and shoot infection can continue as long as shoot growth continues. Buds can become infected as they begin to form, until they are matured for overwintering. Infections occur at temperatures of 65 to 80°F when relative humidity is high. Mildew-susceptible varieties include Cortland, Idared, Jonathan, Monroe, and Rome Beauty.

Disease Management

Protective mildew sprays should begin at the tight cluster bud stage. Where the disease is severe, mildew fungicides should be continued until new shoots stop growing, or around the fourth cover spray. Choose varieties that are resistant to powdery mildew. Some scab-resistant apple varieties are resistant to this disease (see Table 4.1).

Rust Diseases of Apple

There are three rust diseases: cedar-apple rust, hawthorn rust, and quince rust. All three fungi spend part of their life cycle on the eastern red cedar and are problems only when red cedar is found close to the orchard. The most common is cedar-apple rust. These diseases can cause economic losses in several ways. Severe leaf infection and defoliation may make trees susceptible to winter injury. Severe defoliation reduces fruit size and quality, and infected fruit is deformed, sometimes very seriously. The hosts of cedar-apple rust are leaves and fruit of apple and crabapple trees. The hosts of Hawthorn rust include the leaves of pear, hawthorn, apple, and crabapple. The hosts of quince rust include the leaves and fruit of quince and the fruit of pear, apple, and crabapple.

Symptoms

Cedar-apple rust is caused by the fungus *Gymnosporangium juniperi-virginianae*. Symptoms first appear as small, pale-yellow spots on the upper surfaces of leaves. The spots enlarge, and eventually tiny, black, fruiting bodies (pycnia) become visible. Often, a number of orange-yellow pustules, called aecia, are produced in each spot on the leaf. Infected leaves may remain on the tree or turn yellow and drop. Quince rust, caused by the related fungus *Gymnosporangium clavipes*, does not infect apple leaves but does infect leaves and fruit of

quince and hawthorn and can be observed in the spring on cedar branches.

Fruit lesions caused by the cedar-apple rust fungus are somewhat like leaf lesions, they but are much larger and often cause fruit to become disfigured or to develop unevenly. Light-brown to reddish-brown galls form on the branches of red cedar. When they are dry and hard, they may be ½ to 2 inches in diameter and are known as “cedar apples.” The surfaces of the galls are covered with depressions much like those on a golf ball. In the spring, when the “cedar apples” become wet, a yellow-orange, gelatinous horn up to 2 inches long protrudes from each depression. Fruit infected by quince rust is usually puckered and distorted at the calyx end.

Disease Cycle

Spores discharged from these gelatinous horns on red cedar are easily windborne and infect apple leaves and fruit. Spore discharge begins at about the pink stage of apple bloom and is usually completed in a few weeks. Following a few wet periods, the cedar galls die. Spots on apple leaves appear about 10 days after infection. Visible fruit infections require a somewhat longer time.

Aecia on the undersides of apple leaves or on fruit lesions themselves produce spores. These spores can be carried back to the red cedar by wind and rain. After lodging in leaf axils or in crevices on cedar twigs, they germinate, infect the twig, and produce tiny galls the following spring. One year later, these galls become able to produce gelatinous horns bearing spores that can reinfect apple trees.

Disease Management

Remove red cedar trees from the vicinity of apple trees. Plant scab-resistant apple varieties. Some scab-resistant varieties are immune to cedar-apple rust (see Table 4.1).
◆ Apply fungicides at the pink bud stage of apple.

Sooty Blotch and Flyspeck of Apple

Sooty blotch and flyspeck of apple are separate diseases affecting apple, crabapple, and pear trees. Oftentimes both diseases are normally present on the same fruit. They cause only surface blemishes that detract from fruit appearance and lower fruit quality and market value. Sooty blotch also shortens fruit storage life because of increased water loss. Sooty blotch is a disease complex caused by several unrelated fungi. Flyspeck is caused by the fungus *Zygothiala jamaicensis*.

Symptoms

Sooty blotch appears on fruit surfaces as sooty or cloudy

blotches with indefinite borders. These blotches are olive green to black and can be removed by rubbing vigorously. Flyspeck looks like true “flyspecks,” characterized by sharply defined, small, black, shiny dots in groups of a few to nearly 100 or more.

Disease Cycle

Both fungi overwinter on the twigs of many woody plants, as well as on apple and pear trees. The diseases are spread by these overwintering hosts. Spores of the fungi are windblown into and throughout the orchard, and fruit infection can occur anytime after petal fall. It is most prevalent in mid- to late summer. Disease outbreaks are favored by extended periods of above-normal summer temperatures, combined with frequent rainfall and high humidity. These diseases usually appear on fruit late in the season.

Disease Management

Routine fungicide sprays normally control these diseases in Pennsylvania. Cultural controls include the removal of alternate hosts such as brambles from the orchard and surrounding hedgerows. Dormant-season and summer pruning that opens up the tree canopy and facilitates air movement and the drying of fruit after a rain period will help control these diseases. ◆ Thinning to separate the fruit clusters also will help prevent disease.

Sooty Mold of Pear

Sooty mold fungi of the genus *Capnodium* cause an unsightly blackening over the surface of fruit and leaves. Sooty mold attacks many plants and is most common on pear, although it can affect all tree fruits and tree nuts. The fungi live on honeydew excreted by insects such as aphids, psylla, and whiteflies. When only a few insects are present on host plants excreting only a small amount of honeydew, sooty mold appears in spots. When insect secretions are abundant, the surfaces of leaves and fruit might have a near-continuous coating of the black, tissue-paper-thin, sooty mold.

Disease Management

Control is directed against the insects producing the honeydew. These insects need to be identified before appropriate controls can be undertaken.

White Rot of Apple

The white rot fungus, *Botryosphaeria dothidea*, often referred to as “Bot rot” or *Botryosphaeria* rot, occurs most commonly on apple trees, but also attacks crabapple, pear, grape, and chestnut trees. On apple trees, it

can be observed as a distinct canker on twigs, limbs, and trunks; leaf infections do not occur. Losses from fruit rot can be considerable, especially in southeastern regions of the United States. Drought stress and winter injury have been associated with an increase in infection and canker expansion sizes in northern states.

Symptoms

New infections on twigs and limbs become evident by early summer, appearing as small, circular spots or blisters. As the lesions expand, the area becomes slightly depressed. Cankers stop enlarging in late fall and can be indistinguishable from black rot canker (caused by *Botryosphaeria obtusa*), making isolation of the pathogen necessary for correct identification of the fungus. By spring, small, black pycnidia—the spore-containing structures of the fungus—appear on the smooth surface of new cankers. On older cankers, these might be present throughout the year. Cankers exhibit a scaly, papery outer bark that often is orange. Tissues beneath the canker surfaces are watery or slimy and brown. Most cankers are not deep, extending at most to the wood.

Fruit rot first appears as small, slightly sunken, brown spots that can be surrounded by a red halo. As the decayed area expands, the core and eventually the entire fruit become rotten. Red-skinned apple varieties can bleach during the decay process and become a light brown. Because of this characteristic, the disease sometimes is referred to as “white rot.”

Bot rot of fruit can be confused with both black rot and bitter rot. The decayed apple flesh of black rot is firm and somewhat leathery, that of *Botryosphaeria* rot is soft. Bitter rot causes a cone-shaped area of decay and concentric rings of spores on the surface.

Disease Cycle

The fungus grows best under warm conditions, with the optimum temperature for infection about 86°F. Conversely, for black rot infection, the optimum temperature is about 68°F.

White rot overwinters in dead bark, twigs, and cankers within the tree. Fire-blighted branches and dead wood are colonized rapidly and are an important source of inoculum. Living twigs, branches, and trunks might also be attacked. During spring and summer rains, spores ooze from these structures and are splashed onto other parts of the tree. Fruit infections can occur at any time from the bloom period to harvest. Infections in young apples usually are not evident until the apples are nearly mature. Drought, heat stress, mechanical wounding, and winter injury favor disease development.

Disease Management

Same as for black rot of apple.

PEST MANAGEMENT

The diseases and insect pests of apples occur at different times during the growing season, depending on environmental and biological factors (see Table 4.4). Many strategies should be used to control these pests, and pesticides should be applied only when no other control strategy is available. Cultural controls are listed below, and further information on disease control strategies is included in the previous section under specific insects and diseases. Tables 4.5 through 4.9 (at the end of this chapter) provide information about pesticides and their use on pome fruit.

Cultural Disease Management ♦

Many insect and disease problems can be prevented before they occur. Once present, diseases and insects can be very difficult to control. See basic cultural guidelines under “Pest Management,” discussed on page 24 in Chapter 2.

Apple Scab

Plant scab-resistant apple trees. If susceptible varieties are being grown, remove leaves soon after they have fallen to reduce the carryover of disease from one season to the next. Never allow fruit to remain on the ground from one season to the next. Prune the trees annually to improve air circulation and rapid drying.

Apple Powdery Mildew

Plant mildew-resistant apple trees. If susceptible varieties are being grown, prune off white infected terminals as they appear from bloom to mid-June. Remove prunings from the orchard.

Cedar Apple Rust

Plant rust-resistant apple trees. If susceptible varieties are being grown, remove red cedar trees from the orchard area if possible. If it is not possible to remove the red cedar trees, then prune the galls off the cedar trees each spring before the apples bloom.

Apple Summer Rots

No variety resistance to the summer rots is known. Prune trees annually to improve air circulation and reduce the potential for disease. Remove rotted fruit from the tree or the ground as it occurs. Be careful to prevent wounding of the fruit since the rot fungi readily infect the fruit at wounds. Prune out dead branches

and remove prunings from the orchard area. The apple rotting fungi survive well on dead wood and can spread to fruit on the tree. Cool fruit after picking to retard the development of the disease.

Sooty Blotch and Flyspeck of Apple

No variety resistance to these diseases is known. Prune trees annually to improve air circulation and reduce the potential for disease. Cool fruit after picking to retard the development of the disease.

Fire Blight of Apple and Pear

Apple varieties vary in their susceptibility to fire blight. All pear varieties are susceptible to fire blight. If apple or pear trees are overfertilized and are too vigorous, fire blight will be a more severe problem. It is important to maintain a balanced fertilization program to control this disease; refer to the section on fertilization for more information. Crabapple trees also are susceptible to fire blight, and the disease might spread from crabapple to apple trees in the area. Removing blighted shoots when

Table 4.4 Occurrence of diseases, insects, and mites on apples and pears during the growing season.

Diseases		Insects and Mites																					
Timing	S	PM	R	BER	CR	SB	SR	FS	AM	CM	EAS	ERM	GA	GM	OFM	PC	PP	RAA	SJS	TPB	TSM	WAL	
Dormant									—	—		—	+		—	—	++	++	++	—	—	—	—
1/2-inch green	++	—	—	—	—	—	—	—	—	—		+	+		—	—	++	++	++	+	—	—	—
Prepink	++	++	—	—	—	—	—	—	—	—		+	+		+	—	++	++	—	++	—	—	—
Pink	++	++	+	—	—	—	—	—	—	—	++	+	+		++	—	++	++	—	++	—	—	—
Bloom period	++	++	++	++	++	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—
Petal fall	++	++	++	++	++	—	—	—	—	—	++	++	+	++	++	+	+	+	++	++	—	+	+
Mid-June	++	++	++	++	++	—	—	—	—	++		+	++	++	+	++	+	+	++	+	—	—	++
Late June	++	++	—	—	—	++	++	++	+	++		+	++		++	++	++	+	++	+	+	+	++
Early July	++	++	—	—	—	++	++	++	++	+		+	++		+	—	++	—	+	+	+	—	—
Mid-July	++	++	—	—	—	++	++	++	++	+		++	—		++	—	++	—	+	+	+	++	—
Late-July	++	++	—	—	—	++	++	++	++	++		++	—		++	—	++	—	+	+	++	+	+
Early-mid-Aug.	++	—	—	—	—	++	++	++	++	++		+	+		++	—	+	—	++	+	+	+	++
Late Aug-mid-Sept.	++	—	—	—	—	++	++	++	++	—		+			++	—	+	—	++	+	—	—	+

+ = pest present, possible control
 ++ = proper timing of control
 — = control generally is not needed at this time

Apply pesticides only if pests are present in damaging numbers. Bloom period is assumed to occur during the second week in May; this date should be adjusted depending on local conditions. Dates listed for sprays are approximate; they should be applied about once every two weeks.

they appear (about 2 weeks after bloom to late summer) is an important control strategy to keep the disease from spreading within the tree or to nearby trees. When pruning out blighted shoots, breaking out the shoots by hand is better than pruning them off since the bacteria that cause fire blight can be spread on pruning tools. Break out shoots 8 to 12 inches below the obviously blighted or killed wood to ensure the removal of all of the diseased wood. If pruning tools must be used to remove larger wood, disinfect the tools between each cut with a 10 percent chlorine liquid bleach solution. Wash the tools well after use since bleach is highly corrosive to the metal. Insects might spread the disease once it is established in an area. Good pest control measures must also be followed in the summer, if the spread of fire blight is to be limited.

Pear Scab and Leaf Spot

No variety resistance to pear scab is known. Remove leaves soon after they have fallen to reduce the carry-over of disease from one season to the next. Never allow fruit to remain on the ground from one season to the next. Prune the trees annually to improve air circulation and rapid drying.

Table 4.5. Efficacy of fungicides on apples and pears.

Diseases

FF = fruit finish

FR = fruit rots (black rot, white rot, bitter rot)

PM = powdery mildew

R = rusts

S = apple scab

SB + FS = sooty blotch and flyspeck

Pesticides	S	PM	R	FR	SB + FS	FF
Captan	1	5	5	1	2	1*
Copper	2	1	3	2	2	4
Lime Sulfur	1	2	3	1	1	1
Maneb	1	5	1	1	1	1
Neem	4	4	4	4	4	?
Myclobutanil	1	1	1	5	5	1
Sulfur	2	1	2	3	3	2

Degree of control: 1 = best; 2 = good; 3 = fair; 4 = slight; 5 = none

FF = Fruit finish on yellow varieties when used as recommended: 1 = very good; 2 = good; 3 = fair; 4 = poor

* Lime sulfur may also cause leaf burning

Table 4.6. Efficacy of insecticides and miticides on apples and pears.

Note: Due to a wide array of various products containing the same active ingredient for insecticide recommendations, when appropriate, the active ingredient is listed instead of the name of formulated product.

Insects and Mites

AM = apple maggot
 CM = codling moth
 EAS = European apple sawfly
 ERM = European red mite
 GAA = green apple aphid
 GM = gypsy moth
 OFM = oriental fruit moth
 PC = plum curculio
 PP = pear psylla
 RAA = rosy apple aphid
 SB = stink bugs
 SJS = San Jose scale
 TPB = tarnished plant bug
 TSM = two-spotted spider mite

Pesticides	AM	CM	EAS	ERM	GAA	GM	OFM	PC	PP	RAA	SB	SJS	TPB	TSM
Azadirachtin	—	—		3	3	4	—	—	—	3	3	—	4	—
<i>Bacillus thuringiensis</i> (Bt)	4	3		4	4	1	3	4	4	4	4	4	4	4
Carbaryl ^a	2	2		4	2	1	2	2	3	3	3	3	3	4
Diazinon	2	2		3	2	2	2	2	2	2	2	2	2	3
Esfenvalerate ^b	2	2	2	4	2	2	2	2	2	2	2	4	2	4
Horticultural Oil	4	4		1	2	4	4	—	2	3	4	1	4	1
CM granulosus virus	—	1		—	—	—	3	—	—	—	—	—	—	—
Imidacloprid	2	—		—	1	4	—	3	1	1	3	—	3	—
Malathion	2	2	3	4	4	2	2	2	3	4	—	2	2	3
Pyrethrum	4	4	3	—	3	4	4	3	3	3	3	—	3	—
Rotenone	3	3	3	—	—	3	3	3	—	—	3	—	3	—
Safer Soap	4	4		2	4	4	4	4	2	4	—	2	4	2
Spinosad	2	4		—	—	1	4	—	—	—	4	—	4	—
Surround	3	4	3	4	4	—	4	2	1	3	3	—	3	4

a. Sevin may worsen the mite problem and, when used shortly after bloom, can cause apples to fall from the tree.

b. This compound is very toxic to bees and should not be used until after petal fall.

Degree of control: 1 = best; 2 = good; 3 = fair; 4 = poor

Table 4.7. Pesticide recommendations for apples.

The following spray schedule will provide desirable disease and insect control during normal seasons. If the weather is dry, the time between spray applications can be increased to 21 days; if the weather is wet, sprays should be applied every 10 to 14 days. To avoid harming bees, do not use an insecticide in sprays applied during the bloom period. Due to a wide array of various products containing the same active ingredient for insecticide recommendations, when appropriate, the active ingredient is listed instead of the name of formulated product. Follow all instructions and application rates listed on pesticide labels.

Time to Spray	Suggested Materials^a	Pests to Be Controlled
Green Tip—when leaves are 1/4 inch long	Oil <i>plus</i> Copper	Scales, mite eggs aphids, scab, powdery mildew ^b
Prepink—first pink color of flower buds ^c	GPProduct mix, <i>or</i> Captan 50WP	Scab, aphids, caterpillars, scales, rust, powdery mildew
Pink—just before blossoms open ^c	Same materials as Prepink <i>plus</i> Safer Soap ^c	Scab, rust, powdery mildew aphids, scales
Petal Fall—90% of flower petals off ^c	Captan <i>plus</i> imidacloprid <i>plus</i> esfenvalerate <i>or</i> Surround <i>plus</i> CM granulosis virus	Scab, rust, powdery mildew curculio, caterpillars, oriental fruit moth, European apple sawfly
10–14 days after petal fall ^c	GPProduct mix, <i>or</i> Captan, <i>plus</i> Spinosad, <i>plus</i> Last Call mating disruption, <i>plus</i> CM granulosis virus	Scab, rust, powdery mildew leafrollers, codling moth, oriental fruit moth
14 days later ^{c, d, e}	GPProduct mix, <i>or</i> Captan 50WP <i>plus</i> Spinosad, <i>plus</i> Surround, <i>or</i> Safer Soap ^c , <i>or</i> summer oil ^e Calcium chloride	Summer rots, sooty blotch, flyspeck, scab, caterpillars, aphids Corking, bitter pit of apple
Continue applications on ^{c, d, e} 10- to 14-day interval until harvest. Read the label as to the preharvest interval of when to stop spraying.	Same materials as last spray	Scab, summer rots, sooty blotch, flyspeck, scab, apple maggots, mites, worms

Notes

- Match pesticide efficacy against problem pests before selecting spray material (see Tables 4.5 and 4.6).
- Where powdery mildew is a problem, add wettable sulfur in prepink through late-June sprays. Do not apply sulfur if the temperature is predicted to be 80°F or higher on the day of application.
- Safer Soap will probably russet fruit.
- If cork spot or bitter pit is a problem, the addition of calcium chloride can help reduce their occurrence.
- Summer oil can not be used 14 days before and after captan application or fruit russetting will occur.

Table 4.8. Pesticide recommendations for pears.

To avoid harming bees, do not use an insecticide in sprays applied during the bloom period. Due to a wide array of various products containing the same active ingredient, for insecticide recommendations, when appropriate the active ingredient is listed instead of the name of formulated product. Always consult the label before making pesticide applications. Labels vary greatly between commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides.

Time to Spray	Suggested Materials	Pests to Be Controlled
Dormant to green tip	Oil <i>plus</i> Copper	Scales, pear psylla, mites leafspot
Green cluster bud	Esfenvalerate ^d <i>plus</i> Oil <i>or</i> Surround	Pear psylla
Pink	GPProduct mix ^a <i>or</i> Sulfur Esfenvalerate <i>or</i> Surround	Leaf spot Pear psylla
Just before blossoms open	Esfenvalerate <i>or</i> Surround	Pear psylla
Bloom ^b Two sprays needed: (1) 20% of blossom open (2) 7 days later	Streptomyces sulfate + Sulfur	Fire blight
Petal fall	GPProduct mix <i>or</i> Sulfur	Leaf and fruit spot, scab
90–95% of petals fallen ^b	Surround <i>plus</i> Esfenvalerate <i>or</i> Safer Soap ^c <i>plus</i> Imidacloprid <i>plus</i> Surround	Curculio, pear psylla Codling moth, oriental fruit moth Aphids, pear psylla
Mid-June 16 days after petal fall ^b	Same as Petal Fall	Same as above
Late June 16 days after mid-June ^b	Same as Petal Fall	Same as above
Early July ^b	Same as Petal Fall	Same as above
Late July	GPProduct mix <i>or</i> Sulfur Esfenvalerate <i>or</i> Safer Soap ^c <i>plus</i> Esfenvalerate <i>or</i> Imidacloprid <i>plus</i> Surround	Same as above
Mid-August	Sulfur	Fruit rot, sooty mold

Notes

- General purpose products may contain captan, which is not approved for pears.
- Bloom sprays are not needed on Kieffer pears. Only spray for fire blight if this disease was a problem in the past. Break off fire-blighted shoots and branches as they occur during the growing season.
- Safer Soap will probably russet fruit.
- Multiple applications of Esfenvalerate can lead to severe outbreaks of phytophagous mites.

Table 4.9. Pesticide recommendations for scab-resistant apple varieties.

The following spray schedule and times might vary by as much as 2 weeks, depending on the region of Pennsylvania in which the trees are located. Apply sprays only if disease and insects have been a problem as determined by scouting procedures. These varieties can tolerate some disease and insect pressure without adversely affecting tree health and fruit quality. Varieties differ in their susceptibility to pests, and young trees are more susceptible to all pests. Due to a wide array of various products containing the same active ingredient, for insecticide recommendations, when appropriate the active ingredient is listed instead of the name of formulated product. Always consult the label before making pesticide applications. Labels vary greatly between commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides. To avoid harming bees, do not use an insecticide in sprays applied during the bloom period.

Time to Spray	Suggested Materials	Pests to Be Controlled
Dormant—late March to early April	Oil (dormant oil)	Aphid and mite eggs
Green tip—when leaves are ¼ inch long	Superior Oil plus Esfenvalerate	Mites and rosy apple aphids Scales
Prepink—first pink color of flower buds	<i>Bacillus thuringiensis</i>	Tent caterpillars Gypsy moth larvae ^a
Petal fall ^b —90% of flower petals off	Imidacloprid <i>plus</i> Surround <i>plus</i> Esfenvalerate	Plum curculio, codling moth
Mid-June to mid-August	Captan Safer Insecticidal Soap CM granulosis virus <i>or</i> Last Call mating disruption	Summer fruit rots ^c , sooty blotch, flyspeck Green aphids mites Codling moth, oriental fruit moth
Mid-July to August	CM granulosis virus <i>plus</i> Imidacloprid	Codling moth, Japanese beetle
Early July to early September	Spinosad rotenone	Apple maggot, leafrollers

a. If larvae numbers are high and if trees are young, two spray applications might be necessary.

b. Plum curculio and codling moth can severely damage fruit. If the amount of fruit damage was severe the previous season, a second application 7 to 10 days after petal fall might be necessary.

c. A total of two to four fungicide applications per season might be needed to protect fruit surfaces, depending on the amount of disease in the orchard.

Stone Fruits: Peaches, Nectarines, Plums, Apricots, and Cherries

Peaches, nectarines, plums, apricots, and cherries are all members of the *Prunus* genus and are therefore closely related. They commonly are referred to as “stone fruits” because the seed is very large and hard. Although stone fruit crops can provide delicious fruit from June through September, most stone fruits are native to warmer climates of the world and therefore are very susceptible to injury from low winter temperatures. In addition, because they bloom early in the spring, the flowers frequently suffer damage from spring frosts. Because of this, the backyard culture of stone fruits is more difficult than that of apples or pears.

Nectarines also are more difficult because they are more susceptible to the disease organism that causes brown rot. Sweet cherries tend to crack as harvest nears if excessive rainfall occurs. Peaches, nectarines, and apricots generally will not bear fruit consistently when planted north of a line located roughly along Interstate 80 in Pennsylvania. Cherries and plums are a little hardier. Regardless of your location within the state, you should plant stone fruits only on the very best sites with excellent air and water drainage and protection from high winds.

VARIETY SELECTION

Currently, no suitable dwarfing rootstocks exist for peaches, nectarines, plums, or apricot that will survive under Pennsylvania conditions. Two dwarfing rootstocks have recently been introduced for cherries. They are named Gisela 5 and Gisela 6. They may be available on a limited basis. Pennsylvania growers should disregard advertisements for those fruits on dwarfing rootstocks. It is doubtful that the available peach, nectarine, and apricot varieties will do well in the colder areas of the state.

Peach Varieties

The number in parentheses is the number of days a variety ripens before (-) or after (+) Redhaven.

CANDOR: (-20) The first early peach of the season with any quality, its fruit are yellow and medium in size. A

large percentage of the fruit tend to produce split seeds, which limits this variety’s usefulness in canning. The fruit ripens approximately 20 days before Redhaven.

HARROW DIAMOND: (-15) A medium to medium-large fruit with an attractive scarlet-red skin over a greenish-yellow ground color. The fruit is semiclingstone.

GARNET BEAUTY: (-10) A good early peach that ripens just before Redhaven. Semiclingstone to freestone, very productive, and medium sized.

GLENGLO: (-8) This yellow-fleshed peach is attractive, medium large in size, moderately firm and semifreestone. This variety has low susceptibility to bacterial spot.

RELIANCE: (-6) Developed in New Hampshire, its chief advantage is that it has better-than-average bud hardiness. The fruit quality is only fair, but if growers are on a marginal site in the state for growing peaches, this is the only variety they should try.

REDHAVEN: (0) The standard and most popular peach variety in the industry. The fruit quality is good, although fruit size may be small if it is not properly thinned. The fruit has above-average quality for freezing but below-average quality for canning. The average first harvest in southcentral Pennsylvania is around August 1. In central Pennsylvania it is around August 8.

HARBRITE: (+4) Released from Agriculture Canada at the Harrow Station, this is a productive freestone with medium to large, round fruit. It has good winter hardiness and is reported to have some resistance to bacterial spot and brown rot.

REDKIST: (+14) A medium to medium-large fruit with a crimson-red skin. Fruit is firm and freestone. Tree has low susceptibility to bacterial spot.

BEEKMAN: (+16) A red sport of Sunhigh found in an orchard in Boyertown, Pa. The fruit is very firm and of a high quality, and the flowers are very showy and large.

HARMONY: (+21) This is a productive, winter-hardy variety. The fruit is medium to large and freezes well. It

also is sometimes listed in nursery catalogs as Canadian Harmony.

MADISON: (+24) This firm-fleshed, high-quality peach is good for freezing. The trees are more tolerant to frost than other varieties and are recommended in northern areas of the state.

CRESTHAVEN: (+27) The fruit is medium to large, nearly round, and very uniform. The color is golden, overlaid with an abundance of bright red. This is a yellow-fleshed freestone that shows considerable red around the pit. Harvest is approximately 27 days after Redhaven.

ENCORE: (+30) A large-size, 60 to 70 percent crimson-red fruit with a greenish-yellow ground color. Fruit is firm freestone and ripens in late August to early September.

Nectarine Varieties

HARFLAME: A medium, dark red-skinned fruit with a yellow ground color. Fruit are semifreestone. The flavor is somewhat acidic but very good. It matures about 7 to 10 days before Redhaven peach.

HARBLAZE: A medium to large fruit with bright-red skin with an orange-yellow ground color. The fruit are semiclingstone and ripen approximately 4 days before Redhaven peach.

CRIMSON SNOW: This is a new white-fleshed nectarine that has a pinkish overcolor with a slight greenish ground color. Fruit may be on the small size and needs to be heavily thinned. Fruit ripens with Redhaven peach.

FANTASIA: A large, yellow-fleshed fruit that is firm, highly colored, and of good quality. The tree is somewhat susceptible to bacterial spot. Harvest is approximately 27 days after Redhaven.

REDGOLD: A good late-maturing freestone, whose skin color is red over yellow. The flesh is yellow with red around the pit. It is susceptible to bacterial spot. Harvest is approximately 20 days after Redhaven.

Plum Varieties

Two types of plums are commonly grown: Japanese and European. The former are used only for fresh eating, whereas the latter can be used for fresh eating or, as is more common in Pennsylvania, for drying or processing.

METHLEY: An early ripening Japanese plum of good quality and appearance. It has round, sweet, very juicy purple fruit with a red blush. The flowers are partially self-fruitful, but the addition of Shiro or Ozark Premier

will increase yields. It ripens around mid-July in south-central Pennsylvania.

SHIRO: A round, yellow Japanese plum with an occasional pink blush. Although they are clingstone, the fruits are very juicy. Harvest in southcentral Pennsylvania is around August 1.

CASTLETON: A dual-purpose prune/plum released by Cornell University. The fruit is blue, round, and similar in appearance to Stanley. Approximate ripening date is August 10 in southcentral Pennsylvania.

OZARK PREMIER: This Japanese type is a large, bright-red fruit with a tough skin. The flesh is yellow and juicy and of a fair quality. The flavor tends to be on the tart side. This is a clingstone fruit, but with a small seed. Harvest in southcentral Pennsylvania is around August 15. Will not pollinate Stanley or Bluefre.

BLUEBYRD: A European type plum developed at the USDA station in Kearneysville, West Virginia, and named for Senator Robert C. Byrd. The fruit is firm and sweet with a yellow flesh; it ripens around the middle of August.

SENECA: A second recent release from Cornell University. The fruit are large, reddish blue, and have excellent dessert quality. The fruit is reported to be resistant to cracking and to brown rot. Approximate ripening date is August 22 in southcentral Pennsylvania.

STANLEY: A medium, dark-blue freestone that is oval in shape with a distinctive neck. The fruit is very well suited for processing and drying. The flesh is greenish yellow, juicy, and fine grained. Harvest is around the last week in August.

LONG JOHN: Developed at Cornell University, this European type produces large, long, teardrop-shaped fruit. The blue-colored fruit are freestone and ripen with Stanley.

BLUEFRE: A European type that produces large, blue, yellow-fleshed, freestone fruit. Fruit hangs well on the tree but produces many split pits. Harvest is approximately the first week in September.

Disease-Resistant Plums

A breeding program at Auburn University has developed a series of new plum varieties that have resistance to black knot, brown rot, and bacterial canker. These plums would be good candidates for homeowners that want to minimize their use of fungicides. Locating all of the varieties may be a little difficult. We currently do not have any experience with growing these varieties in Pennsylvania

AU AMBER: The fruit is medium sized with a purple skin and excellent flavor. Fruit is smaller than that of AU Rosa and AU Rubrum. Partially self-fruitful.

AU ROSA: The fruit has a bright-red skin with yellow flesh.

AU RUBRUM: The fruit is large and firm with a maroon skin with red flesh. Reported to be self-fruitful.

AU CHERRY: A small plum that has consistently produced large crops.

AU ROADSIDE: Sometimes listed as “War Eagle!” in nursery catalogs. The red-skinned fruit and flesh is of high quality. Flowers are self-fruitful.

Apricot Varieties

Although apricots have good flower hardiness to low winter temperatures, they tend to bloom too early. Therefore, plant them only on the best sites or in a sheltered area. All the apricots listed are self-fruitful.

HARCOT: Introduced from Canada, this has been a consistent producer when not frosted out. It needs to be well thinned to achieve acceptable size. The fruit is attractive with a red blush, has good fresh quality for the early season, but is unsuitable for canning. Harvest is approximately the first week in July in southcentral Pennsylvania. Reports from New York indicate the fruit is resistant to brown rot and bacterial spot.

VEECOT: The fruit is medium to large, round, and very firm with a deep-orange color. The flesh is smooth textured, slightly juicy, and cans well. Harvest is approximately the second week in July.

HARGRAND: Developed in Harrow, Ontario, these glossy fruits average a 50 percent orange-red surface blush. The fruit is somewhat flattened but has a mild good flavor. Reports from New York indicate the fruit is resistant to brown rot and bacterial spot.

HAROGEM: A medium-sized fruit that has a bright-red, glossy blush over an orange background. Tree growth is very upright, and the trees are very resistant to cold. Ripens about July 21 in southcentral Pennsylvania. Reports from New York indicate the fruit is resistant to brown rot.

HARLAYNE: Bright-red, blushed fruit, often small in size, therefore requiring careful thinning. The fruit is best suited for fresh eating. Harvest is approximately the third to fourth week in July. Reports from New York indicate the fruit is resistant to brown rot and bacterial spot.

Cherry Varieties

Cherries can be classified into two types: sweet and tart. The sweets are used mainly for fresh eating, while the tarts are used for pies and canning. Sweets have a disadvantage—the fruit will split or crack as it approaches maturity if rainfall occurs. Some of the sweets are less susceptible to this tendency and should be the only ones planted. With both sweet and tart cherries, bird damage will be a major problem; steps should be taken to reduce bird feeding. Tart cherries are self-fruitful and do not require a pollinizer. Many of the older sweet cherries, on the other hand, do require specific varieties for pollinators (see compatibility chart below). The exceptions are four recently released self-fertile varieties: Lapins, Starkrimson, Stella, and Sunburst it is not necessary to plant more than one variety. Little is known, however, about these varieties’ performance in Pennsylvania.

Tart Varieties

JUBILEUM: A new tart cherry developed in Hungary. The fruit are very large and have a dark red flesh. Although it is considered a tart cherry it is not as tart as Montmorency. Fruit has very high sugar levels.

DANUBE: A popular variety from Europe, the fruit are dark red and slightly sweeter than Montmorency. The fruit are medium to large. The trees may be a little less winter hardy than Montmorency. Fruit ripens about 1 week before Montmorency.

MONTMORENCY: This is the number one tart variety and the industry standard. It is productive, but the flowers are susceptible to late spring frosts. It ripens around the last week of June to the first week of July.

SUREFIRE: A recent introduction from Cornell University. This tart variety is late blooming thereby, avoiding damage from spring frosts. The fruit is bright red and medium in size.

BALATON: A new late-maturing tart variety that ripens about 7 to 10 days after Montmorency. The fruit is large, very firm with a red burgundy juicy flesh.

NORTHSTAR: A dark-juiced cherry with mahogany-red fruit, medium in size. Trees are very hardy and small, which makes them easier to cover with a net to keep birds out. It ripens about July 7 in southcentral Pennsylvania.

METEOR: Medium-sized, semifirm, good-quality fruit. The trees are somewhat larger than Northstar and are equally hardy. Because the oddly shaped pit can shatter during processing, this variety has not been commercially accepted; for home use, this is not a problem. Harvest is approximately 3 to 7 days after Northstar.

Sweet Varieties

The following list of sweet cherry varieties are all self-unfertilized and will require a compatible pollen source. Before ordering from a nursery, be sure the varieties you have chosen are compatible.

VISTA: A nearly black, excellent-quality fruit, 7/8 inch in size. It ripens around the last week in June.

ULSTER: A medium-sized, firm, dark-skinned, dark-fleshed cherry introduced from New York. Harvest is approximately 2 days after Vista.

VIVA: Released from the Vineland Research Station in Canada. The fruit is dark red and 3/4 inch in diameter. It ripens around July 4.

HARTLAND: Early season crack-resistant black cherry. It is a vigorous tree that crops consistently and ripens around July 4.

ROYALTON: Released from the New York Agricultural Experiment Station as a large dark sweet cherry, it has high sugar levels in the fruit and is somewhat crack resistant. It is cross-compatible with Emperor Francis, Kristin, Sam, Schmidt, and Ulster.

EMPEROR FRANCIS: A large, high-quality cherry of the Napoleon type, but less subject to cracking. It can be used either for brining or for fresh use. The fruit has an attractive red blush over a yellowish background. The harvest date is approximately 1 week after Vista.

SAM: An early ripening, large, black sweet cherry. The tree is large, vigorous, and upright, and it blooms later than most other sweets. The fruit has good resistance to rain-induced cracking. The harvest date is approximately 11 days after Vista. Sam is pollen incompatible with Royalton and Schmidt.

KRISTIN: Introduced from Norway, the fruit averages 1 inch in diameter. It is of a good quality, combining good flavor and high sugar content. It has moderate resistance to rain cracking. Harvest is approximately the last week in June in southcentral Pennsylvania. Kristin is pollen incompatible with Somerset and Group I cherries.

VISCOUNT: Introduced in 1983 from Canada, it produces medium-large, firm, good-quality, dark glossy-red cherries. It is productive and has good crack resistance. Harvest is approximately July 2 in southcentral Pennsylvania.

HEDELINGEN: This is a medium-large, firm, good-quality black cherry with moderate resistance to cracking. Trees are early bearing and very productive. Harvest is approximately July 3 in southcentral Pennsylvania.

Sweet Cherry Pollination Compatibility Chart

Many of the older cherry varieties are self-unfruitful; they produce viable pollen but are not always compatible with all varieties. Many sweet cherry groups are cross-incompatible. Varieties within a group should not be planted together without a suitable pollinizer. Below are some of the more common cross-incompatible groupings of the varieties recommended in this guide, as well as some commonly advertised in nursery catalogs. The Roman numeral indicates the classification group used by breeders.

I. Bing, Lambert, Napoleon, Emperor Francis

VI. Stark's Gold, Hartland

IX. Van, Venus, Windsor

X. Gold, Viva, Vogue

XI. Hedelfingen, Vic, Ulster

XII. Hudson, Schmidt, Rainier, Viscount

XIII. Seneca, Vega, Vista

Self-Fertile Sweet Cherry Varieties

The following list contains cherry varieties that are all self-fertile. Therefore, you can plant just a single tree if you only have space for one. They can also be used as universal pollen donors for any of the self-unfertilized varieties listed above, as long as their bloom periods overlap. Even though they are self-fertile, they may not be immune to cracking or bird depredation. Many of these varieties were developed in the Pacific Northwest. Therefore, we do not have good data on how they will perform in Pennsylvania.

VANDALAY: Large, wine-red colored fruit have a kidney shape and purple juice. Vandalay was developed in Vineland, Canada.

STELLA: This is a large, dark-red fruit. Trees are productive but can be tender in cold winters; it is not recommended in more northern areas of the state. Its outstanding feature is that it is self-fertile.

TEHRANIVEE: A mid-season cherry developed in Ontario, Canada. Cracking can be a problem.

SONATA: Developed in British Columbia and introduced in 1996. It is sometimes labeled as Sumleta™. The fruit is very large, black, and moderately sweet.

WHITEGOLD™: An early mid-season, self-fertile, sweet cherry selection developed by Cornell University. Its primary use is for processing and would be used in a similar fashion as Napoleon (Royal Anne). It has con-

siderable potential for brining and processing markets that currently use Royal Ann (Napoleon).

SYMPHONY: Introduced in 1997 from British Columbia, the fruit is bright red and matures late in the season. The fruit is moderately sweet and very large. Of the varieties released from this program, it has shown better rain-cracking resistance.

BLACKGOLD™: A late mid-season, self-fertile, sweet cherry selection developed by Cornell University. This is the latest-blooming sweet cherry in the Cornell collection and it has remarkable tolerance to spring frost. Its primary use is for fresh eating.

SUNBURST: Developed in British Columbia and introduced in 1983. Fruit is large and firm. Trees are productive.

LAPINS: This was released from the Summerland Research Center in British Columbia. One of its parents is Stella, which makes this variety self-fertile. The fruit is very large and somewhat crack resistant.

SKEENA: A dark mahogany cherry that is very large. It is superior to Lapins, but its cracking susceptibility is unknown. Blooms in mid-season.

SWEETHEART: A high-quality cherry developed in British Columbia, Canada. Fruit matures late and is very large. Trees are productive, yielding dark-red, medium to large fruit that is firm with a good flavor.

Nursery Stock Selection

The old adage “you get what you pay for” is an important consideration when buying fruit trees. Bargain plants might not be healthy or might be a variety not adapted to your area. Buy only recommended varieties from a reliable source. Keep in mind the following points when purchasing fruit trees:

- A healthy *one-year-old whip*, approximately 4 to 6 feet tall, with a 0.5-inch caliper and a good root system, is preferred.
- A smaller tree with a good root system is more desirable than a large tree with a poor root system.
- Trees that are two years old or older often are not as good as one-year-old trees. The older trees frequently do not have enough buds on the lower portion of the trunk to develop a good framework.
- Trees that appear stunted, poorly grown, diseased, or insect-injured should not be purchased.
- Check the label closely to make sure that you are getting the variety and rootstock that you desire.

PLANTING

In the absence of a soil test, lime a 10-by-10-foot area where each tree will be planted. Dig each planting hole wide enough to accommodate all of the root system without bending or bunching it, and deep enough so that the bud union of grafted plants will be no more than 1 to 2 inches above the ground line after the soil settles. Space the planting holes according to Table 5.1.

Keep root pruning to a minimum, but cut off all broken or mutilated root parts with pruning shears. Even though many stone fruits do not have dwarfing rootstocks, it is still best to set the plants with the graft or bud union no more than 1 to 2 inches above the soil line (Figure 5.1). Work the soil in and around the roots. When the hole is half full, you should firm the soil with your feet before filling the rest of the hole. When the hole is full, be sure you pack the soil firmly. Do not leave a depression around the tree. Also, do not place fertilizer in the planting hole or fertilize the soil immediately after planting. Fertilize only after the soil has been settled by a drenching rain.

After planting, apply sufficient water to thoroughly soak the soil around the tree roots. This watering will help to bring the soil into closer contact with all sides of the roots and eliminate air pockets around the roots.

NUTRITIONAL REQUIREMENTS

Shortly after planting, apply 8 ounces of 10-10-10 per plant. *Do not place fertilizer in the planting hole.* In subsequent years, broadcast ½ pound of 10-10-10 under each tree in the early spring. Increase the amount applied by another ½ pound per year, up to 5 pounds per

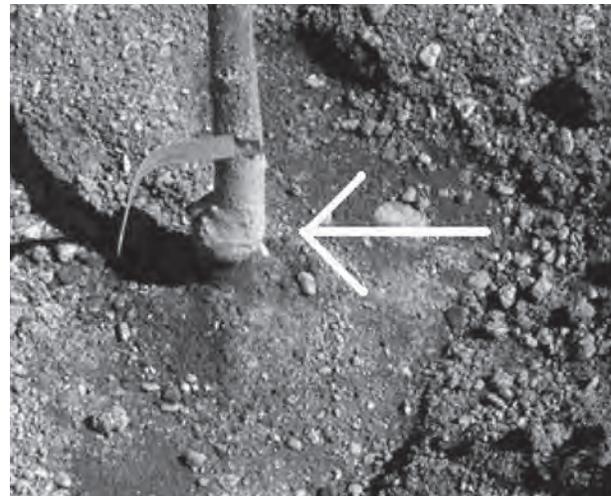


Figure 5.1. Appropriate height, as indicated by the arrow, at which to set stone fruit trees.

tree regardless of age. Maintain pH at 6.0 to 6.5. Never fertilize after July 15.

STONE FRUIT FLOWERING HABITS

Stone fruit trees produce vegetative buds and flower buds. Peaches and nectarines produce their flower buds on one-year-old wood, i.e., shoots that grew the previous year. The terminal bud of peach and nectarine shoots is always vegetative. The flower buds are produced at each node (the point on the shoot where the leaf is attached) with two flower buds on either side of a vegetative bud. In cherries, apricots, and plums, flower buds are produced laterally and terminally on one-year-old shoots and on spurs on older wood. The number and distribution of flower buds can vary with tree vigor, the variety, and the light exposure under which the shoot was developed. Moderately vigorous shoots have a high proportion of good flower buds.

PRUNING AND TRAINING TO AN OPEN CENTER

Pruning a young tree controls its shape by developing a strong, well-balanced framework of scaffold branches. Unwanted branches should be removed or cut back early to avoid the necessity of large cuts in later years. The pruning system best suited for all stone fruits that keeps the fruit-bearing surface close to the ground is called the “open center.” Pruning and training the trees to this system produces a vase-shaped tree. All stone fruits are very susceptible to brown rot. Open-center trees allow better air circulation and light penetration within the tree—both important factors in reducing the development of brown rot on fruit.

Pruning at Planting

If you purchase an unbranched tree, or one with no branches 20 to 30 inches above the soil line, cut the tree at 26 to 30 inches above the ground after planting. Failure to do so will result in a tree whose major branches are too high above the ground (Figure 5.2). The scaffold branches will develop within 4 to 6 inches below the cut.

If you purchase a tree with healthy branches located 15 to 30 inches above the soil line, select three or four branches, one at each of the compass points. Choose branches that initially develop from the main axis at a 60- to 90-degree angle. Cut them back by one-half to a healthy outside-facing bud. Remove all branches that are less than 15 inches above the soil line and cut the tree off just above the topmost selected scaffold (see

Figure 5.2). During the summer, pinch off any shoots that begin to grow toward the center of the tree.

Cut unbranched trees 24 to 30 inches above the soil line. Cut branched trees back to 30 inches and cut three to four side branches in half, removing all others.

By the end of the first summer, trees should begin to take on the typical open vase shape. Three or four permanent scaffold limbs should be selected at this time and the others removed. The permanent or primary scaffolds chosen should be distributed evenly around the trunk, approximately 6 inches apart vertically. Small side branches along the scaffolds can be left for early fruiting. Do not select primary scaffold limbs that are directly above one another. The limbs selected should have an angle of 60 to 90 degrees from vertical.

