Penn State Tree Fruit Production Guide

— 2018–2019 —

PennState Extension

Production Guide Coordinator
K. A. Peter

Horticulture
R. M. Crassweller, section coordinator
T. A. Baugher, R. P. Marini, and J. R. Schupp

Entomology
G. Krawczyk, section coordinator
D. J. Biddinger

Pollination and Bee Management
D. J. Biddinger
J. Hopwood, E. Mader, E. May, and M. Vaughan, Xerces Society

Plant Pathology and Nematology
K. A. Peter, section coordinator
B. L. Lehman

Wildlife Resources
M. C. Brittingham

Pesticide Safety
Penn State Pesticide Education Program

Harvest and Postharvest Handling
R. M. Crassweller, J. R. Schupp

Cider Production and Food Safety
L. F. LaBorde

Orchard Budgets
J. K. Harper, L. F. Kime

Farm Labor Regulations
M. Sean High, R. H. Pifer

Marketing
K. M. Kelley

Disease, Insect Figures
C. Gregory, C. Jung

Cover Photo
K. A. Peter

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Contents

Introduction

The 2018–2019 edition of the *Penn State Tree Fruit Production Guide* has been updated and revised to make it as accurate as possible for current recommendations and pesticide registrations. The chapters, or parts, are printed on the back cover with tab markings to make them easy to locate. Comprehensive tables of contents are provided at the beginning of each part. Chemical management tables are grouped together to make them easily accessible. New parts were added to Parts I, II, III and IV. The pesticide registration information included in this guide reflects available labels as of September 2017. Always read the current pesticide label before any pesticide application.

OVERVIEW OF THE PENN STATE TREE FRUIT PRODUCTION GUIDE

More than a "spray guide," the *Penn State Tree Fruit Production Guide* collates information on the full range of commercial tree fruit production issues. The guide is revised every two years with input by a score of Penn State faculty members and other consultants. It is meant to be a reference that growers and other fruit industry personnel can turn to often.

Part I, Cultural Information, contains guidelines for establishing an orchard, choosing a tree fruit nursery, caring for nonbearing trees, and maintaining bearing orchards. Included is a listing of nurseries, up-to-date information on disease-resistant cultivars and rootstock availability, cookbook directions for pruning apples to different systems, a listing of apple and peach cultivars, as well as recommendations for summer pruning. Environmental monitoring and frost protection also are discussed in detail. The bee and pollination issues are also discussed in this chapter.

Part II, Diseases Disorders, Pests, and Natural Enemies, stresses the use of all possible control strategies in pest and pesticide management. It contains information on the biology of tree fruit pests and provides control options other than pesticides, including biological, biorational, and cultural pest management tools. In addition, commonly encountered disorders on fruit and leaves are also included.

Part III, Chemical Management, describes the appropriate use of chemicals within integrated pest management (IPM) and pesticide resistant management (PRM) strategies. It also deals with safety, spraying, and the use of individual pesticides.

Part IV, Chemical Management Tables, includes efficacy and timing tables for pesticide use in the various tree fruit crops. It also covers reentry and preharvest intervals and pesticide storage.

Part V, Integrated Pest Management Spray Programs, offers specific suggestions for pesticide use on apples, pears, peaches, nectarines, apricots, cherries, and plums. Remember that the pesticide label is the document that ultimately prescribes how a chemical can be used, and that labels can change. When applying a chemical, have a copy of the label in hand.

Part VI, Harvest and Postharvest Handling, incorporates new information on controlled-atmosphere fruit storage. Also discussed are fruit testing to determine maturity, storage guidelines, and the control of common postharvest fruit disorders and diseases.

Part VII, Cider Production, describes how to make, handle, and market safe, high-quality apple cider. Good manufacturing practices for cider production are described.

Part VIII, Maintaining the Safety of Apples and Apple Products, describes good management practices for growing, packing, and cider production to avoid potential food safety hazards.

Part IX, Farm Management, presents sample budgets for land preparation, orchard planting, and mature orchards, as well as production budgets for fresh-market apples, processing apples, fresh-market peaches, and other tree fruit. Also included in Part IX are updated descriptions of state and federal laws that apply to Pennsylvania fruit producers, including those governing hiring, wages and withholding, worker and community safety, workplace discrimination, and seasonal/migrant labor.

Part X, Marketing, provides basic information about marketing products and is intended to help growers consider whether they are fully utilizing their retail outlet, offering the right products to the right consumers, and using the right promotional strategy.

Appendix: Tree Fruit on the Web is a list of websites with information for growers. A bibliography of important reference texts follows the web listings. Finally, a chart of useful conversions for weights and measures is included.

The IPM Approach

Pesticide use and pest resistance can be decreased—and even eliminated in some cases—by understanding diseases and insects clearly, scouting for pests routinely, and monitoring environmental conditions daily. Effective pesticide programs require careful pesticide applications and correct timing. The combination of thorough orchard monitoring, horticultural controls, and judicious pesticide use is known as integrated pest management (IPM).

IPM is the guiding concept of the 2018–2019 *Penn State Tree Fruit Production Guide.* To make the best use of this guide, study and understand the biology of diseases and insects. Then incorporate horticultural control measures, as well as chemical ones, into your management strategy.

Always read the label before using any chemical on your farm. Application rates in this guide's tables and spray programs are given as amounts of the commercial formulations. Consult the section on pesticide safety (in Part III) or your county extension

office concerning the safe disposal of any chemical mentioned in this publication.

All pesticides discussed in this guide are registered for the indicated crops as of September 2017. Application suggestions are based on the continued registration of each pesticide. If any material listed should lose or change its registered usage, a notice to that effect will be announced. A brief update of the information in this guide may be published in early 2019 and distributed at extension educational meetings and local extension offices. Do not use this publication after the 2019 season.

