Water Quality and Sprayer and Spreader Calibration

A.H. Bruneau, Extension Crop Science Specialist
L.T. Lucas, Extension Plant Pathology Specialist
C.E. Hartwiger, Graduate Student in Crop Science
G.R. Taylor, Graduate Student in Crop Science

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Proper application of pesticides and fertilizers, which protects water quality, is possible only with a sprayer or spreader that is accurately calibrated. Pesticides applied with equipment that has not been calibrated may be misapplied by more than 10 percent. That may lead to repeat applications, damaged plants, excess cost, and contamination of the environment.

Sprayers

Sprayers should be calibrated after every fourth application and the sprayer system and nozzles should be checked before every use. The time it takes to gather the information needed to calibrate a sprayer may more than offset losses due to an improperly calibrated sprayer.

SPRAYER CALIBRATION

There are three main calculations used in calibrating a sprayer:

1. **Miles per Hour - speed of the sprayer**
2. **Gallons per Acre - rate of output**
3. **Gallons per Minute - amount of output over a given area**

These calculations are used to determine or change the appropriate output for a given area.

FIGURE 1. **IMPROPER CALIBRATION CAN RESULT IN TURF INJURY.**

Miles Per Hour (MPH)

Before you can make any of the other calibration calculations you have to know the speed of the sprayer.

1. Mark off a 200-foot course on terrain that is typical of your area.

2. Fill spray tank to 1/2 full.

3. Extend the booms of the sprayer.

4. Test to determine which gear and RPM will allow the sprayer to maintain 40 PSI pressure on the nozzles while maintaining a constant speed of between 3 and 5 MPH.

Drive the sprayer through the 200-foot course at least three times, and record the length of time of each run (in seconds). Start far enough away from the course that the sprayer can attain the desired speed before reaching the first marker and maintain it through the run.

Average the three test run times:

$$\text{Average time of sprayer to cross 200 ft} = \frac{\text{Time 1} + \text{Time 2} + \text{Time 3}}{3}$$

Fill in the appropriate course distance and average time (in seconds) into the following formula to calculate the miles per hour (MPH) of your sprayer at the selected gear and RPM setting.

FIGURE 2. **DETERMINE MILES PER HOUR BY DRIVING THE SPRAYER THROUGH A 200-FOOT COURSE.**

5. Calculate the miles per hour.

$$\text{MPH} = \frac{\text{Distance (ft)} \times 60}{\text{Average Time (s)} \times 88}$$

Example:
You set up your 200-foot distance, made three test runs, and logged the following times: Time 1 = 31.5 seconds, Time 2 = 30.3 seconds, Time 3 = 29.2 seconds. Determine the average time as follows:

$$\text{Average Time} = \frac{31.5 + 30.3 + 29.2}{3} = 30.3$$

Fill in the average time to determine the MPH.

$$\text{MPH} = \frac{\text{Distance (200 ft) X 60}}{\text{Average Time (30.3) X 88}} = 4.5$$

Gallons Per Acre (GPA)

Now that you have calculated the speed of your sprayer, you need to determine the output. The number of gallons per acre can be figured from the output of a single nozzle.

FIGURE 3. DETERMINE THE OUTPUT OF A SINGLE NOZZLE.

1. Determine the gallons per minute (GPM) of the test nozzle, measured in tenths of a gallon. Each type of nozzle has a specified GPM. For more information on GPM, refer to the next section.
2. Measure the width in inches between two nozzles on the boom.
3. Calculate the gallons per acre.

$$\text{GPA} = \frac{\text{GPM X 5,940}}{\text{MPH X Width}}$$

Example:
Assume the following information has been gathered from your sprayer:

- GPM = 0.5 (output of a single nozzle is 1/2 gallon per minute)
- MPH = 4.5 (as calculated from the MPH formula)
- Width = 18 inches (measures distance between two nozzles on the boom of the sprayer)

$$\text{GPA} = \frac{0.5 \text{ X } 5{,}940}{4.5 \text{ X } 18} = \frac{2{,}970}{81} = 36.67$$

To determine the equivalent gallons per 1,000 square feet, divide the GPA by 43.56.

$$\text{Gallons per 1,000 sq. ft.} = \frac{36.67\ \text{GPA}}{43.56} = 0.84$$

Gallons Per Minute (GPM)

If the GPA calculated according to the formula above does not meet the requirements of a specific application, the rate of output can be adjusted by switching the nozzle. To determine the nozzle with the correct output, use the GPM formula.