Pruning the Winter after Planting

Always prune most stone fruit trees in late winter. The best time to prune is from just before bloom to 2 weeks after petal fall. Do not prune the trees from January through March, and do not prune before budswell.

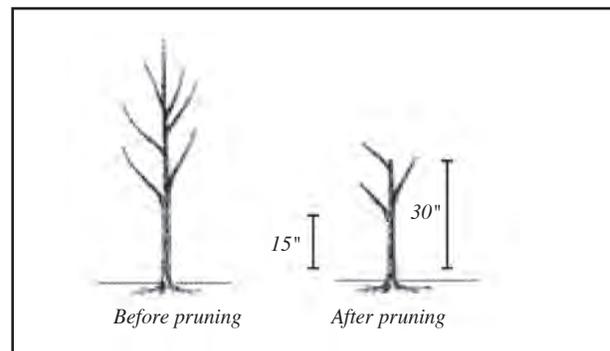


Figure 5.2. Pruning stone fruit at planting.



Figure 5.3. Two-year-old peach tree before (left) and after pruning.

Stone fruit trees are very susceptible to a disease called cytospora canker. If pruned in the winter, the trees cannot protect the pruning wounds from infection by this disease. The exception is sweet cherries, which are best pruned after they have fruited or in early July.

First, remove any broken or diseased branches. Second, cut out any vigorous upright shoots that might have developed on the inside of the main scaffolds. Ultimately, prune the tree so it becomes vase shaped with no branches in the center (Figure 5.3).

Pruning the Second Winter

Trees that have grown well for 2 years may be 5 to 7 feet tall, 6 to 8 feet wide, and have trunks 3 to 6 inches in diameter. During the second winter after planting, the trees should begin to develop secondary or subscaffold branches on the primary scaffolds. Select two or three limbs per branch that developed during the second summer. They should be spaced 6 to 8 inches apart, 18 to 24 inches from the main trunk, and on opposite sides of the branch (Figure 5.4). Remove all other limbs. Head the chosen side-limbs back by one-half. Head back the primary scaffold by one-half. Large, vertical growing limbs on the primary scaffolds should be completely removed, leaving only the less vigorous wood for fruiting.

Pruning the Third and Subsequent Years

After careful pruning and training during the first 2 years, heavy pruning should not be necessary. Light corrective pruning should maintain the open center (Figure 5.5). A well trained tree should have 3 to 5 scaffold



Figure 5.4. Pruning the second winter after planting.

branches with wide angles evenly distributed around the tree. Thin out and shorten inside limbs to prevent shading of the center. Remove large, branched water sprouts. These shoots may be 4 to 7 feet long. They are not very fruitful and shade the tree center. Prune every year to keep the tree within its allotted space and to prevent limb breakage. Remove vigorous upright branches and leave the less vigorous ones. Head back limbs to encourage the development of new fruiting wood.



Figure 5.5. Mature peach tree before (left) and after pruning.

Pruning Mature Trees

Limit the height and spread of older mature trees. Their height can be limited to 7 to 9 feet tall by removing large branches from the upper side of scaffolds, leaving only small fruit-producing shoots. Head back primary scaffold branches to an outside-growing side branch. Remove or cut back damaged portions of larger branches. Maintain the open center to prevent shading of the interior portion of the tree. Retain shoots that grow horizontally and 12- to 18-inch fruiting shoots, regardless of their orientation. Thin fruiting shoots to a spacing of about 4 to 6 inches apart on the limbs.

You can view the slide set *Pruning and Training Fruit Trees* to assist you in learning how to prune at <http://tfpg.cas.psu.edu/pruning/slide1.htm>.

FRUIT THINNING

The practice of fruit thinning apples, pears, and stone fruits is much discussed but little understood. Thinning is done for two reasons. First, a certain portion of the fruit is removed so that the remainder will develop adequate size and quality, and, second, the thinning process serves to increase the plant's ability to form flower buds for the next year—provided the thinning is done early enough.

Thin excess fruit when the fruits are the size of the end of your little finger—about 1/2 inch in diameter. If you have a lot of trees to thin, you can start earlier, even when blossoms are still present. Unlike apples and pears, no chemicals are labeled for thinning stone fruits.

Simply start at one end of a branch and systematically remove fruit, leaving one fruit every 6 to 10 inches. Be sure to leave only one fruit at a given site; doubles provide homes for insects and diseases. Keep in mind that only 7 or 8 percent of the tree's flowers are needed to set a full crop of fruit.

Thinning also reduces the total load on the branches and prevents breakage. Thinning is only necessary for apples, peaches, nectarines, pears, and plums; tart cherries should not be thinned.

INSECT AND MITE PESTS

For descriptions of the European red mite, rosy apple aphid, green apple aphid, plum curculio, and San Jose scale, see Chapter 4.

Green Peach Aphid

The green peach aphid, *Myzus persicae*, is a common pest of peaches in Pennsylvania. Peach trees are its primary host and overwintering source. Green peach aphids overwinter as wingless females and/or eggs underneath peach buds. Eggs hatch and young nymphs develop into stem mothers, which produce living young. Aphids have a high reproductive potential, although wind, rain, cold weather, and predators are important in regulating populations. After several generations of wingless adults, winged aphids appear during June, and all aphids leave peach trees during June and July to fly to alternate hosts. In the fall, aphids return to peach trees to overwinter.

The aphid is soft bodied, 1/16 inch long, and yellowish green. It is characteristically pear shaped with fairly long antennae and a pair of cornicles ("tailpipes") at the end of its body.

Aphids cause direct injury by extracting sap from plants. Toxins emitted by feeding aphids cause curling, distortion, occasional foliage discoloration, and premature leaf drop. Feeding aphids also excrete copious amounts of honeydew as a waste product, upon which grows a black, sooty fungus that causes smutting of leaves and fruit. Finding hundreds or thousands of aphids per plant is not uncommon.

Trees should be inspected weekly from petal fall until the terminals harden off. If more than two colonies per tree are found, an insecticide containing imidacloprid should be applied. Thorough coverage of lower leaf surfaces with an insecticide is necessary to control green peach aphid.

Japanese Beetle

The Japanese beetle, *Popillia japonica*, is one of the most common pests encountered by Pennsylvania fruit growers, nursery operators, and gardeners. It is often the most important pest of tree-ripened peaches and can cause severe damage to other important crops.

The Japanese beetle is beautifully colored—the head, thorax, and abdomen are bright metallic green, and the legs are dark green. Coppery brown wing covers extend near the tip of the abdomen, where two prominent white tufts of hair occur. Five similar tufts occur along the side of each wing cover.

The egg is pearly white, elliptical, and $\frac{1}{16}$ inch in diameter. The soft-bodied grub is “C” shaped, whitish with a brown head, and 1 inch long at maturity.

The Japanese beetle overwinters in the soil as a grub and completes its growth in early spring. Adults emerge in greatest numbers during July and are active for a month. The gregarious beetles are most active on warm, sunny days on favorite hosts. Adults enter the ground in the early evening.

During their life cycle, females lay 40 to 60 eggs that hatch in 2 weeks. Grubs feed on organic matter and fine grass roots until late fall. They reach maturity in early spring and, after spending 3 to 4 weeks in the pupal stage, emerge as adults. Only one generation is hatched each year.

Beetles chew leaf tissue between veins and leave a lacelike skeleton. Severely injured leaves soon turn brown and often drop. The fruit of early ripening peach trees might be gouged in irregular, shallow patches or completely devoured.

Fruit and foliage can be protected by using a broad-spectrum insecticide beginning when beetles first cause injury and as necessary when beetle feeding causes unacceptable damage. Since sprayed trees can be reinvaded, they should be inspected weekly when adults are present.

Lesser Peachtree Borer

Lesser peachtree borer, *Synanthedon pictipes*, is an important pest in peach and cherry orchards throughout Pennsylvania and surrounding states. Problems are almost always associated with widespread incidence of Cytospora canker and, to a much lesser extent, pruning wounds, winter injury, and mechanical damage.

Adults are day-flying moths that resemble wasps. Veins and margins of transparent wings are fringed with steel-blue scales; the body is blue and narrowly fringed with yellow. Males of lesser peachtree borer have yellow scales on the top of the head between the eyes and black scales between the antennae. This combination differentiates them from peachtree borer males, which have black scales between the eyes and yellow scales between the antennae. Lesser peachtree borer larvae are white with a yellowish-brown head and reach 1 inch at maturity.

There are two generations each year; the first flight occurs during May and June, and the second during August and September. The lesser peachtree borer overwinters as larvae and reaches full growth during April and May. Larvae eat an exit hole nearly through

the bark, spin a cocoon, and pupate in a small cavity. In 3 to 4 weeks, a clear-winged moth emerges, leaving an empty pupal skin projecting from the burrow. Adults are active for several weeks. The female moth is capable of laying several hundred eggs in cracks, under bark scales, and in cankered areas. Moths are attracted to trees that have been injured or previously infested. Eggs hatch in a week to 10 days, and young worms move to the inner bark and continue to feed.

Growers first notice evidence of borer infestation by checking for pupal skins in cankered areas. An early sign of lesser peachtree borer injury is the presence of wood chips, sawdust, and frass produced by feeding borers in the gum in cankered areas. If the gum does not contain this particulate material, the injury is probably not caused by borers. As an aid in timing sprays, growers should obtain pheromone trap records on flight activity. Treat at peak flight, usually toward the end of June, if there is an average of more than two borers per tree, and again in late summer. If fewer than two pupal skins are located in each tree, target only the second generation in late summer.

Any horticultural practice that prevents canker and maintains good tree development will help prevent borer damage. If chemical control is necessary, high-volume handgun sprays thoroughly wetting trunk and scaffold limbs are recommended, with at least 1 gallon of spray mixture applied per tree. The late-summer spray can be applied after harvest. If peachtree borer is also a problem this spray should be made within the first 2 weeks of September. If only lesser peachtree borer is present, sprays may be applied to late-maturing varieties in early August. Do not allow spray residue to contaminate fruit.

Oriental Fruit Moth

The oriental fruit moth (OFM), *Grapholita molesta*, is a pest of most stone and pome fruits. On pome fruits, its appearance and injury is similar to that of the codling moth.

Adults are gray, with a wingspread of $\frac{1}{2}$ inch; the wings are gray with brown markings. Larvae are grayish white with a black head and are $\frac{1}{2}$ inch long when fully grown. OFM larvae have a black “anal comb” on the top of the last body segment, distinguishing them from codling moth larvae. The presence of legs distinguishes them from plum curculio larvae. Oriental fruit moth attack the fruit in much the same manner as the codling moth attacks the apple (see Chapter 4). Several generations of fruit moths are produced each year, but the first generation is the most numerous. They overwinter as

larvae in silken cocoons on the tree or on the ground, pupate in April, and begin to emerge as adults during late April, shortly before fruit trees bloom. Most of the eggs (up to 200 per female) are laid during May as single, flat, whitish ovals on twigs or the undersides of leaves. The succeeding overlapping generations extend into September and October.

The earliest indication of injury is a dying back of the new growth of twigs in spring. This is especially noticeable in stone fruit. A first-generation larva enters at a leaf axil near the tip of a shoot and bores down the central core for several inches, causing the terminal to wilt, or “flag.” Later-generation larvae may enter the fruit near the stem end and make feeding burrows that usually extend to the pit. The mature larva exits the fruit from the side, leaving a large gumming hole with much frass.

Spray timing can be aided by using a pheromone trap. Hang traps in early April and check them weekly. To affect the exposed egg-laying females and eggs, apply sprays after the peak of the male trap catch. Orchard sanitation also helps, through the removal of dropped fruit and other ground litter that can act as development or overwintering sites.

◆ Mating disruption (i.e., attract-and-kill Last Call OFM) can be used to manage this pest. Pheromone and insecticide solution droplets should be placed in the mid to upper level of the tree canopy at the label rate at pink stage of apples and again at about every 45 days. The droplets remain effective for at least 6 to 7 weeks. Moreover, monitoring should proceed as usual to check the effectiveness of disruption.

Peachtree Borer

The peachtree borer, *Synanthedon exitiosa*, is a pest primarily of peach and nectarine trees, but it also attacks apricot, cherry, and plum trees.

The peachtree borer larva is white with a brown head, and is 1½ inches long at maturity. When flying, adults resemble wasps and often are mistaken for them. The female moth is dark blue with a broad orange band around the body; the forewings are darker than the back wings, which are clear. The male is smaller and has three to four narrow, yellowish bands across his body; both pairs of wings are clear.

Borers overwinter in the larval stage in a range of sizes. Larvae become active and resume feeding in April; larger larvae complete their feeding during June and July. Most adults emerge and lay eggs during July and August.

The female moth is capable of laying approximately 500 eggs. They are laid on tree trunks, in cracks or under bark scales, and in soil near the tree trunk. Eggs hatch in 10 days, and young larvae feed on tree bark, working their way into the trunk as they become larger. They are attracted to previously infested or injured trees. Only one generation is hatched each year.

One of the first signs of peachtree borer attack is a mass of gum exuding from the trunk base anywhere from 3 inches below to 1 foot above the soil surface. This gum mass contains bits of wood chips, sawdust, and frass produced by the feeding larvae. Burrowing larvae weaken the tree, resulting in lower fruit production or, if borers are numerous, in the death of the tree. Neglected trees, or those suffering from drought or winter injury, are most likely to be infested by these borers.

Several methods can be used to control this pest after infestations have been noted. Individual larvae can be killed by stabbing them with a length of wire inserted into their burrows. A different control method involves spraying a pesticide containing one of the pyrethroid insecticides such as esfenvalerate or permethrin onto the affected area of the trunk.

Plant Bugs and Stink Bugs

The plant bugs and stink bugs that attack peaches, nectarines, apples, and pears feed on many different wild and cultivated plants, including numerous other horticultural and agronomic crops. They are found in significant numbers throughout Pennsylvania.

Sucking bug pests vary greatly in color, size, and shape but share certain characteristics. The front half of the forewing is leathery, the back half membranous. Mouthparts, arising on the front of the head, are of the piercing-sucking type and are held below the body between the legs when not in use. Antennae are usually long. Nymphs (the immature stage) generally are similar to adults but do not have wings.

The tarnished plant bug, *Lygus lineolaris*, is a small, oval, fragile-looking, green to dark-brown insect, flecked with white, yellow, reddish-brown, and black markings. Nymphs are pale yellow to green. Adults are about ¼ inch long.

Stink bugs are broadly shield shaped, flattened, with a narrow head and rather short legs, and are green to brown. They generally are larger than tarnished plant bugs.

Sucking bugs, as the name implies, feed by sucking sap from plants. They are believed to inject a toxic substance into the plant when feeding to break down plant tissues. Their feeding is very destructive to fruit

and other tender plant parts. The earliest injury to fruit is caused by tarnished plant bugs, other *Lygus* species, and possibly stink bugs, which are active in the early spring. Tarnished plant bugs often cause the most damage because they normally are present in high numbers when fruit starts to grow in the spring. They feed on swelling fruit and leaf buds, causing the buds to dry up. When fruit buds are damaged, blossoms might never open or might be deformed. Later, feeding on open blossoms or small fruit usually causes the damaged blossoms or fruit to fall. If damaged fruit does not fall, it becomes scarred and malformed (catfaced or dimpled) as it grows. Cold weather or hail can cause similar injury. Tarnished plant bug feeding on young, tender, terminal or lateral shoots also can cause wilting and dying back, sometimes giving young trees a brushy appearance.

Most severe catfacing and dimpling damage is done immediately following bloom, from petal fall until fruit are $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter. Cells are destroyed and fruit development inhibited at the feeding site, while surrounding tissues continue to grow and expand. As fruit increases in size, feeding by plant bugs or stink bugs causes less scarring and distortion of the fruit. When fruit is mature or nearly mature, it is attacked, primarily by stink bugs. Beads or strings of gum can exude from the feeding site and shallow, dry, corky, sunken areas might develop at the sites of injury. Fruit is usually injured earliest and most severely on the edges of orchards bordering woodlands, fencerows, or fields. Most sucking bugs that attack fruit overwinter as adults in protected places, such as in ground debris or between the leaves of various plants. Many periodically become active on warm days during the winter. Their time of emergence from hibernation in the spring varies with the species, but most bugs emerge in early spring.

Tarnished plant bugs are often present in fruit orchards by the time buds begin to swell. They feed on the flower buds of fruit trees and numerous other plants. They are strongly attracted to orchards that have winter annual weeds in bloom. Egg laying begins shortly after adults emerge, and most eggs are laid in the tender shoots or flower heads of herbaceous weeds, vegetables, and legumes. The eggs hatch in about 10 days, and the emerging nymphs begin to feed. The nymphal stage lasts about a month. Several generations of tarnished plant bugs hatch each year, but the bugs normally begin to leave the fruit shortly after petal fall and move to other hosts.

Stink bugs feed at almost any time during the growing season. One or two generations hatch each year, depending on the species. Recently introduced from Asia, the brown marmorated stink bug (*Halyomorpha halys*),

in addition to feeding on various plant parts, is also a nuisance pest that invades homes during the fall.

The number and species of sucking bugs present in fruit trees at any given time during the season are greatly dependent on the weather, the surrounding vegetation (alternate host plants), the orchard history, and other factors. Bugs normally are most abundant from bud break until about 6 weeks after bloom.

To sample plant bug and stink bug populations, shake trees over a ground sheet or beating tray. Begin sampling no later than pink bud, concentrating on trees or sections of orchards bordering woodlands, fencerows, or other favorable hibernation sites. White or yellow sticky-board traps also have been used to sample sucking bug populations. Preventing serious catfacing injury depends largely on well-timed, early season, broad-spectrum insecticide applications. Applications at petal fall, shuck fall, and 10 days after petal or shuck fall typically provide good control. Sprays during pink bud sometimes are applied when tarnished plant bugs are a major problem. Surround (kaolin clay) applications before and after bloom should provide partial reduction of plant bug and stink bug injuries.

◆ Cultural practices can provide some suppression of sucking bugs. Destroying broadleaved winter annual weeds and legumes in and around orchards is an excellent practice. Legumes such as clover and vetch should be avoided as cover crops. Destroying early blooming broadleaved weeds before fruit tree bloom lowers the number of early catfacing insects. However, disturbing weeds during bloom or shortly thereafter might drive the bugs into the trees, causing more damage.

Two-Spotted Spider Mite

The two-spotted spider mite, *Tetranychus urticae*, a pest of apple, peach, and other fruit trees, also feeds on a wide range of both wild and cultivated plants. These insect-like organisms are tiny ($\frac{1}{20}$ inch) and are difficult to see without a magnifying glass. Despite their small size, their populations build to high numbers very rapidly on the leaves of fruit trees, causing the leaves to yellow.

Fully grown females and some immature males overwinter under bark scales on tree trunks or among fallen leaves and in other protected places on the ground. With the arrival of warm weather in the spring, these mites leave their places of hibernation and start wandering about looking for food plants. Almost all of those on tree trunks crawl down to the ground, where they feed on weeds and grasses.

The first eggs usually can be found around the first week in May. In warm weather, they hatch in 5 to 8 days. A complete generation from egg to adult might require no more than 3 weeks. From five to nine generations hatch in the orchard each season, depending on the weather. In mid- or late summer, when drought and other factors such as weed removal cause poor food conditions among weeds and grasses, mites move from the old host up tree trunks or to low-hanging apple branches in contact with ground vegetation. Low-hanging branches that touch grass or weeds usually are attacked first; then the mites spread upward and into the tree's interior.

Once established, the population can become a serious infestation and might cause injury. Injury to leaves resembles that caused by the European red mite, except that a grayish cast is more prevalent. These mites also spin a fine silken web over many infested leaves. In the fall, the adults either remain in the tree or leave it and hibernate among weeds, leaves, or in the soil.

Two-spotted spider mites should be monitored and managed in much the same way as European red mites.

DISEASE DESCRIPTIONS AND MANAGEMENT

See basic cultural guidelines for the control of plant diseases under "Pest Management," discussed on page 24 in Chapter 2. Table 2.4 lists pesticides available on various fruit crops for the control of diseases. Pictures of fruit diseases can be found in the *Fruit Pathology Fact Sheets* at <http://fpath.cas.psu.edu/factsite.html>.

Bacterial Spot of Stone Fruit

Bacterial spot occurs in most countries where stone fruits are grown. Common hosts include peach, nectarine, prune, plum, and apricot. Other hosts are sweet and tart cherry, almond, and wild peach. Varieties within *Prunus* species vary widely in their susceptibility to this disease. Other names for the disease are bacteriosis, shot hole, and black spot. The causal bacteria, *Xanthomonas campestris* pv. *pruni*, can attack fruit, leaves, and twigs. Fruit loss on some varieties can be very high. Early and severe defoliation can affect fruit size and the winter hardiness of buds and wood.

Symptoms

The symptoms of bacterial spot are quite different from other diseases of stone fruits. They may be confused with nitrogen deficiency and spray injury. The disease first appears as small, water-soaked, grayish areas on

the undersides of leaves. Later the spots become angular and purple, black, or brown in color. The mature spots remain angular and are most numerous at the tip ends and along the midribs of leaves. The infected areas may drop out, giving the infected leaves a shot-holed, tattered appearance. On plum, the shot-hole effect is more pronounced than on other stone fruits. Infected leaves eventually turn yellow and drop. Severe defoliation often results in reduced fruit size, increased sunburn, and fruit cracking. As a result, tree vigor and winter hardiness are also reduced. Other leafspot diseases and spots due to spray injury tend to be much more circular in outline. Often, these are not confined by veins in the leaf as is bacterial spot. Leaf spots due to nitrogen deficiency are normally red in color.

Fruit infected early in the season develop unsightly blemishes and may exhibit gumming. Since the infected areas cannot expand with increased fruit size, the spots crack. Pits or cracks on the fruit surface extend into the flesh and create large, brown to black depressed areas on the fruit surface. Lesions that develop during the pre-harvest period are usually superficial and give the fruit a mottled appearance. On plum, the fruit symptoms are likely to be quite different in that large, black, sunken areas are most common. On a few varieties, small pit-like spots occur.

There are two distinct twig cankers on peach and nectarine. Lesions that develop on green shoots and twigs in the summer are called summer cankers. These are small to large purple-black lesions, slightly sunken to deeply cracked, and circular to elliptical in shape. Lesions that develop after bud break are called spring cankers. They develop on the previous season's growth beginning from about the time of bud swell through the bloom period. They may appear as small, somewhat blister-like, darkened areas often around or near a bud. Later, the epidermis ruptures and the bacteria become exposed. Spring cankers also are seen as a tip dieback of the twig. Summer cankers are usually located between nodes and spring cankers are located at nodes.

The cankers on plums and apricots eventually appear quite different. On susceptible varieties, the bacteria may survive for 2 or 3 years, slowly enlarging and deepening the cankered area. The results are deep-seated cankers deforming the small branches so they have a knotty appearance. Some of these branches may be killed or they may break from the weight of the fruit. Bacterial spot may affect sweet and tart cherry leaves. While rarely happening, the leaf symptoms are like those on peach.

Disease Cycle

The bacteria overwinter in the twigs, buds, and symptomless plant tissue. In the spring, the bacteria are spread by rain to leaves, shoots, and fruit. Spring infections can occur anytime after the leaves begin to unfold. Temperatures above 65°F and warm rains are needed for the bacteria to multiply, become exposed, and be disseminated. After these first infections, which are rarely noticed but do initiate the disease each year, the severity of the secondary infections depends entirely on the weather. A moderately warm season—with light, frequent rains accompanied by heavy winds—favors severe outbreaks of bacterial spot. Any recent injury to the leaves or fruit, such as wind-blown soil particles and hail, may result in severe outbreaks.

Secondary spread of the bacteria can occur from oozing summer cankers and leaf and fruit lesions during warm, wet weather. The systemic movement of the bacteria from leaves and shoots contributes to the formation of cankers. These cankers can be spread by budding to healthy nursery trees.

Disease Management

Maximum use of resistant varieties is the most effective control measure. Growing numbers of good peaches are highly tolerant of bacterial spot. Resistance in plums, nectarines, and apricots is not as common. Nurserymen are well aware of the degree of susceptibility of the varieties they sell and they can provide good information for specific areas. Since trees in poor vigor are more susceptible, orchard management programs should be designed to maintain good vigor. Major outbreaks of bacterial canker in young orchards are often attributed to poor cultural practices.

No completely successful spray programs exist for control of bacterial spot. Chemical sprays can help reduce the amount of fruit and leaf infection but must be applied before symptoms occur. In seasons when disease incidence is light, special programs do help. In those when infections are numerous, spray programs can reduce the number of infections, but not enough to prevent defoliation and fruit infection. Chemical applications suppress the development of disease but do not eliminate it. Because chemical control is uncertain, the use of resistant varieties appears to be the best control strategy.

Black Knot of Plum

Black knot of plum, caused by the fungus *Apiosporina mobosa*, is well-named because of the characteristic black, warty knots it forms on the branches of infected

trees. Infected trees grow poorly and gradually become stunted; occasionally, their limbs are girdled. The disease is most important on plum, prune, and sour and wild cherry trees.

Symptoms

The disease is present only in the woody parts of trees, occurring most frequently on twigs and branches and sometimes on trunks and scaffold limbs. The warty swellings first become visible in late summer or the following spring on new shoots. At first, the knots are somewhat greenish and corky, but with age they become black and hard. They vary in length from an inch to nearly a foot. Often, they do not completely encircle the branch. Those a year old or older can become covered with the pinkish-white mold of another fungus and become riddled with insects, especially the lesser peach borer. Limbs and sometimes whole trees are stunted and eventually killed by the ever-expanding knots.

Disease Cycle

Around the time new seasonal growth is ½ inch long, spores of the fungus are discharged from tiny sacs in the surface of the knots. These are spread by rain and wind to the new growth, where infection takes place. Spore discharge and infection are greatest during wet periods, at temperatures ranging from 55 to 75°F. Infections continue to occur until terminal growth stops. A few greenish, corky swellings might become visible the fall after infection occurs, but most will not be noticed until the following spring. Generally, the knots produce no spores until the second spring after they become visible. The fungus in woody tissues continues to grow in the spring and fall, increasing the length of the knots. Their eventual size depends greatly on the host species and variety.

Disease Management ♦

New plantings of plums should not be made next to old ones with black knot. Remove any wild plum and cherry trees from nearby woods and fence rows for at least 500 feet from the new orchard. Inspect orchards and surrounding wooded areas each winter for knots and prune out infected shoots and limbs. Once the disease appears in the trees, remove and burn the knots before bud break. When they occur on twigs and small branches, prune out the infected branches about 4 inches below the knot. Cut out the knots on large branches and trunks. This is done most successfully during August when the fungus does not extend far beyond the visible swelling. Remove the diseased wood and about 1 inch

of clean wood around the knot. It is best to prune off the knots before growth begins in the spring. Remove the prunings from the orchard, as they will continue to produce spores for several weeks after removal. Plant black knot-resistant varieties when possible. The plum varieties Shropshire and Stanley are highly susceptible; Brodshaw, Early Italian, Fellenburg, Methley, and Milton are moderately susceptible; Formosa, Santa Rosa, and Shiro are slightly susceptible; and President apparently is resistant to black knot.

Brown Rot of Stone Fruit

Brown rot, caused by the fungus *Monilinia fructicola*, is one of the major stone fruit diseases in Pennsylvania. The disease affects peaches, apricots, nectarines, plums, cherries, and most commercially grown *Prunus* species. The fungus can cause a blossom and twig blight, a canker, a leaf infection, and a fruit rot. Infected fruit will rot on the tree and after being harvested.

Symptoms

Brown rot first affects blossoms, which wilt and turn brown. The infected blossom parts serve as a source of the fungus for future fruit infections. Blossom infections can extend into and eventually girdle a twig, causing a canker to form. These cankers also serve as sources of inoculum. The cankers do not usually extend into the previous year's wood; however, they may girdle the twig, causing it to die.

Fruit decay occurs as the fruit ripens. The infections begin as small, brown spots, and the entire fruit can rot within a few hours under favorable conditions. Under wet and humid conditions, ash-gray to brown tufts of fungus develop over the surface of the infected area. If favorable weather conditions persist, the infection can spread from the fruit into small twigs, and again cause cankers to form. Rotted fruits dry out, become mummified, and either remain attached to the tree or fall to the ground.

Disease Cycle

The fungus overwinters in mummies formed the previous season, in blighted twigs, and in cankers. Conidia produced on mummies (in the tree) and cankers are the more common inoculum for blossom infections in the spring. An additional source of conidia is produced on apothecia. Apothecia are fruiting structures of the fungus that form on mummies that have fallen on the orchard floor.

The first fungus spores are formed about the time the blossoms begin to open. Upon wetting, the spores are

forcibly ejected into the air to be blown to blossoms by the wind. Infected blossoms serve as a source of the fungus for future fruit infections. Environmental conditions are important for the development of the disease. Warm, wet, or humid weather is very favorable for disease development. The severity of brown rot increases as the fruit ripens. Wounded fruit are more susceptible to infection. Mature fruit can completely decay in 2 days from the time of infection under favorable weather conditions.

Disease Management ♦

Removing all mummies and blighted twigs after harvest is important in reducing the amount of fungus overwintering in the orchard. Adequate pruning will increase air circulation, allowing faster drying and fewer fruit infections. Fungicide sprays are necessary during bloom and as the fruit ripens. For effective brown rot control, it is important to manage insect pests that serve as vectors and/or provide wounds for new infections to occur.

Cherry Leaf Spot

Cherry leaf spot, caused by the fungus *Blumeriella jappa*, attacks the leaves, leaf stems, fruit, and fruit stems of tart, sweet, and English Morello cherries. The disease is most severe on leaves and can cause them to drop prematurely. When defoliation occurs before harvest, the fruit fails to mature normally, remaining light colored and low in sugar. Buds and wood become susceptible to winter injury, which might show the next season as poor growth, dead spurs, and dead limbs.

Symptoms

The disease first emerges on the upper sides of leaves as tiny, red to purple, circular spots. These enlarge in diameter and become red brown to brown. By then, spots show brown on the undersides of leaves; during wet periods, tiny whitish, felt-like patches appear in their centers. These contain the spores (conidia) of the fungus. On sweet cherry leaves, the spots tend to be somewhat larger. Some drop out, leaving a "shot-holed" appearance. After the leaves become infected, they turn yellow and fall.

Disease Cycle

The fungus overwinters in diseased leaves on the ground. Around bloom or shortly afterward, spores (ascospores) mature and are discharged. They are blown to young, expanded leaves where infection takes place through the stomates (air pores) on the undersides. These first infections often are so few in number that

they might be overlooked. Once unfolded, leaves are susceptible throughout the season, but as the leaves age, they become less susceptible. Each succeeding wave of infection becomes heavier, and severe defoliation begins. High humidity and rainfall increase the spread of the disease.

Disease Management ◆

Rotary mowing the orchard after leaves drop in the fall will hasten leaf decay and reduce overwintering inoculum. Otherwise, fungicide applications are the primary means of control. Begin fungicide applications when the first leaves have unfolded.

Crown Gall of Peach

Crown gall is caused by a bacterium, *Agrobacterium tumefaciens*, and affects peach, nectarine, apricot, plum, cherry, apple, pear, and quince trees. Peach and Mazzard cherry rootstocks are especially susceptible. The disease is common in tree fruit nurseries and can occur in orchards.

Symptoms

Crown gall can be recognized readily by the formation of tumors or galls on tree roots and crowns. Occasionally, the galls can be seen aboveground on trunks or branches. Young galls are light in color and become dark and hard with age. When galls are numerous, or if they are located on major roots or the crown, they might disrupt the flow of water and nutrients. These trees show reduced growth, an unhealthy appearance, and possibly nutritional deficiency symptoms.

Disease Cycle

The bacteria causing crown gall are distributed widely in numerous soils and can attack many different kinds of plants. Soil might become contaminated if planted with infected nursery stock.

Bacteria entering the plant must do so through a wound. Wounds commonly are made during digging and tree-planting operations, by tillage equipment, and by injury from root-feeding insects and nematodes. Secondary galls can develop a considerable distance from the initial infection. These can be formed in the absence of the crown gall bacteria, apparently due to a tumor-inducing substance produced at the site of the original infection.

Disease Management ◆

Avoid planting infected nursery stock or wounding trees at the time of planting.

Cytospora Canker of Stone Fruits

Cytospora canker is one of the most destructive diseases of peaches, nectarines, apricots, sweet cherries, and plums in Pennsylvania. Also known as perennial canker, peach canker, Valsa canker, and *Leucostoma* canker, the disease can cause trees in young orchards to die. Infected trees in older orchards gradually lose productivity and slowly decline.

Symptoms

The fungus attacks the woody parts of stone fruit trees through bark injuries, pruning cuts, dead shoots, and buds. Visible first is the exudation of gum at the point of infection. The canker forms from a small necrotic center that slowly enlarges with the collapse of the inner bark tissue. Cankers enlarge more along the length than the width of the branch. Older cankers therefore are oval to elongated in outline.

The outer bark of new cankers usually remains intact, except at points of gumming. In older cankers the bark in the center becomes torn. The gum turns black from alternate wetting and drying and from the presence of saprophytic fungi. Older cankers are surrounded by a roll of callus tissue. Each year, the canker enlarges by repeated invasion of healthy tissue. With renewed growth in the spring, the tree forms a callus ring around the canker as a defense mechanism. This can be a very effective defense except when the lesser peachtree borer breaks the callus ring by burrowing through it into healthy tissue.

Disease Cycle

The fungi causing the disease overwinter in cankers and dead twigs. Small, black, fruiting bodies appear on the smooth bark covering diseased areas of dead wood and begin to produce spores once temperatures are above freezing. Wet weather washes the spores from the fruiting structures. Infections do not usually occur when trees are growing vigorously; most occur during early spring, fall, and winter.

Healthy bark or buds are not attacked by the fungus. Cold-injured buds or wood and pruning cuts are the most important sites of infection. The fungus also can penetrate brown rot cankers, oriental fruit moth damage, sunscale wounds, hail injury, leaf scars, and mechanical wounds. Once established in the wood, the fungus forms a canker by invading the surrounding healthy tissue.

Disease Management ◆

Managing *Cytospora* canker involves total orchard management. Since no stone fruit tree is immune and

fungicide treatments alone are not effective, control efforts must be aimed at reducing tree injuries where infection could begin.

Planning a New Orchard ♦

- Select a site well away from old cytospora-infected trees. This has proven to be the best method of keeping canker out of newly planted orchards.
- Select a site with deep, well-drained soil and good air drainage to reduce the possibility of winter injury.
- Plant only the hardier varieties, especially if cytospora canker has been a major problem in your orchard. Also, painting the southwest side of trunks and the lower scaffold limbs of cold-susceptible varieties with white latex paint will moderate temperatures somewhat under the bark and reduce cold injury and canker in critical areas of the tree.
- Plant only disease-free nursery stock. If trees are planted when infected with cytospora they will probably not live to produce fruit.
- Plant whips no larger than $\frac{9}{16}$ inch in diameter. Large-diameter whips do not heal properly when headed back and can become rapidly infected with cytospora. The infection becomes obvious in the crotch of the tree when it is 3 to 4 years old.

Fertilizing ♦

- To avoid late, cold-tender growth in the fall, fertilize in late winter or early spring.
- Avoid excessive nitrogen fertilization. Excessively vigorous trees are slow to harden off in the fall and can be injured by cold if early frosts occur. Cold-injured tissue is very susceptible to cytospora infection.

Training and Pruning ♦

- Start training young trees early to prevent broken limbs as a result of poor tree structure. Broken branches create susceptible sites for cytospora infection.
- Prune regularly so that large cuts will not be necessary. Prune during or after bloom; actively growing trees can protect pruning cuts from infection. Do not leave pruning stubs; stubs die and can harbor the disease, which can then infect healthy branches. Remove or spread narrow-angled crotches since they tend to split and serve as infection sites. Remove all weak and dead wood and fruit mummies. Spray

newly pruned trees the same day if possible or before the next rain with a fungicide used to control brown rot.

Controlling Insects and Other Diseases

- Control lesser peachtree borer—it aids in canker expansion and the eventual death of the tree.
- Control brown rot and remove any brown-rotted fruit from trees before cankers form on the twigs. Annual brown rot cankers can serve as infection sites for cytospora.
- Control oriental fruit moth and peachtree borer. Injuries inflicted by these insects serve as infection sites.

Eradicating Cytospora Canker ♦

- During bloom or later, remove all cankers on small branches, cutting at least 4 inches below the margin of the canker.
- Surgically removing cankers on younger trees can prevent the slow decline and ultimate death of the tree. Recent research trials have shown that although this procedure is time consuming (the average treatment time ranges from 1 to 5 minutes per canker), it is nearly 100 percent effective. If the surgery is done improperly, however, the canker is almost never eradicated. When surgery is conducted before too many cankers are evident on each tree, cankers can be eliminated from young orchards before extensive infection and tree death occur.

The best time of the year for canker surgery is May and June. To remove diseased tissue and promote maximum healing, take the following steps (Figure 5.6):

1. Do not attempt surgery on cankers encompassing more than half the branch circumference. Diseased tissue often extends beyond the canker margin that is visible at the bark surface.
2. Place your knife at the top of the canker $\frac{1}{2}$ to 1 inch above visible diseased tissue.
3. Outline the area to be removed, maintaining a $\frac{1}{2}$ - to 1-inch margin beyond the canker. Outline a point at the top and at the bottom of the area to be removed. When outlining, press the knife blade straight through the bark into the wood.
4. Push the knife blade beneath the bark of the outlined area and remove the diseased tissue. It is not necessary to dig into the hardwood.
5. Clean out all diseased tissue. Note: If the diseased brown tissue extends into the margin of the cut,

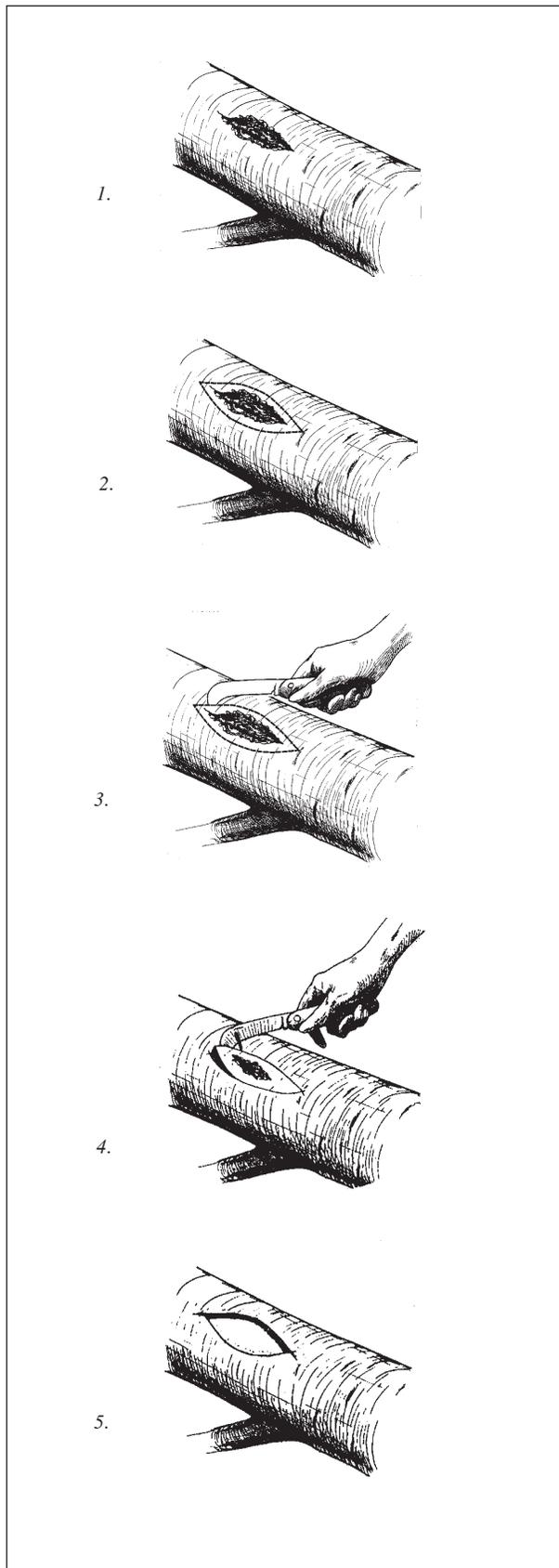


Figure 5.6. Eradicating *Cytospora canker*.

expand the margin until only healthy (green) tissue is evident at the margin. Keep the margin of the cut clean; torn tissue will not heal properly.

6. Do not paint cut surfaces with standard wound dressings (water asphalt emulsions, oil-based paints, or Latex paints). They have not proven beneficial in the wound-healing process.

Peach Leaf Curl

Peach leaf curl, caused by the fungus *Taphrina deformans*, is a common disease of peach and nectarine. This fungus destroys young peach leaves. Although new leaves develop, their growth reduces established food reserves, weakens the tree, and can reduce yield. Defoliation by peach leaf curl in successive seasons can kill the tree.

Symptoms

Infected leaves, which begin appearing in mid-May, are easily distinguished from healthy leaves because they are curled, puckered, and thicker than normal. Deformed areas are red to yellow at first and then turn brown. The infected leaves eventually fall from the tree.

Disease Cycle

Spores of the leaf curl fungus overwinter on the surface of peach twigs. In spring, the spores multiply during periods of moist weather until the leaf buds swell and open. Rain is necessary for infection. The spores are carried on a film of water into the buds, where leaves are infected. Cool, wet weather slows leaf development and allows more time for leaf curl infection. Infection occurs readily at 50° to 70°F. Dry weather during bud swell and bud break limits leaf curl infection.

After the deformed and discolored leaves turn brown and fall, they produce powdery gray spores. These are blown by winds to peach twig surfaces and remain there for the winter.

Disease Management, Chemical

Peach leaf curl is not difficult to control. A single fungicide application, made in the fall after the leaves have dropped or in the spring before bud swell, will control the disease. The spring application must be made before bud swell. Once the fungus enters the leaf, the disease cannot be controlled.

The fungicide kills the spores on twig surfaces. For either the spring or the fall spray to be effective, application must be thorough. Complete coverage of the twigs, branches, and trunks is essential.

Secondary infections do not occur after the initial infections. The disease does not spread later in the season.

Disease Management, Cultural ♦

Where leaf curl is severe, it is very important to maintain tree vigor by:

- thinning fruit to reduce demand on the tree.
- irrigating to reduce drought stress.
- fertilizing the trees with nitrogen by June 15.

Be careful not to overstimulate the trees. Redhaven and most varieties derived from Redhaven are more resistant to leaf curl than Redskin and varieties derived from Redskin.

Plum Leaf Spot

Leaf spot of plums and prune-type plums is caused by the fungus *Coccomyces prunophorae*. The fungus, its life cycle, and the disease it causes are very similar to those of cherry leaf spot. On plum leaves, the spots tend to be smaller, and severely infected leaves often have a tattered appearance. Unlike cherry infection, severe plum leaf infection is often followed by a heavy fruit drop.

Disease Management

Most varieties are susceptible to the disease, so fungicide sprays, along with the sanitation practices suggested for cherry leaf spot, are necessary for control. A light diskings should be done just before overwintered spores on leaves are ready to be discharged, about the time of shuck fall.

Plum Pockets

A number of stone fruit diseases are caused by fungi similar to the leaf curl fungus. In the northeastern United States, the most important disease affecting American-type plums is known as plum pockets, or bladder plum. It is caused by *Taphrina pruni*. This fungus occurs on wild or abandoned plum trees and is rare.

Symptoms

First signs of the disease on fruit are small, white blisters. These enlarge rapidly and soon spread over the entire fruit. The fruit becomes spongy and tissues of the seed cavity wither and die. Fruit become bladder like, abnormally large, and misshapen with thick, spongy flesh. As their spongy interiors dry up, the plums turn velvety gray as spores grow on their surfaces. Infected fruit become hollow in the center, turn brown, wither, and fall from the tree.

New shoots and leaves usually are infected, as well as the fruit. Shoots thicken and often are curled or twisted. Diseased leaves are thickened and curled as in leaf curl.

Disease Cycle

Spores overwinter on twigs, and during cool, wet periods in early bloom can be splashed to the opening buds, where infection takes place. Developing ascospores give the infected fruit a velvety gray appearance, thus completing the disease cycle.

Disease Management

A spray program similar to the one for peach leaf curl also can control plum pockets.

Powdery Mildew of Cherry and Plum

This disease is caused by *Podosphaera clandestina*, one of the common species of the powdery mildew group of fungi. The same fungus reportedly causes powdery mildew in peaches, apricots, apples, pears, quinces, persimmons, and a few ornamental plants. This discussion will be limited to the disease as it affects plums and tart and sweet cherries, although it is rare on sweet cherries in the eastern United States.

