CHAPTER 8
Using Pesticides in Small Fruit Production

Pesticide Application

Pesticide Labels

A pesticide label is a legal document. Each user is required by law to apply any pesticide only in a manner that is consistent with label directions. If for any reason, use rates or application guidelines presented in this publication or other references are not consistent with instructions on the label, users are reminded that the label takes precedence and must be obeyed. It is, however, LEGAL to apply pesticides at lower concentrations, at lower rates, and less frequently than the label instructs. In some state, including Ohio, pesticides may be used legally to control pests not named on the label if the target crop and site (for example, field vs. greenhouse) is listed on the label and other restrictions are observed. Growers can check with their state department of agriculture officials to clarify this policy in their state.

It is ILLEGAL to apply pesticides using less water than the label instructs (increasing the concentration), at a higher rate per acre than the label instructs, or more frequently than the label instructs. Specified preharvest intervals (minimum number of days between the last application and crop harvest) also must be obeyed.

Pesticide Formulations

Pesticide products contain at least one active ingredient that is combined with liquid or solid carriers to produce formulations that are safer or more practical to apply than the active ingredient alone. Common formulations include wettable powders, liquid concentrates, emulsifiable concentrates, dry flowable formulations, flowable liquids, soluble powders, dusts, and granules.

Wettable powders (WP) are dry formulations of pesticides that are to be mixed with water for application. The toxicant is mixed with specific powders; wetting agents are added to make the mixture blend readily with water. Wettable powders form a suspension that must be kept agitated in the spray tank. Sprays prepared from wettable powders are less likely than other sprays to cause injury to fruit or foliage.

Liquid concentrates (L or LC) are formulations containing toxicants that are water soluble. No emulsifying agents or organic solvents are required. ***Note:*** The designations L and LC are sometimes used by formulators on emulsifiable concentrates that are not water soluble.

Emulsifiable concentrates (EC) contain a pesticide and an emulsifying agent in a solvent. ECs form suspensions when they are diluted with water for application as sprays. They leave much less visible residue than WP formulations but are more likely to injure fruit and foliage.

Dry Flowable (DF) formulations are similar to wettable powders, but the powders (clay particles) are formed into small particles. They do not readily cake together, so they flow easily from the product container. Another name for this type of formulation is **Water Dispersible Granule** (WDG) (WG).

Flowable (F) formulations are a liquid or viscous concentrate of suspended pesticide in water. They usually cause less injury to fruit and foliage than EC formulations and generally, but not always, are as safe as WP formulations.

Soluble powders (SP) are powder formulations that dissolve in water. A few pesticides and many fertilizers are prepared as soluble powders.

Dusts (D) are usually made by mixing a chemical toxicant with finely ground talc, clay, or dried plant materials.

Granules (G) are formed by saturating an inert material such as sand or clay with a pesticide. Particles (granules) range in size from 30 to 60 mesh. Granules are applied as dry material, usually to soil or water.

Spray Adjuvants

Several types of additives are available to improve the effectiveness of spray applications. Known collectively as adjuvants, they include:

Activators — Materials that increase the effect of a pesticide by increasing the penetration of a spray solution through leaf hairs or a waxy cuticle and into a leaf or fruit.

Acidifiers — Materials that lower the pH of alkaline spray water to reduce the potential breakdown of certain pesticides in the spray tank.

Buffers — Materials that change the pH of spray water, then hold it at the desired degree of acidity.

De-Foamers — Materials that, when added to the spray tank, break down or prevent the formation of foam.

Elasticizers or Drift Control Agents — Materials that reduce the breakup of spray droplets into very fine particles and thereby minimize drift.

Surfactants, Spreaders, and Wetting Agents — Different names for products that reduce the surface tension around a spray droplet, allowing it to spread out more evenly on the surface of a leaf or fruit.

CAUTION: Some surfactants used in combination with certain pesticides can function as activators, causing plant injury. Consult labels or chemical suppliers for more information.

Stickers — Materials that cause a pesticide to stick to the surface after the spray dries, thereby reducing the potential for loss from rain or overhead irrigation.

Spreader-Stickers — A term commonly misused when referring to a surfactant or spreader. A true spreader-sticker combines the characteristics of a surfactant with that of a sticker.

A note of caution on adjuvants: Do not use an adjuvant with any pesticide without first consulting the specific pesticide label. Improper selection or use can result in crop injury or reduced effectiveness, particularly when adjuvants are mixed with emulsible concentrates.

Conversion of Label Formulation Rates to Actual Toxicant Rates

Pesticide recommendations often list amounts of active ingredient for use on a per-acre or per-hectare basis. This is done so that a single listing summarizes the correct use rate for several formulations of a particular pesticide. However, commercial formulations contain formulating agents, not just active ingredients. For example, in a 50% WP (a wettable powder formulation), the active ingredient makes up only 50% of the package's net weight. In a 4 EC formulation, the emulsifiable concentrate contains 4 pounds active ingredient per gallon. For metric conversion, see Tables 8-1, 8-2, and 8-3. Use Table 8-4 to convert from large volumes (100 gallons) to small volumes (1 gallon) of spray mixtures.

Table 8-1. Conversion Factors for Weights and Measures: Proportions.	
Proportions	
Metric	**U.S.**
100 g/ha	1.4 oz/acre
1 kg/ha	0.9 lb/acre
1 ton(metric)/ha	0.446 tons (US)/acre
1 l/ha	0.4 qt/acre
1 kg/1000 l	1 lb/100 gal
g/1000 kg	1 ppm
1 km/hr	0.6 mph
U.S.	**Metric**
1 oz/acre	70 g/ha
1 lb/acre	1.12 kg/ha
1 ton (US)/acre	2.24 tons (metric)/ha
1 fl oz/acre	73 ml/ha
1 gal/acre	9.39 l/ha
l lb/100 gal	1 kg/1000 l
1 ppm	1 g/1000 kg
1 mph	1.6 km/hr

Table 8-2. Conversion Factors for Weights and Measures: Temperatures.	
Temperatures	
Celsius (Centigrade)	**Fahrenheit**
-30	-22
-20	-4
-10	14
0	32
10	50
20	68
30	86
40	104
Fahrenheit	**Celsius (Centigrade)**
0	-18
10	-12
20	-7
30	-1
40	4
50	10
60	16
70	21
80	27
90	32

Table 8-3. Conversion Factors for Weights and Measures: Equivalents.		
Common Equivalents		
	Metric	**U.S.**
Length	1 Millimeter	0.039 in.
	1 Centimeter (10 mm)	0.39 in.
	1 Meter (100 cm)	39.4 in.
	1 Kilometer (1,000 m)	0.62 mi.
Area	1 Square Centimeter	0.155 sq. in.
	1 Square Meter	1.2 sq. yd.
	1 Hectare (10,000 sq m)	2.47 acres
	1 Sq. Kilometer (100 ha)	247 acres
Weight	1 Gram	0.035 ounces
	1 Kilogram (1,000 g)	2.2 pounds
	1 Ton (metric) 1,00 kg)	1.1 tons (US)
Volume	1 Milliliter	0.034 fluid oz.
	1 Liter (1,000 ml)	1.056 quarts
	1 Cubic Meter (1,000 l)	264.17 gal. (US)
	U.S.	**Metric**
Length	1 Inch	2.54 centimeters
	1 Foot (12 in.)	30.5 centimeters
	1 Yard (3 ft.)	0.91 meters
	1 Mile (5,280 ft.)	1.6 kilometers
Area	1 Square Inch	6.5 square centimeters
	1 Square Foot (1.44 sq. in.)	930 square centimeters
	1 Square Yard (9 sq. ft.)	0.84 square meters
	1 Acre (43,560 sq. ft.)	0.405 hectares
	1 Square Mile (640 acres)	259 hectares
Weight	1 Ounce	28.3 grams
	1 Pound (16 oz.)	0.454 kilograms
	1 Ton (US) 2,000 lb.)	0.907 tons (metric)
Volume	1 Tablespoon (3 teaspoons)	14.79 milliliters
	1 Fluid ounce (2 tablespoons)	29.6 milliliters
	1 Cup (8 fl. oz.)	0.237 liters
	1 Pint (2 cups)	0.473 liters
	1 Quart (4 cups)	0.946 liters
	1 Gallon (US) (4 qts)	3.8 liters
	1 Cubic Foot	28.3 liters
Metric Abbreviations: mm - millimeter; cm - centimeter; m - meter; km - kilometer; ha - hectare; mg - milligram; g - gram; kg - kilogram; ml - milliliter; l - liter.		

