

## Calibration of Sprayers (Also Seeders)

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Various methods for calibrating sprayers and seeders and related application information.

Applying the correct rate of a product is an important part of obtaining good results with both seeders and pesticide sprayers. With seeders too little seed reduces crop yields and increases weeds while too much seed increases costs and may reduce yields. With a pesticide application, too little product can mean poor control, while too much can mean crop injury, extra costs, and possible residue on the crop and/or carryover.

Many methods can be used to calibrate sprayers, including the ounce calibration and formula-based methods. With the ounce calibration method, 1/128 of an acre is sprayed and the spray is collected. When measured in ounces the amount collected would be equal to the number of gallons applied per acre since there are 128 ounces in a gallon. Other methods involve using formulas which need to be remembered or recorded for easy use. These methods also may require converting some of the information you have.

The methods discussed in this NebGuide are simple relationships and do not require remembering formulas. However, you do need a general understanding of cross multiplication. The important thing is to be consistent: if you put an item on top of an equation on one side, the same item also goes on the top on the other side.

**Three factors determine sprayer application rate:**

1. Speed
2. Nozzle spacing
3. Nozzle output (determined by orifice size, pressure, and density of spray solution)

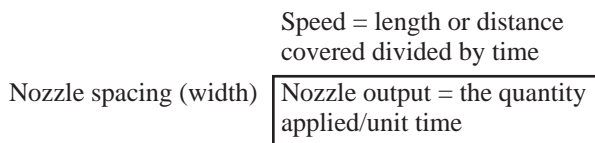
Where:

Speed = Length or distance covered divided by time

Nozzle spacing = Width

Nozzle output = The quantity applied/unit time

The following diagram shows how these three factors are related:



For example, to determine speed:

1 mile per hour (mph) is:

1 mile (5,280 ft) in 1 hour (60 minutes)

Or  $1 \text{ mph} = \frac{5,280 \text{ ft/hour}}{60 \text{ min/hour}} = 88 \text{ ft/min}$

**Problem 1. Determine speed in mph.**

If we travel 440 feet (ft) in 30 seconds (sec), what is our speed in mph?

The objective is to determine the distance traveled in 60 seconds (1 minute) and divide by 88 (88 feet/minute is equal to 1 mph).

$$\frac{30 \text{ sec}}{\text{for } 440 \text{ ft}} = \frac{60 \text{ sec}}{D} \quad (\text{D is the distance we are solving in the equation})$$

We cross multiply to find the value of D

$$30 D = 60 \times 440$$

$$30 D = 26,400$$

$$D = \frac{26,400}{30}$$

$$D = 880 \text{ ft}/60 \text{ sec}$$

Since every 88 ft traveled/60 sec (1 min) is equal to 1 mph, we divide 880 by 88 to get 10 mph

**Problem 2. Determine speed in mph.**

If we travel 297 feet in 27 seconds, what is our speed?

$$\frac{27 \text{ sec}}{297 \text{ ft}} = \frac{60 \text{ sec}}{D}$$

$$27 D = 60 \times 297$$

$$27 D = 17,820$$

$$D = \frac{17,820}{27}$$

$$D = 660 \text{ ft}/60 \text{ sec}$$

Divide by 88 since 1 mph = 88 ft/60 sec (1 min)

$$\frac{660}{88} = 7.5 \text{ mph}$$

**Problem 3. Determine speed in mph.**

If we travel 660 feet in 1 minute and 15 seconds, what is our speed?

First, convert 1 minute and 15 seconds to seconds:  
60 + 15 = 75 seconds

$$\frac{75 \text{ (sec)}}{660 \text{ (ft)}} = \frac{60 \text{ (sec)}}{D}$$

$$75 D = 39,600$$

$$D = 528$$

$$\frac{528}{88} = 6 \text{ mph}$$

**Problem 4. Determine rate/acre.**

If the sprayer is moving at 6 mph, the distance covered in one minute is 528 feet (6 mph x 88 ft/min = 528 feet).