Symptoms

The fungus attacks leaves and twigs, producing symptoms much like powdery mildew on apples. Infected leaves curl upward. Newly developed leaves on new shoot growth become progressively smaller, are generally pale, and are somewhat distorted. New shoots are shorter in length than normal. By mid-season, the whitish fungus can be seen growing over the leaves and shoots, sometimes in patches and other times covering most of the new growth. Such symptoms are especially common in nursery trees. The growth of sour cherry trees in the nursery and in young orchards is reduced by this disease.

Disease Cycle

The fungus can overwinter on diseased, fallen leaves, but more commonly it overwinters in infected buds as it does in apple powdery mildew. When infected buds expand in the spring, the new growth becomes overrun by the fungus. Much of the visible white growth consists of conidia, which are spread by wind to other new leaves and shoots. Dry summers with humidities high enough to produce morning fog or dews are ideal for the rapid increase of the disease.

Disease Management

Fungicides can be applied as the disease develops. Cultural practices such as pruning orchard trees and removing hedgerows located close to the orchard aid in the drying of foliage and fruit and help control this disease.

Powdery Mildew of Peach, Nectarine, and Apricot

Powdery mildew, sometimes called “rose mildew” (it affects some woody ornamentals), is often not serious. The causal fungus, *Sphaerotheca pannosa*, and rusty spot, a disease associated with mildew fungi, usually are rare in peach orchards. The fungus can attack leaves, twigs, and fruit.

Symptoms

On fruit, the disease first appears as round, whitish spots 2 to 4 weeks after shuck fall. The spots get bigger until they cover much of the fruit. The white spots are produced by the fungus mycelium and its spores. Later, the mycelium sloughs off and leaves a rusty-colored patch with dead epidermal cells. About the time of pit hardening, the skin of the fruit under the spot turns pinkish, and the fungus and its spores disappear. Eventually, the skin becomes leathery or hard, turns brown, and can crack.

Diseased leaves often fail to unfold normally, while those of new shoots become narrow, strap like, and distorted. New shoots are shorter than normal and distorted. The white mycelium and spores of the fungus can cover infected leaves and shoots or appear as whitish patches.

Disease Cycle

The fungus overwinters in dormant peach buds. Flower buds of infected shoots often do not survive the winter. As leaf buds expand in the spring, young leaves become infected and the spores produced on the leaves serve to infect young fruit, new shoot growth, and newly expanding leaves. Leaves are susceptible to infection when young but become resistant as they age. Fruit also are more susceptible when young and become resistant at pit hardening.

Disease Management

Routine fungicides adequately control this disease. Most peach varieties are resistant to powdery mildew; however, Rio-Oso-Gem and Redskin are susceptible. ♦

Rhizopus Rot of Stone Fruit

Rhizopus rot, caused by *Rhizopus stolonifer*, can be very destructive to harvested fruit. Although it can develop in hail-injured or cracked fruit on the tree, it most commonly affects fruit in storage, during transit, and at the marketplace. Ripe fruit of peaches, nectarines, sweet cherries, and plums are most susceptible. Rhizopus fruit rot usually is of minor importance in the field, but can cause important postharvest losses.

Symptoms

Rhizopus rot begins much like brown rot—as a small, brown, circular spot—but with a detectable difference. The skin of Rhizopus rot–infected fruit slips readily from the underlying flesh, while the skin of brown-rotted areas is tough and leathery. At normal temperatures, the small spots of Rhizopus rot enlarge rapidly and can involve the entire fruit in 24 to 48 hours. A white, whiskery mold appears on the surface of infected fruits, spreading to nearby fruit and the walls of the container. By this time, the fruit tends to leak and to smell like vinegar. Finally, tiny, black, spherical structures are produced on stalks above the white mold. Each of these contains thousands of spores that are released to float in the air. At this stage, the mold looks mostly black.

Disease Cycle

Rhizopus rot occurs on all decaying vegetation, including ripe fruits and vegetables. When environmental conditions are not favorable, it produces thick-walled resistant spores that can withstand long periods of cold and drying. These are present on dead vegetation, used fruit containers, packing houses, and storage facilities. Thus, some type of spore of the Rhizopus rot fungus is always present where fruit is handled.

An injury through the fruit skin must be present for the first infections to occur, and injuries as tiny as the prick of a pin are sufficient. In packed fruit or clustered ripe fruit on trees, the fungus can spread over the uninjured skin from an infected nearby fruit and eventually cause a rot. High temperatures and humidities favor the rapid growth of the fungus and the decay of the fruit.

Disease Management

Preventing skin cuts and punctures during harvest and packing is of prime importance in controlling Rhizopus rot. Clean containers and good housekeeping in the packing shed and storage will aid greatly in reducing the spore population. Store fruit at or below 39°F—the fungus does not grow at temperatures below 40°F. ♦

Pest Management

The following list of cultural control suggestions will help you manage pests on stone fruit. Tables 5.2 through 5.4 provide additional information about pests and pesticides. Also see the basic cultural guidelines for the control of plant diseases under “Pest Management,” discussed on page 24 in Chapter 2.

General Cultural Controls ◆

- Remove, burn, or bury all dead and diseased wood.
- Remove fruit mummies from within the tree and from the orchard floor.
- Remove all rotted fruit from within the tree and dispose of it.
- Do not let new terminal growth extend beyond 1 to 1½ feet per year.
- Cultivate. Do not let sod grow within 3 feet of the tree trunk.
- Keep trees openly pruned to facilitate better drying conditions.

Table 5.2. Occurrence of insect and mite pests during the stone fruit growing season

Apply pesticides only if pests are present in damaging numbers. Bloom period is assumed to occur during the second week in May. Dates listed for sprays are approximate; they should be applied about once every two weeks.

Insects and Mites

ERM	=	European red mite	PC	=	plum curculio
GPA	=	green peach aphid	SJS	=	San Jose scale
JB	=	Japanese beetle	SB	=	stink bugs
OFM	=	oriental fruit moth	TPB	=	tarnished plant bug
PTB	=	peachtree borer	TSM	=	two-spotted spider mite

Timing	ERM	GPA	JB	OFM	PTB	PC	SJS	SB	TPB	TSM
Dormant	+	+	-	-	-	-	++	-	-	-
Pink	-	++	-	-	-	-	-	-	++	-
Bloom	-	-	-	-	-	-	-	-	-	-
Petal Fall	+	++	-	+	-	-	-	+	++	-
Shuck Fall	+	+	-	+	-	++	-	++	++	-
Early June	+	+	-	++	-	++	-	++	+	+
Mid-June	+	+	+	++	+	+	+	+	+	+
Early July	+	-	++	++	++	-	++	+	+	+
Mid-July	+	-	++	++	++	-	++	+	-	+
Early Aug	-	++	++	++	++	++	-	-	+	+

+ = pest present, possible control

++ = proper timing of control

- = control generally is not needed at this time

Table 5.3. Efficacy of pesticides on peaches and nectarines.

Due to a wide array of various products containing the same active ingredient, for insecticide recommendations, when appropriate, the active ingredient is listed instead of the name of formulated product

Insects and Mites

ERM	=	European red mite	PC	=	plum curculio
GPA	=	green peach aphid	SJS	=	San Jose scale
JB	=	Japanese beetle	SB	=	stink bugs
OFM	=	oriental fruit moth	TPB	=	tarnished plant bug
PTB	=	peachtree borer	TSM	=	two-spotted spider mite

Pesticides	ERM	GPA	JB	OFM	PTB	PC	SJS	SB	TPB	TSM
Azadirachtin	3	3	3	—	—	—	—	3	4	—
Carbaryl ^a	4	4	2	2	3	3	3	3	3	4
Esfenvalerate	—	3	1	2	2	2	—	2	2	—
Horticultural Oil	1	2	4	4	4	4	1	4	4	1
Imidacloprid	—	1	2	—	—	3	—	3	3	—
Malathion	4	3	2	2	2	3	2	2	2	3
Safer's Soap	2	3	4	4	4	4	2	—	—	2
Spinosad	—	—	3	4	—	—	—	4	4	—

Degree of control: 1 = excellent; 2 = good; 3 = fair; 4 = poor; — = no rating available

a. Carbaryl may worsen mite problems.

Table 5.4. Efficacy of fungicides on stone fruit.**Diseases**

S = scab

BR = brown rot

PM = powdery mildew

BS = bacterial spot

CLS = cherry leaf spot

LC = leaf curl

Pesticides	S	PM	CLS	BR	BS	LC
Captan	1	5	3	2	3	4
Chlorothalonil	1	4	1	1	5	1
Copper	2	1	1	3	1	1
Lime Sulfur*	1	1	2	2	3	2
Neem	4	4	4	4	4	4
Myclobutanil	1	1	1	2	5	5
Sulfur	2	1	3	3	3	3

Degree of control: 1 = best; 2 = good; 3 = fair; 4 = slight; 5 = none

* Lime sulfur may also cause leaf burning and cannot be used on apricots.

Table 5.5. Pesticide recommendations for stone fruit.

This schedule will not provide desirable control of brown rot unless there is Captan in the GPProduct mix. Always consult the label before making pesticide applications. Labels vary greatly between commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides. Due to a wide array of various products containing the same active ingredient, for insecticide recommendations, when appropriate, the active ingredient is listed instead of the name of formulated product.

Time to Spray	Suggested Materials	Pests to Be Controlled
Dormant—before green	Copper Oil	Leaf curl scales, mites, aphids ^b
Pink—just before blossoms open	GPProduct mix ^a <i>plus</i> either Captan or Chlorothalonil	Brown rot plant bug
Bloom	Chlorothalonil or Captan	Brown rot
Petal fall	Same materials as for pink <i>or</i> Esfenvalerate <i>plus</i> Imidacloprid <i>or</i> Malathion <i>plus</i> Chlorothalonil <i>or</i> Captan 50WP	Brown rot, cherry leaf spot, oriental fruit moth curculio, aphids, plant bug ^b
Shuck fall—when most shucks have fallen	Captan + myclobutanil Esfenvalerate or carbaryl	scab, cherry leaf spot, bacterial spot powdery mildew Same as above
Early June—14 days after shuck fall	Captan + myclobutanil Same materials as Shuck Fall	scab, cherry leaf spot, bacterial spot powdery mildew Same as above
Before harvest—3 weeks before harvest	Captan + myclobutanil Spinosad <i>plus</i> Same materials as Shuck Fall	Brown rot, leaf spot leafrollers, thrips Oriental fruit moth, maggot, Japanese beetle
One week before harvest and during harvest	Captan	Brown rot
After harvest—need only on cherry trees immediately after harvest	GPProduct mix, <i>or</i> Chlorothalonil Diazinon <i>or</i> Methoxychlor	Leaf spot slugs, Japanese beetle ^b

a. Use the GPProduct mix or Methoxychlor and Malathion from the pink through the before harvest sprays.

b. Match pesticide efficacy against problem pests before selecting spray material (see Table 5.4).

Grapes

Grapes are one of the most ancient crops known. They can be eaten fresh as table grapes or enjoyed in a variety of products such as juice, jelly, and the ultimate processed grape product, wine—created from the controlled fermentation of grape juice. [For information on home winemaking, refer to *Winemaking as a Hobby* (AGRS-49), available through Penn State county extension offices.] Grapes are a wonderful crop to grow in the backyard. Many species are native to North America and are extremely easy to grow, whereas others (primarily wine grapes) are natives of Europe and can present a true horticultural challenge to the backyard grower. Because grapes are vines, the form to which they are trained is limited only

by the grower’s imagination—from arbors to fences to more standard trellis systems, grapes can be trained to conform to many shapes and sizes.

VARIETY SELECTION

Site selection is extremely important for growing the more cold-tender grape varieties, although American types such as Concord and Niagara thrive in most places in Pennsylvania that meet the criteria outlined in Chapter 1. Site evaluation criteria for temperature are outlined in Table 6.1, and grapes are classified by hardiness in Table 6.2. An ideal site for the cold-tender varieties should also have 160 or more frost-free days.

Table 6.1. Site criteria for planting grapes.

Classification of Site	Frequency ^a of Temperatures of -5°F	Frequency of Temperatures of -10°F	Long-term Minimum (°F)	Suitable Grape Varieties
excellent	three times or less over 10 years	a maximum of once every 10 years	-10	all varieties listed
good	four times in 10 years	a maximum of once every 10 years	-15	all varieties; however, tender and very tender will be injured in some years
acceptable	every year	a maximum of four times in 10 years	-15	varieties of medium or greater hardiness

a. If winter temperatures reach -10°F five or more times in 10 years, and/or winter temperatures drop to -15°F three or more times in 10 years, this site is not suitable for grape production.

Table 6.2. Relative cold-hardiness of grapevines grown in Pennsylvania (courtesy of Michigan State University).

Very Hardy	Hardy	Medium	Tender	Very Tender
Concord	Aurore	Alden	Chardonnay	Gewurztraminer
DeChaunac	Canadice	Chancellor	Suffolk Red	Sauvignon Blanc
Marechal Foch	Catawba	Chambourcin	Interlaken	Pinot Gris
	Cayuga	Chelois	White Riesling	
	Delaware	Chardonel	Pinot Noir	
	Fredonia	Einset	Cabernet Sauvignon	
	Mars	Himrod	Cabernet Franc	
	New York Muscat	Lakemont		
	Niagara	Seyval		
	Reliance	Steuben		
	Vignoles	Traminette		
		Vanessa		
		Vidal		

After choosing an appropriate site, the most important decision a prospective grape producer must make is the selection of appropriate varieties. Variety selection is determined by at least two primary factors. The first is the purpose of the grapes. Although Concord makes a wonderful juice and jelly, it makes a wine of limited appeal; in addition, many people dislike seeds in their fresh-eating grapes. On the other hand, Concord is wonderfully adapted to our climate in Pennsylvania, having good pest resistance and cold hardiness. European grapes (*Vitis vinifera*) such as Chardonnay or Cabernet Sauvignon have excellent winemaking characteristics, but they are susceptible to a whole host of diseases and are more cold tender than native grapes. In many cases, French-

American hybrid grapes offer a good compromise for wine production because they have good winemaking characteristics as well as better horticultural traits than their European cousins. Tables 6.3 and 6.4 delineate characteristics of wine and table/juice grape varieties.

PURCHASING AND PLANTING

Grapes are sold as rooted cuttings (referred to as “own-rooted” plants) or grafted plants. Both usually are sold as bare-root dormant plants, which should be planted in the spring as soon as the soil can be worked. Only the European grapes require grafting since they are susceptible to the root louse phylloxera, which is ubiquitous in

Table 6.3. Wine grape varieties for Pennsylvania.

Variety	Approximate Harvest Season	Winter Hardiness	Wine Quality	Disease Susceptibility				Sulfur Sensitivity
				BR	DM	PM	BUR	
White Wines								
Aurora ^{a, b}	Early	Hardy	Fair	3	1	2	3	No
Catawba ^f	Late	Hardy	Good	3	3	2	1	No
Cayuga White ^c	Early	Semihardy	Good–Excellent	2	2	1	1	No
Chardonnay	Late	Semihardy	Good–Excellent	—	2	3	2	No
Chardonnay ^{a, b, g}	Early Mid-season	Tender	Excellent	3	3	3	2	No
Delaware	Early	Hardy	Fair	2	3	2	1	No
Gewurztraminer ^g	Early Mid-season	Tender	Excellent	3	3	3	2	No
Muscat Ottonel	Late	Tender	Excellent	3	3	3	2	No
Niagara	Early Mid-season	Hardy	Good	3	3	2	1	No
Seyval ^{a, b, c, d, e}	Mid-season	Semihardy	Good–Excellent	2	2	1	1	No
Vidal 256 ^d	Late	Semihardy	Good–Excellent	1	2	2	1	No
White Riesling ^{b, c, g}	Late	Tender	Excellent	2	3	3	3	No
Red Wines								
Cabernet Franc ^{g, h}	Mid-season	Tender ^h	Excellent	3	3	3	1	No
Cabernet Sauvignon ^g	Late	Tender	Excellent	3	3	3	1	No
Chambourcin	Mid-season	Medium	Good–Excellent	3	1	1	2	No
Chancellor ^{b, c}	Mid-season	Hardy	Good–Excellent	3	3	3	1	Yes
Concord	Mid-season	Hardy	Good–Excellent	3	1	3	1	Yes
DeChaunac ^a	Mid-season	Hardy	Good–Excellent	3	3	2	1	No
Leon Millot ^a	Very Early	Hardy	Good–Excellent	3	2	3	—	No
Marechal Foch ^a	Very Early	Hardy	Good–Excellent	2	1	2	1	Yes
Rougeon	Mid-season	Moderately Hardy	Good	2	3	3	2	Yes
Steuben ^d	Late	Medium	Good–Excellent	2	1	1	2	No

Diseases: BR = black rot; DM = downy mildew; PM = powdery mildew; BUR = bunch rot

Disease susceptibility: 1 = low susceptibility; 2 = moderately susceptible; 3 = very susceptible; — = no information

a. Susceptible to bird depredation

b. Fruit may crack after heavy rains

c. Frequent shoot breakage during growing season

d. Shoots tend to die back in fall and winter

e. Susceptible to aerial form of *Phylloxera*

f. Use sulfur only in postbloom sprays

g. Varieties are European grapes, or *Vitis vinifera*

h. The most cold-hardy of the European red grapes

our soils. Grafting onto a resistant rootstock takes care of this problem.

Most grape plants will be rooted cuttings, but note that grapes are also propagated easily from dormant cane cuttings. Collect dormant wood (pencil thickness, exposed to full sun) in December and store it in a cold, but not freezing, place until spring, making sure to note which end of the cuttings is “up.” The plants will not root if put in the soil upside down. In the spring, put two nodes of the cutting into friable, moist, well-drained soil, and keep the cuttings watered. Rooting generally will occur in 4 weeks or so. Transplant the following spring to the desired site.

Regardless of whether you buy or propagate your own plants, plant them in a large hole with the roots 4 to 6 inches below the soil surface, pruning off damaged roots and spreading the remainder. Prune back to one cane, and leave only two to three nodes on each cane. After shoot growth begins and the danger of spring frost is past, remove all but the two strongest shoots (Figure 6.1). Be sure to keep the new vines watered and weeded, and remove all flower clusters in this first year. Remember that your first goal is to establish the plant. A well-established grapevine that is well adapted to its climate

will produce fruit for 50 years or more! Vines can be staked as needed, and the desired trellis system can be erected during the summer or the fall. How the plants are supported is up to the individual, of course; the grape plant adapts graciously to most forms. A standard trellis used in commercial vineyards is about 6 feet tall, with wires at 3 and 6 feet to support the grapes. Be sure to monitor and control insect and disease pests (see pest descriptions and recommendations below).

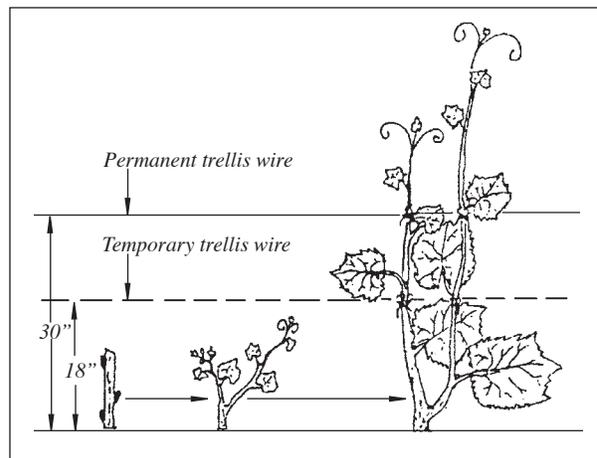


Figure 6.1. Vine management during the first growing season.

Table 6.4. Table and juice varieties for Pennsylvania.

Variety	Approximate Harvest Season	Fruit Hardiness	Berry Color	Size ^a
Seedless				
Canadice	Early	Hardy	Red	Small–Medium
Einset ^c	Early	Hardy	Red	Medium
Glenora	Mid	Medium–Hardy	Blue	Small
Himrod ^b	Early	Medium–Hardy	White	Very Small–Small
Interlaken ^b	Very Early	Medium–Hardy	White	Small
Lakemont ^b	Early–Mid	Medium–Hardy	White	Medium
Mars ^d	Mid	Medium–Hardy	Blue	Large
Reliance	Early	Hardy	Red	Large
Remily ^c	Late	Semihardy	White	Large
Romulus	Mid–Late	Semihardy	White	Very Small
Suffolk Red	Mid	Semihardy	Red	Small
Vanessa	Mid	Medium–Hardy	Red	Medium
Seeded				
Alden	Late	Medium	Blue-Black	Very Large
Buffalo	Early	Medium	Blue-Black	Large
Concord	Mid	Hardy	Blue-Black	Large
Monticello	Early	Hardy	Blue-Black	Large
Niagara	Mid	Hardy	White	Large
Steuben	Late	Medium	Blue	Large

a. As determined by weight

b. Tends to develop poor clusters

c. Has crisper texture and nonslip skin

d. Tends to develop seed traces in cooler climates

NUTRITIONAL REQUIREMENTS

Test and amend the soil according to the soil test directions a year before planting. Two to three weeks after planting, apply 2 ounces of 33-0-0 to the plants, taking care to keep the fertilizer 1 foot away from the vine. In subsequent years, apply 4, 6, or 8 ounces of 33-0-0 per plant or 1 to 2 pounds of 10-10-10 per plant before the buds start to swell in the spring. If vines are too vigorous, omit nitrogen for 1 to 2 years. Test the soil periodically (every 3 to 5 years) and maintain a soil pH between 5.6 and 6.4.

PRUNING

Grapes can be grown to conform to numerous shapes: arbors, fences, and decorative trellises are only a few of the possibilities. The grower's imagination is the only limit to how the vines can be trained. Since many home gardeners opt to use a less traditional training system, they should remember the following pruning and training principles:

- The structure to which you are training the grapevine should be reasonably filled but not overgrown. This is easier said than done because even though the vine initially grows fairly slowly, as it matures it can become a monster of vegetation. One to two layers of leaves for any area on the canopy are best for flower bud and fruit development.
- Mature grapevines, by their very nature, produce much more wood than they can support. Think of the wild grapevine growing in the woods—it produces

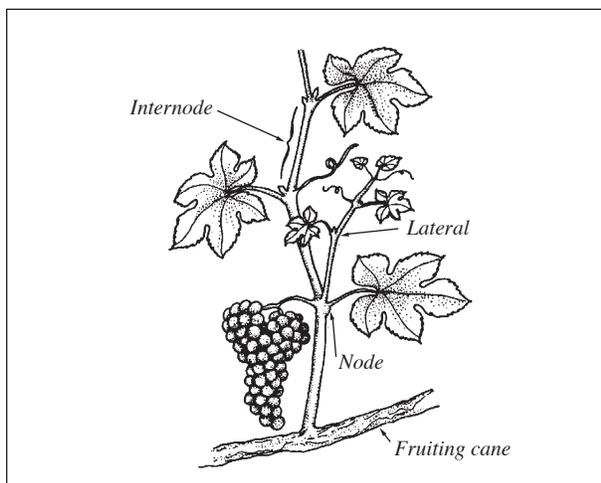


Figure 6.2. A grape shoot. Fruiting cane is last year's growth. The shoot emerges in the spring. (Courtesy of Oregon State University.)

a huge amount of wood just to climb to the sunlight. Your grapevines won't need to do that since you're cultivating them, but, nevertheless, they will produce much more wood than is necessary or desirable.

Typically, 90 percent of the new growth of a mature grapevine is removed during dormant pruning. Plan on leaving about three to four buds per foot of cordon (the horizontal trunk on a grapevine).

- Grapes bear their fruit on one-year-old wood. Figure 6.2 shows the cane that is formed from a single bud on a one-year-old cane.
- Different grape varieties have different growth habits. American grape canes tend to grow in a willowy, downward direction, while those of European and many French-American hybrid grapes tend to grow directly up. Choose your training system with this in mind.

By way of guidance, some of the traditional training systems employed by commercial and backyard viticulturists (grape growers) are described below. All figures shown depict a vine in the early spring after dormant pruning, which is usually done in February or March in Pennsylvania.

Selected Training Systems

Single-Curtain Cordon, or Hudson River Umbrella, System (Figure 6.3)

The top wire in this system should be galvanized, crinkle wire, or brite basic number 8 wire that has the property of low stretchability. This is because once this

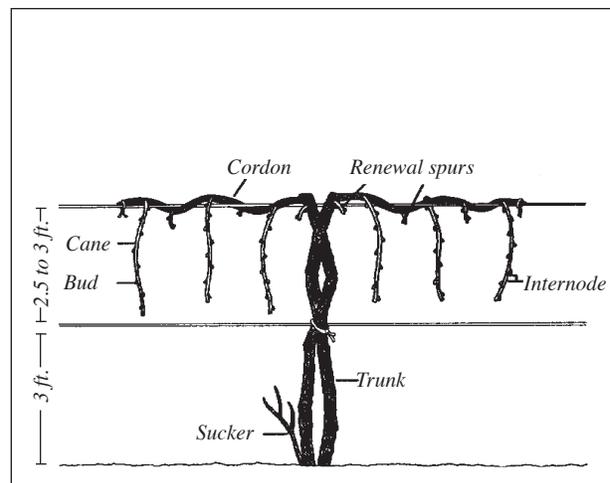


Figure 6.3. The Hudson River umbrella. (Courtesy of Michigan State University.)

system is established, the wire cannot be retightened. In training a vine to this system, select two strong canes or arms and place them bilaterally along the top wire. Arms from one vine should not overlap with arms from adjacent vines. For first-year pruning, leave several branches (spurs) that are five to seven buds long. These spurs should be spaced 6 to 12 inches apart. For each seven-bud spur, also leave a one-bud renewal spur. In selecting arms, be careful to avoid scored wood where canes cross over the top wire. The fruiting shoots will hang like a “curtain” in groups from the spurs that originate from the arms along the top wire. The arms should be wrapped loosely around the wire and tied at each end. One and one-half turns should be sufficient for each arm. Using a bottom wire is necessary only for young vines or for trunk position control.

Shoots should be separated carefully and placed vertically downward from the top wire for a distance of 18 to 24 inches. Positioning should be carried out as soon as the shoots have toughened, usually 2 to 3 weeks after peak bloom. Peak bloom is when 50 percent of the fused petals (calyptas) have fallen, exposing the rest of the flower parts. Extreme care must be exercised during shoot positioning since any shoot lost at this time can result in a poorly filled trellis.

During the second year and thereafter, leave at least five buds on each spur along the arms of the vine for fruiting purposes. The total number of buds should be adjusted in accordance with the capacity of the vine, as explained for other systems.

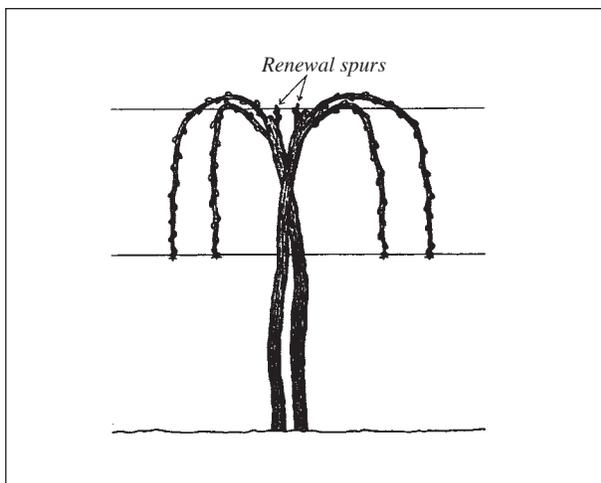


Figure 6.4. The umbrella Kniffin. (Courtesy of Michigan State University.)

Umbrella Kniffin System (Figure 6.4)

This system is established by bringing the trunk up to the top wire and leaving four or more canes, bearing a final total of 50 to 60 buds, near the top of the trunk (head). Remove all other wood except two renewal spurs (short canes of two buds) near the head. After adjusting the number of buds, retie the trunk. Then, bend the canes rather sharply over the top wire so the outer bark cracks, and tie the tips to the bottom wire. The renewal buds will develop into shoots that probably will not be fruitful but should be allowed to grow. They are there to be used, if necessary, for retaining canes the next year. The buds on the four or more canes will form fruiting shoots that do not need to be tied because the vine already has been trained. Some of those shoots probably will be well located and can replace the original canes the following season, in which case the renewal shoots are not needed.

Four-Cane Kniffin System (Figure 6.5)

This is a variation of the umbrella Kniffin system, except that canes are selected from both the top and the middle of the trunk. It is most often used on low-vigor varieties. Although the lower canes take advantage of the lower wire, because they are shaded they might have less fruit, later fruit maturation, and/or lower fruit quality than the fruit from the top-wire-trained cordons.

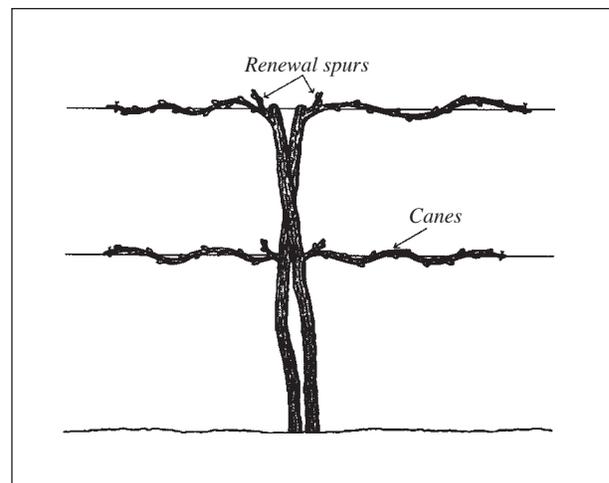


Figure 6.5. The four-cane Kniffin. (Courtesy of Michigan State University.)

Other Training Systems

Other training systems are shown in Figure 6.6.

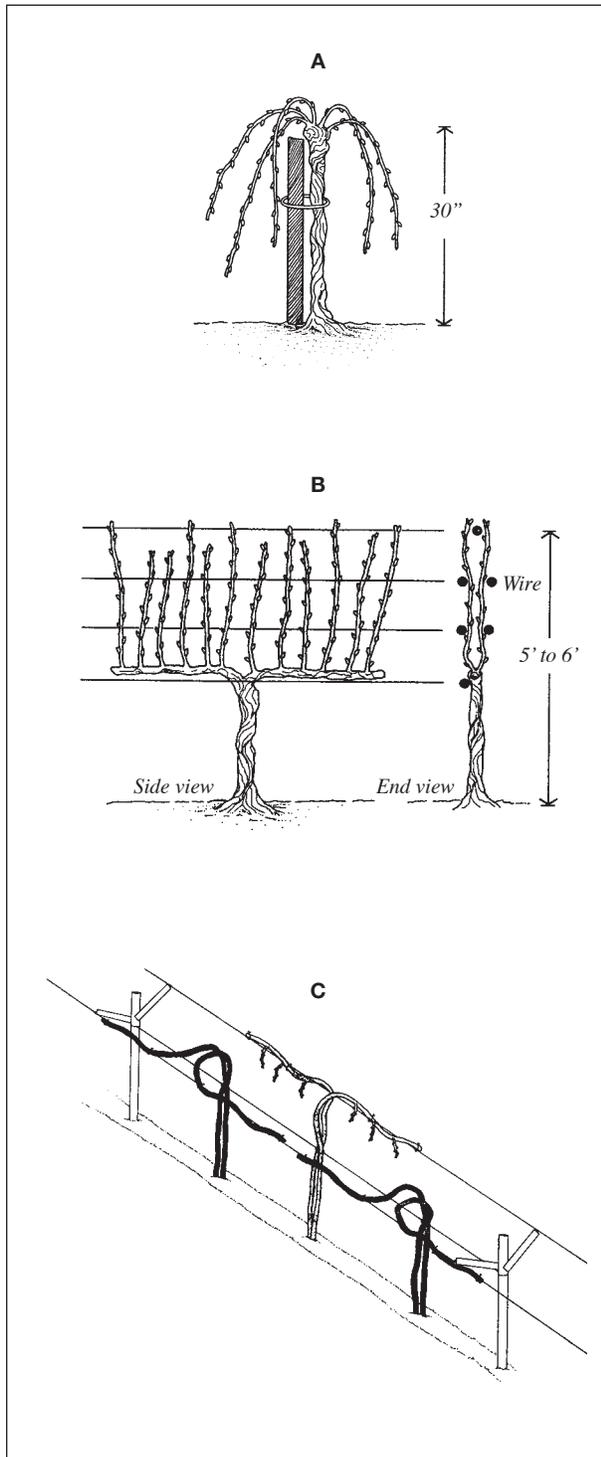


Figure 6.6. Other useful training systems. (A) Head system, (B) Low-wire bilateral cordon, (C) Geneva Double Curtain. (Courtesy of Oregon State University and Michigan State University.)

INSECT AND NEMATODE PESTS

The following descriptions of insect damage are general guidelines that can vary in severity based on a number of factors. Provisional action thresholds prescribe treatment when 15 percent or more of the leaves are destroyed by defoliating insects, or when 4 percent or more of the clusters are destroyed by cluster-feeding insects.

CLIMBING CUTWORMS are known to feed on grapes. The larvae hide in the soil litter below the grape trellis and climb onto vines on warm nights to feed on developing primary grape buds. Only during bud swell are cutworms able to inflict serious damage to a vineyard. To examine for cutworms, search under the bark and in the soil litter beneath a vine with damaged buds, or search the vine with a flashlight after dark.

EUROPEAN RED MITES, *Panonychus ulmi* (Koch), are spider mites. They are especially severe in vineyards adjacent to apple orchards. Adult mites are small, dark red, and eight legged. Both adults and nymphs pierce the cells on the leaf undersides and extract plant juices. Heavily infested leaves take on a characteristic bronze coloration. Several generations occur in a season.

GRAPE BERRY MOTHS, *Endopiza viteana* (Clemens), are one of the more serious insect pests affecting grapes in Pennsylvania. Two and occasionally three generations of moths hatch per season. Overwintered pupae emerge as adult moths in late May and lay eggs among the grape clusters. The larvae are small (up to $\frac{1}{3}$ inch long) and feed internally in grape berries. External signs of moth feeding are the silk webs that tie several berries together. The larvae cut flaps in grape leaves and pupate inside, emerging as adult moths with wingspans of $\frac{1}{2}$ inch. Timing of sprays is best accomplished with a combination of pheromone traps and visual scouting for “stung” berries.

GRAPE LEAFHOPPERS overwinter under leaves and litter and enter vineyards in the spring. These overwintered adults do not cause serious damage. Depending on the length of the growing season, several generations can occur, with rapid population increases. Both the $\frac{1}{8}$ -inch adults and the nymphs feed on the underside of grape leaves by piercing the tissue and sucking out the plant juices. Damaged leaves become blotchy and yellow. A moderate infestation of grape leafhopper does not significantly affect yield and quality.

GRAPE PHYLLOXERA, *Daktulosphaira vitifoliae* (Fitch), are minute insects with a complex life cycle. Two forms of phylloxera occur within the same species, and several generations of each can occur in any given year. The

root gall form feeds on the outside of galls or swellings on the roots. Loss due to this form can be reduced substantially by grafting it to a phylloxera-resistant rootstock. This grafting will not affect injury caused by the leaf gall form of the phylloxera. The leaf gall form lives inside galls on the underside of grape leaves. Grape varieties vary widely in their susceptibility to both forms of phylloxera. Examine foliage on a weekly basis before and after bloom. Spray when 15 percent of the shoots become infested. If new growth becomes infested, spray again in 10 to 14 days.

GRAPE ROOT BORERS, *Vitacea polistiformes* (Harris), are clear-winged moths that strongly resemble paper wasps. At present, they occur only in southern and eastern Pennsylvania. Larvae feed on grape roots for a two-year period. Mature larvae burrow to just below the soil surface, spin a dirty-brown silk cocoon, and pupate. Adults emerge in mid- to late summer, mate, and lay eggs beneath the vines. The eggs hatch and reenter the root system. There is no registered method for controlling the subterranean stages of this insect. Careful monitoring for pupal cases on the soil surface beneath vines will reveal when pupation is occurring and, thereby, will aid in timing the application of the soil barrier.

GRAPE CANE GALLMAKERS, *Ampelogypter sesostris* (LeConte), are small ($\frac{1}{8}$ -inch), brown weevils that form scars in shoots, typically beyond the last grape cluster. The $\frac{3}{4}$ -inch reddish swellings are quite noticeable on green shoots. Berry size and percentage of sugar are not affected, and the scars are easily found and removed during winter pruning. In areas where this insect previously has been a problem, apply control sprays to plantings when shoots are 4 to 6 inches long.

GRAPE CANE GIRDLEERS, *Ampelogypter ater* (LeConte), are small ($\frac{1}{8}$ -inch), black weevils that girdle grape canes by chewing two series of holes several inches apart. The girdles are generally beyond the last grape cluster, so there usually is no loss of fruit. Control sprays should be applied at the new shoot stage to provide protection through bloom. To culturally control grape cane girdlers, cut off and burn infested parts of the canes before adults emerge from them in late summer.

GRAPEVINE FLEA BEETLES, *Altica chalybea* (Illiger), are small ($\frac{3}{16}$ -inch), bluish-black beetles that damage vines by feeding on small ($\frac{1}{2}$ -inch) grape buds. In addition, their $\frac{1}{4}$ -inch larvae feed on the upper surface of the leaves. If adult beetles are present in damaging numbers in the early season, they should be controlled by the bud swell spray.

JAPANESE BEETLES, *Popillia japonica* (Newman), are $\frac{1}{2}$ inch long and are distinguished by a metallic-green abdomen and coppery outer wings. Tufts of white hairs are arranged along the side of the body and behind the wing tips. Adults cause damage by feeding on the foliage and occasionally the berries. One generation hatches each year, with the peak of adult activity occurring in mid-summer. Vines with smooth thin leaves are most susceptible to Japanese beetle attack. Young vines should be monitored closely to prevent excessive damage.

RED-BANDED LEAF ROLLER, *Argyrotaenia velutinana* (Walker), larvae occasionally attack grape clusters. Their life cycle is similar to that of the grape berry moth, except that the larvae feed on the surface of the grape berry rather than internally. Early generations are rarely a problem.

ROSE CHAFERS, *Macrodactylus subspinosus* (Fabricius), are clumsy, light-brown beetles about $\frac{5}{8}$ inch long. Damage from these insects occurs around bloom and chiefly consists of feeding damage to leaves and, to a lesser extent, to flowers. Populations usually are present for only 5 to 10 days.

NEMATODES. Poor vine growth can be a result of high nematode populations feeding on the roots. Nematode feeding can result in increased winter injury. One species present in Pennsylvania soils can transmit one or more virus diseases. Refer to Chapter 2 for more information on nematodes.

DISEASE DESCRIPTIONS AND MANAGEMENT

See basic cultural guidelines for the control of plant diseases under “Pest Management,” discussed on page 24 in Chapter 2. A list of pesticides available on various fruit crops for the control of diseases can be found in Table 2.4. Pictures of fruit diseases can be found in the Fruit Pathology Fact Sheets at <http://fpath.cas.psu.edu/factsite.html>.

Black Rot

Black rot is one of the most serious diseases of grapes in the eastern United States. Crop losses can range from 5 to 80 percent, depending on the amount of disease in the vineyard, the weather, and variety susceptibility. The fungus *Guignardia bidwelli* can infect all green parts of the vine. Most damaging is the effect on fruit. Later fruit infections can destroy many grapes, even the entire crop.

Symptoms

Infected leaves develop reddish-brown, circular spots (lesions) on the upper leaf surface. As the lesions mature, the center becomes brown and small, black, pimple-like fruiting bodies called pycnidia appear in the center. They are usually arranged in a loose ring just inside a dark border. Infected berries become dark brown and are covered with numerous black pycnidia on the surface. The berries eventually shrivel into hard, black mummies. Most serious fruit infections occur when the grape is pea sized or larger.

Disease Cycle

The black rot fungus overwinters in mummified fruit on the vineyard floor or in old fruit clusters that hang in the vines. The fungus can also overwinter within cane lesions. Spores of the fungus are produced within the diseased fruit and infect leaves, blossoms, and young fruit during spring rains. Fruit infections occur from mid-bloom until the berries begins to color. Mature leaves and ripe fruit are not susceptible. Very few fruit or leaves are infected after late July, and none are infected after the end of August. Black rot infections depend on the temperature and the length of time the leaves are wet. Infections occur if susceptible tissue remains wet for a sufficient length of time, depending on temperature (see table below).

Hours of leaf wetness required for a black rot infection period at various temperatures following a rain.

Temperature (°F) ^a	Hours of Leaf Wetness ^b
50	24
55	12
60	9
65	8
70	7
75	7
80	6
85	9
90	12

a. Average temperature over the wetting period.

b. Begin counting when the leaves first become wet; stop counting when the leaves have dried off.

Disease Management ♦

Infected prunings and mummified berries should be removed, burned, and/or buried in the soil before new growth begins in the spring. In vineyards with susceptible varieties or where black rot was a problem the previous year, early season fungicide sprays should be timed

to prevent the earliest infections. Should infections become numerous, protecting against fruit rot is very difficult later in the growing season. Planting resistant varieties is strongly suggested. Variety selections are presented in Table 6.3.

Botrytis Bunch Rot

Botrytis bunch rot, or gray mold, exists in all vineyards worldwide. This disease is caused by the fungus *Botrytis cinerea* and is commonly associated with the decay of ripe or nearly ripe grapes. Temperature and damp climates favor disease development. The bunch rot phase of the disease causes the greatest economic losses.

Symptoms

Buds and young fruit infected in early spring turn brown and dry out. Prior to bloom, large, reddish-brown patches appear on the leaves. By the end of bloom, the fungus develops on aborted berries that are attached to or trapped in the fruit clusters. From ripening onward, the grapes are infected directly through the epidermis or through wounds. The entire cluster eventually becomes moldy. When weather is dry, infected berries dry out; in wet weather, they tend to burst and a brownish-gray mold forms on the surface.

Disease Cycle

Botrytis bunch rot also infects numerous wild hosts and cultivated plants. The fungus can live on these alternate hosts as a saprophyte on dead tissue. The fungus also overwinters in debris on the vineyard floor or on the vine in bark and dormant buds. In the spring, spores are produced by the fungus and infect leaves and young grape clusters. Spores on decaying and dead vegetation are moved about mainly by air currents. Water is necessary for germination, but this requires only 1 to 4 hours, depending on the temperature. High relative humidities allow infection to take place after the spore has germinated. Any break in the skin of ripening grapes provides an ideal entry point for the *Botrytis* fungus as well as a moist medium in which the spore can germinate.

Disease Management

Management of botrytis is best accomplished through a combination of cultural and chemical procedures. Any practice that opens up the canopy and improves air circulation, thereby reducing humidity and facilitating the drying of leaves, will help reduce botrytis infection. Applying two fungicide sprays on very susceptible varieties is suggested during the bloom period. The sprays will reduce the number of infected flower parts and the

incidence of young fruit infection. Any practice that reduces skin cracking or skin punctures near harvest helps control ripe fruit rot. Preharvest fungicide applications are also recommended. When possible, plant botrytis-resistant grape varieties. Variety selections are presented in Table 6.3.

Crown Gall

Crown gall occurs on more than 600 species of plants. The disease is characterized by galls or overgrowths that form on the roots, trunk, and arms of grape vines. *V. vinifera* varieties are more susceptible to crown gall than *V. labrusca* varieties. These galls are found mostly on the lower trunk near the soil line. Large galls can develop rapidly and completely girdle a young vine in one season. When galls are numerous, or when they are located on major roots or on the root crown, they disrupt the translocation of water and nutrients, leading to poor growth, gradual dieback, and sometimes the death of the vine. In general, affected plants are more susceptible to adverse environmental conditions, especially winter injury.

Symptoms

The major symptom of the crown gall disease is the fleshy galls. Current-season galls appear in early summer as white, fleshy growths that usually develop near injured vines. By late summer, the galls turn brown. In the fall, they become dry and corky and might fall off the vine in a few years.

Disease Cycle

The disease organism is caused by the soilborne bacterium *Agrobacterium tumefaciens*. The bacterium survives for long periods of time in vineyard soils, within galls and within infested vines. A fresh wound is required for gall formation to start in the grapevine. Contaminated planting material (nursery stock) is another source of the disease.

Disease Management ♦

Because the bacterium lives in the soil, it cannot be controlled by chemical sprays. It is necessary to examine new plants before planting and discard any that have galls. In the vineyard, remove large galls on the upper parts of the trunk or on the arms by pruning the arm or trunk below the affected tissue. Then, renew the vine by means of a shoot from the base of the vine.

The development of crown gall is closely correlated with wounding and freeze injury. Practices that reduce wounding, especially during pruning and machinery

operation, are useful in managing the disease. Management practices that minimize the risk of cold injury are another technique in the prevention of crown gall. Preventing freeze injuries also is important. In some areas, growers bury young vines in the fall to reduce this type of injury.

Downy Mildew

Downy mildew is caused by a fungus that can infect berries, leaves and young shoots. It occurs wherever it is wet and warm during the growing season. There is some variety resistance, with *V. vinifera* varieties being the most susceptible and *V. rotundifolia* being the most resistant.