1 Cultural Information

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ORCHARD ESTABLISHMENT

Site Selection

The success of an orchard is only as good as the planning and site preparation that go into it. This is a simple maxim, but one that is often overlooked by novice and experienced grower alike. Shortcuts and haphazard approaches can result in less-than-ideal growth and other problems during the orchard's life. It is easier to amend a site before the trees are planted than it is once they are in the ground.

To build a good orchard, you need a good foundation. The ideal site is on rolling or elevated land so that cold air can drain during spring frosts. Figure 1-1 shows typical site arrangements. Site A is a warm location that receives more sun. This site is not affected by late spring frosts because cold air drains to lower-lying areas. Site B also misses late spring frosts, but the top may be too cold in winter because of exposure. Site C is similar to site A but colder, warming up later in the spring. Site D is the most susceptible to spring frosts because cold air drains into it from elevated areas. Site E can still be frosty, but the woods act as a windbreak, sheltering this site from prevailing winds. Site F is not desirable because of the dense woods at the base of the hill. Woods can trap cold air and prevent it from draining to lower-lying areas. Site G is similar to site B.

Slope exposure should be considered for its effect on fruit trees as they come out of dormancy. A southern-facing slope warms up faster in spring, while the opposite is true of a northern slope. Eastern-facing slopes are intermediate. In Mid-Atlantic areas, a western-facing slope tends to be windier. Wind can cause spraying problems during the growing season.

While uphill or rolling land is the most desirable, the degree of slope can also limit its suitability. The ideal site has a 4 to 8 percent slope. It may be difficult to operate machinery on slopes of more than 10 percent.

Selecting a site for an orchard involves belowground considerations as well, primarily soil depth and soil texture. An old recommendation for a desirable orchard soil is that it be deep and well drained.

Soil drainage is probably the most important factor in the longevity of an orchard. This is because of the inherent inability of certain types of fruit trees to survive when planted in imperfectly drained soils. Stone fruits (peaches, cherries, and plums) are the most susceptible to poor drainage. Apples are intermediate, and pears can survive on the more poorly drained soils.

Soils are made up of four basic ingredients: mineral elements, pore space, organic matter, and other items consisting mainly of living organisms, including fungi, bacteria, and nematodes. One classification of soils is based on the mineral part of soil and consists of four sizes of particles. Clay particles are the smallest, followed by silt, sand, and gravel. The USDA has devised another system of classifying soil particles. In this system soil is divided into seven categories: clay, silt, and five sizes of sand.

Soil texture is determined by the percentage of sand, silt, and clay in the soil. Arendtsville gravelly loam, Highfield channery silt loam, and Steinsberg sandy loam are examples of soil types having different textures. The structure of a soil is influenced by soil texture and also by the aggregation of small soil particles into larger particles. The amount of aggregation in a soil is strongly influenced by the amount of organic matter present.

The pore spaces in a soil are normally filled with air or water. As the amount of water increases, the amount of air must therefore decrease. The pores of a well-drained soil have certain physical characteristics that, after a period of heavy rainfall, enable water to rapidly drain away and allow air to return to its original percentage.

The amount of organic matter in soil is an important factor in soil structure. Organic matter consists of dead and decomposing plant and animal parts. Living organisms break down plant debris into organic matter.

The cation exchange capacity, or the ability of soil to store cations (positively charged particles) is highly dependent on the amount of clay and organic matter in the soil. Clay and organic matter contain predominantly negatively charged sites that attract cations. Applied nutrients such as ammonium nitrogen, potassium, calcium, and magnesium attach themselves to the negatively charged soil particles. This phenomenon is called cation exchange, and it allows the soil to be a reservoir for plant nutrients.

Before selecting a site for an orchard, consult a county soil map. Soil surveys are available at most Natural Resources Conservation Service offices in Pennsylvania. These publications are valuable in determining if your particular site has the detailed requirements for a long-term viable orchard operation. If your orchard is located outside of Pennsylvania, you may be able to access soil information at the USDA NRCS Web Soil Survey at **websoilsurvey.nrcs.usda.gov**. Another source of soil data is the UC Davis California Soil Resource Lab in collaboration with the USDA Natural Resources Conservation Service located at **casoilresource.lawr.ucdavis.edu/gmap**. You can enter the geographical coordinates of your site and see the satellite image of the field with the soil types mapped. A more detailed site evaluation is probably warranted, and we recommend that a backhoe be used to dig holes 5 to 7 feet deep so that the soil profile can be examined. A test similar to a percolation test used for installing septic systems may also be advisable where internal soil drainage is questionable. Poorly drained soils often have horizontal layers of light-colored material.

Although pH and fertility are often considered important factors for orchard soils, internal soil drainage is actually the most important. Soil fertility can often be corrected by applying fertilizer or by increasing the level of organic matter in the soil. Soil pH can be corrected and is not usually a limiting factor unless a site is highly acid. In this case only the plow layer depth can be corrected with applications of lime.

The best soil is a well-drained loam a minimum of 3 to 4 feet deep. Good drainage, however, should take preference over depth. In Figure 1-1, soils at site B are most likely to be the shallowest

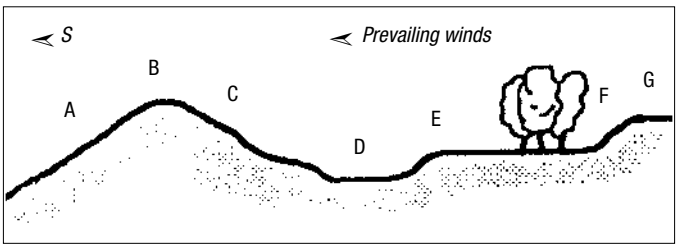


Figure 1-1. *Considerations for orchard sites.*

Table 1-9. Toxicity of insecticides, miticides, fungicides, and blossom- and fruit-thinning agents to bees, and suggested timing of application.

