

# Calibration of Commercial Pesticide Application Equipment (Ornamentals)

The performance of any pesticide depends upon the proper application over a given area. This section will cover calibration of equipment used by commercial landscape applicators for liquid and dry applications of pesticides. For ornamentals such as shrubs and small trees, manually operated sprayers or low-pressure, power sprayers fitted with single-nozzle spray guns are normally used. For spraying tall shade trees, high-pressure, high-volume hydraulic or air-carrier sprayers are commonly utilized.

## Manual Sprayers

Manual sprayers such as compressed air and knapsack sprayers are designed for spot treatment and for restricted areas unsuitable for larger units (**Figure 1.7.1**). For pressurizing the supply tank, most manual sprayers use compressed air or carbon dioxide which forces the spray liquid through a nozzle. Several types of small power sprayers that deliver 1 to 3 gallons per minute (GPM) at pressures up to 300 pounds per square inch (psi) are available. Adjustable handguns are usually used with

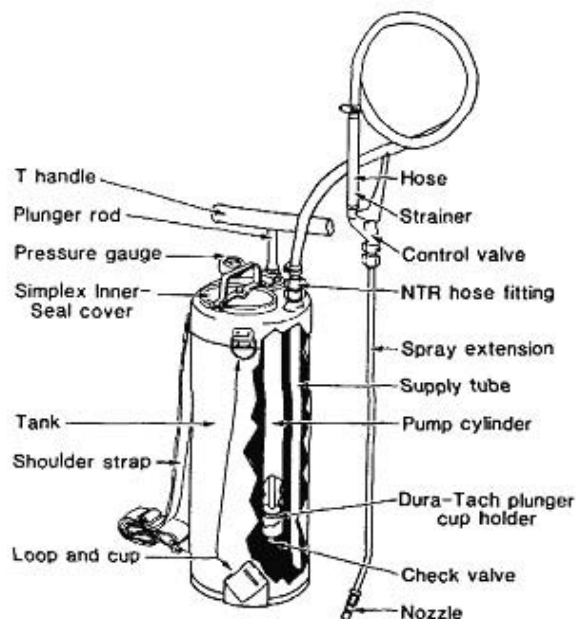


Figure 1.7.1. Compressed air sprayer.

these units, but spray booms are available on some models. These sprayers are relatively inexpensive, simple to operate, maneuverable and easy to clean and store.

## How Do I Calibrate My Manual Sprayer?

Manual sprayers are generally used on small areas, so it is recommended that the amount of spray to be applied should be determined on small areas, such as 1,000 square feet. Most manual compressed air sprayers do not have pressure gages or pressure controls. The pressure in the tank will drop as the material is sprayed from the tank. This pressure drop can be partly overcome by filling the tank only two-thirds full with spray material, so a considerable air space is left for initial expansion, and by repressurizing the tank frequently. If the sprayer has a pressure gage, repressurize when the pressure drops approximately 10 psi from the initial reading.

When spraying, either hold the nozzle at a steady, constant height and spray back and forth in swaths, or swing the nozzle back and forth at a uniform speed in a sweeping, overlapping motion. A uniform walking speed must be maintained during application.

The amount of spray solution applied per 1,000 square feet can be determined as follows:

**Step 1.** Measure and mark an area of 1,000 square feet (for example, 20 feet by 50 feet). Using water, practice spraying the area. To obtain the most uniform application, spray the area twice with the second application at right angles to the first.

**Step 2.** Place a measured amount of water in the tank, spray the area and then measure the amount of water remaining in the tank. The difference between the amount in the tank before and after spraying is the amount used.

**Example:** 2 gal. added, minus 0.5 gal. left = 1.5 gal./1,000 sq. ft.

# Power Sprayers

## How Do I Select the Proper Tip Size for a Self-Propelled Sprayer?

The size of the nozzle tip will depend upon the application rate (gallons per acre, or GPA), ground speed (miles per hour, or mph) and effective sprayed width (W) that you plan to use. Some manufacturers advertise gallons-per-acre nozzles, but this rating is useful only for standard conditions (usually 30 psi, 4 mph and 20-inch spacings). The gallons-per-acre rating is useless if any one of your conditions varies from the standard.

A more exact method of choosing the correct nozzle tip is to determine the gallons per minute (GPM) required for your conditions and then select nozzles that provide this flow rate when operated within the recommended pressure range. By following the five steps described below, you can select the nozzle required for each application well ahead of the spraying season.

**Step 1.** Select the spray application rate in gallons per acre (GPA) that you want to use. Pesticide labels recommend ranges for various types of equipment. The spray application rate is the gallons of carrier (water, fertilizer, etc.) and pesticide applied per treated acre.

**Step 2.** Select or measure an appropriate ground speed in miles per hour (mph), according to existing field conditions. Do not rely upon speedometers as an accurate measure of speed. Slippage and variation in tire sizes can result in speedometer errors of 30 percent or more. If you do not know the actual ground speed, you can easily measure it. (See the section entitled, "How Is Ground Speed Measured?")

**Step 3.** Determine the effective sprayed width per nozzle (W) in inches. For broadcast spraying, W = the nozzle spacing.

**Step 4.** Determine the flow rate required from each nozzle in gallons per minute (GPM) by using a nozzle catalog, tables or the following equation.

Table 1.7.1. Regular flat fan nozzles.

Delavan Tip No.	Spraying Systems Liquid Tip No.	Capacity Pressure in psi	1 Nozzle in GPM
LF-67 (100 mesh)	80067 (100 mesh)	20	.05
		25	.055
		30	.06
		40	.067
LF-1 (100 mesh)	8001 (100 mesh)	20	.07
		25	.08
		30	.09
		40	.10
LF-1.5 (100 mesh)	80015 (100 mesh)	20	.11
		25	.12
		30	.13
		40	.15
LF-2 (50 mesh)	8002 (50 mesh)	20	.14
		25	.16
		30	.26
		40	.20
LF-3 (50 mesh)	8003 (50 mesh)	20	.21
		25	.24
		30	.26
		40	.30
LF-4 (50 mesh)	8004 (50 mesh)	20	.28
		25	.32
		30	.35
		40	.40
LF-5 (50 mesh)	8005 (50 mesh)	20	.35
		25	.40
		30	.43
		40	.50
LF-6 (50 mesh)	8006 (50 mesh)	20	.42
		25	.47
		30	.52
		40	.60
LF-8 (50 mesh)	8008 (50 mesh)	20	.57
		25	.63
		30	.69
		40	.80
LF-10	8010 (no strainer)	20	.71
		35	.79
		30	.67
		40	1.00
LF-15	8015 (no strainer)	20	1.12
		25	1.06
		30	1.19
		40	1.30
		40	1.50
		50	1.68

$$\text{GPM} = \frac{\text{GPA} \times \text{mph} \times \text{W}}{5,940} \quad \text{(Equation 1)}$$

GPM = gallons per minute of output from each nozzle.  
 GPA = gallons per acre desired from Step 1.  
 mph = miles per hour from Step 2.  
 W = inches sprayed per nozzle from Step 3.  
 5,940 = a constant to convert gallons per minute, miles per hour, and inches to gallons per acre.

**Step 5.** Select a nozzle that will give the flow rate determined in Step 4 when the nozzle is operated within the recommended pressure range. You should obtain a catalog listing available nozzle tips. These catalogs may be obtained free of charge from equipment dealers or nozzle manufacturers. If you decide to use nozzles that you already have, return to Step 2 and select a speed that allows you to operate within the recommended pressure range.

**Example:** You want to broadcast an herbicide at 25 GPA (Step 1) at a speed of 5 mph (Step 2), using regular flat-fan nozzles spaced 20 inches apart at the boom (Step 3). What nozzle tip should you select?

The required flow rate for each nozzle (Step 4) is as follows:

$$\text{GPM} = \frac{\text{GPA} \times \text{mph} \times \text{W}}{5,940}$$

$$\text{GPM} = \frac{25 \times 5 \times 20}{5,940} = \frac{2,500}{5,940} = 0.42 \text{ gal.}$$

The nozzle that you select must have a flow rate of 0.42 GPM when operated within the recommended pressure range of 15 to 30 psi. **Table 1.7.1** shows the GPM at various pressures for several Spraying Systems and Delavan nozzles. For example, the Spraying Systems 8006 and Delavan LF6 nozzles have a rated output of 0.42 GPM at 20 psi (Step 5). Either of these nozzles can be purchased for this application.

## How Do I Select the Proper Nozzle Tip Size for My Hand-Held Boom?

The size of the nozzle tip will depend upon the application rate (gallons per 1,000 square feet), the walking speed (seconds per 1,000 square feet) and the effective sprayed width (feet between the nozzles, multiplied by the number of nozzles).

An exact method for choosing the correct nozzle tip is to determine the gallons per minute (GPM) required for your conditions and then select nozzles from a nozzle manufacturer's catalog that provide this flow rate when operated within the recommended pressure range. By following the steps described below, you can select the nozzles required for each application well ahead of the spraying season.