Symptoms

The fungus attacks all green parts of the vine, especially the leaves. Lesions on leaves are angular, yellowish, sometimes oily, and are located between the veins. As the disease progresses, a white cottony growth can be observed on the lower leaf surface. Severely infected leaves will drop. If enough defoliation occurs, the overwintering buds will be more susceptible to winter injury. Infected shoot tips become thick, curl, and eventually turn brown and die. Young berries are highly susceptible, appearing grayish when infected. Berries become less susceptible when mature. Infected berries remain firm compared to healthy berries, which soften as they ripen. Infected berries will eventually drop.

Disease Cycle

The disease is caused by the fungus *Plasmopara viticola*, which overwinters as dormant spores within infected leaves on the vineyard floor which become active in the spring. This fungus has two types of spores, both germinating to give rise to swimming spores. These spores swim to the stomates (breathing pores) of plants and cause infection. Water is necessary for the spores to swim and to infect, so outbreaks of the disease coincide with periods of wet weather. Downy mildew is favored by all factors that increase the moisture content of soil, air, and the plant, with rainfall being the principal factor for infection. The frequency of rain and the duration of wet periods correlate with the number of additional infections during the growing season. Downy mildew infection can become a severe problem when a wet winter is followed by a wet spring and a warm summer with a lot of rainfall.

Disease Management

Some control can be achieved by preventative management practices. Spring cultivation to bury fallen, infected leaves from the previous year may help reduce early season disease pressure. Pruning out the ends of infected shoots and practices that improve air circulation and speed drying within the vine canopy will also help to control downy mildew. ♦ Fungicides, however, are the most important control measure, especially on susceptible varieties. They should be applied just before bloom, 7 to 10 days later (usually at the end of bloom), 10 to 14 days after that, and, finally, 3 weeks after the third application. For varieties very susceptible to downy mildew, or where the disease was severe the previous season, an additional application is suggested about 2 weeks before the first blossoms open.

Eutypa Dieback

Eutypa dieback is a fungal disease appearing as cankers on trunks and arms of infected grapevines. It is one of the most destructive diseases on the woody tissue of grapes. The fungus causing this disease has a wide host range, which includes at least 80 species in 27 botanical families. Most of its hosts are tree species that are common in natural forests.

Symptoms

The earliest symptoms of the disease are cankers formed around pruning wounds. The cankers are hard to detect since they are concealed by old, dead bark, which can become somewhat flattened. A cross-section of the infected area might show a wedge-shaped area of darkened wood coming to a point in the center of the trunk. Symptoms of Eutypa dieback are apparent after the canker has become well established, perhaps 2 to 4 years after the infection of the pruning wound. As new shoots develop on the trunk or arms above the cankered area, vine growth appears stunted and the internodes become shortened. Symptoms are not readily visible until late spring because affected shoots usually are covered up by healthy shoots. Infected leaves are small, yellow, and crinkled. Symptoms on the foliage of diseased arms become more extensive each year until eventually the diseased arm fails to produce shoots in the spring. Clusters on affected shoots can have a mixture of both large and small berries.

Disease Cycle

The disease is caused by the fungus *Eutypa lata*. This disease is entirely different from that responsible for phomopsis cane, leaf spot, and fruit rot. Rain is necessary for the spread of this disease, and infections occur on freshly made wounds. The susceptibility of wounds decreases as they become older (2 to 4 weeks after pruning). The disease is slow to develop on grapes and usually is not seen until the third or fourth season. By this time, a canker usually is present, along with symptomatic foliage. Several more years might elapse before the diseased arm or trunk is killed.

Disease Management ♦

No grape varieties are known to be immune to this disease. Also, none of the chemicals routinely used to control other grape diseases provides protection against this fungus. Some evidence indicates that the manual treatment of individual wounds with benomyl at the time of pruning can provide a barrier against the fungus and prevent it from invading the wounds. It is suggested to treat all wounds in wood 2 years of age or older, especially large wounds. Sanitation practices also will help control this fungus. Since the fungus survives in vines remaining on the tree or as prunings in the vineyard, affected vines should be pruned when leaf symptoms appear. Single-trunk vines should be cut off at the ground line; double-trunk vines should be cut off at the junction of the second trunk. Affected prunings must be removed from the vineyard immediately and destroyed. One or more suckers can be retained for vine renewal.

Phomopsis Cane, Leaf Spot, and Fruit Rot

Phomopsis cane, leaf spot, and fruit rot is one of two distinct diseases that used to be referred to as “dead arm” and is widely distributed in vineyards. The disease can weaken vines, reduce yields, and lower fruit quality.

Symptoms

This disease was often the first disease of the growing season to appear in the vineyard. Infections on new shoots first appear as reddish spots about 1/16 inch in diameter. These are most common on the first 8 inches of new shoots and can be seen when the shoots are about 18 inches long. Infected portions of the leaf turn yellow then brown. When infections on shoots are numerous, they often run together and form dark blotches that crack. Cluster stems can blight and become brittle if infections are high. These clusters usually break and the fruit is lost. This fungus also causes a fruit rot. Infected

fruit will turn brown, shrivel, and eventually drop. In winter, cane infections can be observed.

Disease Cycle

The disease is caused by the fungus *Phomopsis viticola*. The fungus overwinters in bark and leaf petioles. In the spring, especially under wet conditions, spores produced by the fungus exude from infected tissue and are splashed onto shoot tips. Only very young tissues are infected. The fungus becomes inactive in summer, but by fall it resumes activity. Infection in the vineyard is localized because disease is spread mostly within the vine rather than from vine to vine. If the disease is not controlled, it will become more severe in the vineyard with each year.

Disease Management ♦

Phomopsis cane and leaf spot can be controlled by a combination of sanitation and fungicide application. At pruning, remove dead and diseased wood. Destroy prunings and debris by burning, burying, or plowing them into the soil. The cane and leaf infections can be prevented by one or two early season fungicide sprays. The number of new shoot infections during the previous 2 years and the frequency of prolonged rainy periods during the current year are indicators for performing zero, one, or two fungicide applications. Fruit and cluster stem infections occur from bloom until the fruit are pea sized. Regular fungicide applications are necessary to prevent disease.

PEST MANAGEMENT

Groundcover Management and Weed Control

Herbicides currently registered for use in commercial vineyards are not recommended for home gardeners. Physical control of weeds under the trellis by mowing, cultivation, hand hoeing, and pulling is suggested. Growth in row middles should be controlled by mowing.

Insect and Disease Control Suggestions

- Use varieties and rootstocks resistant to root louse (*Phylloxera*).
- Prune to keep the vines vigorous.
- Prune off and dispose of all dead, diseased, and broken parts.
- Rake the soil clean under the vine and remove old and shriveled fruit from the vine before spring growth starts.
- Identify insects and diseases accurately.
- Spray when necessary. Tables 6.5 and 6.6 provide information about the use of pesticides on grapes.

Table 6.5. Efficacy of pesticides for grape disease control.

Always consult the label before making pesticide applications. Labels vary greatly among commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides.

Diseases

P = Phomopsis
BR = black rot
DM = downy mildew
PM = powdery mildew
BO = Botrytis rot

Fungicides	P	BR	DM	PM	BO
Captan	1	1	3	4	1
Copper	2	2	2	1	3
Maneb	1	1	1	4	4
Mancozeb	1	1	1	4	4
Mycobutanil	4	1	4	1	4
Neem Oil	4	4	4	4	4
Sulfur	3	3	3	1	3

Efficacy rating: 1 = highly effective; 2 = moderately effective; 3 = slightly effective; 4 = not effective

Table 6.6. Pesticide recommendations for grapes.

The sprays listed below will not provide adequate control of black rot. Where black rot is a problem, apply a fungicide every 14 days after the “New Shoot” spray up to and including the “Before Ripening” spray. During long rainy periods, shorten the interval to 7 to 10 days between sprays. Spray in the rain, if necessary, to maintain the schedule of applications. Always consult the label before making pesticide applications. Labels vary greatly among commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides. Due to a wide array of various products containing the same active ingredient, for insecticide recommendations, when appropriate, the active ingredient is listed instead of the name of formulated product.

Follow all instructions and application rates listed on pesticide labels.

Time to Spray	Suggested Materials	Pests to Be Controlled
New Shoot—when new shoot growth averages 4 inches	Captan <i>plus</i> Mycobutanil <i>or</i> Mancozeb + Mycobutanil	Phomopsis, black rot
Before Bloom—just before blossoms open	Captan <i>plus</i> Mycobutanil <i>or</i> Mancozeb + Mycobutanil <i>or</i> Carbaryl <i>or</i> Imidcloprid	Black rot, downy mildew, rose chafer, leafhopper
Post-Bloom—immediately after Bloom	Mancozeb + Mycobutanil <i>or</i> <i>Bacillus thuringiensis</i> , <i>or</i> Imidacloprid, <i>or</i> Azadirachtin	Black rot, downy and powdery mildew, botrytis rot, berry moth, leafhopper
First Cover—apply 10 days after Post-Bloom	Captan + Sulfur Same as Post-Bloom	Black rot, downy and powdery mildew, botrytis rot Japanese beetle
Second Cover—apply 3 weeks after First Cover	Captan + Sulfur	Black rot, downy and powdery mildew Fruit rots
Third Cover—late July or early August	Captan + Sulfur	Fruit rots, powdery mildew
Before Ripening—10 days before picking	Captan + Sulfur	Fruit rots, powdery mildew

Brambles

Brambles are defined as any species belonging to the *Rubus* genus. This definition covers a large number of plants found growing in the woods and fields surrounding us. Practically speaking, however, the brambles of concern to the home gardener are raspberries (red, black, and purple), blackberries (thornless and thorny), and some of the recently developed hybrids such as tayberries.

Brambles are, in some ways, the perfect home garden plant. They are relatively easy to grow, requiring little more than a patch of full sun and some well-drained soil. They are highly perishable or often unavailable commercially, so home planting assures a supply of this delicious treat.

Plants belonging to the *Rubus* genus typically have perennial roots with shoots that are biennial. This means that the shoots (called “canes”) grow vegetatively in the first growing season. However, some raspberries have the capability of producing a crop on the current season’s growth as well. This crop is produced in the fall after the new canes have reached their full height.

Raspberries and blackberries are the two most common bramble crops. Red, black, and purple raspberries are the three most commonly grown raspberry types. The word “type” is used intentionally because the differences among them include not only the color of the fruit, but also the growth habit (and hence the cultural practices), disease problems, and other characteristics.

BLACK RASPBERRIES initiate new canes from the crown of the plant rather than from root suckers. Because of this, they are grown in a “hill” system: each plant is grown independently, with pruning and maintenance done on a per-plant basis. They require summer tipping, unlike red raspberries, because individual canes will grow to unmanageable lengths. Black raspberries bear their fruit in late June through July and are the most winter tender of the raspberries.

EASTERN BLACKBERRIES can be thorny and erect, or thornless and trailing. Thornless types are much more cold sensitive (to 0°F) and can be grown only in the

southern or warmer portions of Pennsylvania. However, cold sensitivity of many varieties may be due to failing to survive fluctuating spring temperatures, rather than failing to survive winter temperatures when the plants are fully dormant. Because of their trailing growth habit, they require trellising. Thorny types often have excellent fruit quality, but the thorns are brutal. Generally, thorny types of blackberries will tolerate temperatures to about -5°F. They do not require trellising. The recent development of primocane-bearing blackberry varieties may allow the production of cultivated blackberries in the coldest regions of the state. Because the canes are mowed to the ground each spring, winter survival of the canes is no longer an issue.

GOLD RASPBERRIES also are available, but they are not widely grown. Efforts are under way to develop a commercially viable gold raspberry (see “Variety Selection”).

PURPLE RASPBERRIES initiate new canes predominantly from the crown but may sucker between plants as well. They are grown essentially as black raspberries are and have intermediate cold hardiness.

RED RASPBERRIES can be either of two types. Summer-bearing red raspberries bear their fruit from late June to August. They have the typical biennial life cycle of a bramble, so their canes die after fruiting. Primocane-bearing types, such as Heritage, fruit during the first year, as mentioned above. Also called “everbearing” raspberries, they will fruit again in the spring on the buds below those that fruited the previous fall. Because both of these red raspberries produce new canes (suckers) primarily from the root system, they usually are grown in a hedgerow. They are the most winter hardy of the raspberries.

TAYBERRIES were bred by crossing a blackberry with a raspberry. The flavor of the fruit reflects this parentage, and many people feel that a ripe tayberry is the most flavorful bramble of all. Unfortunately, tayberries are very soft when fully ripe, so they don’t lend themselves to commercial production. Although they are quite thorny,

they grow in a manner similar to thornless blackberries and require similar planting, training, and pruning techniques.

OTHER BRAMBLES, most of which are either hybrids among *Rubus* species or specific varieties of blackberry, such as Boysenberry, Loganberry, Marionberry, and Olallaberry, are grown extensively in the Pacific Northwest of the United States. They have excellent fruit quality but are not well adapted to environmental conditions in

Pennsylvania and should not be grown here. Their most limiting characteristic is their cold tenderness.

VARIETY SELECTION

Selecting appropriate varieties might be the most important decision a gardener makes, and certainly is a difficult one to change once the plants are established. Descriptions of individual varieties follow, with further information given in Table 7.1.

Table 7.1. Recommended raspberry varieties for Pennsylvania.

Varieties	Season ^a	Relative Productivity ^b	Fruit Size ^b	Fruit Firmness ^b	Fruit Quality ^b	Hardiness ^b	Disease ^c
Summer-Bearing Reds							
Boyne	1	2	2	2	1	3	
Canby	1	2	2	2	3	2	
Killarney	2	2	2	2	3	3	
Latham	3	2	1	3	2	3	S-3; R-4
Nova	3	3	2	3	2	2	
Reveille	1	3	2	1	3	3	
Taylor	3	2	3	2	3	2	S-4
Titan	2	3	3	2	2	2	S-7
Fall-Bearing Reds							
Autumn Bliss	8	3	2	2	2	3	
Autumn Britten	8	2	3	3	3	3	
Caroline	7	3	3	2	3	3	
Dinkum	8	2	3	3	3	3	
Heritage	8	3	2	3	3	3	
Fall-Bearing Yellows							
Anne	9	1	3	2	3	3	
Fallgold	8	2	2	2	2	2	
Goldie	8	3	2	2	2	3	
Kiwigold	8	3	2	2	2	3	
Blacks							
Allen	1	3	3	2	3	2	S-4, 6
Bristol	1	3	2	3	2	1	S-4, 6
Cumberland	1	3	2	3	2	1	S-4, 6
Jewel	1	2	2	3	3	2	S-4, 6; R-3
Munger	1	3	2	3	2	2	S-4, 6
Purples							
Brandywine	3	2	2	3	2	3	
Royalty	3	3	3	2	3	2	S-5; R-4

a. Season: 1 = early summer, 9 = early fall

b. 3 = excellent, 2 = good, 1 = fair

c. Disease: S = susceptible; R = partially resistant; 1 = anthracnose, 2 = botrytis, 3 = mildew; 4 = viruses; 5 = spur blight; 6 = orange rust; 7 = crown gall

Red Raspberries (Summer Bearing)

In Pennsylvania, summer-bearing red raspberries bloom from late May to early June and ripen in July.

BOYNE: Very winter hardy and productive. Berries are dark red and small to medium sized. Plants are short.

CANBY: A mid-season berry that is moderately winter hardy and nearly thornless. It is productive, with attractive medium to large fruit.

KILLARNEY: An old variety that's been around for over 50 years. Killarney is very winter hardy. Fruit is medium sized with excellent flavor.

LATHAM: A mid-season berry with excellent cold hardiness. Although the plant is susceptible to mildew, it tolerates viruses fairly well. Fruit size is small to medium, flavor is acceptable, firmness is good; it has a relatively long bearing season. An old standard eastern variety.

NOVA: Bright-red, firm fruit with good flavor but average size. Plants are vigorous, high yielding, and winter hardy. Resistant to cane diseases and late leaf rust.

REVEILLE: A very early berry with good cold hardiness and vigor. Fruit is soft but excellent for home garden use. Flavor is good, size is intermediate, and productivity is fair. Very cold hardy.

TAYLOR: A late-season berry with medium fruit size, very good flavor, and moderate winter hardiness. Very susceptible to mosaic, fungal diseases, and two-spotted spider mites.

TITAN: A productive variety with mildly flavored, very large cone-shaped berries. The plants have excellent vigor, but poor to moderate winter hardiness. The fruits are soft, and some growers feel the appearance is too "rough." Titan is particularly susceptible to phytophthora root rot but resistant to the raspberry aphid, which spreads some viruses.

Red Raspberries (Primocane Bearing)

Primocane-bearing red raspberries bloom in early August and produce fruit from mid-August through the first heavy frost or freeze.

AUTUMN BLISS: Extremely high yielding and vigorous. Canes have a large diameter and are of medium height; they tend to sucker in clumps around original plants. Ripens about 2 weeks earlier than Heritage, although overall productivity is similar in most years. Might be useful in the northern tier of Pennsylvania.

AUTUMN BRITTEN: Large uniform fruit with excellent flavor. Cane density is lower than average, so plants

should be planted slightly closer together than usual (18–20 inches between plants).

CAROLINE: High-yielding plants due to the production of many suckers. Yields 1 to 2 weeks earlier than Heritage. Fruit is dark red and conical and has excellent flavor.

DINKUM: Flavorful, firm, rounded fruit. More susceptible to damage from leafhoppers than other varieties.

HERITAGE: A medium-sized, firm fruit of excellent quality. Season begins in mid- to late August in Pennsylvania and continues through severe frost or freeze. Fruit tolerates light frosts well. Plants are very vigorous and sucker well. This is the most widely planted red raspberry variety in Pennsylvania; it continues to be the standard among primocane fruiting types.

Yellow Raspberries (Primocane Bearing)

Primocane-bearing yellow raspberries have very similar characteristics, except for their golden color, to primocane-bearing red raspberries.

ANNE: Yields late in season. Cane density is sparse, so closer spacings (16–18 inches) within the row should be used. Flavor is wonderful and unique.

FALLGOLD: Fruit is soft and may develop a reddish blush. Flavor is excellent. Ripens with Heritage and is moderately winter hardy.

GOLDIE: Fruit color is gold to apricot. A sport of Heritage, so plant and fruit characteristics, except for fruit color, are similar. Very susceptible to sunscald.

KIWIGOLD: Also a sport of Heritage, so many characteristics, except for fruit color, are similar.

Black Raspberries

Black raspberries bloom in May and ripen in late June through early July. They generally fruit earlier than red raspberries, but there is very little difference among the ripening periods of black raspberry varieties.

ALLEN: Fruit size comparable to Jewel; large and attractive, growing on vigorous, productive plants. Flavor is mild, hardiness intermediate.

BRISTOL: Most widely grown black raspberry in Pennsylvania. High yielding and early, with medium-sized fruit of excellent flavor. Susceptible to anthracnose, but tolerant of powdery mildew.

CUMBERLAND: Very difficult to distinguish from Bristol.

JEWEL: A particularly vigorous productive plant with excellent cold hardiness. Fruit is larger than that of Bristol. Fruit is more susceptible to Botrytis development after harvest.

MUNGER: A mid-season variety with firm, average-sized fruit. Resistant to many fungal diseases.

Purple Raspberries

Purple raspberries bloom in June and are ready for harvest in July. Plants generally begin fruiting 2 to 3 weeks after red raspberries begin.

BRANDYWINE: A round, tart, reddish fruit. Very vigorous with good winter hardiness and fruit firmness. The plant will not spread because suckers grow only from the crown.

ROYALTY: A cone-shaped fruit that is sweeter than Brandywine. Fruit is too soft for shipping, although it can be picked slightly before it is ripe for this purpose. It suckers freely from roots, so it grows more like a red raspberry in hedgerows. It is resistant to raspberry aphid, which spreads some viruses, but is especially susceptible to crown gall.

Thornless Blackberries

Thornless blackberries can be grown in warmer areas of Pennsylvania. Some varieties are trailing and will need a trellis for support. The following varieties are recommended.

APACHE: A new variety with improved size and yields over Arapaho and Navaho. Winter hardiness is still a concern.

ARAPAHO: The earliest thornless blackberry. Medium-sized fruit with small seeds. Fairly erect in growth habit.

CHESTER: Ripens relatively late in the season. One of the most commonly grown thornless blackberries, in part due to good-quality fruit. Has a trailing growth habit.

NAVAHO: Relatively late fruiting. Fruit is medium sized and has good flavor. Growth habit is erect.

OUACHITA: A very recent release. Has produced large fruit and high yields in other areas of the country but is untested in Pennsylvania.

TRIPLE CROWN: Very productive. Fruit is large and sweeter than other thornless blackberry varieties. Growth habit is intermediate between erect and trailing types.

Thorny Blackberries

Thorny blackberries are not widely grown, but they offer potential for small diversified farms with niche markets. The thorns are a significant impediment to culture and harvest.

CHICKASAW: Large fruit and improved firmness over

most other varieties. Produces fruit late in the season. Untested in Pennsylvania. Winter hardiness may be a concern.

CHOCTAW: Very productive and early fruiting, producing large fruit with small seeds. Again, hardiness is questionable since the variety has not been grown extensively in the state. Currently being tested in Pennsylvania.

DARROW: An early, very erect plant that bears medium-sized, firm fruit with good flavor. Plants are vigorous and very winter hardy.

ILLINI HARDY: A very vigorous and hardy variety. Berries are of medium size with good flavor.

KIOWA: Produces very large fruit, and bears over a long harvest season.

SHAWNEE: A very productive plant that bears late, extremely large, sweet fruit. Resistant to orange rust. Hardiness purported to reach -10°F, but variety has not been planted widely in Pennsylvania.

Primocane-Bearing Blackberries

These blackberries may make cultivated blackberry production possible in regions of the state where it is too cold for floricanes-bearing varieties to produce a crop.

PRIME-JAN: Fruit is medium sized, and flavor may be a bit tart. Use in processed products such as jellies may be the best use of the fruit.

PRIME-JIM: Plants are extremely thorny. Similar to Prime-Jan. Pennsylvania trials of both Prime-Jim and Prime-Jan are underway.

PLANTING

For raspberries, virus-indexed, tissue-cultured plants should be planted in the early spring. Raspberries should *not* be planted in poorly drained soils or after any of the verticillium-susceptible crops (tomatoes, potatoes, peppers, eggplant, strawberries). If available, use tissue-cultured blackberries as well; however, dormant canes may also be planted. In-row spacings (spaces between the plants) are as follows: red raspberries, 24 inches; black raspberries, 30 inches; purple raspberries, 36 inches; blackberries, 36 to 60 inches. Between-row spacing should be no less than 8 feet, although the spacing depends on the size of the equipment that will be used to maintain the planting. Between rows, allow at least 4 feet more than the width of the widest implement to be used in the planting. Remove flower blossoms in the first year to encourage plant establishment.

NUTRITIONAL REQUIREMENTS

See Chapter 1 for soil testing procedures prior to planting. If the soil is prepared properly before planting, only nitrogen is routinely necessary on an annual basis. The soil should be tested every 3 to 4 years after planting to determine the need for other nutrients. Apply no more than 5 pounds of 10-10-10 per 100 linear feet of row in the first year and no more than 10 pounds in subsequent years. *Do not overfertilize.* If plants appear to be overly vigorous, reduce the amount of fertilization.

Brambles benefit from irrigation, especially during fruit swell, which occurs during the week prior to ripening. Trickle irrigation is preferred for brambles because wetting the fruit with overhead irrigation can increase the incidence of disease. Plants generally require 2 inches of water per week, up to 4 inches during harvest.

PRUNING

Fruiting canes of all brambles except the primocane-bearing types will die after fruiting is completed. These dead canes should be removed immediately after fruiting to facilitate air circulation through the hedge.

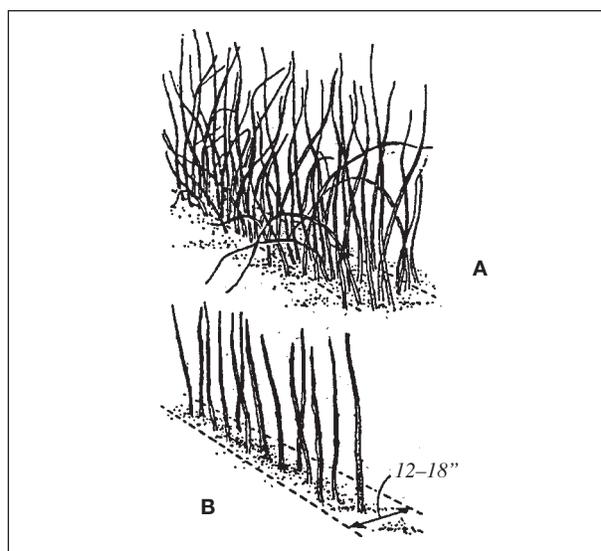


Figure 7.1. Red raspberry pruning.

JUNE-BEARING RED RASPBERRIES will grow naturally in a hedgerow system, as Figure 7.1 illustrates. The suckers, originating from the root system, will fill in the entire length of the row. No summer pruning (except for spent floricanes removal) is necessary, although suckers growing outside the 12-inch hedgerow may be removed at any time. March is the best time to prune in Pennsylvania because any cane dieback from cold will be apparent; however, raspberries can be dormant pruned any time canes are fully dormant. In the dormant season, remove canes outside the 12-inch width of the row, thin canes to 6 to 8 inches between canes, and top remaining canes to 48 to 60 inches in height, removing about one-fourth of the cane. Be sure to retain those canes with the largest diameter.

BLACK AND PURPLE RASPBERRIES require *summer topping* throughout the summer in addition to floricanes removal. Black and purple raspberries should be topped at 36 inches, removing 3 to 4 inches of new growth (Figure 7.2). Do this two to three times during the season to top all of the canes as they grow. Topping encourages the development of lateral (fruiting) branches and increases the strength of the cane. (Note: Black raspberries will tend to have a very prostrate growth habit in the first year. If canes are pruned back in the dormant season, they will attain a more erect habit in subsequent years.)

For dormant pruning, remove all dead, damaged, and weak canes. Thin remaining canes to five to ten canes per plant. Lateral branches should be headed back to 4 to 7 inches (for blacks) or 6 to 10 inches (for purples). More vigorous plants can support longer lateral branches. All canes should be topped to 36 inches if they were not topped earlier.

Erect blackberries do not require trellising. They have, as the name suggests, very strong upright canes. They should be pruned similarly to black and purple raspberries; specifically, they should be headed back to 36 inches in the summer, with laterals cut back to 12 to 18 inches and canes thinned to 10 inches apart in the hedgerow during the dormant pruning.

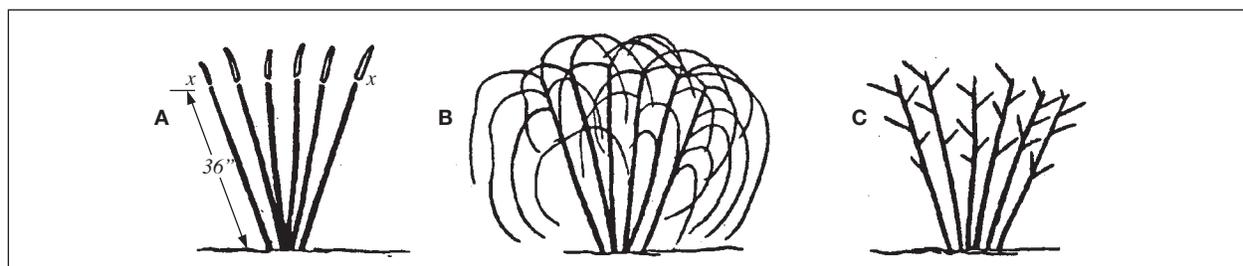


Figure 7.2. Black and purple raspberry pruning. (A) top the new canes at X; (B) laterals that develop after tip of cane is removed; (C) pruned plant with 6 to 8 inches of laterals left.

EVERBEARING RED (OR GOLD) RASPBERRIES should be mowed to a height of 1 to 2 inches in the dormant season. Although some gardeners prune them like June-bearing red raspberries to obtain the spring crop (only about 10 percent of the total crop for Heritage), it is more practical to plant some of the June bearers if a spring and a fall crop are desired.

TRAILING BLACKBERRIES should be summer tipped at about 6 inches above the highest trellis wire and tied to it during the summer months. For dormant pruning, select five to eight of the strongest canes, remove all laterals originating on the lower 3 feet of the canes, and tip back remaining laterals to 12 to 18 inches.

Trellis Systems

The home garden environment provides some unique opportunities for trellising. Consider growing thornless blackberries along a split-rail fence, or use thornless blackberries or black raspberries as a screen on a 6-foot fence. You are limited only by your imagination!

Trellis systems generally do not affect the type of pruning a plant receives. In other words, black and purple raspberries still require summer tipping, but the trellis determines the height of tipping. Trellises allow plants to support more surface area for fruit production. Several trellises have been experimented with successfully. See Figure 7.3 for possible trellis designs.

HARVEST AND POSTHARVEST CARE

Brambles, like all small fruit crops, should be harvested in the morning after the dew has dried. This allows a minimum of field heat buildup in the fruit and will result in longer shelf life. Ripe berries will detach easily. They should be rolled off the plant, rather than squeezed or pulled, and put in half-pint containers. Larger containers cause the lower layers of berries to be crushed.

Raspberries are notorious for their poor shelf life. To maximize shelf life, maintain good disease control in the field and pick berries in the morning after the dew has dried but before field heat can build up in the berry. Do not allow overripe berries to remain on the canes. Refrigerate berries immediately. They can be kept for up to a week under these conditions. Blackberries should be handled similarly, although blackberry shelf life is several days longer than that of raspberries.

INSECT AND MITE PESTS

Raspberry Cane Borer

The raspberry cane borers, *Obera bimaculata* (Olivier), are slender beetles, about 1/2 inch long, with antennae about as long as the body. The beetles are black except for a section behind the head that is bright orange with two or three black spots. The beetles appear in raspberry plantings in June, and the females deposit their eggs singly in the pith of the tender new growth, about 6 inches below the tip of the cane. The beetle makes two characteristic rows of punctures that encircle the cane about 3/4 to 1 inch apart; between these, but nearer the lower row, an egg is inserted. The girdling of the cane causes the tip to wilt. When the eggs hatch, the larvae tunnel toward the base of the cane. By one account (MacNab and Tetrault), the larvae reach the base of the cane by fall. By another account (Mills and Dewey) the larvae spend the first winter within an inch or two of the row of punctures and then complete their journey to the base of the cane the next growing season. In any case, the cane is weakened and usually is killed before the fruit matures.

Remove wilted tips several inches below punctures by midsummer. Remove and destroy older canes whenever they are observed. Destroy any nearby wild brambles.

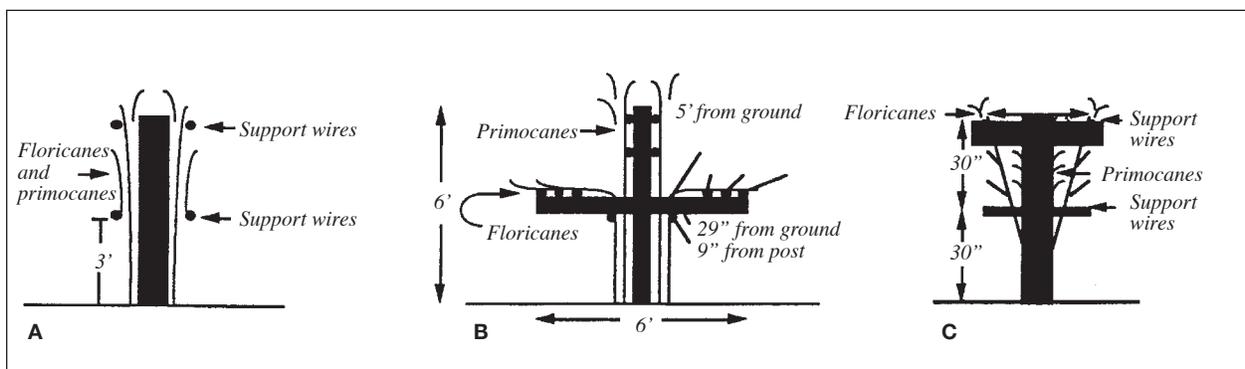


Figure 7.3. Raspberry trellis systems: (A) the "I" trellis; (B) the "T" trellis; (C) the "V" trellis.

Red-Necked Cane Borer

The adult red-necked cane borers, *Agrilus ruficollis* (Fabricius), can be identified by the reddish section (thorax) behind their head; the rest of the body is black. Characteristic injury caused by these borers is a swelling of the cane that can be from ¼ to 3 inches long and can occur at any place on the cane. The cane usually is weakened or breaks off at the swelling.

The adult beetles are present from late May until early August and range from Canada to the gulf states and as far west as Minnesota. On sunny days, they can be seen feeding on the bark of new growth. The creamy-white larvae, approximately ¾ inch long, have a pair of darkly colored forceps-like prongs on the abdomen. The young larvae bore into the sapwood of the current year's growth (primocane), make winding tunnels around the stem that split the bark, and finally work through the hardwood and into the pith. Infested canes are weakened and often die.

This insect usually is controlled by cutting out and removing infested canes from late fall to early spring. Prebloom and/or postharvest sprays of broad-spectrum insecticide may be considered when heavy populations are present.

Aphids

Aphids are pear-shaped, tiny (¼ to ⅜ inch long), soft-bodied, sucking insects with small heads and a pair of cornicles ("exhaust pipes"). At least three genera and eight species of aphids occur on raspberries in North America. Four species are found in the Northeast. Aphids have a complex life cycle involving overwintering eggs hatching in spring into wingless females, which give birth parthenogenetically to young that mature as wingless females. Populations increase rapidly during times of rapid plant growth. Later in the summer, winged females that fly to other plants and often to other plant species are produced. The last winged female generation of the season flies back to the primary host species. In the fall, wingless males and egg-laying females are produced and mated; eggs are laid on the primary host.

Aphids cause two types of damage to raspberries. First, they are piercing-sucking insects, removing nutrients from phloem tissue. Second, their feeding activities can spread disease, notably viruses. These viruses can in turn stunt plant growth, distort and discolor leaves, and decrease flower and fruit production. Plant viruses are credited with the sharp decline in raspberry acreage in recent decades. All stages except the egg in the aphid life cycle are capable of transmitting viruses. The minimum

feeding time necessary for aphids to pick up a virus from an infected plant is about 15 to 30 minutes. Aphids can retain the virus for several hours and are very efficient at transmitting the virus from plant to plant; a single feeding probe by a single aphid suffices.

The migration and dispersal of aphid populations, which takes place in June through mid-August, must be understood to appreciate the potential that aphids have for disease transmission. The local dispersal of aphids within rows is accomplished mainly by wingless females early in the season. Winged females are responsible for long-distance dispersal. The maximum distance that aphids travel is unknown, but if an aphid flies up into a stiff breeze it can be carried for miles. Of course, the probability that aphids will establish new colonies decreases rapidly with distance. Aphids also can be carried to new plants by animals, equipment, and even people.

Aphid control is important in reducing the secondary spread of viruses. The virus problem can be reduced in the following ways:

- Eliminate virus-infected wild and cultivated raspberries. Remember that not all viruses show symptoms, and healthy-looking plants may still harbor a virus.
- Plant raspberries that are certified to be virus free, and use proper fertilization, pruning, and irrigation practices. Certified virus-free stock remain infection free for at least 2 years and produce larger crops on healthy, vigorous plants; however, the local spread of a virus after planting must be maintained at low levels. This means roguing infected plants and controlling aphid vectors.
- Control aphids with horticultural oil or safer soap and by conserving natural enemies. Monitor plantings beginning at egg hatch (approximately May). Initiate a spray program when aphids are spotted. Other insects such as ladybird beetles can devour great numbers of aphids. These beneficial insects should be conserved by using insecticides or other tools only when necessary.
- Use varieties that are resistant to aphids. For instance, the purple-red Royalty variety is immune or resistant to two aphid species and the raspberry fruitworm.
- Use virus-resistant varieties.
- Maintain 500 to 1,000 feet between new plantings and virus-infected wild and cultivated raspberries.

Japanese Beetle

The ½-inch-long copper and green adult Japanese beetles, *Popillia japonica* (Newman), may appear in large numbers at harvest in late June to feed on the leaves. Leaves on the upper parts of the cane are affected more severely, and different varieties of raspberries vary in their susceptibility to beetle attack. Infestations peak in July but can continue through September. Japanese beetles spend the winter and spring as larvae in the soil, feeding on grass roots.

Beetle feeding can be controlled with broad-spectrum insecticide applications if necessary; however, beetles can fly substantial distances from untreated overwintering sites such as pastures and reinfest plantings. Weekly inspections of plantings therefore are recommended from harvest onward.

Mites

Leaves infested by the two-spotted spider mite, *Tetranychus urticae* (Koch), first appear to have areas of white stippling. Later, the leaves may bronze, dry, and eventually fall off. This is the result of mites piercing plant cells to remove nutrients and chlorophyll. In heavy infestations, the undersides of the leaves also will have silken threads spun across the surface. Mites are more prevalent during hot, dry periods, and injury is exacerbated if soil moisture is low. Heavy mite populations also can predispose plants to winter injury.

The adult female is tiny (1/50 inch long), greenish, and has two black spots on her back. Females overwinter in the folds of old leaves on the ground, in cracks and crevices of the posts and canes, and so forth. In the spring, lower leaves usually are infested first, but the mites move up the cane as the season progresses. Several overlapping generations hatch during the summer, and tremendous populations can build in a short time if conditions are right.

Insecticides applied for other pests can contribute to mite problems. Chemicals that kill beneficial predators of mites often do not kill the mites themselves. Fields should be inspected weekly and treated with a horticultural oil or safer soap if a sharp population increase is noted or if leaf spotting appears. Populations isolated within a field can be spot treated.

Tarnished Plant Bug

Plant bugs, especially the tarnished plant bug *Lygus lineolaris* (Palisot de Beauvois), but also including stink bugs and others, are generalist plant pests, feeding on

a variety of crop and noncrop species. Tarnished plant bugs appear when fruit buds form and plants begin to bloom. Feeding on buds and immature berries causes deformed berries. Plant bugs are more serious in small fields bordered by woods and fence rows, where weeds are plentiful.

Deformed berries can be caused by a variety of reasons, and it is important to be able to diagnose the causes of the various deformities. Raspberry fruits are clusters of drupelets attached to a central receptacle. Each drupelet is made up of a hard seed and a sugary, soft, fleshy portion. If the fruit appears abnormally small, then a fertility, plant vigor, or virus problem should be suspected. If the fruit is of normal size but has abnormally few drupelets with no deformed drupelets, then poor pollination should be suspected. If, however, there are abnormally few fully developed drupelets and the remaining drupelets are shriveled and seed like, then plant bug feeding should be suspected.

Apply an insecticide when more than 20 to 25 plant bugs are noted per 50 flower clusters. Pay particular attention to field borders.

Tree Crickets

Tree crickets deposit eggs in punctures in long rows in the canes of raspberries. Each puncture is distinct and more or less circular in outline, so the row of eggs appears as a series of dots, from a few to more than fifty. The eggs are laid through the outer layer of the wood and placed diagonally across the pith. Eggs usually are laid beginning in August. Egg-laying injuries occasionally girdle and kill the cane above the injury. Eggs hatch into tiny nymphs in the early spring near the end of May. During the five nymphal stages, the crickets are a snowy-white color, but they take on a greenish color after molting to the adult stage. All stages feed on a variety of plants.

Tree crickets rarely have been reported as a serious problem in Pennsylvania, although small infestations have been noted. If egg-laying damage is noted, clip off the cane below the egg-laying scars and destroy it.

Sap Beetles

Sap or picnic beetles are pests of fruit. The picnic beetle—the most frequent pest of raspberries—is about ¼ inch long and has four orange spots on its back. Other species of sap beetles also are found occasionally in raspberries.

As the fruit begins to ripen, the adult beetles are attracted, especially to overripe or decaying fruit.

Moreover, anything damaging fruit during harvest can stimulate sap beetle attacks. Sap beetles bore into the fruit, devour a portion, and lay eggs. If disturbed, the adults fall to the ground and seek cover. These beetles also are implicated in the transmission of rot organisms. Damage to the fruit by larvae is inconsequential because it does not take place until the fruit begins decomposing and is unmarketable.

Field control is best accomplished by prevention. Remove damaged, overripe, or diseased fruit from the planting at regular intervals. Other decomposing fruit also should be removed from the area. An insecticide application 3 to 5 days before the first picking also might be necessary.

DISEASE DESCRIPTIONS AND MANAGEMENT

The diseases discussed below are common to all brambles; however, susceptibility to these diseases varies within the bramble groups. See basic cultural guidelines for the control of plant diseases under “Pest Management,” discussed on page 24 in Chapter 2. Table 2.4 lists pesticides available for the control of diseases on various fruit crops. Pictures of fruit diseases can be found in the *Fruit Pathology Fact Sheets* at <http://fpath.cas.psu.edu/factsite.html>.

Anthracnose

Anthracnose, commonly called “cane spot” or “gray bark,” occurs in several species of *Rubus*. It is considered an extremely serious disease of black, purple, and susceptible varieties of red raspberry. Severe yield loss can result due to defoliation, wilting of lateral shoots, death of fruiting canes, and reduction in fruit size and quality.

Symptoms

Anthracnose symptoms are most conspicuous on canes but can also occur on leaves, petioles, flower buds, and fruit. In the spring, reddish-purple spots appear on young canes. As the disease progresses, the spots enlarge and the centers become sunken. These early lesions on the cane are called pit lesions. By late summer or early fall, the typical “gray bark” symptom can be observed, especially on the red raspberry. Within these lesions, spores are produced and then are spread by running water, splashing rain, and wind. Canes weakened by anthracnose are more susceptible to winter injury and eventually may die. Cankered canes also might produce abnormal fruiting branches with malformed fruit,

especially in seasons of drought. Fruit infections are not common unless there is a high level of anthracnose in the plantings. Infected fruit is typically dry and seedy. Most economic loss results from defoliation, reduction in fruit size and quality, and death of canes, either directly from the disease or from winter injury.

Disease Cycle

Anthracnose is caused by the fungus *Elsinoe veneta*, which overwinters on canes infected the previous season. In the spring, fungal spores are produced on these diseased canes. These spores are spread to very young green tissue, and infection takes place. The primary damage to plants is caused by these early infections. Black and purple raspberries are more susceptible than red raspberries.

Disease Management ♦

Infections that take place early in the growing season cause the most damage, so controls should be instituted early in the season. Anthracnose can be managed by sanitation and spraying. Although sanitation is labor intensive, it is an effective management practice for the control of anthracnose. Planting clean, disease-free nursery stock is important. Cut out all diseased canes, cane “handles,” and any infections observed on new plants. Good air movement through the planting should be provided by the removal of weeds and spindly canes. If possible, all noncultivated brambles within the vicinity should be rouged because these wild plants will also harbor the pathogen. If fungicides are necessary, a dormant to delayed-dormant application of lime sulfur is the most effective method of reducing the incidence of this disease. Refer to Table 7.5 for pesticide recommendations.

Botrytis Fruit Rot

Botrytis fruit rot or gray mold is the most common and most serious disease of *Rubus* species worldwide. The disease is caused by the fungus *Botrytis cinerea*. This pathogen has a wide host range and can survive on either living or dead tissue. It can overwinter on dead leaves, plant debris, and on the stems. The fungus rots fruit in the field before harvest, especially if rain occurs during blossoming. Most overripe and bruised fruit are susceptible, especially red raspberries. Aging leaves also are attacked, giving rise to cane infections.

Symptoms

Infections in the spring can be observed on canes, appearing as bleached-out, whitish areas. Infected berries

become covered with masses of fungal spores, which give the disease its characteristic name “gray mold.” If not harvested, infected berries become mummified, remain attached to the plant, and can serve as additional sources of inoculum in the planting. Botrytis can also cause a cane blight and leaf spotting.

Disease Management ♦

Cultural practices that create an open plant canopy, improve air circulation, increase light penetration, and speed the drying of plant surfaces after rain aid in the control of the disease. Avoiding excess nitrogen fertilizer and eliminating weeds help maintain an environment less susceptible to gray mold. It is also important to harvest fruit before it is overripe. If fungicides are necessary, they should be applied during bloom, with additional applications made during harvest if needed. Refer to Table 7.5 for pesticide recommendations.

Cane Blight

Cane blight usually affects only canes that have been wounded in their vegetative year. It sporadically attacks canes of all *Rubus* species. Black raspberry is more susceptible to this disease than the other brambles.

Symptoms

All symptoms of cane blight occur in close association with wounds. Infection occurs in late spring or early summer through pruning and insect wounds. In the spring, buds fail to break dormancy, lateral shoots wilt, or fruiting canes die when the fruit begins to ripen. Canes are usually brittle at the point of infection, and may break if bent. Symptoms appear late in the season on new shoots where plants have been pruned. Infected areas are brownish purple and develop from the cut ends. Branches originating in the infected areas wilt and die. Fruiting canes show a sudden wilting of branches when the fruit begins to ripen. Weakened canes are more susceptible to winter injury.

