PNW 320
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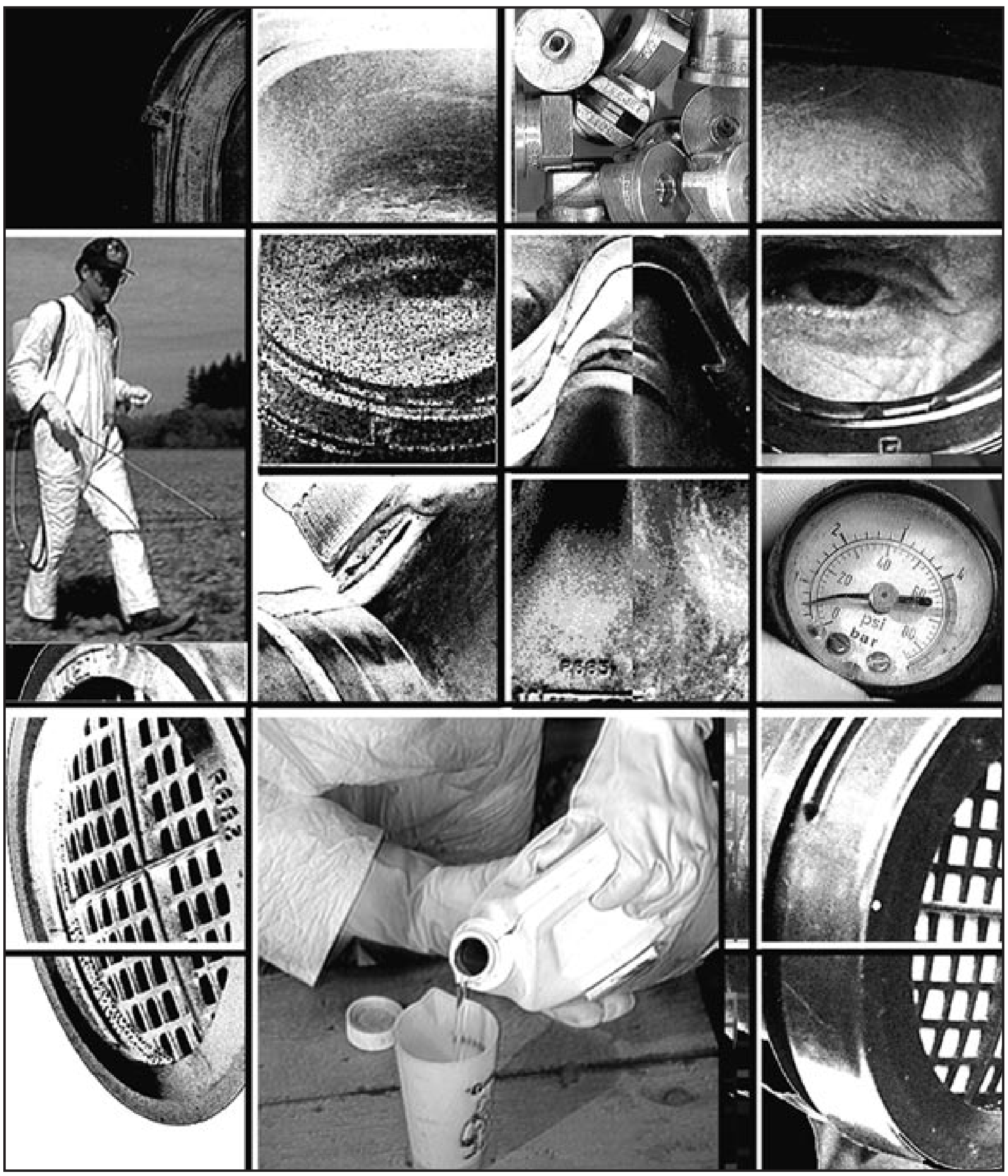
CALIBRATING AND USING

BACKPACK SPRAYERS



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Contents

Use pesticides safely!

- **Wear** protective clothing and safety devices as recommended on the label. **Bathe** or shower after each use.
- **Read** the pesticide label—even if you've used the pesticide before. **Follow closely** the instructions on the label (and any other directions you have).
- **Be cautious** when you apply pesticides. **Know** your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide misuse.

Calibrating and Using Backpack Sprayers

C.G. Landgren

Backpack sprayers are extremely versatile tools. Unfortunately, many users fail to calibrate their sprayer, and know little about available accessories. The consequences of improper sprayer use can be severe—dead crops, wasted money, or poor pest control.

But be warned: To successfully calibrate and use your sprayer, you'll need to work through some examples, take some time, and. . . practice. It isn't complicated, but it will demand effort on your part.

This publication will help you understand how to use and calibrate a backpack sprayer. It has four parts: (1) What is a backpack sprayer? What are appropriate uses? (2) Sprayer characteristics and accessories, (3) Nozzle components, and (4) Calibration and operation.

This publication also can be used in combination with a video (VTP-017) of the same title. Viewing the action often helps make the calculations more understandable. (See *For more information*, page 19.)

What is a backpack sprayer? What are appropriate uses?

A backpack (or knapsack) sprayer consists of a tank, a pump, and a spray wand with one or more nozzles (Figure 1). The small size, transportability, and ease of use make the sprayer a versatile tool.

You can spray many acres with a backpack sprayer; however, the effort of carrying the spray mix and walking over each area you spray takes its toll on your strength and enthusiasm.

Figure 1.—Backpack sprayer application.

