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Calibrating and using a backpack sprayer

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Backpack sprayers are extremely versatile tools. Unfortunately, most users fail to calibrate, and they know little about available accessories. The consequences of improper sprayer use can be severe – dead crops, wasted money, or environmental contamination.

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 attention 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.

What is a backpack sprayer? What are appropriate uses?

A backpack sprayer consists of a tank, a hand-lever-operated pump, and a spray wand with one or more nozzles. 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.

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, and
3. spraying jobs where larger sprayer units (tractors, helicopters, etc.) are unavailable.

Sprayer characteristics and accessories

You'll find a wide array of sprayers and accessories on the market. 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.



Figure 1. Backpack sprayer application.



Figure 2. Typical boom application.

Types of pumps

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

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 will become.

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

They're available preassembled, or you can build one for a particular purpose (see appendix D for plans).

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. Straps should be comfortable with 25- to 40-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.

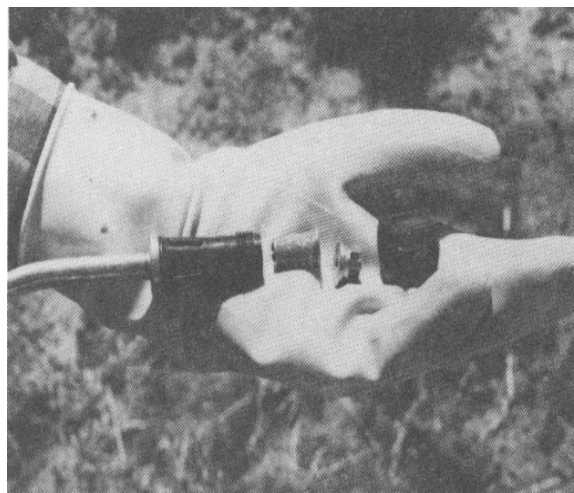


Figure 3. Typical nozzle assembly.

For a complete discussion on the importance of these and other backpack sprayer features, see Lever-Operated Knapsack Sprayers. “A Practical Scrutiny and Assessment of Features, Components, and Operation” (“For further reading”).

Nozzle components

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

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 propels the droplets in the proper direction. Unfortunately, most users pay little attention to the spray tip they have and know very little about available types.

Nozzle tips are designed for various uses, crops, and spray pressures. Some of those most useful for backpack sprayers are shown in table 1.

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 makes them less expensive in the long run.

For example, tests indicate that with bronze tips, the flow rate increased by 8% 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% 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 like an 8001LP (Spraying Systems) require a 100-mesh screen, but larger nozzle openings like an 8004 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

Selecting important variables

The amount of spray you apply to an area will depend on four variables: your walking speed, the pressure you select, your width of coverage, and the nozzle 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 situation. You simply must calibrate your spraying 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 coverage interact.

Walking speed

If you double your walking speed while maintaining pressure and coverage, 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.

Coverage and nozzles

A change in the nozzle tip or in the nozzle height will change effective output. At the same walking speed and pressure, output can vary from 1 to several hundred gallons per acre, just by changing your nozzle. Raising or lowering the nozzle alters the area sprayed with each step.

But beware of changing nozzle height beyond the range specified by the manufacturer. Holding nozzles too high above the target can cause excessive drift of small-size droplets. This wastes spray and could damage nearby crops.

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, and nozzle-tip selection.

Uniform pressure

Nozzle pressure on backpack sprayers is maintained by hand pumping. Try for a constant pressure between 15 and 20 psi. With broadcast spraying, low-pressure tips are designed to operate in this pressure range; therefore, they'll often be the tip choice for this application.

