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Protecting Our Water Quality with Sprayer Calibration

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Introduction
The use of agricultural pesticides to help crop production while protecting our environment has become an important issue for farm operators. Often overlooked in this discussion, however, is how the pesticides are applied.

Efficient and safe use of agricultural pesticides depends on proper application. Farm operators must know exactly how much product to use to avoid surface and groundwater pollution, possible crop injury, and excessive residue carryover from over-application. Under-application can be a problem, too, if it results in a second application at added costs for chemicals, labor, and fuel. The second application also may come at a less effective time in the growth cycle of the pest.

To apply the correct amount of pesticides, operators must know their equipment and how it functions under various field conditions. They also must calibrate, or check their sprayer's output, frequently for accuracy. This publication will look at the basic principles of sprayer calibration.

Although new pesticides are more selective, and therefore more effective, studies have shown that a majority of sprayers aren't calibrated to apply those chemicals accurately. Checks of pesticide sprayers in the field have shown that many operators cannot predict the actual amount of tank mix being applied by their equipment, except through trial-and-error. The U.S. Department of Agriculture recommends a 10 percent tolerance range—five percent above or below the intended rate—for sprayer calibration.

In 1979, 152 private and commercial pesticide applicators in Nebraska were surveyed to check both calibration and mixing accuracy. Researchers found that 85 percent of the applicators had calibration and/or mixing errors of more than five percent.

A 1983 check of farm sprayers in North Dakota showed that 60 percent had calibration errors of 10 percent or more. Only 11 sprayers, or 18 percent, were found to be in good shape and were applying chemicals at the rate that the owner predicted.

Thirty-two percent of the applicators used inaccurate travel speeds when spraying pesticides, which also results in over- or under-application.

Drive-in calibration clinics throughout Iowa and Ohio in the mid-1980s showed a similar problem. Only 22 percent of the sprayers checked were applying a tank mix within the intended range. Sprayer calibration errors resulted in as much as a 75 percent under-application of pesticides to nearly 50 percent over-application.

A 1986 Nebraska study showed that only one out of every three farm operators were applying pesticides within the recommended tolerance range. Most of the errors were attributed to incorrect calibration of sprayers.

Research shows the need for more knowledge about sprayer calibration. Common practice is to use the same sprayer settings year after year, and to adjust nozzle sizes or pressure during field application or as problems arise. However, careful calibration of a sprayer at the beginning of the season, and possibly several

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times during the season, will save time and guarantee good results from pesticide use.

Sprayer calibration
A basic understanding of sprayers is helpful when calibrating a pesticide sprayer. Sprayer output is influenced generally by three factors: tractor speed, nozzle size, and operating pressure.

Improper tractor speed is a major cause of poor sprayer calibration. Speed measurement problems occur when applicators rely on their speedometers, which may be in error due to mud sticking on a wheel, improper tire inflation, or slippage. Therefore, it is important to re-calibrate sprayers as field conditions or equipment change.

Since the speed at which the sprayer travels through the field directly affects sprayer output, it's a good idea to verify the accuracy of your tractor speedometer. Radar speedometers usually provide accurate speed measurement, but you also can check the speedometer in the field yourself by recording the time required to cover specific distances at various miles per hour (see Table 1).

To check your tractor speedometer, measure a test course in the area to be sprayed or in one with similar conditions. Use a test course at least 200 feet long for measuring speeds over 5 miles per hour. Drive the course with a partially full sprayer and engine and gear setting that simulates actual spraying conditions. Repeat the test run several times to get an average time. Compare your average time with figures in Table 1 to determine your approximate ground speed.

Table 1. Travel and speed measurement.

Speed in MPH (miles per hour)	Time in SECONDS to travel a distance of:		
	100 feet	200 feet	300 feet
3.0	23	45	68
3.5	20	39	58
4.0	17	34	51
4.5	15	30	45
5.0	14	27	41
6.0	–	23	34
7.0	–	19	29
7.5	–	18	27
8.0	–	17	26
9.0	–	15	23

The amount of pesticide applied by a sprayer will vary significantly with even slight differences in tractor speed. A change in nozzle size also can result in large increases or decreases in sprayer output. For smaller adjustments on sprayer output, change the spray pressure.

How to calibrate
Sprayer calibration requires only a watch with a second hand or a stop watch, a measuring cup, and measuring tape. After becoming familiar with calibration, growers should be able to complete this in less than an hour. The important thing is that the sprayer is calibrated routinely at the beginning of a season, and several times during the season, depending on wear and use of the nozzles as well as changes in field conditions. Sprayer calibration is done in two steps: determining output and checking for uniform distribution across the sprayer boom.

Determine sprayer output
There are several ways to determine sprayer output, all of which are equally accurate. Here is an explanation of three widely used methods, including the 1/128 of an acre method, the calculation method, and the use of specialized equipment on sprayers.

1/128 of an acre method: This is the most popular method. It uses the fact that there are 128 fluid ounces in a gallon as a way to simplify the calibration process. Instead of measuring the number of gallons of tank mix actually used to cover one acre, you complete a test run to determine the number of ounces of water used to cover 1/128 of an acre. You can verify that what you've collected is the amount recommended on the pesticide label. Each nozzle is checked individually to make sure that it's operating at the proper rate. This method takes into account the tractor speed by measuring the time needed to cover 1/128 of an acre. No other calculation is needed to determine speed.