To determine the area you cover with one nozzle in one minute if your sprayer has a 30-inch nozzle spacing:

$$\begin{array}{l} \text{Distance traveled } 6 \times 88 = 528 \text{ ft/min} \\ 30 \text{ in (2.5 ft)} \quad \boxed{\phantom{0.25 \text{ gpm}}} \\ \text{Area sprayed} = 1,320 \text{ sq. ft. (2.5 ft x 528} \\ \text{ft/min)} \end{array}$$

Collect the output of several nozzles and determine the average output per nozzle. All nozzles should be within 10 percent of the manufacturer's rating for that nozzle. For example an XR11003 delivers 0.3 gpm at 40 psi. If it delivers more than 0.33 gpm or 42.24 (128 x .33) ounces/min at 40 psi, the nozzle should be replaced. Any nozzle delivering 5 percent above or below the average delivery rate for all the nozzles should be replaced.

For this example, the average nozzle output is 32 oz per minute or

$$32 \text{ (oz/min)} \div 128 \text{ (oz/gallon)} = 0.25 \text{ gpm}$$

What is the rate per acre? One way to calculate application rate without remembering a formula is to use a relationship: The amount applied and the area sprayed per minute are the same as the amount applied and the area sprayed per acre. R = gals/acre

$$\begin{array}{l} \text{Minute Box} \qquad \qquad \qquad \text{Acre Box} \\ \text{Distance} \\ 6 \times 88 = 528 \text{ ft} \\ \text{Nozzle Spacing} \quad \boxed{0.25 \text{ gpm}} = \boxed{R} \\ 30 \text{ in} \div 12 = 2.5 \text{ ft} \\ 528 \times 2.5 = 1320 \text{ sq ft} \qquad 43,560 \text{ sq ft} \end{array}$$

$$\text{From minute box } \frac{0.25}{1320} = \frac{R}{43,560} \text{ From acre box}$$

$$1320R = 10,890 \text{ (0.25 x 43,560)} \\ R = 8.25 \text{ gals/acre}$$

**Problem 5. Determine the acres sprayed per minute.**

Travel distance in one minute = 616 ft  
Nozzle spacing = 30 in (20 nozzles on sprayer)  
Nozzle output = 64 oz/minute

What is travel speed?  $616 \div 88 = 7 \text{ mph}$  (Remember 88 ft/min = 1 mph)

What is sprayer width? 20 nozzles x 2.5 ft (30-inch spacing) per nozzle = 50 ft

What is application rate?  $\frac{64 \text{ oz/minute}}{128 \text{ oz/gallon}} = 0.5 \text{ gpm}$

$$\begin{array}{l} \text{Minute Box} \qquad \qquad \qquad \text{Acre Box} \\ \text{Distance } 616 \text{ ft} \\ 30\text{-inch nozzle spacing} \quad \boxed{64 \text{ oz or } 0.5 \text{ gpm}} = \boxed{R} \\ (2.5 \text{ ft}) \\ 1,540 \text{ sq ft} \qquad 43,560 \text{ sq ft} \end{array}$$

$$\frac{0.5}{1,540} = \frac{R}{43,560}$$

$$1540R = 21,780 \\ R = 14.14 \text{ gals/acre}$$

To determine the area covered by the sprayer in one minute:

$$1,540 \text{ sq ft/nozzle/minute} \\ 20 \text{ nozzles } 1,540 \times 20 \div 43,560 \text{ sq ft/A} = 0.71 \text{ acre/minute}$$

**Problem 6. Determine nozzle size needed to achieve the operational goal.**

Sprayer speed = 7 mph  
Nozzle spacing = 20 inches  
Application rate desired = 17 gpa  
Nozzle flow rate = F

$$\begin{array}{l} \text{Minute Box} \qquad \qquad \qquad \text{Acre Box} \\ 7 \times 88 = 616 \text{ ft} \\ \text{Nozzle Spacing} \quad \boxed{F = \text{gpm}} = \boxed{17 \text{ gpa}} \\ \frac{20 \text{ in}}{12 \text{ in/ft}} = 1.67 \text{ ft} \\ 1,029 \text{ sq ft} \qquad 43,560 \text{ sq ft} \\ \frac{F}{1,029} = \frac{17}{43,560} \end{array}$$

$$43,560 F = 17,493 \\ F = 0.40 \text{ gpm} \quad \text{or XR8004* at 40 psi}$$

If we need 0.40 gpm, by design an XR8005\* will give 0.5 gpm at 40 psi. Output varies by the square root of the pressure.