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

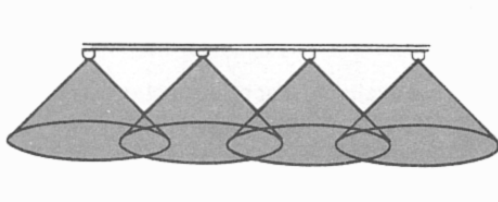
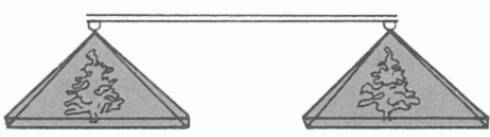
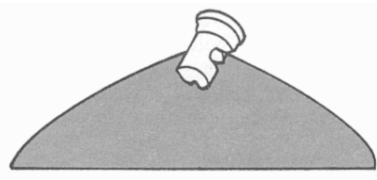
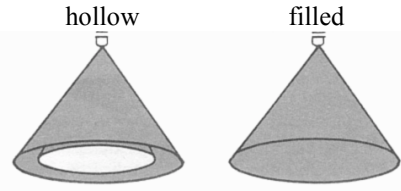
		Remarks and examples
Tip	Use	
Flat tips (overlap)	Boom spraying with multiple nozzles	These tapered tips are designed for at least 30% overlap of each nozzle in the spray pattern. Manufacturers include Delevan, Spraying Systems, and Hardi. Tips are designated (usually on the tip itself) by spray angle and gallon per minute (gpm) output at a specified pressure. Example: Spraying Systems Co. tip 8002LP. This code has 3 parts: • The first 2 numbers indicate the spray angle (80=80°). Tips are available from 25° to 150°. • The second 2 numbers indicate gpm output (02=.2 gpm, at 15 psi because this is a low-pressure tip). Tips are available from .08 to 2 gpm outputs. • The final letter(s) indicate a special feature (LP = a low-pressure tip calibrated at 15 psi). Tips are available to use at various pressures.
		
Flat tips (even)	Band spraying	Tips deliver an even spray, edge to edge. Manufacturers: same as for flat tips (overlap). Example: Spraying Systems Co. tip 9503E. This code has 3 parts: • The first 2 numbers indicate the spray angle (95=95°). Tips are available at 80° and 95° angles. • The second 2 numbers indicate gpm output (03=3 gpm, at 40 psi). Tips are available from .1 to 1.5 gpm outputs. • The final letter(s) indicate a special feature (E = even output, edge to edge).
		
Flooding	Broadcast spraying	Flooding tips are useful in situations where wide coverage is needed and a boom can't be used. Spray droplets are often larger than with boom spray, and some spray uniformity may be sacrificed. Manufacturers - Delevan, Imperial Chemical Co. (ICI), Spraying Systems, Hardi. 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	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.
		
Hollow and filled cone	Spot Spraying	These tips operate in the 40- to 400-psi range and are rarely used with backpacks because of their high-pressure requirements. They're normally used with insecticides.
		

Table 2. Wear comparison of common spray tips.

Material	Life compared to brass
Plastic or nylon	0.7 to 1 time
Stainless steel	3.5 times
Hardened stainless	10 to 15 times
Ceramic	90 to 100 times
Tungsten carbide	150 to 200 times

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, and nozzle-tip selection.

Uniform pressure

Nozzle pressure on backpack sprayers is maintained by hand pumping. Try for a constant pressure between 15 and 20 psi. With broadcast spraying, low-pressure tips are designed to operate in this pressure range; therefore, they'll often be the tip choice for this application.

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 whole time you intend to spray. It must also be the same speed at which you calibrate the sprayer.

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 serious crop injury can result.

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

- synchronizing your pace with a portable metronome,
- counting paces to the same tempo, or
- using a stopwatch along a measured distance.

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 walking speed will also be helpful when you select a nozzle tip.

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

Selecting a nozzle tip

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

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

Let's assume we 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, we find that nozzle output should be around .15 gallon/minute. Most tips are coded to indicate output/minute at various pressures. For example, a Spraying Systems 80015LP tip will give .15 gallon/minute at 15 psi and would be an appropriate tip for our needs.

Steps in calibration

There are a number of 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 coverage (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! (See figure 4.)
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, and
 - 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 × width).
8. Calculate how much of an acre you covered:

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

9. Calculate how many gallons/acre you sprayed:

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

Example. Let's say that we sprayed 3 rows of Christmas trees with 2 gallons. Rows were 5 feet apart, and each row was 387 feet long. The area sprayed was:

$$3 \text{ rows} \times 5 \text{ ft/row} \times 387 \text{ ft} = 5,805 \text{ ft}^2$$

Now calculate gallons/acre, in two steps:

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

$$\frac{5,805 \text{ ft}^2 \text{ sprayed}}{43,560 \text{ ft}^2/\text{acre}} = .13 \text{ acre}$$

Next, divide our 2 gallons by .13 acre, to find our gallons/acre rate:

$$\frac{2 \text{ gal}}{.13 \text{ acre}} = 15 \text{ gal/acre}$$

With the above walking speed, nozzle(s), pressure, and coverage, we 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 can also see that if you fill the sprayer with 5 gallons each time, it will require 3 tankfuls of pesticide and water to cover 1 acre completely.

