



Calibrating Hand-Held and Backpack Sprayers for Applying Pesticides

S. M. Zedaker, Professor of Forestry, Virginia Tech

Introduction

Hand-held and backpack sprayers are inexpensive tools used to apply pesticides on small acreages. Home gardens, yards, small orchards, and Christmas tree plantations are examples of areas that often require pesticide applications to protect them from weeds, insects, and diseases. Effective pest control depends on applying the proper amount of pesticide. This can only be done if the spray equipment is calibrated accurately.

Equipment Description and Care

Every pesticide application tool consists of three major parts: a tank to hold the spray mix, a pump to provide pressure, and a nozzle/wand to deliver the chemical in the desired spray pattern. Figure 1 shows some examples of common hand-held and backpack sprayers.

Most backpack sprayers have pressure regulators that allow delivery of the spray mix at a constant pressure. Since a constant pressure must be maintained for consistent application rates, these devices must be kept in good working order. Follow the manufacturer's recommended procedure for periodic cleaning and inspection. Few hand-held sprayers contain pressure regulators, but fairly even pressure can be maintained if the hand pump is operated at a constant number of pumps per minute. It is not necessary to know the exact pressure output to calibrate your hand-held sprayer, just that it be constant.

The total volume of the spray tank must be known in order to determine the area that can be covered per tankful. Most backpack sprayers hold 4 to 6 gallons of spray mix; hand-held sprayers hold 1 to 3 gallons. Spray tanks should be rinsed thoroughly after each use, because many pesticides are corrosive and can damage internal parts. It is also advisable to use different sprayers for insecticides and herbicides. If your spray tank is plastic and

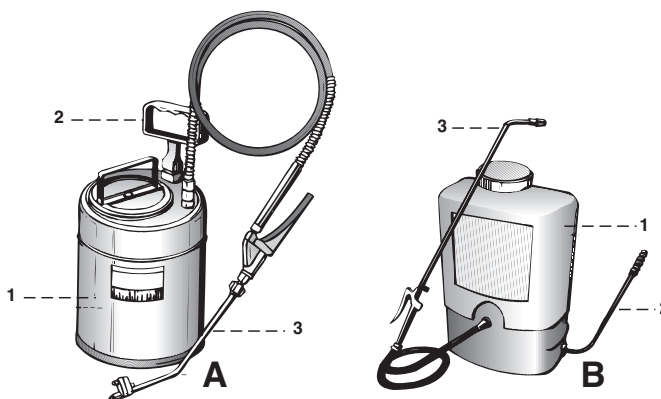


Figure 1. (A) Two-gallon hand-held sprayer; (B) five-gallon backpack sprayer. The three major parts are: (1) tank, (2) pump, and (3) boom/nozzle.

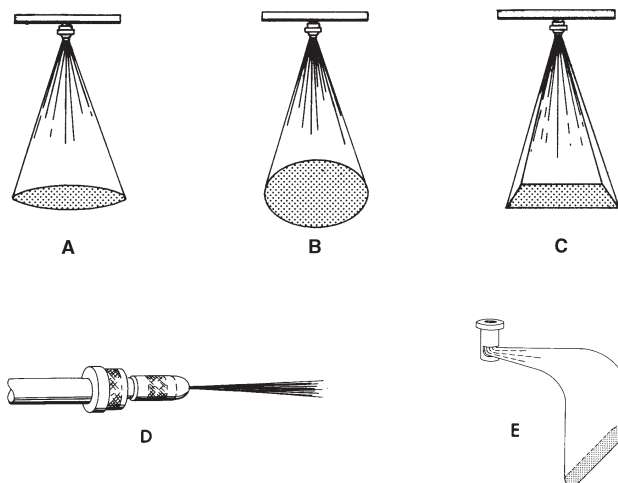


Figure 2. Common types of nozzles: (A) flat-fan nozzle — makes a narrow, oval pattern with tapered edges; (B) solid-cone nozzle — used for spot treatment; (C) even-flat-fan nozzle — makes a uniform pattern across its width, used for band or strip spraying; (D) adjustable nozzle common on hand-held sprayers — adjusts from solid stream to solid cone; (E) flood nozzle, also used for band or strip spraying — a wide, uniform pattern.

diesel or fuel oil is used as a carrier, the tank should be cleaned with detergent immediately after use. The oil may impregnate the plastic, leaving pesticide residue that could affect future applications.