**Step 1.** Determine the application rate in gallons per 1,000 square feet. Pesticide labels contain recommended volume ranges for various types of equipment and pests. The spray application rate may be given in gallons of carrier (water, fertilizer, etc.) and pesticide applied per acre (GPA) rather than gallons per 1,000 square feet. GPA can be converted to gallons per 1,000 square feet by the following equation:

$$\text{Gal./1,000 sq. ft.} = \frac{\text{Gal./acre} \times 1,000 \text{ sq. ft.}}{43,560 \text{ sq. ft./acre}} \quad \text{(Equation 2)}$$

**Example:** A fungicide label recommends using 50 gal./acre. What is the application rate in gal./1,000 square feet?

$$\text{Gal./1,000 sq. ft.} = \frac{50 \text{ gal./acre} \times 1,000 \text{ sq. ft.}}{43,560 \text{ sq. ft./acre}}$$

$$\frac{50,000}{43,560} = 1.15 \text{ gal./1,000 sq. ft.}$$

**Step 2.** Determine the effective sprayed width in feet. For hand-held booms, this is the distance between the nozzles multiplied by the number of nozzles on the spray boom.

**Example:** Your walking boom has two nozzles spaced 30 inches apart. What is the effective sprayed width? (30 inches = 2.5 feet) Effective sprayed width = 2 nozzles x 2.5 feet = 5 feet.

**Step 3.** Measure the time in seconds required to spray a 1,000 square foot area. This can be easily determined by using your sprayed width from Step 2 and laying out a course of 1,000 square feet. To lay out a single pass course that has 1,000 square feet, use the following equation:

$$\text{Length of course (ft.)} = \frac{1,000 \text{ sq. ft.}}{\text{(ft.) sprayed width}} \quad \text{(Equation 3)}$$

**Example:** Your boom has a five-foot effective sprayed width. What length course would be required for 1,000 square feet?

Length of course (ft.) =

$$\frac{1,000 \text{ sq. ft.}}{5 \text{ ft. sprayed width}} = 200 \text{ ft.}$$

Mark off a 200-foot course, and time your walking speed through this course. Do this several times and record the average time.

**Example:**

$$\text{Average time} = \frac{44 + 46}{2} = 45 \text{ seconds}$$

$$\frac{45 \text{ sec.}}{60 \text{ sec./min.}} = 0.75 \text{ min. to walk 200-ft. course}$$

This means that it will take you 0.75 minutes to cover 1,000 square foot area with your two-nozzle hand boom.

**Step 4.** Determine the flow rate required from each nozzle in gallons per minute (GPM) by using the following equation:

$$\text{GPM} = \frac{\text{gal./1,000 sq. ft.}}{\text{min./1,000 sq. ft.}} \quad (\text{Equation 4})$$

**Example:** The gal./1,000 square feet is 1.15 (Step 1) and 0.75 minute is required to spray 1,000 square feet (Step 3). What is the required nozzle flow rate from the boom?

$$\text{GPM} = \frac{1.15 \text{ gal./1,000 sq. ft.}}{0.75 \text{ min./1,000 sq. ft.}} = 1.5 \text{ gal./min.}$$

Since there are two nozzles per boom, the required flow rate per nozzle is 0.75 gal./min. ( $1.5 \div 2 = 0.75$ ).

**Step 5.** Select a nozzle that will give the flow rate determined in Step 4 when the nozzle is operated within the recommended pressure range. You should obtain a catalog that lists available nozzle tips. These catalogs may be obtained free of charge from equipment dealers or nozzle manufacturers.

## How Do I Calibrate My Sprayer?

### Precalibration Check

After making sure that your sprayer is clean, install the selected nozzle tips, partially fill the tank with clean water and operate the sprayer at a pressure within the recommended

range. Place a container (for example, a container marked in inches) under each nozzle. Check to see whether all of the jars fill at about the same time. Replace any nozzle that has an output of 5 percent more or less than the average of all the nozzles, an obviously different fan angle or an uneven appearance in spray pattern.

To obtain uniform coverage, you must consider the spray angle and height of the nozzle. The height must be adjusted for uniform coverage with various spray angles and nozzle spacings. Do not use nozzles with different spray angles on the same boom for broadcast spraying.

Worn or partially plugged nozzles produce uneven patterns. Misalignment of nozzle tips is a common cause of uneven coverage. The boom must be level at all times – coverage will be uneven if one end of the boom is allowed to droop. A practical method for determining the exact nozzle height that will produce the most uniform coverage is to spray on a warm surface, such as a road, and observe the drying rate. Adjust the height to eliminate excess streaking.

### Sprayer Calibration

Now that you have selected and installed the proper nozzle tips (Steps 1 and 5), you are ready to complete the calibration of your sprayer (Steps 6 to 10). Check the calibration every few days during the season or when changing the pesticides being applied. New nozzles do not lessen the need to calibrate, because some nozzles “wear in” and will increase their flow rate rapidly during the first few hours of use. Once you have learned the following calibration method, you can check application rates quickly and easily.

**Step 6.** Determine the required flow rate for each nozzle in ounces per minute (OPM). To convert the GPM (Step 4) to OPM, use the following equation:

$$\text{OPM} = \text{GPM} \times 128 \quad (\text{Equation 5})$$

(1 gallon = 128 ounces)

**Example:** The required nozzle flow rate = 0.56 GPM. What is the required OPM?

$$\text{OPM} = 0.56 \times 128 = 71.7 \text{ OPM}$$

**Step 7.** Collect the output from one of the nozzles in a container marked in ounces. Adjust the pressure until the ounces per minute (OPM) collected is the same as the amount that you calculated for their outputs to fall within 5 percent of the desired OPM.

If it becomes impossible to obtain the desired output within the recommended range of operating pressures, select larger or smaller nozzle tips and recalibrate. It is important for spray nozzles to be operated within the recommended pressure range. (The range of operating pressures is for pressure at the nozzle tip. Line losses, nozzles check valves, etc., may require the main pressure gage at the boom or at the controls to reach a much higher level.)

**Step 8.** Determine the amount of pesticide needed for each tankful or for the area to be sprayed. (See the “Mixing and Loading Pesticides” section.) Add the pesticide according to label directions or to a partially filled tank of carrier (water, fertilizer, etc.), then add the carrier with continuous agitation to the desired level.

**Step 9.** Operate the sprayer at the speed and pressure determined in Step 7. You will be spraying at the application rate that you selected in Step 1. After spraying a known area, check the liquid level in the tank to verify that the application rate is correct.

**Step 10.** Check the nozzle flow rate frequently. Adjust the pressure to compensate for small changes in nozzle output resulting from nozzle wear or variations in other spraying components. Replace the nozzle tips and recalibrate when the output has changed 10 percent or more from that of a new nozzle or when the pattern has become uneven.

## How Is Ground Speed Measured?

To apply pesticides accurately, you must maintain the proper ground speed. When using trucks or tractor-powered equipment, do not rely on speedometers as an accurate measure of speed. Slippage can result in errors of 30 percent or higher in speedometer readings. Changes in tire size also affect speedometer readings, and the accuracy of all speedometers should be checked periodically. Speedometer kits are available that do not use drive wheels for speed measurements. Ground speed must also be determined for hand-held application equipment. Ground speed is determined the same way for both power-driven and hand-held equipment.

To determine ground speed, measure a distance in the area to be sprayed or in an area with similar surface conditions. Suggested distances are 100 feet for speeds up to 5 mph, 200 feet for speeds from 5 to 10 mph and at least 300 feet for speeds above 10 mph. At the engine

throttle setting and gear that you plan to use during spraying with a loaded power sprayer, determine the travel time between the measuring stakes in each direction. Average these speeds and use the following equation to determine ground speed:

$$\text{Speed (mph)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88} \quad (\text{Equation 6})$$

$$(1 \text{ mph} = 88 \text{ feet in } 60 \text{ seconds})$$

**Example:** You measure a 200-foot course and discover that 22 seconds are required for the first pass and 24 seconds for the return pass.

$$\text{Average time} = \frac{22 + 24}{2} = 23 \text{ seconds}$$

$$\text{mph} = \frac{200 \times 60}{23 \times 88} = \frac{12,000}{202} = 5.9 \text{ mph}$$

Once you have decided upon a particular speed, record the throttle setting and drive gear used.

## How Do I Check the Spray Rate When Using Existing Nozzles?

You may already have a set of nozzle tips in your boom, and you want to know the spray rate (GPA or gal./1,000 sq. ft.) when operating at a particular nozzle pressure and speed.

Add water to the spray tank and make a precalibration check to be sure that all of the spray components are working properly. Remember, the type, size and fan angle of all the nozzle tips must be the same. The flow rate from each nozzle must be within 5 percent of the average flow rate from the other nozzles.

**Step 1.** Operate the sprayer at the desired operating pressure. Use a container marked in ounces to collect the output of a nozzle for a measured length of time, such as 1 minute. Check several other nozzles to determine the average number of ounces per minute (OPM) output from each nozzle.

**Step 2.** Convert OPM of flow to GPM of flow by dividing the OPM by 128 (the number of ounces in 1 gallon),

**Step 3.** Determine the spraying speed. For mounted boom sprayers, the speed in mph can easily be measured (Equation 7).