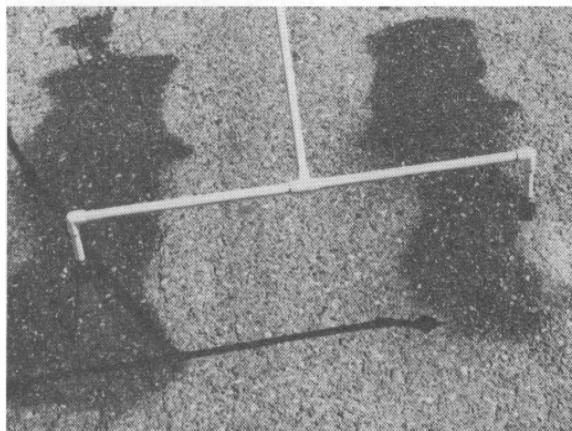


Figure 4. Check your coverage before spraying (nozzle pattern should overlap when you use flat fan tips – if not, correct before proceeding).

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's usually easier to apply liquid than dry formulations.

Conversion table

You may find these conversion values handy when mixing pesticides.

Liquid	Oz	Dry	Oz
teaspoon	.17	gram	.035
tablespoon	.5	pound	16.0
cup	8.0	kilogram	35.0
pint	16.0		
quart	32.0		
liter	34.0		
gallon	128.0		

Liquid pesticides

Let's assume we need to apply atrazine liquid (Aatrex 4L), a herbicide, at 4 quarts (128 ounces) of product per acre.

We calculated previously that we'll apply 15 gallons of spray per acre. To determine how much herbicide to add per gallon of spray, divide the 128 ounces of product by our 15gallon/acre rate:

$$\frac{128 \text{ oz Aatrex 4L/acre}}{15 \text{ gal/acre}} = 8.53 \text{ oz Aatrex 4L/gal mix}$$

Each gallon of solution in the sprayer must include 8.53 ounces of atrazine. If we are filling the sprayer to 5 gallons, we add 42.7 ounces of atrazine (5×8.53) per 5-gallon sprayer.

Table 4 shows another method of determining the amount of liquid product to add per gallon. The two items we need to know are, again, sprayer output and the amount of liquid product to apply per acre. In our case, we locate the number that matches up with the column indicating 1 gallon of product and the row showing 15 gallons of sprayer output. If you do this, you'll find the 8.5 ounces/gallon that we calculated above.

Table 4. Ounces of product per gallon of carrier.

Sprayer output (gal/ acre)	Amount of product/acre					
	1 pt	1 qt	1.5 qt	2 qt	3 qt	1 gal
	(16 oz)	(32 oz)	(48 oz)	(64 oz)	(96 oz)	(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

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 5 pounds of the product should be applied per acre for a particular use.

To determine the amounts to add, first convert pounds to ounces:

$$5 \text{ lb} \times 16 \text{ oz/lb} = 80 \text{ oz}$$

Next, divide the 80 ounces by our rate per acre:

$$\frac{80 \text{ oz}}{15 \text{ gal/acre}} = 5.33 \text{ oz/gal}$$

For a 5-gallon sprayer, add 27 ounces (5×5.33 ounces) of product.

The best way to measure this amount is with a small scale. If a scale isn't available, you can measure dry herbicides with liquid measuring utensils and use a weight-to-volume conversion (see appendix B). These calculate the weight of a given volume of product per cup or tablespoon.

Keep in mind: These conversion values vary, depending on moisture content of the product and the amount of settling.

Appendix B shows conversions from weight to volume, using Aatrex Nine-O as an example. Appendix C has additional calculation examples for small quantities.

With some dry products (and even with some liquids), your calibration can change when you spray 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.

So start at the same spot you began in calibrating and spray the area with the same amount (2 gallons in our 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.

A number of dry formulations, such as wettable powder and water-dispersible granules, settle in the spray tank. Since backpack sprayers don't have recirculating pumps and built-in agitators, it's very important to keep these products mixed. Two good suggestions: jostle the tank while you walk; stop now and then to give the backpack a good shake.

Active ingredients vs. product

A number of 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 ingredients per acre) by the decimal form of the % active ingredient for the product you are using:

$$\frac{4 \text{ lb ai/acre}}{.8} = 5 \text{ lb atrazine 80 WP/acre}$$

Figure 5 illustrates a product label and shows how the % active ingredient is depicted for use in the above calculation. Appendix C has numerous 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 results.