To provide some perspective, many backpack applicators consider 4 to 5 acres of broadcast spraying (the entire area sprayed) as a full day's effort. A helicopter, in contrast, may spray the same area in a matter of seconds. Appropriate tasks for backpack sprayers then tend to be:

1. Small acreages and spot spraying
2. Hard-to-reach locations
3. Spraying jobs where larger sprayer units (tractors, helicopters, etc.) are unavailable

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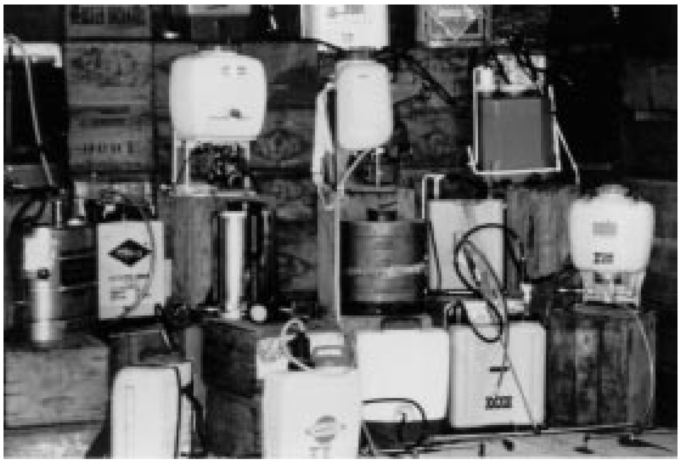


Figure 2.—A wide variety of sprayer types is available.

Sprayer characteristics and accessories

You'll find a wide array of sprayers and accessories on the market (Figure 2). The next five sections outline some key differences among the sprayers commonly sold: types of pumps, pressure regulation, availability of nozzles and booms, sprayer tank volume, and other features.

Types of pumps

Both piston and diaphragm pumps are available. The piston type generally is capable of developing higher pressures, around 90 psi (compared to around 40 psi for common diaphragm types). The piston rings on these pumps wear and lose pressure after extensive use, particularly with abrasive wettable powder herbicides.

Diaphragm pumps are simpler mechanically, which may mean less maintenance. If you use one, be sure the diaphragm material is resistant to the chemical or solvent you plan to use. Diesel oil, for example, may degrade some diaphragms.

Pressure regulation

Proper calibration demands a constant uniform pressure. Some sprayers have built-in valves to regulate pressure. Others have pressure gauges on the handle. Either type is acceptable as long as you maintain uniform pressure.

Availability of nozzles and booms

Before you buy, be sure the sprayer can accept different spray tips, booms, shielded spray wands, and other accessories. The greater the number of attachments you can use, the more versatile your sprayer.

Spray booms, for example, increase the area you spray during each pass through the field. This saves you time and effort and can improve coverage uniformity. Booms are available in many configurations. They may be oriented vertically for spraying along the height of trees or horizontally for field spraying.

Sprayer tank volume

Sprayer capacities range from 2 to 5.5 gallons. You can decide how much weight you want to carry (water weighs 8.3 pounds/gallon). The tank should have an easy-to-read volume gauge printed or embossed along the side.

Other features

There are a number of additional features that are important in selecting a sprayer. Here are some:

1. The pumping lever should be in a comfortable position. Consider, too, a sprayer with a reversible lever (one that you can use left- or right-handed).
2. The wand and hand grip should be comfortable and easy to remove and clean.
3. The sprayer should balance comfortably and solidly on your back. The straps should be comfortable when you're carrying a 25- to 70-pound weight. The sprayer should be stable when it sits on the ground.

4. Hoses should be durable and reinforced, with secure attachment to the tank.
5. In-line screens are available in some models (usually in the handle). These help to reduce clogging at the nozzle.
6. The filling hole should be large, with a tight-fitting lid—to prevent spray liquid from spilling on you when you bend or walk.

Nozzle components

Typically, a nozzle is composed of four items—spray tip, screen (strainer), cap, and nozzle body (Figure 3).

Figure 3.—Typical nozzle assembly.

Spray tip

The spray tip is the most important nozzle accessory for your sprayer. It breaks the liquid into droplets of the correct size, forms the spray pattern, and directs the droplets. Unfortunately, most users pay little attention to the spray tip and know little about alternative tips.

Nozzle tips are designed for various uses, crops, and spray pressures. Table 1 shows some of those most useful for backpack sprayers.

Tips are made from a variety of materials. Table 2 compares the durability of various spray-tip materials. Tips made of harder materials may cost more initially, but their longer wear life often results in lower long-run costs.

For example, tests indicate that with bronze tips, the flow rate increased by 8 percent after 50 hours of use with a 2,4-D herbicide in water. More abrasive formulations, like wettable powders, will cause even more rapid wear. As a general rule, if tip output varies by 10 percent above or below rated capacity, replace it.

Screens (strainers)

Screens are needed in advance of the spray tips to reduce clogging. The smaller the tip opening, the finer the screen mesh needed to protect the tip. Nozzle tips such as an XR8001 (Spraying Systems) require a 100-mesh screen, but larger nozzle openings such as an XR8004 need only 50-mesh. The manufacturer will recommend the screen mesh size you need.

Screens are available that also function as check valves. These prevent nozzle dripping when the line pressure drops below a certain level (you select the level, from 5 to 40 psi). These do cause a pressure drop of 5 to 10 psi at the nozzle, and they require careful cleaning and storage for proper functioning.

Calibration and operation

Important variables

The amount of spray you apply to an area will depend on four variables: your walking speed, the pressure you select, your spray swath width, and the nozzle tip you've chosen. *If you change any one of these, you change the amount of spray you apply.*

This is why, with broadcast spraying, it's impossible to say, "Always add 2 ounces of the pesticide per gallon of water." You could be spraying 10 times too much or 10 times too little, depending on your

Table 1.—**Common backpack sprayer nozzle tips, uses, and examples**.