**Step 4.** Determine the sprayed width per nozzle (W) in inches. For broadcast spraying, W = the nozzle spacing.

**Step 5.** Calculate the sprayer application rate. For mounted boom sprayers, use Equation 1.

$$\text{GPM} = \frac{\text{GPM} \times 5,940}{\text{mph} \times W}$$

**Example:** The measured nozzle output is 54 OPM, the measured ground speed is 6 mph and the nozzle spacing (W) is 20 inches.

$$\text{GPM} = \frac{54}{128} = 0.42$$

$$\text{GPA} = \frac{0.42 \times 5,940}{6 \times 20} = \frac{2,495}{120} = 20.8 \text{ GPA}$$

Application rate can be adjusted by changing the ground speed or nozzle pressure and then recalibrating. Changes in nozzle pressure should be used only to make small changes in output and must be maintained within the recommended pressure range.

## Granular Applicators

Many lawn and ornamental care service applicators use granular products as a part of their program or even as a complete program. Proper selection, care, calibration and use of granular applicators can minimize costs and maximize the results obtained. Improper use of granular applicators can reduce product efficiency, cause injury to ornamentals, increase costs and harm the environment.

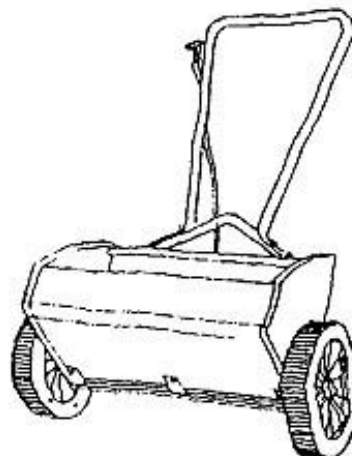
### What Type of Granular Applicator Should I Select?

Drop (gravity) and rotary (centrifugal) spreaders are available for applying granules. Drop spreaders (**Figure 1.7.2**) are generally more precise and deliver a better pattern. Since the granules drop straight down, there is less pesticide drift and better control. Some drop spreaders will not handle large granules, and ground clearance in ornamental settings can be a problem. Since the edge of the drop spreader is the limit of pesticide distribution, the applicator must be very careful to align the swaths correctly to provide proper application. It is easy to either overlap or skip areas with drop spreaders if one is not attuned to the pattern of the spreaders.

Rotary or centrifugal spreaders (**Figure 1.7.3**) cover a wide swath and thus cover a

given area faster. However, they are less precise than drop spreaders in terms of uniformity and distribution. Because of pattern feathering, steering errors are less critical. Since they do not have a full width agitator to turn, they require less effort to push. Rotary spreaders normally handle large particles well, but drift is a problem with fine particles when wind is excessive. Ground clearance in ornamental settings is usually a problem for rotary spreaders also. Since rotary patterns vary, more calibration time is needed. A major advantage of rotary spreaders is that they can be made of plastics and fiberglass and therefore are more resistant to corrosion. Rotary spreaders are also more durable in commercial use and less likely to be knocked out of calibration than some drop spreaders.

Experienced operators are familiar with proper use of granular applicators, but new operators should review the basic operating procedures.



**Figure 1.7.2.** Drop spreader.



**Figure 1.7.3.** Centrifugal spreader.

Begin by reading the operator's manual or instruction booklet provided by the manufacturer and follow the manufacturer's instructions. The second obvious recommendation is to follow the instructions on the product label, modifying rate and pattern settings, if necessary, for specific conditions.

Header strips at each end of the ornamental area provide a place to turn around and realign the spreader and serve to make the border area more uniform. Operators should always get the spreader moving at rated speed (normally 3 miles per hour) on the header strip or on a driveway, sidewalk, etc., and then open the spreader as the spreader crosses into the area to be treated. At the other end, the spreader should be closed when moving into the header strip and turning. A spreader should be closed when stopped to prevent the product from being applied to a small area. Likewise, the end turns should be made with the spreader closed, since the application pattern would be very irregular while turning.

Occasionally, it may be impossible to obtain a completely acceptable pattern with a rotary spreader, and striping of the ornamental bed may result. A common approach to this problem is to reduce the setting to a half rate and go over the bed twice at right angles. This is not a valid solution to the problem. This approach will not average out the pattern, but will merely change stripes into a diagonal checkerboard. If pattern problems cannot be corrected, the proper procedure is to reduce the setting to a half rate and reduce the swath width in half, but still go back and forth in parallel swaths.

## General Considerations

Normally, a spreader should not be operated backwards. It is obvious with most rotary spreaders that pulling the spreader backwards will deliver an unacceptable pattern. There is a problem also with reversing the direction of a drop spreader. Most drop spreaders will deliver granules at a considerably different rate at the same setting if reversed. In some cases such as in loose soil with new seedlings, the spreader may be easier to pull than to push. If it is desired to operate a spreader backwards, a different setting must be determined.

Some rotary spreaders enable you to cut off one side of the pattern. This feature is desirable when edging along driveways, sidewalks, etc.

Fill the spreader on a paved surface rather than in the bed. If a spill occurs, a driveway is much easier to sweep clean than a bed.

There are two important aspects to the precise application of granular products. The first is the product application rate. This term refers to the overall average amount of product applied in pounds per thousand square feet. Overapplication is costly, increases the risk of plant injury and may be illegal if label recommendations are exceeded. Underapplication can reduce the product efficacy and cause customer dissatisfaction. Flow rate from granular applicators does not change proportionately with changes in speed. Therefore, uniform ground speed is necessary to maintain a uniform application rate, and constant speed is needed if predeveloped settings are to be accurate.

Equally important is uniform distribution. This aspect is different from the application rate. A pesticide might be labeled for application at 4 pounds per 1,000 square feet. If a spreader applies 20 pounds to a 5,000 square foot bed, the apparent rate of application is correct, but it is possible some areas of the bed will receive twice as much pesticide per square foot as other areas. It is impossible to achieve absolutely uniform distribution with any granular applicator, but the most uniform distribution possible is particularly important with ornamentals. Under certain conditions, small differences in rate on different areas may result in poor pest control.

With drop spreaders, the distribution pattern, whether good or bad, is normally the same within a fairly broad range, regardless of speed, product physical characteristics, the environment and other factors. Rotary spreader patterns, on the other hand, are sensitive to these variables, and severe pattern skewing can result if the operator neglects these variables. The pattern applied by a rotary spreader is dependent on impeller characteristics (height, angle, speed, shape and roughness), ground speed, drop point of the product on the impeller, product physical parameters (density, shape and roughness of particles) and environmental factors (temperature and humidity). Most of these factors are beyond the control of the spreader operator.

Spreader engineers normally try to design rotary spreaders to give an acceptable distribution pattern for a broad range of products and operating conditions. Small rotaries, particularly homeowner models, usually do not have any

pattern adjustment and are designed to perform well with average products and to work acceptably well with a fairly wide range of products. This is possible because of the limited swath width. The wider pattern of the larger commercial rotary spreaders is more susceptible to skewing, thus a means of adjustment is usually provided for pattern distribution. This adjustment typically consists of blocking off part of the metering port(s) on smaller units and moving the metering point or changing the impeller geometry on larger units.

It is essential the operator be aware of the need for pattern adjustments and know how to make adjustments. The operator should first follow the manufacturer's recommendation on pattern adjustment. If the skewing cannot be fully corrected, there are other means that can be used, such as varying the speed or tilting the impeller. In extreme cases where a product is so heavy or so light that skewing cannot be eliminated, it may be necessary to use a wider swath width on one side than on the other.

## How Do I Calibrate My Granular Applicator?

Because of many variables, it is highly recommended all spreaders be calibrated for proper delivery rate with the specific operator and product to be used. Many product suppliers furnish recommended settings and swath widths. These are as precise as the manufacturer can make them, but factors just mentioned can add up to a significant rate variation in some cases. Label settings should be used only as the initial setting for verification runs by the operator prior to large-scale use.

Calibration should be checked and corrected according to the manufacturer's directions at least once a week when the spreader is in regular use and more frequently if the spreader has suffered any abuse or mechanical damage.

The easiest way for an operator to check the delivery rate of a spreader is to spread a weighed amount of product on a measured area, preferably at least 1,000 square feet for a drop spreader and 5,000 for a rotary, and then weigh the product remaining to determine the rate actually delivered.

