Pesticide Application

Calibrating Pesticide Sprayers

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Calibration of pesticide application equipment is the process of adjusting speed, nozzle orifice size, and pressure (and for multi-nozzle booms, the number of nozzles), to apply a precise amount of pesticide mixture uniformly in a precise area. The most important reason pesticides fail to control pests is because of faulty and improperly adjusted (calibrated) equipment.

Before applying pesticides, inspect your application equipment for mechanical problems, including leaky hoses, faulty nozzles, screens and filters, boom height, pressure gauges, etc. Once you confirm that equipment is in proper condition, you are ready to consider the three factors of speed, nozzle orifice size, and pressure.

Tables 1 and 2 show the impact that speed, nozzle orifice size, and pressure have on sprayer output (amount of liquid a sprayer will apply in 1 acre).

Table 1. Relationship between speed and output of a sprayer

Output (MPH)	Speed (GPA)
2	100
4	50
6	33
8	25

Note: The output of a sprayer has a direct inverse relationship to sprayer speed. For example, doubling speed reduces output by 50%. To calculate mph, measure a known distance (in feet), determine the time in seconds needed to travel that distance, then use the following formula:

$$\text{mph} = \frac{\text{distance traveled (in ft)} \times 0.60}{\text{time of travel (in seconds)} \times 88}$$

This can be written as:

$$\frac{\text{distance traveled}}{\text{time of travel}} \times 0.6818$$

Example:

measured distance = 300 ft
time to travel 300 ft = 45 seconds

$$\text{mph} = \frac{300}{45} \times 0.6818 = 4.55 \text{ mph}$$

Table 2 shows the impact of nozzle orifice size and pressure on sprayer output.

Output increases directly according to nozzle orifice size. But, upon doubling pressure, the output only increases by 43%. So, for major changes in output, change speed and/or nozzle orifice size. For example, to reduce output, increase speed or reduce nozzle orifice size. Use pressure for minor adjustments.

Table 2. Effect of nozzle orifice size and pressure on sprayer output

Nozzle orifice size (TeeJet)	Output (GPM) @ 20 psi	Output (GPM) 40 @ psi	% change in output due to pressure	% change in output due to size
8001	0.07	0.1	43	—
8002	0.14	0.2	43	100
8003	0.21	0.3	43	100
8004	0.28	0.4	43	100

Calibrating Knapsack (backpack) Sprayers

The following is a simple method to calibrate knapsack sprayers. First, the operator should complete the following:

- Be familiar with sprayer functions.
- Inspect your application equipment to be sure all parts are working properly.
- Choose the desired nozzle and determine the correct nozzle height.

Using a single nozzle increases the potential for errors in overlap between individual passes. We often use a 4-nozzle boom with our knapsack sprayer for larger areas. With a little practice, you can develop a cadence for walking and pumping; for example, one pump stroke for every 3 steps. This greatly enhances your ability to maintain a steady speed and a steady pumping pace, which results in more uniform pressure and a more precise application.

Because speed, nozzle orifice size, and pressure all affect sprayer output, each individual must calibrate with the specific

sprayer he or she will be using. You cannot assume that you will get the same output (gallons per acre) with any knapsack sprayer, if you only calibrate with one. Likewise, another person cannot assume that he or she will walk and pump at the same speed that you do, so he or she cannot assume to apply the exact amount as you, using your calibration.

A. Calibration

With only water in the sprayer:

- Mark out area (test area). Do this in the area where the pesticide is to be applied.

  Length × width = square feet (ft^2).
- Determine the amount of water used in the test area. Two methods can be used for this.

  Refill method. Put water in the sprayer. Spray the test area and measure the amount of water used by refilling to the original level. If you used the graduated marks on the sprayer, make sure the sprayer is in exactly the same position for both measurements; if it is tilted on one of the measurements, a significant error can result.