1. Determine the rate of output required for a specific application.

2. Calculate the gallons per minute.

$$\text{GPM} = \frac{\text{GPA X MPH X Width}}{5{,}940}$$

Example:
You have a pesticide that must be applied in 22 gallons of water per acre, so 33.88 GPA from the calculation is too much for your purposes. You can do one of two things: you can increase the speed of the sprayer, or you can change the output of the nozzles. You should not increase the speed of the sprayer because you are already close to the maximum recommended speed of 5 MPH. But you can easily change the output of the nozzles just by switching to a nozzle that has a lower output.

Using the same information from the GPA example, but substituting 22 GPA for the 33.88 GPA we calculated for the sprayer:

$$\text{GPM} = \frac{22\ \text{GPA X 4.5 MPH X 18}}{5{,}940} = 0.30$$

3. Change to nozzles that put out 0.30 GPM to apply 22 gallons of mixed material per acre.

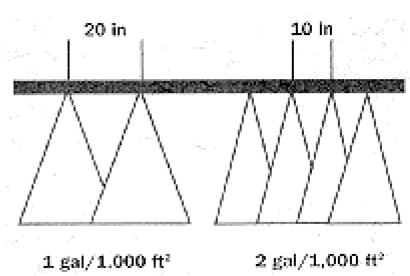

FIGURE 4. **NOZZLE SPACING CAN AFFECT OUTPUT.**

Doubling the distance between nozzles decreases the output per 1,000 square feet by 50 percent.

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NOZZLE CALIBRATION

As mentioned in the calculation of the GPA, each type of nozzle has a specific output rate. This specification includes the spray angle and the output rate of the nozzle in gallons per minute.

> **Example:**
> A flat fan nozzle, which has a specification number of *8003*, sprays at an angle of 80 degrees and has an output rate of 0.3 gallons per minute.

To calculate the percent error for a nozzle which may be worn or old you would complete the following steps:

1. Set the proper PSI for the nozzles on the boom. For many nozzles the rated pressure is 40 PSI.

2. Start the spray flow for the boom using water only.

3. Collect the water sprayed from a single nozzle in a large measuring cup for 1 minute. The cup should be one reserved for use only with pesticides and calibration tests.

4. Divide the total ounces caught in the cup for 1 minute by 128 (number of ounces in 1 gallon) to find GPM.

GPM	=	oz. Collected --------------------------- 128

5. Subtract the actual GPM from the GPM from the nozzle number to get the difference in GPM.

6. Divide the difference in GPM by the GPM from the nozzle number to determine the percent error in the nozzle. If a nozzle is off by more than 10 percent (0.10), replace it with a new one! If more than one nozzle is off by more than 10 percent, replace all nozzles on the boom.

> **Example:**You have *8003* nozzles on your boom. You collect 75 ounces in one minute from the first nozzle.

GPM	=	45 oz. Collected --------------------------- 128 oz. Per Gallon	=	0.35

0.35 actual GPM
-0.30 specified GPM

0.05 difference in GPM

0.05 difference in GPM --------------------------- 0.30 specified GPM	=	17 percent difference

Because the difference in actual output compared to the specified output is more than 10 percent, the nozzle needs to be replaced. Repeat these steps to test a second nozzle. If the second nozzle is found to be off by more than 10 percent replace all of the nozzles on the boom.

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SPRAYER MAINTENANCE

1. Fill the sprayer tank 1/2 full with water. *Never add pesticides to a sprayer before it is checked for leaks and operating condition.*

2. Check the tank, hoses, and fittings from the tank for leaks.

3. Start the sprayer's engine to begin circulating the water through the system.

4. Check all hoses, fittings, and the pump for leaks. Take the time to fix any leaks. A small leak at the beginning of the spraying operation may quickly turn into a break while spraying.

5. Turn on the spray boom and check for leaks in the hoses to the boom, the nozzle hoses, and the nozzle assemblies.

6. Remove and clean the main in-line filter.

7. Remove each of the nozzles on the boom, and clean and replace the screens, if necessary.

8. With the nozzles removed, start the pump to flush any particles or debris out of the system.

9. Return the nozzles to their assemblies, making sure that the spray pattern is in line with the boom. However, if the nozzles are the flat fan type, the spray pattern should be slightly off line to allow for a 30 percent overlap.

10. Check the spray pattern from each of the nozzles. If a pattern is inconsistent, replace the nozzle with a new one of the same style and output volume as the others on the boom.