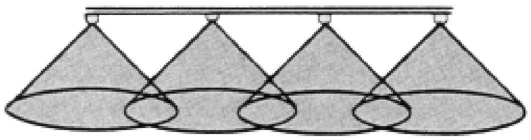
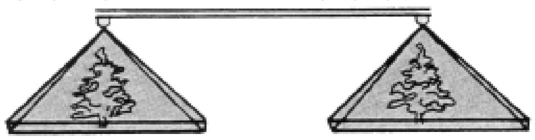
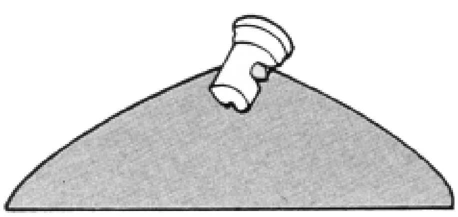
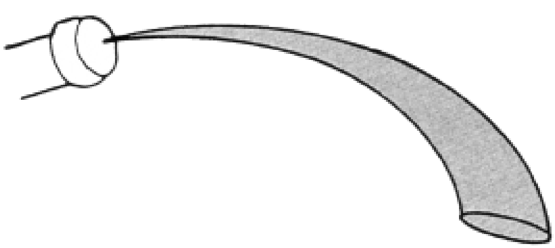
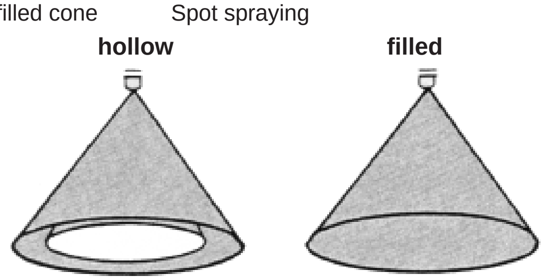
Tip	Use	Remarks and examples
Flat tips (overlap) 	Boom spraying with multiple nozzles	These tapered tips are designed for at least 30 percent overlap of each nozzle in the spray pattern. *Manufacturers* include Delevan, Hardi, and Spraying Systems. Tips are designated (usually on the tip itself) by spray angle and gallon per minute (gpm) output at a specified pressure. *Example:* Spraying Systems Co. tip XR8002. This code has three parts: • The first two letters “XR” denote an “Extend Range” tip. These maintain spray distribution over a range of pressures (15–60 psi). • The first two numbers indicate the spray angle (80 = 80°). Tips are available from 25° to 150°. • The second two numbers indicate gpm output (02 = 0.2 gpm, at 40 psi). Tips are available from 0.06 to 2 gpm outputs.
Flat tips (even) 	Band spraying	Tips deliver an even spray, edge to edge. *Manufacturers:* same as for overlap flat tips. *Example:* Delevan tip 95-3E. This code has three parts: • The first two numbers indicate the spray angle (95 = 95°). • The second number indicates gpm output (-3 = 0.3 gpm, at 40 psi). • The final letter(s) indicate a special feature (E = even output, edge to edge).
Flooding or impact 	Broadcast spraying	Flooding tips are useful in situations where a wide spray swath is needed and a boom can’t be used. Spray droplets often are larger than those with flat tips, and some spray uniformity may be sacrificed. *Manufacturers:* Delevan, Hardi, Imperial Chemical Co. (lCI), Spraying Systems. *Examples:* ICI makes a series of 4-color-coded nylon tips. Depending on the tip used, they provide swath widths from 2 to 7 feet when held 20 inches above the ground.
Adjustable cone 	Spot spraying, bark applications	Adjustable cone tips can be set to spray a straight stream or coarse cone. These are especially useful in spot-spraying clumps of brush up to 20 feet away. They also have uses in straight stream or basal drench bark applications.
Hollow and filled cone 	Spot spraying	These tips operate in the 15- to 300-psi range. There is a wide variety of tips and uses in this category.

Table 2.—**Wear comparison of common spray tips**.

Material	Life compared to brass
Plastic or nylon	0.7 to 1 time
Stainless steel	4 to 6 times
Hardened stainless	8 to 15 times
Ceramic	70 to 120 times
Tungsten carbide	150 to 200 times

situation. You simply *must* calibrate your sprayer before adding pesticide.

Before going through step-by-step examples of calibration for broadcast, band, and spot spraying, let's discuss how walking speed, pressure, nozzles, and swath width interact.

Walking speed. If you double your walking speed while maintaining pressure and swath width, you'll apply half as much spray. For example, if your walking speed is 1 mph and you spray 20 gallons per acre, at 2 mph you'd apply only 10 gallons per acre. At 2 mph, then, you'd require more pesticide per gallon (that is, a greater concentration) to apply the same amount of pesticide per acre.

Pressure. If you change the pressure while you spray, you change output. Suppose you changed pressure from 15 to 30 psi at 4 mph, with an 8002LP nozzle; this would change your output from 15 to 21 gallons per acre.

Nozzle tip selection. The proper tip will depend on the situation (see Table 1). Tips are available that cover a wide range of output volumes, spray widths, and pressures.

Most backpack sprayers come with a single flat fan nozzle. Attempting to use this one nozzle tip in, for example, a 4-acre broadcast application, wastes operator time and usually results in poor application uniformity. Check with nozzle tip suppliers about booms, flooding tips, or other options.

Swath width/nozzle height. Tips are designed for use within certain heights and pressures. Within these ranges, some tips deliver narrow bands; others, like flooding tips, provide swath widths up to 7 feet. The wider each swath width, the less time the operator spends walking up and down fields.

The height at which you hold the spray tip above the target influences the swath width. Suggested spray heights vary by tip type. Flat tips commonly have suggested heights in the 17- to 28-inch range. Flooding tips do not have suggested heights. Spraying as close to the target as is practical minimizes drift and operator contact.