  Time method. Record the *time* needed to spray the test area. Then, while stationary, pump at the same pace you used in the test area and spray into a container for the recorded time and measure the amount of water used.
- Calculate gallons per acre (gal/a) with the following formula:

Formula 1
Amount of gallons per acre:

$$\text{gal/a} = \frac{\text{water used (gal)} \times 43{,}560 \text{ ft}^2/\text{a}}{\text{test area (ft}^2\text{)}}$$

Example:

test area = 12 ft × 30 ft = 360 ft²

water used = 42.2 oz (1 gal = 128 oz)

So, 42.2 oz / 128 oz/gal = 0.33 gallons. Thus:

$$\frac{0.33 \text{ gal} \times 43{,}560 \text{ ft}^2/\text{a}}{360 \text{ ft}^2} = 40 \text{ gal/a}$$

B. Amount of water needed in a given area

Once you have calibrated (output in gal/a), multiply the area to be sprayed (ft²) by sprayer output (gal/a) and divide by 43,560 ft² as shown in the following formula.

Formula 2

Amount of water needed to spray a given area:

$$\frac{\text{area to spray (ft}^2\text{)} \times \text{sprayer output (gal/a)}}{43{,}560 \text{ ft}^2/\text{a}}$$

Example:

Sprayer output = 35 gal/a. You want to apply a pesticide in an area measuring 42 ft × 35 ft. How much water will you need?

(42 ft × 35 ft = 1,470 ft²). Thus:

$$\frac{1{,}470 \text{ ft}^2 \times 35 \text{ gal/a}}{443{,}560 \text{ ft}^2/\text{a}} = 1.18 \text{ gal in } 1{,}470 \text{ ft}^2$$

(1.18 gal × 128 oz/gal = 151 oz)

C. Amount of pesticide to add per gallon of water (carrier)

Once you know the volume your sprayer is applying per acre, you are ready to calculate the amount of pesticide to add for each gallon of water (or other carrier) you will use.

Formula 3

Amount of commercial product to add per gallon of water:

$$\frac{\text{desired pesticide rate}}{\text{sprayer output (gal/a)}}$$

Example:

Pesticide rate = 3 qt/a (3 qt = 96 oz)

Sprayer output = 35 gal/a

$$\frac{96 \text{ oz/a}}{35 \text{ gal/a}} = 2.74 \text{ oz per gallon of water}$$

Using the example under Formula 2, in which you sprayed 1.18 gallons of water in an area 42 ft × 35 ft, you would add 2.74 oz of pesticide per gallon of water: 1.18 gal × 2.74 oz = 3.2 oz of pesticide product for the 1,470 ft²

- If the desired rate is given as active ingredient (ai), then to determine the amount of commercial product per gallon of water, divide the final number in Formula 3 by the percent ai (expressed as a decimal for dry formulations, or actual pounds ai/gal for liquids). For example, using the same sprayer above, assume you wanted to apply 6.5 lb ai/a of DCPA in 8,000 ft². (Dacthal 70 WP contains 70% of the active ingredient DCPA). First determine the amount of water needed in the area.

Formula 2

$$\frac{8{,}000 \text{ ft}^2 \times 35 \text{ gal/a}}{43{,}560 \text{ ft}^2/\text{a}} = 6.43 \text{ gal in } 8{,}000 \text{ ft}^2$$

Formula 3

$$\text{Dacthal/gallon} = \frac{6.5 \text{ lb ai/a}}{35 \text{ gal/a}} = \frac{0.186}{0.7} = 0.27 \text{ lb}$$

(0.27 lb × 16 oz per lb = 4.25 oz of Dacthal 70 WP per gallon)

You need 6.43 gallons for the 8,000 ft². If you have a 4 gallon sprayer, the first full sprayer will have 4 gallons × 4.32 oz/gal of Dacthal 70 WP = 17.3 oz. The second tank will require 2.43 gallons of water × 4.32 oz/gal = 10.5 oz of Dacthal 70 WP.

If the pesticide were a liquid formulation containing 3 lb ai/gal, divide 0.186 by 3 lb/gal (instead of 0.7). This would give 0.062 gallons of pesticide per gallon of water (0.062 gal × 128 oz/gal = 7.94 liquid ounces of pesticide per gallon of water). Thus, in a 4-gal sprayer, you would add 7.94 oz/gal × 4 gallons = 31.7 oz of pesticide, and in the second sprayer you would add 7.94 oz/gal × 2.42 gallons = 19.3 oz of pesticide.