Calibration for band spraying

Band spraying involves treating the crop row rather than the entire area. The steps are identical to calibrating for broadcast spraying. Keep in mind that you base application

rates on the actual acres treated. The 15 gallons/acre of spray in the “Example” (previous) may actually cover several 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 is often done on a “spray until wet” basis. In other words, you apply 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.”

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

To mix a 2% solution, multiply $.02 \times 128$ (ounces in 1 gallon) to get 2.6 ounces per gallon. In a 5-gallon sprayer, mix 13 ounces of Roundup (5×2.6 ounces). Table 5 lists rates for various spray concentrations.

AAtrex[®] Nine-O

Herbicide

For season-long weed control in corn and sorghum

For weed control in certain other crops; in noncrop areas; and industrial sites:

Active Ingredients:

Atrazine: 2-chloro-4-ethylamino-6-isopropyl-amino- s-triazine	85.5%
Related compounds	4.5%
Inert Ingredients:	10.0%
Total:.....	100.0%

AAtrex Nine-O is a water dispersible granule

Keep Out of Reach of Children.

Caution

See additional precautionary statements at end of label booklet

See directions for use inside booklet.

EPA Reg. No. 100-585/EPA Est. 100-LA-1

AAtrex[®] trademark of CIBA-GEIGY for atrazine

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CGA 7L101C 064

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Figure 5. A sample label for atrazine showing the % active ingredients.

Table 5. Rates for spot spraying.

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

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, and stage of weed growth 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 a toothbrush, 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. One method of maintaining this height over the target plants is to attach a weighted string to the end of the boom or wand. Maintain the string at a constant height for accurate application.

Agitate pesticides

All pesticides must be mixed thoroughly and agitated in the tank to insure uniform coverage. Some products (like wettable powders) tend to settle. Others (like emulsifiable concentrates) tend to separate. When you spray these products, jostle or agitate the tank with a brisk sidestep to avoid settling.

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).

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.

Read the 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.

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. Wear long-sleeved shirts and long pants. Your product label may specify additional protection, such as respirator, rain gear, or face shield.

Conclusions

Accurate calibration is vital. The fact that your neighbor adds so much 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. Coverage. Your output changes with different tips and spray widths. Changing the tip size is the best way to change output, once you establish walking speed and pressure.

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.

Remember: Pesticides must be applied at exactly the correct rate and timing.

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 6. Again, let's assume that our pressure is 15 psi, our walking speed will be constant at 2.5 miles per hour, and we want to spray 10 to 20 gallons of spray per acre.

Table 6. 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	5 mph
8001 LP (100-mesh)	15	.10	7.4	5.9
	20	.12	8.6	6.9
	30	.14	10.5	8.4
80015LP (50-mesh)	15	.15	11.1	8.9
	20	.17	12.9	10.3
	30	.21	15.8	12.6
8002LP (50-mesh)	15	.20	14.9	11.9
	20	.23	17.2	13.7
	30	.28	21.0	16.8

^aExcerpted, with permission, from a chart in Spraying Systems Co. Catalog #38A (1984), page 12.

Table 6 doesn't cover speeds as low as 2.5 miles per hour at 15 psi, but we can see that for each drop of 1 mph in speed, there's a 2- to 3-gallon/acre increase in the spray amount we 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. We selected the 80015LP nozzle on that basis. Table 6 also suggests we need a 50-mesh screen behind our 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:

$$\text{Spray tip gal/min} = \frac{\text{gal/acre} \times \text{ft}^2/\text{min}}{43,450 \text{ ft}^2/\text{acre}}$$

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:

$$\begin{aligned}\text{ft}^2/\text{min} &= \frac{2.5 \text{ mph} \times 2.5 \text{ ft.} \times 5,280 \text{ ft/mile}}{60 \text{ min/hour}} \\ &= 550 \text{ ft}^2/\text{min}\end{aligned}$$

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

$$\begin{aligned}\text{Spray tip gal/min} &= \frac{10 \text{ gal/acre} \times 550 \text{ ft}^2/\text{min}}{43,560 \text{ ft}^2/\text{acre}} \\ &= .13 \text{ spray tip gal/min}\end{aligned}$$

Thus, a spray tip delivering around .13 gallon/minute at 15 psi is the answer. Again, the 80015LP tip would be appropriate.

B. Weight-to-volume conversions for selected dry herbicides

Table 7 shows weight-to-volume conversions for several products. Note that conversions for products below the dotted line are variable, because of settling and moisture content.