$$\text{For example: } \sqrt{40 \text{ psi}} = 6.32 \text{ psi} \\ \frac{6.32}{\sqrt{10 \text{ psi}}} = 2 \\ \sqrt{10 \text{ psi}} = 3.16 \text{ psi}$$

Raising the pressure from 10 to 40 psi (4 times  $\sqrt{4} = 2$ ) doubles output.

Therefore we need to reduce output to 0.40 gpm which is 80 percent of the 0.5 gpm that an XR8005 puts out at 40 psi.

$$\sqrt{40} = 6.32 \times 0.8 = 5.056$$

$$\sqrt{P} \\ \text{To solve for "P" take the result multiplied by itself.} \\ 5.056 \times 5.056 = 25.6 \text{ psi} \\ \text{an XR8005 at 25.6 psi will give you 0.40 gpm}$$

\*Selected from TeeJet Nozzle Booklet by Spraying Systems.

**Problem 7. Calibrating a hand sprayer.**

First fill sprayer with water to a known level, a mark you can later refill to accurately. (Tip: It's best to spray a test area over concrete so you can see the evenness of application.)

$$\begin{array}{l} \text{Spray test area } 100 \text{ sq ft} = 10 \text{ ft} \times 10 \text{ ft} \\ \text{or } 250 \text{ sq ft} = 10 \text{ ft} \times 25 \text{ ft} \\ \text{or } 500 \text{ sq ft} = 10 \text{ ft} \times 50 \text{ ft or } 20 \text{ ft} \times 25 \text{ ft} \end{array}$$

Refill sprayer to same level as before, measuring amount of water it takes to refill sprayer.

If the pesticide recommendation is for 2 liquid ounces of product per 1,000 sq ft, the amount to include per 1,000 sq ft would be 1/4 cup or 4 tablespoons or 12 teaspoons. (See Weights and Measures Conversions on page 4.)

If during the test, 28 oz of water were applied over 250 sq ft, how much water and pesticide should be added to a 3 gallon sprayer?

The amount of water you applied in test area  $\frac{28 \text{ oz}}{250 \text{ sq ft}} = \frac{V \text{ for volume}}{1,000 \text{ sq ft}}$  How much water you will apply per 1,000 sq ft

$$250 V = 28,000$$

$$V = 112 \text{ ounces or } \div 32 \text{ (ounces/qt)} = 3.5 \text{ qt of water per 1,000 sq ft}$$

This indicates that 2 oz of pesticide should be added for every 3.5 qt of sprayer capacity.

With a 3-gallon sprayer, 12 qt (3 x 4 qt/gal) of water should be added to the sprayer tank.

$$\frac{2 \text{ oz}}{3.5 \text{ qt}} = \frac{P \text{ for Pesticide}}{12 \text{ qt}}$$

$$3.5 P = 24$$

$$P = 6.86 \text{ oz or } 0.86 \text{ cup (8 oz/cup)}$$

$$6.86/8 = 0.86 \text{ cup}$$

The amount of pesticide to add to a 3-gallon sprayer

**Problem 8. Determining the density of spray solution.**

The rate at which a fluid flows through a spray orifice varies with its density. Since all the tabulations are based on spraying water, which weighs 8.34 lbs per U.S. gallon, conversion factors must be used when spraying solutions which are heavier or lighter than water. To determine the proper size nozzle for the solution to be sprayed, first multiply the desired GPM or GPA of solution by the water rate conversion factor. The conversion factors are the square root of specific gravity. (See Weights and Measures Conversion chart on page 4 for some common fertilizers).