After you add pesticides (especially certain wettable powder formulations or fertilizers) to a sprayer, the flow rate (output) may be affected. After adding the pesticide, spray into a receptacle for the amount of time used in the test area and return the spray solution to the tank. Using Formula 1, recalculate gallons per acre and correct the amount of pesticide per gallon of water. Most catalogs for spray nozzles have conversion factors to correct for change in density of the spray solution.

Calibrating Powered Ground Sprayers

(Assuming pre-calibration check of hoses, nozzle size, spacing and height, etc.)

A. Calibration using "refill method"

With water only (no pesticide) in the sprayer:

1. Spray in actual area, using uniform pressure and speed.
2. Measure area sprayed (length x width = square feet). Note: effective swath width of boom sprayer = number of nozzles × nozzle spacing.
3. Determine the amount of water used in test area.
4. Calculate gallons/acre using Formula 1.

$$\text{gal/a} = \frac{\text{water used (gal)} \times 43{,}560 \text{ ft}^2/\text{a}}{\text{area sprayed (ft}^2\text{)}}$$

Example:

Area sprayed = 12 ft × 300 ft = 3,600 ft²

Water used = 2 gal

Thus:

$$\frac{2 \text{ gal} \times 43{,}560 \text{ ft}^2/\text{a}}{3{,}600 \text{ ft}^2} = 24.2 \text{ gal/a}$$

B. Calibration by time

(This method is recommended with larger sprayers.)

1. Determine the *time* to travel a known distance in the actual area to be sprayed.
2. With sprayer stationary, but operating at the same pressure that will be used in the field, collect discharge from each nozzle for the time required in the test run (replace any nozzle that varies 10 percent from the average). Add output of all nozzles to find the total amount of water used.
3. Determine total area sprayed (length × effective swath width).
4. Calculate gal/a using Formula 1.

Example:

Time to travel 330 ft = 45 seconds

No. of nozzles = 12 at 20-inch spacing (effective swath = 12 nozzles × 20 in = 240 in = 20 ft)

Area = 330 ft × 20 ft = 6,600 ft²

Water used in 45 sec = 30 oz/nozzle × 12 nozzles = 360 oz divided by 128 oz/gal = 2.81 gal

Thus:

$$\text{gal/a} = \frac{2.81 \text{ gal} \times 43{,}560 \text{ ft}^2/\text{a}}{6{,}600 \text{ ft}^2} = 18.5 \text{ gal/a}$$

C. Amount of pesticide to add to tank

Formula 3
Commercial product per gallon of spray water or other carriers, such as liquid fertilizer:

$$\frac{\text{Recommended rate/a}}{\text{Sprayer output (gal/a)}}$$

Example:

Desired rate = 4 lb/a of AAtrex 80 WP

Sprayer output = 20 gal/a

Thus: AAtrex 80 WP per gallon of water =

$$\frac{4 \text{ lb AAtrex 80WP/a}}{20 \text{ gal/a}} = 0.2 \text{ lb AAtrex 80 WP}$$

(0.2 lb × 16 oz/lb = 3.2 oz)

In 60 gallons of water, add: 3.2 oz/gal × 60 gal = 192 oz (12 lb) of AAtrex 80 WP

- Remember, if the recommended rate is given as active ingredient (ai), then to determine the amount of commercial product per gallon of water, divide the final value in Formula 3 by the percent ai (expressed as a decimal for dry formulations, or actual pounds ai/gal for liquids).

Example:

Desired rate = 3 lb/a atrazine

(AAtrex 80 WP contains 80% atrazine)

Sprayer output = 20 gal/a

Thus, the amount of AAtrex to add per gallon of water is:

$$\frac{3 \text{ lb ai/a}}{20 \text{ gal/a}} = \frac{0.15}{0.8 \text{ ai}} = 0.188 \text{ lb AAtrex 80 WP}$$

Note: 16 oz/lb × 0.188 lb = 3 oz

In 40 gallon tank, add 3 oz/gal × 40 gal = 120 oz (7.5 lb) of AAtrex 80 WP

D. The "1/128 acre method"

This is a simple method that more and more applicators are using.

There are 128 ounces in a gallon. If we divide 1 acre (43,560 ft^2) by 128, we have 340 ft^2 (43,560 ft^2 / 128 = 340 ft^2). So, if you find out how many ounces of water you need in order to spray 1/128 of an acre, you can equate this to gallons per acre.

