UMC
Science and Technology
GUIDE
Published by the University of Missouri - Columbia Extension Division

Sprayer Calibration—Broadcast Sprayers

Maurice R. Gebhardt
Agricultural Research, Science and Education Administration, U.S. Department of Agriculture
Agricultural Engineering Department, College of Agriculture

Pesticides are effective only if applied at the correct amount per acre. Too much pesticide can injure crops and leave harmful residues; too little can give inadequate and undependable control.

The volume of spray mix applied per acre by a sprayer depends on (1) nozzle flow rate, (2) width sprayed and (3) travel speed of the sprayer.

Before you calibrate your sprayer, you must select the nozzles to be used. If your sprayer already is equipped with nozzles, be sure all nozzles are the same. Record the nozzle size number for future use.

Example Situation. Suppose you have a tractor-mounted sprayer, with two 200-gallon (gal) saddle-type tanks, with which you'll apply herbicides while planting row crops. The spray boom and nozzles will spray the width planted with your 6-row (30-inch row spacing) planter. You are going to apply a tank mix of alachor plus linuron for pre-emergence weed control in soybeans.

We will give more examples using the above situation as we describe appropriate nozzle selection and calibration procedures.

Nozzle Selection

Step 1. Select the sprayer application rate. A recommended range of sprayer application rates, in gal/acre, is given on the pesticide label. From that range, choose the rate that best fits your operation.

Example: From the recommended range of application rates on the label of both herbicide containers, you select the rate of 20 gal/acre because that rate is easy to use in computations and is the one you generally use.

Step 2. Select the field speed. Choose a speed that you can maintain at all times in the field because speed affects sprayer application rate greatly.

Example: You are farming bottom land and you select a speed of 5 mph because that is the speed at which you plant soybeans.

Step 3. Determine the width sprayed by each nozzle. The width sprayed by each nozzle on a broadcast spray boom is the distance between nozzles. If a sprayer has nozzles spaced every 20 inches on the boom, then the width sprayed by each nozzle is 20 inches. If a sprayer has several nozzles that will

Table 1. Nozzle Flow Rate (gal/min).

Width sprayed (inches)	Travel speed (mph)	Application Rate (gal/acre) 5	10	15	20	25	30	40
10	3	—	—	0.08	0.10	0.13	0.15	0.20
	4	—	0.07	0.10	0.13	0.17	0.20	0.27
	5	—	0.08	0.13	0.17	0.21	0.25	0.34
	10	0.08	0.17	0.25	0.34	0.42	0.51	0.67
12	3	—	—	0.09	0.12	0.15	0.18	0.24
	4	—	0.08	0.12	0.16	0.20	0.24	0.32
	5	—	0.10	0.15	0.20	0.25	0.30	0.40
	10	0.10	0.20	0.30	0.40	0.51	0.61	0.81
15	3	—	0.08	0.11	0.15	0.19	0.23	0.30
	4	—	0.10	0.15	0.20	0.25	0.30	0.40
	5	—	0.13	0.19	0.25	0.32	0.38	0.51
	10	0.13	0.25	0.38	0.51	0.63	0.76	1.01
20	3	—	0.10	0.15	0.20	0.25	0.30	0.40
	4	0.07	0.13	0.20	0.27	0.34	0.40	0.54
	5	0.08	0.17	0.25	0.34	0.42	0.51	0.67
	10	0.17	0.34	0.51	0.67	0.84	1.01	1.35

be used to spray each row, such as the sprayers used to apply insecticides to row crops, then the width sprayed by each nozzle would be the distance between rows divided by the number of nozzles used to spray each row.

Suppose you have a sprayer that has one nozzle that will be above the row and two that will be between rows, and the rows are 30 inches apart. Each row will be sprayed with three nozzles. The effective width sprayed by each nozzle would be 30 inches divided by 3 nozzles, or 10 inches.

Example: The width sprayed by each nozzle on the example situation sprayer is 15 inches because the spray boom and nozzles spray the full width of the planter, or broadcast, and the nozzles on the sprayer are 15 inches apart.

Step 4. Determine the nozzle flow rate. The nozzle flow rate can be determined from Table 1 or calculated by the use of Equation 1.

Table 1 gives the nozzle flow rate for four speeds and seven application rates. You can use this table if your spray width, speed and application rate are among the values listed. For example, if you want to apply 20 gal/acre at a speed of 5 mph with a broadcast boom having nozzles 15 inches apart, you can determine from the table that you will need a nozzle flow rate of 0.25 gal/minute (min).

If you want to *calculate* the nozzle flow rate, use Equation 1.

Equation 1. Nozzle Flow Rate.

$$NFR = \frac{AR \times S \times W}{5{,}940},$$

where

NFR = nozzle flow rate, gal/min

AR = sprayer application rate, gal/acre, as selected in Step 1

S = speed, mph, as selected in Step 2

W = width sprayed by each nozzle, inches, as determined in Step 3

5,940 = a constant (instead of 5,940, you can use 6,000 with an error of 1 percent).

Example: You know that

AR = 20 gal/acre, as selected in Step 1

S = 5 mph, as selected in Step 2

W = 15 inches, as determined in Step 3;

therefore,

$$NFR = \frac{20 \times 5 \times 15}{5{,}940} = 0.25 \text{ gal/min.}$$

Step 5. Select nozzles. Use the nozzle manufacturer's catalog to select a nozzle that will have a flow rate (Step 4) within the range recommended on the pesticide label.