For example, the specific gravity of 28% nitrogen, which weighs 10.65 lbs/gal, is:

$$\frac{10.65 \text{ (Wt of 28-0-0/gal)}}{8.34 \text{ (Wt of water/gal)}} = 1.28 \text{ specific gravity}$$

Conversion factor for 28-0-0 fertilizer or 28% nitrogen is  $\sqrt{1.28} = 1.13$

Weight of Solution	Specific Gravity	Conversion Factors
7.0 lbs per gallon	0.84	0.92
8.0 lbs per gallon	0.96	0.98
8.34 lbs per gallon - Water	1.00	1.00
9.0 lbs per gallon	1.08	1.04
10.0 lbs per gallon	1.20	1.10
10.65 lbs per gallon - 28% nitrogen	1.28	1.13
11.0 lbs per gallon	1.32	1.15
11.06 lbs per gallon - 32% nitrogen	1.33	1.15
12.0 lbs per gallon	1.44	1.20
14.0 lbs per gallon	1.68	1.30

Example of using the conversion factor:

Desired application rate is 20 GPA of 28% N.

$$\text{GPA (solution)} \times \text{Conversion factor} = \text{GPA (water)}$$

$$20 \text{ GPA (28\%)} \times 1.13 = 22.6 \text{ GPA (water)}$$

A nozzle size should be selected to supply 22.6 GPA of water at the desired pressure, speed, and nozzle spacing.

**Problem 9. Determining the density of a spray solution.**

In this example, the following has been recommended for an ecofallow corn field:

75 lbs of nitrogen from 28% UAN

Density of 28% N = 10.65 lbs/gal

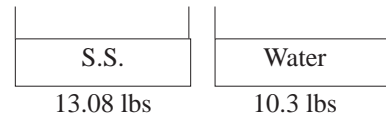
$$10.65 \times .28 = 2.982 \text{ lbs N/gal}$$

$$\frac{75 \text{ lbs N}}{2.982 \text{ lbs N/gal}} = 25.15 \text{ gal of 28\% solution}$$

Ingredient	Amount	Gallons
28% Nitrogen	75 lb N	25.151
Balance Pro	2.0 oz	0.016
Fultime	2.25 qt	0.563
Gramoxone Extra	2 pt	0.250
Crop Oil Concentrate	1 qt	0.250
2,4-D 6 LVE	1/2 pt	0.063
		26.293 or 26.3 gal/acre

To determine how this will spray out and what gallonage of water is needed to get 26.3 gal/acre of this spray solution, three steps are required:

- To determine specific gravity weigh an equal amount of the spray solution and an equal amount of water.



Determine specific gravity weight of spray solution:

$$\frac{13.08 \text{ lbs (wt of spray solution)}}{10.3 \text{ (wt of water)}} = 1.27 \text{ specific gravity}$$

- Determine conversion factor  $\sqrt{1.27} = 1.13$
- Determine the quantity of water to calibrate sprayer:  
 $\text{Spray Rate} \times \text{Conversion Factor} = \text{Water Amount Equivalent}$   
 $26.3 \text{ gal/acre} \times 1.13 = 29.6 \text{ gal/acre}$   
 Now you need to calibrate the equipment to apply 29.6 gallons of water per acre.

**Problem 10. To calibrate a seeder.**

How many pounds of seed are needed to plant 18 seeds/ft in a row with 10-in spacing. Seed size is 15,000 seeds/lb and seed is collected for 500 ft.

To determine pounds of seed needed per acre:

$$\frac{12 \text{ in/ft}}{10 \text{ in/row}} = 1.2 \quad 1.2 \times 43,560 \text{ ft}^2/\text{A} = 52,272 \text{ ft of row/acre}$$

$$52,272 \times 18 \text{ seeds/ft row} = 940,896 \text{ seeds/acre} \div 15,000 \text{ seeds/lb} = 62.7 \text{ lb/A}$$

Determine area seeded with one opener on one acre:

$$\frac{10 \text{ in}}{12 \text{ in/ft}} = 0.83 \text{ ft}$$

Test Box 500 ft long	=	Acre Box
Wt for weight of seed calibrated	=	62.7 lb seed/acre
415 sq ft (500 x .83)		43,560 sq ft

Then cross multiply:

$$\frac{Wt}{415} = \frac{62.7}{43,560}$$

$$43,560 Wt = 26,020.5 (62.7 \times 415)$$

$$Wt = 0.6 \text{ lb/opener or } 9.6 \text{ oz/opener}$$

Reference to commercial products or trade names is made with the understanding that no discrimination is intended of those not mentioned and no endorsement by University of Nebraska–Lincoln Extension is implied for those mentioned.