Disease Cycle

Cane blight is caused by the fungus *Leptosphaeria coniothyrium*, which also causes a canker on roses and a fruit rot of apple and pear. The fungus requires a wound or damaged tissue to infect a plant. The fungus overwinters on dead canes, which is where spores form for spring infection. These spores are spread by splashing rain, wind, and insects from early spring to late fall. Old stubs can continue to produce inoculum for several years. Black raspberries are more susceptible to cane blight than other brambles.

Disease Management ♦

Any practice that improves drying of foliage, such as keeping fruiting rows narrow and weeded, will help in the control of cane blight. A major consideration in the control of this disease is the prevention of damage to or wounding of the canes. Eliminate weeds and thin out weak canes to speed up the drying of plants. Prune out and dispose of old, diseased canes promptly after harvest. Choose a planting site with good air movement, and time pruning so that cuts have 3 days to dry before a rain. ♦ Fertilize to promote plant vigor, remove old canes after harvest, and control insect pests to reduce plant injuries. If fungicides are necessary, they should be applied during bloom with additional applications made during harvest if needed. Refer to Table 7.5 for pesticide recommendations.

Crown Gall and Cane Gall

Crown and cane gall are bacterial diseases that seriously limit raspberry production in Pennsylvania. Crown gall is the more widespread of the two diseases and affects all brambles as well as apples, grapes, peaches, and roses. Only grass-like plants seem to be immune to crown gall. Cane gall occurs only on brambles, with black and purple raspberries being more frequently infected than red raspberries and blackberries. The impact of the disease on plant growth and production can range from no apparent effect to the death of the plant.

Symptoms

Crown and cane gall are characterized by the spongy, rough, pinhead- to golf ball-sized, tumor-like swellings that become brown, woody knots with age. Crown galls develop in the spring on the underground parts—the roots and crown—of the plants. Cane galls develop as whitish eruptions on the fruiting canes in mid-June. These eruptions later turn brown and then black and begin to disintegrate. More intense gall formation seems to occur in years with higher incidence of winter injury. The diseases cause the production of dry, seedy berries and the stunting and prevention of new cane formation. Weakened canes are broken easily by the wind and are more susceptible to winter injury. The plants might show water stress and nutrient deficiency symptoms since the movement of water and nutrients throughout the plant is disrupted. With cane gall, black and purple raspberries are more often infected than red raspberries and blackberries.

Disease Cycle

Both diseases are caused by soilborne bacteria (crown gall: *Agrobacterium tumefaciens* and cane gall: *Agrobacterium rubi*) that infect the plant only through wounds. Wounds can result from natural causes (e.g., insect feeding, frost damage) or from mechanical causes (e.g., pruning, cultivating, harvesting). The bacteria overwinter in the soil and in galls. Bacteria are then spread by splashing rain, running water, cultivation, and pruning from soil and infected plants. As the galls enlarge, the soil can become heavily infested and will remain so for many years.

Disease Management ♦

The best control measure is prevention. Plant only certified, disease-free nursery stock, and take care not to wound the plants, especially the root systems, at planting time. Try to plant only in sites with no history of the diseases, or wait at least 3 to 5 years before replanting in the site. If a diseased plant is detected, remove and burn the roots and tops of the plant. Dispose of the soil surrounding the roots of the affected plant. Titan seems to be especially susceptible to crown gall, as do some of its relatives. No chemical control is known.

Rust Diseases of Brambles

Orange rust is a fungal disease that occurs only on brambles, particularly blackberries, dewberries, and black raspberries. This disease is not known to affect red or purple raspberries. This is a systemic disease. Once the plant is infected, the entire plant is infected for life.

Symptoms

The diagnostic symptoms of orange rust occur early in the spring when the new shoots begin their growth. The new leaves are stunted, deformed, and pale green or yellowish. Waxy blisters cover the undersides of the leaves. These blisters later become bright orange and powdery, the characteristic that gives the disease its name “orange rust.” Canes produced on the diseased plants may appear healthy. However, these infected canes are usually spineless and do not produce blossoms. The diagnostic orange pustules will be produced on the leaves of these canes the following spring. Infected plants generally take on a bushy appearance since many short, upright shoots arise from one bud.

Disease Cycle

Orange rust is caused by two fungi: *Arthuriomyces peckianus* and *Gymnoconia nitens*. The disease occurs only on black raspberries, blackberries, dewberries, and

possibly purple raspberries. The two fungi that cause the disease are very similar. The disease is not known to affect red raspberries. The fungus is systemic and overwinters in diseased roots and canes. Orange rust generally is favored by cool wet conditions. When the orange spore pustules mature and break open in June or July, the spores are spread to other plants by the wind. The fungus enters the plant through the leaves and grows internally through the canes, crowns, and roots. Newly infected plants seldom show symptoms until the following spring.

Disease Management

Many initial problems in the bramble planting can be prevented by starting with certified, disease-free nursery stock. Inspect all plants in the spring for symptoms of infection. As soon as symptoms of orange rust are detected, remove the entire plant. Remove and destroy all wild blackberries and raspberries in the area that might serve as a source of disease. Any practice that speeds the drying of foliage, such as keeping plantings weeded and rows narrowed back, will assist in control since spores need a relatively long period of leaf wetness in order to be able to germinate and penetrate the leaves in the spring. Avoid tipping canes in the fall because transporting inoculum on hands is easy during this operation. No chemical control is known for this disease. Some blackberries, specifically Ebony King, Eldorado, and Raven, are reported to exhibit resistance. If fungicides are used, they should be applied from the time orange pustules are first seen until the leaves on which they were produced die and dry up, and then again during late summer or fall when temperatures cool. Refer to Table 7.5 for pesticide recommendations.

Late Leaf Rust

Late leaf rust can be a problem on fall-bearing raspberries. The disease infects red and purple raspberries but not black raspberries or blackberries. This rust, unlike orange rust, is not systemic.

Symptoms

Yellow masses of spores are noticed primarily on fall fruit of primocane-bearing varieties, making the fruit unmarketable. Because symptoms on the fruit do not usually develop until late in the season, infections in plantings of summer-bearing varieties may go unnoticed. Powdery yellow spores also form on the undersides of leaves, causing badly infected leaves to drop prematurely, but this symptom is generally not noticed until infected fruit is seen.

Disease Cycle

There are several species of late leaf rust fungi world-wide. In our region, *Pucciniastrum americanum* is believed to be the causal agent. White spruce and Engelmann spruce serve as alternate hosts, and their closeness to a planting may increase the likelihood of occurrence. Spores are produced on infected spruce needles in early summer and can infect raspberries. High humidity is necessary for infection to take place. The raspberries will show symptoms shortly afterward. However, spruce are thought not to be necessary for the rust to survive in a planting once infected since this disease has occurred in successive years in plantings with no spruce in the vicinity. Spores are disseminated by wind but may also be physically moved from infected to uninfected plantings by people or machinery.

Disease Management

Clean nursery stock is important since planting stock can be the initial source of inoculum. Control is aided by cultural practices that increase air circulation within the planting such as thinning canes, keeping rows narrow, and practicing good weed control. Prune fall bearers to the ground; do not keep canes around for a summer crop and rake and dispose of all old leaves. Removing floricanes and infected primocanes in winter will reduce the amount of inoculum. This disease has been especially problematic on summer-bearing Festival and fall-bearing Heritage and Jaclyn. Fall-bearing Josephine and spring-bearing Nova and Esta red raspberries tend to be resistant. Because this fungus is not systemic, eliminating the disease from plants is possible. Refer to Table 7.5 for pesticide recommendations.

Phytophthora Root Rot

Phytophthora root rot is now regarded as a major cause of declining red raspberry plantings. Blackberries and black raspberries appear to be less susceptible than red or purple raspberries. Wet soil conditions favor the development of the disease, which can often be observed in low-lying areas of a field. Declining plants previously diagnosed as suffering from “wet feet” or winter injury usually are infected by this root rot.

Symptoms

Symptoms show up primarily in wet sections of the field. Death of plants may be sudden or gradual. Leaves of infected canes yellow prematurely or appear scorched along the margins and between the veins. Infected canes have weak lateral shoots and are stunted. Severely

infected fruiting canes wilt and die as the weather grows warmer before harvest. Few canes are produced, in contrast to when the cause is of aboveground origin (e.g., winter injury, cankers, borers) where normal numbers of primocanes are produced. The root systems of affected canes must be examined to diagnose phytophthora root rot. This is done by digging up plants that are wilting but that have not yet died and scraping away the outer surface (epidermis) of the main roots and crown. Infected roots have a characteristic red-brown color, whereas healthy roots appear white. A distinct line can be seen where infected and healthy tissue meet.

Disease Cycle

Phytophthora root rot is caused by at least 8 different species of soilborne fungi belonging to the genus *Phytophthora*. Depending on the species of phytophthora causing the infection, inoculum may already have existed in the planting site, or may have been brought in on infected plants. Once phytophthora is present, saturated soil is necessary for spread of the disease. A certain period of flooding may be necessary in order for infection to take place. Resistant spores of the fungus can persist in the soil for a number of years. They are resistant to environmental extremes and chemicals. The fungus requires high levels of moisture and cool temperatures for reproduction. The fungus infects plants in the spring and during the onset of dormancy.

Disease Management ♦

Use only clean planting stock. Good soil drainage and proper variety selection are necessary for controlling phytophthora root rot. Plant all brambles in well-drained soil or in raised-bed plantings. At no time should water be standing in the field. Highly susceptible varieties include Hilton, Ruby, and Titan. Canby, Cumberland, Festival, Munger, Reveille, and Taylor also appear to be very susceptible. Bristol, Cherokee, Jewel, Latham, and Newburgh are the least susceptible and the safest choices if berries are on marginal sites. Black and purple raspberries are relatively, but not completely, resistant. No raspberry is immune, although black and purple raspberries are somewhat resistant.

Powdery Mildew

Blackberries are seldom severely infected by powdery mildew. It is occasionally a serious problem on susceptible varieties of red and black raspberries, especially the Black Hawk and Latham varieties. Infected plants may be stunted and less productive.

Symptoms and Disease Cycle

The disease is caused by the fungus *Sphaerotheca macularis*, which overwinters in infected cane tips and dormant buds. When temperatures reach 50 to 60°F, the spores are discharged and spread by wind. The characteristic sign of this disease is a white, powdery growth, primarily on the underside of the leaves. Infected leaves are dwarfed and twisted and have a yellow appearance on the upper surface. Powdery mildew is favored by warm weather without rainfall and is most serious in years and plantings with poor air circulation.

Disease Management

Unlike with most fungi, free water will reduce the incidence of this disease. Plant disease-resistant varieties when possible. Removing suckers that are infected with powdery mildew and pruning canes in the spring to a desirable height can reduce sources of the disease. Practices that allow good air circulation, such as cane thinning, proper plant spacing, and maintaining narrow rows, can be helpful in control. Apply fungicide sprays (see Table 7.5) when symptoms first appear, usually from midsummer through fall. If powdery mildew was severe in black raspberries the previous season, begin fungicide sprays in mid-June. Three to four applications might be required.

Spur Blight

Red and purple raspberries are more affected by spur blight than black raspberries. Blackberries appear to be immune. In extremely overgrown and weedy plantings, the disease can cause a loss in yields, especially if excessive nitrogen is applied.

Symptoms and Disease Cycle

Spur blight is caused by the fungus *Didymella applanata*, which overwinters in infected canes. Symptoms appear in late spring or early summer as chocolate-brown, dark-blue, or purplish spots or bands on new canes and petioles. These lesions enlarge until the cane is girdled. By late summer, canes may crack and split lengthwise, at which time the reproductive, pimple-like, black fruiting structures of the fungus can be seen. These structures overwinter and the following spring discharge spores into the air or may ooze to the surface of the stem during wet periods. Symptoms on leaves appear as chocolate-brown, angular, or wedge-shaped areas. The effects of spur blight are increased plant susceptibility to winter injury and reduced yield as a result of the withering and eventual death of infected laterals. Leaflets also wither and drop prematurely.

Disease Management

Suggested controls are the same as those for cane blight, botrytis blight, and anthracnose. Keeping the plant canopy open to ensure that leaves and canes dry rapidly after rain will help in controlling this disease. Thorough pruning, including the removal of pruned canes from the planting, is helpful. Lime sulfur and sanitation are useful, and keeping row width narrow to increase air movement is particularly effective. Producing only the fall crop on primocane bearers has greatly reduced the incidence of the disease. Several fungicides can be used during the season. Refer to Table 7.5 for pesticide recommendations.

Verticillium Wilt

Verticillium wilt is caused by two common soilborne fungi. These fungi have a wide host range and attack more than 300 woody and herbaceous plants. The disease can be widespread and extremely destructive. Black raspberries are more susceptible to the disease than red raspberries. Blackberries also are attacked by the pathogen but are not as prone to wilting.

Symptoms

Symptoms on plants become obvious by June or early July. Shoots are stunted and leaves, starting at the base of the infected plant, turn yellow, wilt, and drop. The entire shoot will wither and die shortly thereafter. Black raspberry canes might show a blue or purple streak from the soil line extending upward. This purple streak is not detectable on red raspberry canes. Fruiting canes, infected the previous year, either die in the spring or develop yellow and stunted leaves. If the canes die before reaching maturity, the fruit becomes mummified. Losses are heavier in black raspberries than in red raspberries.

Disease Cycle

The disease is caused by the fungi *Verticillium dahliae* and *Verticillium albo-atrum*. These fungi can exist in the soil prior to planting, may be brought in on planting stock, or may move in on wind-blown soil. The fungi can survive either in plant debris or free in the soil. The fungus enters the roots through breaks or wounds and moves into the vascular system, causing a systemic infection. After the plant or plant portions die, the fungus continues to survive in the soil for long periods of time. Factors that can increase disease are heavy soils and cold, wet spring weather.

Disease Management

Verticillium is favored by cool weather and is most severe in poorly drained soils following a cool, wet spring. There are no effective fungicides for management once the plants are in the ground. To minimize this disease, choose a planting site with no known history of this problem. Avoid land recently planted with tomatoes, potatoes, eggplants, peppers, strawberries, raspberries, or stone fruits; and land infested with horse nettle, ground cherry, red-root pigweed, and lamb's-quarter. Plant verticillium-free nursery stock. The number of years required to eliminate verticillium, especially the resting spores from the soil, is unknown. In spite of this, planting with verticillium-free black raspberry stock on uninfested soil usually ensures many years of avoidance of this disease.

Virus Diseases of Brambles

Virus diseases can seriously damage brambles, especially raspberries, and can affect the lifetime of a planting. Once the plant is infected with the virus, the entire plant will be infected for the remainder of its life. Virus infections cause decreased productivity, so it is important to start a planting with healthy plant stock obtained from a reputable nursery.

Clean planting stock usually is obtained through meristem-tip culturing. Meristem-tip culturing produces an essentially virus-free plant. These indexing methods vary with the type of virus to be detected. The virus-indexed plants then are used to propagate more plants to commercial quantities. For the plants to remain essentially disease free, they must not be increased in the field where viruses and other pathogens can infect the plant. These propagation methods also reduce the likelihood of other diseases such as crown gall.

Once the planting is established, viruses can be introduced into the planting by various means. The virus must be carried to the raspberry bushes by a vector. The vectors responsible for spreading viruses are pollen, aphids, nematodes, and possibly leafhoppers and whiteflies. Thus, the active control of virus diseases is based on preventing the initial infection of clean stock by removing sources of virus near the planting, mainly wild bramble bushes, and by controlling the vectors. If a young planting shows virus symptoms, the planting stock probably was infected at the time of planting since symptoms do not usually appear during the first season of infection.

Five major virus diseases are associated with brambles: mosaic, leaf curl, crumbly berry, black raspberry streak, and tomato ringspot virus.

Mosaic Virus

Mosaic affects all raspberries but seldom affects blackberries. The mosaic virus complex overwinters in infected plants and is spread by aphids. Symptoms of raspberry mosaic vary with the raspberry variety, the type of virus infection, and the time of year. In general, symptoms might include delayed leafing out, dieback of shoot tips, and stunted canes or clusters of shoots from the same node. Plants usually die in a few years. Mottling or yellowish spotting and cupping or blistering of the leaves are common symptoms most easily seen in the early spring when the new leaves are expanding. Leaf symptoms often disappear during hot weather later in the season. Red raspberries are not as severely affected as black ones, but they still suffer reduced plant vigor and yield. Care must be taken in diagnosis since these symptoms can be mimicked by late spring frosts, powdery mildew, mite injury, fungicide and herbicide sprays, and boron deficiency.

The mosaic virus complex overwinters in infected plants and is spread by aphids. Feeding time needed to transmit viruses in the complex is only a few minutes. Standard control practices of establishing plants as far as possible from wild or older populations of brambles and using planting stock propagated from virus-free plants are useful. Controlling aphids may assist in slowing the spread of viruses within the planting; however, because the viruses are transmitted very quickly, it is unlikely that transmission can be thwarted. Of purple and black raspberries, Black Hawk, Bristol, and New Logan are tolerant; Cumberland is very susceptible. Canby, Reveille, and Titan, red raspberries are reportedly resistant because aphid vectors avoid them; most other red raspberry varieties are susceptible. Aphid vectors also avoid Royalty.

Leaf Curl Virus

Raspberries are affected more severely by leaf curl than are blackberries. Many blackberry varieties remain symptomless when infected. Symptoms of infection by the leaf curl virus gave rise to the disease name. The leaves on infected canes are stiffly arched or curled downward. Leaves of red raspberry become yellow, while those of black raspberry take on a dark-green, greasy cast. Clusters of stunted lateral fruiting shoots arise from single nodes on the canes. The canes are stiff and brittle, and the fruit small and crumbly. Symptoms on red raspberry are very mild or might not appear until the season after infection. This virus is spread by aphids and petiole grafting.

Two different strains of this virus exist, with one strain infecting red raspberries and the other infecting black raspberries. Both infect blackberries, although most varieties are symptomless. This virus is spread by at least one species of aphid. Spread of the virus is slow. Control includes the standard practices of starting with clean stock, keeping plantings from wild raspberries or infected plants, and roguing plants that show symptoms. Using insecticides to control aphids also slows the spread of this virus.

Crumbly Berry, Raspberry Bushy Dwarf Virus

Crumbly berry is the most common bramble virus in the Mid-Atlantic region. This is a red raspberry disease caused by the tomato ringspot virus and spread by the dagger nematode. Many plants that appear normal produce small fruit that fall apart when picked, which results from the failure of some of the drupelets to develop. Since this virus primarily acts on the vitality of pollen, poor pollen performance results in unfertilized seed and undeveloped seed, which result in undeveloped drupelets. This virus has a wide host range, including many weeds such as dandelion. Symptoms of this disease vary with raspberry variety. Yellow ringspots can be seen on the expanding leaves of new shoots that often will disappear in midsummer. The canes sometimes are stunted and plant vigor is reduced.

Plants are infected when infected pollen is transferred by pollinators or by wind. Infected plants can be found in the wild as well as in flowering plantings. New plantings located near infected plants frequently become infected within two or three flowering seasons.

Management can be especially difficult because this virus is pollen vectored. Wild brambles in the vicinity should be eliminated, but because pollinators can travel long distances, eliminating enough plants to eliminate the virus may not always be possible. Esta and Heritage seem to be resistant to this virus.

Tomato Ringspot Virus

Tomato ringspot virus is a very common virus in the Mid-Atlantic region. It is vectored by dagger nematodes (*Xiphinema* spp.) and possibly pollen. This virus has a wide host range, including many weeds such as dandelion and chickweed. Other hosts include the following fruit crops: strawberry, blueberry, apple, and peach. Seeds of chickweed and dandelion can be infected, and if spread throughout the field, plants developing from these seeds can serve as sources of infection.

Symptoms of the disease vary with raspberry variety. They include yellow ringspots, especially in Royalty, which often disappear in midsummer on the expanding leaves of new shoots. Other symptoms on spring foliage may be streaks or yellowing. Some cultivars produce crumbly fruit, whereas others may eventually die out. Canes are more commonly stunted, and this virus will eventually render a planting unproductive. Fruit is commonly crumbly and small, as with other viruses, which affects pollen viability. Yield and fruit quality in the cultivar Canby appear to be relatively unaffected even when the plants are infected.

Control measures include planting stock that is free of tomato ringspot virus along with roguing of infected plants and their neighbors, which may be symptomless. Weeds should be controlled since they could be a host for the virus.

Black Raspberry Streak

Inconspicuous purple streaks less than 1 inch long form during warm periods on the lower part of infected canes. Infected plants usually are vigorous, sometimes with no symptoms of virus infection. The fruit, however, display diagnostic characteristics—they lack a glossy appearance, have drupelets that ripen unevenly, and are sometimes small, blotchy, and seedy. The vector of this virus is not known.

This virus is very unevenly distributed in plants, which makes detection difficult. Use of planting stock from virus-free indexed mother plants and isolation from plants that could be sources of this virus are recommended control measures.

Virus Disease Control

Control measures are aimed mainly at removing sources of the virus particles from within and around the raspberry planting. Wild and neglected brambles should be destroyed within 600 to 1,000 feet of the planting. A good weed-control program should be used to eliminate host plants for the viruses. Soil should be tested for dagger nematodes, which vector viruses. Plants should be examined throughout the season for virus infection symptoms. If symptoms are detected, the plant must be removed. Strict aphid control should be maintained to prevent infection. These measures all are very important to the lifetime of a planting since the plant will remain infected for life once it is infected with a virus.

PEST MANAGEMENT

Fruit growers can use many methods to control bramble diseases. Table 7.2 summarizes disease control strategies, and Table 7.5 lists some fungicides for some of the important diseases. Fungicides, however, are only one of the control options and are not always successful on

brambles. Table 7.3 describes the occurrence of insects and mites on brambles, and Tables 7.4 and 7.5 provide information about pesticide use. A general discussion of insect management appears in Chapter 2.

The following practices will help in both insect and disease control.

Table 7.2. Summary of bramble disease control strategies.

All possible control strategies must be employed if bramble diseases are to be controlled.

Diseases

CB = cane blights: anthracnose, cane blight, spur blight, and botrytis blight

FR = fruit rots

OR = orange rust

PM = powdery mildew

V = viruses: mosaic (raspberry), leaf curl (raspberry, with blackberry symptomless), ringspot (red raspberry), and streak (purple and black raspberry)

VW = verticillium wilt

Disease Control Considerations	CB	FR	OR	PM	V	VW
1. Good air/water drainage	++	++	-	+	-	-
2. 500+ ft from brambles	-	-	-	-	++	-
3. Rotation	+	-	-	-	+	++
4. Tolerance/resistance	-	-	++	+	++	++
5. Avoid adjacent plantings	-	-	-	+	++	-
6. Eliminate wild brambles	-	-	++	+	++	-
7. Disease-free stock	++	-	++	+	++	++
8. Aphid control (vectors)	-	-	-	-	++	-
9. Rogue infected plants	-	-	++	-	++	-
10. Speed drying (weeds, pruning)	++	++	+	-	-	-
11. Prune 3 days before rain	++	-	-	-	-	-
12. Dispose of pruned canes	++	-	+	-	-	+
13. Maintain plant vigor	++	-	-	-	-	-
14. Fungicide sprays	++	+	-	++	-	-
15. Harvest before overripe	-	-	-	-	-	-
16. Fruit storage conditions	-	-	-	-	-	-

++ = most important controls; + = helpful controls; - = no effect

Table 7.3. Occurrence of insects and mites on brambles during the growing season.

Insects and Mites

A = aphid

CB = cane borer

JB = Japanese beetle

M = mite

SB = sap beetle

TC = tree cricket

TPB = tarnished plant bug

Timing	A	CB	JB	M	SB	TC	TPB
Dormant	-	++	-	-	-	++	-
Bud Break	-	-	-	-	-	-	+
8" Shoots	-	-	-	-	-	-	++
Petal Fall	+	+	-	+	-	-	++
Preharvest	++	+	+	+	++	-	++
Midharvest	++	+	++	++	-	-	-
Postharvest	++	++	++	++	-	+	-

+ = pest present, possible control; ++ = proper timing of control; - = control generally is not needed at this time

Good Air/Water Drainage ♦

Good air drainage and circulation within the planting speeds the drying off of plants and reduces the potential for infection. Many disease organisms require wet foliage or fruit for infection to take place. Similarly, it is important that the soil dries out quickly after rain. Waterlogged soil increases the likelihood of disease infection in the root system. Several important disease organisms on brambles will infect the root system in wet soil.

Table 7.4. Efficacy of insecticides on brambles.**Insects and Mites**

A = aphid

SB = sap beetle

JB = Japanese beetle

M = mite

Pesticides	A	JB	SB	M
Azadirachtin	3	3	—	—
Malathion	2	2	2	3
Carbaryl	3	1	—	4
Esfenvalerate	2	2	3	4
Rotenone	3	3	—	—

Degree of control: 1 = best; 2 = good; 3 = fair; 4 = slight; — = no rating available

Plant Brambles More Than 500 Feet from Existing Brambles ♦

This control is aimed primarily at reducing the spread of viruses from existing brambles to young healthy plants. Because of the widespread occurrence of virus-infected wild brambles in Pennsylvania, it generally is assumed that older domestic plantings or wild brambles all contain viruses, and that new plantings should be placed well away from the area. Sometimes planting new brambles 500 feet from older or wild brambles is not possible. In that case, the next best option is to put the new planting upwind. Viruses are spread primarily by aphids, so planting upwind will reduce the potential for virus spread since flying against the wind will be more difficult for the aphids.

Rotation ♦

Some crops can build disease organisms in the soil, which can devastate the next crop if it is susceptible to the disease. Brambles should not follow tomatoes, potatoes, eggplants, peppers, strawberries, raspberries, or stone fruits for 5 years since these crops may harbor the *Verticillium* fungus, which is very severe on brambles. Avoid an area with a history of verticillium problems. Grass crops or corn are recommended before red raspberries are planted since nematodes will lose the crumbly berry virus once they feed on corn or grasses.

Table 7.5. Pesticide recommendations for brambles.

The important insects and diseases to be controlled, except for viruses, are listed in the right-hand column of this spray schedule. Always consult the label before making pesticide applications. Labels vary greatly among commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides. Due to a wide array of various products containing the same active ingredient, for insecticide recommendations, when appropriate, the active ingredient is listed instead of the name of formulated product.

Follow all instructions and application rates listed on pesticide labels.

Time to Spray	Suggested Materials	Pests to Be Controlled
Dormant (blackberries)—before buds open	Lime sulfur	Anthraco-nose, cane blight, powdery mildew, rust
Delayed Dormant—just as buds begin to open	Lime sulfur	Anthraco-nose; spur blight on raspberries; powdery mildew, rust, and cane blight on blackberries
New shoots 8 inches long	Sulfur; Malathion; Esfenvalerate	Anthraco-nose; Botrytis, cane blight, and spur blight on raspberries; fruit worms; plant bugs
Petal Fall	Sulfur; Carbaryl <i>plus</i> Rotenone or Pyrethrum	Anthraco-nose; Botrytis, cane blight, and spur blight on raspberries; fruit worms; rose chafer; aphids; mites; plant bugs
Preharvest	Sulfur	Fruit rots
Midharvest	Sulfur	Fruit rots
Postharvest	Malathion <i>plus</i> Carbaryl	Aphids, if present; Japanese beetles

Tolerance or Resistance

Some plants are not susceptible to some diseases or are less susceptible than other varieties. Resistance or tolerance to diseases will eliminate or greatly reduce the need for disease control.

Avoid Adjacent Plantings ♦

Keep black and purple raspberries away from red raspberries because mosaic virus can spread from red raspberries and is more severe on black and purple raspberries. Keep all red raspberries away from blackberries because blackberries can be a symptomless carrier of curl virus.

Eliminate Wild Brambles ♦

Wild raspberries serve as a host for many insect and disease problems that spread to domestic plantings. Removing wild brambles will reduce the need for insect and disease control. Remember, many virus-infected plants may not show symptoms.

Disease-Free Planting Stock ♦

Use only disease-free planting material. Since viruses and bacteria cannot be seen at the time of planting, the grower must rely on good propagation and methods used by the nursery. Virus-infected plants are infected for life, and bacteria-infected plants will contaminate the site for many years. Buy only healthy plants from reputable nurseries.

Aphid Control

Aphids are vectors of viruses and must be controlled if virus diseases are to be managed.

Rogue Diseased Plants

Pulling out diseased plants helps to reduce the amount of disease in a planting. This is an especially important control tactic for orange rust and verticillium wilt.

Speed Drying ♦

Most disease organisms that cause foliage or fruit diseases require wet surface areas for infection to take place. By speeding the drying time after rain or heavy dew, the potential for disease development can be greatly reduced. Two important methods for accomplishing this in a bramble planting are good weed control and adequate pruning to allow good air circulation within the canopy.

Prune Three Days before Rain ♦

Cane blight can be a serious problem on black raspberries. The fungus requires a fresh pruning wound and wet surface for infection to take place. If it is possible to time pruning so that these do not occur at the same time, no disease will develop.

Dispose of Pruned Canes ♦

Anthracnose, a serious problem on brambles, can survive on dead canes that have been pruned off. If pruned canes are left in or near the planting, the disease can spread back into the planting. Removing the pruned canes reduces the potential for disease development.

Maintain Plant Vigor ♦

Some diseases, like cane blight, can more easily infect weak canes than healthy ones. Maintain plant vigor through a good nutritional program to reduce the potential for cane blight development.

Fungicide Sprays

Fungicide applications should be used only if other control strategies are not adequate to control the disease. Fungicide sprays will help in the control of cane blight, powdery mildew, and fruit rots.

Harvest before Fruit Becomes Overripe ♦

The fruit rots will spread more quickly on overripe fruit. Overripe fruit will also allow a disease to build up in the planting, making control more difficult.

Fruit Storage Conditions ♦

Fruit rots will develop more slowly or not at all if the fruit is cooled rapidly (to 40°F) after picking.

Groundcover Management and Weed Control

It is best to grow sod between bramble rows. This prevents soil erosion and allows the home gardener to easily walk between rows. The grass should be mowed regularly to discourage rodents from nesting near the planting. Weeds, especially dandelion, can serve as hosts for viruses. Weeds adjacent to or between plants should be removed mechanically by hoeing, hand pulling, or shallow cultivation.

Strawberries

Strawberries are the ideal fruit crop for growers with very limited space. The plants are low growing perennials and provide a delicious supply of fruit either in June (from the appropriately named “June bearers”) or throughout the summer (from the day-neutral types). Plants fruit well in rows, beds, or even in pots, and make an attractive groundcover when not fruiting.

The strawberry plant is in many ways unique. It is an herbaceous perennial, composed of leaves, a crown (a compressed, modified stem), and a root system (Figure 8.1). In heavier soils such as clay loams, 90 percent of the roots can be located in the top 6 inches of soil. This shallow root system is, in part, responsible for the strawberry plant’s sensitivity to water deficit and excess. Runners, or stolons, arise from buds at the base (axils) of the leaves; they are the strawberry plant’s device for asexual propagation.

VARIETY SELECTION

Because strawberry varieties are extremely sensitive to local conditions, a variety that performs well in one location may do poorly in another area. Varieties that perform satisfactorily in northern Pennsylvania might fail miserably in the southern portion. Because of these differences in variety performance, gardeners are strongly advised to experiment with a number of varieties. Varieties with resistance to red stele and verticillium wilt are highly recommended.

June-Bearing Strawberries

The strawberry most commonly grown in Pennsylvania is the June-bearing strawberry. June bearers are the type most often grown by commercial growers, and are the result of decades of breeding for productivity, size, and other attributes. These varieties are rated as early, mid-season, or late according to when they bear (Table 8.1). The early varieties may be more subject to frost injury because they bloom earlier, and the opened blossom is the stage of fruit development most susceptible to frost

injury. Strawberry varieties all ripen about 30 days after bloom.

Day-Neutral Strawberries

Day-neutral strawberry varieties bear throughout the growing season. They are highly productive and have very flavorful berries. Day-neutral plants have three peaks of production each year: one in June, one in midsummer, and one from late August through frost. Day-neutral strawberries have been grown successfully in commercial plantings in Pennsylvania; however, the summer crop often is very small due to high temperatures. The high-temperature effects can be ameliorated by a heavy straw mulch to keep soil temperatures low; however, even with this precaution, day-neutral varieties may not perform well in the southern half of Pennsylvania. Cultural practices for these berries differ from those of June bearers; some of these differences are outlined in subsequent sections of this publication.

Text continued on page 140.

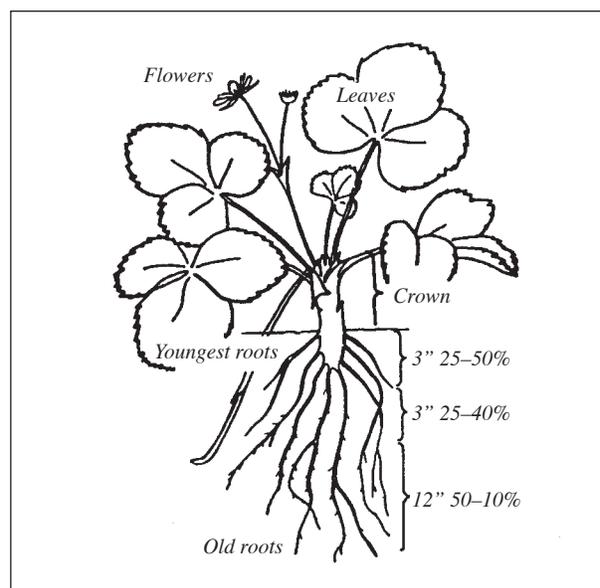


Figure 8.1. The strawberry plant and its root distribution. (Courtesy of the University of Wisconsin.)

Table 8.1. Strawberry variety descriptions.

	Season	Susceptibility to:					Description
		Vert. wilt	Red Stele	P.M.	Leaf Spot	Leaf Scorch	
June-Bearers							
Annapolis	Early	I	R	S	S	S	Medium to large fruit with good flavor. Produces many runners and dense beds, increasing Botrytis incidence.
Earliglow	Early	R	R	I	I	R	The best early season cultivar for flavor and disease resistance. Moderately productive; size runs down quickly.
Evangeline	Early	U	S	R	R	R	Dark-red fruit with good flavor and uniform size and shape. Resistant to leaf diseases, so caps remain green. Fruit is beautiful but very small.
Northeaster	Early	R	R	S	I	I	Large, aromatic fruit, may have a perfume-like flavor. Similar yields and season to Earliglow. Early berries start out large, but size runs down quickly.
Sable	Early	U	R	S	R	R	Dense foliage low to ground, fruit is susceptible to Botrytis. Yields are high, but even the primary berries are small. Medium-red fruit with sweet flavor.
Brunswick	Early-mid	U	R	S	R	I	Yields well, but has average flavor. More likely to perform better in cooler locations. Susceptible to Phytophthora crown rot.
Cavendish	Early-mid	I	R	S	R	R	Large fruit with good flavor. Productive, but ripens unevenly in some years due to heat.
Honeye	Early-mid	S	S	T	R	R	Very productive, with a perfume-like flavor, but become very dark, soft, and bland in hot weather. Better in cooler locations. Susceptible to two-spotted spider mites.
L'Amour	Early-mid	U	U	U	R	I	Nicely shaped fruit with good size, medium-red color and above-average flavor. Yields below average.
Primetime	Early-mid	R	R	U	R	R	Large, light-colored berries with very good flavor and productivity. Prone to fruit rots due to softness of fruit.
Surecrop	Early-mid	R	R	R	U	U	Vigorous. Easy to grow and appears to have wide adaptability.
Allstar	Mid	R-T	R	T	R	I	Productive, with good flavor. Drawback is its light orange-red color when ripe. Susceptible to angular leaf spot.
Clancy	Mid	U	R	U	R	S	Deep red color with good size, but yields are low in PA. Produces few runners.
Darselect	Mid	U	U	U	I	I	Nice size, shape, and flavor. Yields typically somewhat lower than expected. Susceptible to anthracnose fruit rot.
Delmarvel	Mid	R	R	U	R	R	Performed well in the DelMarVA peninsula, with high yields and vigorous plants. Somewhat less impressive in PA.
Eros	Mid	S	R	U	I	I	Allstar hybrid. Productive. Good size and flavor, but color is light. Fruit can be very soft and prone to Botrytis infection.
Guardian	Mid	R	R	U	R	U	Very productive. Large fruit. Tends to be prone to fruit rots and to damage to slugs and sap beetles.
Kent	Mid	S	S	T	U	I	Cold hardy and vigorous. Fruit is large but borne on short pedicels (stems), so rots can be a problem. Average flavor.

Table 8.1. Strawberry variety descriptions (continued).

	Season	Susceptibility to:					Description
		Vert. wilt	Red Stele	P.M.	Leaf Spot	Leaf Scorch	
Lester	Mid	S	R	U	R	R	Productive berry with good flavor. Size starts out good, but runs down quickly. Fruit is susceptible to Botrytis.
Mesabi	Mid	R	R	R	I	I	Productive, but fruit can dark, soft, and flavorless in hot weather. Susceptible to two-spotted spider mite damage.
Mira	Mid	U	R	S	I	I	Nice fruit, medium-red color, good flavor. Has produced very high yields in some PA locations.
Raritan	Mid	S	S	S	S	S	Flavorful. First fruits are large, but size runs down quickly. Susceptible to anthracnose fruit rot.
Cabot	Mid-late	U	R	S	R	I	Huge fruit, high yields. Produces few runners. Primary (first) berries are oddly shaped. Good flavor, but fruit center may be hollow. An interesting specimen.
Canoga	Mid-late	I	I	U	R	R	Older cultivar that has been resurrected. Good flavor and yields. Produces few runners, so plants should be spaced more tightly than usual.
Chandler	Mid-late	U	S	R	S	T	Large fruit with excellent flavor. A consistent performer across environments. Very susceptible to fruit anthracnose, however.
Jewel	Mid-late	S	S	R	R	R	All-around good performer. Nice size and shape with good color and flavor. Productive.
Lateglow	Mid-late	R	R	T	R	R	Large fruit, but light colored and somewhat soft. Good flavor. Plants are very vigorous.
Seneca	Mid-late	S	S	U	U	U	Perhaps too firm for home garden use. Good size, round shape, and medium-red color. Flavor is mild.
Sparkle	Mid-late	S	R	S	U	U	Soft berry with good flavor. Better suited for home gardens than for commercial production.
Winona	Mid-late	T	R	U	R	R	Berries may color unevenly and have short pedicels (stems), so fruit is in close contact with the ground and is prone to various rots. Conical berries, average flavor.
Idea	Late	R	R	U	I	S	Late, but fruit has orange color and is poorly shaped with “bumpy” appearance. Flavor is good. Extremely susceptible to leaf scorch.
Ovation	Late	U	U	U	T	I	Gives new meaning to “late-season.” Nicely shaped berries with medium-red color. Good flavor. Yields are low for the amount of foliage, but is the best late-season berry.
Day-Neutrals							
Tribute	Not applicable	T	R	R	T	T	Flavor a bit milder than for Tristar, but still tart. Firm. Plants are fairly vigorous.
Tristar	Not applicable	R	R	R	T	T	Flavor is good but can be tart. Firm fruit; size is small in hot weather.
Seascape	Not applicable	U	S	U	S	U	Sweet flavor makes this a top choice for a day-neutral. Nice shape, medium-red color.
Everest	Not applicable	S	R	R	U	U	Soft fruit with mild flavor.

Everbearing Strawberries

These varieties bear two crops during the year and generally are not as high in quality or as productive as the day-neutral types. For this reason, we recommend that you plant the day-neutral types rather than the everbearers if continuous cropping is desired. Descriptions in nursery catalogs often refer to day-neutral varieties as everbearers, however, so making this distinction can be difficult. All of the day-neutral varieties discussed in the chapter are true day-neutrals.

PLANTING

Keep plants in a shady area or refrigerator until planting. Place the roots in water about ½ hour prior to planting. Do not allow the roots to dry out during the planting process. Strawberries should be planted in April, as soon as the soil is in good condition—well worked, without excess moisture. Planting after June 1 is not recommended.

Plant June-bearing strawberries 18 to 24 inches apart in rows at least 36 inches apart with the soil line above the roots but not covering the growing point of the crown (Figure 8.2). Day-neutral strawberries should be planted closer together, about 5 to 9 inches apart. Additionally, day-neutral plants should be mulched immediately since they are sensitive to warm soil temperatures. Mulch with about 4 inches of clean straw.

Flower buds of June-bearing strawberries should be removed manually in the first year to avoid flowering and fruiting stress on the young plant. Flower buds and runners on the day-neutrals should be removed only through early July of the first year and may be allowed to fruit after this date. Removing flowers allows the plants to direct their energy into root-system establishment and the development of a healthy, large leaf canopy that will “fuel” the next year’s crop.

The importance of establishing a healthy stand of plants cannot be overemphasized. The planted field

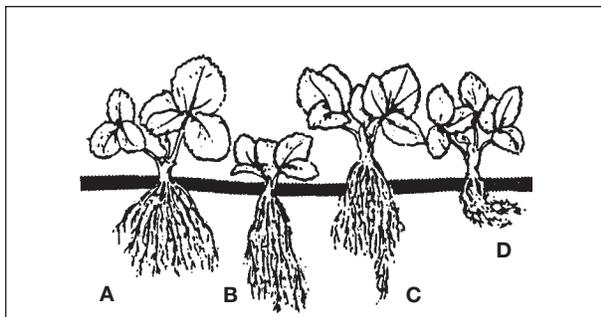


Figure 8.2. Strawberry planting depth. A = correct, B = too deep, C = too shallow, D = hole too shallow.

should be irrigated immediately. Optimal soil moisture levels need to be maintained throughout the season so that plants become well established.

NUTRITIONAL REQUIREMENTS

Apply 2 pounds of 10-10-10 per 100 feet of row after planting and an additional 2 pounds in late August. Day-neutral varieties should receive a more constant nitrogen rate through the planting year. Apply 1 pound of ammonium nitrate per 100 feet of row once a month from June through the first day of September. Strawberry size can be increased dramatically by timely irrigation as the berry enlarges. Avoid overwatering since too much water will dilute the flavor of the berry, giving it a bland, unappealing taste.

OVERWINTERING

Strawberry plantings require mulching for protection from the cold and soil heaving that can result from sudden drops in temperature.

Approximately 4 inches of clean (weed-free) wheat, oat, or rye straw or salt marsh hay should be applied in December. Do not apply mulch in clumps because this can smother plants. Mulch should be removed in spring, usually from mid-March to early April, after the danger of freezing is past but before much leaf yellowing occurs. Straw should be left in the rows as a bed for the berries to ripen on.

RENOVATION

June-bearing strawberry beds can be renovated and maintained for several years. Renovation thins the beds and invigorates the remaining plants. Plant thinning is essential because beds that retain too many plants yield small berries that are difficult to find under the dense foliage.

The renovation process should begin immediately after the harvest is completed. This gives the plants time to develop the canopy, which in the fall will determine the number and quality of flower buds that will produce fruit the following spring.

To renovate, remove weeds, narrow the rows to 6 to 12 inches, and thin the plants so that there is a plant about every 3 to 4 inches. Try to select strong runner (daughter) plants, and remove mother plants when they are 3 to 4 years old, replacing them with strong runner plants. Clip or mow the leaves off and fertilize the plants with about 5 pounds of 10-10-10 per 100 feet of row. Irrigate if the weather is exceptionally dry. Renovation is not recommended for day-neutral strawberries.

These plants will need to be replaced every third year. With proper renovation and pest control each year, a strawberry planting should produce abundant large berries for at least 5 years.

A NEW SYSTEM—STRAWBERRY PLASTICULTURE

Strawberry plants can also be grown on raised beds covered with black plastic. When black plastic is used, planting stock can be either dormant plants or plants grown from rooted runner tips (called plug plants). With this system, trickle tape under the plastic for irrigation and row covers (lightweight spun-bonded material) for winter protection will also be needed. Plants should be grown in a protected location.

Plug plants are planted through the plastic in late summer or early fall; dormant plants are planted in July. Plants are spaced more closely than usual at about one foot apart in staggered double rows. Row covers are placed over the beds in mid-October to increase fall growth, and runners produced during the fall should be pinched off. Bloom and harvest begins earlier than usual in the spring, which means that frost damage is of greater concern.

About 1½ pounds of 10-10-10 fertilizer per 100 square feet should be worked into the bed prior to planting. After planting, water-soluble fertilizers need to be used since granular fertilizers cannot be applied with the plastic in place. Three ounces of a 20-20-20 water-soluble fertilizer per 100 feet of row should be applied in the spring in each of three applications (9 ounces total) a week apart, starting when the plants make good growth. Dilute the fertilizer according to package directions to avoid burning the plants. Decrease or omit fertilizer applications if growth is overly vigorous.

Plantings can be kept for a second year of harvest. After the fruit production ends for the season, trim off the plants as close to the plastic as possible and allow them to regrow. Keep the plants watered and fertilize them with 9 ounces of 20-20-20 soluble fertilizer in late August, again decreasing amounts if growth is very vigorous.