Hand-held and backpack sprayers usually come equipped with a trigger valve and spray wand to which a single nozzle is attached. Nozzles come in various shapes and sizes and are carried by most agricultural chemical dealers (Figure 2). The newer nylon nozzles are lighter, more resistant to abrasive damage, and will not corrode. For spot applications, hollow or solid-cone nozzles work well, but only even-flat-fan or flood-jet types should be used for single-nozzle band applications. These nozzles will deliver a relatively even pattern and a constant application rate across the band. Nozzle output is measured in gallons per minute (GPM) at different pressures. Nozzles with low delivery rates (less volume per minute) are best for small sprayers, since more acreage can be covered with less carrier (water, oil, etc.). The angle of a nozzle's spray pattern and the height at which it is held from the ground determine the width of the spray pattern (Figure 3). This width is known as the effective swath width (ESW) and is important for sprayer calibration.

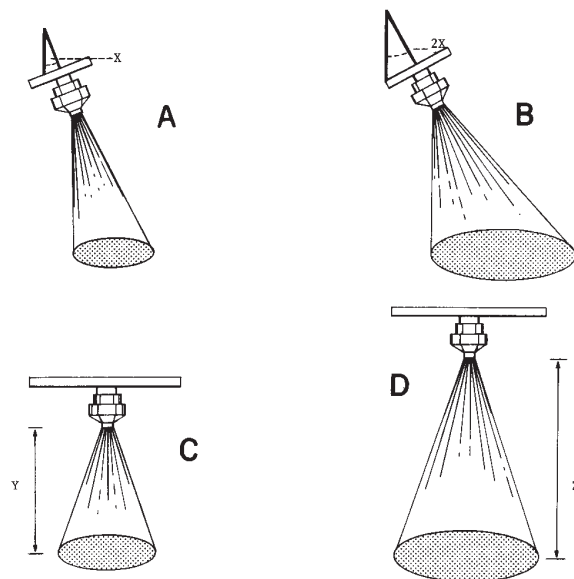


Figure 3. (A) and (B) show how the angle of the spray pattern affects the width of the pattern. As the angle, x , is increased from (A) to $2x$ in (B), the pattern width increases proportionately. The height of the nozzle above the ground also affects the width of the spray pattern, as shown in (C) and (D). As the height, y , in (C) increases to a height of z in (D), the pattern width increases proportionately.

Sprayer Calibration

Two methods of calibration will be described. These are (1) spray delivery rate and (2) known area rate. Although either can be used alone, both should be completed as a check for accuracy. Method 1 is the idealized calibration, while Method 2 is the operational check. Adjustments in the rate of travel, nozzle height, or pressure/pump rate can be made if calibrations by the two methods do not match. Calibrations should be done with only water in the tank and in calm air, with wind not exceeding 7 miles per hour.

Method 1 — Spray Delivery Rate

1. Lay out a 100-foot-long course in your plantation, yard, field, driveway, or road.
2. Fill your sprayer half full, and pump it to the normal operating pressure to simulate the average spray situation.
3. Traverse the course four times, spraying in a straight line as you would in a band application. Record time of each traverse to the nearest second, and measure the effective swath width (ESW) — width of wetted ground, foliage, or pavement — at several points along each traverse. Hold the nozzle at a consistent height above the ground. The height will vary for different people, but it should be one that is comfortable, normally between 18 and 24 inches above the ground.
4. Next, fill a gallon container four times from the sprayer, using the pump rate or pressure setting and nozzle used in the traverse in step #3 above. Time each fill to the nearest second. Determine the average gallons/minute using:

$$\frac{60 \text{ seconds/minute}}{\text{average seconds/gallon}} = \text{gallons/minute}$$

For example, if the times for filling the gallon container are 350 seconds, 338 seconds, 335 seconds, and 340 seconds, the average time is 340.8 seconds/gallon. Using the formula, gallons/minute are then calculated:

$$\frac{60 \text{ seconds/minute}}{340.8 \text{ seconds/gallon}} = 0.176 \text{ gallons/minute}$$

5. Determine the area covered per minute by the following formula (assuming a 100-foot traverse):

$$\frac{\text{ESW in inches}}{\text{average time in seconds for traverse}} \times \frac{1}{87.12} = \text{acres/minute}$$

For example, if the sprayer's ESW is 24 inches, and the four 100-foot traverses are timed at 23, 25, 23, and 24 seconds, the average time is 23.75 seconds. Using the above formula, acres covered per minute are calculated:

$$\frac{24}{23.75} \times \frac{1}{87.12} = \frac{24}{2069.1} = 0.0116 \text{ acres/minute}$$

6. Determine gallons/acre using:

$$\frac{\text{gallons/minute}}{\text{acres/minute}} = \text{gallons/acre}$$

This is the carrier rate your sprayer delivers using the pressure setting/pump rate, nozzle, nozzle height, and walking speed you have.