The spray height you select needs to be maintained during calibration and field application—otherwise your output per acre changes. Some operators have tried using height stakes or weighted drop strings to maintain a constant height. These aids may be useful reminders while practicing.

Calibrating for broadcast spraying

Broadcast spraying requires a uniform application over the entire area you plan to spray. To accomplish uniform application, you must establish some standard application practices regarding pressure, walking speed, nozzle-tip selection, and height.

Uniform pressure. Nozzle pressure on backpack sprayers is maintained by hand pumping. Try for a constant pressure that is easily maintained while walking/pumping. With broadcast spraying, tips designed to operate in the 15–40 psi pressure range often will be the tip of choice for this application (i.e., low pressure, extended range, and FloodJet® tips).

Constant walking speed. In broadcast spraying, walking speed must be constant, regardless of slope or terrain conditions. This constant walking speed should be one that you can comfortably maintain over the entire time you intend to spray. It also must be the same speed at which you calibrate the sprayer.

Table 3.—**Converting the time (seconds) needed to walk 100 feet to miles per hour (mph)**.	
Sec/100 ft	Mph
68	1.0
45	1.5
34	2.0
27	2.5
23	3.0
19	3.5
17	4.0
15	4.5
14	5.0

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

Be aware, too, that most people tend to slow down when they spray, to make sure they apply enough herbicide. *This is wrong!* You must apply herbicides at the correct rate, or you may injure your crop.

There are various methods of achieving a consistent walking speed—for example:

- Counting paces to a steady tempo
- Using a stopwatch along a measured distance, such as a plantation row
- Developing a cadence between steps and pumping strokes

One common aid in achieving consistency is to periodically retime your walking speed over a 100-foot distance. Table 3 converts the time it takes to walk 100 feet into miles per hour (mph). Knowing your walking speed also will be helpful when you select a nozzle tip.

Selecting a nozzle tip. The nozzle tip you select depends on your spraying need and the amount of pesticide and carrier you choose to apply per acre. In general, applying 10 to 20 gallons/acre of carrier and pesticide is adequate, but check the pesticide label to be sure.

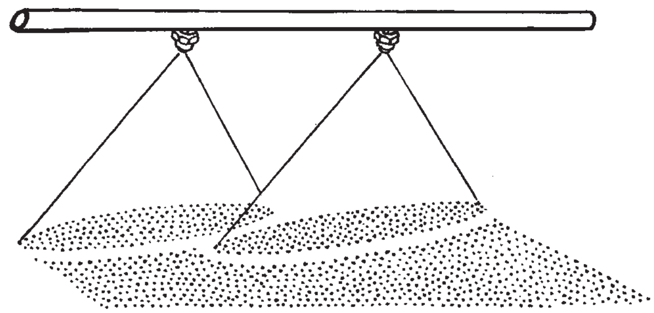


Figure 4.—Check your coverage before spraying. (Nozzle pattern should overlap when you use flat fan tips—if not, correct before proceeding.).

Also keep in mind that it's generally better to change nozzle(s) to alter spray volume than to change walking speed or pressure.

Let's assume you need to find a tip that will provide around 10 gallons/acre at 2.5 mph walking speed and 15 psi. There are two ways to do this—use a formula or use a spray catalog. Appendix A gives examples of both methods.

Using either method, you will find that nozzle output should be around 0.15 gallon/minute. Most tips are coded to indicate output/minute at various pressures. For example, a Spraying Systems 80015LP tip with a 50-mesh filter screen will give 0.15 gallon/minute at 15 psi and would be an appropriate tip for your needs.

Steps in calibration. There are different ways to calibrate sprayers. This method is one that may be easier with backpack sprayers. You'll need a tape measure, and you may find a calculator convenient:

1. Select the spray tip or boom that provides the desired output (see Appendix A).
2. Add water, and spray the ground or dry pavement as if you were spraying your field. Now check the spray pattern for uniformity (and proper spray pattern overlap if you're using a boom). Adjust nozzle spacing and/or height until you achieve the desired pattern. Be certain you're getting uniform coverage before you proceed! (Figure 4.) Check fittings and hoses for leaks.

Try to calibrate in the same field or under the same conditions as where the spray application will occur.

3. If all is well, add exactly 2 gallons of water to the tank. (Note: You can use any amount of water, but remember to substitute your figure whenever you see "2 gallons" in the example that follows Step 9.)
4. Mark your starting spot.
5. Spray the water as if you were actually spraying your field. Remember, you must maintain:
   - Constant pressure
   - Constant walking speed
   - Consistent height of the nozzle or boom over your spray target
6. When the water is gone, stop and mark the spot.
7. Measure the area you sprayed and calculate square feet (length of swath x width).
8. Calculate how much of an acre you covered:

$$\frac{\text{number of ft}^2\text{ you sprayed}}{43{,}560\text{ ft}^2\text{/acre}} = \text{acres sprayed}$$

9. Calculate how many gallons/acre you sprayed:

$$\frac{\text{2 gal sprayed}}{\text{acres sprayed}} = \text{gal/acre}$$

Example. Let's say you sprayed two rows of Christmas trees with 2 gallons. Rows were 5 feet apart, and each row was 580 feet long. The area sprayed was:

$$\text{2 rows x 5 ft/row x 580 ft} = 5{,}800\text{ ft}^2$$

Now, calculate gallons/acre, in two steps:

First, to find the acres you sprayed with 2 gallons, divide the square feet you sprayed by the number of square feet in an acre:

$$\frac{5{,}800\text{ ft}^2\text{ sprayed}}{43{,}560\text{ ft}^2\text{/acre}} = 0.13\text{ acre}$$

Next, divide 2 gallons by 0.13 acre, to find your gallons/acre rate:

$$\frac{\text{2 gal}}{\text{0.13 acre}} = \text{15 gal/acre}$$

With the above walking speed, nozzle(s), pressure, and swath width, you sprayed 15 gallons/acre. That's a very important number. You'll need it to determine the amount of pesticide to add per gallon. You also can see that if you fill the sprayer with 5 gallons each time, it will require 3 tankfuls of pesticide and carrier (often water) to cover 1 acre completely.