11. Adjust the distance between nozzles and their height above the ground to the recommended measurements. There should be a 30 percent overlap for flat fan nozzles and a 100 percent overlap for hollow-cone nozzles.

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Spreaders

Proper maintenance, operation, and calibration of spreaders is essential to optimize the effectiveness of fertilizers, pesticides, and other materials applied to turf. Calibration involves a determination of the distribution pattern and the application rate of material being applied for a particular spreader. Techniques for measuring the distribution pattern and the application rate will depend on the spreader type.

Rotary spreaders

Rotary spreaders cover a wider area faster and are preferred for larger areas. Rotary spreaders have distribution patterns that are more forgiving of operator error, require a lower push effort, have better ground clearance, and have less delicate rate mechanisms, allowing them to hold their calibration longer over time. However, proper calibration will require a determination of optimum overlap to achieve a uniform application of material.

Drop Spreaders

Drop spreaders have uniform and consistent patterns, low drift potential, and precise control of the edges of the patterns which is useful for edging around small areas such as driveways and flower beds or near environmentally sensitive areas such as ponds or streams.

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SPREADER CALIBRATION FACTORS

Four factors affecting the distribution patterns of rotary spreader, and to some extent drop spreader calibration, are design factors, product factors, environmental factors, and operator factors.

Spreader Design
The impeller (paddle or spinner) characteristics such as impeller diameter, speed (gear ratio), concavity (flat or concave), height above the ground, fin shape and angle, and surface characteristics, are all determined by the manufacturer.

Application Product
The characteristics of the application product (fertilizer or pesticide) such as the particle shape, size, size uniformity, density, critical relative humidity (the humidity at which the fertilizer becomes sticky), and surface friction, all affect distribution.

Environment
Wind speed and direction are two obvious factors affecting distribution, but temperature and relative humidity are also influential. You need to decide if applications should be made under current weather conditions or postponed until conditions become acceptable.

Spreader Operator
The walking speed, handle height, and pattern of travel can be controlled by the operator. The radial drop point of the material onto the impeller may be adjusted on some spreaders equipped with an adjustable port or a pattern adjustment.

To give a valid indication of spreader performance, conduct the calibration under conditions similar to those of the actual operation of the spreader. Ground speed, rate and pattern settings, operator, wind speed and direction, terrain, temperature, humidity, and the application product should all be similar.

For the calibration of all types of spreaders, select a walking speed suitable for the applicator. Three miles per hour is a reasonable walking speed. Pacing devices are available that can help achieve a consistent walking pace. For the purposes of calibration, use the setting suggested by the manufacturer of the spreader.

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ROTARY SPREADERS

Calibration of rotary spreaders involves collecting and weighing the material being spread and analyzing the pattern of distribution across the application area.

1. Place collection pans in a line perpendicular to the travel direction of the spreader. Use at least 10 pans to cover the full width of the spread. Twenty to thirty pans may be required for large spreaders.

Note:
All collection pans must be identical in size. One square foot by 1 to 2 inches deep for small spreaders, and 2 to 4 inches deep for larger spreaders, is recommended. Rectangular shaped pans are preferred.

Pans should be padded or baffled. Material bouncing into or out of the pans can affect results.

2. Make several passes *in the same direction* over the pans. Make sure the spreader is open before reaching the pans and remember to walk at the same speed you will use to distribute the material later.

3. Collect and weigh the material in each pan on an accurate scale (grams preferred unit). The data collected will be used to determine the distribution pattern and the application rate.

4. Empty each collection container into separate identical cylindrical tubes and examine the distribution pattern across the series of tubes. A desirable pattern is one that peaks in the center and descends evenly on each side forming a bell-shaped curve.

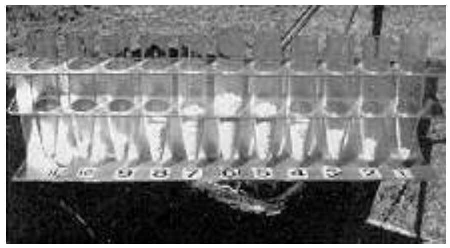

FIGURE 5. **AN IDEAL SPREADER PATTERN IS ONE THAT PEAKS IN THE CENTER AND DESCENDS EVENLY ON EACH SIDE.**

Unlike the drop spreader, some overlap of the pattern will be required to achieve a uniform distribution of the material, due to the bell-shaped nature of the distribution pattern of the rotary spreader. It is important that similar quantities of material are being applied to the left and to the right of the spreader. Skewing of the spread may be corrected by repositioning the pattern adjustment control, if the spreader has one, or restricting the discharge ports.