Here's how the 1/128 of an acre method works:
1. Fill the spray tank approximately half full with water to simulate average spraying conditions. Check the suggested sprayer application rate listed in gallons per acre on the pesticide label. This will be the number of ounces you want to collect from each sprayer nozzle.

2. Check the nozzle spacing on your sprayer and, using Table 2, select the proper travel distance (in feet) for the 1/128 acre test run.

3. In the field, drive the designated distance at your normal spraying speed. Record travel time in seconds. Drive the distance several times and use the average.

4. Set the desired pressure on the sprayer. With the sprayer parked, collect the output from each nozzle in the measuring cup for the recorded travel time. Record the output of each nozzle separately, in ounces.

5. The number of ounces you collect from each nozzle is equal to the sprayer application rate, measured in gallons per acre.

For example, if nozzles are mounted 20 inches apart, your test run will be 204 feet. If your recorded travel time is 18 seconds, then you would collect water from each nozzle for 18 seconds. If your sprayer application rate is 12 gallons per acre, you would want to collect 12 ounces of water from each nozzle.

6. If nozzle discharge does not equal the sprayer application rate, you can change the rate by adjusting the pressure of the nozzles, adjusting your travel speed, or changing nozzle size. After the changes are made, do the entire calibration process over again to verify that the sprayer is operating at the proper rate.

It is critical to determine the travel time under the same field conditions in which you will apply the pesticides. Re-calibrate the sprayer whenever field conditions change significantly.

Table 2. Test run distance for sprayer calibration.

Nozzle spacing (inches)	Travel distance (feet)
20	204
30	136
36	113
38	107
40	102

The calculation method: This method uses a formula that can be found in most sprayer manuals and nozzle catalogs. This method is particularly useful when several different application rates need to be computed, or when the appropriate size nozzle must be determined when purchasing new nozzles.

Operators first must know several variables that are inserted into the formula. Those variables are:
➔ Sprayer output, shown in gallons per acre, or GPA;
➔ Individual nozzle output, shown in gallons per minute, or GPM;
➔ Travel speed of the sprayer, shown in miles per hour, or MPH;
➔ Spacing of the nozzles, shown in inches as width, or W. (For broadcast sprayers, use the number of inches between each nozzle as width in the formula. For banding applicators, use the sprayed band width of each nozzle.)

Insert the variables into the following formula to determine the application rate in gallons per acre (GPA).

$$\text{GPA} = \frac{5940 \times \text{GPM}}{\text{MPH} \times \text{W}}$$

Don't rely solely on the tractor speedometer to determine the sprayer travel speed used in this formula. Check the sprayer over a known distance in the field to accurately determine the travel speed. This is important when using the calculation method.

Spray controllers or monitors: Newer sprayers often are equipped with a spray controller and monitor that is able to adjust the sprayer while moving to ensure uniform application.

A monitor on the sprayer senses flow rate and tractor speed. The controller can adjust flow rates in response to changes in tractor speed, and consistent output can be maintained.

Such equipment can give a grower confidence that pesticides are being applied properly. However, this equipment should be checked periodically for accuracy. It may be checked by the operator or a reputable dealer or service unit.

Uniform sprayer distribution Regardless of the method used to determine sprayer output, it is necessary that spray is uniform throughout length of the boom. To do this, collect spray from each nozzle on the boom for the same length of time. If any nozzle

varies more than 5 percent from the average, it should be replaced. As nozzles wear with age, output usually increases. Because of this, it is recommended that all nozzles be replaced at the same time.

Wear rates depend on the quality, size, and type of nozzle. Less expensive brass nozzles usually wear out more rapidly than nozzles made with stainless steel.

Uniformity of output across the length of the boom also is affected by other factors; including nozzle type, nozzle spacing and orientation, boom height, and spray pressure.

With most nozzle types, it is necessary to have overlap of the spray pattern to achieve uniform spray distribution. For flat fan tips, a 30 percent overlap is recommended. Flood tips should have a 100 percent overlap. Adjust the amount of overlap by changing nozzle spacing or boom height. Raising the height of the boom will create a larger overlap.

Spray pressure influences the pattern produced by spray nozzles, and therefore can influence application uniformity. Do not operate a nozzle outside its suggested pressure range. This can distort the pattern and result in poor or uneven application. Certain nozzle types have wider operating ranges than others, and are better suited for use in sprayers equipped with spray controllers that adjust pressure to maintain a uniform output at different tractor speeds.

Summary

Proper calibration of pesticide sprayers is critical to achieve economical crop management and responsible stewardship of natural resources. Precise application minimizes potential problems while maximizing the effectiveness of the pesticide. Professional crop producers who want to protect their natural resources know they must devote their full attention to calibration. It's one of the most important parts of effective and safe pesticide use.

This publication accompanies a series of video programs, Protecting Our Water Quality, available at local Extension or Soil Conservation Service offices. This publication was reviewed and originally prepared by Mark Hanna, Extension agricultural engineer; edited by Laura Miller and designed by Dennis Melchert, former Extension communication specialists.

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