# 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:

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

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

**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:

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

# 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.