A quick check. There is a way to quickly check your calibration results. It is based on the amount of time it takes to spray a 340 square foot area. It works because 340 square feet is $\frac{1}{128}$ of an acre (remember, there are 128 ounces in a gallon, so ounces collected convert directly to gallons per acre). The steps are as follows:

1. Measure out a 340 square foot area to spray (e.g., 5 ft x 68 ft). It's best to make this a convenient width for your nozzle/height configuration and to flag the beginning and ending points.
2. Spray the 340 square foot area, and time yourself. Do this several times, until you have consistent results.
3. Next, insert the spray tip into a measuring device graduated into ounces. Spray into the measuring device for the same time required to spray the 340 square feet (Step 2). Remember to match the pressure used in Step 2.
4. Now, read the number of ounces you sprayed into the measuring device. The number of ounces you collect converts to gallons per acre of output. For example, let's say it took you 45 seconds to spray the 340 square foot area. You then collected the spray from the nozzle for 45 seconds in the measuring device. In that time,

you collected 10 ounces of water. Since you sprayed 1⁄128 of an acre, the ounces you collected represent a 10-gallon-per-acre output.

Remember—pressure, walking speed, nozzle tips and swath width must remain unaltered during the actual spraying.

How much pesticide to add?

Pesticides are sold as liquids, emulsifiable concentrates, wettable powders, flowables, and other forms, to be mixed with water or other carriers. Each product label contains use instructions, safety precautions, use restrictions, application rates, and conditions for application.

Application rates are listed on the package, most commonly in pounds per acre or amount of liquid per acre. Given a choice, it usually is easier to apply liquid than dry formulations.

Conversion table. You may find these conversion values handy when mixing pesticides.

Table 4.—**Conversion values for measuring pesticides.**

Liquid (volume)	Oz	Dry (weight)	Oz
teaspoon	0.17	gram	0.035
tablespoon	0.5	pound	16
cup	8	kilogram	35
pint	16		
quart	32		
liter	34		
gallon	128		

Liquid pesticides. Let's assume you need to apply 1 quart (32 oz) of the herbicide Roundup® (48 percent ai glyphosate) per acre.

You calculated previously that you'll apply 15 gallons of spray solution (pesticide plus water) per acre. To determine how much herbicide to add per gallon of spray, divide the 32 ounces of product by your 15 gallon/acre output:

$$\frac{\text{32 oz Roundup®/acre}}{\text{15 gal/acre}} = \text{2.13 oz Roundup®/gal}$$

Table 5.—**Required ounces of product per gallon of spray mix by output/acre and target product amount.**

Sprayer output (gal/acre)	Target amount of product/acre					
	1 pt (16 oz)	1 qt (32 oz)	1.5 qt (48 oz)	2 qt (64 oz)	3 qt (96 oz)	1 gal (128 oz)
7	2.3	4.6	6.9	9.1	13.7	18.3
10	1.6	3.2	4.8	6.4	9.6	12.8
12	1.3	2.7	4.0	5.3	8.0	10.7
15	1.1	2.1	3.2	4.3	6.4	8.5
17	0.9	1.9	2.8	3.8	5.6	7.5
20	0.8	1.6	2.4	3.2	4.8	6.4
25	0.6	1.3	1.9	2.6	3.8	5.1

Each gallon of solution in the sprayer must include 2.13 ounces of this particular Roundup® formulation. If you are filling the sprayer to 5 gallons, you add 10.7 ounces of Roundup® (5 x 2.13) per 5-gallon sprayer.

Table 5 shows another method of determining the amount of liquid product to add per gallon. The two items you need to know are, again, sprayer output and the amount of liquid product to apply per acre. In this case, locate the number that matches up with the column indicating 1 quart of product and the row showing 15 gallons of sprayer output. If you do this, you'll find the 2.1 ounces/gallon calculated above.

Spraying trees. At times, backpack sprayers are used to spray trees or shrubs for insect or disease problems.

Pesticide recommendations commonly are given in two ways. One is an amount of product to apply per acre. Another is an amount of product per 100 gallons of carrier, with the assumption that the 100 gallons covers an acre.

The difficulty in calibration is that your target is now vertical (trees and shrubs), rather than horizontal (the ground). The recommendations for the amount of product to apply are based on a horizontal acre and assume the trees or target crop is average size and age and the entire area is sprayed, not just a tree here and there.

Since the recommendation is based on an amount applied per acre, calibration is similar to past examples, except that now you are spraying the tree rather than the ground. Here's an example.

Situation. Your Christmas trees have aphids, and you need to apply 1.5 pints of an insecticide per acre. These aphids occur on the new growth so you need to cover the new growth with spray mix. You have 1,200 trees/acre ranging in size from 4 to 7 feet.

Follow these steps:

1. Pick out a row or area where the trees represent the "average" tree height and spacing for your field.
2. Fill the sprayer with a known volume of water. (Let's assume 3 gallons.)
3. Spray the trees as you would with the spray mix, trying for adequate coverage for the target pest.
4. After spraying the 3 gallons of water, count the number of trees you sprayed. (Let's say you sprayed 120 trees.)
5. Next, determine what part of an acre you sprayed with 3 gallons.

$$\frac{\text{120 trees}}{\text{1,200 trees/acre}} = \text{0.10 acre}$$

6. Determine your gallon/acre output by dividing volume by area.

$$\frac{\text{3 gal}}{0.10} = \text{30 gal/acre}$$

7. Finally, determine how to divide the 1.5 pints (24 oz) for the acre application.

$$\frac{\text{24 oz/acre}}{\text{30 gal/acre}} = \text{0.8 oz/gal}$$

Each gallon of water in the spray solution should contain 0.8 ounces of insecticide.