Thus, using the data calculated in examples #4 and #5 and the formula above, the number of gallons required per acre can be determined:

$$\frac{0.176 \text{ gallons/minute}}{0.0116 \text{ acres/minute}} = 15.17 \text{ gallons/acre}$$

7. Determine the area that can be sprayed by your sprayer for each tankful using:

$$\frac{\text{gallons/tank}}{\text{gallons/acre}} = \text{acres/tank}$$

Finally, using the above calculations, the area that can be sprayed with each tankful of a 5-gallon sprayer is:

$$\frac{5 \text{ gallons/tank}}{15.17 \text{ gallons/acre}} = 0.33 \text{ acres/tank}$$

Method 2:

1. Fill your sprayer to a known mark between 1/2 and 3/4 full.
2. Lay out a 66-foot by 66-foot square plot (1/10 acre) in your plantation, yard, field, or other level area.
3. Spray the plot at the pace and nozzle height used in Method 1. Be sure to cover the plot completely, but do not overlap spray swaths.
4. Refill the sprayer to the known mark, measuring the amount of water needed to the nearest cup (8 fluid ounces).
5. Calculate the gallons/acre using the following:

$$\frac{\text{no. of cups}}{16 \text{ cups/gallon}} \times 10 = \text{gallons/acre}$$

For example, if you measure 24.5 cups in step #4 above, the gallons/acre will be:

$$\frac{24.5 \text{ no. of cups}}{16 \text{ cups/gallon}} \times 10 = 15.31 \text{ gallons/acre}$$

6. Calculate the area that can be covered by your sprayer per tankful using Method 1, #7. Recall that the formula used in Method 1, #7, was:

$$\frac{\text{gallons/tank}}{\text{gallons/acre}} = \text{acres/tank}$$

Therefore, using the same 5-gallon sprayer and the gallons/acre calculated in #5 above:

$$\frac{5 \text{ gallons/tank}}{15.31 \text{ gallons/acre}} = 0.327 \text{ acres/tank}$$

For accurate chemical application, gallons/acre calculations for Methods 1 and 2 should agree within 10 percent. To check this, use:

$$\frac{\text{gallons/acre Method 1} - \text{gallons/acre Method 2}}{\text{gallons/acre Method 1}} \times 100 = +/\text{-}\% \text{ error}$$

For example, in Method 1, 0.330 acres were covered per tank, and in Method 2, 0.327 acres were covered per tank. Using the above formula, determine the percentage of error:

$$\frac{(0.330 - 0.327)}{0.330} \times 100 = 0.009 \times 100 = 0.9\% \text{ error}$$

An error of 0.9 percent is within the desired accuracy range of ± 10 percent.

If your actual calibrations result in an error exceeding 10 percent, recheck your calculations. If still in error, repeat Method 2, adjusting your pace, nozzle height, or pump rate to more closely approximate those used in Method 1. Be more careful to completely cover the 1/10 acre, but do not overlap spray swaths. Accuracy will improve with practice, but you should always strive to be within the ± 10 percent allowable error.

Spray Mixture

Once your sprayer is calibrated, you must determine the amount of pesticide needed per tank and for your entire operation. If pesticide recommendations are given in amount (pounds or gallons) of product/acre to apply, simply multiply amount/acre by acres/tank to determine amount/tank of pesticide needed.

For example, if 4 pounds of product are recommended per acre and the sprayer used can cover 0.2 acres per tank, the amount needed per tank is:

$$\frac{4 \text{ pounds}}{1 \text{ acre}} \times \frac{0.2 \text{ acres}}{\text{tank}} = 0.8 \text{ pounds/tank}$$

Often, pesticide rates are given in amount of active ingredient per acre (a.i./acre). Since pesticides are never formulated as pure active ingredient, it is necessary to compute the amount of product/acre needed to apply the desired amount of a.i./acre. To calculate this for dry-formulated chemicals, divide the a.i./acre by the percentage of active ingredient listed on the label expressed by a decimal.

For example, if the active ingredient is listed as 75 percent of the formulated product, and 3 pounds of active ingredient per acre are recommended, then 3 pounds a.i./acre divided by 0.75 a.i./pound equals 4 pounds of product needed per acre ($3 \div 0.75 = 4$).

Liquid formulations often state the pounds a.i./gallon. If the application rate is given in pounds a.i./acre, divide pounds a.i./acre by pounds a.i./gallon to give gallons/acre of product necessary.

For example, if the product label lists the formulation as 4 pounds a.i./gallon and the recommendation calls for 3 pounds a.i./acre, then:

$$\frac{3 \text{ pounds a.i. /acre}}{4 \text{ pounds a.i. /gallon}} = 0.75 \text{ gallons/acre of product required}$$

Regardless of the formulations, once the amount of product/acre is calculated, again simply multiply the amount/acre by acres/tank from your calibration to determine amount of pesticide to be added for each tankful of spray mix. Thus, if 0.75 gallons of product are needed per acre and 0.2 acres can be sprayed per tank, then 0.75 gallons/acre x 0.2 acre/tank = 0.15 gallons/tank.