Table 8-4. Approximate Dilutions for Small Volumes of Spray Mixes.				
Type of Equivalent Rates for Different Quantities of Water				
Formulation	**100 gallons**	**5 gallons**	**3 gallons**	**1 gallon**
Wettable Powder	5 pounds	15 tablespoons	9 tablespoons	3 tablespoons
	4 pounds	13 tablespoons	8 tablespoons	8 teaspoons
	3 pounds	10 tablespoons	6 tablespoons	2 tablespoons
	2 pounds	8 tablespoons	4 tablespoons	4 teaspoons
	1 pound	3 tablespoons	6 teaspoons	2 teaspoons
	1/2 pound	5 teaspoons	1 tablespoon	1 teaspoon
Emulsifiable Concentrate	5 gallons	1 quart	1/4 pints	13 tablespoons
	4 gallons	1-1/2 pints	1 pint	10 tablespoons
	3 gallons	1-1/4 pints	3/4 pint	1/4 pint
	2 gallons	3/4 pint	1/2 pint	5 tablespoons
	1 gallon	1/2 pint	8 tablespoons	3 tablespoons
	1 quart	3 tablespoons	2 tablespoons	2 teaspoons
	1 pint	5 teaspoons	1 tablespoon	1 teaspoon

When necessary, converting recommendations from an active ingredient basis to a formulation basis is quite simple and can be done in the manner described in these examples:

Example 1: A recommendation calls for 1 lb active ingredient per acre and the label calls for a range of 1 to 2 quarts of 4 EC per acre. The number preceding the letters EC tells how many pounds of active ingredient are in a gallon of this product. Remember that there are 8 pints in a gallon. In this case, the lower end of the label range, 1 qt (= 2 pints) of 4 EC, matches the recommendation of 1 pound active ingredient per acre.

The formula for this conversion is:

$$\text{Pints of EC (liquid)} = \frac{\text{amount of active ingredient/gal x 8 (a constant)}}{\text{lbs active ingredient/gal of formulation}}$$

In this example:

$$= \frac{1 \text{ lb} \times 8}{4}$$

$$= 2 \text{ pts (= 1 qt)}$$

Example 2: A recommendation calls for 2.25 lbs of active ingredient per acre and the product that you are using is a 75% WP. Use the following formula to determine how much of the 75% WP formulation to use in order to match the recommended rate.

$$\text{Lbs dry formulation} = \frac{\text{recommended lbs. of active ingredient x 100 \%}}{\text{active ingredient (from label)}}$$

In this example:

$$= \frac{2.25 \times 100}{75} = 3 \text{ lbs.}$$

Calibrating Single Nozzle and Boom Sprayers

Calibration is an essential step in the use of any application equipment. For boom sprayers, a satisfactory spray pattern can be achieved only if the output from individual nozzles does not differ more than 10 percent.

Owner's manuals for sprayers contain specific instructions for calibration and adjustment. A good time to calibrate is in early spring, right after the sprayer has been reassembled and is being readied for early season operations. Check for worn disks and be sure that all nozzle tips have the same angle and capacity rating. The use of wettable powder sprays enlarges nozzle openings, so calibration of each nozzle is essential. Use only clean water when calibrating sprayers. Start the season with a calibrated sprayer, and depending upon the number of gallons sprayed and on the cleanliness of the water you have used, calibrate the sprayer again according to intervals specified in the owner's manual (or no later than halfway through the spray season).

To Check Nozzle Uniformity

1. Hang a container under each nozzle.
2. Operate the sprayer at the usual application pressure until about a pint of water has been collected in each of the containers.
3. Measure and record the output of each nozzle. Measurements can be made by a "dip stick" method, but the use of a graduated cylinder with indications for fluid ounces or milliliters is better.
4. Determine the total output collected from all the nozzles.
5. Determine the average per nozzle by dividing the total output by the number of nozzles on the boom.
6. Multiply the average by 5% (0.05).
7. Subtract this figure from the average. This will be the lower limit of the 10% allowable spread.
8. Add this 5% figure to the average. This will be the upper limit of the 10% allowable spread.
9. The allowable 10% spread is between the low figure (7) and the high figure (8).
10. Compare the output of each nozzle to these low and high figures.
    a. Take apart and clean or replace all nozzles with outputs less than the lower limit.
    b. Replace all nozzles with outputs greater than the upper limit.
11. After cleaning or replacing nozzles, repeat steps 1 through 10 to make sure that your repairs have been successful. Output of new nozzles often fails to match the average of existing nozzles.

Spray Pattern Alignment

Single and double spray patterns can be aligned on a driveway or other flat surface. The edges of a single spray pattern should overlap only very slightly and be offset just enough that the sprays from adjacent nozzles do not collide.

Alignment of nozzles in a double spray or double overlap pattern requires that adjacent nozzle angles be offset slightly so that the area to be treated receives spray from two nozzles, yet the spray patterns do not collide. Remember, a double or overlapping spray pattern will use twice as much spray per acre as a single spray pattern if pump pressure and sprayer speed remain the same. A double spray pattern is most useful for treating dense or tall vegetation.

Calibration of Air-Blast Sprayers

Accurate calibration is the only way to ensure that a sprayer is applying the intended amount of chemical. The operator must know the amount of water that will be applied per unit of area in order to make a proper spray mix. Failure to calibrate a sprayer can result in crop injury, creation of a hazardous situation, and wasted money. Frequent calibration identifies worn nozzles and keeps the operator aware of factors affecting application rate such as travel speed, pressure, and type of nozzle in use.

Precalibration Check

Before calibrating, check the sprayer carefully. Be sure the nozzle tips are clean. Replace all worn or damaged nozzles. Check all hoses and fittings for leaks and aging. Make sure the pressure is constant and the tank is free of dirt and debris.

Determining Sprayer Speed

The rate of travel needed for proper distribution of spray within the canopy can be determined by trial by placing water sensitive spray paper at various locations within the trellis. For proper pesticide application, the air within the canopy must be completely replaced with spray-laden air from the sprayer. In general, a travel speed of 1 to 3 miles per hour has proved to be satisfactory, depending on the size and density of the canopy and capacity of the sprayer.

Before a sprayer can be calibrated, the travel speed must be determined in miles per hour (mph). To determine the travel speed, load the sprayer with clear water and make a test run in the vineyard. Always make the test run in the vineyard or on similar ground as tractor speed changes dramatically from soft to firm surfaces. Set the tractor throttle at a level sufficient to operate the sprayer (pto speed) and select an appropriate gear. Remember or mark these settings. Speed can be calculated by measuring the time required to travel any measured distance. A good conversion factor to remember is that 1 mph = 88 feet/min. A convenient test length is 176 ft because it is a multiple (2X) of 88. The following formula can be used to determine travel speed:

$$\text{Speed (mph)} = \frac{\text{distance (ft)} \times 60}{\text{time (sec)} \times 88}$$

For example, if it requires 60 seconds to travel a measured distance of 176 ft, the travel speed is:

$$\text{mph} = \frac{176 \times 60}{60 \times 88} = \frac{10{,}560}{5{,}280} = 2 \text{ mph}$$

Table 8-5 can be used to determine tractor speed on a course 176 feet long.

Determining Nozzle Flow Rate

To select the correct nozzle and whirlplate sizes, the total gallons per minute (gpm) of output for each particular application must be determined.

To determine the gpm it is necessary to know the travel speed of the sprayer (mph), the gallons per acre (gpa) to be applied, and the spacing (W) between the rows of vines. Once these three variables are measured or selected, a simple equation can be used to calculate the gpm. This equation is for one side of the sprayer manifold only. Double the calculated answer if both sides of the sprayer are to be used. Once the nozzle and whirlplate combinations are determined, place the same size nozzles and whirlplates in both sides of the sprayer if both sides are to be used.

Step 1: Calculate the total gpm required per side:

$$\text{gpm (per side)} = \frac{\text{gpa} \times \text{mph} \times W}{1{,}000}$$

gpm = gallons per minute (per side)
gpa = gallons per acre
mph = speed in miles per hour
W = spacing between rows in feet

Example: You have decided to apply 70 gpa while traveling 2 mph, and the rows are spaced 10 ft apart. What would the gpm per side be?

$$\text{gpm} = \frac{70 \times 2 \times 10}{1{,}000} = \frac{1{,}400}{1{,}000} = 1.4 \text{ gpm}$$

Step 2: Select the correct nozzle-whirlplate combination and operating pressure. Air-blast sprayers normally use disk-core-type cone spray tips. The correct size nozzles and whirlplates can be selected by using a table, which indicates the

Table 8-5. Tractor Speed by Measured Travel.