It is important to note that this example assumes that the trees are uniformly spaced over an acre, that the entire area is occupied with trees, and that you need to spray each tree. It also is important to remember that the 1.5 pints/acre of insecticide represents the maximum recommended amount that can or should be applied for any acre.

If the trees do not occupy the entire area or you do not need to spray all the trees in an acre, the amount of pesticide you need to apply per unit area is reduced proportionally to the untreated area.

Dry pesticides. Pesticides formulated as wettable powders, dispersible granules, or other dry forms require similar calculations. For example, the label for Aatrex® Nine-O® may state that 2.5 pounds of the product should be applied per acre for a particular use.

To determine the amount of product to add to water, first convert pounds to ounces:

2.5 lb x 16 oz/lb = 40 oz

Next, divide the 40 ounces by your sprayer output rate per acre:

$$\frac{\text{40 oz}}{\text{15 gal/acre}} = \text{2.7 oz/gal}$$

For a 5-gallon sprayer, add 13 ounces (5 x 2.7 ounces) of product.

The best way to measure 2.7 oz is with a scale. If a scale isn't available, you can measure dry herbicides with liquid measuring utensils and use a weight-to-volume conversion, which calculates the weight of a given volume of product per cup or tablespoon.

Example. From the calculations above, you want to have 2.7 ounces of product (Aatrex® Nine-O®) in each gallon. Remember, these are dry ounces. For this product, you know there are 4 dry (weight) ounces per cup (calculated from prior usage).

This is a specimen label which was not prepared by Ciba-Geigy Corporation. Ciba-Geigy Corporation is not responsible for the accuracy of the information contained herein. As labels are subject to revision, always carefully read and follow the label on the product container.

Princep® Caliber 90®

HERBICIDE

For weed control in certain crops.

ACTIVE INGREDIENT:

Simazine: 2-chloro-4.6-bis (ethylamino)-*s*-triazine	90%
INERT INGREDIENTS:	10%
TOTAL	100%

EPA Reg. No. 100-603/EPA Est. 100-LA-1

Princep Caliber 90 is a water dispersible granule.

KEEP OUT OF REACH OF CHILDREN

CAUTION

See additional precautionary statements and directions for use.

DIRECTIONS FOR USE AND CONDITIONS OF SALE AND WARRANTY

IMPORTANT: Read the entire Directions for Use and the Conditions of Sale and Warranty before using this product. If terms are not acceptable, return the unopened product container at once.

Figure 5.—A sample label for Princep® showing the percent active ingredients.

Knowing this, you can develop a conversion from weight to volume.

$$\frac{2.7 \text{ oz (dry)/gal}}{4 \text{ oz (dry)/cup}} = 0.68 \text{ cup or } 5.4 \text{ liquid oz/gal}$$

This allows the operator to use volume/liquid measuring devices, rather than a scale. You can develop similar weight/volume conversions for other products.

With some dry products (and even some liquids), sprayer output can change when you apply pesticides since you're no longer spraying just water. A thicker solution may pass through the tips more slowly. To check for this, it's often useful to respray the area of your original calibration test—assuming it's part of the field you wish to spray.

Start at the same spot you began in calibrating, and spray the area with the same amount (2 gallons in the example) of water and pesticide. You should finish very close to the same spot. If you don't, recalculate the area you sprayed, and adjust your calculations for your next batch.

Some dry formulations, such as wettable powder and water-dispersible granules, settle in the spray tank. Since few backpack sprayers have recirculating pumps and built-in agitators, it's very important to keep these products mixed. Two helpful suggestions: jostle the tank while you walk; stop now and then to give the backpack a good shake.

Active ingredients vs. product. Some herbicide guides list suggested rates on the basis of active ingredients (ai) per acre rather than as an amount of product to apply per acre. The reason is that the same herbicide can have a number of different formulations and concentrations.

To calculate the amount of product to apply per acre, divide the application rate (in active ingredient per acre) by the *decimal form* of the percent active ingredient for the product you are using:

$$\frac{4 \text{ lb ai/acre}}{0.9} = 4.4 \text{ lb Princep}^{\circledR} \text{ Caliber } 90^{\circledR} \text{ WPG}$$

Figure 5 illustrates a product label and shows how the percent active ingredient is depicted for use in the above calculation. Appendix B has other examples of these calculations.

Be certain you're clear on this point: Is the recommendation you're using based on active ingredients or product amount? An incorrect assumption could cause crop damage or reduced effectiveness.

Calibration for band spraying

Band spraying involves treating a crop row or band rather than the entire area. The steps are identical to calibrating for broadcast spraying (page 8). Keep in mind that you base application rates on the area treated. The 15 gallons/acre of spray in the example on page 10 may cover several field acres in a banding application, depending on the width of the band.

Calibration for spot spraying

Spot spraying is common on clumps of brush or weeds that are scattered or difficult to walk through. Sprayer calibration often is done on a "spray until wet" basis. In other words, you spray until the vegetation appears to be covered by a light rain.

When "spraying to wet," you'll likely apply between 30 and 75 gallons/acre, depending on how you define "wet" and the amount of foliage to cover. Remember, spray solution that drips off foliage is wasted.