Active ingredients (example trade names)	Highly toxic	Moderately toxic	Slightly toxic	Non-toxic	Guidelines for timing of applications	Residual toxicity
Insecticides						
Abamectin/avermectin (Agri-Mek), ≤0.025 lb ai/A	X				Apply only during late evening	8 hours
Abamectin/avermectin (Agri-Mek), >0.025 lb ai/A	X				Do not apply on blooming crops or weeds	1–3 days
Acetamiprid (Assail)			X		Apply only in late evening, night, or early morning	
Azadirachtin (Azatin, Neemix)		X			Apply only in late evening, night, or early morning	Up to 2 hours
Azinphos-methyl WSP (Guthion)	X				Do not apply on blooming crops or weeds	4 days
Bacillus thuringiensis, Bt (Dipel)				X	Apply at any time	
Bifenthrin (Brigade), < 0.04 lb ai/A	X				Apply only in late evening, night, or early morning	
Bifenthrin (Brigade), 0.04 lb ai/A	X				Apply only in late evening	
Bifenthrin (Brigade), ≥0.06 lb ai/A	X				Do not apply on blooming crops or weeds	Up to 1 day
Buprofezin (Centaur)				X	Apply at any time	Sublethal reproductive effects on adults within 24 hours of application; contaminated pollen lethal to larvae
Carbaryl 4F (Sevin), 1 lb ai/A or less	X				Apply only in late evening	
Carbaryl 4F (Sevin), 2 lb ai/A	X				Do not apply on blooming crops or weeds	
Carbaryl WP (Sevin)	X				Do not apply on blooming crops or weeds	3–7 days
Carbaryl XLR (Sevin), ≤1.5 lb ai/A	X				Apply only in late evening	8 hours
Carbaryl XLR (Sevin), ≥1.5 lb ai/A	X				Do not apply on blooming crops or weeds	Less than 2 days
Chlorantraniliprole (Altacor)				X	Apply only in late evening, night, or early morning	2 hours
Chlorpyrifos EC (Lorsban)	X				Do not apply on blooming crops or weeds	4–6 days
Clothianidin (Clutch)	X				Do not apply on blooming crops or weeds	If applied before bloom, pollen and nectar will be contaminated
Cydia pomonella granulosis virus (Carpovirusine, Cyd-X)				X	Apply at any time	
Cyfluthrin (Baythroid)	X				Do not apply on blooming crops or weeds	Less than 2 days
Deltamethrin (Decis)	X				Apply only in late evening, night, or early morning	4 hours
Diazinon EC or WP	X				Do not apply on blooming crops or weeds	2 days
Dinotefuran (Venom/Scorpion)	X				Do not apply on blooming crops or weeds	If applied before bloom, pollen and nectar will be contaminated
Emamectin benzoate (Proclaim)	X				Apply only in late evening, night, or early morning	2 hours
Endosulfan (Thiodan, Thionex), ≤0.5 lb ai/A		X			Apply only in late evening, night, or early morning	3 hours
Endosulfan (Thiodan, Thionex), >0.5 lb ai/A		X			Apply only in late evening	8 hours
Esfenvalerate (Asana), ≤0.025 lb ai/A	X				Apply only in late evening	
Esfenvalerate (Asana), 0.0375 lb ai/A	X				Do not apply on blooming crops or weeds	1 day
Fenpropathrin (Danitol)	X				Do not apply on blooming crops or weeds	1 day
Flonicamid (Beleaf 50SG)			X		Apply only in late evening, night, or early morning	

Table 1-9. Toxicity of insecticides, miticides, fungicides, and blossom- and fruit-thinning agents to bees, and suggested timing of application (continued).

Active ingredients (example trade names)	Highly toxic	Moderately toxic	Slightly toxic	Non-toxic	Guidelines for timing of applications	Residual toxicity
Flupyradifurone (Sivanto)			X		Apply only in late evening, night, or early morning	
Formetanate HCl (Carzol), ≥1 lb ai/A	X				Apply only in late evening	12 hours
Horticultural mineral oils		X			Apply only in late evening, night, or early morning	3 hours
Imidacloprid (Provado), ≤0.1 lb ai/A	X				Do not apply on blooming crops or weeds	8 hours; if applied before bloom, pollen and nectar will be contaminated
Indoxacarb (Avaunt)	X				Apply only in late evening, night, or early morning	3 hours
Kaolin clay (Surround)				X	Apply at any time	
Lambda-cyhalothrin (Warrior), ≤0.02 lb ai/A	X				Apply only in late evening	
Lambda-cyhalothrin (Warrior), ≥0.03 lb ai/A	X				Do not apply on blooming crops or weeds	1 day
Lime sulfur				X	Apply at any time	Repellent for up to 7 days
Malathion EC	X				Apply only in late evening	6 hours
Malathion ULV, ≤3 fl oz ai/A	X				Apply only in late evening, night, or early morning	3 hours
Malathion ULV, 8 fl oz ai/A	X				Do not apply on blooming crops or weeds	6 days
Malathion WP	X				Do not apply on blooming crops or weeds	2 days
Methidathion (Supracide)	X				Do not apply on blooming crops or weeds	3 days
Methomyl (Lannate)	X				Apply only in late evening	2 hours
Methoxyfenozide (Intrepid)				X	Apply at any time	
Novaluron (Rimon)	X	X			Do not apply on blooming crops or weeds	Sublethal reproductive effects on adults within 24 hours of application; contaminated pollen lethal to larvae
Oxamyl (Vydate), ≤ 0.5 lb ai/A	X				Apply only in late evening, night, or early morning	3 hours
Oxamyl (Vydate), ≥1 lb ai/A	X				Apply only in late evening	8 hours
Permethrin (Ambush, Pounce), 0.1 lb ai/A	X				Do not apply on blooming crops or weeds	Up to 2 days
Phosmet (Imidan), 1 lb ai/acre	X				Do not apply on blooming crops or weeds	Less than 4 days
Potassium salts of fatty acids/soap (M-Pede)				X	Apply at any time	
Pyrethrins (Pyrenonee, Pyrocide)	X				Apply only in late evening, night, or early morning	2 hours
Pyridaben (Nexter)	X				Apply only in late evening, night, or early morning	2 hours
Pyriproxyfen (Esteem)				X	Apply at any time	Sublethal reproductive effects on adults within 24 hours of application; contaminated pollen lethal to larvae
Rotenone		X			Apply only in late evening, night, or early morning	
Spinosad (Entrust, Success)	X				Apply only in late evening, night, or early morning	2 hours
Spinetoram (Delegate)	X				Apply only in late evening, night, or early morning	2 hours
Spirotetramat (Movento)			X		Apply at any time	
Sulfoxaflor (Closer)	X				Do not apply on blooming crops or weeds; check **isoclasttankmix.com** before tank-mixing.	14 days; if applied before bloom, pollen and nectar will be contaminated
Sulfur				X	Apply at any time	