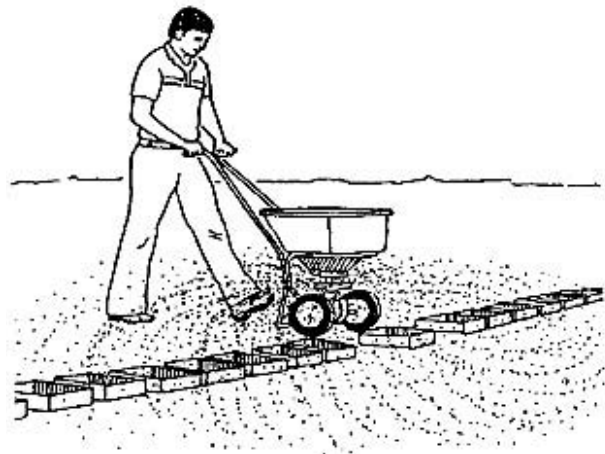
To avoid contamination of the ornamental area for initial calibration, the spreader can be supported above a floor and the drive wheel spun

at the correct speed with the spreader remaining stationary. Granules can be collected and reused with this technique. Another method of rate verification that can be used with drop spreaders is to hang a catch pan under the spreader and push the spreader a measured distance at the proper speed. This method can be precise, but it is essential that the pan be hung on the spreader so that there is no interference with the shut-off bar or rate control linkage.

With rotary spreaders, it is also necessary to check and correct the distribution pattern. Again, the product label may give a recommended setting and width, but a custom applicator should check the setting and width before using. A quick pattern check can be made by operating the spreader over a paved area and observing the pattern. However, this method is not highly accurate, since even major distribution errors may not be visible because of particle bounce and scatter.

A preferred method is to lay out a row of shallow cardboard boxes on a line perpendicular to the directions of travel (**Figure 1.7.4**). Boxes 1 to 2 inches high with an area of about 1 square foot and spaced on 1-foot centers are good for commercial push-type rotaries. The row of boxes should cover one and one-half to two times the anticipated effective swath width.

To conduct the test, pour some product into the spreader and set it at the label setting for rate and pattern. Make three passes over the boxes, operating in the same direction each time. The material caught in each box can be weighed and a distribution pattern plotted. However, a simpler procedure is to pour the material from



**Figure 1.7.4.** A row of shallow boxes can be used as a pattern check.

each box into a test tube, vial or small bottle. With the bottles standing side by side in order, a plot of the pattern is visible.

This method can be used to detect and correct skewing and to determine swath width. The effective swath width is twice the distance out to the point where the rate is one-half the average rate at the center. For example, if the center three to four bottles have material 2 inches deep, and the bottles from the 6-foot positions (6 feet left of the spreader center line and 6 feet right of the spreader center line) have material 1 inch deep, the effective swath width is 12 feet.

## Shade Tree Sprayers

Spraying tall ornamentals and shade trees for insect and disease control requires thorough coverage of leaf, stem and trunk surface. Much more energy is required for trees than for ground spraying because of the greater distances the spray must be projected and the necessity for covering large surface areas.

Tree and ornamental spraying is normally accomplished with either high-pressure, high-volume hydraulic sprayers or air-carrier sprayers. Hydraulic sprayers use sufficient pressure in the liquid system to propel the spray droplets from the point of release to the point of application. Air-carrier sprayers use an airstream to transport and distribute the spray droplets. They may utilize either high- or low-pressure liquid systems.

## How Is Uniform Coverage of Shade Trees Obtained With Hydraulic Sprayers?

Hydraulic sprayers used for spraying tall ornamentals generally have tanks, pumps and control systems that can handle high volumes of spray materials at high pressures. Sprayers are available with tank capacities up to 1,500 gallons and with pumps that can supply up to 60 gallons per minutes at pressures up to 800 psi. Hand-operated spray guns are used to direct the spray onto the ornamental.

Positive displacement piston pumps are generally used to produce the high pressures required. Abrasion-resistant cylinder linings are desirable to prevent damage to the pump

when spraying wettable powders. However, piston pumps produce a pulsating flow that can damage gages, valves, hose fittings and even the pump itself. Therefore, a surge tank should be installed to absorb the pressure peaks. Air-chamber surge tanks are available for intermittent spraying at pressures up to 400 psi. Although the initial cost of a piston pump is high, its rugged construction, dependability and long life make it economical for continuous, hard usage.

A relief valve is necessary to protect the system from excessive pressure and to control the pressure applied to the spray gun. Tension on the spring in the relief valve is adjusted to maintain a constant pressure in the system by bypassing some of the liquid to the supply tank. When the line to the handgun is shut off, the entire output of the pump is bypassed to the tank. The relief valve must be sized to handle the desired flow rates of pressures. Some are available with two or more springs that make it possible to operate the spray system over a wide range of pressures. When the system is used at a low pressure, only the more responsive, low-pressure spring is energized.

When pressures of over 200 psi are to be used, the relief valve should be replaced with an unloader valve. This type of valve will decrease the pressure on the pump and the load on the engine when the spray valve is closed. Remember, if an unloader valve is used in a system having hydraulic agitation, the agitation flow may be insufficient when the valve is unloading.

A pressure gage, covering the range of pressures to be used, should be installed in the supply line to assist in adjusting and monitoring the sprayer's operation. A damper is needed to protect the gage from the pump pulsations. All components of the system must be designed to withstand the high pressures produced by the pump.

Nearly every hydraulic tree sprayer uses a hand-held gun. For short trees and shrubs, a multiple-outlet gun can be used, but the single-outlet gun with a pistol-grip valve is the most common. Many applicators use a variable discharge-angle gun. With a twist of the handle, the spray angle can be adjusted to a wide angle for short trees and shrubs and to a solid stream for tall trees.

Generally, coverage by a spray gun is relatively good with a high volume of water. If problems occur, they are usually with the tops of very tall trees. For optimum results, the correct combination of nozzle flow rate and pressure must be selected. **Figure 1.7.5** shows the effect of flow rate and pressure on the vertical reach of typical spray gun nozzles.

To reach the tops of trees, large drops are required, but the size of the drops emitted decreases with increasing pressure. Hence, there are limits to pressure increases to extend the vertical range of spray stream. Relatively large droplets are necessary to keep wind from dissipating or spreading the liquid stream. As can be seen in **Figure 1.7.5**, the vertical reach increases only slightly for pressures above 400 psi.

When vertical reach becomes a problem, better results will be obtained by selecting a nozzle of larger capacity than by increasing the pressure. The greater the nozzle capacity and the narrower its spray pattern, the higher it will reach. Guns and nozzle kits are available to spray trees up to 100 feet tall at pressures between 350 to 450 psi. Ladders, elevated truck-mounted platforms or gun extensions can also be used to gain the necessary height.

Disc-type nozzle orifices are usually numbered to represent the orifice diameter in 64ths of an inch. **Table 1.7.2** shows the relationship between flow rate, pressure and orifice size. At any given pressure, the flow rate will increase by a factor of four when the orifice diameter is doubled. Conversely, for any size orifice, the pressure must be increased by

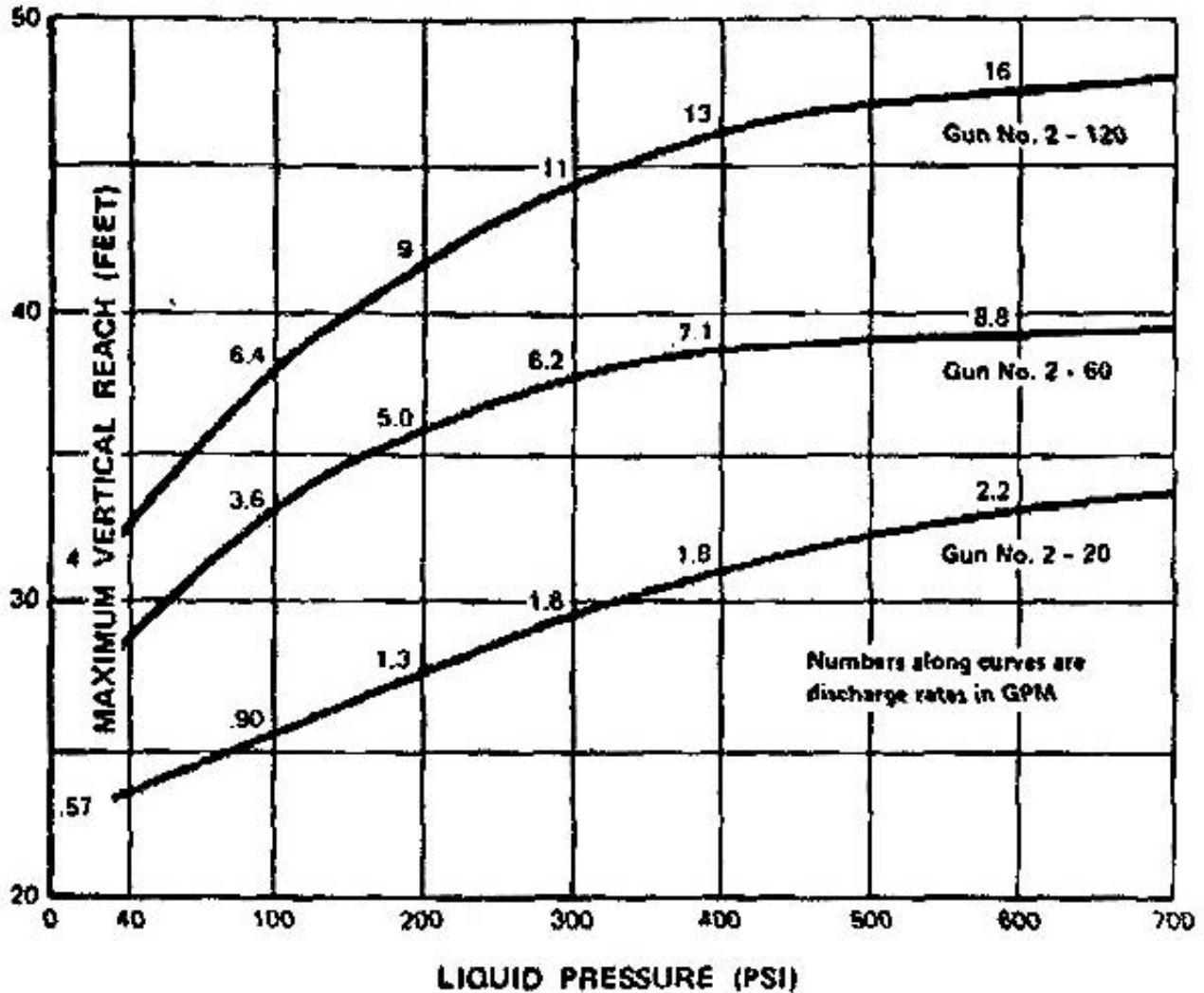


Figure 1.7.5. Maximizing vertical reach should be obtained by selecting a nozzle of larger capacity, rather than increasing the pressure.