5. Determine the width of turf covered by each pass of the spreader, where the tray on the left and right are equal to one half the amount in the center tray.

6. Use the weight of material collected from the pan in the center of the pattern in the equation below:

$$\text{Grams Material per 1,000 sq. ft} = 1{,}000 \times \frac{\text{Grams Material Collected in Center Pan}}{\text{ft}^2\text{ Pan} \times \text{\# of Pans} \times \text{\# of Passes}}$$

Continue this process until the desired rate is achieved, either by increasing or decreasing the spreader setting (size of the discharge ports).

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DROP SPREADERS

Calibration of drop spreaders involves collecting and weighing the material being spread.

Pan Method

Push the spreader over a pan(s) and collect and weigh the material that was spread. By knowing the area of the pan and weight of the material, the application rate can be determined by:

$$\text{Grams Material per 1,000 sq. ft} = 1{,}000 \times \frac{\text{Grams Material Collected}}{\text{ft}^2 \text{ Pan} \times \#\text{ of Pans} \times \#\text{ of Passes}}$$

Sweep and Weigh Method

Push the spreader over a clean, smooth surface of a known distance and sweep and weigh the material. The application rate can be determined by:

$$\text{Grams Material per 1,000 sq. ft} = 1{,}000 \times \frac{\text{Grams Material Collected}}{\text{Spreader Width} \times \text{Distance Traveled}}$$

Catch Pan Method

Attach a catch pan to the bottom of the drop spreader. Establish and mark two points of a known distance. Push the spreader over the known distance, opening the hopper at the starting point, and closing at the finish point, while collecting the dropped material in the catch pan. The application rate is determined by using the following formula:

$$\text{Grams Material per 1,000 sq. ft} = 1{,}000 \times \frac{\text{Grams Material Collected}}{\text{Spreader Width} \times \text{Distance Traveled}}$$

Whichever method is used, make enough passes or travel enough distance so that the material collected is enough to be weighed accurately. If the calculated rate is too high, reduce the setting adjustment. If it is too low, increase the setting adjustment. Continue this process until the desired rate is achieved.

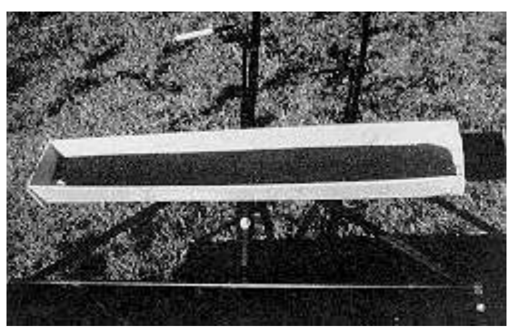

FIGURE 6. **CATCH PANS CAN BE ATTACHED TO THE BOTTOM OF THE HOPPER OF THE DROP SPREADER AND THE MATERIAL COLLECTED AFTER TRAVELING A CERTAIN DISTANCE.**

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SPREADER OPERATION

Following are some general tips on operating a spreader:

1. Make sure the distribution lever is closed before filling the hopper.

2. Do not overfill the hopper.

3. Make sure the screen filter is in place to prevent clogging.

4. Push the spreader. Do not pull it.

5. Push the spreader as close to the calibrated speed as possible.

6. Start walking before opening the lever; close the lever before stopping forward motion.

7. Hold the handle at the height used in calibration. The impeller should be level.

8. Walk in straight lines using reference points such as the spreader wheel marks or footprints.

9. Do not spread while turning. Generally, only one wheel drives the impeller. The impeller will either speed up or slow down during a turn, affecting the distribution pattern.

10. Do not make sensitive applications if wind speed is greater than 5 miles per hour.

11. Keep material dry to prevent caking and clogging of the ports.

12. Try to buy products with good application characteristics.

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SPREADER MAINTENANCE

Even a properly calibrated spreader will not perform well if it is not operated or maintained correctly. Here are some operation and maintenance tips.

1. Wash the spreader after each day's use to avoid buildup around ports and on the impeller. Cold or hot water is adequate for cleaning water soluble products. When using plastic or waxy products, a solvent or scraping may be required. Be sure to consult the manufacturer for appropriate solvents.

4. Consult the operator's manual for appropriate lubricant and parts requiring lubrication.
5. Use proper replacement parts and keep frequently used parts on hand.
6. Store spreader in a cool, dry place without a load in the hopper.
7. Proper maintenance will increase the life of your spreader.

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