(continued)

Table 1-9. Toxicity of insecticides, miticides, fungicides, and blossom- and fruit-thinning agents to bees, and suggested timing of application (continued).

Active ingredients (example trade names)	Highly toxic	Moderately toxic	Slightly toxic	Non-toxic	Guidelines for timing of applications	Residual toxicity
Tebufenozide (Confirm)				X	Apply at any time	
Thiacloprid (Calypso)			X		Apply only in late evening, night, or early morning	
Thiamethoxam (Actara)	X				Do not apply on blooming crops or weeds	14 days; if applied before bloom, pollen and nectar will be contaminated
Miticides						
Abamectin/avermectin (Agri-Mek), ≤0.025 lb ai/A	X				Apply only during late evening	8 hours
Abamectin/avermectin (Agri-Mek), >0.025 lb ai/A	X				Do not apply on blooming crops or weeds	1–3 days
Acequinocyl (Kanemite)				X	Apply at any time	
Bifenazate (Acramite)		X			Apply only in late evening, night, or early morning	
Bifenthrin (Brigade), < 0.04 lb ai/A	X				Apply only in late evening, night, or early morning	
Bifenthrin (Brigade), 0.04 lb ai/A	X				Apply only in late evening	
Bifenthrin (Brigade), ≥0.06 lb ai/A	X				Do not apply on blooming crops or weeds	Up to 1 day
Clofentezine (Apollo)				X	Apply at any time	
Dimethoate (Cygon)	X				Do not apply on blooming crops or weeds	3 hours
Etoxazole WDG (Zeal)				X	Apply at any time	
Fenbutatin-oxide (Vendex)				X	Apply at any time	
Fenpyroximate (Portal)				X	Apply at any time	
Formetanate HCl (Carzol), ≥1 lb ai/A	X				Apply only in late evening	12 hours
Hexythiazox (Onager, Savey)				X	Apply at any time	
Horticultural mineral oils		X			Apply only in late evening, night, or early morning	3 hours
Spirodiclofen (Envidor)	X				Do not apply on blooming crops or weeds	Toxic to larvae w/ contaminated pollen
Plant Growth Regulators						
Ethephon (Ethrel)				X	Apply at any time	
NAA/1-Naphthaleneacetic acid				X	Apply at any time	Possibly repellent
Fungicides						
Captan		X				
Lime sulfur, sulfur				X		
Mancozeb				X		
Sterol inhibitors (Indar/Nova/Rally/Rubigan)				X		
Strobilurins (Flint/Sovran)				X		

Insecticide toxicity is generally measured using acute contact toxicity values LD_{50} (the exposure level that causes 50 percent of the population exposed to die). Toxicity thresholds are generally as follows to adult bees and indicated in the table:

- *Highly toxic = acute LD_{50} of < 2/ µg/bee*
- *Moderately toxic = acute LD_{50} of 2–10.99µg/bee*
- *Slightly toxic = acute LD_{50} of 11–100µg/bee*
- *Non-toxic = acute LD_{50} of > 100µg/bee)*

Do not return managed bees to the field until after the time period when residuals remain toxic. Additional label restrictions may apply; see pesticide label.

Source: Adapted from Hooven, Sagili, and Johansen (2013), "How to Reduce Bee Poisoning from Pesticides. Pacific Northwest," Oregon State Extension Publication 591, http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/42829/PNW%20591.pdf; May, Wilson, and Isaacs (2015), "Minimizing Pesticide Risk to Bees in Fruit Crops," Michigan State University Extension Bulletin E3245, http://msue.anr.msu.edu/uploads/236/68700/E-3245.pdf; and unpublished data from Biddinger, Joshi, Rajotte, Shugure, and Phan.

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 may 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 one to five 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 per 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. Do not attempt surgery on cankers encompassing more than half the branch diameter. The diseased tissue often extends beyond the canker margin that is visible at the surface of the bark. To remove diseased tissue and promote maximum healing, take the following steps (Figure 2-2):

1. Place your knife at the top of the canker ½ to 1 inch above visible diseased tissue.
2. Outline the area to be removed, maintaining a ½- 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.
3. 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. Clean out all diseased tissue. Note: If the diseased brown tissue extends into the margin of the cut, expand the margin until only healthy (green) tissue is evident at the margin.
4. Keep the margin of the cut clean; torn tissue will not heal properly.
5. 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.