HARVEST AND POSTHARVEST CARE

Berries are generally ripe 28 to 30 days after full bloom. Pick the berries after the plants have dried in the morning, and keep the picked berries out of direct sunlight. Pick when the berries are fully colored, retaining the caps. Refrigerate the strawberries as soon as possible. Do not wash the berries until just prior to use.

INSECT AND MITE PESTS

Fruit Feeders

Strawberry Bud Weevil or Strawberry Clipper

The strawberry bud weevil, *Anthonomus signatus* (Say), is one of the state's most destructive strawberry pests. This dark reddish-brown weevil is about 1/10 inch long with a head elongated into a slender, curved snout about half as long as the body. Its back has two large black spots. In the eastern United States, this insect is known as the "strawberry clipper" or simply the "clipper" because of its habit of clipping buds.

The beetles leave their winter quarters in fence rows and woodlots in the spring as temperatures approach 60°F, usually around the end of April. They immediately proceed to a number of plants with early fruit bud developments, of which strawberries are phenologically ideal. First, they feed on immature pollen by puncturing the blossom buds with their long snouts. The female deposits a single egg inside the nearly mature bud and then girdles the bud. She then clips the bud so it hangs by a mere thread or falls to the ground. In about one week, the egg hatches into a white, legless grub. The larva develops inside the bud and reaches maturity in 3 or 4 weeks.

Adult weevils emerge from the buds in June. After feeding on the pollen of various flowers for a short time, the new adults seek hibernating sites in midsummer and remain inactive for the rest of the season. Weevils remain in these sites until the next spring. Only one brood appears each year. Injury is most likely to occur when strawberries are grown adjacent to woodlots or other suitable hibernating quarters.

Clipping begins in early May, and growers should check their field carefully at that time for the first signs of damage. To determine if a pesticide treatment is necessary, walk random rows of plants, keeping track of the number of cut buds per linear foot of row. Sample five separate 10-foot sections from throughout the field. Divide the total number of cut buds observed by the total number of linear row feet inspected. If more than one cut bud per linear row foot is found, a pesticide treatment is justified. Pay particular attention to fields near woods and hedgerows. Treatment of field borders only may be sufficient in some instances. (this was meant to imply that you may only need to treat the edge of the field) Apply the first spray in early May when there is one cutback per linear foot of row. Apply a second spray 10 days later.

Mulches and full canopy beds can encourage newly emerged adults to remain in the planting, causing dam-

age to occur in succeeding years. ♦ Cropping fields less than 3 years, plowing under old beds immediately after harvest, and removing the foliage and mulch to reduce the suitability of overwintering sites help lessen the chances of clipper damage.

Tarnished Plant Bug and Other True Bugs

This inconspicuous sucking plant bug is a general feeder attacking a great variety of cultivated and wild plants. The adult tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), is about 1/4 inch long and is brown with yellowish and black dashes and a brassy appearance. The adults overwinter in protected places. They return to the field about the time of bud burst and are found feeding on tender foliage of all sorts. They are very active, taking to flight with the slightest disturbance. Several generations hatch each year; adults and nymphs of all stages can be found from April until heavy frost in the fall.

As a strawberry pest, the tarnished plant bug often causes considerable loss by feeding on the seeds of the young fruits before the receptacle expands. In feeding, it sucks out plant juices. The damaged seeds cause the receptacle to expand unevenly. Thus, berries that are injured remain small, have a woody texture, and fail to mature. Berries become knobbed with seeds grouped apically and are unsalable. This injury is known as “button berry” and is a serious problem in some areas. Later-maturing varieties are more severely affected. Although several plant bugs (*Lygus* spp. and others) may be involved, the tarnished plant bug appears to be the chief culprit.

Small, underdeveloped berries can be caused by other factors, most notably poor pollination; however, fruits that are small due to poor pollination will not have developed seeds, but instead will have small, hollow, hair-like projections where the seeds should be. If the deformed berry has developed seeds, it probably has sustained plant bug injury.

An insecticide application might be necessary if nymphs are present just before bloom. Growers also should sample fruit clusters on a weekly schedule when fruit begins to form. Shaking flower and fruit clusters over a light-colored plate will dislodge bugs and allow them to be seen more easily. When an average of 20 to 25 bugs per 50 flower clusters is found, spraying is advisable.

Strawberry Sap Beetle

The pest status of the strawberry sap beetle, *Stelidota geminata* (Say), has been accelerated along with the change in marketing systems from grower harvesting to

pick-your-own operations. Unskilled pickers leave large numbers of ripe and overripe berries in the field, which attract the beetle.

The strawberry sap beetle is small, oval, and less than 1/8 inch long. It is brown and has a slightly mottled appearance. In extremely overripe berries, another sap beetle, the picnic beetle (*Glischrochilus quadrisignatus* or *G. fasciatus*) also might be found. The picnic beetle is larger and has four orange blotches on its back.

As the berries begin to ripen in May and June, adult sap beetles are attracted to the patch. They attack ripe, nearly ripe, or decaying fruit by boring into the berry and devouring a portion. On sound berries the sap beetles usually gain entrance from under the berry, eating a hole straight into the berry. This occurs more often when the fruit is in contact with the ground or the mulch layer. The hole can be seen if the fruit is picked, but it is not usually conspicuous unless several sap beetles are working together. The adults are seldom seen because they fall to the ground and scurry away when fruit is disturbed.

The primary injuries caused by strawberry sap beetles are the cavities eaten by one or, more commonly, by a group of beetles. The beetles also disseminate organisms that cause rots in the fruits and carry these to other fruits as they move about. Any damage to the berries near harvest, such as other insects' attacking the fruit or mechanical injury, might stimulate an invasion of sap beetles. Larval damage is much less obvious because it occurs in decomposing fruit, but it is the worm-infested fruit that is of concern to the grower and consumer.

Cultural control is useful in the reduction of sap beetle outbreaks. ♦ Removing damaged, diseased, and overripe fruit from the patch at regular intervals is known to assist in reducing populations. Problems with sap beetles often arise with the buildup of overripe berries when rain occurs during harvest. Boxes or flats of harvested berries should be removed from the field immediately or covered to keep beetles out. Provide pickers with special containers for unmarketable berries and bury the boxes as soon as possible. Pesticides can be used, but they are not as effective as the cultural control practices.

Slugs

Although slugs are not insects, they can cause considerable damage that is not unlike insect damage. Slugs, which are mollusks, and snails look alike in the early stages, but slugs do not form a shell in their older stages. Slugs are 1/4 inch to 8 inches long, depending on the species. They vary in color from cream to grayish black,

and some species are spotted. As slugs move about they leave a trail of slime.

Slugs are favored by mulch in the field and are able to overwinter in protected places beneath the mulch. They lay eggs in groups in cracks and holes in the soil. Thus, their entire life cycle can be completed in the strawberry field. Slugs require 3 to 7 months to attain adulthood. Most injury from slugs is encountered during damp, rainy spring months.

Slugs of all sizes make small, moderately deep holes in ripening berries. Most of the feeding takes place at night or on dark, overcast days; however, the Arion slug is very aggressive and has been seen feeding on bright sunny days. Holes made by the slugs can be almost anywhere on the fruit; however, feeding usually takes place under the cap. It is fairly easy to identify slug injury by the telltale slimy trail left on the surface of the fruit.

Slug control begins with the removal of nesting and breeding places such as boards, stones, trash piles, and compost piles. ♦ Traps made of wet boards or burlap bags can be set in the evening. Remove and destroy the trapped slugs in the morning. If slug damage is severe, a pesticide application might be necessary. Bait formulations usually provide control where slugs are a problem. Diatomaceous earth, a desiccant, also can be applied if a nontoxic material is desired.

Spider Mites

The spider mites, *Tetranychus* spp., especially the two-spotted spider mite, frequently attack strawberry plants. They are distributed widely and can be found in almost every field. They attack a wide variety of plants, including truck crops, shade and fruit trees, and ornamental plants.

The eight-legged adult is about 1/50 inch in length. It varies in color from pale greenish-yellow to green and usually is marked with two dark spots. Feeding and egg deposition occur on the underside of the leaves, and a tangle of fine, silken webs occurs there during heavy infestations.

The length of the life cycle varies with seasonal and weather conditions but may be completed in about 2 weeks. Early in the spring, the feeding begins on the undersides of newly produced leaves in small colonies. Reproduction may be continuous from early spring until late fall. The female lays two to six eggs per day, up to about 70 eggs per mite; the eggs hatch in about 4 days. Ten to fifteen generations may hatch each year. The species overwinters as mature, fertile females in protected places in the field. Hot, dry weather favors rapid population increases. Spider mites' small size and habit of

feeding on the underside of leaves means that they might be overlooked until the population is so large that serious damage has occurred. Because these mites can be borne by the wind in their silken webbing, newly planted fields can become infested quickly.

Heavily infested fields lose their healthy green color, and the undersides of the leaves become brown until the entire leaf looks bronzed. This may be caused by as few as 20 mites per leaf. The mites suck sap from the leaves and can interfere with normal physiological processes such as the production of sugars. Plants might become stunted, and yield can be reduced greatly.

Spider mites have many natural enemies, including insects and other mites, which often keep them in check. Insecticide treatments often cause spider mite outbreaks by destroying these natural enemies. Examine the undersides of leaves weekly during the dormant and spring periods for mites or webbing. Beginning early in the season, examine the undersides of leaves of 50 randomly selected plants for mites or webbing. A hand lens might be necessary because these mites are barely visible to the unaided eye. Plants can tolerate low populations of this pest, but if a sharp population increase is noted from one week to the next, or if plant symptoms begin to appear, a miticide should be used. It is important to catch population increases early because control of large, established populations is difficult and expensive. In certain fields or certain areas within fields, "hot spots" of mite activity can develop. Keeping an eye on these known hot spots will help warn of an impending outbreak. Thorough coverage is essential when applying miticides, so use plenty of water.

Stem and Crown Feeders

Meadow Spittlebug

Nymphs of the meadow spittlebug, *Philaenus spumarius* (L.), are small, orange to green insects enclosed in white, frothy, irregular masses 1/2 inch or more in diameter. These sometimes appear on the stems and leaves of strawberries at about the time of bloom. The insects are known as spittlebugs because of the peculiar, spittle-like substance with which they cover themselves. They often are seen in meadows and on plants in uncultivated fields.

Spittlebugs have sharp beaks with which they pierce the stems of plants and suck the plant juices. The insects first feed at the base of the plants but later move up to the more tender foliage. The nymph or young stage produces the frothy material and remains in this protective substance until developing into the adult stage.

The insect overwinters as an egg. Nymphs appear in May or June and complete their development in 5 to 8

weeks. Egg laying occurs primarily during September and October. Eggs are inserted into the lower parts of the strawberry plant. Only one generation appears each year.

Feeding activities of large numbers of these insects cause plants to become stunted, and berries do not attain full size; however, the greatest impact of this insect is the spittle masses on the plants, which are very annoying to strawberry pickers. Weedy fields are more heavily attacked.

Control might be indicated if nymphs (without frothy masses) are present when the first blossom clusters separate. Spittlebug populations infrequently need pesticide treatment and should be treated only when there are more than a few per square feet.

White Grubs

White grubs do severe damage when strawberries follow sod that has been infested with grubs. White grubs are the immature forms, or larvae, of May beetles or “June bugs.” The grubs are large, thick bodied, and dirty white. When fully grown, they range from about 1 to 1½ inches in length. White grubs feed on the roots of a variety of plants and often completely cut off strawberry plants just below the crown. When dug from the ground, the larvae always lie in a curved position, forming the letter “C.”

May beetles are dark brown and vary in length from ½ to ¾ inch. They often are attracted to lights and sometimes can be seen in considerable numbers around street lights during May.

The beetles remain concealed near the soil during the day, but at dusk they emerge and fly to ornamental and forest trees to feed. Sometimes they congregate in such numbers that they completely defoliate isolated trees. They return to the soil just before dawn.

Eggs are deposited in the soil at a depth of 1 to several inches. They apparently are deposited most abundantly in sod that has not been disturbed for years, although they occur in almost any type of soil porous enough to permit the female beetles to crawl into it.

Eggs hatch in 3 or 4 weeks. Tiny larvae feed largely on vegetable matter in the soil during the remainder of the first season. When cold weather appears, most species of white grubs burrow down below the frost line and remain there until the following spring.

Grubs spend all of the next summer feeding on the roots of plants. During the second winter, they continue as larvae below the frost line in the soil. In the third year, they return to the plant roots and feed until late June or July, when they change to pupae in small earthen cells. The adults emerge from the pupal cases a few weeks later but remain in the soil until spring. Thus, eggs are laid

every third year, and the severe damage caused by their offspring usually occurs only every third year.

Two species complete development and change to the adult stage in one year. One of these is the well-known Japanese beetle, *Popillia japonica* (Newman); the other is the northern masked chafer, *Cyclocephala borealis* (Arrow). These species attack roots of certain grasses and may become abundant enough to cause severe damage.

The most severe damage usually occurs between the time of planting and runner development. Damage is most likely to occur when strawberries are planted on newly plowed sod. The grubs feed on the roots of strawberry plants and either kill or severely weaken them.

Avoid planting strawberries on newly plowed grassland. The danger of insect damage can be reduced by rotating crops and cleanly cultivating the crop that precedes strawberries.

DISEASE DESCRIPTIONS AND MANAGEMENT

When planting strawberry varieties, plant disease-resistant varieties when possible. ♦ For strawberry variety descriptions, see Table 8.1. Basic cultural guidelines for the control of plant diseases are discussed under “Pest Management” on page 24 in Chapter 2. Table 2.4 lists pesticides available on various fruit crops for the control of diseases. Pictures of fruit diseases can be found in the Fruit Pathology Fact Sheets at <http://fpath.cas.psu.edu/factsite.html>.

Anthracnose

Anthracnose is caused by several different species in the genus *Colletotrichum*. These fungi cause a fruit rot, crown rot, and/or leaf spots, as well as lesions on petioles and runner stolons. The plants normally don't show symptoms until after being transplanted to the production field. The fungus overwinters as inoculum mainly in infected plants and in plant debris. This inoculum is primarily disseminated by splashing water. To survive, the fungus needs plant tissue, so the inoculum does not remain in the soil for long periods of time as with many other rots.

Symptoms and Disease Cycle

Anthracnose is a problem mainly in rainy, warm harvest seasons. Symptoms of anthracnose fruit rot are light-brown spots on fruit that typically turn dark brown or black and then enlarge. Flowers and flower buds can also become infected and can appear to dry out. Symp-

toms of anthracnose crown rot are rarely noticed until the plants collapse or die, usually in the fall or spring following transplanting during warm weather. When the crown is cut through lengthwise, a brownish horizontal V shape can be found, originating near the base of a petiole. Leaf spots either resemble ink spots or appear as irregular lesions at the tips or margins of leaves, depending on the species causing the infection. On the runners and petioles, lesions begin as small, red streaks and then turn dark, sunken, and elongated.

Disease Management

Control practices include mulching with straw. When watering strawberries use drip irrigation or carefully hand water. Wet fruit and foliage increases the spread of the disease. The use of raised beds or plastic mulch seems to also increase disease, possibly because of the higher microenvironment temperatures or because water drops bounce and splash off the plastic. Immediately plow down infected areas of a bed, especially if disease occurs in certain areas. This practice may keep infection from spreading.

Black Root Rot

Black root rot is known as a “disease complex,” meaning that it can be caused by several factors. This complex is associated with a number of pathogenic soil fungi (most commonly *Rhizoctonia* and *Pythium* species) and root-infecting nematodes; environmental conditions that can include drought, winter injury to the root system, and the freezing or waterlogging of the soil; nutrient deficiencies; fertilizer burn; pesticide injury; or a combination of all these factors. Most older plantings or replanted fields are affected.

Symptoms and Disease Cycle

Symptoms include an uneven “patchy” appearance in the strawberry bed. The first evidence of infection is the appearance of brown areas on the normally white or tan roots. Eventually, death of the feeder rootlets will result and the structural roots of the mother plant will blacken and deteriorate. As the disease progresses, the entire root will break off when bent, leaving a short stub at the crown. Affected plants become stunted and produce few berries and runners. Older infected roots are called “rattails.”

Disease Management

The disease generally is associated with soil types of high clay content. Planting in well-drained, well-aerated soils such as those with a high organic matter content

(greater than 6 percent) is strongly recommended. ♦ Soil compaction and excessive irrigation should be avoided. Mulching to decrease winter injury, purchasing disease-free plants, and rotating crops for 3 to 5 years also are methods of controlling black root rot. There are no fungicides for control.

Gray Mold

Gray mold, or botrytis blight, is a common disease of a number of nonwoody plants worldwide and causes a greater loss of strawberry flowers and fruit than any other disease. It is found on green as well as ripening and harvested fruit.

Symptoms

Botrytis blight usually starts as a blossom blight, which eventually invades the developing fruits, causing them to rot. This rot can destroy the berry within 48 hours and may appear first at the base of the fruit or when the berry is in contact with the soil, other damp surfaces, or other rotten fruit. As ripening increases and humidity remains high, a characteristic gray, fuzzy coating or web, produced by the fruiting of the fungus, covers the strawberry fruit. As the disease progresses, spores are produced and are easily blown or splashed onto healthy foliage. Once the fungus becomes established, it can produce spores continuously throughout the growing season.

Disease Cycle

The causal organism, *Botrytis cinerea*, can live as a parasite as well as a saprophyte on decaying plant debris. Under favorable conditions, the fungus produces spores that are spread by air currents and rain. The flower parts become infected first, and the disease spreads to developing fruit. Gray mold is favored by cold temperatures and high humidity.

Disease Management

Moisture is necessary for the spores to germinate and infect plants; therefore, the disease is favored by high humidity and relatively cool conditions. Practices that help reduce humidity and increase air movement, such as opening up plants by cultivation, controlling weeds, spacing rows and plants farther apart help control gray mold. The fungus thrives on debris, and sanitation is essential for control. Dead plants and fallen leaves should be removed and burned or buried. Some strawberry varieties are less susceptible to gray mold than others. ♦

Leaf Spots

A wide array of leaf spots infect cultivated and wild strawberry species, including birds-eye leaf spot, black leaf spot, septoria leaf spot, cercospora leaf spot, alternaria leaf spot, red spot, and angular leaf spot. These leaf pathogens are caused by several fungi and can occur with other foliar diseases. Disease development is usually favored by rain and warm, humid weather.

Symptoms and Disease Cycle

The fungi overwinter on infected plants, plant debris, and weed hosts. In the spring, spores are produced and are discharged by splashing rain into air currents. They then land on and infect new leaves. Lesions or “spots” are more numerous on upper leaf surfaces and appear circular to irregular in shape. These lesions often have definite reddish-purple to rusty-brown borders that surround a necrotic area. Lesion size and appearance often are influenced by the host variety and the ambient temperature. The leaf spots sometimes cause severe problems, often depending on the variety planted. Susceptible varieties can be defoliated partly or completely by late summer. In years that are particularly favorable for disease development, they can be severely weakened.

Disease Management

Sanitation and the use of resistant varieties are advised, as well as adequate plant and row spacing and keeping plants out of the shade. ♦ The application of protective fungicides at blossom time and before fruiting will give adequate leaf spot control.

Angular Leaf Spot

Angular leaf spot is caused by the bacterium *Xanthomonas fragariae*, which causes a water-soaked lesion on the lower leaf surface. Under moist conditions, the bacterium produces an exudate that appears as a whitish, scaly film when dry. The pathogen not only infects the foliage but also can invade the vascular system of the plant, causing decline. Important commercial varieties have not been found to exhibit resistance to angular leaf spot. Antibiotics are applied for the control of this disease. The bacterium that causes angular leaf spot is systemic, which means it exists throughout the plant. This bacterium overwinters in infected plants and dead leaves. Exudate from infected leaves can be splashed to uninfected plants by water. Young tissue is most easily infected. Temperatures just above freezing and moist conditions favor disease development.

Disease Management

Varieties vary in susceptibility, but none are resistant. Because this disease is caused by a bacterium rather than a fungus, fungicides have no effect. Since the bacterium prefers cool temperatures and wet conditions, any practice that minimizes the amount of frost protection needed (site and variety selection) is recommended, as are practices that maximize drying of the foliage.

Leather Rot

Leather or crown rot occurs in most temperate regions of the world on a wide variety of plants. Infection is favored by warm, wet weather and poorly drained soil. The fungus attacks berries in the field at all stages of growth. Fruit rot occurs when the berries come in contact with the soil. The pathogen may also cause a serious crown rot, which can develop along with the fruit rot.

Symptoms and Disease Cycle

Crown rot is caused by the soil-inhabiting fungus *Phytophthora cactorum*. The pathogen infects the roots of the strawberry through wounds in the root tissue. Symptoms are different depending on the fruit stage. On immature, green fruit, the infected areas appear dark brown or normal green with a brown edge. On ripe, mature fruit, they can appear either without color change or bleached and ranging in color from light lilac to purple. Fruit rot occurs when berries come in contact with the soil. A serious crown rot can develop along with the fruit rot. Infected fruits are characteristically tough and leathery, having a bitter taste. When weather conditions are warm and rainfall is abundant, the pathogen releases its spores into the soil. These infested soil particles are dispersed onto the fruits by splashing rain or wind.

Disease Management

Practices, such as mulching, that keep the fruit off the ground and aid in minimizing rain splash will help control leather rot. ♦ Growers also should plant resistant varieties, provide good soil drainage, and avoid planting in low spots.

Powdery Mildew

Powdery mildew occurs on a wide range of hosts and almost everywhere the strawberry is grown. It is observed mostly as a foliage disease, but it occasionally causes a serious fruit rot. Severe foliar infection can damage leaves and reduce photosynthesis.

Symptoms and Disease Cycle

The disease is caused by the fungus *Sphaerotheca macularis* and is an “obligate parasite.” This type of pathogen needs to reside in a living host for its survival and can be found overwintering in old, but living leaves. The pathogen can affect the flowers and fruit in all stages of development. Flowers are deformed and killed, immature fruit becomes hard and does not ripen normally, and mature, ripe fruit is soft, pulpy, and may fail to color. In the spring, the fungus sporulates on the leaves, causing the leaflets to curl upwards along the edges. The lower leaf surface may turn reddish, and a powdery, “frosty” growth of the fungus is often seen. Disease development is influenced primarily by rainfall and temperature, with dry weather and cool temperatures being more favorable.

Disease Management

The use of resistant varieties and adequate plant and row spacing aid in the control of this disease. The removal of overwintering leaves may be of some benefit. ♦

Red Stele

Red stele, or red core, is the most serious disease of strawberry in areas with cool, moist soil conditions. This disease develops primarily in soils that are heavy in clay content and saturated with water during cool weather.

Symptoms and Disease Cycle

The disease is caused by the soil-inhabiting fungus *Phytophthora fragariae*. Healthy roots are infected by spores produced from other infected plants. These spores can move through the soil and penetrate the tips of roots, growing within the root system. A few days after infection, the roots begin to rot. The fungus produces spores within this rotted tissue; eventually, the spores and the rotted roots become incorporated into the soil.

Frequently, the diseased area in the bed follows a definite pattern. Plants showing aboveground symptoms occur in patches where the soil is wettest. Symptoms depend on the severity of the root rotting. Severely diseased plants are stunted, with the younger leaves turning a blue green and the older ones, red, yellow, or orange. Plants will eventually wilt and die. As the number of diseased roots increases, plant size, yield, and berry size decrease. When a young, infected root is cut open lengthwise, the stele or core above the rot is red. This diagnostic symptom occurs when the soil is cool. As the disease progresses, the lateral roots die, giving the main roots a “rattail” appearance.

Disease Management

Because the spores of this pathogen can travel long distances in surface water, maintaining good drainage in strawberry beds is important. This also minimizes runoff and avoids soil compaction. Plant resistant varieties and purchase stock that has been inspected and tested for *P. fragariae*. Also remember that there are several different strains of red stele fungi and not all varieties of strawberries marketed as “red stele resistant” are equally resistant to all strains of the pathogen. ♦

Verticillium Wilt

Verticillium wilt of strawberry, caused by the soilborne fungus *Verticillium albo-atrum*, occurs throughout the temperate zones of the world, infecting more than 300 kinds of cultivated plants. Its hosts are annual and perennial crops as well as weed species.

Symptoms and Disease Cycle

Strawberry plants are most susceptible in their first year of growth. Initial symptoms appear rapidly in late spring, especially in periods of environmental stress. The outer and older strawberry leaves wilt and dry, turning a reddish yellow to dark brown at the margins and between the veins. The inner leaves remain green and turgid until the plant dies. This symptom helps distinguish verticillium wilt from the root and crown diseases caused by *Phytophthora* species, in which both the young and mature leaves wilt. The disease intensity may depend on fertilization practices and the amounts of “residual” field inoculum left from previous crops. Plants with lush growth due to high nitrogen applications are more severely affected than plants receiving moderate amounts of nitrogen. Previous crops of Solanaceous plants (e.g., tomatoes, potatoes, eggplant) might have harbored the pathogen and caused a buildup of soil inoculum. It is advisable not to plant a new strawberry bed following crops of this family.

Disease Management

Planting resistant varieties and disease-free plants will help control verticillium wilt. A rotation schedule of 3 to 5 years also is recommended. ♦

Pest Management

Fruit growers can use many methods to control strawberry diseases, all of which are important to successful disease control. Fungicides are only one of the control options and are not always successful. Table 8.2 summarizes the control options and their effectiveness for each of the strawberry diseases. Table 8.3 describes

the effectiveness of fungicides on strawberries. Table 8.4 describes the occurrence of insects and mites on strawberries, and Tables 8.5 and 8.6 provide information about pesticide use. A general discussion of insect management appears in Chapter 2.

The following practices will help in both insect and disease control.

Good Air/Water Drainage ◆

Good air drainage and circulation within the strawberry planting speeds the drying off of plants and reduces the potential for infection. Botrytis (gray mold) requires wet foliage or fruit for infection to take place. Similarly, it is important that the soil dries out quickly after rain. Waterlogged soil increases the likelihood of disease infection in the root system. Red stele and verticillium are two soil fungi that can infect strawberry root systems more easily in wet soil.

No Shade ◆

Plants need full sunlight to grow and produce fruit, but sunlight also helps the foliage and fruit to dry off quickly after a rain or heavy dew. Rapid drying will reduce fruit and leaf diseases.

No Infested Runoff

Disease organisms (e.g., red stele, verticillium, black root rot) can be carried in runoff water from a diseased planting to a healthy planting. Do not plant new fruit plantings below older, diseased plantings.

Rotation

Some crops can build disease organisms in the soil, which can devastate the next crop if it is susceptible to the disease. Strawberries should not follow tomatoes, potatoes, eggplant, peppers, strawberries, raspberries or stone fruits for 5 years since these crops might harbor the *Verticillium* fungus. Avoid an area with a history of verticillium or red stele problems.

Resistant Varieties ◆

Some plants are not susceptible to certain diseases or are less susceptible than other varieties. Resistance or tolerance to diseases will eliminate or greatly reduce the need for disease control. Refer to Table 8.1 for specific examples.

Disease-Free Planting Stock

Plant only disease-free planting material. Since viruses cannot be seen at the time of planting, the grower must rely on good propagation and cultural practice methods used by the nursery in producing the plants. Virus-

infected plants are infected for life, and plants infected with soil-inhabiting fungi can contaminate the site for many years. Buy only healthy plants from reputable nurseries.

Adequate Plant and Row Spacing ◆

Most disease organisms that cause foliage or fruit diseases require wet surface areas for infection to take place. By speeding the drying time after rain or heavy dew, the grower can greatly reduce the potential for disease development. Two important methods for accomplishing this in a strawberry planting are to maintain narrow rows and a low plant density within each row.

No Cultivation from Infested Soil

Cultivating in a diseased planting and then moving that equipment to a healthy planting without washing the soil from the equipment can transport disease organisms between plantings.

Mulch to Prevent Winter Injury ◆

Mulch will protect a strawberry plant from winter injury. In some cases, strawberry plants may be injured but not killed by cold temperatures. Those plants are often susceptible to black root rot.

Avoid Frosted Blossoms

Strawberry flowers that have been injured by frost are more susceptible to botrytis (gray mold). Avoid frost injury to blossoms to reduce gray mold incidence in a planting.

Fungicide Sprays

Fungicide applications should be used only if other control strategies are not adequate to control the disease. Fungicide sprays will help in the control of powdery mildew and fruit rots.

Harvest before Overripe ◆

The fruit rots will spread more quickly on overripe fruit. Overripe fruit also will allow a disease to build up in the planting, therefore making control more difficult.

Fruit Storage Conditions ◆

Fruit rots will develop more slowly or not at all if the fruit is cooled rapidly (to 40°F) after picking.

Weed Control

Weeds can be a big problem in strawberry beds. Hand weeding and using a generous layer of straw mulch are the best options for control.

Table 8.2. Summary of strawberry disease control strategies.

All possible control strategies must be employed if strawberry diseases are to be controlled.

Diseases

VW = verticillium wilt
 RS = red stele
 BRR = black root rot
 N = nematodes

V = viruses
 FR = fruit rot
 LS = leaf spots
 PM = powdery mildew

Disease Control Considerations	VW	RS	BRR	N	V	FR	LS	PM
1. Good drainage	-	++	++	-	-	+	+	-
2. No shade	-	+	-	-	-	++	++	-
3. No infested runoff	+	++	+	+	-	-	-	-
4. Rotation	++	++	++	++	-	-	+	-
5. Resistant varieties	++	++	-	-	-	+	++	++
6. Disease-free plants	++	++	++	+	++	-	+	+
7. Adequate plant and row spacing	-	-	-	-	-	++	++	+
8. No cultivation from infested soil	+	++	+	+	-	-	-	-
9. Mulch against winter injury	-	-	++	-	-	-	-	-
10. Avoid frosted blossoms	-	-	-	-	-	+	-	-
11. Fungicide sprays	-	-	-	-	-	++	++	++
12. Overripe fruit	-	-	-	-	-	++	-	-
13. Fruit storage conditions	-	-	-	-	-	++	-	-
14. Renovation	-	-	++	-	-	-	+	+

++ = most important controls; + = helpful controls; - = no effect

Table 8.3. Efficacy of fungicides on strawberries.

Always consult the label before making pesticide applications. Labels vary greatly among commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides.

Diseases

GM = gray mold LS = leaf spot
 LR = leather rot PM = powdery mildew

Pesticide	GM	LR	LS	PM
Captan	2	4	1	4
Copper	4	2	3	1
Sulfur	3	4	3	1
Neem Oil	4	4	4	4

Efficacy rating system: 1 = highly effective; 2 = moderately effective; 3 = slightly effective; 4 = not effective

Table 8.4. Occurrence of insect and mite pests during the strawberry growing season.

Diseases

SBW = strawberry bud weevils SB = sap beetles
 PB = plant bugs S = slugs
 M = mites SPB = spittle bugs

Timing	SBW	PB	SB	S	M	SPB
Dormant	-	-	-	-	-	-
Flower Buds	-	+	-	-	+	-
Prebloom	-	+	-	-	++	-
10% Bloom	+	+	-	+	++	-
>10 days after						
10% bloom	+	++	+	+	++	++
Petal Fall	+	++	++	++	+	-
Harvest	++	++	++	++	+	-
Renovation	-	-	-	-	+	-
Summer	-	-	-	-	++	-

+ = pest present, possible control; ++ = proper timing of control; - = control generally is not needed at this time

Table 8.5. Efficacy of insecticides and miticides on strawberries.**Insects and Mites**

SC	= strawberry clipper	S	= slug
TPB	= tarnished plant bug	M	= mite
SB	= sap beetle	SPB	= spittle bug

Insecticides and

Miticides	SC	TPB	SB	S	M	SPB
Carbaryl	3	2	3	—	—	3
Malathion	2	2	2	—	3	2
Sevin bait or Methaldehyde bait	—	—	—	2	—	—
Pyrethrum	—	3	4	—	—	3
Rotenone	—	3	—	—	—	3

Degree of control: 1 = best, 2 = good, 3 = fair, 4 = slight, — = no rating available

Table 8.6. Pesticide recommendations for strawberries.

The important insects and diseases to be controlled, except for viruses, root rot, verticillium wilt, and nematodes, are listed in the right-hand column in the spray schedule. Always consult the label before making pesticide applications. Labels vary greatly among commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides. Due to a wide array of various products containing the same active ingredient, for insecticide recommendations, when appropriate, the active ingredient is listed instead of the name of formulated product.

Follow all instructions and application rates listed on pesticide labels.

Time to Spray	Suggested Materials	Pests to Be Controlled
Before flowers open	Malathion or Pyrethrum	
Bloom	Captan	Fruit rot, leaf spot
Fruit coloring through harvest	Captan	Fruit rot, leaf spot
Postharvest	Captan + Sulfur; Malathion <i>or</i> Pyrethrum <i>or</i> Carbaryl, Safer Soap, summer oils	Leaf spot; powdery mildew; mites, if present

Blueberries

Several blueberry species are indigenous to the United States. These include the lowbush blueberry (*Vaccinium angustifolium*), which is of commercial importance in Maine and Canada; the rabbiteye blueberry (*V. ashei*), which is grown commercially in the southern United States; and the highbush blueberry (*V. corymbosum*), which is the commercial blueberry of importance in Pennsylvania and in the Mid-Atlantic and Midwestern regions of the United States. The information that follows pertains solely to highbush blueberry production since this type of blueberry is of primary interest. Managing lowbush types in a home garden tends to be a challenge because the plants spread and form a dense mat. Rabbiteye blueberries can be grown in the extreme southeastern part of the state; their culture is similar to that described below for highbush production. Little information is available on performance of various rabbiteye varieties, however. Production of rabbiteye plants in cooler areas of the state has been very variable.

THE BLUEBERRY PLANT

Although the highbush blueberry plant is indigenous to North America, its value as a commercial fruit crop has been exploited only in the past 60 years or so. Original breeding work and research was conducted by Mrs. Elizabeth White and Dr. Frederick Coville, beginning shortly after the turn of the century.

The blueberry plant is a perennial, consisting of a shallow root system and woody canes that originate from the crown of the plant. The root system is very fibrous but devoid of root hairs. (Root hairs in most plants function by increasing the surface area of the root for water and nutrient uptake.) This characteristic makes the blueberry plant very sensitive to changing soil water conditions.

A mature cultivated blueberry usually has 15 to 18 canes. Its growth habit varies among varieties, with some bushes growing very upright and others having a more spreading growth habit. The fruit is borne on buds that are formed the previous growing season.

SITE SELECTION AND PREPARATION

Cold Hardiness

Blueberries generally will tolerate temperatures to -20°F, although varieties vary somewhat. Most require 750 hours of chilling below 45°F. In Pennsylvania, this requirement is met usually by no later than early February. After the chilling requirement is met, the plant loses its dormancy and thus its cold hardiness with each warm period, making it increasingly susceptible to cold injury as the season progresses.

Soils

The best soils for blueberries are moist, porous, and acid. The soil pH should be between 4.5 and 5.0. A lower pH can result in manganese or aluminum toxicity, while a higher pH results in the unavailability of certain nutrients, most notably iron. In southern New Jersey and Michigan, where much commercial blueberry production is located, blueberries are grown on very sandy soils in areas where the water table is very shallow. Many parts of Pennsylvania do not have these very light soils, so soils usually need to be amended.

Preparation

In the year before planting, eliminate all noxious weeds, increase soil organic matter by compost application and/or cover crops, and test the soil. Soil test kits are available from county extension offices. Amend the soil according to test recommendations. The effects of sulfur (to lower the soil pH) and phosphorus (if needed) require time, so these materials should be added in the fall before planting. Potassium can be added either in the fall or when nitrogen is applied in the spring. *Do not* plant blueberry plants in high-pH soils without amending them first! Because sulfur does not move readily through the soil, surface sulfur applications after the plants are in place are ineffective in lowering the pH, and the plants will not thrive.

Irrigation and Mulch

Because the blueberry plant is very sensitive to fluctuating soil moisture, mulch and irrigation are essential for a healthy planting and consistent yields. Plants should be kept well watered, especially during hot spells in the summer. Hardwood bark mulch (such as that used for landscaping) and rotted sawdust are good mulches. Mulch should be applied to a depth of 4 inches and replenished whenever necessary. Avoid mulches with a high pH such as mushroom compost or noncomposted leaves, which may be high in natural toxins.

VARIETY SELECTION

Appropriate variety selection is crucial for any perennial crop. Blueberry varieties can be selected so they can be harvested from July through mid-September, if desired. A description of many available varieties follows. These are grouped according to production season. Varieties are divided into “standard” varieties, with which there is considerable experience in the region, and “recent releases,” on which there is little information so far on performance in Pennsylvania.

Early Season

Standard Varieties

BLUETTA: Bush is short, compact, low growing, spreading, and of medium vigor. Fruit is medium sized, soft, and blue-black with fair flavor. Fruit can hang on the plant for a long time. Consistent production may be a problem. Winters well and does not break dormancy too early. Moderately resistant to mummy berry disease; highly susceptible to anthracnose and red ringspot virus.

EARLIBLUE: Bush is vigorous and upright spreading. Fruit is large, firm, and light blue with fair flavor. Not recommended commercially in many areas because of erratic fruit set. Fruit does not drop easily when ripe. Plants have some resistance to powdery mildew.

WEYMOUTH: Old variety (from 1936) that has been widely grown. Fruit is a bit soft, of average size, and has a mild flavor. Resistant to many diseases.

Recent Releases

CHANTICLEER: Very early, but the early bloom time can cause this variety to be very susceptible to spring frosts. Yields tend to be biennial. Early plantings not deemed successful by commercial growers. Needs a well-drained soil. Highly susceptible to anthracnose.

POLARIS: A cold-hardy release from Minnesota (half-high). Moderate productivity and average berry size, but has very good flavor and aroma. Not self-pollinating.

SUNRISE: Moderately vigorous bush, tall, and relatively upright. Fruit is similar to that of Bluetta in size and color, but firmness and flavor are superior. Resistant to red ringspot virus.

Early Mid-Season

Standard Varieties

BLUEHAVEN: Bush is upright and productive but not sufficiently hardy for northern areas of the state. Berry is large, light blue, and exceptionally flavorful.

BLUEJAY: Bush is vigorous, upright, and open. Berries are long stemmed and hang in loose clusters; they hold on the bush without losing their quality until most are ripe. Fruit is of medium size. Berries are firm and light blue. Wood and buds are resistant to low winter temperatures. Flowers are less resistant to frost than Bluecrop. Production is sometimes erratic. Moderately resistant to mummy berry and resistant to shoestring virus.

BLUERAY: Plant is vigorous and propagates easily. Fruit is borne on small, tight clusters and canes tend to bend over. Tight clusters can cause berries to drop, especially in hot weather. Berries are large, dark blue, and firm, with good flavor. Consistently productive, but may overproduce if not pruned properly. Upright spreading habit; very hardy. Highly susceptible to mummy berry disease and anthracnose; also susceptible to red ringspot virus.

COLLINS: Ripens about 5 to 7 days after Earliblue; susceptible to winter injury. Bush is vigorous and upright with some spreading canes. May not sucker freely. Fruit is large, firm, light blue, and has very good flavor. Has narrow soil adaptation and produces only moderately.

DUKE: A vigorous, upright bush bearing medium-sized, light-blue, firm fruit with a small dry scar. Blooms late, avoiding early frosts, but ripens relatively early. Plant has numerous canes that are stocky and moderately branched. Buds and wood tolerate fluctuating winter temperatures well. Harvest can be completed in two or three pickings. Flavor is mild and sweet. This variety is performing well in a number of locations. Moderately susceptible to mummy berry and anthracnose. Stem blight problems have been noticed.

PATRIOT: Plant is upright and vigorous, though only small to medium in height. Fruit is large and firm and has excellent flavor. Fruit must be completely ripe to have good flavor. Though hardy during the winter, this variety blooms early and is subject to frost. Developed in Maine and has excellent cold hardiness. Plants resistant to root rot.

SPARTAN: Plants are vigorous, upright, and open. Fruits are large, firm, light blue, and highly flavored, but plant performs poorly on amended “upland” soils. Blooms late, but harvests relatively early. Late bloom date helps prevent frost injury. Highly susceptible to anthracnose; partially resistant to mummy berry.

Recent Releases

DRAPER: A new release from the breeding program at Michigan State. Ripens with Duke, but with better flavor.

NUI: Produces a very high-quality, large berry. However, winter hardiness is questionable and growth is slow.

REKA: An introduction from New Zealand. Untested in the northeastern United States. Upright, vigorous habit that has been very productive where grown. This variety’s outstanding characteristic is that it appears to be very adaptable to a wide range of soil types. Moderately susceptible to anthracnose.

Mid-Season

Standard Varieties

BLUECROP: Best mid-season variety presently available; bush is vigorous and upright, but canes tend to be slender and whippy. Fruit is medium in size and numerous with, good flavor. Variety has shown consistently high production and good winter hardiness; season tends to be prolonged. Berries appear to be ripe (completely blue) well before full sweetness is achieved, so they need to be picked 5 to 7 days after the full blue color is present. Resistant to shoestring virus and red ringspot virus, moderately resistant to mummy berry and powdery mildew. Very susceptible to anthracnose.

ELIZABETH: Extremely flavorful, with very large berries. No longer commercially important because of inconsistent productivity, but of interest to home gardeners because of its excellent flavor.

NORTHLAND: Fruit is soft and of average quality, so it tends not to store well. Plants are bushy. Consistently productive. Resistant to mummy berry.

Recent Releases

BLUEGOLD: Very productive and cold hardy. Has a very bushy growth habit, however. Ripening is concentrated. Primary downside to variety is that the stem tends to remain on the fruit, or when removed, the skin tears.

CHIPPEWA: A cold-hardy release from Minnesota (half-high). Compact bushes with medium to large, light-blue, firm, sweet fruit. For trial in areas where cold tolerance is needed.

LEGACY: Legacy has some *V. darrowi* (an evergreen blueberry native to Florida) in its background and holds its leaves through the winter, so its winter hardiness is suspect. However, its outstanding characteristic is extremely high yields due to a long harvest season while still having good flavor and quality. For trial only in mild or protected locations, or provide winter protection such as burlap. Resistant to anthracnose.

PURU: Purported to have excellent flavor and fruit quality. Upright, moderately vigorous bushes with light-blue, medium to large fruit. Winter hardiness is uncertain.

TORO: A vigorous, upright bush that is consistently highly productive. Fruit is large with good color and flavor. Begins ripening with Bluecrop but has a concentrated ripening, and harvest can be completed in two pickings. Tolerates fluctuating winter temperatures well. Not very self-fertile, so it should be planted with another variety.

Mid-Late Season

Standard Varieties

BERKELEY: Late mid-season. Bush is tall, open, and spreading but tends to drop fruit. Flavor is only fair. Winter hardiness is limited. Production can be inconsistent. Tends to be susceptible to fungus diseases during wet seasons; also especially susceptible to some viral diseases.

DARROW: Very large fruit on vigorous, upright plants. Fruit is firm with excellent flavor, but can be slightly acidic.

HERBERT: An older variety that is a favorite among home gardeners. Fruit is sweet and huge. Skin of the berry tends to tear when picked, however, which increases its susceptibility to fruit rots if not used quickly.

RUBEL: A wild selection with small, firm fruit. Bush is erect and very productive. Flavor is fair. Plants are very stemmy during drought or if harvest is delayed. Has higher concentrations of antioxidants than larger-fruited varieties, so it is of even more interest for its health benefits than other blueberry varieties. Susceptible to stunt and resistant to red ringspot virus.

Recent Releases

BONUS: Large fruited. Not really a recent release, but very little testing has been done on this variety.

BRIGITTA: Upright, vigorous, cold-hardy bush with moderate productivity. Fruit is large, firm, and very light blue. Plant with other varieties to ensure good pollination. Clusters are loose and ripening concentrated. Excellent fruit quality and shelf life. Slow to “shut

down” in the fall, increasing its susceptibility to winter injury, so don’t fertilize after the early season. Resistant to anthracnose and mummy berry.

CHANDLER: Extremely large fruit ripens over a long harvest season, so this variety has good potential, especially for pick-your-own operations. Winter hardiness is questionable.

NELSON: A vigorous, upright bush. Fruit is large, of size similar to that of Spartan, firm, and light blue with very good flavor. Initial tests show it to tolerate cold temperatures well. Test plot yields in New Jersey and Michigan have been high.

OZARKBLUE: Very late flowering. Slow to produce new canes. Quality is similar to that of Bluecrop.

SIERRA: A vigorous, upright, productive bush. Fruit is medium sized with good color and has excellent flavor and firmness. Because Sierra is an inter-specific hybrid of four species, its cold hardiness is unknown.

Late Season

Standard Varieties

COVILLE: Bush is very vigorous and has a spreading habit. Has open fruit clusters. Needs bees for best pollination. Berry is large, medium blue, highly aromatic, and tart. Occasionally does not set fruit well, which can limit its productivity. Narrow soil adaptation and produces only moderately. Fruit is susceptible to anthracnose.