1. Inspect your application equipment to be sure all parts are working properly.
2. Figure the distance you need to travel for the test. The distance of travel varies according to nozzle spacing. Divide 340 ft^2 by the spacing (in feet) between the nozzles on your boom (or use the actual band width for band spraying). For example, if your nozzles are spaced 12 inches apart (1 ft), divide 340 ft^2 by 1 ft.

$$\frac{340 \text{ ft}^2}{1 \text{ ft}} = 340 \text{ ft}$$

So, 340 feet is the distance of travel for the test.

3. Measure how long (time in seconds) it takes you to drive 340 feet (the test run).
4. Collect liquid from your nozzles for this amount of time at the same pressure you will use in the field. Use the average volume per nozzle (not total volume from all nozzles) as ounces collected. The average ounces collected per nozzle are equal to gallons per acre.

Example:

You have nozzles spaced 22 inches apart. Divide 22 inches by 12 in/ft.

$$\frac{22 \text{ in}}{12 \text{ in/ft}} = 1.83 \text{ ft}$$

Divide 340 ft^2 by 1.83 ft.

$$\frac{340 \text{ ft}^2}{1.83 \text{ ft}} = 185.8 \text{ ft}$$

You need to find out how long it takes you to travel 185.8 ft.

The amount of water (in ounces) that you collect from a nozzle in this amount of time is equal to the gallons of water you will apply to an acre.

Be sure to collect from as many nozzles as possible, and use the average flow rate (add the amount each nozzle discharges in the test time and divide by the number of nozzles). Remember, you should replace any nozzle that varies by more than 10 percent from the average.

The chart below shows the distance you need to travel for each nozzle spacing to spray 1/128 of an acre.

Nozzle spacing or band width (in)	Row travel distance (ft)
6	681
8	511
10	408
12	340
14	292
16	255
18	227
20	204
22	186
24	170

You also can calculate for other spacing that is not shown here.

Band spraying

Sometimes, to reduce the total amount of pesticide you use, you apply pesticide only over a strip down the crop row. This is called band spraying or band application.

Using the traditional method to figure the gallons per acre in the bands (sprayed strips), we need to determine the area of the bands and the amount of water used in a given length of bands. Multiply the band width by the number of bands by their length and measure the amount of water used in the test run. Divide the amount of water used by the area sprayed to get gallons per acre.

Example:

Assume you planted corn in rows that are 30 inches apart, and will apply a herbicide at 3 lb/a, in bands 12 inches wide over the corn rows. In a 600-ft test run with an 8-row corn planter-sprayer, you used 1.2 gallons of water.

$$\text{acres} = \frac{\text{band width} \times \text{number of bands} \times \text{length}}{43{,}560\ \text{ft}^2/\text{a}}$$

$$\frac{1\ \text{ft} \times 8 \times 600\ \text{ft}}{43{,}560\ \text{ft}^2/\text{a}} = 0.11\ \text{acre}$$

Galls/sprayed acre:

$$\frac{\text{gallons used}}{\text{area sprayed}} = \frac{1.2\ \text{gal}}{0.11\ \text{acre}} = 10.9\ \text{gal/a}$$

Note that by using the "1/128" acre method, you can easily determine this directly. In the above example, you collected 1.2 gallons (153.6 oz) from 8 nozzles in 600 ft. This equals 19.2 oz per nozzle in 600 ft. With a 12-inch band, you would need to travel 340 ft to have 1⁄128 of an acre.

$$\frac{19.2\ \text{oz}}{600\ \text{ft}} = \frac{x\ \text{oz}}{340\ \text{ft}}$$

x = 10.9 oz in 340 ft, which equals 10.9 gallons per acre.

How much herbicide would you put in a 150-gallon spray tank for this application? First, determine how many acres you can spray with 150 gallons.

$$\frac{150\ \text{gal}}{10.9\ \text{gal/a}} = 13.8\ \text{acres can be sprayed with one tankful}$$

Since you will apply 3 pounds of herbicide per acre, and the full tank will spray 13.8 acres, you need a total of 3 pounds × 13.8 acres, for a total of 41.3 pounds of herbicide per tankful.

