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Boom Sprayer Calibration

A tractor- or utility vehicle-mounted boom sprayer applies fertilizers and pesticides to large turfgrass areas. Materials are mixed and continuously agitated in a spray tank. The solution is pumped mechanically through a set of nozzles that are equally spaced across a boom.

Proper application of pesticides and fertilizers is only possible with an accurately calibrated sprayer. Calibration is the process of measuring and adjusting output of application equipment in order to apply the correct amount of material uniformly over a given area. Failure to care for and correctly calibrate spray equipment can result in misapplication of pesticides and fertilizers, repeat applications, damaged plants, excess cost, and environmental contamination.

Photo courtesy of Mike Fidanza, Ph.D.

Boom Sprayer Calibration

Pre-Calibration Checklist

Proper maintenance and preparation of spray equipment will minimize application mistakes and prolong the life of your sprayer. Follow the guidelines below before making a pesticide or fertilizer application.

- Fill the sprayer tank ½ full of clean water. Use only clean water. Do not add pesticides until the sprayer has been checked for leaks, is in good operating condition, and has been calibrated.
- Be sure your nozzle tips are the correct type and size for the spray application you want to make. The nozzle tip is perhaps the most important, yet most neglected, component of the sprayer. It is critical to use the appropriate nozzle tip for the intended pest target and turfgrass conditions. The nozzle tip determines the spray pattern and droplet size.
- Make sure that all nozzles are properly spaced along the boom and are mounted at the proper height above the target. Proper height and spacing ensures uniform spray coverage. Refer to the nozzle supplier's catalog to determine the appropriate nozzle spacing, position, and height that will result in the spray pattern uniformity that you need.
- Remove, clean, and replace (if necessary) the screen behind each nozzle tip. Clean nozzle tips and screens in soapy water with a soft brush. Remove any deposits from the nozzle opening with a toothpick or compressed air. Never use a knife or metallic object to clean tips as it will ruin them. Never try to unclog a tip by blowing through it with your mouth.
- With the nozzle tips removed, and in a place away from wells and water supplies, pressurize the sprayer and flush hoses and boom with plenty of water to flush out any particles or debris.
- Turn off the pump and return nozzle tips to their assemblies. Pressurize the sprayer within the recommended range and check tips for a uniform spray pattern. This can be done by spraying water on a paved or bare surface and watching for streaks as the spray dries. Wet streaks that occur directly under the nozzles may result from damaged or worn nozzle tips, low operating pressure, or low boom height. Streaking that occurs midway between adjacent nozzles may result from improper nozzle alignment or boom height. Clogged nozzles may produce streaks anywhere in the spray pattern of the affected nozzle. If a nozzle has an improper spray pattern, replace it with a new nozzle tip that is the same style and output volume.
- Visually inspect the tank, hoses, and fittings for leaks while the sprayer is pressurized. Fix any leaks before calibration or making a fertilizer or pesticide application.
- Be sure all tires on your sprayer are at recommended tire pressures.

Calibration Process

The output of a boom sprayer is affected by sprayer speed of travel, nozzle flow rate, and nozzle spacing. There are several different ways to accurately calibrate a sprayer. The process being outlined in this bulletin is the 128th Acre Calibration Method. The spray collected from a single nozzle measured in fluid ounces directly converts to gallons per acre regardless of the number of nozzles on the boom. Because there are 128 fluid ounces in a gallon, the fluid ounces collected from 1/128th of an acre will equal gallons of solution per acre.

Remember:

1 acre = 43,560 square feet
1/128th of an acre = 340.31 square feet
1/128th of an acre = 18.5 feet by 18.5 feet
1 gallon = 128 fluid ounces

A worksheet has been provided at the end of the document to help you move through each step and calculation to successfully calibrate your sprayer.

Collect materials needed to calibrate the sprayer:

- Sprayer
- Correct nozzle tips (identical across the boom)
- Measuring tape
- Water
- Flags
- Measuring container (measurement in fluid ounces)
- Stopwatch

Step 1: Determine the travel distance based on nozzle spacing.

Nozzle spacing is the distance, in inches, between two nozzles on the sprayer boom. The type of nozzle used for the application determines nozzle spacing.

Measure the distance (in inches) between nozzles on the spray boom. Then refer to Table 1 to obtain the test course distance (in feet).

Table 1: Calibration distances for a known nozzle spacing.