Herbicide rates for spot spraying typically are given as a percentage dilution. For example, a typical recommendation for blackberry control might be to apply a 2 percent solution of Roundup® (48 percent ai glyphosate) in the fall.

To mix a 2 percent solution, multiply 0.02 x 128 (ounces in 1 gallon) to get 2.6 ounces per gallon. In a 5-gallon sprayer, mix 13 ounces of Roundup® (5 x 2.6 ounces). Table 6 lists various product amounts per volume by herbicide recommendation.

Spot spraying devices, such as the Meter Jet™, that deliver a metered volume of spray solution also are available. The area sprayed with this metered volume is determined by the tip size and height of the tip above the target. Again, calibration is based on the spray volume per unit area. Since the use of the Meter Jet™ is increasing, let's run through an example.

Situation. Let's assume you are having a problem with grass surrounding 3-year-old Douglas-fir seedlings. You want to control the grass just around each tree, not over the entire area. You have a recommendation that you need to apply 3 quarts of Velpar-L product per acre. You have a Meter Jet™ using a Full Jet FL-8VS tip, and will apply 14 ml of spray mix (water and Velpar-L) in a 4' diameter circle around each tree.

Table 6.—**Amount of product per volume for various herbicide recommendations.**

Herbicide recommendation (%)	Amount herbicide (oz) to add to:		
	1 gal	3 gal	5 gal
1%	1.3	4	6
2%	2.6	8	13
3%	3.8	11	19
4%	5.1	15	26
5%	6.4	19	32

Solution. First, determine the total volume of spray mix needed to spray, for example, 300 trees. Here you multiply the volume per tree by the number of trees.

14 ml x 300 trees = 4,200 ml

Next, since it often is easier to measure in ounces, convert ml to ounces (34 oz per 1,000 ml) in the following way:

(4,200 ml ÷ 1,000 ml/l) x 34 oz/l = 142 oz

Now that you have calculated the spray mix needed for 300 trees (142 ounces), you can move on to calculate the area. The formula for the area of a circle is (π) x (radius squared). Your spray circle had a 4-foot diameter. The radius is one-half the diameter. So, the area for 1 tree is:

$(2 \text{ ft radius})^2 \times 3.14 = 12.56 \text{ sq ft}$

The area occupied by 300 trees is:

300 x 12.56 = 3,768 sq ft

Since your spray mix recommendation is based on an acre, you need to determine how much of an acre 300 trees represent. As in past examples, there are 43,560 square feet in an acre.

$$\frac{3{,}768 \text{ sq ft}}{43{,}560 \text{ sq ft/acre}} = 0.087 \text{ acres}$$

Finally, combine your spray volume with the spray area calculation and find that your application rate is 12.8 gallons/acre.

$$\frac{142 \text{ oz}}{0.087 \text{ acre}} = 1{,}632 \text{ oz/acre}$$

or

$$\frac{1{,}632 \text{ oz/acre}}{128 \text{ oz/gal}} = 12.8 \text{ gal/acre}$$

So, in that 12.8 gallons (1,632 oz) of spray mix you need 3 quarts of Velpar (96 oz). So, each gallon in the sprayer should contain 7.5 oz of Velpar-L product.

$$\frac{96 \text{ oz}}{12.8 \text{ gal}} = 7.5 \text{ oz of Velpar-L per gal}$$

One last caution in using the Meter Jet™. Remember that height is critical. Hold the tip the same height above the target (ground) on each tree.

Operating hints

Here are some useful operating tips. Following them will help you do a more proficient spray job.

Keep records. Complete records help you duplicate successful spraying jobs and avoid repeating mistakes. Record these especially (and other notes you think might help in the future): spray tips used, date of spray application, pressure, spray mixture, weather (during spraying and for 24 hours after), and stage of weed and crop growth.

Remember to do this job immediately after you spray—and after results are evident, make notes on your impressions for future reference.

Clean your nozzle(s). Have an old toothbrush or other fine brush, clean water, gloves, and pliers handy. Clean the tip and screen after your first two tankfuls, and thereafter as needed. Use only a soft brush or compressed air to clean the tip opening.

Maintain correct boom or nozzle height. Keeping the nozzles at the calibrated height above your target is critical. The wand or boom tends to drop as the applicator tires. This should be avoided.

Agitate pesticides. All pesticides must be mixed thoroughly and agitated in the tank to ensure uniform coverage. Some products (such as wettable powders) tend to settle. Others (such as emulsifiable concentrates) tend to separate. When you spray these products, jostle or agitate the tank with a brisk sidestep to keep the solution well mixed.

Clean your tank. Thoroughly clean and triple-rinse your sprayer after use. Useful cleaners are water and ammonia (6 ounces of household ammonia per tank), commercially prepared tank-cleaning compounds, and trisodium phosphate (2 fluid ounces TSP per tank). Ammonia is recommended for cleaning after spraying 2,4-D.

When you use oil-based herbicides like 2,4-D esters, rinse the sprayer first with a light oil (diesel oil or kerosene).

Cleaning is especially critical if you plan to use the same sprayer for insecticide and herbicide sprays. In fact, many users have two sprayers—one for insecticides and one for herbicides, because total cleaning sometimes is difficult.

Review current label. The product label contains a wealth of information, from safety data to application tips. Read it carefully, refer to it often, and heed the advice. Especially be aware of toxicity classification and needed protective gear.

Use protective or safety clothing/gear. In many ways, backpack sprayer users are in closer contact with the pesticide than tractor operators are. Frequent refilling and mixing, walking over sprayed surfaces, etc. *means you must be very careful.*

Rubber boots and gloves, and eye protectors, are a must. Your product label may specify additional protection, such as respirator, rain gear, or face shield.

Use liquids when possible. Most liquids mix easier and stay mixed longer. Powders and granules tend to require more agitation and can clog nozzles and screens more easily.