Time (seconds)	Travel Distance (feet)	Speed (mph)
120	176	1.0
60	176	2.0
50	176	2.4
40	176	3.0
30	176	4.0
20	176	6.0

nozzle size and gallons per minute output at various pressures using specific whirlplates. These tables can be found in the sprayer manufacturer's literature or in nozzle catalogs.

The arrangement of nozzles in the sprayer manifold should be such that approximately *2/3 of the total flow comes from nozzles in the upper half* of the manifold and *1/3 from nozzles in the lower half.* This should be adjusted to provide uniform coverage throughout the canopy. It should provide adequate penetration to the top and center of the trellis while avoiding excess application rate in the lower outside areas.

Step 3. Install the nozzles in their proper outlets. Inspect and clean all nozzles and outlets and determine that the sprayer is operating correctly. Nozzles are a very important part of the sprayer; if any defects or wear are showing in the nozzles, they should be replaced.

Step 4. Measure the total gpm from all the nozzles selected in Step 2. Fill the sprayer tank at least half full. Prime the sprayer system and check all the nozzles to make sure none are clogged or partially clogged. Record the exact level of water in the spray tank. Bring the sprayer up to the desired pressure and turn the nozzles on. Use a stop watch to record the amount of time the sprayer is running. The sprayer should be operated for at least three minutes. Record the new level in the tank or measure the amount of water needed to refill the tank to the original level.

Example: The spray tank is filled to the 100-gallon level. It was predetermined from the manufacturer's tables that the nozzles selected would give a total gpm output of 4. The sprayer was operated for five minutes at 150 psi on the gauge. After the five minutes, the sight gauge was read and found to be at a level of 75 gals.

The actual output was:

100 gals. (start) - 75 gals. (stop) = 25 gal per 5 min or 5 gpm

The theoretical output from table information, however, was 4 gpm.

When the actual output is different from the calculated output, adjustments can be made by changing the pressure (when the difference is small) or changing the nozzle sizes (when the difference is large). Experiment with the pressure to see if the output can be fine tuned. Refer to manufacturer's tables for recommended operating pressures for nozzles. Never operate above or below recommended pressures.

Repeat these calibration procedures whenever changes are made in the speed, gallons per acre, or row spacing. Periodically check the output from the nozzles during the spraying season. Remember, the effectiveness of the spray material is directly dependent on your skill as an operator.

Field test to confirm calculations:

$$\text{gpa (gallons per acre)} = \frac{\text{gal. sprayed} \times 43{,}560\ \text{ft}^2}{\text{distance traveled (ft.)} \times \text{row width (ft.)}}$$

Example:

A field test is run in which 10 rows, each 200-ft long, were sprayed. Row spacing was 10 ft. It took 35 gal to refill the sprayer to the original level. What was the gpa?

$$\frac{35\ \text{gal} \times 43{,}560\ \text{ft}^2}{2{,}000\ \text{ft} \times 10\ \text{ft}} = 76\ \text{gpa}$$

Determining the Amount of Spray to Apply per Acre

Always do calibration trials by driving the spray rig over terrain that is similar to that which will be sprayed.

1. Fill the tank with water.
2. Operate the sprayer at the usual pump pressure and tractor speed for a minimum distance of 500 to 800 feet.
3. Determine the square footage in the swath treated by multiplying the measured distance traveled by the length of the boom spray pattern. (Be sure to subtract the few inches that the end nozzle patterns will overlap.)
   Example: distance = 730 feet and boom length = 21 feet. The square footage of the swath treated is 15,330.
4. Determine the amount of water that was sprayed on the swath by refilling the tank. Example: 6.4 gallons.
5. Divide 43,560 (there are 43,560 square feet in an acre) by the square footage of the treated swath

(example = 15,330). The answer (example = 2.84) tells how many treated swaths would comprise 1 acre.

6. Determine the amount of water needed to cover an acre by multiplying 2.84 by the amount of water used (example = 6.4 gallons). The result is 18.18 gallons, a little less than the 20 gallons per acre that is generally recommended.
7. To attain the 20-gallon-per-acre rate, it would be better to slow down the rate of travel rather than increase pump pressure. Increased pump pressure usually results in finer droplets that are more likely to drift. Caution: Decreasing pump pressure will result in larger droplets, poorer coverage, and less effective control.

Remember: Should different types or sizes of nozzles be needed for a particular spray job, the entire sprayer must be recalibrated.

How Much Pesticide Is Needed per Tank?

If your spray rig has a 350-gallon tank and has been calibrated to apply 20 gallons per acre, you will be able to treat 17.5 acres with each full tank of mixed spray. If the label of a 2-pound-per-gallon pesticide formulation calls for 1.5 pounds active ingredient per acre, you will need to add 13.12 gallons per tankful. Explanation:

1. Determine the number of acres each spray tank will treat by dividing the tank capacity (350 gallons) by the number of gallons the sprayer applies per acre (20).
   350 divided by 20 = 17.5 acres
2. Calculate how many pounds of active ingredient must be added to each full tank by multiplying the number of acres the tank will treat by the pounds of active ingredient per acre.
   17.5 acres x 1.5 lbs per acre = 26.25 pounds
3. Determine how many gallons of 2 EC must be added to the tank by dividing the pounds of active ingredient to be added to each full tank by 2 pounds per gallon.

   26.26 pounds x 2 pounds per gallon = 13.12 gallons of the 2 EC formulation

Cleaning Spray Equipment

After each day's use, thoroughly flush and rinse the sprayer, inside and out, with water to prevent accumulation of pesticides. Choose a cleanup area where discharged cleaning water will not contaminate ground water, surface water, crops, or injure other plants. Discharge water should not form puddles that are accessible to children, livestock, pets, or wildlife.

When you change pesticides or finish spraying for the season, clean the sprayer thoroughly, both inside and out. For thorough cleaning, follow these steps:

1. Hose down the inside of the tank completely, then fill it half-full with water. Flush the cleaning water through the boom and nozzles by operating the sprayer.
2. Repeat the procedure in Step 1.
3. Remove nozzle tips and screens and clean them in kerosene or in a detergent solution, using a soft brush. Do not use a knife, wire, or other hard device to clean nozzle tips. The finely machined surfaces of nozzle tips can be damaged easily, causing distortion of spray patterns and an increased rate of application. Reassemble nozzles and attach them to the boom.
4. Again, fill the tank about half-full with water and add about 1 tablespoon of detergent for every 3 gallons of water.
5. Run the sprayer to flush the detergent solution through the boom and nozzles.
6. If you have used 2,4-D or an organophosphorus insecticide:
   a. Fill tank about half-full with water and add 1 pint of ammonia for every 25 gallons of water.
   b. Operate the pump to circulate the ammonia solution through the sprayer for about five minutes, then discharge a small amount through the boom and nozzles.
   c. Keep the remaining solution in the sprayer overnight. The next morning:
   d. Flush the ammonia solution through the boom and nozzles by operating the sprayer.
7. Fill tank about half-full with clean water while rinsing it (inside and outside); then flush this final rinse through boom and nozzles.

When you have finished with the sprayer for the season, remove and store the nozzle tips, strainers,

and screens in light oil. Store the sprayer in a clean, dry shed. If the pump cannot be drained completely, store the sprayer where it cannot freeze. Support the sprayer on blocks to take the weight off the tires.

Pesticide Safety

Toxicity of Pesticides

Pesticides are manufactured to be toxic, or poisonous, to pests. Because many pesticides are toxic to a broad range of organisms, they are potentially hazardous to humans, livestock, and other animals. Because the toxicity of different pesticides varies greatly, people who use pesticides should have a general knowledge of the relative toxicity of the chemicals that they apply.

The acute toxicity of a particular pesticide is determined by subjecting test animals (usually rats, mice, rabbits, and dogs) to different dosages of the active ingredient in the pesticide product. In the most common of these tests, the active ingredient may be administered orally, by feeding the chemical to test animals, or dermally, by applying the chemical to the animals' skin. (Other methods of exposure may also be tested.) Results are analyzed to produce an estimate of an LD_{50} — the lethal dose that kills 50% of the test animals. LD_{50} values are expressed as mg of pesticide per kg of the test animal's weight.

Based on LD_{50} values and similar estimates of acute toxicity, pesticide labels contain signal words that categorize the pesticide's acute toxicity. Labels for highly toxic pesticides (those with very low LD_{50} values) display the words DANGER — POISON and a skull-and-crossbones symbol. Moderately toxic pesticides have the word WARNING on the label, and the least toxic pesticides are labeled with the signal word CAUTION. Table 8-6 summarizes the relationships among pesticide toxicity ratings, LD_{50} estimates, and estimated lethal doses for adult humans. All pesticide labels bear the statement: KEEP OUT OF REACH OF CHILDREN.