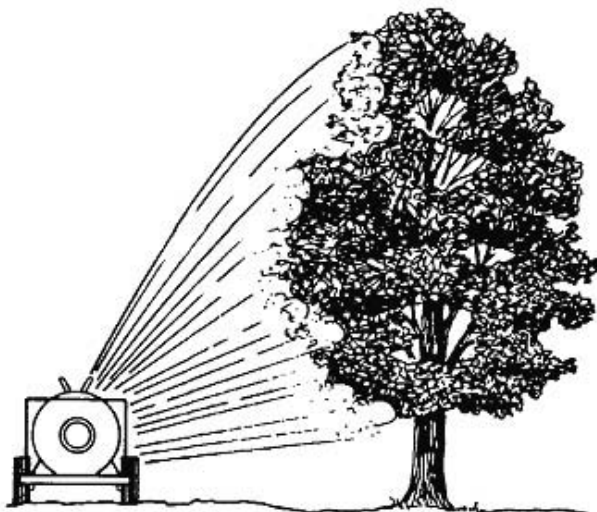
**Table 1.7.2. Spray gun flow rates, in gallons per minute, for various nozzle orifice sizes.**

Orifice Disc. No.	Pressure (pounds per square inch)					
	50	100	200	300	600	800
2	.3	.4	.5	.7	.9	1.0
4	.6	.9	1.2	1.6	2.1	2.4
6	1.3	1.8	2.5	3.4	4.1	4.6
8	2.1	3.0	4.3	6.0	7.1	8.0
10	3.1	4.4	6.2	8.7	10.5	12.0
12	4.4	6.2	8.7	12.0	14.2	16.0
16	7.4	10.0	13.8	18.9	22.6	25.8

a factor of four to double the output. Nozzles wear with use, particularly when they are used to spray abrasive materials, such as wettable powders. As nozzles wear, the nozzle orifices become larger and nozzle output increases. Because of the high stress on the nozzles, hardened stainless steel, chrome-plated brass, or ceramic nozzle components should be used. Discs are available with hard center cores that can be replaced when worn.

Multiple nozzle arrangements with smaller nozzles may be used and tend to provide better coverage because they produce smaller droplets. However, drift increases and vertical reach decreases with smaller droplet sizes.

A major requirement for good application is to apply the pesticide uniformly to all surfaces of the tree. This requires a competent operator. To ensure adequate coverage, trees are usually sprayed to the point of runoff (**Figure 1.7.6**).



**Figure 1.7.6. Air-carrier sprayer used on tall trees.**

The amount of spray required to reach the point of runoff depends on the size and shape of the trees, density of the foliage and the application techniques used by the operator.

Often it is desirable to know the amount of spray required to wet a tree to the point of runoff. This is easily determined by measuring the flow rate of the spray gun and multiplying by the time required to spray the tree. For example, if a spray gun delivers 6 gallons per minute and a tree requires 3 minutes to spray, 18 gallons of spray mix are applied. Flow rate of a spray gun can be determined by collecting the output for a timed period. For example, if a gun fills a 3-gallon pail in 30 seconds, the flow rate is 6 gallons per minute.

Mixing is an important part of spraying ornamentals and trees. Most label rates are given as the amount of pesticide active ingredient, or product, to add to 100 gallons of water. If recommendations are given as active ingredients, then you must convert the amount of active ingredient into the amount of formulated product that is needed.

### **Can Air-Carrier Sprayers Be Used to Obtain Effective Pest Control in Shade Trees?**

Sprayers that blow the spray into the trees with a blast of air are equipped with powerful fans to generate the required air current. Nozzles dispense the spray droplets into the high velocity air stream. Various combinations of air volume, air velocity, liquid volume and liquid pressure are used in air sprayers to obtain uniform spray distribution. Research has shown that more spray volume should be directed toward the top of the tree than to the lower

portions to obtain uniform coverage, because the larger droplets containing most of the spray volume settle out of the air stream very rapidly.

Since air sprayers use both air and water as diluents, they give full coverage with less water than hydraulic sprayers. The use of a lower water-to-pesticide ratio with air sprayers is termed concentrate or low-volume spraying. With this technique, three, five or even 10 times the amount of pesticide is used per 100 gallons of spray, but only one-third, one-fifth or one-tenth as many gallons of spray are applied to the trees. In concentrate spraying, this rate is referred to as 3x, 5x or 10x application. The resulting deposit of pesticide on leaves should be the same as with the dilute method. **Table 1.7.3** shows the amount of spray required per tree for various degrees of concentrate spraying.

Basing the degree of concentration on the dilute application rate (spraying to the point of runoff) has caused considerable confusion. A 5x concentrate may mean 10 gallons per tree in one area, but 8 gallons per tree in another area. The difference is that different operators apply different amounts to obtain satisfactory coverage to treat the same tree. The quantity of foliage, amount of runoff, timing and spraying technique are all causes of variance.

The primary advantages of using concentrated sprays are that they require less labor, water and time than applying dilute mixtures. However, competent operation is

essential when using air-blast sprayers, since the spray pattern is almost invisible. It is also impossible to determine the extent of coverage since there is no runoff.

Trees to be sprayed must be directly accessible to the sprayer unit because best coverage and distribution are obtained by spraying up through the canopy. If the distance from the tree to the sprayer is too great, the velocity will be insufficient to penetrate the canopy. Most airstreams lose 75 percent of their velocity in the first 25 feet after leaving the sprayer. Therefore, the sprayer should be immediately adjacent to the tree.

Two factors affecting the coverage obtained with air-carrier sprayers are airstream velocity and volume. In addition to canopy penetration, velocity is important in getting the spray to the top of tall trees. Spray material must be forced into the foliage with a turbulent force. To achieve this, air velocity is nearly 100 mph when leaving the sprayer and must be at least 15 mph at the tree surfaces.

Generally, increasing the volume of air applied improves the spray distribution. The blower must displace the volume of air in the tree with air from the sprayer containing spray droplets. When the available energy is fixed, the higher the ratio of air velocity to volume, the better the distribution.

Air-carrier sprayers are not trouble free. In addition to wind conditions, a potential problem

**Table 1.7.3. Gallons of concentrate spray required per tree.\***

Concentrate To Be Applied	Pressure (pounds per square inch)					
	5.0	8.0	10.0	15.0	20.0	50.0
Dilute 1x						
2x	2.5	4.0	5.0	7.5	10.0	25.0
3x	1.7	2.7	3.8	5.0	6.7	16.7
4x	1.3	2.0	2.5	3.8	5.0	12.5
5x	1.0	1.6	2.0	3.0	4.0	10.0
6x	0.8	1.3	1.7	2.5	3.3	8.3
8x	0.6	1.0	1.3	1.9	2.5	6.3
10x		0.8	1.0	1.5	2.0	5.0
15x		0.5	0.7	1.0	1.3	3.3
20x			0.5	0.8	1.0	2.5
30x				0.5	0.7	1.7

\*The first line in the table is the amount of spray applied per tree to the point of runoff. From that basis, the amount of spray can be determined for the various concentrations.

during cold weather is freezing of the spray droplets, both on the nozzles and while airborne. Evaporative cooling may cause ice to accumulate on the nozzles. This can alter the droplet size as well as the distribution pattern. Also, after leaving the nozzle, sometimes droplets will form ice crystals and coverage is negligible. To avoid freezing problems, air-blast spraying should be done only when the temperature is above 45°F. Air-carrier sprayers often are difficult to use in Arkansas because of spray drift. The combination of fine spray particles and wind creates a situation for drift to occur. In urban landscapes, there is no room for allowing pesticide drift.

Although air sprayers can reach tall trees, their energy consumption far exceeds that of hydraulic sprayers. Since the energy needed is greater because air-blast sprayers must move both air and liquid, some air sprayers require a 140-HP engine. On the other hand, air sprayers cover trees faster and require less refilling than hydraulic sprayers. When spraying a large number of trees, timely application can result in pest control equal to hydraulic sprayers with lower overall costs.