Nozzle Spacing (inches)	Distance (feet)
40	102
38	107
36	113
34	120
32	127
30	136
28	146
26	157
24	170
22	185
20	204
18	227
16	255
14	291

Example:
There are 20 inches between each nozzle on the spray boom. Therefore, the distance the sprayer must travel during the calibration test run is 204 feet to equal 128th of an acre.

If the nozzle spacing is not reflected on the above chart, follow these steps:
Example: There are 21 inches between each nozzle on the spray boom.

Determine travel distance based on 128th of an acre:

$$\frac{4080}{21 \text{ inches}} = 194.3 \text{ feet or } 194 \text{ feet}$$

The time it takes the sprayer to travel 194 feet must be determined for calibration. Measure and flag a 194 foot distance on terrain and turfgrass similar to that being sprayed.

Remember:

4,080 feet long x 1 inch wide = 128th of an acre

$$\frac{4080}{\text{Nozzle spacing (in inches)}} = \text{test course travel distance}$$

Step 2: Determine the time it takes to travel the determined distance.

Fill the sprayer tank ½ full of clean water. Use only clean water during calibration. Never add pesticides to a sprayer until it is properly calibrated and ready for use.

Select the machine/tractor gear and RPM (revolutions per minute) that will be used during the spray operation. It is critical to maintain a consistent travel speed during calibration and application. A change in speed will have a direct effect on the amount of chemical applied. As speed increases, the amount applied decreases. As speed decreases, amount applied increases. The gear and RPM settings should allow a speed between 3 to 5 miles per hour. Actual speed should be based on the conditions of the site to be sprayed and operator ability. Always recalibrate the sprayer any time the speed of the sprayer is changed.

Have the sprayer moving at the operating speed before crossing the starting line of the measured course. Driving at the same speed as application speed, use a stopwatch to measure the time in seconds it takes to travel the determined distance. Drive beyond the ending flag to maintain a uniform speed within the flagged distance. Make several passes (equally down and back) to consider any slope in the terrain. Always make at least 3-4 runs over the measured course and calculate an average time.

Example:
The flagged distance is 194 feet long.
Run 1: 45 seconds
Run 2: 48 seconds
Run 3: 44 seconds
Run 4: 48 seconds

To determine average time to cover 194 feet:

$$\frac{\text{185 total seconds}}{\text{4 runs}} = \text{46.25 seconds or 46 seconds}$$

Remember:

$$\frac{\text{Sum of total seconds}}{\text{Number of runs}} = \text{average time traveled in seconds}$$

Step 3: Measure nozzle output.

Nozzle flow rate is the amount of liquid sprayed from the nozzle in a given amount of time.
Operate the sprayer with water in the tank at the desired pressure with a good flow of water running through the spray tips. Using a stopwatch and measuring cup marked in fluid ounces, collect water from a single nozzle for the time (in seconds) it took to travel the predetermined distance. Record the amount collected.

Example:
It took 46 seconds to travel 194 feet. Using a measuring cup, collect water from one nozzle for 46 seconds. Amount collected after 46 seconds is 44 fluid ounces.

Photo by Micah Woods, Asian Turfgrass Center

Step 4: Determine uniformity of spray across the boom.

To check the uniformity of all nozzles on the boom, collect the water sprayed from one nozzle for the average time it took to drive the test course. After catching the spray from each nozzle individually, add the amounts collected and divide by the number of nozzles to get the average output per nozzle. If the flow rate of any spray tip is 7 percent greater or less than the average nozzle output, clean or replace the nozzle tip. If any of the nozzles need to be cleaned or replaced, recheck the output from all nozzles and recalculate the average.

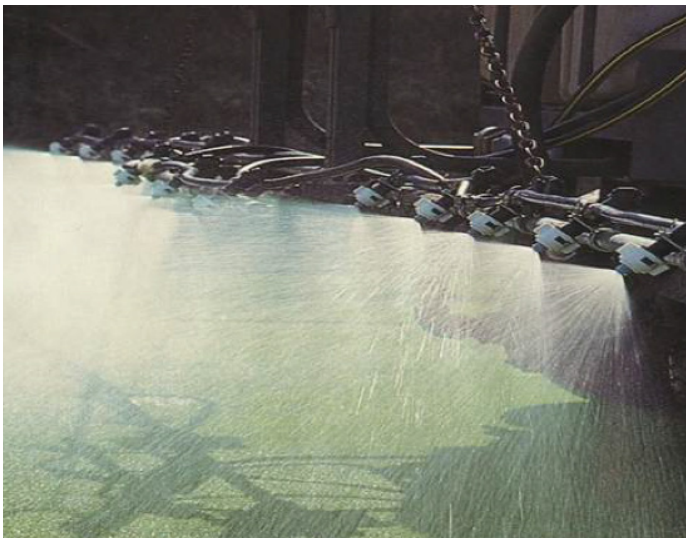

Photo courtesy of Brad Fresenburg, Ph.D.