Table 7-Weight-to-volume conversions for selected dry herbicides^a

Herbicide name	Formulation ^b	Weight (oz)	
		Per tbsp	Per cup
Aatrex Nine-O (atrazine).	90% ai WDG .	.25	4.0
Aatrex 80W (atrazine)	80% ai WP	.22	3.6
Princep 80W (simazine)	80% ai WP	.21	3.4
Dowpon M (dalapon)	84.5% ai WSP	.23	3.7
Surflan (oryzalin)	75% ai WP	.16	2.5
Kerb (pronamide)	50% ai WP	.18	2.9

^aAdapted from a table prepared by R.L. Ticknor, North Willamette Experimental Station, Oregon State University, January 1986. Conversions for products below the dotted line are variable, because of settling and moisture content.

^bWDG, water dispersible granule; WP, wettable powder; WSP, water soluble powder.

Example

Suppose we apply 4 pounds (64 ounces) Aatrex Nine-O product/acre in 15 gallons of water/acre. First, calculate ounces of product/gal:

$$\frac{64 \text{ oz Aatrex}}{15 \text{ gal}} = 4.3 \text{ oz/gal}$$

Next, convert weight to volume:

$$\frac{4.3 \text{ oz/gal}}{4 \text{ oz/cup}} = 1.1 \text{ cup Aatrex/gal water}$$

C. 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 calibrated application rate when calculating for your purposes.

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:

$$3 \text{ qt/acre} \times 32 \text{ oz/qt} = 96 \text{ oz/acre}$$

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

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

Roundup. Assume you want to apply 1 quart of product/acre. How much do you add per gallon? First, convert to ounces (1 qt = 32 oz).

Now, to find the amount per gallon, divide 32 ounces by 15 gallons/acre:

$$\frac{32 \text{ oz}}{15 \text{ gal/acre}} = 2.1 \text{ oz Roundup/gal}$$

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:

$$\frac{2 \text{ lb ae/acre}}{3.75 \text{ lb ae/gal}} = .53 \text{ gal product/acre}$$

Next, convert to ounces:

$$.53 \text{ gal/acre} \times 128 \text{ oz/gal} = 68 \text{ oz/acre}$$

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

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

Dry products

Dowpon. The weed control guide states, for example, “Add 4 pounds active ingredient/acre.” The product is 85% active ingredient. How much do you add per gallon?

First, determine the amount of product for 1 acre:

$$\frac{4 \text{ lb ai/acre}}{.85 \text{ ai/lb product}} = 4.7 \text{ lb product/acre}$$

Next, convert weight to liquid measurement in ounces (the 3.7 dry ounces/cup comes from table 7):

$$\frac{4.7 \text{ lb/acre} \times 16 \text{ oz/lb}}{3.7 \text{ dry oz/cup}} = 20.3 \text{ cup product/acre}$$

Now, to find the amount per gallon, divide 20.3 cups/acre by 15 gallons/acre:

$$\frac{20.3 \text{ cup Dowpon/acre}}{15 \text{ gal/acre}} = 1.4 \text{ cup Dowpon/gal}$$

D. Building an inexpensive boom for a backpack sprayer.

Booms provide tremendous versatility for a sprayer. They can increase your coverage and thus save you time.

Figure 6 shows two examples of lightweight, inexpensive booms that you can build yourself. Commercial, pre-assembled units are also available.

You can modify these plans to meet specific application needs.