Keep a safe distance between adjacent applicators. To minimize possible contact, it is wise to keep some distance between adjacent applicators.

Investigate accessories and have a supply of tips. Much of the versatility of backpack sprayers comes in the use of accessories such as booms, shields and the various tips available. Investigate options and consider their use where appropriate.

Conclusions

Accurate calibration is vital. The fact that your neighbor adds a certain amount of herbicide per gallon and gets good results is no reason for you to expect the same.

You might walk more slowly; you might have different nozzles; or you might use greater pressure. You simply *must* calibrate for your conditions.

Remember: You control these factors:

1. Pressure. If you increase the spray pressure, you increase output.
2. Walking speed. If you slow down, you increase output per acre.
3. Swath width/nozzle height. Your output (gal/acre) may change with different nozzle tips, nozzle heights, and swath widths. It often is best to first establish walking speed and pressure and then change your tip selection to achieve a desired output.

It's critical that you clearly understand the suggested application rates. Are they based on the amount of actual product you should apply, or on the amount of active ingredients? Is the product you're applying the same as the product on which the recommendation was based?

Above all, work safe and work smart. Don't rush and neglect important details. As you spray, periodically check yourself to verify accurate application.

Appendixes

A. Selecting a nozzle

Using a catalog. Nozzle catalogs are very helpful in making your first selection of tips. This doesn't save you from the need to calibrate each tip, but it does help determine which tips will get you "in the ballpark" of where you want to be in terms of application rates.

For example, consider Table 7. Again, let's assume that your pressure is 15 psi, your walking speed will be constant at 2.5 miles per hour, and you want to spray 10 to 20 gallons of spray per acre.

Table 7 doesn't cover speeds as low as 2.5 miles per hour at 15 psi, but you can see that for each drop of 1 mph in speed, there's a 2- to 3-gallon/acre increase in the spray amount you apply.

Using this logic, at 2.5 mph and 15 psi, the 80001LP tip would deliver around 9 gallons per acre. The 80015LP would deliver around 14 gallons per acre. You selected the 80015LP nozzle on that basis. Table 7 also suggests you need a 50-mesh screen behind your nozzle tip.

Using formulas. To determine gallons sprayed per minute, multiply gallons per acre times square feet per minute. Divide your answer by the number of square feet in an acre:

$$\text{spray tip gal/min} = \frac{\text{gal/acre x ft}^2\text{ /min}}{43{,}560\text{ ft}^2\text{/acre}}$$

To determine square feet per minute, multiply spray width times walking speed (mph) times 5,280 ft/mile. Divide your answer by 60 min/hour:

$$\text{ft}^2\text{/min} = \frac{2.5\text{ mph x }2.5\text{ ft x }5{,}280\text{ ft/mile}}{60\text{ min/hour}}$$

$$= 550\text{ ft}^2\text{/min}$$

Table 7.—**Low pressure flat fan spray tips**[a].

Tip no. fix (strainer & screen size)	Liquid pressure (psi)	Capacity 1 nozzle (gpm)	Gal/acre 20" spacing 4 mph	Gal/acre 20" spacing 5 mph
8001LP-SS	15	.10	7.4	5.9
(100-mesh)	20	.12	8.6	6.9
	30	.14	10.5	8.4
80015LP-SS	15	.15	11.1	8.9
(50-mesh)	20	.17	12.9	10.3
	30	.21	15.8	12.6
8002LP-SS	15	.20	14.9	11.9
(50-mesh)	20	.23	17.2	13.7
	30	.28	21.0	16.8

[a]Excerpted with permission from a chart in Spraying Systems Co. Catalog #44 (1993), page 25.

Using these values, you determine spray tip gallons/ minute:

$$\frac{10\text{ gal/acre x }550\text{ ft}^2\text{ /min}}{43{,}560\text{ ft}^2\text{/acre}} = \text{spray tip gal/min}$$

$$= 0.13\text{ spray tip gal/min}$$

Thus, a spray tip delivering around 0.13 gallon/ minute at 15 psi is the answer. Again, the 80015LP tip would be appropriate.

B. Calculating herbicide mixtures for small quantities

The following examples should help you when you mix small quantities of herbicides. Assume that your calibrated application rate of carrier (water) is 15 gallons/acre—but remember to use your actual calibrated application rate, not this assumed rate.

Liquid products (Velpar). How much per gallon do you add if you want to apply 3 quarts of product per acre? First, convert 3 quarts to ounces:

3 qt/acre x 32 oz/qt = 96 oz/acre

Next, knowing your calibrated application rate, determine how much product to add per gallon of final spray mix:

$$\frac{96 \text{ oz/acre}}{15 \text{ gal/acre}} = 6.4 \text{ oz Velpar/gal mix}$$

2,4-D. Here, let's assume your herbicide guide reads, "Add 2 pounds of acid equivalent (ae) per acre." (Because there are several 2,4-D formulations, most weed control guides state acid equivalent rather than amount of product or active ingredients.)

Read the 2,4-D product label. It will state the concentration of product in pounds of acid equivalent/gallon. Let's assume yours is 3.75 pounds acid equivalent/gallon. How much do you add per gallon?

First, determine gallons of product for one acre:

$$\frac{2 \text{ lb ae/acre}}{3.75 \text{ lb ae/gal}} = 0.53 \text{ gal product/acre}$$

Next, convert to ounces:
0.53 gal/acre x 128 oz/gal = 68 oz/acre

Now, to find the amount of product to add per gallon, divide 68 oz/acre by 15 gal/acre:

$$\frac{68 \text{ oz/acre}}{15 \text{ gal/acre}} = 4.5 \text{ oz/gal}$$

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