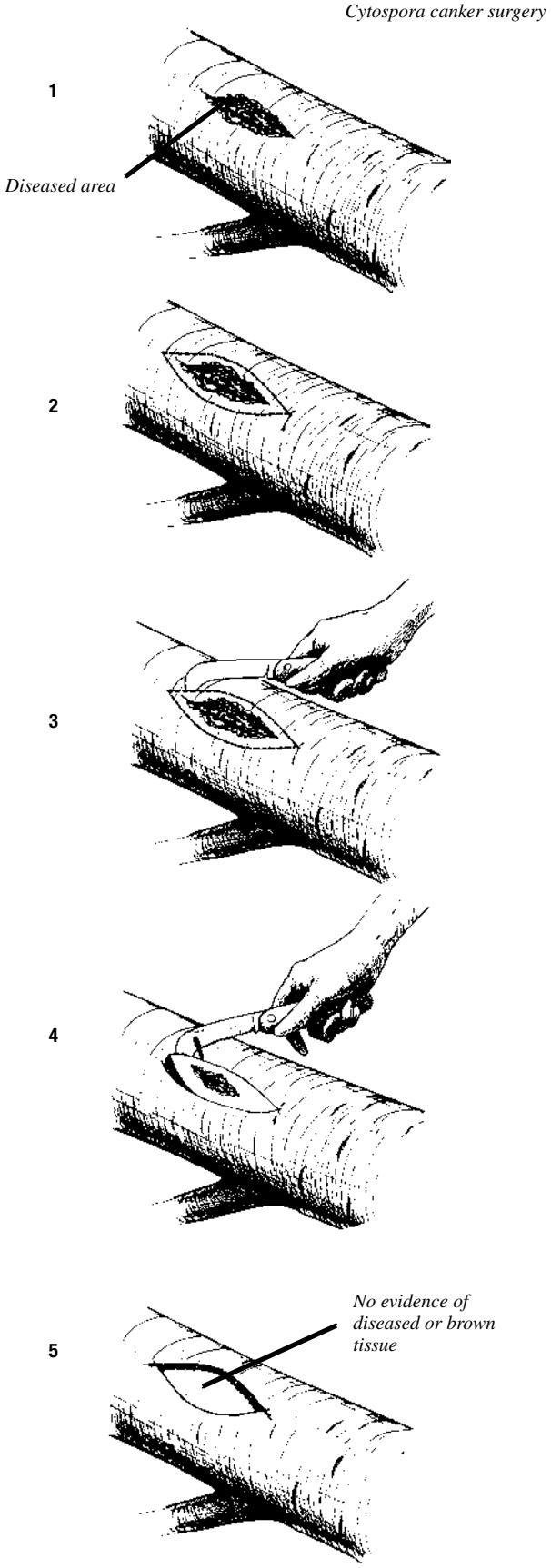


Figure 2-2. *Eradicating Cytospora canker.*

FIRE BLIGHT

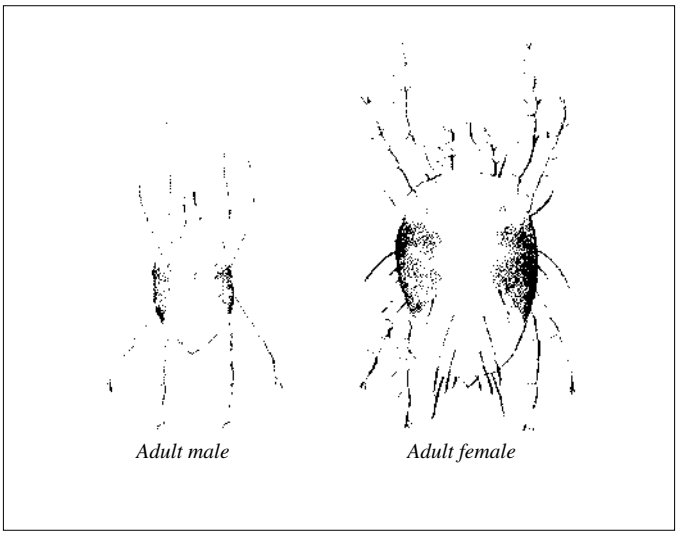
Fire blight is destructive to apples and quince and is the most serious pear disease in the eastern United States. Caused by the bacterium *Erwinia amylovora,* the disease can attack some 75 species of plants of the rose family. Fire blight also occurs frequently on pyracantha, spirea, hawthorn, and mountain ash. In fruit trees, the disease can kill blossoms, fruit, shoots, limbs, and tree trunks. Varieties and rootstocks vary in susceptibility.

Symptoms

The disease gains entry to the tree through two main points, blossoms and new shoots, and often appears first in spring as blossom, fruit spur, and new shoot blight. Infected blossoms wilt rapidly and turn light to dark brown. Bacteria may move through the pedicel to the fruit spur and out into the leaves. Here they follow the midrib and main veins, which soon darken. The leaves wilt, turning brown on apples and quince and dark brown to black on pear. The blighted flowers and 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

The embryo's red eyespots are plainly visible at this time. Newly hatched larvae are round, about the size of the egg, have six legs, and are colorless except for red eyes. Feeding begins at once and the color changes to pale green, brownish-green, or very dark green; two black spots appear, one on each side of the eyespot. Protonymphs, larger and more oval in outline than the larva, have four pairs of legs. They are pale green to dark green, sometimes brownish green. The two spots are larger and more pronounced than in the larvae. Deutonymphs are generally a shade of green, which apparently is influenced by food. The spots are larger and more distinct.



Twospotted Spider Mite

Full-grown females and some immature mites 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 can usually be found about the first week in May. In warm weather, they hatch in five to eight days. A complete generation from egg to adult may require no more than three weeks. There are from five to nine generations in the orchard each season, depending on the weather. In mid- or late summer, when drought and other factors, such as herbicide applications, 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 are usually attacked first; then the mites spread upward and into the tree interior.

Once established, the population may become a serious infestation and may cause injury. Injury to leaves resembles that caused by the European red mite, except that a grayish cast is more prevalent. As indicated previously, these mites also spin a fine silken web over many infested leaves. In the fall the adults either leave the trees and hibernate among weeds, leaves, or in the soil, or remain in the tree.

Monitoring and management

Twospotted spider mites should be monitored and managed in much the same way as European red mites. Counts of the two

Table 2-13. Degree-day look-up table for tufted apple bud moth (lower threshold 45°F, upper threshold 91°F) and Oriental fruit moth (45–90°F) (horizontal cut off, using sine-wave curve).