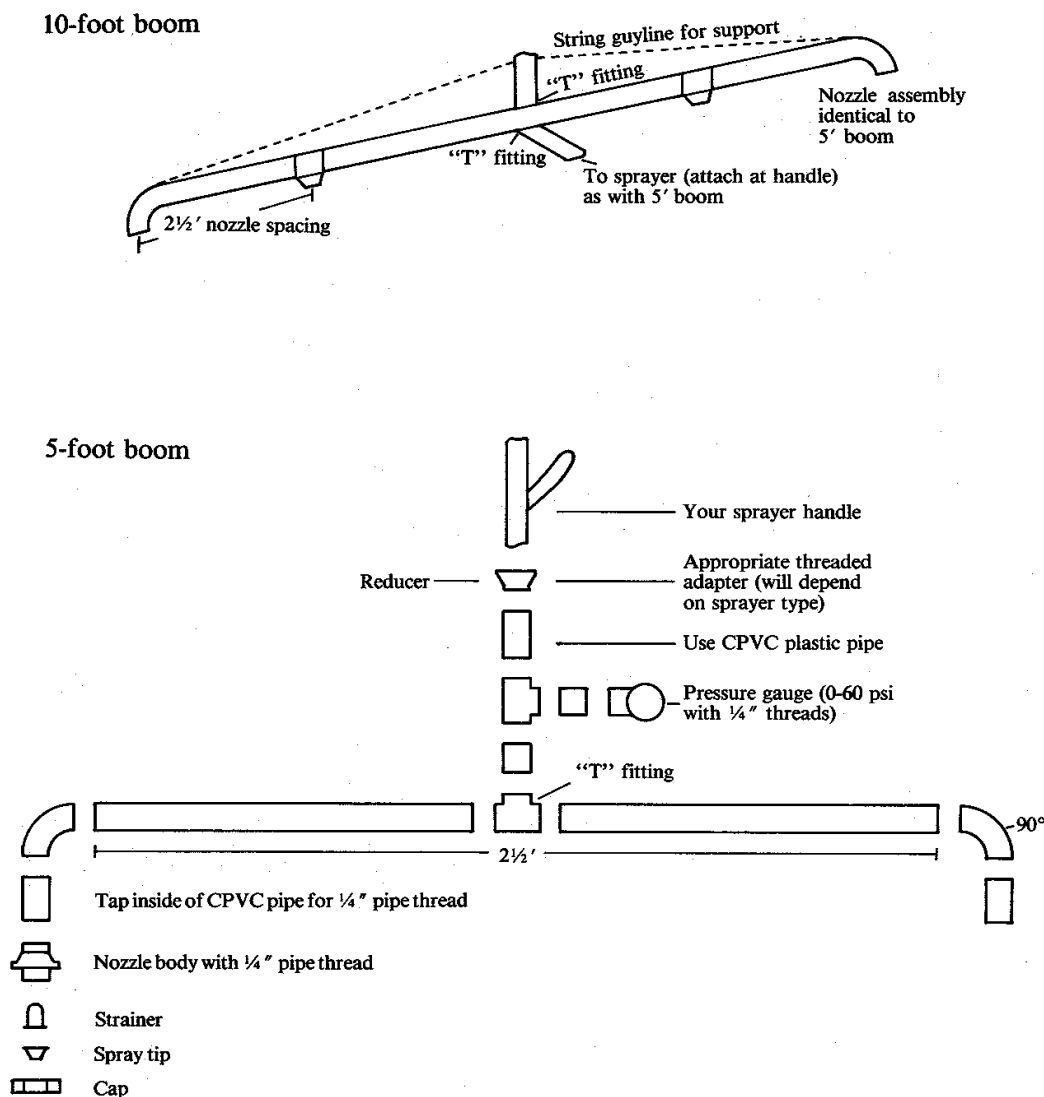


Figure 6. Plans for inexpensive, 10- and 5-foot booms for a backpack sprayer. Note that nozzle spacing depends on the nozzle and height above the ground you select. (Plans developed by Rob Woods, World Forestry Center, Portland, Oregon; reproduced by permission.)

For further reading

- H. H. Fisher and A. E. Deutsch, *Lever-Operated Knapsack Sprayers: A Practical Scrutiny and Assessment of Features, Components, and Operation—Implications for Purchasers, Users, and Manufacturers* (1985). Single copy \$5.00; order from International Plant Protection Center, Oregon State University, Corvallis, OR 97331.
- Karsky, Thomas J., *Spray Equipment and Calibration*, University of Idaho Cooperative Extension Service Bulletin No. 658 (Moscow, 1986). Order from Agricultural Publications Bldg., University of Idaho, Moscow, ID 83843. Single copy \$2.00 postpaid.
- Karsky, Thomas J., Hugh W. Homan, and Gene P. Carpenter, *First Aid for Pesticide Poisoning*, Pacific Northwest Extension publication PNW 278 (University of Idaho, Moscow, 1985). Order from Agricultural

tural Communications, Publications Orders, Oregon State University, Corvallis, OR 97331-2119. Single copy 50 cents plus postage and handling.

Pacific Northwest Weed Control Handbook, a Pacific Northwest Extension publication (latest edition; published annually). Order from Agricultural Communications, Publications Orders, Oregon State University, Corvallis, OR 97331-2119 (single copy \$15.00 plus \$2.25 postage and handling), or Bulletin Dept., Cooperative Extension Service, Cooper Publications Bldg., Washington State University, Pullman, WA 99164-5912 (single copy \$17.25 postpaid).

Spraying Systems Co. Catalog, current edition, Spraying Systems Co., North Ave., Wheaton, IL 60188. No charge for single copy.