Example:

Nozzle Test
Output collected from each nozzle after 46 seconds:
Nozzle 1 – 44 fluid ounces
Nozzle 2 – 45 fluid ounces
Nozzle 3 – 44 fluid ounces
Nozzle 4 – 45 fluid ounces
Nozzle 5 – 45 fluid ounces
Nozzle 6 – 44 fluid ounces
Nozzle 7 – 44 fluid ounces
Nozzle 8 – 46 fluid ounces

Total output from all nozzles: 357 fluid ounces

Determine average output for each nozzle:

$$\frac{\text{357 fluid ounces}}{\text{8 nozzles}} = \text{44.6 or 45 fluid ounces average nozzle output}$$

Remember:

$$\frac{\text{Sum of total fluid ounces}}{\text{Number of nozzles}} = \text{average nozzle output in fluid ounces}$$

Check that all nozzles are within 7 percent of the average nozzle output.

0.07 x 45 fluid ounces = 3.15

The acceptable range for nozzle output is between 41.9 to 48.2 fluid ounces. All of the nozzles in the example fall within the acceptable range. If they do not, clean or replace the nozzle tips and repeat this step.

The sprayer is now correctly calibrated. The average amount of water collected in fluid ounces equals the gallons applied per acre (GPA).

Example:
45 fluid ounces was the average nozzle output. Therefore, the sprayer is calibrated to deliver 45 gallons per acre.

Remember:
The concept of the 128th method is based on the time it takes to spray 128th of an acre with a single nozzle. That time requirement is then used to collect fluid ounces from a single nozzle. Since there are 128 fluid ounces in a gallon, the simple conversion or result is in gallons per acre (GPA).

Applying the Concept:

Liquid Formulation:
An herbicide label calls for 3.5 pints of product per acre. In the above example, it was determined that the sprayer was currently calibrated to deliver 45 gallons per acre. If the goal is to treat one acre, add a few gallons of water to the tank, then add the 3.5 pints of product required to treat an acre. Add water to bring the final tank volume to 45 gallons. If treating two acres, follow the same strategy, but add 7 pints of herbicide and bring the final tank volume to 90 gallons, and so forth.

Dry Formulation:
Some pesticides are dry formulations intended to be applied in suspension with a spraying system. Because of the formulation, there are a few more calculations required to determine the product amount. Wettable powders (WP) or water dispersible granules (WDG) are two common dry formulations used to deliver pesticides to athletic fields with a spray system.

Use the label to determine the amount of product required per area to be treated. For example:
The goal is to treat one acre with the labeled rate for a WDG fungicide of 3.2 dry ounces per 1000 square feet.

Determine how many dry ounces to apply per acre:

3.2 dry ounces x 43.56 = 139 dry ounces of the WDG formulation required per acre
(43.56 is the conversion factor to convert units per 1000 square feet to an acre basis)

Determine how many pounds to apply per acre:

$$\frac{\text{139 dry ounces}}{\text{16 ounces per pound}} = \text{8.7 pounds of WDG formulation required per acre}$$

As before, add a few gallons of water to the tank, add the 8.7 lbs of WDG formulation, and bring the final volume to 45 gallons in order to treat one acre as the sprayer is currently calibrated.

Tips for Product Application

Correct and accurate application of any fertilizer or pesticide product to a turfgrass area is essential to prevent damage to the turfgrass and prevent pollution of water sources. Use the following tips for accurate and safe applications with your sprayer:

- Read all product labels to ensure safe handling, proper application, and correct use rates. In addition, be sure to comply with all state and federal environmental regulations.
- Make sure the sprayer is in good operating condition. Review the Pre-Calibration Checklist before each fertilizer or pesticide application.
- Calibrate the sprayer every fourth application to ensure the sprayer and nozzles are still delivering the correct volume of product.
- Always stay a safe distance from water sources to prevent any possible pollution.
- Don't apply fertilizers or pesticides on windy days.
- Drive the sprayer at the same speed used during the calibration process to deliver an accurate amount of product.
- If using a dry formulation, ensure that the suspension is properly agitated to ensure accurate and uniform chemical delivery.
- Be sure to clean the sprayer thoroughly after applying fertilizer and pesticide products to prevent build up and corrosion on sprayer parts. Also, lubricate gears and other moving parts before storing.