ELLIOTT: Last to fruit of all standard varieties. Bush is vigorous and upright; plants very productive, hardy, and resistant to mummy berry disease. Berry is medium and light blue, with firm flesh and only fair flavor. Late small fruit can be tart, and berry can be fully blue when not fully ripe, so fruit should be allowed to remain on bush after coloring. Interplanting with another late-blooming variety has provided cross-pollination and improved size and flavor. Stores well. Resistant to anthracnose.

JERSEY: Bush is vigorous and erect with open fruit clusters. Medium-sized, firm fruit with good color and fair flavor. May have fruit set problems; tends to set fruit without undergoing pollination, so fruit does not size. Considered by some to have sweetest flavor. Resistant to anthracnose.

LATEBLUE: Bush is erect, vigorous, and very productive. Berries are firm, light blue in color, and are fine flavored, but tart. High temperature during harvest may lead to stems staying on the berries when picked.

Recent Releases

AURORA: A new release from the breeding program at Michigan State. Ripens very late—in some cases, later than Elliott. Excellent fruit quality.

LIBERTY: A new release from the breeding program at Michigan State. Ripens late with Elliott, but with better flavor than Elliott.

PLANTING

As with other small fruit crops, a blueberry planting should be planned at least one year in advance. The soil should be tested and sulfur and phosphorus applied (if needed) during the fall prior to planting. Because most blueberry varieties are not well adapted to heavy upland soils, most soils will require considerable amendment with organic matter if plants are to thrive. Compost application and/or the use of cover crops in the year prior to planting will increase soil organic matter. Sawdust or peat moss also should be worked into the planting hole, replacing about one-half of the original soil with the organic material. After watering in and applying the fertilizer, mulch the plants heavily along the length of the row with about 4 inches of rotted sawdust or other organic matter. Avoid using green sawdust since it may burn the tender green stems and will compete with the plant for nitrogen.

Immediately after planting, prune back 50 to 60 percent of the wood. Remove the flowers from two-year-old plants completely so the plant will become well established. Sacrificing this small amount of fruit is well worth the dividend of establishing a planting that will fruit for 50 years or more if well maintained! Some of the crop also should be removed the following year to encourage sound establishment.

NUTRITIONAL REQUIREMENTS

If the soil is properly prepared prior to planting, only nitrogen fertilizer is required on a routine annual basis. Do not fertilize in the first year since the root system is very susceptible to root burning at this stage. In subsequent years, always fertilize with ammonium sulfate in March or April. To each plant, apply 4 ounces of ammonium sulfate in year two, 5 ounces in year three, 6 ounces in year four, 7 ounces in year five, and 8 ounces in year six and subsequent years. Retest the soil every 5 years or so to make sure that the soil pH is in the correct range. If nutrient deficiency symptoms (e.g., light-green or red leaves in the summer, poor growth, poor yield) appear, it is likely that the soil pH is no longer in the optimum range of 4.5 to 5.0.

POLLINATION

Most plantings will produce satisfactory crops when only one variety is included, but pollen from other varieties generally will result in increased yields, larger fruits, and earlier ripening. A planting design in which a row of one variety is alternated with a row of another variety will encourage cross-pollination. Make sure there is good bee activity. A honeybee hive in the vicinity will provide consistently high yields and better berries.

PRUNING

Pruning controls the crop load, thus increasing fruit quality. It also invigorates the plant, forcing essential new growth from the base of the plant. The philosophy behind blueberry pruning is to constantly renew the older, decreasingly productive canes by cutting them out and forcing new canes. The plant is continually replacing old canes with new canes, while the majority of the canes are in a productive, intermediate stage.

Pruning is best accomplished toward the end of the dormant season, usually sometime in March. Fall pruning is not recommended since it can force the plant to produce new shoots that will be killed by winter cold. In March, fruit buds are easily recognizable since they are plumper than vegetative buds (Figure 9.1). For the first growing season, all of these fruit buds should be removed. This forces vegetative growth in the plant. This first year should be spent establishing the plant, which, if properly cared for, will bear fruit for 50 years or more.

Figure 9.2 shows a mature blueberry plant before and after pruning. To prune, first remove small, spindly branches and canes that lie on the ground. When thinning canes, try to maximize light conditions inside the plant by removing the centermost canes, which block the sunlight. Once the plant is mature (6 years old), it

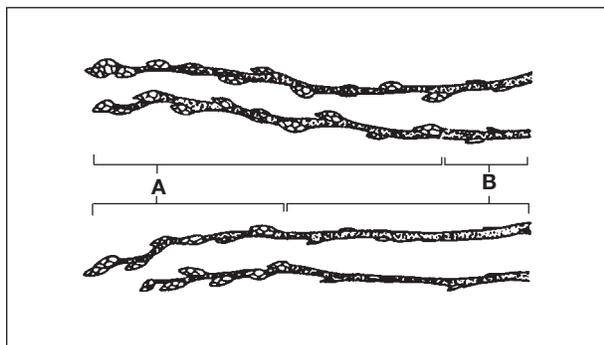


Figure 9.1. One-year-old blueberry stem sections showing fruit buds (A) and leaf buds (B).

should be producing three to five new shoots per year. If it is not, check your fertilizer program. The production of new shoots is somewhat variety dependent, and some may not respond as well as others. Every year, select the best two to three new canes to retain. After 5 years, begin removing the oldest (5 years or older) canes while retaining the three best new canes. This will result in a plant that has two to three canes each of new, 1-, 2-, 3-, and 4-year-old canes, or 10 to 15 canes. As with any biological system, this is an optimal range—many plants will deviate from this ideal.

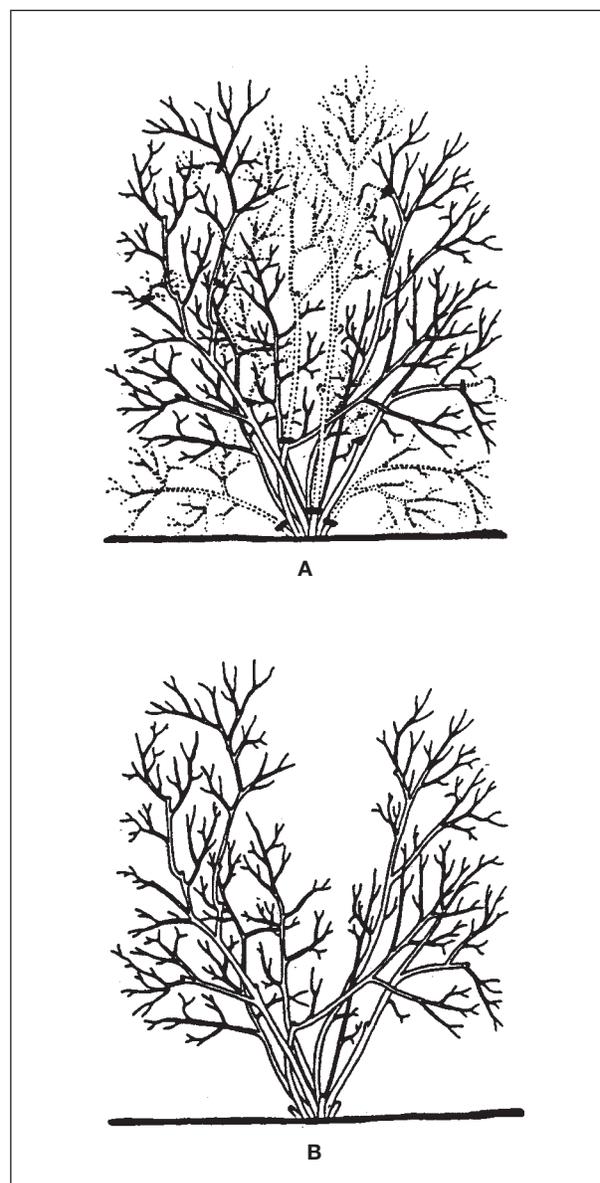


Figure 9.2. Blueberry pruning. A = mature bush showing typical pruning cuts (solid bars) and wood to be removed. B = mature bush after pruning. (courtesy of Virginia Polytechnic Institute.)

After removing the canes, thin those that remain. To do this, remove weak lateral branches and dense bushy twigs. Thin out the center of erect varieties while removing the low-spreading growth of more spreading varieties. Long canes with many flower buds also should be headed back to remove some of the crop. Bear in mind that thicker wood will bear larger berries, which bloom slightly later. The later blooming can be an advantage where late frosts are a problem.

If plants have not been pruned for many years, they can be rejuvenated by cutting back all of the canes and allowing regrowth, or by cutting back half the canes in one year and half in the following year. The latter method may be preferred, since it prevents a lapse in cropping.

SPREADING (OPEN) GROWTH HABIT: Most of the pruning of plants in this category should be directed to the outer edge of the bush. Keeping the growth habit pruned to a more erect form facilitates cultural operations and harvesting. Recommended for Berkeley, Bluetta, Coville, Patriot, and Weymouth.

UPRIGHT (ERECT) HABIT: Plants in this category become dense in the center, which causes shading that reduces both shoot formation and flower bud initiation. Remove the older central canes to produce a better growth situation. Recommended for Bluecrop, Blueray, Collins, Darrow, Earliblue, Elliot, Herbert, Jersey, and Lateblue.

VIGOROUS VARIETIES: Plants in this category yield better when “thinned out” rather than “detail” pruned. The entire removal of older canes (6 years and older) has a beneficial effect on yield and growth. This is especially applicable for Blueray, Collins, Coville, Earliblue, and Herbert.

WEAK (SLOW-GROWING) VARIETIES: These plants usually produce many short, weak shoots that lack productivity. Detailed pruning (removing short, one-year growth) will improve overall berry quality on the remaining shoots. The systematic removal of thin shoots (less than 1/8 inch in diameter) and those less than 6 inches long will improve fruit quality. This is of special importance when pruning Bluetta.

HARVEST AND POSTHARVEST CARE

A mature blueberry plant will produce 6 to 10 pounds (7 to 10 pints) of fruit per year. Harvest begins in June for varieties such as Earliblue and may continue through mid-September for latest varieties. Berries turn blue 3 to 4 days before they attain maximum sweetness and flavor. They should be picked every 7 to 10 days. Do not pick berries with a reddish tinge since they are underripe.

Blueberries, like other fruits, should be picked in the morning after the dew has evaporated. If picked in the afternoon, the berries are more likely to be warm, which makes the berry more susceptible to postharvest breakdown.

Cellophane covers reduce water loss from the berries after harvest. Blueberries may be stored for as long as 14 days under the best of conditions; however, this is not usually desirable since off-flavors are often absorbed.

INSECT PESTS

Plum Curculio

The plum curculio, *Conotrachelus nenuphar* (Herbst), is a weevil (a type of beetle). It is dark brown, 1/4 inch long, and has four humps on its back and a long (one-third of the body length) snout projecting forward and downward from its head. The beetles overwinter as adults under debris in the woods or field margins and migrate into the fields at about petal fall. They migrate more heavily when temperatures exceed 75°F and are slowed significantly when the weather is damp and cool (below 70°F). Plum curculio is usually more prevalent on plants adjacent to woods, fence rows, and trashy fields.

Females lay eggs in shallow pits excavated on the surface of green berries. Usually, a single egg is laid in each berry, and a crescent-shaped scar develops on the surface at this site. Upon hatching, larvae burrow into the fruit where they feed on the pulp for about 2 weeks, many times causing the fruit to drop. Infested berries sometimes remain on the plant, however, and can contaminate harvested flats. Fully grown larvae leave the fruit, burrow into the soil, and pupate within an earthen chamber. The adults emerge about 4 weeks later. Most of these adults enter diapause after several weeks of feeding, but if green berries are still present, a few will mate and produce a second generation.

Infestations of plum curculio usually can be detected by examining green berries for the typical oviposition scar. These berries are usually the first to turn blue. Adult curculio are nocturnal, but they can be found early in the morning or late in the evening by shaking the branches of a bush over a white cloth that has been placed on the ground. Adults disturbed in this manner drop onto the sheet and feign death by folding their legs tightly against their body and remaining motionless. They can be easily mistaken for debris.

Because the weevil spends much of its life cycle on the ground under the bushes, frequent cultivation can

facilitate its control. Effective control can be obtained by postpollination applications of broad spectrum insecticides. Make sure flowers have dropped from treated blocks so bees will not be killed.

Cranberry Fruitworm

Found throughout the eastern United States wherever wild blueberries grow, the cranberry fruitworm, *Acrobasis vaccinii* (Riley), affects cultivated blueberries that are poorly maintained. This pest overwinters as a fully grown larva in the litter near the soil surface under the bushes. The small, brown, adult moths emerge when the berries of early varieties begin to form, and they begin inserting eggs along the rim of the calyx cup. After hatching from the egg, the larva enters the berry. It eventually webs several berries together with silk, feeding inside as many as four. One generation hatches each year. The cranberry fruitworm infestation is characterized by masses of brown frass (excrement) and silk.

Cranberry fruitworm infestations can be difficult to detect early. Look for a pin-sized entry hole near the stem of any small, shrunken berries that have turned blue, and then open adjacent berries to find the larva. The distinctive frass and webbing do not appear until later in the larva's lifetime when it begins to move between berries. One method of control for this pest (and for cherry fruitworm) is to pick and destroy infested berry clusters showing evidence of webbing. Repeated disking to eliminate weeds and trash also helps in its control. Pesticides used for plum curculio also usually result in control of cranberry fruitworm.

Cherry Fruitworm

The cherry fruitworm, *Grapholita packardi* (Zeller), overwinters as large larvae in cavities usually made in the dead wood on the bush. The small, dark-gray moths with brown banded wings emerge in the late spring. The green-white flattened eggs are laid on the undersurfaces of leaves and on the fruit. After hatching, the larvae enter the berries. The $\frac{3}{8}$ -inch, pink and red larvae usually feed on one berry at a time and then penetrate and feed on another. Unlike cranberry fruitworms, the cherry fruitworms seal entrance holes with silk so that frass is not visible outside the berries, and an infestation is evidenced only by prematurely blue, shrunken berries webbed together by silk.

Both fruitworms can be controlled with two broad spectrum insecticide sprays. Apply the first at petal fall on a variety-by-variety basis to avoid poisoning bees. It is important to remove bee hives from the area before

any insecticide spraying takes place. Spray again about 10 days later.

Blueberry Maggot

The blueberry maggot, *Rhagoletis mendax* (Curran), is the major pest of blueberries in many parts of the Northeast; however, blueberry plantings in Pennsylvania have not been heavily attacked to date. The presence of infested fruit at harvest can result in the condemnation of whole fields of harvested fruit. Moreover, the control of the insect is complicated by its long emergence period, its migration tendencies, and the fact that it usually does not attack fruit until after harvest has begun.

The female fly is about $\frac{3}{16}$ inch long. The abdomen is pointed and black with white cross bands. The wings are clear and marked with heavy black bands in the shape of an upside-down "W." Several other species of fruit flies can be confused with blueberry maggot if they are not inspected carefully.

Overwintering as pupae buried anywhere from just beneath the leaf litter to 6 inches deep in the soil, the blueberry maggots emerge from the soil as flies in June or July. After emerging, the flies, which live for about 30 days, spend the first 2 weeks resting and feeding on nectar, dew, and honeydew. Mating takes place near the end of this resting period, and females seek large, ripened berries in which to lay eggs. The female pierces the skin of the fruit with her egg-laying apparatus and deposits a single egg in each berry. Each fly may lay up to 100 eggs in a 2- to 3-week period. Upon leaving the berry, the female deposits a chemical that deters other flies from laying eggs in that berry. The egg hatches in about 5 days, and the larva burrows into the berry and feeds on the pulp for about 2 weeks. The mature larva leaves the berry and drops to the soil to pupate and remain until the next summer. Only one generation hatches each year, but a few pupae may remain in the soil for 2 to 3 years.

The potential for infestations of blueberry maggots can be assessed by trapping adults before their numbers reach damaging levels. The traps are yellow sticky boards placed near the planting at least a week before the first flies are expected to emerge (early June). These boards are baited with a feeding attractant—either ammonium acetate or protein hydrolysates. Baited traps can be purchased or made. Trapping should continue through harvest, and the traps should be replaced every 3 weeks or when they become clogged with insects. The flies on each trap should be counted and removed each week. Insecticides should be applied when three adults per trap per

week or five adults per field per week are found. Note: Several other fly species will be trapped on the boards (along with other insects). Make sure that only blueberry maggot flies are counted. If species identification is a problem, consult your county extension agent.

If control is necessary, a relatively nontoxic, short residual insecticide should be used so that it does not interfere with harvest. If ripe berries are present, they should be harvested before the spray is applied. Tank mixing the insecticide with protein hydrolysate will increase the treatment efficacy. Once spraying has begun, it should be continued with an application every 7 to 10 days until all unharvested fruit has dropped.

Scales, Including Putnam Scale and Terrapin Scale

These insects may be common in blueberry plantings, especially if pruning has been neglected for several years and the scales' parasites and predators have been destroyed by insecticide sprays. Scales spend most of their lives as legless, sedentary individuals, usually clustered with other scale insects to form what appears to be a crust—in the case of Putnam scale, *Aspidiotus ancyclus* (Putnam); or shiny brown hemispheres, in the case of terrapin scale, *Lecanium nigrofasciatum* (Pergande)—on the wood surface. Some scales also reside on leaves and fruit.

Males are produced in late summer; after they mate, the females settle on the wood to overwinter. Live offspring issue forth in the spring to early summer in the form of "crawlers," thereby affecting the spread of these insects. Scales feed by removing sap from the plant, which can reduce vigor, decrease yield, and even cause the decline of the plant. Some scales also produce large quantities of honeydew—a sugary liquid that coats the leaves and fruit and promotes the growth of sooty mold, which can decrease berry quality.

Good scale control is accomplished first by good pruning practices. Removing and destroying old wood during pruning often does much to reduce scale populations. The second approach is the use of dormant oils to smother the overwintering scales. Cover sprays during the growing season usually are ineffective because the scales are protected by their secreted "shell"; however, sprays timed to coincide with crawler emergence can be effective.

DISEASE DESCRIPTIONS AND MANAGEMENT

See basic cultural guidelines for the control of plant diseases under "Pest Management" on page 24 in Chapter 2. Table 2.4 lists pesticides available on various fruit

crops for the control of diseases. Pictures of fruit diseases can be found in the *Fruit Pathology Fact Sheets* at <http://fpath.cas.psu.edu/factsite.html>. Blueberry varieties differ in their susceptibility to the various diseases. See the section on variety selection for more information.

Botrytis Blight and Fruit Rot

Botrytis blight and fruit rot are common occurrences, especially in cool, humid weather on many crops throughout the world.

Symptoms and Disease Cycle

Botrytis blight is caused by the fungus *Botrytis cinerea*, which overwinters on infected plants. Under favorable conditions, the fungus can infect blossoms, twigs, and fruit. Tips of infected shoots will die back and turn brown to black. Infected blossoms appear water soaked and turn brown, and the discoloration can spread down the twig. This blossom blight stage causes the most loss. Blighted blossoms often cling to clusters. Immature fruits shrivel and turn a bluish purple, whereas ripe, mature fruits become tan. In damp weather, all infected plant parts become covered with the characteristic "gray mold" of the fungus. Spores of the fungus are disseminated primarily by wind.

Disease Management ♦

Cultural practices that improve air movement, such as pruning, aid in the control of blight and fruit rot. Avoid excessive use of nitrogen fertilizer in the spring because rapidly growing tips are more susceptible.

Mummy Berry

Mummy berry is the most serious and widespread disease of highbush, lowbush, and rabbiteye blueberries. It is most serious in the north following moist, spring weather conditions. Crop losses can be severe, depending on environmental conditions and variety susceptibility. Blueberry varieties differ in their susceptibility to this disease.

Symptoms and Disease Cycle

Mummy berry is caused by the fungus *Monilinia vaccinii-corymbosi*. Spores within berries infected by this pathogen can remain viable in or on the soil for several years. In the spring, tips of the newly infected leaves, buds, stems, and flower clusters suddenly will wilt, turn brown, and eventually become covered with a powdery mass of spores produced by the fungus. Spores from these blighted shoots are carried to open flowers along with the pollen. The fungus colonizes the developing fruit

by growing into and colonizing the ovaries. When nearly mature, infected berries become dry, shrivel, and drop early. These shriveled berries, on which the fungus will overwinter, are called “mummies.” In the spring, cup-shaped fruiting bodies are produced on the mummies and can be found on the soil surface. These fruiting “cups” release spores that infect new plants. Mummy berry usually is more severe in low-lying areas of the field.

Disease Management ♦

Clean cultivation aids in the control of this disease. Remove and dispose of fallen leaves and old berries either by burying or burning. Cover old berries with at least 2 inches of soil by disking between rows or adding 2 inches of new mulch. Before berries blossom, thoroughly cultivate between rows and under plants after each hard rain. An application of urea fertilizer or a shallow cultivation of the ground between rows and beneath infected bushes before bud break kills the exposed mushroom-like apothecia (mummy cups). The Bluetta, Collins, Coville, and Darrow varieties may have some resistance. Susceptible varieties include Berkeley, Bluecrop, Blueray, Earliblue, Jersey, and Weymouth. If using fungicides, apply at bud break and follow up at 10- to 14-day intervals through bloom. This will control the disease effectively. Once the flowers have been pollinated, no further infection can take place.

Phomopsis Canker and Twig Blight

Only in recent years have phomopsis twig blight and canker become important diseases of blueberries. Bushes that have been weakened by other factors usually are more prone to infection. In addition to twig blight and canker, the fungus causes a fruit rot.

Symptoms and Disease Development

Phomopsis canker is caused by the fungus *Phomopsis vaccinii*, which overwinters in infected plant parts. The primary symptom of twig infection is a blighting of one-year-old woody stems that have flower buds. As with other canker diseases, the most conspicuous symptom is “flagging”—during the summer, individual stems wilt and die while leaves turn reddish and remain attached. Under severe disease conditions, several individual canes may be affected on a single bush. The fungus enters the flower buds and eventually moves into the stem. Infected stems will wilt and die, and young twigs will die back from elongated cankers produced by the fungus. Cankers on one-year-old stems become obvious by early summer and continue to progress downward, eventually encircling the entire shoot. In hot weather,

leaves on infected twigs turn brown and remain attached to the stem. As canes mature, they become girdled by the diseased lesions. Fruiting structures of the fungus will form on dead twigs and leaves. These fruiting structures look like small, black dots, which are the spore-containing bodies (pycnidia) of the fungus. These spores are spread primarily by rain splash. Infected fruit are soft and often split and leak juice.

Disease Management

Recommendations include removing and burning all blighted or discolored wood during dormant pruning. When blighted tips appear in the summer, cut shoots back to a point where the pith appears normal. Avoid planting sites prone to spring frosts and use fertilization, irrigation, and weed control practices that discourage late-season growth and promote early hardening off. Sprays for mummy berry and botrytis may help, particularly during flowering. However, remember that fungicides active against mummy berry may not be active against phomopsis canker and vice versa. No commercial varieties show strong resistance to phomopsis canker. A few blueberry varieties vary in their resistance to the twig blight phase.

Virus Diseases

Blueberries are susceptible to a number of virus and virus-like diseases. Virus diseases are spread to healthy blueberry plants by vectors that include primarily aphids, nematodes, leafhoppers, and occasionally honeybees, which can spread virus-infected pollen. Virus diseases also are spread by diseased plants from infected nursery stock. Once a bush is infected with a virus, it remains infected for the life of the plant.

Virus diseases cannot be controlled like a fungal or bacterial disease with chemicals. Prevention and sanitation measures are the best control for virus diseases. Suggested control practices include planting virus-free clean stock plants in clean soil, destroying alternate hosts such as wild blueberries that may harbor viruses, removing and destroying plants that are diseased or suspected of having virus infections, and controlling insect and nematode vectors.

Some of the more common viruses that affect blueberries are listed below.

Blueberry Scorch Virus

Blueberry scorch virus can cause severe flower and leaf browning in highbush blueberries. All varieties of highbush blueberry are considered susceptible. This disease is spread by aphids, with transmission from infected to

uninfected plants taking place in a matter of minutes or hours. Aphid control is the best method available to stop the infection of the entire field. The virus spreads outward from the first plants infected.

The symptoms of blueberry scorch first appear during bloom in late April to early May. Symptoms in some varieties consist primarily of blossom blight with a few brown leaves near the blighted flower clusters and some marginal yellowing of leaves produced on older wood. The blighted blossoms often are retained throughout the summer but fail to develop into fruit. Affected bushes develop symptoms every year. Initially, only one or a few branches are affected. Bushes appear to recover as the season progresses; however, yield is reduced or eliminated. Symptoms reappear in following years with more branches affected. Plants can be killed in 3 to 6 years, with all plants eventually infected. Tolerant varieties may not show symptoms but still serve as sources of inoculum.

Blueberry scorch can spread rapidly. The best method of control is to plant virus-free stock. The spread of the virus has been recorded only over short distances. If no known blueberry scorch exists in close proximity to a grower's field, scorch should not become a problem. The problem occurs when a neighbor has tolerant varieties that are infected with this virus—these will be a constant source of potential new vector-spread infections. If an infection is observed early—when only a few plants are showing symptoms—then an aphid-control program combined with removing and burning diseased bushes over a 3-year period should prevent further spread of this virus. The Blue-ray, Blue-tta, Duke, Chanticleer, Elliott, and Weymouth varieties are susceptible. Jersey is tolerant, and Bluecrop is intermediate.

Shoestring Disease

The blueberry aphid spreads shoestring virus. There is a latent period of 4 years between infection of the plant and expression of symptoms. Shoestring-infected wild blueberries also have been found in the wooded areas.

The most prominent symptoms are elongated reddish streaks about $\frac{1}{8}$ inch wide by $\frac{1}{2}$ to $\frac{3}{4}$ inch long on current-year and 1-year-old stems, especially on the side exposed to the sun. During blossoming, flowers of infected bushes exhibit pinkish to reddish petals. Infected leaves often are straplike, hence the name "shoestring." Many leaves on a bush might appear this way, although in some cases just a few clumps near the crown will show this symptom. A few leaves may show red vein-banding or reddish streaking along the midrib of the leaf. In some cases, an "oak leaf" pattern will

show on the leaf blade. Other leaves may be crescent shaped and partially or totally reddened. Infected stems may appear crooked, especially the tip-end half.

Aphid control is critical to preventing the spread of Shoestring virus. The first insecticide application should begin when aphids first appear on the terminals of the stems, usually by late May or early June. Two or three sprays may be required throughout the growing season to keep aphid levels low. The long latent period makes identifying infected bushes before they serve as sources of inoculum impossible, so roguing is not feasible or effective. Clean planting stock is critical. Bluecrop shows resistance. Also, diseased wood used for propagation is another way to spread the virus from one field to another.

Tomato Ringspot Virus Disease

Tomato ringspot virus is vectored by the dagger nematode. This virus can infect many different species of plants, including other fruit crops such as apples, peaches, and raspberries, and weeds such as chickweed and dandelion. Infection spreads slowly.

Symptoms include leaves that are malformed and have circular chlorotic spots on them, $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter. In addition, stems, twigs, and branches may exhibit circular, brownish necrotic spots of similar size. Younger terminal leaves tend to be strap shaped and have a mottled pattern (alternating yellowish to greenish stippling). Fruit production may be reduced and infected plants may eventually die. One indication that the disease is spread by the dagger nematode is that symptoms spread slowly in a circular pattern at a rate of about 3 feet per year in all directions.

The best control for this virus is to test the soil for nematodes before planting and avoid following with fruit crops. Weeds, especially dandelion, serve as a reservoir for the nematode and should be controlled. Plant only virus-tested clean stock.

Red Ringspot Disease

The cause of red ringspot virus is unknown. Mealybugs, however, may be involved in transmitting this virus.

Infected stems at least 1 year old often exhibit reddish-brown spots with green centers. The spots, $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, also develop on the upper surfaces of older leaves in mid- to late summer. The powdery mildew fungus can cause similar symptoms on both sides of the leaf. Plants with this disease exhibit a loss of crop; the amount varies with variety.

Because the vector has not yet been identified, the primary form of control is the use of virus-free stock

and removal of infected bushes. Blueray and Bluetta are especially susceptible.

Stunt

Stunt is caused by a phytoplasma not a virus. Viruses and phytoplasmas are quite different, but they are often grouped together in discussions of plant pathogens. Viruses consist only of protein and genetic material (DNA or RNA) and cannot replicate (reproduce) on their own, instead needing to infect cells to complete the process. Phytoplasmas are essentially a type of bacteria without cell walls. Both become systemic throughout the plant.

Stunt is a very important disease of blueberry throughout the United States and eastern Canada. Most varieties of highbush blueberry are susceptible. Stunt can be found in wild highbush and lowbush in the woods. No yield data are available on the losses caused by stunt, but symptomatic bushes are usually less than half the size of healthy bushes, and crop yields vary from very light to none.

Overall dwarfing of the bush is the primary symptom, hence the name “stunt.” Small leaves that are cupped downward or puckered are characteristic symptoms. Leaves of infected bushes are often yellow, with yellowing most pronounced along leaf margins and between lateral veins. Midribs and lateral veins usually retain normal green coloration. Yellow areas often turn a brilliant red in the late summer. Stem internodes become shortened, and growth of normally dormant buds causes twiggy branching.

Stunt is actively spread in the field by the sharp-nosed leafhopper. The pattern of stunt disease spread appears random. Leafhoppers are strong fliers and may come into a field from a great distance. Insecticides applied on a timely basis to control the leafhopper help keep the disease in check. Also use virus-tested planting stock when establishing a new field.

PEST MANAGEMENT

Table 9.1 describes the occurrence of insects on blueberries during the growing season, and Tables 9.2 and 9.3 provide information about pesticide use.

Table 9.1. Occurrence of insects during the blueberry growing season.

<i>Insects</i>				
S	= scale		PC	= plum curculio
BM	= blueberry maggot		F	= fruitworms
Timing	S	BM	PC	F
Dormant	++	-	-	-
Prebloom	-	-	-	-
Bloom	-	-	-	-
Petal Fall	+	-	++	++
Berries begin to color	-	++	+	++
Harvest	-	++	-	+
Postharvest	-	-	-	+

+ = pest present, possible control; ++ = proper timing of control; - = control generally is not needed at this time

Table 9.2. Efficacy of insecticides on blueberries.

<i>Insects</i>					
PC	= plum curculio		BM	= blueberry maggot	
CRF	= cranberry fruitworm		S	= scale	
CHF	= cherry fruitworm				
Pesticides	PC	CRF	CHF	BM	S
<i>Bacillus thuringiensis</i>	—	2	2	—	—
Dormant oil	—	—	—	—	1
Esfenvalerate	2	2	2	2	—
Malathion	2	2	2	2	3
Carbaryl	2	3	3	2	3
Pyrethrum	3	3	3	3	—
Rotenone	—	—	—	—	3
Spinosad	—	3	3	—	—

Degree of control: 1 = best; 2 = good; 3 = fair; 4 = slight; — = no rating available

Table 9.3. Pesticide recommendations for blueberries.

The important insects and diseases to be controlled, except for viruses, are listed in the right-hand column of this spray schedule. Always consult the label before making pesticide applications. Labels vary greatly among commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides.

Follow all instructions and application rates listed on pesticide labels.

Time to Spray	Suggested Materials	Pests to Be Controlled
Delayed Dormant— buds show ¼- to ½-inch green	Oil; lime sulfur	Scales; Phomopsis twig blight
Loose Bud—7 days later and just before blossoming	Captan	Phomopsis twig blight, mummy berry, and Botrytis blight
Pre-Bloom	Captan	Mummy berry and Botrytis blight
Full-Bloom	Same as Pre-Bloom	Same as Pre-bloom
Petal Fall	Same as Pre-Bloom <i>plus</i> Malathion <i>or</i> Carbaryl	Same as Pre-bloom plus fruitworms, weevils
First Cover—10 days after Petal Fall	Malathion <i>or</i> Carbaryl <i>or</i> Spinosad <i>or</i> Ensfenvalerate	Fruitworms, weevils
Maggot Sprays ^a —about July 1, repeat at 10-day intervals	Carbaryl <i>plus</i> Malathion <i>or</i> Spinosad <i>or</i> Pyrethrum <i>or</i> Rotenone	Maggots

a. Malathion may be applied one day before harvest.

Gooseberries and Currants

Gooseberries and currants (*Ribes* spp.) have enjoyed great popularity in the past, particularly in Europe, where in the 1800s as many as 722 gooseberry varieties were in existence, and “gooseberry clubs” were established by enthusiasts. Most of the European varieties were large fruited and sweet as a result of centuries of selection and breeding, while American types had less desirable flavor and more disease resistance. The gooseberries grown today are primarily hybrids of these two types, offering good flavor as well as disease (mildew) resistance. Although they seldom are eaten fresh due to their tart flavor, both red and white currants make excellent jams and jellies. Gooseberries and currants are woody perennial shrubs that reach a height of 3 to 6 feet when mature. Unlike other fruiting plants, they will tolerate partial shade. Plants are self-fruitful and, therefore, do not require two or more varieties for adequate pollination. Currants and gooseberries also are very winter hardy, tolerating temperatures as low as -22 to -31°F.

LEGAL RESTRICTIONS

Confusion often exists about the legality of growing gooseberries and currants since up until 1966 a federal ban prohibited the growth of *Ribes*. The ban was established because gooseberries and currants can serve as alternate hosts to white pine blister rust (*Cronartium ribicola*), a fungus that needs both *Ribes* and white pine to complete its life cycle. This federal legislation was rescinded in 1966. In 1933, Pennsylvania passed a law that limited growing gooseberries and currants in certain areas; however, the law is not enforced. Therefore, all *Ribes* can be grown in the state. If you have white pine nearby, though, you may want to consider growing less-susceptible types of *Ribes*. Black currant (*Ribes nigrum*) is by far the most susceptible, and for this reason many areas outside of Pennsylvania still prohibit growing it. Resistant black currant varieties are available. Red and white currants are less susceptible, and gooseberry is the least susceptible.

VARIETY SELECTION

Gooseberries

CAPTIVATOR is an American-European hybrid that produces large, sweet, pinkish-red fruit. Plants are resistant to mildew.

PIXWELL: Sold most often and is very productive and hardy, but the fruit is of only fair quality. Fruit is best if harvested slightly underripe. Plants are mildew-resistant.

POORMAN: Red-fruited, large, and flavorful. It ripens fruit over a long season and is the best variety of the American types for the home gardens since it is vigorous and has fewer and smaller thorns than most varieties. It is resistant to powdery mildew.

Several European varieties are available from specialty nurseries. The fruit of the European types usually is larger and better flavored; however, the varieties without resistance to powdery mildew can be devastated by the strains of the fungus found in the United States.

HINNONMAKI RED: Has a tart skin but sweet, aromatic flesh. Plants are moderately vigorous and partially resistant to mildew.

INVICTA: Has large, pale-green fruit and less flavor than most European types. Plants are large and have many spines. Has good resistance to powdery mildew.

Currants (Red)

CASCADE: Matures early. Fruit is large and dark red, but vigor and productivity is only medium.

JONKEERS VAN TETS: Produces heavy yields. Fruit is dark red and has a very good flavor. Resistant to mildew and aphids; susceptible to botrytis.

RED LAKE: A vigorous, hardy, and productive variety. The fruit is large, bright red when mature, and of good quality. The long-stemmed clusters are easy to pick. Susceptible to powdery mildew.

ROVADA: A dependable producer. It blooms and fruits late, so frost is less of a problem than with other varieties. Resistant to powdery mildew and other leaf diseases.

WILDER: Very much like Red Lake—high yielding with good-quality berries. Has more resistance to leaf spot.

Currants (White and Pink)

BLANKA: Dependable and produces heavy yields. Plants are vigorous and easy to grow.

PINK CHAMPAGNE: Has good quality and flavor. As the name indicates, fruit is an interesting shade of pink, but yields tend to be low.

PRIMUS: Produces fruit late in the season. Plants are vigorous. Similar to Blanka in most characteristics, but yields are slightly lower.

WHITE IMPERIAL: Has low acidity and produces moderate yields. Plants have a spreading habit.

Currants (Black)

Only varieties with good resistance to white pine blister rust are listed below.

CONSORT: Produces a medium crop of small to medium fruit. Plants are self-fertile. Though resistant to white pink blister rust, this variety is susceptible to leaf spots and mildew.

CORONET: Yields are usually low and fruit is of marginal quality. A pollinator is required.

CRUSADER: Only marginally productive, and quality is low. A pollinator is required.

TITIANA: Produces heavy crops of large, high-quality fruit. Has very high resistance to white pine blister rust.

Currants (Clove or Buffalo)

CRANDALL: A native species of currant that is sometimes considered more closely related to the gooseberries than currants. Valued for its highly fragrant blossoms.

PLANTING AND NUTRITIONAL REQUIREMENTS

In fall or early spring, plant well-rooted, 1- or 2-year-old dormant plants, cutting back the top portions of the plant to 6 to 10 inches. Space plants 3 to 4 feet apart in rows 6 to 8 feet apart. Note that plants can be vegetatively propagated by stem cuttings. Another possibility is to graft gooseberries and/or currants onto a tree species of *Ribes* called *Ribes aureum*. Grafting can be done on a convenient height of the tree, allowing the bush to produce fruit higher up, thus aiding in ease of harvest and weed control around the base of the plants. Remove flower blossoms from plants in the first year to encourage plant

establishment and growth for future years. Well-established plants can fruit for 10 to 15 years or more.

To fertilize, apply 6 to 8 ounces of 10-10-10 annually in an 18-inch ring around the plant in early spring.

PRUNING

Red currants and gooseberries produce fruit at the base of 1-year-old wood, with the greatest production on spurs of 2- and 3-year-old wood. After 3 or 4 years, the older wood becomes less productive and therefore should be gradually replaced with young shoots by a thinning and renewal process. Black currants produce the best fruit on wood that is 1 year old, although this wood is supported by the 2- to 3-year-old shoots. All canes older than 3 years old should be removed to encourage the growth of new canes.

Prune dormant plants in early spring just before growth resumes, usually in March or early April in Pennsylvania. Remove canes that drop on the soil or canes that shade out the center of the plant. After the first season of growth, remove all but six to eight of the most vigorous shoots. After the second season, retain four or five 1-year-old shoots and three or four 2-year-old canes. Following the third season, keep three or four canes each of 1-, 2-, and 3-year-old wood. In subsequent years, remove all of the oldest canes, replacing them annually with new canes.

HARVEST

Pick fully colored fruit as they appear, usually in late June or July in Pennsylvania. Each plant will produce between 5 to 7 pounds when mature (usually during the third or fourth year).

INSECT PESTS

(Courtesy of and adapted with modifications from the University of Wisconsin)

Under most conditions, insects are not perennially serious pests of currants and gooseberries; however, certain insects occasionally will become abundant enough to cause serious damage if left uncontrolled.

Currant Aphid

The currant aphid, *Cryptomyzus ribis* (L.), overwinters in the egg stage on plant stems. Eggs hatch in early spring, and the insects feed by sucking out the plant juices, which results in stunted and distorted new growth. As leaves continue to develop, they will be crinkled with downturned edges. Areas between veins on

the upper leaf surface may be reddened. As the aphids feed, they excrete excess sugar and water in small droplets called honeydew. Ants may feed on this, and a black fungus—sooty mold—often grows on it. The aphids themselves are small (up to about 2 millimeters), green, and usually found in colonies. Other aphid species also occasionally feed on currants and gooseberries.

Aphids often are kept under good natural control by predators such as ladybugs, small parasitic wasps, and even some insect diseases. In some areas or during certain years, these natural controls may not be adequate, and you might choose to use a chemical spray. Dormant sprays are effective, as are summer horticultural oil or insecticidal soap if applied when the aphids are first seen.

Currant Borer

The damaging stage of the currant borer, *Synanthedon tipuliformis* (Clerk), is a pale, yellow, wormlike larva that tunnels through the pith of the cane. A member of the clear-winged moth family, the wasp-like adult lays its eggs on the canes in early June. After hatching, the worm enters the cane and feeds all season. It overwinters in the larval stage in the cane, emerging as the adult moth the following spring. Feeding damage will kill the cane; the first symptom is yellowing foliage on individual canes in late spring. Red currants are attacked most frequently.

Cut out and destroy infested canes as early as possible. Once the larvae bore into canes, chemical control is not possible.

Imported Currant Worm

The imported currant worm, *Nematis ribesii* (Scopoli), is the most serious insect pest of currants and gooseberries, with the latter being the favored host. Foliage is consumed by several small, spotted, caterpillar-like larvae. The adults are sawflies about the size of a housefly. Two generations hatch each year, causing damage in the spring and again in late summer.

Bacillus thuringiensis-based products and/or a broad-spectrum insecticide should control this insect. Start looking for damage shortly after the leaves have fully expanded. The second generation usually is less severe than the first and does not require treatment.

Currant Stem Girdler

Adult sawflies, *Janus integer* (Norton), make numerous punctures in canes during egg laying in spring, resulting in drooping and wilting of new shoots in late spring. Further

damage occurs as the larvae tunnel through the canes.

This insect also attacks poplar and willow trees, and damage usually is more severe near stands of these trees.

Removing and destroying infested canes at the first sign of wilting is the best control. ♦

Fourlined Plant Bug

The fourlined plant bug, *Poecilocapsus lineatus* (Fabricius), is yellowish green with four dark stripes on its back. It is quite active and runs and flies readily. It sucks plant juices from leaves and young stem growth, causing deformed and brown foliage. Older leaves will be spotted with many tiny, light spots. This insect feeds on numerous wild hosts, and damage occurs most frequently when such plants are allowed to grow near currants and gooseberries.

In areas where plant bugs have been a problem, they can be controlled by an early season application of pyrethrum-based or pyrethroid compounds.

Gooseberry Fruitworm

The larval stage of the gooseberry fruitworm, *Zophodia convolutella* (Hübner), is a greenish worm with darker stripes along the sides. The worms feed by hollowing out the insides of the fruit of both currants and gooseberries; each worm consumes several berries. The adult is a moth.

Bacillus thuringiensis-based products and/or a broad-spectrum insecticide should control this insect. Make two applications 10 days apart, starting at early fruit development.

Currant Fruit Fly

Fruits infested by the currant fruit fly, *Epochra canadensis* (Loew), drop early and have dark spots surrounded by a red area. Small, white maggots will be found in such fruit. Late-maturing varieties are preferred by this insect.

The removal and burial or the destruction of dropped fruit will keep populations from building. The insecticide program for gooseberry fruitworm also will control fruit flies.

San Jose Scale

The adult San Jose scale, *Quadraspidiotus perniciosus* (Comstock), is a small, grayish, disk-shaped speck about 2 millimeters across with a raised spot in the center. It is found most frequently on the canes. For most of its life, the scale insect is incapable of movement and merely sits and sucks out the plant juices. Heavily

infested plants will have canes encrusted with scales. In such cases, single canes or even entire plants will be killed.

Dormant sprays of lime sulfur or superior oil will control San Jose scale.

DISEASE DESCRIPTIONS

See basic cultural guidelines for the control of plant diseases under "Pest Management" discussed on page 24 in Chapter 2. Table 2.4 lists pesticides available on various fruit crops for the control of diseases. Pictures of fruit diseases can be found in the Fruit Pathology Fact Sheets at <http://fpath.cas.psu.edu/factsite.html>.

The more common diseases found on currants and gooseberries are anthracnose, leaf spot, and powdery mildew. Other diseases of less importance are cane blight or wilt, botrytis dieback and gray mold berry rot, white pine blister rust, and virus infections. The most common virus disease is currant mosaic.

Anthracnose

This is a fungus infection appearing first as numerous dark-brown to black dots scattered at random over one or both surfaces of the leaf. The infection may appear at any time during the growing season. The spots enlarge, become more angular in outline, and sometimes have a purplish margin. Affected leaves soon turn yellow and then drop. This weakens the plant, reduces vigor and productivity, and results in smaller fruit of lower quality.

Leaf Spot

This disease quite commonly is called septoria leaf spot, the name of the parasitic stage of the fungus causing the infection. This leaf spot can be distinguished from that caused by anthracnose by certain characteristics. The spots typically appear on the foliage in June, at which time they resemble anthracnose. Spots enlarge and the central area becomes light in color with a brown border. Tiny, black specks soon appear scattered over the surface of each spot. These specks are the bodies of the fungus, which contain the spores. They do not appear on anthracnose leaf spots. The diseased leaves, especially on currants, turn yellow and drop.

Powdery Mildew

Two types of powdery mildew, American and European, attack *Ribes* plants. We are concerned only with the American type. Mildew is most important as a disease of gooseberries, but it does occur in a mild form on

currants. White, powdery patches of the fungus appear first on the lower parts of the bush, attacking the leaves, shoots, and berries. As the infection progresses, the entire surface of these parts becomes covered with a whitish growth. Older infections form a thin, felt-like coating, which is tan to reddish brown in color. Black dots called perithecia, which contain spores of the fungus, appear in the fungal mats covering the affected areas. Heavy mildew deposits will cause stunting and premature drying of the foliage, affecting fruit production and weakening the plants.

Diseases of Minor Importance

Caneblight or Wilt

This is a fungal organism that causes a sudden wilting and dying of scattered canes or whole bushes. It is most evident just before fruit ripens.