## Mixing and Loading Pesticides

### How Much Pesticide Do I Add to My Spray Tank or Granular Applicator?

To determine the amount of pesticide to add to the spray tank, you need to know the recommended application rate of pesticide, the capacity of the spray tank and the calibrated output of the sprayer.

The recommended application rate of the pesticide is given on the label. The rate is usually indicated as pounds per acre for wettable powders, and pints, quarts or gallons per acre for liquids. Sometimes the recommendation is given as pounds of active ingredient (lb. a.i.) per acre, rather than the amount of total product per acre. The active ingredient must be converted to actual product.

### Dry Formulation

**Example 1.** A carbaryl recommendation calls for two pounds of active ingredient (a.i.) per acre. You have purchased Sevin (80 percent wettable powder). Your sprayer has a 200-gallon

tank and is calibrated to apply 20 gallons per acre. How much Sevin should be added to the spray tank?

**Step 1.** Determine the number of acres that you can spray with each tankful.

$$\text{Tank capacity (gallons/tank)} = \frac{200}{20}$$

$$\text{Spray rate (gallons/acre)} = 10 \text{ acres sprayed per tankful}$$

**Step 2.** Determine the pounds of pesticide product needed per acre. Because not all of the Sevin in the bag is an active ingredient, you will have to add more than 2 pounds of the product to each “acre’s worth” of water in your tank. How much more? The calculation is simple: divide the percentage of active ingredient (80) into the total (100).

$$2 \text{ lb. a.i./acre} \times \frac{100\%}{80\%} = 2 \times 1.125 = 2.5 \text{ lb. of product/acre}$$

You will need 2.5 pounds of product for each “acre’s worth” of water in the tank to apply 2 pounds of active ingredient per acre.

**Step 3.** Determine the amount of pesticide to add to each tankful. With each tankful, you will cover 10 acres (Step 1), and you want 2.5 pounds of product per acre (Step 2). Add 25 pounds (10 acres x 2.5 pounds per acre = 25 pounds) of Sevin to each tankful.

**Example 2:** The insecticide Diazinon recommendation calls for 4 pounds per acre. Your 5-gallon air compression sprayer applies 1.25 gallons per 1,000 square feet. How many ounces should you add to the spray tank?

**Step 1.** Convert the recommended rate to oz./1,000 square feet.

$$\text{oz./1,000 sq. ft.} = \frac{\text{recommended lb./A} \times 1,000 \text{ sq. ft.}}{2,722^*} =$$

$$\frac{4 \times 1,000}{2,722} = \frac{4,000}{2,722} = 1.5 \text{ oz./1,000 sq. ft.}$$

\*2,722 = a constant arrived at by dividing the number of square feet in one acre (43,560) by the number of ounces in one pound (16).

**Step 2.** Determine the amount of pesticide to add to each tankful.

$$\text{oz. pest./tankful} = \frac{\text{gal./tank} \times \text{oz. pest./1,000 sq. ft.}}{\text{gal. applied/1,000 sq. ft.}} =$$

$$\frac{5 \times 1.5}{1.25} = 6 \text{ oz./tankful}$$

## Liquid Formulation

**Example 1:** A trichlorfon recommendation calls for 1 pound of active ingredient (a.i.) per acre. You have purchased Dylox 4E (4-pounds-per-gallon formulation). Your sprayer has a 150-gallon tank, and it is calibrated at 15 gallons per acre. How much Dylox should you add to the spray tank?

**Step 1.** Determine the number of acres that you can spray with each tankful. Your sprayer has a 150-gallon tank, and it is calibrated for 15 gallons per acre.

$$\begin{aligned}\text{Tank capacity (gallons/tank)} &= \frac{150}{15} \\ &= 10 \text{ acres sprayed with} \\ &\quad \text{each tankful}\end{aligned}$$

**Step 2.** Determine the amount of product needed per acre by dividing the recommended a.i. per acre by the concentration of the formulation.

$$1 \text{ lb. a.i. per acre} = 1/4 \text{ gallon per 4 lb. a.i. per gallon acre}$$

One-fourth gallon or 1 quart of product is needed for each "acre's worth" of water in the tank to apply 1 pound of active ingredient (a.i.) per acre.

**Step 3.** Determine the amount of pesticide to add to each tankful. With each tankful, you will cover 10 acres (Step 1), and you want 1/4 gallon (1 quart) of product per acre (Step 2). Add 10 quarts (10 acres x 1 quart per acre = 10) of trichlorfon to each tankful.

**Example 2:** The recommendation for the insecticide malathion calls for 1 gallon of product per acre. You have a 4-gallon knapsack sprayer that has been calibrated to apply 1/2 gallon per 1,000 square feet. How many ounces should you add to the spray tank?

**Step 1.** Convert the recommended rate to pints/acre.

$$\text{pints/acre} = \frac{1 \text{ gal.}}{\text{acre}} \times \frac{8 \text{ pts.}}{\text{gal./acre}} = 1 \times 8 = 8 \text{ pts.}$$

**Step 2.** Convert the required pints/acre to oz./1,000 square feet.

$$\begin{aligned}\text{oz./1,000 sq. ft.} &= \frac{\text{recommended pt./A} \times 1,000 \text{ sq. ft.}}{2,722} \\ &= \frac{8 \times 1,000}{2,722} = 3 \text{ oz./1,000 sq. ft.}\end{aligned}$$

**Step 3.** Determine the amount of pesticide to add to each tankful.

$$\text{oz./1,000 sq. ft.} = \frac{4 \times 3}{0.5} = 24 \text{ oz./1,000 sq. ft.}$$

## Adjuvants

The manufacturer may recommend that you add a small amount of an adjuvant (spreader-sticker, surfactant, etc.) in addition to the regular chemical. This recommendation is often given as "percent concentration."

If you use an adjuvant at a 1/2 percent concentration by volume, how much should you add to a 300-gallon tank?

**Solution 1:**

$$\begin{aligned}1\% \text{ of } 100 \text{ gallons} &= 1 \text{ gallon} \quad (0.01 \times 100 = 1) \\ 1/2\% \text{ of } 100 \text{ gallons} &= 1/2 \text{ gallon}\end{aligned}$$

You will need 1/2 gallon per 100 gallons, or 1 1/2 gallons for 300 gallons (1/2 x 3 = 1 1/2).

**Solution 2:**

$$\begin{aligned}1/2\% &= 0.005 \\ 0.005 \times 300 \text{ gallons} &= 1.5 \text{ gallons}\end{aligned}$$

## Granules

**Example:** You are using a spinner granular spreader on a flowerbed 300 feet by 200 feet. The recommendation for Diazinon is 10 pounds a.i./acre. You have purchased Diazinon 14G. How many pounds of product will it take to cover this bed?

**Step 1.** Convert pounds active ingredient to pound product.

$$\begin{aligned}\text{Pounds product per acre} &= \text{lb. a.i./acre} \times \frac{100\%}{\% \text{ a.i.}} \\ &= 10 \text{ lb. a.i.} \times \frac{100}{14} = 10 \times 7.14 = 71.4 \text{ lb.}\end{aligned}$$

**Step 2.** Determine the number of ounces required to cover this bed.

$$\text{Ounces required} = \frac{\text{lb./A} \times \text{area treated (sq. ft.)}}{2,722}$$

$$\text{Ounces required} = \frac{71.4 \text{ lb./A} \times 60,000 \text{ sq. ft.}}{2,722}$$

$$\frac{4,284,000}{2,722} = 1,573.8 \text{ oz. or } 98 \text{ lb.}$$

# Land Area Management

## How Do I Measure Small Land Areas?

It is essential to know the amount of area you intend to cover when applying pesticides or fertilizer. Small ornamental areas, such as lawns, golf course greens and fairways, should be measured in square feet or acres, depending on the units needed.

### Rectangular Areas

Area = l x w

**Example:** A flowerbed measures 980 feet long by 150 feet wide. What is the area?

Area = 980 ft. x 150 ft. = 147,000 sq. ft.

Area in acres =  $\frac{147,000 \text{ sq. ft.}}{43,560 \text{ sq. ft./acre}} = 3.4 \text{ acres}$

\*1 acre = 43,560 sq. ft.

### Triangular Areas

Area =  $\frac{b \times h}{2}$

**Example:** An ornamental area in a corner lot has a base of 500 feet and a height of 100 feet. What is the area?

Area =  $\frac{500 \text{ ft.} \times 100 \text{ ft.}}{2} = 25,000 \text{ sq. ft.}$

Area in acres =  $\frac{25,000 \text{ sq. ft.}}{43,560 \text{ sq. ft.}} = 0.6 \text{ acres}$

### Circular Areas

Area =  $\pi r^2$  where  $\pi = 3.14$  and  $r$  = the radius of the circle OR

Area =  $\frac{\pi d^2}{4}$  where  $\pi = 3.14$  and  $d$  = the diameter of the circle

**Example:** A ground cover underneath a tree has a diameter of 40 ft. What is the area?

Area =  $\frac{3.14 \times 40^2}{4} = \frac{5,024}{4} = 1,256 \text{ sq. ft.}$

Area in acres =  $\frac{1,256 \text{ sq. ft.}}{43,560 \text{ sq. ft.}} = 0.03 \text{ acres}$

## Irregularly Shaped Areas

Any irregularly shaped ornamental area can generally be reduced to one or more of the geometric figures shown previously. The area of each is calculated and added together to obtain the total area.