Table 8-7 summarizes LD_{50} estimates for several common pesticides used in small fruit production. LD_{50} values are useful indicators of danger, but they do not describe all aspects of pesticide toxicity. They do not, for example, indicate risks of eye injury, throat or lung irritation, chemical burns, or neurological damage. Additionally, the chronic effects of repeated low-dose exposures to pesticides are difficult to assess. As a result, applicators are urged to apply pesticides only when necessary and to use protective clothing and equipment to avoid exposures by oral, dermal, or inhalation routes.

Pesticide Applicator Certification

The United States Environmental Protection Agency (EPA) has classified certain pesticides as Restricted-Use Pesticides. Growers who wish to use these pesticides must be certified as private applicators. A fruit grower may become certified as a private applicator by attending training sessions conducted by the Extension Service in each state. Training at these sessions covers pesticide labeling; safety factors, including employee safety; environmental concerns; identification of common pests; pesticides and their use; equipment and application techniques; and state and federal regulations. Extension staff members

Table 8-6. Oral, Dermal, and Inhalation Toxicity Ratings of Pesticides.[1]

Toxicity Rating	Label Signal Words	Oral LD_{50} (Mg/kg)	Dermal LD_{50} (Mg/kg)	Lethal Oral Dose, 150-Pound Man
High	Danger-Poison	0 - 50	0 - 200	few drops to teaspoon
Moderate	Warning	50 - 500	200 - 2,000	1 teaspoon to 1 ounce (2 tablespoons)
Low	Caution	500 - 5,000	2,000 - 20,000	1 ounce to 1 pint, or 2 pounds
Very low	Caution	5,000+	20,000+	1 pint or more, or 2 pounds or more

[1] Note that values in these categories indicate LETHAL (deadly) doses; much lower doses may cause severe injury or chronic health effects.

Table 8-7. LD_{50} Values for Common Small Fruit Pesticides.			
Trade Name™	**Common Name**	**Oral LD_{50}[1] mg/kg**	**Dermal LD_{50}[1] mg/kg**
Fungicides			
Aliette	fosetyl-AL	2860	>2,000
Bayleton	triadimefon	1,020	>5,000
Benlate	benomyl	>10,000	>10,000
Captan	captan	9,000	--
Dithane M45	mancozeb	11,200	>15,000
Dyrene	anilazine	>5,000	>5,000
Funginex	triforine	6,000	>2,000
Karathane	dinocap	980	--
Manzate 200	mancozeb	11,200	>15,000
Nova	myclobutanil	1,600 to 2,290	>5,000
Penncozeb	mancozeb	11,200	>15,000
Ridomil	metalaxyl	669	>3,100
Ronilan	vinclozolin	>10,000	--
Rovral	iprodione	4,400	>2,000
Rubigan	fenarimol	2,500	--
Sulfur	sulfur	--	--
Thiram	thiram	780	>5,000
Topsin-M	thiophanate-methyl	7,500	--
Zineb	zineb	>5,200	>10,000
Herbicides			
Casoron	dichlobenil	603 to 3160	1,350
Dacthal	DCPA	>10,000	>10,000
Devrinol	napropamide	>5,000	>4,640
Dual	metolachlor	2,780	>10,000
2,4-D	2,4-D	300-1,000	--
Fusilade	fluazifop	2,712	>2,420
Goal	oxyfluorfen	>5,000	>10,000
Gramoxone Extra	paraquat	100	--
Karmex	diuron	3,400	>5,000
Kerb	pronamide	5,620	>3,160
Poast	sethoxydim	2,676	--
Princep	simazine	>5,000	>10,000
Prowl	pendimethalin	3,956	>2,200
Roundup	glyphosate	5,400	>5,000
Sinbar	terbacil	>5,000	>5,000
Snapshot	asoxaben/oryzalin	>5,000	--
Solicam	norfluazon	>10,000	>20,000
Surflan	oryzalin	>10,000	--
Touchdown	sulfosate	--	--

Table 8-7 (Continued). LD_{50} Values for Common Small Fruit Pesticides.			
Trade Name™	**Common Name**	**Oral LD_{50}[1] mg/kg**	**Dermal LD_{50}[1] mg/kg**
Insecticides			
Acramite	bifenazate	>5000	>5000
Admire	imidacloprid	4143-4870	>2000
Agri-Mek	abamectin	300	>1,800
Asana	esfenvalerate	458	>2000
Assail	acetamiprid	1064	>2000
Brigade	bifenthrin	375	>2,000
Capture	bifenthrin	262	>2000
Confirm	tebufenozide	>5000	>5000
Danitol	fenpropathrin	71-164	>2,000
Diazinon	diazinon	300-400	3,600
Dibrom	naled	191	360
Dipel[2]	*Bacillus thuringiensis*	Nontoxic	Nontoxic
Entrust	spinosad	>5000	>2000
Esteem	pyriproxyfen	>5000	>5000
Furadan	carbofuran	7	6783
Guthion	azinphosmethyl	5-20	220
Imidan	phosmet	147-316	>4,640
Intrepid	methoxyfenozide	>5000	>2000
Kelthane	dicofol	820-960	2,100
Lannate	methomyl	17-24	5,880
Lorsban	chlorpyrifos	96-270	2,000
Malathion	malathion	1,000-2,800	4,100
Metaldehyde	metaldehyde	630	--
M-Pede	fatty acid soap	16,500	Nontoxic
Neemix	azadirachtin	13,000	--
Provado	imidacloprid	4143-3870	>2000
Pyramite, Nexter	pyridaben	1930	>2000
Pyrellin	pyrethrins + rotenone	1620	NA
Pyronyl	pyrethrins	2370	>2000
Rotenone	rotenone	132-1,500	940-3,000
Savey	hexythiazox	>5000	>5000
Sevin	carbaryl	246-283	>2,000
Spintor	spinosad	>5000	>5000
Surround	kaolin	>5000	NA
Thiodan	endosulfan	160	359
Vendex	fenbutatin-oxide	2,631	>2,000
Zeal	etoxazole	>5000	>5000

™ Where names are used, no discrimination is intended and no endorsement by Extension is implied.

[1] Expressed in milligrams of pesticide product per kilogram of body weight in mammalian tests.
[2] Other trade names include Agree, Cutlass, and Javelin.

usually conduct these training meetings, and a test may be required in addition to or in lieu of attending training sessions. Contact local Extension personnel for more information.

Among the pesticides registered for use in small fruit, those classified for Restricted Use include:

Agri-Mek (abamectin)
Asana (esfenvalerate)
Brigade (bifenthrin)
Capture (bifenthrin)
Danitol (fenpropathrin)
Diazinon
Gramoxone Extra (paraquat)
Guthion (azinphosmethyl)
Lannate (methomyl)
Lorsban 4E (chlorpyrifos)
All soil fumigants (see Table 8-8).

There are no Restricted-Use fungicides at the present time.

Table 8-8. Fumigant Rates and Spectrums of Activity.

Common Name	Trade Name	Rates/ Acre	Level of Control[a]			Comments
			Nema-todes	Fungi	Weeds	
D-D Mixture[b]	Telone II	16-20 gal	4	1	0	Slight suppression of some soil-borne organisms
D-D Mixture[b] + chloropicrin	Telone C17	30-40 gal	4	5	1	Effective against most soil-borne diseases; some weed seed suppression.
	Terr-O-cide 15D	30-40 gal	4	5	1	
	Terr-O-cide 30D	25-35 gal	4	5	1	
methyl isothiocyanate compounds	Vapam	50-100 gal	4	4	3	Most effective when applied through over-head irrigation; incorporate thoroughly in soil.
	Basamid 99G	250-350 lb	4	4	3	
methyl bromide	Brom-O-Gas	275-350 lb	5	4	4-5	Requires a plastic seal; highly toxic to humans; weak against some Pythium species.
methyl bromide +	Terr-O-Gas 67	275-350 lb	5	5	4-5	Most effective for control of weeds, chloropicrin soil- borne disease; nema todes, and insects; requires plastic seal; highly toxic.

[a] 0 = no control; 5 = excellent control.
[b] Mixture of dichloropropanes and dichloropropenes in various ratios.

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Record Keeping, Worker Protection, and Reentry Times

EPA regulations enacted in 1994 and 1995 include specific requirements for pesticide record-keeping and a Worker Protection Standard that covers worker training and reentry intervals (time periods, after pesticide application, during which unprotected workers are not to enter treated areas). Growers must keep records of applications of Restricted-Use Pesticides. Records must include:

- The brand name or product name and the EPA registration number of the pesticide.
- The total amount of the product (formulated material, not active ingredient) applied.
- The location of the application.
- The size of the treated area.
- The crop, commodity, or site treated.
- The month, day, and year of the application.
- The name and certification or license number of the applicator.