To find the total degree-days for a day, locate the minimum and maximum temperatures and follow the rows to where they intersect. For temperatures between those listed, use the nearest shown. Temperatures and degree-days must be determined on a daily basis.

Maximum temperature	Minimum temperature																											
	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80
44	0	0	0	0	0	0	0	0																		
46	0	0	0	0	0	0	0	0	1																	
48	1	1	1	1	1	1	1	1	2	3																
50	1	1	1	1	1	2	2	2	3	4	5															
52	2	2	2	2	2	2	3	3	4	5	6	7														
54	2	3	3	3	3	3	4	4	5	6	7	8	9													
56	3	3	4	4	4	4	5	5	6	7	8	9	10	11												
58	4	4	4	5	5	5	6	6	7	8	9	10	11	12	13											
60	5	5	5	5	6	6	7	7	8	9	10	11	12	13	14	15										
62	6	6	6	6	7	7	8	8	9	10	11	12	13	14	15	16	17									
64	6	7	7	7	8	8	8	9	10	11	12	13	14	15	16	17	18	19								
66	7	8	8	8	9	9	9	10	11	12	13	14	15	16	17	18	19	20	21							
68	8	8	9	9	9	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23						
70	9	9	10	10	10	11	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25					
72	10	10	11	11	11	12	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27				
74	11	11	12	12	12	13	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29			
76	12	12	12	13	13	14	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
78	13	13	13	14	14	15	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
80	14	14	14	15	15	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
82	15	15	15	16	16	17	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
84	15	16	16	17	17	18	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
86	16	17	17	18	18	19	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
88	17	18	18	19	19	20	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
90	18	19	19	20	20	21	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
92	19	20	20	21	21	22	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
94	20	20	21	21	22	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	38	39	40	41
96	21	21	21	22	22	23	24	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
98	21	22	22	22	23	24	24	25	26	27	28	29	30	31	32	33	34	35	36	37	37	38	39	40	41	42
100	22	22	23	23	24	24	25	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	41	42

Diseases and Disorders

2,4-D damage
Rob Crassweller

Alternaria leaf blotch
Keith Yoder

Alternaria fruit rot on cherry
Kari Peter

Anthracnose on peach fruit
John Hartman, University of Kentucky, Bugwood.org

Apple scab on leaves
Kari Peter

Apple scab on fruit
Kari Peter

Apple union necrosis
John Halbrendt

Bacterial canker on a cherry limb
Kari Peter

Bacterial spot on peach fruit
Kari Peter

Diseases and Disorders

Bacterial spot on peach leaves
Kari Peter

Bitter pit
Rob Crassweller

Bitter rot on apple fruit
Kari Peter

Black knot of plum
Joseph O'Brien, USDA Forest Service, Bugwood.org

Black rot on apple fruit
Jim Travis

Frogeye leaf spot on apple leaves
Alan Biggs

Black rot on apple branch
Alan Biggs

Blister spot on Crispin
Alan Biggs

Blossom end rot on apple fruit
Mary Ann Hansen, Virginia Polytechnic Institute and State University, Bugwood.org

III Chemical Management

CONTENTS

TABLES

FIGURES

If Pennsylvania growers are to produce a commercially acceptable and profitable product, they often need to rely on the use of pesticides. For years, many growers in the state have practiced and continue to practice integrated pest management (IPM) where pesticides play a vital role. Applicators must clearly understand their legal obligations when using pesticides. Furthermore, applicators who implement pesticide safety practices and take proper precautions will greatly reduce the possibility of accidents.

USING PESTICIDES SAFELY

General Guidelines for Pesticide Safety

Always read the label!

When pesticides are necessary it is important to make sure many factors are considered when selecting the specific chemical to use. 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. Using a pesticide in a way that is not allowed by the label 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. It is also critical to help ensure pest control without damaging crops. For example, in some cases when rates that are higher than recommended by the label are used, crop injury occurs. Proper use will ensure that chemical residues on crops and livestock 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 personal protective equipment, PPE) according to instructions on the pesticide label.
- Minimum clothing requirements are long pants, long-sleeved shirt, socks, and shoes. In addition, the applicator should wear chemically 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 within 24 hours of the application. In addition, if workers/handlers are employed that are covered under the Worker Protection Standard (WPS), this information must be documented at the completion of the application. It must also be available at a central location where employees have unrestricted access to the information.
- Bathe or shower in hot, soapy water after applying pesticides.
- Wash clothing worn while applying pesticides separately from other laundry, in hot, soapy water. Contaminated clothing must be handled with the same precautions as the pesticide itself.

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 × Actual Exposure

Toxicity is a measure of a pesticide's ability to cause injury, which is a property of the chemical itself. Pesticide toxicity is determined by exposing test animals to different dosages of the concentrated 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 the correct PPE. For example, over 90 percent of all pesticide exposure comes from dermal exposure, primarily to the hands and forearms. By wearing chemically resistant gloves, this exposure can be reduced by at least 90 percent. Therefore, by wearing the correct PPE, the hazard of pesticide use can be reduced significantly 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 ocular (eyes). Acute toxicity is determined by examining the dermal toxicity, inhalation toxicity, and oral toxicity of test animals. In addition, the potential for eye and skin irritation are also examined.

Acute toxicity is usually expressed as LD_{50} (lethal dose 50) or LC_{50} (lethal concentration 50) values. 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. The most common practice is for the toxicity of pesticides to be referred to by their LD_{50} values. The LD_{50} of a pesticide is recorded in milligrams of pesticide per kilogram of body weight of the test animal (mg/kg), or in parts per million (ppm). LC_{50} 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 one minute in two years.

The LD_{50} and LC_{50} values are useful in comparing the toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD_{50} 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

customers interact with the products. Do they notice the products, pick them up, and purchase them? Develop some criteria that you will use to determine what niche products to sell.