Boom Sprayer Calibration Worksheet

Color-coded squares are meant to help in entering repeated numbers.

Key for color codes:

: travel distance of calibration run length measured in feet
: sum of seconds to travel calibration run length
: average time to travel calibration run length measured in seconds
: sum of fluid ounces collected from each nozzle
: average individual nozzle output measured in fluid ounces
: number used to determine acceptable range for nozzle output
: minimum number of fluid ounces that is acceptable from each nozzle
: maximum number of fluid ounces that is acceptable from each nozzle

Remember:

1 acre = 43,560 square feet
1/128th of an acre = 340.31 square feet
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Step 1: Determine the travel distance based on nozzle spacing.

Calibration distances for a known nozzle spacing.

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24	170
22	185
20	204
18	227
16	255
14	291

If nozzle spacing is not reflected on the table above, follow these steps:

Determine travel distance based on 128th of an acre.

$$\frac{4080}{\text{\_\_\_\_\_ inches (nozzle spacing)}} = \text{\_\_\_\_ feet (travel distance)}$$

Measure and flag _____ feet over terrain and turfgrass similar to that being sprayed.

Step 2: Determine the time it takes to travel the determined distance.

Run 1: _____ seconds
Run 2: _____ seconds
Run 3: _____ seconds
Run 4: _____ seconds

Total: _____ seconds

Determine average time:

$$\frac{\text{\_\_\_\_ seconds}}{\text{\_\_\_\_\_ runs}} = \text{\_\_\_\_ seconds}$$

Average Time: _____ seconds

Step 3: Measure nozzle output.

Using a stopwatch, collect water output from a single nozzle for the average time it took to travel the calibration run length.

Collect water output for _____ seconds

Amount collected from a single nozzle: _____ fluid ounces

Step 4: Determine uniformity of spray across the boom.

Output collected from each nozzle after _____ seconds:
Nozzle 1: _____ fluid ounces
Nozzle 2: _____ fluid ounces
Nozzle 3: _____ fluid ounces
Nozzle 4: _____ fluid ounces
Nozzle 5: _____ fluid ounces
Nozzle 6: _____ fluid ounces
Nozzle 7: _____ fluid ounces
Nozzle 8: _____ fluid ounces
Nozzle 9: _____ fluid ounces
Nozzle 10: _____ fluid ounces

Total output from all nozzles: _____ fluid ounces

Determine average output for each nozzle:

$$\frac{\text{\_\_\_\_ fluid ounces}}{\text{\_\_\_\_\_ nozzles}} = \text{\_\_\_\_ fluid ounces average nozzle output}$$

Average nozzle output: _____ fluid ounces

Check that all nozzles are within 7 percent of the average nozzle output by determining the range.

0.07 x _____ fluid ounces = _____ (range)

Minimum acceptable fluid ounces that can be collected from each nozzle:
_____ fluid ounces - _____ = _____ fluid ounces

Maximum acceptable fluid ounces that can be collected from each nozzle:
_____ fluid ounces + _____ = _____ fluid ounces

The acceptable range for individual nozzle output is between _____ fluid ounces to _____ fluid ounces.

Boom Sprayer Calibration

If a nozzle does not fall within the acceptable range, clean or replace the nozzle and repeat this step. Once nozzle output falls within the acceptable range, the sprayer is calibrated. Remember, the concept of the 128th method is based on the time it takes to spray 128th of an acre with a single nozzle. That time requirement is then used to collect fluid ounces from a single nozzle. Since there are 128 fluid ounces in a gallon, the simple conversion or result is in gallons per acre (GPA).

Average nozzle output: _____ fluid ounces is equal to _____ GPA
The sprayer is calibrated to deliver _____ gallons per acre.

References:
STMA Information Outreach Committee
University of Missouri – Don't forget to calibrate that sprayer… - http://turfpath.missouri.edu/reports/128%20Calibration.pdf
Texas Agricultural Extension Service – Sprayer Calibration for Turfgrass - http://publications.tamu.edu/TURF_LANDSCAPE/PUB_turf_Sprayer%20Calibration%20for%20Turfgrass.pdf
North Carolina State University – The Calibration of Turfgrass Boom Sprayers and Spreaders - http://www.turfgrass.ncsu.edu/Articles/admin/2008/Calibration_of_Turfgrass_Boom_Sprayers_and_Spreaders_(AG-628).pdf