Botrytis

This fungal infection produces a dark-colored dieback of the tips of the branches and a gray mold rot of the berries. Infection occurs during wet, humid weather in plantings in low areas with poor air circulation.

White Pine Blister Rust

In the spring, small, yellow spots can be seen on the underside of leaves. By late summer, a yellow to brown, threadlike growth develops on or near these infection spots. These growths contain another type of spore, which germinate and infect the white pine in the fall. European black currants and wild gooseberries are the main hosts of blister rust when white pines are growing in the vicinity.

Cluster Cup Rust

This rust disease can produce striking symptoms on species of wild gooseberries or in neglected home garden plantings but causes slight damage. The rust affects leaves, stems, and fruit but is commonly found on the leaves and leaf petioles. The leaf is thickened where the cluster cup later appears. The spots have a reddish appearance. The sedge plant is the alternate host of this rust.

Currant Mosaic

This viral disease appears as a chlorotic pattern (light and dark areas) on the leaves. The lighter-green areas gradually turn white.

PEST MANAGEMENT

Many cultural methods such as pruning and sanitation practices will help in keeping disease organisms out of your plantings. See basic cultural guidelines for the control of plant diseases under “Pest Management” discussed on page 24 in Chapter 2.

To help prevent the introduction of currant mosaic virus and white pine blister rust, plant only disease-free stock. Try to obtain certified plants from a reputable nursery or agency. Locate the planting at least 1,000 feet from any wild currant or gooseberry bushes or white pine plantings.

Suggestions for Controlling Insect and Disease Problems ♦

- To control mildew, plant only multistem, well-rooted, one-year-old plants that are listed as resistant or tolerant to mildew.
- *Ribes* spp. are the alternate host of white pine blister rust; use resistant varieties such as Consort.
- Plant on a well-drained site.
- In March, prune off and dispose of winter injuries—old, nonproductive canes and dry, dead wood.
- To prevent leaf spots, rake the ground clean around each plant in early spring.
- To prevent winter injury, do not overfertilize.
- Remove insects by pruning when practical or by hand.
- Spray when necessary. Table 10.1 provides information about pesticide use on gooseberries and currants.

Table 10.1. Pesticide recommendations for gooseberries and currants.

Always consult the label before making pesticide applications. Labels vary greatly among commercial products of the same material. It is important to refer to the label for the best timing and application rates when applying pesticides. Also read the text for information on cultural practices to minimize the application of pesticides.

Follow all instructions and application rates listed on pesticide labels.

Time to Spray	Suggested Materials	Pests to Be Controlled
Dormant	Horticultural oil	Scales
Before Bloom—when green tissue is present but no flowers	Sulfur	Leaf spot, fruit rot
After Bloom	Sulfur; Malathion ^a ; Safer soap	Leaf spot; fruit rot; aphids
2 Weeks After Bloom	Sulfur; Malathion, <i>Bacillus thuringiensis</i> ; Safer soap	Leaf spot, fruit rot; worms; aphids
7- to 14-day	Same materials as 2 weeks after Bloom (stop all sprays 7 days before harvest.)	Aphids, worms, beetles, leaf spot
After Harvest	Sulfur	Leaf spot

a. Make sure currants and/or gooseberries, as appropriate, are included on the product label.

Elderberries

Because of their tartness and relative seediness, elderberries are eaten fresh only rarely; however, they offer a low-cost, low-maintenance fruit crop from which a delightful jelly or pie can be produced. Their fruit is extremely rich in vitamin C (ascorbic acid), and the plant is well adapted to Pennsylvania conditions.

The American elder, *Sambucus canadensis* (L.), is a shrub with individual canes that grow in a clump and reach 4 to 15 feet in height. It is indigenous to North America, with a range from Nova Scotia to Minnesota and south to Florida and Texas. The leaves are pinnately compound, with five to eleven leaflets averaging 5 inches in length and having finely serrate margins. The flower cluster, which is called a cyme, ranges from 3 to 10 inches in diameter. The plants are extremely winter hardy, the flowers are pleasantly scented, and the plant may be used as an ornamental.

Like most fruit plants, elderberries require well-drained soil with a pH between 5.5 and 6.5. The root system is very fibrous and shallow, so cultivation should be shallow. The plants come into full production after 3 to 4 years, with berries maturing in late August to early September.

VARIETY SELECTION

Although relatively little breeding has been done, several elderberry varieties are readily available. Since elderberries are only partially self-fruitful, plant at least two varieties no more than 60 feet apart.

ADAMS #1 and ADAMS #2: The oldest varieties, which are vigorous and productive, with large fruit clusters and berries. They ripen in early September.

JOHNS: Also very vigorous, producing 10-foot canes on fertile soils. It ripens about 10 days earlier than the Adams varieties.

SCOTIA: Yields berries with a higher sugar content than other varieties, although the bushes are somewhat smaller.

NOVA: Has larger, sweeter berries than the Adams varieties. It also lacks the astringency of some varieties.

YORK: Productive and matures relatively late. Plants are large and vigorous.

PLANTING AND FERTILIZATION

In early spring, plant rooted cuttings 5 to 7 feet apart in the row, with a minimum of 10 feet between rows. Apply 2 ounces of ammonium nitrate per year of the plant's age (up to no higher than 1 pound per plant) in a ring around the plant in early spring.

PRUNING

New shoots from healthy elderberry plants usually produce several new canes each year; these attain their full height during that first year. The most fruitful are 2-year-old canes with several lateral branches. Unlike on most other fruiting plants, clusters are born terminally on the current season's growth. Because older trunks lose vigor and become weak after 2 to 3 years, they should be removed along with any dead, broken, or weak canes. Remove canes at ground level during the dormant season, leaving an equal number of 1-, 2-, and 3-year-old canes.

HARVEST

Clusters should be cut and the berries stripped from the stems and processed quickly. Avoid excessive heat buildup in the field.

INSECT PESTS

(Courtesy of and adapted from the University of Wisconsin)

Because elderberry is a native plant, several native insects and mites feed on it. Although most of these are checked by natural controls, some plant damage occasionally will take place. Few insecticides are registered for use on elderberries, so controls must be primarily cultural.

Elder Shoot Borer

The larval stage of the elder shoot borer, *Achatodes zeae* (Harris), is a worm that bores in the stems and shoots. The adult moth lays eggs in July and August in canes at least 1 year old. Eggs hatch the following April or May. The larvae feed first within the unfolding leaf whorls, then bore into new lateral shoots. When partially grown, they migrate to the ground shoots, entering these at the bases and feeding upwards into the shoots. When the larvae are fully grown in mid-June, they leave the ground shoots and tunnel into dead canes to pupate, leaving small piles of frass (sawdust) on the ground at the base of the old wood.

To control, prune out infested shoots or canes. Eliminate dead canes to discourage pupation. Remove old canes with holes or with piles of frass at their bases. Destroy all prunings. ♦

Cecropia Moth

Larval cecropia moths, *Hyalophora cecropia* (L.), are large caterpillars that can remove much foliage during feeding. They are most abundant near wooded areas. Control them by hand removal and destruction. ♦

Aphids

Certain species of aphids occasionally are found feeding on elderberry. Although feeding may cause stunted and distorted leaves, usually only a few terminals are involved. If aphids become numerous, wash them from the plants with a strong spray of water, or prune out and destroy the infested terminals. Insecticidal soap or oil may control aphids. ♦

DISEASE DESCRIPTIONS

Many cultural methods such as pruning and sanitation practices will help in keeping disease organisms out of your plantings. See basic cultural guidelines for the control of plant diseases under “Pest Management” discussed on page 24 in Chapter 2.

The more common diseases of elderberry are cankers, leaf spots, and powdery mildews.

Cankers

Cankers on twigs and branches can be caused by any of a number of fungi. The cankers may girdle the entire branch, causing it to die.

Leaf Spots

Many fungi can cause leaf spots. They usually are not important enough to warrant control measures.

Powdery Mildews

Four species of powdery mildew fungi affect elderberry by producing the typical white coating of the leaves.

Other Diseases

Elderberry also is susceptible to thread blight, root rots, and verticillium wilt.

PEST MANAGEMENT

No pesticides are currently registered for use. In March, prune off and dispose of the old, nonproductive canes, the winter-injured twig tips on 2-year-old branched canes, and any dry dead wood. Dormant pruning is especially helpful for borer control. ♦

Cankers are best controlled by pruning and burning the stems and twigs that show cankers. ♦

Hardy Kiwi

Although the kiwi fruit, once referred to as the “Chinese gooseberry,” has been grown and collected from the wild for centuries in Asia, it only recently has become commonly available in the Western world. This hen’s egg–sized fruit is covered with a brown, fuzzy skin and has a melting green and very tasty pulp. Fuzzy kiwi, which we can purchase readily from our grocery stores, *cannot be grown in Pennsylvania* because of its cold tenderness and long growing season. A relative of this kiwi, though, the hardy kiwi (belonging to the species *Actinidia arguta* and *Actinidia kolomikta*) is much more cold hardy than the plant of the commercially available fruit. Hardy kiwi is of interest due to its flavor, relatively smooth (and edible) skin, “out of hand” eating size (about the size of a large grape), and its good shelf life. Commercial plantings have been established in several locations in Pennsylvania, but success does require a commitment to learning the nuances of growing the crop. Hardy kiwis have some horticultural traits that must be understood:

- Male and female flowers are born on different plants, so both males and females must be planted in roughly a 1:6 ratio of males to females.
- The plants often take several years to mature and usually do not bear fruit until they are 5 to 9 years old.
- Although the plants are extremely winter hardy—tolerating temperatures as low as -30°F —they develop shoots early in the spring that are extremely sensitive to frost. In most years, we see some shoot “burning” due to frost, although the plant usually survives, regrows, and fruits despite some spring shoot removal. If flowers are frosted, fruit will not develop that year.
- Hardy kiwi are extremely vigorously growing vines that require a substantial supporting trellis.

Despite the challenges, once one has sampled the fruit, kiwi growing gains appeal. The fruit is aromatic with fuzzy kiwi, banana, strawberry, mint, and pear flavors contained in the fruit of various varieties.

VARIETY SELECTION

Hardy kiwi variety development is in its infancy because of the newness of this crop; however, a couple of varieties are available and can be obtained from the nurseries listed in Appendix B.

ARCTIC BEAUTY: This name is the common name for kiwi of the species *Actinidia kolomikta*, rather than being a true variety. This species of kiwi has been difficult to establish in several locations.

ANANASNAYA: The name of this variety in Russian means “pineapple like.” Because of the tongue-twisting name, many nursery catalogs will refer to this variety as “Anna.” The fruit is of very good quality, with a sweet aroma and intense flavor. The skin is green and develops a purple-red blush in the sun. A very vigorous vine, this variety is currently the only “standard” that we have to compare to others.

DUMBARTON OAKS: Named after the public garden in which an old vine of this variety was growing and from which plants of this variety were originally propagated. Has good flavor.

GENEVA: Several Geneva selections are available through nurseries. Even though they are not widely tested, it is known that the fruit ripens earlier than either Anna or Issai, and that it has a good flavor.

ISSAI: The only self-fertile variety (not requiring a male pollinator). This variety has not performed well in Pennsylvania. It is from Japan and is less vigorous than other hardy kiwi varieties, with small fruit and good flavor. Harvesting it is a challenge because the fruit ripens unevenly within a cluster.

MEADER: Available as both a male and a female. Make sure to order the female if you want fruit from it. The fruit is medium sized.

PLANTING AND ESTABLISHMENT

Vines are usually purchased from nurseries as rooted cuttings or as potted plants. Order male plants that flower at the same time as your female varieties. Dormant

rooted cuttings should be planted 10 feet apart as soon as the soil can be worked in the spring. The planting row width, if rows are used, will depend on the type of trellis and the equipment used in the planting. Containerized plants may be planted in the spring after the danger of frost has passed. Distribute male plants throughout the planting. When planting, you may need to trim the roots. Plant vines just deeply enough to cover the roots well with soil, and water well. Irrigate throughout the season as needed, and monitor for insect and disease pests.

NUTRITIONAL REQUIREMENTS

Because hardy kiwi roots burn rather easily, apply fertilizer cautiously. No fertilizer will be necessary in the year of planting. In the spring of the second year, apply 2 ounces of 10-10-10 per plant, and increase this amount by 2 ounces each year until plants receive a total of 8 ounces per plant.

PRUNING AND TRAINING

In order to manage the high level of vigor of the hardy kiwi vine, plants must be pruned and trained. Like most perennial fruit plants, they require dormant pruning; however, they also need to be pruned several times during the summer by cutting back the terminal growth to four to six leaves beyond the last flower. Also remove watersprouts (vigorous shoots originating from older wood) and shoots from the trunk, as well as vines that become entangled. This removal may be substantial during the summer.

Dormant pruning should be done sometime from December to March in Pennsylvania. On this species, flowers develop on current-season shoots that come from 1-year-old canes (last year's growth); shoots from older wood rarely produce flowers. As with grapes, a large percentage of the wood—as much as 70 percent—will be removed. New fruiting canes will have developed at the base of last year's growth (Figure 12.1). Replacement canes are left for future fruiting, and fruiting canes should be spaced between 8 and 12 inches on the cordons (permanent horizontal branches).

Training should begin in the first year of planting. Like grapes, these flexible vines can be trained to a

number of forms; although in commercial plantings, a pergola (Figure 12.2) is the most common training system since it accommodates the kiwi's high level of vigor. Also, like grapes, establishing the trunks and structure of the vine early in its development will ensure fruit production for many years to come. Figure 12.3 shows a typical hardy kiwi plant training system over the first 2 years of its life. For additional options, see the training systems in Chapter 6.

HARVEST AND POSTHARVEST CARE

A single mature hardy kiwi plant will can yield between 50 and 100 pounds of fruit, though 50 pounds is closer to the average. Hardy kiwi can be allowed to “vine ripen,” at which time they will have about 18 to 25 percent sugar. At this time, a single harvest, rather than a selective one over several pickings, is acceptable. Unlike the other small fruits, hardy kiwi will “after ripen.” Specifically, they can be harvested at a less-than-optimal ripeness (about 8 to 9 percent sugar) and then placed in storage to ripen. When picked in this manner and refrigerated, hardy kiwi will keep in a cooler for up to 2 months.

DISEASES AND PESTS

The hardy kiwi is a relatively new crop to our area. Little information is available on the disease and insect pests that affect this crop. Disease organisms known to infect the hardy kiwi are phytophthora crown and root rot, botrytis rot, and sclerotinia blight. Phytophthora crown and root rot is reported to be one of the most serious diseases of this fruit. The symptoms, disease cycle, and control practices for this disease are described throughout this book in the chapters on various other crops.

Hardy kiwi plants also are damaged by root knot nematodes. Insect problems include two-spotted spider mites, leaf rollers, thrips, and Japanese beetles. To control these pests, refer to the control measures listed in the chapters covering other fruit crops. As with every other crop, only compounds registered for use on hardy kiwi can be used for pest control.

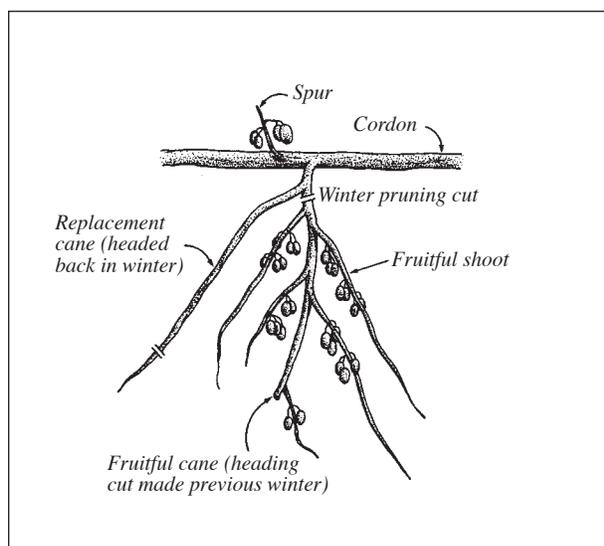


Figure 12.1. A fruiting branch of hardy kiwi. (To simplify the figure, leaves are not shown.) Fruit are produced on shoots growing from last year's growth. Winter pruning cuts are shown by //. (Courtesy of Oregon State University.)

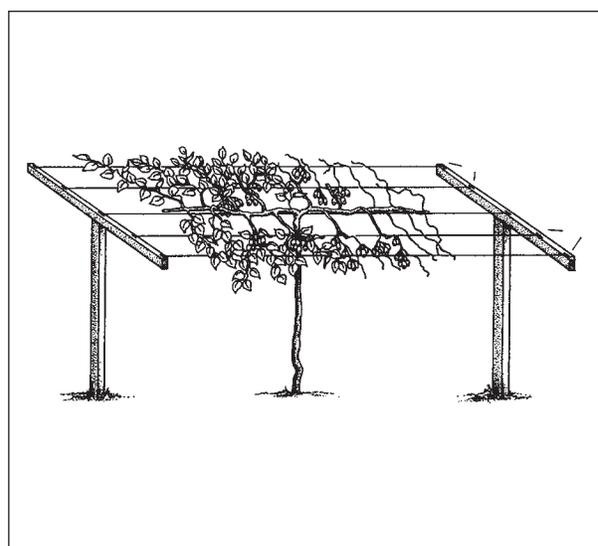


Figure 12.2. Kiwi vines trained to a pergola (T-bar) trellis. (Courtesy of Oregon State University.)

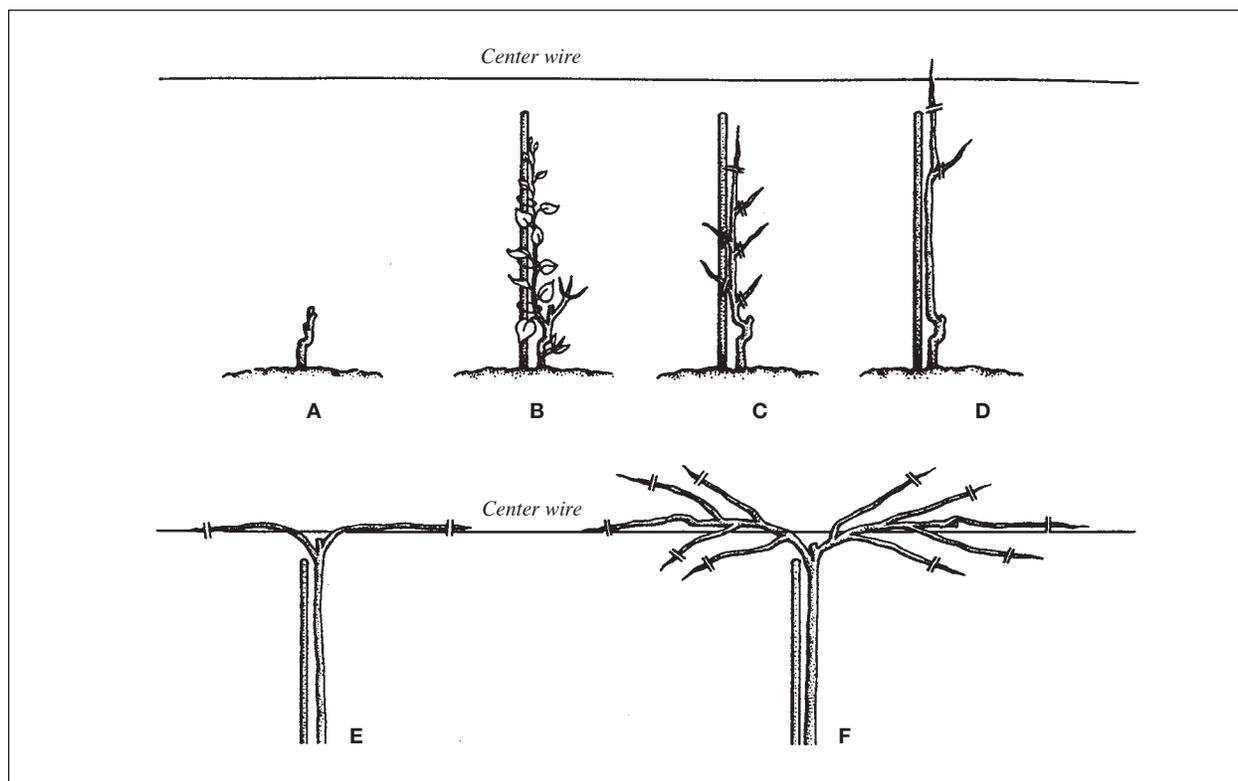


Figure 12.3. The first two years of training a kiwi vine. (Courtesy of Oregon State University.)

- (A) Prune to two buds at planting.
 (B) Train one shoot as trunk, remove all others (growing season, year 1).
 (C) Head back trunk as shoot growth at terminal loses vigor (growing season, year 1).
 (D) Continue to remove lateral shoots, let trunk grow beyond wire, then head to just below top wire (growing season, year 1).
 (E) Choose two shoots to form cordons (lateral trunks). Head back to $\frac{1}{4}$ inch diameter in dormant season (growing season, year 1).
 (F) Shoot growth, year 2. Pruning cuts in dormant season of year 2 also are shown by //.

Nursery Sources for Tree Fruit Plants

Adams County Nursery, Inc. ♦

26 Nursery Road
P.O. Box 108
Aspers, PA 17304
Phone: 717-677-8105
<http://www.acnursery.com/>

Boyer Nursery and Orchards ♦

405 Boyer Nursery Road
Biglerville, PA 17307
Phone: 717-677-8558
<http://www.boynurseries.com/index.htm>

C & O Nursery Co.
Box 116
Wenatchee, WA 98807-0116
<http://www.c-onursery.com/>

Columbia Basin Nursery
P.O. Box 458
18936 Highway 28 West
Quincy, WA 98848
<http://www.cbnllc.com/>

Cummins Nursery
4233 Glass Factory Bay
Geneva, NY 14456
Phone: 315-789-7083
<http://www.cumminsnursery.com/>

Johnson's Orchard & Nursery
Route 5, Box 29-J
Ellijay, GA 30540

Miller Nurseries
5060 West Lake Rd.
Canandaigua, NY 14424
Phone: 800-836-9630
<http://www.millernurseries.com/>

Stark Bro's Nurseries & Orchards Co. ♦
P.O. Box 1800
Louisiana, MO 63353
<http://www.starkbros.com/>

Treco Inc.
P.O. Box 98
10906 Monitor-McKee Rd. NE
Woodburn, OR 97071
<http://www.treco.nu/>

Wafler Nurseries ♦

10662 Slaght Road
Wolcott, NY 14590
Phone: 877-397-0874
<http://www.waflernursery.com/>

Van Well Nursery, Inc.
2821 Grant Road
P.O. Box 1339
Wenatchee, WA 98807
Phone: 800-572-1553
<http://www.vanwell.net/>

Dave Wilson Nursery
19701 Lake Road
Hickman, CA 95323
<http://www.davewilson.com/>

Willow Drive Nursery
3539 Road 5 NW
Ephrata, WA 98823
Phone: 888-548-7337
<http://www.willowdrive.com/>

Nurseries That Sell Rootstocks

Agri-Sun Nursery
6910 E. Clarkson Avenue
Selma, CA 93662

Southmeadow Fruit Gardens
P.O. Box 211
10603 Cleveland Avenue
Baroda, MI 49101
Phone: 269-422-2411
<http://southmeadowfruitgardens.com/>

Lawyer Nursery Inc.
950 Highway 200 West
Plains, MT 59859
Phone: 406-826-3881
<http://www.lawyernursery.com/>

Treco Inc.
P.O. Box 98
10906 Monitor-McKee Road NE
Woodburn, OR 97071

Willow Drive Nursery, Inc.
Route 1, 348-5 NW
Ephrata, WA 98823

Nurseries That Sell Peach Seeds

Driver Nursery, Inc.
2737 North Avenue
Modesto, CA 95358
Phone: 209-523-2811

Haley Nursery Co., Inc.
1207 Haley Road
Smithville, TN 37166
Phone: 800-251-1878

Nurseries That Specialize in Heirloom Varieties

Big Horse Creek Farm
P.O. Box 70
Lansing, NC 28643
<http://www.bighorsecreekfarm.com/>

Boyer Nursery and Orchards ♦
405 Boyer Nursery Road
Biglerville, PA 17307
Phone: 717-677-8558
<http://www.boynurseries.com/index.htm>

Lawson's Nursery
2730 Yellow Creek Road
Ball Ground, GA 30107-3142
Phone: 770-893-3142

Southmeadow Fruit Gardens
P.O. Box 211
10603 Cleveland Avenue
Baroda, MI 49101
Phone: 269-422-2411
<http://southmeadowfruitgardens.com/>

Nursery Sources of Berry Plants

As a service to our readers, we have cross-referenced various small fruit crops with the nurseries where they may be purchased. No endorsement of the nurseries is intended, and if any nurseries are not included, it means we have not received a recent catalog.

Aarons Creek Farms, Inc.
380 Greenhouse Drive
Buffalo Junction, VA 24529
Phone: 800-487-8502
Fax: 434-374-2055
E-mail: info@strawberryplants.com
Web site: <http://www.strawberryplants.com/>

Beilstein's Blueberry Patch
1285 W. Hanley Road
Mansfield, OH 44904
Phone: 419-884-1797
Fax: 419-884-1798
E-mail: sbeilstein@neo.rr.com

Boston Mountain Nurseries
20189 N. Highway 71
Mountainburg, AR 72946
Phone and fax: 479-369-2007
E-mail: pense@valuelinx.net
Web site: <http://www.alcasoft.com/bostonmountain/>

Daisy Farms
28355 M-152
Dowagiac, MI 49047
Phone: 269-782-6321
Fax: 269-782-7131
E-mail: daisyfarms@beanstalk.net
Web site: <http://www.daisyfarms.net/>

DeGrandchamp's Farm
76241 14th Avenue
South Haven, MI 49090
Phone: 269-637-3915 or 1-888-483-7431
Fax: 269-637-2531
E-mail: info@degrandchamps.com
Web site: <http://www.degrandchamps.com/>

Direct Gardening, Division of House of Wesley
1704 Morrissey Drive
Bloomington, IL 61704
Phone: 309-662-7943
E-mail: customerservice@directgardening.com
Web site: <http://www.directgardening.com/>

Edible Landscaping
361 Spirit Ridge Lane
Afton, VA 22920
Phone: 434-361-9134
Fax: 434-361-1916
E-mail: info@ediblelandscaping.com
Web site: <http://www.eat-it.com/>

Fall Creek Farm and Nursery, Inc.
39318 Jasper-Lowell Road
Lowell, OR 97452
Phone: 541-937-2973
Fax: 541-937-3373
E-mail: blueberries@fallcreeknursery.com
Web site: <http://www.fallcreeknursery.com/>

Finch Blueberry Nursery
P.O. Box 699
Bailey, NC 27807
Phone: 800-245-4662
Fax: 252-235-2411
E-mail: finchnursery@bbnp.com
Web site: <http://www.danfinch.com/>

Hartmann's Plant Co.
P.O. Box 100
Lacota, MI 49063-0100
Phone: 269-253-4281
Fax: 269-253-4457
E-mail: info@hartmannsplantcompany.com
Web site: <http://www.hartmannsplantcompany.com/>

Indiana Berry and Plant Co.
5218 West 500 South
Huntingburg, IN 47542
Phone: 800-295-2226
Fax: 812-683-2004
E-mail: berryinfo@inberry.com
Web site: <http://www.inberry.com/>
(Also carries an interesting assortment of berry-related items such as promotion supplies, picking containers, and bird repellent devices; carries some equipment)

Jersey Asparagus Farms, Inc.
105 Porchtown Road
Pittsgrove, NJ 08318
Phone: 800-499-0013 or 856-358-2548
Fax: 856-358-6127
E-mail: jaf@jafinc.com
Web site: <http://www.jerseyasparagus.com/>

J. W. Jung Seed Company.
335 S. High Street
Randolph, WI 53957-0001
Phone: 920-326-5672
Fax: 800-247-5864
E-mail: info@jungseed.com
Web site: <http://www.jungseed.com/>

Lassen Canyon Nursery, Inc.
1300 Salmon Creek Road
Redding, CA 96003
Phone: 530-223-1075
Fax: 530-223-6754
E-mail: info@lassencanyonnursery.com
Web site: <http://www.lassencanyonnursery.com/>

Mellinger's, Inc.
2310 W. South Range Road
North Lima, OH 44452-9731
Phone: 330-549-9861
Fax: 330-549-3716
E-mail: mellgarden@mellingers.com
Web site: <http://www.mellingers.com/>

Miller Nurseries
5060 West Lake Road
Canandaigua, NY 14424-8904
Phone: 800-836-9630
Fax: 585-396-2154
E-mail: info@millernurseries.com
Web site: <http://www.millernurseries.com/>

Nourse Farms, Inc.
41 River Road
S. Deerfield, MA 01373
Phone: 413-665-2658
Fax: 413-665-7888
E-mail: info@noursefarms.com
Web site: <http://www.noursefarms.com/>

Southmeadow Fruit Gardens
 10603 Cleveland Avenue
 P.O. Box 211
 Baroda, MI 49101
 Phone: 269-422-2411
 Fax: 269-422-1464
 E-mail: smfruit@aol.com
 Web site: <http://www.southmeadowfruitgardens.com/>

St. Lawrence Nurseries
 325 State Highway 345
 Potsdam, NY 13676
 Phone: 315-265-6739
 E-mail: trees@sln.potsdam.ny.us
 Web site: <http://www.sln.potsdam.ny.us/>

Tripple Brook Farm
 37 Middle Road
 Southampton, MA 01073
 Phone: 413-527-4626
 Fax: 413-527-9853
 E-mail: catalog-request@tripplebrookfarm.com
 Web site: <http://www.tripplebrookfarm.com/>

SOURCE	Strawberry		Blueberry	Raspberry				Blackberry	Gooseberry	Currants	Elderberry	Hardy Kiwi	Cranberry	Misc
	Dormants	Plugs		Red	Gold	Black	Purple							
Aarons Creek		■												
Beilstein's			■	■										
Boston Mountain			■	■		■		■	■	■	■			
Daisy Farms	■		■	■		■	■							
DeGrandchamp's			■											
Direct Gardening	■		■	■	■	■		■	■	■	■	■		■
Edible Landscaping	■		■	■	■			■	■	■	■	■	■	■
Fall Creek			■											
Finch			■											
Hartmann's*	■		■	■	■	■	■	■	■	■	■	■	■	■
Indiana Berry*	■		■	■	■	■	■	■	■	■	■	■	■	■
Jersey Asparagus	■		■	■	■		■	■						
J. W. Jung	■		■	■	■	■	■	■	■	■	■	■		■
Lassen Canyon	■													
Mellinger's	■		■	■	■	■	■	■	■	■	■	■	■	■
Miller*	■		■	■	■	■	■	■	■	■	■	■	■	■
Nourse Farms	■		■	■	■		■	■	■	■				
Southmeadow									■	■				■
St. Lawrence			■	■			■							■
Tripple Brook	■		■								■	■	■	■

*Also carries bird control supplies.

Suggested References for the Home Fruit Gardener

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- Childers, N. F., J. R. Morris, G. S. Sibbett. 1995. *Modern Fruit Science*. Horticultural Publications, 3906 NW 31 Place, Gainesville, FL 32606.
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- Ellis, M. A., R. H. Converse, R. N. Williams, and B. Williamson. 1991. *Compendium of Raspberry and Blackberry Diseases and Insects*. The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, MN 55121.
- Forshey, C. G., D. C. Elfving, and R. L. Stebbins. 1992. *Training and Pruning Apple and Pear Trees*. American Society for Horticultural Science, 600 Cameron St., Alexandria, VA 22314-2562 Phone: 703-836-4606
- Gordon, D. 1995. *Growing Fruit in the Upper Midwest*. University of Minnesota Press, 2037 University Ave. Southeast, Minneapolis, MN 55414.
- Hill, L. 1992. *Fruits and Berries for the Home Garden*. Storey Publishing, LLC, North Adams, MA, <http://www.storey.com/>. 280 pp.
- Hogmire, Jr., H. W. 1994. *Mid-Atlantic Orchard Monitoring Guide*. NRAES, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853-5701.
- Jackson, D. I., and N. E. Looney, eds. 1999. *Temperate and Subtropical Fruit Production*. CABI Publishing, New York, NY.
- Jones, A. L., and H. S. Aldwinkle. 1990. *Compendium of Apple and Pear Diseases*. The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, MN 55121.
- Jones, A. L., and T. B. Sutton. 1996. *Diseases of Tree Fruits in the East*. Michigan State University. 95 pp.
- Maas, J. L., ed. 1984. *Compendium of Strawberry Diseases*. The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, MN 55121. 138 pp.
- North American Strawberry Growers Association. *Strawberry Eats and Treats: The Guide to Enjoying Strawberries*. 526 Brittany Drive, State College, PA 16803-1420.
- NRAES Bramble Guide*. 1989. Natural Resource, Agriculture, and Engineering Service (NRAES), Cooperative Extension, P.O. Box 4557, Ithaca, NY 14852-4557. <http://www.nraes.org/>. 189 pp.
- NRAES Highbush Blueberry Guide*. 1992. 1992. Natural Resource, Agriculture, and Engineering Service (NRAES), Cooperative Extension, P.O. Box 4557, Ithaca, NY 14852-4557. <http://www.nraes.org/>. 200 pp.
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- Page, S., and J. Smillie. *Orchard Almanac: A Seasonal Guide to Healthy Fruit Trees*. AgAccess, P.O. Box 2008, Davis, CA 95617.
- Pearson, R. C., and A. C. Goheen. 1988. *Compendium of Grape Diseases*. The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, MN 55121.
- Poe, R. H. 1997. *Deer Proofing Your Yard and Garden*. Storey Publishing, LLC, North Adams, MA. <http://www.storey.com/>. 160 pp.
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- Reisch, B. I., D. V. Peterson, R. M. Pool, and M. H. Martens. 1993. *Table Grape Varieties for Cool Climates*. The Resource Center, Cornell University, P.O. Box 3884, Ithaca, NY 14852-3883. <http://www.cce.cornell.edu/store/customer/home.php/>. 9 pp.
- Reisch, Bruce I., Robert M. Pool, David V. Peterson, Mary-Howell Martens, and Thomas Henick-Kling. 1993. *Wine and Juice Grape Varieties for Cool Climates*. The Resource Center, Cornell University, P.O. Box 3884, Ithaca, NY 14852-3883. <http://www.cce.cornell.edu/store/customer/home.php/>. 19 pp.
- The Resource Center, Cornell University, P.O. Box 3884, Ithaca, NY 1452-3883. Phone 607-255-2080, Fax 607-255-9946. E-mail resctr@cornell.edu. Website <http://www.cce.cornell.edu/store/customer/home.php>
- Westwood, M. N. 1993. *Temperature Zone Pomology*. Timber Press, 9999 S. W. Wilshire, Portland, OR 97225.

Sources for Reducing Pesticide Use in Orchards ♦

These include integrated pest management (IPM) practices, organic methods, and other alternative strategies.

Coleman, E. 1995. *The New Organic Grower: A Master's Manual of Tools and Techniques for the Home and Market Gardener*. Chelsea Green Publishing Company, White River Junction, VT 05001. 340 pp.

Ellis, B. W., and F. M. Bradley, eds. 1992. *The Organic Gardener's Handbook of Natural Insect and Disease Control*. Rodale Press, Book Readers Service, 33 East Minor St., Emmaus, PA 18098.

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Hogmire Jr., H. W. 1994. *Mid-Atlantic Orchard Monitoring Guide*. NRAES, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853-5701.

Integrated Pest Management for Apples and Pears. IPM Education and Publications, Division of Agriculture and Natural Resources, University of California, 6701 San Pablo Ave., Oakland, CA 94608-1239.

Integrated Pest Management for Strawberries in the Northeastern United States. Bulletin Center, Cottage A, Thatcher Way, University of Massachusetts, Amherst, MA 01003. 52 pp.

Lind, K., G. Lafer, K. Schloffer, G. Innerhofer, and H. Meister. 2003. *Organic Fruit Growing*. CABI Publishing, Cambridge, MA. 281 pp.

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Williams, R. N. 1995. *Integrated Pest Management (IPM), Insect Management Guidelines for Grapes in Ohio*. Department of Entomology, Ohio State University, Wooster, Ohio.

Organizations

Backyard Fruit Growers. Contact: Chris and Sarah Manning, 5276 Steelville Road, Steelville, PA 19310. <http://www.sas.upenn.edu/~dailey/Main.htm>.

The Cooperative Extension System. An educational service supported by county, state, and federal monies. It provides educational programs in agriculture, home economics, and natural resources. There is an office in nearly every county in the United States. In Pennsylvania, many counties offer Master Gardener programs that provide training and information about a variety of home horticulture plants in return for volunteer service to the public to train other individuals. Penn State Cooperative Extension offices are listed on the inside back cover.

The International Ribes Association. A clearinghouse of information for amateurs about gooseberry and currant culture. For further information, write to The International Ribes Association, 18200 Mountain Vies Road, Booneville, CA 95415 or call 707-895-2514.

North American Bramble Growers Association. Contact: Debby Wechsler, 1138 Rock Rest Rd., Pittsboro, NC 27312. E-mail: nabga@mindspring.com. Phone: 919-542-3687. Fax: 919-542-4037. <http://www.hort.cornell.edu/grower/nabga/>.

North American Fruit Explorers, Inc. (NAFEX). 1716 Apples Road, Chapin, IL 62628. Phone 217-245-7589. <http://www.nafex.org/>.

North American Strawberry Growers Association. Contact: Patricia E. Heuser, 526 Brittany Drive, State College, PA 16803-1420. Phone: 814-238-3364. Fax: 814-238-7051. E-mail: info@nasga.org. <http://www.nasga.org/>.

State Horticultural Association of Pennsylvania. A nonprofit organization founded in 1858 and devoted to education on fruit production. This society is for the commercial fruit grower or the serious amateur. It cosponsors an annual educational meeting in Hershey, Pennsylvania, publishes a monthly magazine, and holds annual summer tours. Membership information can be obtained by writing to Mrs. Maureen Irving, State Horticultural Association of Pennsylvania, 697 Mountain Rd., Orrtanna, PA 17353 or by calling 717-677-4184.

Sources for Wildlife Damage Control Materials

Repellents that are registered for use against wildlife species are sometimes difficult to find in garden stores. These suppliers might help you to find a store in your area that sells the product. Many garden supply stores carry cage or box traps for live-trapping wildlife. We have included a short list of manufacturers to contact if traps are not locally available. We regret that some companies might not be included in this compilation; we encourage those who were missed to send us their catalog for a future revision. No discrimination or endorsement is intended.

Bird Repellents

Rejex-it
RJ Advantage, Inc.
501 Murray Road
Cincinnati, OH 45217-1014
Phone: 513-242-3300

Mammal Repellents

4 the Squirrels Repellent
B & G Chemicals and Equipment Co., Inc.
10539 Maybank
Dallas, TX 75354-0428
Phone: 800-345-9387

Bonide Rabbit-Deer Repellent and Bulb Saver
Bonide Products, Inc.
2 Wurtz Avenue
Yorkville, NY 13495
Phone: 315-736-8231

Deer-Off Deer Repellent
Deer-Off, Inc./Woodstream
69 N. Locust Street
Lititz, PA 17543

Detour Rabbit and Deer Repellent
Farnam Companies, Inc.
301 Osborn Road
Phoenix, AZ 85013
Phone: 602-285-1660

Gustafson 42-S Thiram Fungicide and Repellent
Gustafson, Inc.
Box 660065
Dallas, TX 75266
Phone: 214-985-8877

Hinder
Pace International, Ltd.
P.O. Box 558
500 7th Avenue South
Kirkland, WA 98083
Phone: 800-247-8711

Hot Sauce Animal Repellent
Miller Chemical and Fertilizer Corp.
Box 333
Hanover, PA 17331
Phone: 717-632-8921

Nibble-Not and Chew-Not
Nott Products Co. Inc.
P.O. Box 975
Coran, NY 11727
Phone: 914-635-3243

Rabbit and Dog Chaser
Faesy and Besthoff, Inc.
143 River Road
P.O. Box 29
Edgewater, NJ 07020
Phone: 201-945-6200

Ro-Pel Animal, Rodent, and Bird Repellent
Burlington Scientific Corp.
222 Sherwood Avenue
Farmingdale, NY 11735
516-694-9000

Spotrete-F
W. A. Cleary Corp.
1049 Route 27, P.O. Box 10
Somerset, NJ 08875
Phone: 800-524-1662

Cage or Box Traps

Animal Management, Inc.
720 Eppley Road
Mechanicsburg, PA 17055-9786
Phone: 800-745-8173

H. B. Sherman Traps, Inc.
Box 20267
Tallahassee, FL 32316
Phone: 904-575-8727

Tomahawk Live Trap Co.
Box 323
Tomahawk, WI 54487
Phone: 800-27A-TRAP

Wildlife Management Supplies Critter Control, Inc.
640 Starkweather Road
Plymouth, MI 48170
Phone: 313-453-6300

Useful Web Sites

Penn State

Agricultural Analytical Service Laboratory: <http://www.aasl.psu.edu/>
 College of Agricultural Sciences: <http://www.cas.psu.edu/>
 College of Agricultural Sciences Publications: <http://pubs.cas.psu.edu/>
 Department of Entomology: <http://www.ento.psu.edu/extension/factsheets.html>
 Department of Horticulture Tree Fruit Fact Sheets: <http://hortweb.cas.psu.edu/extension/treefruit/factsheet-list.html>
 Fruit Pathology Fact Sheets: <http://fpath.cas.psu.edu/factsite.html>
 Fruit Pathology Web Site: <http://fpath.cas.psu.edu/>
 Fruit Production for the Home Gardener (formerly Small-Scale Fruit Production Guide): <http://ssfruit.cas.psu.edu/>
 Fruit Research and Extension Center: <http://frec.cas.psu.edu/>
 The Grapevine Newsletter: <http://winegrape.cas.psu.edu/grapevine/index.html>
 Master Gardener Program: <http://hortweb.cas.psu.edu/mg/index.html>
 PA IPM: <http://www.cas.psu.edu/docs/CASDEPT/IPM/index.html>
 Small Fruit Web Site: <http://hortweb.cas.psu.edu/extension/smallfruits/index.htm>
 Tree Fruit Resources: <http://hortweb.cas.psu.edu/extension/treefruit/trfruit.html>

Universities and Organizations

Cornell Cooperative Extension Publications: <http://www.cce.cornell.edu/store/customer/home.php/>

Cornell Nursery Guide for Berry Cultivars: <http://www.fruit.cornell.edu/berries/nurseries/>
 Michigan State Fruit Resources: <http://web1.msue.msu.edu/fruit/>
 Midwest Small Fruit and Grape Net (Ohio State University): <http://www.ag.ohio-state.edu/%7Esfnet/library.html>
 Minor Fruits and Nuts (University of Georgia): <http://pubs.caes.uga.edu/caespubs/pubcd/b992-w.htm>
 National Sustainable Agriculture Info Service: <http://www.attra.org/>
 Organic Apple Disease Spray Guide (Ohio State University): <http://www.caf.wvu.edu/kearneysville/organic-apple.html>
 Pawpaw Information (Kentucky State University): <http://www.pawpaw.kysu.edu/>
 State Horticultural Association of PA: <http://shaponline.org/>
 Texas Plant Disease Handbook (Texas University): <http://plantpathology.tamu.edu/Textlab/index.htm>
 U.S. Department of Agriculture (USDA): <http://www.usda.gov/>
 Virginia Tech Tree Fruit in the Garden: <http://www.ext.vt.edu/pubs/envirohort/426-841/426-841.html>

Organic, Natural, and Sustainable Sites and Products

ATTRA's Considerations in Organic Apple Production: <http://attra.ncat.org/attra-pub/PDF/omapple.pdf>
 Low Input Viticulture and Enology, Inc.: <http://www.liveinc.org/>
 National Organic Standards Board (NOSB): <http://www.ams.usda.gov/nosb/index.htm>

New Farm, Rodale Institute: <http://www.newfarm.org/>

Organic Materials Review Institute (OMRI): <http://www.omri.org/>

PA Association for Sustainable Agriculture (PASA): <http://www.pasafarming.org/>

PA Certified Organic: <http://www.paorganic.org/>

Other Web Sites of Interest

Berry Insect Pests: http://www.isis.vt.edu/~fanjun/text/Link_pest13c.html

North American Fruit Explorers (NA-FEX): <http://www.nafex.org/>

Pacific Northwest Berry and Grape Info Network: <http://berrygrape.oregon-state.edu/>

Tool for Diagnosing Berry Plant Problems: <http://www.hort.cornell.edu/diagnostic/>

Virtual Orchard: <http://www.virtualorchard.net/default.html>

Fruit Growing Supplies

Ambergs Nursery, Inc.: <http://www.ambergs.com/>

A. M. Leonard: <http://www.amleonard.com/>

Gardens Alive! Organic Products: <http://www.gardensalive.com/>

Orchard Equipment and Supply Company (OESCO): <http://www.oescoinc.com/>

Orchard Valley Supply: <http://orchard-valleysupply.com/>

Peaceful Valley Farm and Garden Supply: <http://www.groworganic.com/>

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