Value-Added Products

Have you ever sat down and really looked at all you do in a day? Many consumers are "time stressed" and have difficulty finding the energy and time to do even the simplest tasks, such as eating. From the moment they wake up, some consumers are "on the go" and would value goods and services that reduce the amount of preparation or responsibility they must assume to complete tasks. Value-added products are processed products that provide consumers with benefits ranging from saving them time when preparing a meal to presenting them with a product they may not feel comfortable preparing themselves (Figure 10-1).

Specialty Foods

Some consumers are looking for food products that are unique in some way, which, in turn, command a higher retail price. This price premium is justified based on one or more factors, such as ingredients that are highly sought after or only available in limited quantity, quality, or origin; packaging and brand; and how the product is distributed and manufactured. There is not one single definition of what a specialty food is; however, examples include balsamic vinegar and BBQ sauce with fruit flavors, apple cider with additional fruit flavors, baked goods with nontraditional fruit or flavorings, and even fresh fruit newly introduced to the country or region. Depending on the consumers you serve, you may find that specialty foods are a welcome addition to your product assortment. It is important that you clearly convey to your customers why the food item is worth the price you charge.

Figure 10-1. *If you provide value-added light options, don't forget to offer tie-in items. For example, if you provide a recipe and assemble ingredients to make three-berry jam, consider adding canning items to your product mix. This strategy could also increase sales.*

Consumer interest in certain specialty food items is on the rise. According to *Specialty Food Magazine*, nearly every category of specialty foods grew in sales between 2010 and 2012, with a dollar volume increase of 22.1 percent. Many consumers seek specialty food items and ingredients that make their meals unique. Consumers often learn about specialty foods through television cooking shows, related magazines, and restaurant meals, as well as from experiences they have with meals when traveling. Be aware of the top two or three trends and determine whether they would be a good fit for your retail outlet.

Snacks

Selling snack items could be a great opportunity for your business. According to a June 2011 report from the USDA Agriculture Research Service, 90 percent of consumers in the United States snack at least once a daily, and 24 percent of men and 28 percent of women snack two or more times a day. Consumers snack for a variety of reasons, including the grab-and-go lifestyle as well as interest in products that help them control portion size. Numerous products meet consumer demand for mid-meal or meal-replacement products.

According to a webinar conducted by the Hartman Group (**www.hartman-group.com**), consumers have an interest in snacks made with authentic "global" or "ethnic" flavors. If consumers eat foods with these flavors at traditional meal times, then it only makes sense that they would have an interest in snacks with a bit of these spices and tastes. Current popular flavors include:

- Korean/kimchi
- Lebanese/falafel
- British gastro pub/pig trotters

Some of the flavors that we should expect to enjoy in the future include:

- Nordic/caraway rye crisps
- Moroccan/fennel crisps
- Ethiopian/puffed millet
- Cambodian/lychee juice

Certainly, several other snack food trends need to be considered, including:

- "Natural" snacks
- Gluten-free options
- Low-calorie foods

Deciding on the best snack for your business hinges on a few factors:

- Snacks that complement your current offering (e.g., seasoned popcorn, nuts, or other crunch snacks)
- Your core products and what snacks make sense for your business (e.g., if you are known for local fruits, consider offering your own brand of dried apple slices)
- Flavors or cuisine you currently focus on (e.g., incorporating products with Asian spices)
- Your customer base (e.g., tap into a local ethnic community to which new snack offerings may appeal)

Appendix: Tree Fruit on the Web

Bees and Pollination

Eastern Apicultural Society ..... www.easternapiculture.org
Mid-Atlantic Apiculture ..... agdev.anr.udel.edu/maarec
Penn State Center for Pollinator Research ..... .ento.psu.edu/pollinators
Pennsylvania Beekeepers Association ..... www.pastatebeekeepers.org
Pollen and Pollination (PollenPro) ..... www.Pollenpro.net
Pollinator Network ..... www.pollinator.cals.cornell.edu
Virtual Beekeeping Gallery ..... www.beekeeping.com/index.html

Fruit—General

Apple Crop Electronic Discussion Group ..... www.virtualorchard.net/applecrop.html
British Columbia Tree Fruit Information www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/crop-production/tree-fruits
Cherry Marketing Institute ..... www.choosecherries.com
Cornell Fruit Resources ..... www.fruit.cornell.edu
eXtension Apple Site ..... www.extension.org/apples
Fruitipedia ..... www.fruitipedia.com
Horticulture New Zealand ..... www.hortnz.co.nz
Market Diseases of Apples, Pears, and Quinces ..... postharvest.tfrec.wsu.edu/marketdiseases/cork.html
Mid-Atlantic Regional Fruit Loop ..... www.virginiafruit.ento.vt.edu
National Agricultural Statistics Service ..... www.nass.usda.gov
NC140 ..... www.nc140.org
Northwest Pear Bureau ..... www.usapears.com
Ontario Ministry of Agriculture and Rural Affairs
- Commercial Apple Growers Information ..... www.omafra.gov.on.ca/english/crops/hort/apples.html
- Tender Fruit in Ontario ..... www.omafra.gov.on.ca/english/crops/hort/tender_fruit.html

Orange Pippin ..... www.orangepippin.com
Organic Apple Production ucanr.edu/sites/placernevadasmallfarms/files/112366.pdf
Pennsylvania Apple Program ..... pennsylvaniaapples.org
Pollination Information from Summit Tree Sales ..... www.summittreesales.com/resources/pollination-charts
Tree Spacing Template ..... ag.umass.edu/fruit/fact-sheets/apple-scionrootstock-selection-planning
University of Maryland Extension: Grapes and Fruit ..... extension.umd.edu/smallfruit/tree-fruit
University of Georgia Peach Production Information ..... extension.uga.edu/agriculture/ag-fruits-vegetables/peaches
USDA-ARS Appalachian Fruit Research Station ..... www.ars.usda.gov/northeast-area/kearneysville-wv/appalachian-fruit-research-laboratory/innovative-fruit-production-improvement-and-protection
USDA-ARS Wenatchee Tree Fruit Lab ..... www.tfrec.wsu.edu
USDA Economics and Statistics Service ..... usda.mannlib.cornell.edu
Virginia Fruit Website (Virginia Tech) ..... www.virginiafruit.ento.vt.edu
Virtual Orchard ..... www.virtualorchard.net/default.html