Although these record-keeping rules cover only Restricted-Use Pesticides, growers are urged to keep complete records on all pesticide applications.

The Worker Protection Standard requires that:

- Workers be trained in pesticide safety.
- Growers display pesticide information at a location accessible to all workers.
- Workers be notified of pesticide applications and any reentry restrictions that apply.
- Unprotected workers be kept out of treated areas until the reentry restrictions have elapsed.
- Growers provide appropriate protective equipment to workers.
- Wash water, soap, and single-use towels be provided at a clean site for decontamination.
- Growers provide emergency assistance to workers who are poisoned or injured in a work-related pesticide exposure.

Growers must comply with the worker protection and reentry requirements stated on pesticide labels. Training programs for pesticide applicator certification include details on record-keeping and worker protection. Contact local Extension personnel for information on training programs.

Pesticide Safety and Use

A few simple but important rules should be followed in all pesticide applications:

1. **USE PESTICIDES ONLY WHEN NECESSARY** and only at the recommended rates and times so that residues on crops do not exceed tolerances set by law.
2. **READ AND FOLLOW ALL PESTICIDE LABEL DIRECTIONS.**
3. Use the right pesticide. Consult up-to-date spray guides and check the pesticide label to be sure that what you spray is registered for the intended use and likely to control the target pest.
4. Avoid spray or dust drift from the target crop.
5. Wear protective clothing and use protective equipment according to instructions on the pesticide label. Never eat, drink, or smoke while applying pesticides.
6. Keep pesticides off your skin and clothing; wash immediately with soap and water and change clothing if accidents result in exposures to pesticides.
7. Bathe and change all clothing after applying pesticides. Wash clothing after each day's use.
8. See a physician immediately if pesticide poisoning is suspected. Show the physician the label from the pesticide suspected of causing the poisoning. Physicians should phone a Poison Control Center for complete information on treatment.

Protecting the Birds and the Bees

Most fungicides and herbicides are only slightly toxic to birds, but many insecticides are highly toxic to birds. Labels for the following pesticides present warnings that poisonings may occur if birds feed in treated areas: azinphosmethyl (Guthion), carbofuran (Furadan), diazinon (Diazinon), endosulfan (Thiodan), fenamiphos (Nemacur), methomyl (Lannate), and oxydemeton-methyl (Metasystox-R). To reduce the risk of bird poisoning, granular insecticides should be incorporated during or immediately after application. Always read and follow label directions for precautions that protect birds and other wildlife.

Honey bees, several species of wild bees, and many other insects aid in pollination of small fruits and countless other crop and noncrop plants. Poor pollination results in smaller, misshapen, or crumbly berries, depending on crop species. Lower yields can result. This is particularly true for raspberries and blueberries. Although wind pollination plays an important role in strawberry fruit set, insect pollination also appears to be important in this crop as well.

The importance of honey bees to the small fruit industries demands that certain guidelines be used whenever a pesticide is considered, ***particularly when the crop is in bloom.*** The major ways to avoid poisoning bees are summarized here:

- Move honey bee colonies into berry fields only after prebloom insecticides have been applied. Remove colonies as soon as pollination is completed.
- Do not apply insecticides that are toxic to bees to fruit crops, cover crops, adjacent crops, or interplantings if these crops are blooming. Similarly, do not apply insecticides that will kill bees to fruit plantings if blooming weeds will be treated. Mowing or otherwise controlling weeds is necessary if such insecticides must be used.
- In aerial applications, do not repeatedly turn the aircraft or transport insecticides across blooming fields. Ground application is generally less hazardous to bees than aerial application.
- Apply most insecticides (and other pesticides according to label directions) in late evening, at night, or early in the morning while few or no bees are foraging (generally between 6 p.m. and 7 a.m. in the north and 8:30 p.m. to 4 a.m. in the south). Evening applications are generally less hazardous to bees than early morning applications. When high temperatures cause bees to start foraging earlier or continue later than usual (5:30 a.m. to 8 p.m.), shift application times accordingly.
- Do not apply insecticides when temperatures are expected to be unusually low following treatment or on nights when heavy dew forms. Residues will remain toxic to bees for a longer time under such conditions.
- Use insecticides that are least hazardous to bees whenever possible (see Table 8-9).
- Choose the least hazardous insecticide formulations. Tests consistently indicate that dusts are more hazardous than sprays of the same insecticide. Emulsifiable (liquid) formulations usually have a shorter residual toxicity to bees than do wettable powders. Granular formulations are generally low in hazard to bees. Sevin XLR, a formulation that includes a sticker, is less hazardous to bees after application than wettable powder formulations of Sevin (carbaryl).
- Ask beekeepers to remove colonies from the area (or keep bees confined during and shortly after application) before applying hazardous pesticides.

Ground Water and Surface Water Protection

Ground water and surface water are invaluable natural resources. They are vulnerable to contamination, however, and pesticides have been detected in water resources in all states. To protect water supplies from contaminants, pesticide applicators must adopt sound practices that include site-specific selection of pesticides; adherence to label directions; accurate calibration and mixing; spill and back-siphon prevention; proper disposal; integrated pest management; and an overall pattern of judicious use of pesticides.

Many factors affect the movement of chemicals and their likelihood of reaching water supplies. Consideration of these factors can minimize contamination problems.

Solubility: Chemicals that are highly soluble in water are easily leached. To minimize leaching, use the least soluble chemicals at the lowest effective rates (see Table 8-10). Nitrogen (N) fertilizers are easily leached. Apply only the needed amount of N. Split applications are most effective for many crops and can reduce leaching because less N is applied at any one time, allowing the crop to use it more efficiently. Winter cover crops also take up leftover N, reducing leaching and erosion. Among pesticides that are now used or that have been used in recent years in small fruits, the insecticides Furadan (carbofuran) and Lannate (methomyl), the fungicides Ridomil

Continued

Table 8-9. Categories of Pesticide Toxicity to Honey Bees.

EXTREMELY TOXIC:

DO NOT apply on blooming crops or weeds.

Asana (esfenvalerate)	Imidan (phosmet)
Danitol (fenpropathrin)	Lannate (methomyl)
Diazinon	Lorsban (chlorpyrifos)
Furadan (carbofuran)	Malathion D or WP
Guthion (azinphos methyl)	Sevin (carbaryl)

HIGHLY TOXIC:

Apply ONLY during late evening.

Admire (imidacloprid)	Malathion EC
Confirm (tebufenozide)	Provado (imidacloprid)
Dibrom EC (naled)	Thiodan (endosulfan)

MODERATELY TOXIC:

Apply ONLY during late evening, night, or early morning.

Fusilade (fluazifop-P-butyl)	Pyramite (pyridaben)
Neemix (azadirachtin)	Pyrellin
Oil sprays (superior types)	Rotenone
Princep (simazine)	Spintor (spinosad)

SLIGHTLY TOXIC OR NONTOXIC:

Can be applied at any time with reasonable safety to bees.

Bacillus thuringiensis	Kyrocide (cryolite)
Benlate (benomyl)	lime-sulfur
Bordeaux mixture	M-Pede (insecticidal soap)
Captan	Metaldehyde baits
Ethrel (ethephon)	Naturalis *(Beauveria)*
Funginex (triforine)	Paraquat/Gramoxone
Karmex (diuron)	Savey (hexythiazox)
Kelthane (dicofol)	Sinbar (terbacil)
Kerb (pronamide)	Vendex (fenbutatin-oxide)

D = Dust; EC = Emulsifiable Concentrate; WP = Wettable Powder.
Caution: Information is unavailable on the hazards posed to honey bees by pesticides not listed in this table.