To determine pesticide needs for your entire operation, multiply acres to be sprayed by amount of product/acre. To determine tankfuls to be mixed, divide acres to be sprayed by acres/tank. Remember, only the area actually sprayed should be used. If band or spot applications are used, this is only a fraction of the total plantation area.

Example

Chris Tree wanted to spray atrazine, as Aatrex 4L (the "4L" indicates that the herbicide is formulated as a liquid that contains 4 lbs. of the inactive ingredient, atrazine, per gallon of the formulated product), in his 20-acre white pine Christmas tree plantation. Mr. Tree marked out a 100-foot traverse in his plantation. He filled his 4-gallon backpack sprayer half full with water, installed a 15-psi (pounds per square inch) pressure spring in the regulator, and attached an even- flat-fan nozzle. Holding the nozzle at a constant height, he then sprayed the traverse four times, timing each traverse and measuring the ESW at several points. His travel times were 21, 24, 23, and 24 seconds. His average travel time was 23 seconds. His average ESW was 36 inches. He then filled a 1-gallon milk jug four times. His average fill time was 182 seconds (3 minutes, 2 seconds). His delivery rate was:

$$\frac{60 \text{ seconds/minute}}{23 \text{ seconds}} = 0.33 \text{ gallons/minute}$$

His area covered per minute was:

$$\frac{36 \text{ inches}}{23 \text{ seconds}} \times \frac{1}{87.12} = 0.01799 \text{ acres/minute}$$

Therefore, his gallons/acre covered were:

$$\frac{0.33 \text{ gallons/minute}}{0.01799 \text{ acres/minute}} = 18.34 \text{ gallons/acre}$$

This is well within the 10-20 gallons/acre carrier rate suggested.

Chris wanted to spray a 3-foot band over his trees, which are planted 5 feet apart in the row and 8 feet between rows in the 20-acre plantation. Since he is spraying 3 feet of every 8 feet, he will need enough chemical to spray 3/8 (or 0.375) x 20 acres = 7.5 acres. His Extension agent recommended spraying 5 pounds active ingredient of atrazine per acre. The label of Aatrex 4L says it contains 4 lbs. of active ingredient per gallon. Since Chris' sprayer holds 4 gallons/tank, he can cover:

$$\frac{4 \text{ gallons/tank}}{18.34 \text{ gallons/acre}} = 0.218 \text{ acres/tank}$$

He will need:

$$\frac{5 \text{ pounds a.i. /acre}}{4 \text{ lbs. a.i./gallon}} = 1.25 \text{ pounds Aatrex 4L/acre}$$

Then, 1.25 gallons/acre x 0.218 acre/tank = 0.2725 gallons Aatrex 4L, which should be added to each 4-gallon tankful to get the rate he desires.

As a check on calculations, he will need 1.25 gallons/acre Aatrex 4L x 7.5 acres = 9.375 gallons of Aatrex 4L. Then, since he can cover 0.218 acres/tank, he will need:

$$\frac{7.5 \text{ acres}}{0.218 \text{ acres/tank}} = 34 \text{ tanks}$$

Then, 34.4 tanks x 0.2725 gallons of Aatrex 4L/tank = 9.375 gallons of Aatrex 4L, which matches the above equation.

Accurate sprayer calibration is essential to a successful application. Following the simple calibration steps described herein will ensure that your time and money will not be wasted on an application that does not give the desired results.

If you have any questions about hand-held or backpack sprayer calibration, the calibration of any other type of sprayers, or the selection of pesticides for application, contact your local Virginia Cooperative Extension office, listed in the phone book with other local government agencies. Your local forester from the Virginia Department of Forestry can provide assistance with pesticides as well as other forest management practices.

Disclaimer

Commercial products are named in this publication for information purposes only. Virginia Cooperative Extension does not endorse these products and does not intend discrimination against other products which also may be suitable.

Keys to the Proper Use of Pesticides

1. Read the label on each pesticide container before each use. Follow the printed instructions to the letter; heed all cautions and warnings; note precautions about residues.
2. Store pesticides in the containers in which you bought them. Put them where children and animals cannot get to them — preferably locked up and away from food, feed, seed, and other materials that may become harmful if contaminated.
3. Dispose of empty pesticide containers in the manner specified on their labels.
4. **See your doctor if symptoms of illness occur during or after use of pesticides.**

This is a revision of VCE Publication 456-502, *Calibrating Hand-Held and Backpack Sprayers for Applying Pesticides* (1986) by S. M. Zedaker and T. J. Nichols (former Extension Specialist and Assistant Professor, Forestry, Virginia Tech).