Guides/Magazines/ Newsletters

Cornell Scaffolds Newsletter ..... www.scaffolds.entomology.cornell.edu
Good Fruit Grower ..... www.goodfruit.com/index.php
New York Fruit Quarterly ..... nyshs.org/fruit-quarterly
Ontario Fruit Growing Information ..... www.omafra.gov.on.ca/english/crops/index.html#fruit
Penn State Fruit Times Newsletter ..... extension.psu.edu/forage-and-food-crops/fruit
Rutgers Plant and Pest Advisory ..... plant-pest-advisory.rutgers.edu
UMass Fruit Advisor ..... http://fruitadvisor.info/tfruit/clements/index.html

Conversion of Weights and Measures

Dry measure
16 ounces = 1 pound
one ton = 2,000 pounds
1 metric ton = 1.102 ton

Square measure
one acre = 43,560 square feet = 4,840 yards
one square foot = 144 square inches
one square yard = 9 square feet

Weights of liquids
1 gallon water = 8.34 pounds
1 cubic foot water = 62.4 pounds
231 cubic inches = 1 gallon

Linear measure
one foot = 12 inches
one yard = 3 feet = 36 inches
one rod = 16.5 feet = 5.5 yards
one mile = 5,280 feet = 8 furlongs
one rod x 1 mile = 2 acres

Cubic measure
1 cubic foot = 1,728 cubic inches
1 cubic yard = 27 cubic feet
231 cubic inches = 1 gallon

Parts per million (ppm)
ppm = % x 10,000
1% = 10,000 ppm
1 ppm = 1 milligram per liter
= 1 milligram per kilogram
1 ppm = one part per million by weight
= 1 pound in 100,000 gals. of water
100 ppm = 1 pound in 1,000 gals. of water
= 1.6 ounces in 100 gals. of water

Liquid measure
1 tablespoon = 3 teaspoons
1 fluid ounce = 2 tablespoons
1 cup = 8 fluid ounces = ½ pint
1 pint = 2 cups = 16 fluid ounces
1 quart = 2 pints = 4 cups = 32 fluid ounces
1 gallon = 4 quarts = 8 pints = 16 cups = 128 fluid ounces

Miscellaneous facts
diameter = circumference x 0.318
area of a circle = diameter^2 x 0.785
volume of a cylinder = 3.14 x radius^2 x height
volume of a sphere = diameter^3 x 0.524
volume of a cone = area of base x height ÷ 3
1 ppm is approximately:
1 inch in 16 miles or
1 minute in 2 years or
1 ounce in 31 tons or
1 cent in $10,000

METRIC WEIGHTS AND MEASURES

Centimeters	Inches	Feet
1.00	0.394	0.0328
2.54	1.000	0.083
30.48	12.000	1.000

Meters	Yards	Inches
1.000	1.093	39.37
0.914	1.000	36.000

Kilometers	Miles
1.000	0.621
1.609	1.000

Acres	Hectares
1.000	0.405
2.471	1.000

Grams	Ounces	Pounds
1.00	0.035	0.002
28.35	1.000	0.063
453.59	16.000	1.000
1000.00	35.274	2.205

Kilograms	Ounces	Pounds
1.000	35.274	2.205
0.028	1.000	0.063
0.454	16.000	1.000

Liters	Pints	Quarts	Gallons
1.000	2.113	1.057	0.264
0.473	1.000	0.500	0.125
0.946	2.000	1.000	0.250
3.785	8.000	4.000	1.000

Milliliter	Teaspoon	Tablespoon	Fluid ounce	Cup
1.000	0.200	0.064	0.032	0.004
15.000	3.000	1.000	0.500	0.063
240.000	48.000	16.000	8.000	1.000
30.000	6.000	2.000	1.000	0.125

COMMON METRIC EQUIVALENTS

Metric	U.S.	
Millimeter	0.039	inches
Centimeter	0.39	inches
Meter (100 cm)	39.4	inches = 3.28 feet
Kilometer (1,000 m)	0.62	miles
Square centimeter	0.155	square inches
Square meter	1.2	square yards
Hectare (10,000 sq m)	2.471	acres
Square kilometer (100 ha)	247	acres
Gram	0.035	ounces
Kilogram (1,000 g)	2.2	pounds
Ton (metric) (1,000 kg)	1.1	tons (U.S.)
Milliliter	0.032	fluid ounce
Liter (1,000 ml)	1.056	quarts = 2.1 pints
Cubic meter (1,000 l)	264.17	gallons (U.S.)

U.S.	Metric	
Inch	2.54	centimeters
Foot (12 in.)	30.5	centimeters
Mile (5,280 ft.)	1.6	kilometers
Square inch	6.5	square centimeters
Square foot (144 sq. in.)	930	square centimeters
Square yard (9 sq. ft.)	0.84	square meters
Acre (43,560 sq. ft.)	0.405	hectares
Ounce	28.3	grams
Pound (16 oz.)	453.5	grams = 0.454 kilograms
Tablespoon (3 teaspoons)	14.79	milliliters
Fluid ounce (2 tablespoons)	29.6	milliliters
Pint (2 cups)	0.473	liters
Quart (4 cups)	0.946	liters
Gallon (U.S.) (4 quarts)	3.8	liters

Penn State Tree Fruit Production Guide 2018–2019

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