Table 8-10. Physical Characteristics of Common Small Fruit Pesticides[1].				
Trade Name	**Common Name**	**Solubility (ppm)[2]**	**Soil Adsorption (K_{OC})[3]**	**Soil 1/2-Life (days)**
Fungicides				
Aliette	fosetyl-AL	122	--[1]	--
Bayleton	tradimefon	260	273	21
Benlate	benomyl	2	190	240
Bordeaux		--	--	--
Captan	captan	4	100	3
Carbamate	ferbam	120	300	17
Fixed copper	fixed copper	--	--	--
Funginex	triforine	6	--	--
Manzate (also Dithane, Penncozeb)	mancozeb	0.5	2,000	70
Nova	myclobutanil	142	--	--
Ridomil	metalaxyl	7,100	16	21
Ronilan	vinclozolin	3	43,000	20
Rovral	iprodione	13.9	1,000	14
Rubigan	fenarimol	14	600	360
Sulfur	sulfur	--	--	--
Syllit	dodine	630	1,000,000	10
Topsin-M	thiophanate methyl	3.5	1,000	10
Thiram	thiram	30	--	--
Herbicides				
Casoron, Norosac	dichlobenil	18	224	60
Dacthal	DCPA	0.5	5,000	100
Devrinol	napropamide	73	--	--
Dual	metalochlor	530	200	20
2,4-D amine	2,4-D amine	796,000	20	10
2,4-D ester	2,4-D ester	1	1,000	10
Fusilade	fluazifop	2	3,000	20
Goal	oxyfluorfen	0.1	1000,000	35
Gramoxone Extra	paraquat	1,000,000	100,000	--
Karmex	diuron	42	--	--
Kerb	pronamide	15	990	60
Poast	sethoxydim	pH	pH	10
Princep	simiazine	6.2	138	75
Prowl	pendimethalin	0.28	24,000	90
Roundup	glyphosate	900,000	24,000	47
Sinbar	terbacil	710	55	120
Snapshot	asoxaben plus	--	--	--
	oryzalin	2.5	600	20

Table 8-10 (Continued). Physical Characteristics of Common Small Fruit Pesticides[1].				
Trade Name	**Common Name**	**Solubility (ppm)[2]**	**Soil Adsorption (K_{OC})[3]**	**Soil 1/2-Life (days)**
Solicam	norfluazon	28	--	24
Surflan	oryzalin	2.5	600	20
Touchdown	sulfosate	430	--	--
Insecticides				
Agri-Mek	abamectin	5	5,000	28
Asana	esgfenvalerate	0.002	5,300	35
Brigade	bifenthrin	0.1	240,000	26
Capture	bifenthrin	0.1	240,000	26
Danitrol	fenpropathrin	0.33	5,000	5
Diazinon	diazinon	60	1,000	40
Dibrom	naled	2000	180	1
Dipel, others	*Bacillus thuringiensis*	--	--	--
Furadan	carbofuran	351	22	50
Guthion	azinphosmethyl	29	1,000	10
Imidan	phosmet	20	820	19
Kelthane	dicofol	0.8	>5,000	45
Lannate	methomyl	58,000	72	30
Lorsban	chlorpyrifos	0.4	6,070	30
Malathion	malathion	130	1,800	1
Metaldehyde	metaldehyde	230	240	10
M-Pede	fatty acids (soaps)	--	--	--
Neemix	azadirachtin	--	--	--
pyrethrins	pyrethrins	0.001	100,000	12
Rotenone	rotenone	0.2	10,000	3
Savey	hexythiazox	0.5	6,200	30
Sevin	carbaryl	120	300	10
Thiodan	endosulfan	0.32	12,040	50
Vendex	fenbutatin-oxide	0.0127	2,300	90

[1] Denotes that information was unavailable.
[2] Water solubility expressed in parts per million.
[3] Higher K_{OC} values indicate greater soil adsorption and a lower potential to leach.

(metalaxyl) and Syllit (dodine), and the herbicides Dual (metolachlor), Gramoxone Extra (paraquat), Roundup (glyphosate), Sinbar (terbacil), Touchdown (sulfosate), and 2,4-D amine are moderately to highly soluble. Not all of these compounds are equally likely to leach into groundwater; however, their use patterns, persistence, and soil sorption characteristics also influence leaching and movement in surface waters.

Adsorption: Some chemicals are tightly attached (adsorbed) to soil particles or organic matter and are not easily moved. Nitrogen in the ammonium form attaches to soil particles, whereas nitrogen in the nitrate form does not. The use of ammonium N is acceptable in many situations and can reduce leaching. Pesticides with high soil adsorption values (see Table 8-10) are less likely to leach than those that do not attach tightly to soil. Pesticides that are bound to soil particles can contaminate surface water, if water or wind erosion carries soil particles and attached pesticide molecules into streams, rivers, or other bodies of water.

Persistence: Persistent chemicals break down slowly and, therefore, have more time to move into surface water and ground water. Many pesticides are broken down by sunlight (photodegradation) and/or microbial action, but incorporation of pesticides into soil reduces or eliminates photodegradation, and microbial activity declines at greater depths in the soil. See Table 8-10 for a listing of the soil half-lives (time required for the half of the original amount of the chemical to break down) of pesticides used in small fruits.

Soil Characteristics: Soil texture and organic matter content greatly influence the movement of pesticides and fertilizers. Fine-textured soils and those with high amounts of organic matter retain more water and allow greater adsorption of agricultural chemicals. Conversely, sandy soils are more permeable to water and allow less adsorption. Highly permeable soils with permeable underlying layers allow rapid downward movement of water and dissolved chemicals, leading to groundwater contamination.

Water Table: High water tables are especially vulnerable to contamination because chemicals must travel only a short distance to reach groundwater. In areas with high water tables, highly soluble or persistent pesticides should not be applied directly to bare soils.

In summary, some risk of groundwater or surface water contamination exists whenever pesticides are used. Where risks are particularly high (coarse soils, low organic matter, high water table, bare soil, or slopes that favor runoff), producers should not apply directly to soil any pesticides that are likely to leach. In general, pesticides with a water solubility of greater than 30 ppm, a soil sorption index of less than 300 to 500, and/or a soil half-life of greater than 21 days are most likely to leach. To protect surface water, do not apply pesticides directly to soil if slopes favor runoff. To slow runoff, maintain vegetation in waterways and ditches.

Safe Storage of Pesticides

- Store pesticides in a clean, cool, dry, well-ventilated building. The building should be locked so that children and other unauthorized people cannot gain access to pesticides. Mark the storage facility with an appropriate warning sign.
- Storages should be equipped with absorbent materials such as clay, sawdust, paper, or kitty litter. Other equipment should include a fire extinguisher (ABC rated), a shovel, broom, dustpan, detergent, hand cleaner, and water. All of this equipment should be dedicated exclusively to the pesticide storage area.
- Never store herbicides alongside other pesticides; the danger of cross-contamination is too great.
- Do not store pesticides where food, water, feed, seeds, fertilizers, or pesticide safety equipment (such as respirators) can become contaminated.
- Store all pesticides in their original containers.
- Check containers frequently for leaks and breaks.
- Clean up spilled chemicals promptly and properly. If the spill is large, inform your state and local emergency response office. Dispose of broken or damaged containers and any pesticide waste in an approved and safe manner.
- Keep an inventory of all chemicals. Mark each container with the year of purchase. Do not remove labels.
- Inform your local fire department and Emergency Response Office of any agricultural chemicals (including fertilizers) stored in large quantity.

- Conform with federal and state regulations concerning reportable quantities of hazardous materials. Consult with your pesticide dealer or local Extension office for further information.
- READ THE LABEL for specific storage instructions and precautions.

Winter Storage of Pesticides

Emulsifiable concentrates should not be subjected to freezing temperatures. Freezing will destroy the emulsion, resulting in loss of effectiveness and increased likelihood of plant injury if the product is applied. Signs of deterioration due to freezing or other poor storage conditions include:

Emulsifiable concentrate (EC): Sludge, sediment, or other evidence of separation of components.

Oils: Milky appearance does not develop when water is added.

Wettable powder (WP): Excessive lumping; powder does not suspend in water.

Dry flowable (DF): Excessive lumping or caking.

If a pesticide is damaged by freezing, move it to a warm storage (50°F to 80°F) area and shake or roll the container every few hours to mix the components and eliminate layering. If layering persists or if crystals do not dissolve completely, do not use the pesticide. If you are unsure about the quality of a pesticide, call the manufacturer.

Safe Disposal of Pesticides

- Avoid disposal problems associated with excess amounts of pesticides by purchasing only the amount of pesticides that you need for planned applications (or at most, for the current growing season). DO NOT STOCKPILE.
- Follow disposal instructions on the pesticide containers. READ AND FOLLOW LABEL DIRECTIONS.
- Use proper safety equipment when disposing of pesticide wastes and containers.
- Mix only as much pesticide as you will need for a particular application. If you mix too much, it is best to apply the spray mix in the recommended manner to one of the crops listed on the label.
- Do not dump pesticides on the ground or pour them down sinks, toilets, or other drains.
- Rinse empty pesticide containers three times with water and pour the rinse water into the spray tank.
- After metal, plastic, or glass containers are rinsed, they should be punctured, broken, or crushed. Disposal of properly rinsed containers in a sanitary landfill is permissible if in accordance with local regulations.
- Combustible containers can be burned according to instructions on the label if local ordinances permit. Do not burn pesticide containers near residential areas or where people will be exposed to the smoke. Avoid smoke from burning pesticide packages; it is likely to contain toxic vapors.
- Large metal drums should be returned to pesticide suppliers for recycling or sent to a reconditioning company.
- Never reuse empty pesticide containers for any purpose.
- Wash thoroughly after handling and disposing of pesticides.