**Example:** What is the total area of this ornamental area?

Area 1 is a triangle =  $\frac{b \times h}{2}$

$\frac{30 \text{ ft.} \times 20 \text{ ft.}}{2} = 300 \text{ sq. ft.}$

Area 2 is a rectangle = l x w

500 ft. x 20 ft. = 10,000 sq. ft.

Area 3 is a circle =  $\frac{\pi d^2}{4}$

$\frac{3.14 \times 40^2}{4} = 1,256 \text{ sq. ft.}$

## Irregular Boundaries

Irregular areas can be reduced to a series of trapezoids by right-angle offsets from points at regular intervals along a measured line AB. The area of this shape is determined by this formula:

Area =  $b \left[ \frac{h_1 + h_2}{2} + \frac{h_2 + h_3}{2} + \frac{h_3 + h_n}{2} \right]$

- b is the length of a common interval between the offsets.
- b must be the same for every interval.
- $h_1, h_2, h_3 \dots h_n$  are the offsets measured perpendicularly from line AB.

**Example:** In this flowerbed, the intervals, or b, are 10 feet. The offsets are measured out from line AB, which is a cord stretched across the bed and marked in 10-foot intervals. What is the area of this bed?

## Suggestions

- A measuring wheel or device can save time over a tape.
- Once the area has been measured, record the measurements for future reference.
- If the area is new to you and you are relying on the figures of someone else, it would be advisable to check them.

**Table 1.7.4. Measurement conversions.**

<b>Square Measure:</b>		
144 square inches	.....	.1 square foot
9 square feet	.....	.1 square yard
30 1/4 square yards	..... 1 square rod	..... .272 1/4 square feet
43,560 square feet	.....	.1 acre
4,840 square yards	.....	.1 acre
160 square rods	.....	.1 acre
640 acres	.....	.1 square mile
<b>Linear measure:</b>		
1 inch	..... 2 1/2 centimeters	..... .25 1/2 millimeters
1 foot	.....	.12 inches
1 yard	.....	.3 feet
1 rod	..... 5 1/2 yards	..... .16 1/2 feet
1 mile	..... .320 rods	..... 1,760 yards
.....	.....	..... .5,280 feet
<b>Fluid Measure:</b>		
1/6 fluid ounce	.....	.1 teaspoon (tsp.)
1/2 fluid ounce	..... 1 tablespoon (Tbs.)	..... .3 teaspoons
1 fluid ounce	..... 2 tablespoons	..... .1/8 cup
8 fluid ounces	..... 1 cup	..... .1/2 pint
16 fluid ounces	..... 2 cups	..... .1 pint
32 fluid ounces	..... 4 cups	..... .1 quart
128 fluid ounces	..... 16 cups	..... .1 gallons
<b>Weights:</b>		
1 ounce	.....	.23 1/3 grams
1 pound	..... 16 ounces	..... .453 1/2 grams
2 1/5 pounds	..... 1 kilogram	..... .1,000 grams
1 ton	..... 2,000 pounds	..... .907 kilograms
1 metric ton	..... 1,000 kilograms	..... .2,205 pounds
<b>Approximate Rates of Application Equivalents:</b>		
1 ounce per square foot	.....	.2,722.5 pounds per acre
1 ounce per square yard	.....	.302.5 pounds per acre
1 ounce per 100 square feet	.....	.27.2 pounds per acre
1 pound per 1,000 square feet	..... 43.56 ounces per acre	..... .2.72 pounds per acre
1 pound per acre	..... 1 ounce per 2,733 square feet	..... .8 1/2 grams per 1,000 square feet
100 pounds per acre	.....	.2.5 pounds per 1,000 square feet
5 gallons per acre	.....	.1 pint per 1,000 square feet
100 gallons per acre	..... 2.5 gallons per 1,000 square feet	..... .1 quart per 100 square feet

## Minimizing Pesticide Hazards to the Consumer

Ornamental pesticides must often be applied in environments frequented by humans, pets and other domestic animals. The pesticide applicator must be constantly alert to the potential risks associated with this situation. Primarily, the problem is twofold – preventing hazardous amounts of pesticides from drifting into non-target areas and preventing humans, pets and other animals from contacting hazardous amounts of pesticides within the treated area. To avoid problems as much as possible, the following safety precautions should be followed:

- Double check to make sure you have the correct yard before spraying.
- Do not allow children or pets to remain in the area being sprayed. Check the neighbors' yards to make sure there are no children, pets or swimming pools which could come in contact with spray drift.
- Remove toys, pet food dishes and bird feeders.
- Be sure all clothing is removed from the area.
- Avoid fishponds and birdbaths.
- Avoid spraying lawn furniture and swimming pools.
- Make sure all house windows are closed.
- Observe pesticide label restrictions concerning tolerance for fruits and vegetables.

- Sweep or rinse away all spray puddles.
- Secure all pesticide containers or spray apparatus before moving to the next job.

## Hazards to the Target Plant

### Phytotoxicity

Probably the greatest hazard to the target plant is an adverse or “phytotoxic” reaction to the pesticide applied. Phytotoxicity, or pesticide damage to plants, results in such things as abnormal growth, leaf drop and discolored, curled and spotted leaves. If phytotoxicity is severe, the plant may die. Symptoms of phytotoxicity include leaf drop, stunting, overgrowth, discolored foliage, leaf curl and stem distortion.

Phytotoxicity often mimics such things as insect damage, plant disease and response to poor growing conditions, including insufficient moisture and improper fertilization. The following items are especially relevant to the phytotoxicity problem:

- A wide variety of plant material.
- Pesticide drift.
- Pesticide persistence beyond the intended period of pest control.
- Improper rate of application or improper technique.

The cause of phytotoxicity may be easy to determine or it may be subtle and hidden. Other causes that create similar symptoms are insects and disease agents, insufficient moisture, improper fertilization and other adverse growing conditions.

Factors that may contribute to pesticide phytotoxicity include:

- High air temperature during and immediately after pesticide application. Several pesticide labels warn of potential injury to plants if applied at or above certain temperatures.
- Excessive rates of pesticide application. Apply the pesticide at rates given on the label. Overdosing generally does not give any better control of the target pest and can injure the plant.
- Too little water. Insufficient dilution of the pesticide when mixing will result in a more

concentrated spray. Plants under moisture stress can be more sensitive to chemical injury.

- Uneven distribution of pesticides. Inadequate mixing of pesticides in the spray tank may result in an uneven distribution of the chemical. Wettable powders in particular need agitation to keep them uniformly suspended in water.
- Formulation. Certain formulations may be more likely to cause injury than other types. Emulsifiable concentrates are more likely to cause injury than wettable powders, because the solvents in them may allow the chemical to come into direct contact with the plant tissue by dissolving the waxy protective layer on the leaves.
- Mixing liquids or emulsifiable concentrates with wettable powders.
- Variety and species differences. A wide range of ornamental plants exists. Variation in sensitivity to certain chemicals exists among varieties of the same kind of plant.
- Growing conditions. Weak plants in shallow soils, wet spots or under other types of stress are more sensitive to chemical injury. Young, tender, fast-growing plants with areas of new growth tend to be more susceptible to injury.

Finally, take special care to avoid injury to landscape plants and turfgrass when using herbicides. Some herbicides leave residues in spray tanks that will injure desirable plants. Use separate sprayers for herbicides and other pesticides to eliminate this source of injury.

### Potential for Phytotoxicity

Ornamental plants vary from herbaceous to semi-woody and distinctly woody species. Generally, herbaceous plants (chrysanthemums, petunias, turfgrass, etc.) are more susceptible to pesticide damage than woody ones. Even the woody plants are more susceptible when growth is young and tender.

Plant damage is more likely to occur with herbicides. Fungicides tend to be less hazardous to plants than herbicides and insecticides. The pesticide label is the best guide for safe use on a specific ornamental plant. Since the registration status of pesticides is continuously being reviewed and is subject to change, read the

product label before purchasing to make sure it is registered for your needs.