### Weights and Measures Conversion

**Weight**

- 16 ounces = 1 pound = 453.6 grams
- 1 gallon water = 8.34 pounds = 3.78 liters
- 1 short ton = 2,000 lbs
- 1 long ton = 2,240 lbs
- 1 cubic foot water = 62.4 lbs

**Liquid Measure**

- 1 fluid ounce = 2 tablespoons = 29.57 milliliters
- 1 tablespoon = 3 teaspoons = 14.79 milliliters
- 1 cup = 16 T = 8 oz = 236.583 milliliters
- 16 fluid ounces = 1 pint = 2 cups
- 8 pints = 4 quarts = 1 gallon

**Dry Measure**

- 1 ounce = 28.3495 grams

**Length**

- 1 inch = 2.54 centimeters
- 3 feet = 1 yard = 91.44 centimeters
- 16.5 feet = 1 rod
- 5,280 feet = 1 mile = 1.61 kilometers
- 320 rods = 1 mile

**Area**

- 9 square feet = 1 square yard
- 43,560 square feet = 1 acre = 160 square rods
- 1 acre = 0.405 hectare
- 640 acres = 1 square mile
- 1 hectare = 2.47 acres

**Speed**

- 88 feet per minute = 1 mph
- 1 mph = 1.61 km/h
- 1 mph = 0.477 meter/sec

**Volume**

- 27 cubic feet = 1 cubic yard
- 1 cubic foot = 1,728 cubic inches = 7.48 gallons
- 1 gallon = 231 cubic inches
- 1 cubic foot = 0.028 cubic meters
- Volume of sphere =  $D^3 \times 0.5236$

**Common Abbreviations and Terms Used**

- GPM = gallons per minute
- GPA = gallons per acre
- psi = pounds per square inch
- mph = miles per hour
- RPM = revolutions per minute
- GPH = gallons per hour
- FPM = feet per minute
- T = Tablespoon
- t = teaspoon

**Circles**

- Diameter x 3.1416 = circumference
- Radius<sup>2</sup> x 3.1416 = area

**Spraying Systems Droplet Size in Microns**

- Very Fine = 153 and less
- Fine = 154 - 241
- Medium = 242 - 358
- Coarse = 359 - 451
- Very coarse = 452 - 740
- Extensively coarse = 741 +

**Fertilizer Facts**

Pounds per gallon of liquid fertilizer at 60°F

10-34-0	11.40
11-37-0	11.60
7-21-7	11.00
28-0-0	10.65
28-0-0	10.65
32-0-0	11.06
82-0-0	5.15
12-0-0-26	11.50

1 ppm = 1 second in 12 days or 0.013 ounces in 100 gallons  
or about 8/10 of 1 teaspoon in 1,000 gallons

1 ppb = 1 second in 32 years or 0.013 ounces in 100,000 gallons  
or about 8/10 of 1 teaspoon in 1,000,000 gal

1 ppt = 1 second in 320 centuries

1 pint of water in ocean = 5,000 molecules in any pint of water

1 psi = 2.31 ft

1 foot of lift of water = 0.433 psi

452 gpm = 1 in/1 acre/1 hr

	<u>Lbs/bu</u>	<u>Moisture %</u>
Corn	56	15.5
Soybeans	60	13.0
Grain sorghum	56	14.0
Wheat	60	13.5
Sunflower	25	10.0

Cu ft x 0.8 = bushel of grain

Cu ft x 0.4 = bushel of ear corn

1 horsepower = 550 ft lbs/sec  
= 33,000 ft lbs/min  
= 746 watts

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