Fungicides and Insecticides for Small Fruits

Fungicides

Several fungicides are labelled for use on small fruits, and each may be very effective against some diseases and yet have little or no effect against others. Most fungicides are effective primarily as protectants — they must be applied before infection to prevent damage. Some locally systemic fungicides have curative activity, which provides some control of infections that have already started. These include Bayleton, Nova, Procure, Ridomil, and Rubigan. Table 8-11 summarizes general information on the fungicides currently registered for use on small fruits; see product labels and an up-to-date annual spray guide for further details on rates, restrictions, and application methods.

Table 8-11. Small Fruit Fungicides.				
Trade Name	**Common Name**	**Formulations**	**For Use On**	**Comments**
Abound	Azoxystrobin	2.08F	Grapes	Controls black rot, powdery mildew, downy mildew and is moderately effective against Botrytis bunch rot. Same fungicide as Quadris.
Aliette	fosetyl-Al	80 WDG	Brambles, Strawberries	Controls Phytophthora root rot of brambles; leather rot and red stele in strawberries.
Bayleton	triadimefon	50 DG	Grapes	Controls black rot and powdery mildew of grapes, but not downy mildew. Some "kickback" curative activity. Tank mix with another fungicide if downy mildew control is needed.
Bordeaux Mix		See comments	Grapes	Controls downy mildew, and powdery mildew of grapes. Provides fair control of black rot. Copper sulfate + hydrated lime may cause plant injury; incompatible with most other pesticides. Most effective if prepared fresh by mixing 2 lbs copper sulfate ("snow form") and 6 lbs lime per 100 gallons water. Vigorous agitation required.
Cabrio	pyraclostrobin	20 EG	Blueberries Brambles Strawberry	Controls anthracnose, spur blight, leaf spot, powdery mildew and rusts on brambles. On blueberry it controls alternaria leaf spot and fruit rot, leaf blotch, phomopsis twig blight and powdery mildew. On strawberry it controls anthracnose fruit rot, leaf spot, and powdery mildew.
Captan	captan	50 WP, 80WP, 4L	Blueberries Grapes Strawberries	Controls stem canker and stem blight of blueberries; Phomopsis cane and leaf spot, downy mildew, and bitter rot in grapes; and is useful in tank mixes with Rovral, Elevate, Switch, or Topsin-M for the control of Botrytis gray mold, leaf spot, and anthracnose fruit rot in strawberries.
Carbamate	ferbam	76 WP	Grapes	Controls black rot but not downy mildew or powdery mildew in grapes. Because the black wettable powder leaves unsightly residues, late-season use is rarely recommended.
Elevate	fenheximide	50 WG	Brambles Strawberry Grapes	Controls Botrytis fruit rot on strawberry and brambles, and Botrytis bunch rot on grapes.
Elite	tebuconazole	45 DF	Grapes	Controls black rot and powdery mildew on grapes, but not downy mildew. Some "kickback" curative activity. Tank mix with another fungicide if downy mildew control is needed.
Endura	boscalid	70WG	Grapes	Provides excellent control of powdery mildew and moderate to good control of Botrytis bunch rot. Has little or no activity on the other grape diseases.

Table 8-11 (Continued). Small Fruit Fungicides.				
Trade Name	**Common Name**	**Formulations**	**For Use On**	**Comments**
"Fixed" Copper		See comments	Grapes	Controls black rot, downy mildew, and powdery mildew of grapes. Fixed copper sprays are relatively insoluble in water and are less injurious to plants than Bordeaux; use is limited by incompatibility with other pesticides and tendency to injure plants. Usually prepared by mixing 2 lbs spray lime with 1 lb fixed copper.
Flint	trifloxystrobin	50 WG	Grapes	Controls black rot and powdery mildew. Not highly effective for downy mildew. Do not apply to Concord grapes.
Potassium Salts Armicarb 100 Nutrol Kaligreen	Potassium Salts	See comments	Grapes Various other small fruits	Armicarb 100 and Kaligreen are formulations of potassium bicarbonate. Nutrol is a formulation of monopotassium phosphate. All of these products are registered for use on grape, and some are registered on other small fruit crops as well (see the label). They have been reported to provide good control of powdery mildew but provide little or no control of other diseases.
Phosphorous Acid ProPhyt Phostrol Agri-Fos	Phosphorous Acid	See comments	Blueberry Brambles Grape Strawberry	Various phosphorous acid products (also called phosphite or phosphonate) are currently registered in various formulations as a fungicide. They provide good to excellent control of downy mildew on grapes. Most are also registered for use as a foliar spray to control phytophthora root rot on blueberry and brambles, and are registered for control of red stele root rot and leather rot on strawberry.
Pristine	pyraclostrobin plus boscalid	38WG	Blueberries Brambles Strawberries Grapes	Controls Alternaria fruit rot, Botrytis gray mold, mummy berry, Phomopsis twig blight and fruit rot, and powdery mildew on blueberry. On brambles, it controls Anthracnose, Botrytis gray mold, leaf spot, powdery mildew, rust diseases, and spur blight. On strawberry, it controls Anthracnose, Botrytis gray mold, leaf spot, and powdery mildew. On grapes, it controls angular leaf spot, Anthracnose, black rot, downy mildew, Phomopsis cane and leaf spot, powdery mildew, and ripe rot.
Mancozeb	See comments	80% WP, 75% DF	Grapes	Controls black rot, Phomopsis cane and leaf spot, and downy mildew of grape. Some common trade names are Dithane M-45, Manzate 200, and Penncozeb. Long pre-harvest interval (66 days) limits use to early season.

Table 8-11 (Continued). Small Fruit Fungicides.				
Trade Name	**Common Name**	**Formulations**	**For Use On**	**Comments**
Nova	myclobutanil	40 WP	Brambles Grapes Strawberry	Controls black rot and powdery mildew of grapes. Some "kickback" or curative activity. Controls powdery mildew, leaf spot and leaf blight on strawberry, and rust diseases, leaf spot, and powdery mildew on brambles.
Procure	triflumizole	50 WSP	Grapes Strawberry	Controls black rot and powdery mildew on grapes, but not downy mildew. Some "kickback" curative activity. Tank mix with another fungicide if downy mildew control is needed. Controls powdery mildew on strawberry.
Ridomil Gold	mefanoxam	EC, WP	Blueberry Brambles Grapes Strawberry	Controls phytophthora root rot on blueberries and brambles, and red stele root rot and leather rot. Does not control Verticillium wilt. On grapes, Ridomil Gold MZ and Ridomil Gold/Copper are wettable powder formulations registered as a foliar application for control of downy mildew.
Rovral	iprodione	50 WP, 4 F	Brambles Grapes Strawberries	Controls Botrytis bunch rot or gray mold of grapes. Also controls Botrytis fruit rot of brambles and strawberries. Tank mix with other fungicides to slow the development of resistant strains of fungi.
Rubigan	fenarimol	1 EC	Grapes	Controls powdery mildew on grapes. Provides moderate control of black rot. Will not control downy mildew.
Sovran	kresoxim-methyl	50 WG	Grapes	Controls black rot and powdery mildew on grapes. Provides good to moderate control of downy mildew if used at higher rates. Moderately effective against Botrytis bunch rot.
Sulfur		See comments	Blueberries Brambles Grapes Strawberries	Available as wettable powder and flowable formulations for control of powdery mildew on brambles, grapes, and strawberries. On strawberry and brambles, alternative fungicides are preferred for powdery mildew control. Important on grape for powdery mildew control, but can damage some cultivars such as Concord (see Table 5-2). Can cause plant damage if applied at temperatures of 85ºF or above.
Switch	cyprodinil plus fludioxinil	62.5 WG	Brambles Strawberries	Controls Botrytis fruit rot on strawberry. Has moderate activity against anthracnose fruit rot.
Syllit	dodine	65 WP	Strawberries	Controls leaf spot, leaf scorch, and leaf blight of strawberries.