Where different plants are rotated in the same soil, a pesticide used to control some pests on one plant may leave residues in the soil that will damage or kill another plant. This is especially true of some herbicides. Also, shrubs and ground covers can be injured by herbicides applied to adjacent turf areas. Other examples of injuries that may be caused by careless spraying are as follows:

- Carbaryl injures Boston ivy.
- Bordeaux mixture may injure certain succulent plants and russet some apple varieties.
- Diazinon injures ferns, hibiscus, gardenias, stephanotis and African violet.
- Dimethoate causes defoliation of honey locust and elm. It may also injure flowering almond, dahlias, plum, peach, cherry, chrysanthemum and Chinese holly.
- Malathion injures Canaert, Sargent's and Burk junipers; Japanese holly; ferns; violets; petunias; and the rose varieties Caledonia and Talisman.
- Oil-sensitive plants include beech, black walnut, butternut, hickory, mountain ash, Japanese maple, red maple, sugar maple, yellow wood, Russian olive, Norway spruce, yews, hemlock, magnolias, redbud, broadleaved evergreens in general and junipers.
- Oxex is toxic to azaleas, beech, boxwood, barberry, deutzia, hollies, raspberry, oak, hawthorn, spruce and sycamore.
- Phorate distorts new growth of Eleyi crabapple trees.
- Sulfur is toxic to viburnums and forsythia.
- Tedion may injure some varieties of roses.
- Thiodan may injure geraniums.

## Drift Problems

The proximity of different plants with varying susceptibility to pesticide damage requires commercial applicators in the ornamental and turf category to be especially aware of drift problems.

Two types of drift are associated with pesticides. The most common, drift of spray droplets or dust particles, is directly affected by such things as spray pressure, nozzle size, wind velocity and pesticide formulations. Drift of a pesticide with low vapor pressure is termed "vapor drift." Vapors or gases can drift in harmful concentrations, even in the absence of wind. Fumigants such as methyl bromide must be confined so they will not drift from the treated area. (Proper sealing with a plastic tarp is essential.) Some pesticide products are volatile or capable of vaporizing from soil and leaf surfaces in potentially harmful concentrations after application.

There are several steps that can be taken to prevent damage to nontarget plants. When several pesticides are available, the applicator should strongly consider the hazard and the toxicity of the active ingredient before making a choice. The applicator should use formulations and methods of application that will result in minimum drift. If possible, pesticides should be selected that are safe for both target and nontarget plants. This can be accomplished by reading the pesticide label and its MSDS. It may be necessary to place a barrier around the target plant or remove susceptible potted plants from the area.

## Persistence Beyond Period of Control

The period of pesticide residual activity varies greatly from one class of pesticides to another. Persistence is directly related to chemical structure, rate of application, soil type or texture, temperature, moisture conditions, rainfall amounts and other factors. Commercial applicators must be familiar with persistence of each pesticide which may be applied to ornamentals, especially where adjacent areas may be affected, treated soil is used to grow other plants or where humans and pets frequent the area.

Persistence is an important part of pest control, since successful pest control requires knowledge of a pesticide's persistence to make subsequent applications. For example, herbicides used for preemergence weed control in turf generally persist for 60 to 90 days, and postemergence herbicides can last from 1 or 2 days to 3 or 4 weeks, depending upon the specific herbicide involved.

Persistence can be an advantage to the applicator for long-term control of the pest. The use of a long-lasting insecticide to control borers is a situation in which pesticide persistence is desired. However, problems can develop when applications are made too frequently, raising the level of the insecticide on the tree or in the soil to potentially phytotoxic amounts.

## Combinations or Mixtures of Pesticides, Mixing and Compatibility

Mixing pesticides in the spray tank is an old and widely used practice. A mixture of an insecticide and fungicide or an insecticide and an acaricide is often used on fruit trees and ornamentals to save an additional application. Different herbicides are sometimes mixed to broaden the spectrum of activity – for example, combining a grass and a broadleaf herbicide. Many of the newer pesticide labels specifically list the mixtures that can or cannot be made with that pesticide.

In general, tank mixes of pesticides or pesticides with fertilizers are considered to be legal unless the label prohibits mixing with certain pesticides or fertilizers. A number of labels provide specific mixing instructions for certain pesticide combinations and fertilizer and pesticide combinations.

Even when pesticides are approved for use in a mixture, problems can still occur. Formulations of a particular pesticide may vary from one product to another, and incompatibility may result from the different wetting agents, solvents and other additives in them. Liquid formulations are particularly susceptible to incompatibility problems, due to the many additives they usually contain. Incompatibility is expressed in different ways, but a crystalline precipitate or a gelatinous mass is common, which would require time to clean out plugged nozzles, screens and regulators. Another common problem is a break in the emulsion in which the different ingredients separate out, as would oil and water. This is the result of the emulsifier being destroyed, and spray injury is likely to result. Sometimes, the addition of soluble salts to the spray tank will cause an emulsion to break. Separation can also take the form of clumping of particles together. Incompatibility can also result in lessened activity of the combination, although no visible problems can be seen. The combined materials inactivate one another, and the resulting mix will be less effective.

Hardness of water may also affect a pesticide or mixture of pesticides. Phosphate and carbamate materials are more susceptible to high alkalinity (high pH) than other pesticides. The addition of lime, lime sulfur, Bordeaux mixture or other highly alkaline materials may cause decomposition, loss of toxicity or phytotoxicity. *Bacillus thuringiensis* is often degraded when used with high alkaline fungicides such as Bordeaux or other fungicides containing copper.

Combinations of oil or petroleum solvents with organic chemicals frequently are injurious to plants. Many emulsifiable concentrates are formulated with petroleum solvents and fall into this category. Sometimes, one or both pesticides precipitate or fall out of the mixture, and spray injury to the crop is the frequent result. In other cases, mixing may cause excessive residues, although no precipitation is noticeable in the tank.

Most ornamental emulsifiable sprays are oil-in-water emulsions producing small particle sizes. When difficulties in emulsifying an oil- or pesticide-in-water spray are encountered, they can usually be corrected by starting with just enough water to cover the agitator, then starting the engine and running the agitator and the pump at full pressure to force the liquid through the by-pass return to the tank. If an additional or separate emulsifier is to be used, it should be added to the tank before adding the pesticide or oil. The pump should be allowed to run for 2 or 3 minutes. Once this emulsion is formed, add the rest of the water to fill the tank while the pump and agitator are running.

Although incompatibility may still be a problem, it can frequently be reduced to the minimum by:

1. Using formulations produced by the same manufacturer.
2. Keeping the equipment clean and well drained.
3. Never putting pesticides in an empty tank. The tank should always be partially filled before adding the pesticide.
4. Never combining concentrates without diluting them first.
5. Mixing wettable powders with water to form a slurry before they are added to the tank (unless you have an inductor system).
6. Adding wettable powders to the tank before the emulsifiable concentrates.

## Mixtures of Pesticides and Fertilizers

Many of the principles for using tank mixtures of pesticides also apply to fertilizer-pesticide mixtures. The most important point to remember is that such mixtures, either wet or dry, should be handled as pesticides – not as fertilizers.

Pesticides are precision tools. The total quantity of a pesticide in the tank may be less than the accepted variation in fertilizer application, which may vary from a plus or minus of 10 to 15 pounds per acre. Timing, placement and distribution are frequently different for pesticides and fertilizers. Compromising one requirement may limit the usefulness and safety of the mixture.

Where tank mixtures are to be used, make sure that agitation is adequate to maintain the suspension. Suspensions also require about 1 to 2 gallons of spray carrier for each pound of product to be suspended. Some products are specifically formulated for use in fertilizer mixtures. Others specify the need to check emulsion stability and add a compatibility agent, if needed.

### Adjuvants or Spray Additives

Pesticides, regardless of formulation, are formulated for general performance purposes under average conditions. For many jobs they perform satisfactorily, but there are also many situations where they fall short of the desired effect. For example, in very hard or soft waters, a formulation may have too little or too much emulsifier, with the consequent problems of difficulty in mixing or excessive foaming. A formulation may evenly distribute a pesticide on the leaves of plants that are not waxy. But on plants with waxy leaves, the spray may form small, round droplets instead of spreading as an even film over the leaf surface. The droplets then run off the plant and onto the ground, leaving no deposit to protect the plant. The addition of an appropriate surfactant to the spray tank will solve this problem.

**A substance added to the spray mixture to aid or improve the performance of the main ingredient is an adjuvant.**

Adjuvants can be added to the spray mixture to:

1. Improve the wetting of the foliage or the pest.
2. Change the evaporation rate of the spray.
3. Improve the ability of the spray deposit to resist weathering,
4. Improve the penetration, absorption and translocation of the pesticide.
5. Adjust or buffer the pH of the spray solution, increasing the effectiveness and longevity of alkaline-sensitive pesticides.
6. Improve the uniformity and amount of the deposit.
7. Improve the ease of mixing or compatibility of the spray mixture.
8. Increase the safety from spray injury to the crop.
9. Reduce the drift hazard to neighboring crops.
10. Improve physical properties of the mixture – for example, antifoaming agents.

Depending upon their intended use, adjuvants are called emulsifiers, wetters, stickers, extenders, spreaders, penetrants, foaming agents, antifoaming agents, etc.

Adjuvants are highly active materials. In most cases, a very small quantity will have great effect. Use only the amount recommended, since too much adjuvant may be just as bad as too little. It makes little difference whether the pesticide runs off the foliage because it balls up or because it forms too thin a film on the foliage. Many products contain adjuvants, and additional adjuvant may cause such problems as the loss of herbicide selectivity, which produces injury on normally tolerant plants. The label should be your guide on the addition of adjuvants.