You can verify this result by using Formula 3. Pesticide rate divided by sprayer output will give us the amount of pesticide per gallon of carrier. This is:

$$\frac{3\ \text{lb/a}}{10.9\ \text{gal/a}} = 0.275\ \text{lb/gal} \times 150\ \text{gallons} = 41.3\ \text{lb herbicide}$$

Air-blast Sprayers

Air-blast sprayers normally are used to spray orchards. The text below tells how to calibrate an air-blast sprayer in an orchard.

Figure size of test area

Just as with broadcast spraying, you need to know the size of the test area and how much water you use in the test area. To figure the size of your test area, take the distance between the orchard rows and multiply by the length of your test run. When running through your test run, drive with at least half a tank of water at the same speed you will use to spray the orchard. Be sure to record the amount of time this takes.

Figure the amount of water used

One way to figure the amount of water you used in your test run is to fill the sprayer tank to a certain level, then spray your test area. You then can measure carefully the amount of water needed to refill the tank to the exact level. Remember, the sprayer must be sitting in the same position for both measurements. If the sprayer sits tilted at a different angle when you refill the tank, then you will get the wrong measurement of how much water was used. Also, in a large tank, it is often hard to figure exactly how much water was used. And, you should check each nozzle for flow rate.

But, because of the way the nozzles are spaced around an air-blast sprayer, the high volume, and the pressure of the air blast, it is hard to catch spray from air-blast nozzles. So, we suggest you follow this method:

1. Put one end of a hose over a nozzle and put the other end into a measuring container.
2. With the machine at a stop, measure how much water is in the container after spraying for the same amount of time it took for your test run.
3. Repeat this same procedure with each nozzle.
4. Find the average flow rate.
5. Replace any nozzle that has an output differing more than 10 percent from the average of identical nozzles. Note: Some air-blast sprayers have different-size nozzles at different positions on the sprayer shroud in order to apply the same amount in different parts of the trees. In such cases, make sure that the respective nozzles on each side of the sprayer are discharging the same amount. Read your manual carefully.

Again, take the total amount of water you used in the test time, and then use Formula 1 to calculate gallons per acre.

Example: Assume that the rows are 18 feet apart in your orchard, and that you traveled 176 feet in 30 seconds, and that you used a total of 10.5 gallons of water.

$$176\ \text{ft} \times 18\ \text{ft} = 3{,}168\ \text{ft}^2\ \text{area sprayed}$$

Calculate with Formula 1:

$$\frac{10.5\ \text{gal} \times 43{,}560\ \text{ft}^2/\text{a}}{3{,}168\ \text{ft}} = 144.3\ \text{gal/a}$$

Find the ground speed

In some cases, it is important to know your ground speed. Your equipment sprays more pesticide on the target as you move slower and less as you move faster. Never measure speed with your speedometer. When wheels slip in mud or loose dirt, or when tires wear down and get smaller, you can be traveling up to 30 percent slower than your speedometer reads. This can cause you to apply 30 percent too much pesticide. To find your ground speed, follow these steps:

1. In the area where you will spray, mark off a test course.
2. With the spray tank at least half full of water, get your vehicle up to your normal spraying speed. Then, record how many seconds it takes to drive the test course.
3. Multiply your distance in feet by 60 (seconds in a minute) and divide by the time it took to cover your test course multiplied by 88 (at 1 mph you travel 88 feet per minute). This tells you your speed in miles per hour. This can be written as:

$$\text{MPH} = \frac{\text{distance (ft} \times 60)}{\text{time (sec} \times 88)} = \frac{\text{distance}}{\text{time}} \times 0.682$$

Example: You record 60 seconds to drive 176 feet. Thus:

$$\frac{176\ \text{ft}}{60\ \text{sec}} \times 0.682 = 2\ \text{mph}$$

Account for tree size and foliage

Because of the great difference in tree size and the amount of foliage on some trees, you might need to slow down where the volume of tree foliage (called tree row volume or TRV) is greater. Where trees are smaller, you may be able to speed up. Some new sprayers have electronic eyes that regulate sprayer output by TRV or even shut off the sprayer if trees are missing.

Get water-sensitive paper from your pesticide dealer. Place the paper in different parts of the trees to see if your application is even. You might have to change the angle of some nozzles for the spray solution to go through different heights in the trees. Take your time to test your sprayer, using water only. You do not want to be sloppy when you apply pesticides.