Table 8-11 (Continued). Small Fruit Fungicides				
Trade Name	**Common Name**	**Formulations**	**For Use On**	**Comments**
Topsin-M	thiophanate-methyl	70 WP	Strawberries	Controls leaf blight, leaf scorch, and Botrytis fruit rot (gray mold) of strawberries. Does not control leather rot. Always tank mix Topsin-M with other fungicides to slow the development of resistant strains of fungi.
Thiram	thiram	65 WP	Strawberries	Controls leaf spot and fruit rot (gray mold) of strawberries; can be tank-mixed with Rovral, Topsin-M, Elevate, or Switch.
JMS Stylet-oil		See comments	Grapes	A highly refined petroleum distillate registered for control of powdery mildew on grapes. Cannot be mixed with Captan or Sulfur and should not be applied within 2 weeks of a Captan or Sulfur application.
Liquid Lime Sulfur		29% solution	Brambles Grapes	Controls anthracnose, cane blight, and spur blight on brambles if applied at the delayed dormant stage (1/4- to 1/2-inch green). A very important spray for these diseases. Also registered as a dormant application on grapes for control of anthracnose and powdery mildew. Not registered for use on any other small fruit crop.
Vangard	cyprodinil	75 WG	Grapes	Controls Botrytis bunch rot on grapes.
Ziram	ziram	76 DF	Grapes	Provides good control of black rot and moderate control of downy mildew and Phomopsis cane and leaf spot on grapes.

Insecticides

Insecticides and miticides also differ greatly in effectiveness against specific pests and in toxicity to beneficial insects. Most insecticides are contact poisons that offer some residual effectiveness for a few days after application by killing insects that contact the residues that remain after spraying. Some insecticides, however, must be eaten by insects to be effective. Among these are formulations of *Bacillus thuringiensis (Bt); Bt* products used in small fruits kill only caterpillars that consume *Bt* spores or toxins. Fatty acid insecticides (insecticidal soaps), such as M-Pede, are effective only if insects are contacted by the spray solution while it is still wet. This limits the effectiveness of such sprays but also reduces mortality in nontarget beneficial insects. Table 8-12 summarizes general information on the insecticides currently registered for use on small fruits.

Table 8-12. Small Fruit Insecticides.					
Family	**Trade Name**	**Common Name**	**Formulations**	**For Use On**	**Comments**
Organophosphates	Diazinon	diazinon	50 WP, AG 500 (4EC), AG600	Blueberries Grapes Strawberries	Controls fruitworms and blueberry maggot on blueberries; fruit flies, grape berry moth, leafhoppers on grapes; aphids, leafrollers on strawberries.
	Dibrom	naled	8 EC	Grapes Strawberries	Controls fruit flies on grapes; spittlebugs, plant bugs on strawberries.
	Guthion, Sniper	azinphos-methyl	50 WP	Blueberries Brambles Grapes Strawberries	Controls grape berry moth, leafrollers, leafhoppers, grape cane girdler on grapes; leafrollers, spittlebug on strawberries; leafroller on brambles; curculio, fruitworms, maggot on blueberries.
	Imidan (by 24c in some states)	phosmet	70 WP	Blueberries Grapes	Controls grape berry moth, leafrollers, Japanese beetle, leafhoppers on grapes; some plum curculio, fruitworms, Japanese beetle, blueberry maggot on blueberries.
	Lorsban	chlorpyrifos	4 EC	Grapes Strawberries	Controls grape root borer on grapes; bud weevil (clipper) on strawberries.
	Malathion	malathion	8 EC, 8 F, 5 EC, ULV (95%)	Blueberries Brambles Grapes Strawberries	Controls fruit flies, leafhoppers, Japanese beetle, mealybug on grapes; Japanese beetle on brambles; maggot, fruitworms, curculio, tip borer on blueberries.
Organochlorines	Kelthane	dicofol	50 WP	Grapes Strawberries	Controls two-spotted spider mite, European red mite, cyclamen mite.
	Thiodan, Thionex, Phaser	endosulfan	50 WP, 3 EC	Blueberries Grapes Strawberries	Controls phylloxera, leafhoppers, rose chafer on grapes; spittlebug, tarnished plant bug, cyclamen mite on strawberries. Used for post-harvest control of blueberry bud mite.
Carbamates	Furadan (by 24c in some states)	carbofuran	4 F	Strawberries	Controls root weevils when used post-harvest.
	Lannate	methomyl	90 SP, LV (2.4 EC)	Blueberries Grapes Strawberries	Controls grape berry moth, leafhoppers on grapes; plant bugs on strawberries; fruitworms on blueberries.
	Sevin	carbaryl	XLR (4EC), 80 S, 4F	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, rose chafer, leafhoppers, flea beetle, cutworms, 8-spotted forester, spittlebug, fruitworms.
Pyrethroids	Asana	esfenvalerate	0.66 EC	Blueberries	Controls fruitworms, blueberry maggot
	Brigade	bifenthrin	10 WP	Strawberries	Controls plant bugs, spittlebug, clipper, sap beetle, spider mites, root weevil.
	Capture	bifenthrin	2 EC	Brambles	Controls leafrollers and root weevils.
	Danitol	fenpropathrin	2.4 EC	Grapes Strawberries	Controls leafhoppers, flea beetle, berry moth, phylloxera (foliar), Japanese beetle, rose chafer, spider mites on grapes; spittlebug, tarnished plant bug, spider mites on strawberries.

Table 8-12 (Continued). Small Fruit Insecticides.					
Family	**Trade Name**	**Common Name**	**Formu-lations**	**For Use On**	**Comments**
Neonico-tinoids	Assail	acetamiprid	70 WP	Grapes	Controls leafhoppers.
	Provado, Admire	imidacloprid	75 WP 1.6 F 2 F	Grapes Strawberries	Controls leafhoppers and mealybugs. Has some systemic activity.
Insect Growth Regulators	Applaud	buprofezin	70 WP	Grapes	Controls leafhopper nymphs.
	Confirm	tebufen-ozide	2 F	Blueberries Brambles	Controls fruitworms, leafrollers, gypsy moth.
	Esteem	pyriproxyfen	35 WP	Blueberries	Controls fruitworms.
	Intrepid	methoxy-fenozide	2 F	Grapes	Controls grape berry moth.
Microbials	Biobit Condor CryMax Deliver DiPel Javelin Lepinox	*Bacillus thuringiensis,* subspecies kurstaki	DF, WG, oil flowable	Blueberries Brambles Grapes Strawberries	Controls caterpillars such as gypsy moth, leafrollers. Pests must eat treated plants. Works best on young caterpillars.
	Agree Ketch XenTari	*Bacillus thuringiensis,* subspecies aizawai	DF, WG	Blueberries Brambles Grapes Strawberries	Controls caterpillars such as gypsy moth, leafrollers. Pests must eat treated plants. Works best on young caterpillars.
	Mycotrol	*Beauveria bassiana*	ES	Blueberries Brambles Grapes Strawberries	Controls whiteflies, aphids, mealybugs, leafhoppers, beetles, plant bugs, weevils.
Botanicals	Aza-Direct Ecozin Neemix	azadirachtin	EC	Blueberries Brambles Grapes Strawberries	Controls plant bugs, leafhoppers, beetles, caterpillars, thrips.
	Pyronyl	pyrethrins	EC	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, yellowjackets, sap beetles, vinegar fruit flies, many other pests.
	Pyrellin	pyrethrins + rotenone	EC	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, aphids, caterpillars, leafhoppers, thrips, many other pests.
	Rotenone	rotenone	D, WP	Blueberries Brambles Grapes Strawberries	Controls Japanese beetle, flea beetles, rose chafer, fruitworms, cane borers, blueberry maggot.
Miscel-laneous	Acramite	bifenazate	50 WP	Grapes Strawberries	Controls two-spotted spider mite
	Agri-Mek	abamectin	0.15 EC	Grapes Strawberries	Controls two-spotted spider mite.
	Deadline MPs	metalde-hyde	Mini-pellet bait	Blueberries Brambles Grapes Strawberries	Controls slugs. Apply as a soil surface treatment.

Table 8-12 (Continued). Small Fruit Insecticides.					
Family	**Trade Name**	**Common Name**	**Formu-lations**	**For Use On**	**Comments**
Miscel-laneous (continued)	M-Pede	soap	Liquid concentrates	Blueberries Brambles Grapes Strawberries	Controls aphids, leafhoppers, spider mites. Thorough coverage required.
	Pyramite, Nexter	pyridaben	60 WP	Grapes	Controls European red mite, two-spotted spider mite, leafhoppers.
	Savey	hexythiazox	50 DF	Brambles Strawberries	Controls two-spotted spider mite.
	Sluggo	iron phosphate	1% Bait	All	Controls slugs.
	SpinTor, Entrust	spinosad	2 SC	Blueberries Brambles Grapes Strawberries	Controls caterpillars and thrips.
	Vendex	fenbutatin-oxide	50 WP	Grapes Strawberries	Controls European red mite, two-spotted spider mite.
	Zeal	etoxazole	5 WG	Strawberries	Controls two-spotted spider mite, European spider mite.