Example: You want to use a flat fan nozzle to apply the herbicides. The nozzle manufacturer's catalog lists the nozzle number, pressure and flow rate. You don't find the exact value of 0.25 gal/min so you select a nozzle with a flow rate range that includes 0.25. Table 2 is an example from a typical nozzle catalog. You decide to use nozzle 8813 because you observe that 0.25 is within the range of flow rates shown for that nozzle. You install the new nozzles and adjust the boom height so the spray fans overlap about 4 inches above the soil.

Table 2. Example from a typical nozzle catalog.

Nozzle no.	*Pressure (psi)*	*Flow rate(gal/min)*
8812	20	0.14
	25	0.16
	30	0.17
	40	0.20
	50	0.23
	60	0.25
8813	20	0.21
	25	0.24
	30	0.26
	40	0.30
	50	0.34
	60	0.37
8814	20	0.28
	25	0.32
	30	0.35
	40	0.40
	50	0.45
	60	0.49

Calibration

Step 1. Check general sprayer operation. Fill the supply tank with water and operate the pump. Check for leaks, proper operation of the pressure gauge and clogged nozzles. Place a container, such as a quart fruit jar, under each nozzle and see whether all jars fill in about the same time; or use a watch with a sweep second hand and collect the output from each nozzle for the same amount of time. If the output varies much, check to see whether any nozzles are clogged and whether all nozzles are the same size. Nozzles that continue to have a flow rate greater or less than 10 percent of the average should be replaced. Sometimes nozzles wear and cause the flow rate to change. Nozzle wear depends on the amount of use, nozzle material and type of pesticide used. Most suspended pesticides cause greater nozzle wear than soluble pesticides. Brass and aluminum nozzles wear more than stainless steel or ceramic nozzles. The following list gives the nozzle life for several nozzle materials:

Table 3. Travel speed (mph).

Distance (feet)	Travel Time (sec) 15	17	20	24	27	30
88	4.0	3.5	3.0	2.5	2.2	2.0
176	8.0	7.0	6.0	5.0	4.5	4.0

Nozzle material	Nozzle life
Brass or aluminum	1
Stainless steel	2 to 3
Hardened stainless steel	10 to 15
Ceramic	lifetime
Carbides (tungsten, chrome)	lifetime

Example: You have operated the sprayer and checked operation of the shut-off valve and for leaks in the spray system. You've checked the nozzles and found that the flow rate of all is within 10 percent of the average.

Step 2. Check travel speed. Lay out a known distance in the field to be sprayed or in one with similar soil conditions. Use a distance of 176 feet for speeds up to 8 mph and 352 feet for speeds greater than 8 mph. Be sure to use a loaded sprayer and operate the sprayer or tractor with the throttle setting and gear you want to use throughout the spraying operation. Measure, once in each direction, the time to travel the known distance. Average the times in seconds (sec) and use Equation 2 or Table 3 to determine the travel speed.

Equation 2. Travel Speed.

$$S = \frac{D \times 60}{T \times 88}$$

where S = travel speed, mph
D = distance, feet
T = travel time, sec
60 = a constant, sec/min
88 = a constant, feet/min per mph

Be sure to mark your throttle setting and gear after you are satisfied with the speed check. Use the tachometer, also, as a check.

Example: You placed two stakes 176 feet apart in the soybean field. You find it takes 23 sec to drive one way and 25 sec to drive the other way, an average of 24 sec. You can calculate the travel speed, using Equation 2.

$$S = \frac{176 \times 60}{24 \times 88} = 5 \text{ mph}$$

You check this speed using Table 3 and find that your calculation is correct. You also note that the tachometer on the tractor indicated a speed of 5.25 mph. The difference between 5.25 and 5 mph is probably due to wheel slippage or an incorrect tachometer.

Step 3. Determine nozzle flow rate. If you have selected nozzles, you have already determined the desired nozzle flow rate in Step 4 of the nozzle selection procedure. If you are going to use the nozzles you now have, you must calculate their flow rate, using Equation 1 or the manufacturer's catalog.

Example: The nozzle flow rate needed for your sprayer was 0.25 gal/min, as calculated using Equation 1 in Step 4 of the nozzle selection procedure.

Step 4. Measure and adjust nozzle output. Convert the output from gal/min to ounces (oz)/min because ounces are easier to measure. Multiply the nozzle flow rate in gal/min by 128, the number of oz/gal. Collect the nozzle output from several nozzles for 1 min and calculate the average flow rate. If the nozzle output is within 5 percent of the desired flow rate, the sprayer is calibrated. If not, readjust the pressure and collect the output again. Repeat this procedure until the output is within 5 percent of that desired.

Example: You plan to use a glass kitchen measure that is graduated in ounces to measure the output from the nozzle. Therefore, you multiply the nozzle flow rate of 0.25 gal/min times 128 and find that the rate in ounces is 32 oz/min. You checked the nozzle catalog and found the approximate pressure needed to obtain a flow rate of 0.25 gal/min with the 8813 nozzle. You found that 0.25 is between 25 and 30 pounds per square inch (psi). You adjust the pressure so that the gauge reads about halfway between 25 and 30. You use a 2-quart glass kitchen measure to collect the output from a nozzle for 1 min. The amount collected is 38 oz. This amount is too much because 38 minus 32 equals 6, which is greater than 5 percent of 32 (32 X 0.05 = 1.6). You lower the pressure and collect the output from three nozzles. This time the average flow rate is 32.5 oz/min. Your sprayer is now calibrated.

Step 5. Recheck the nozzle output. Check the nozzle flow rate frequently. Adjust the pressure, when necessary, to compensate for changes in flow rate caused by nozzle wear and other changes.

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914 in cooperation with the United States Department of Agriculture. Carl N. Scheneman, Vice President for Extension, Cooperative Extension Service, University of Missouri and Lincoln University, Columbia, Missouri 65211. ■ An equal opportunity institution.