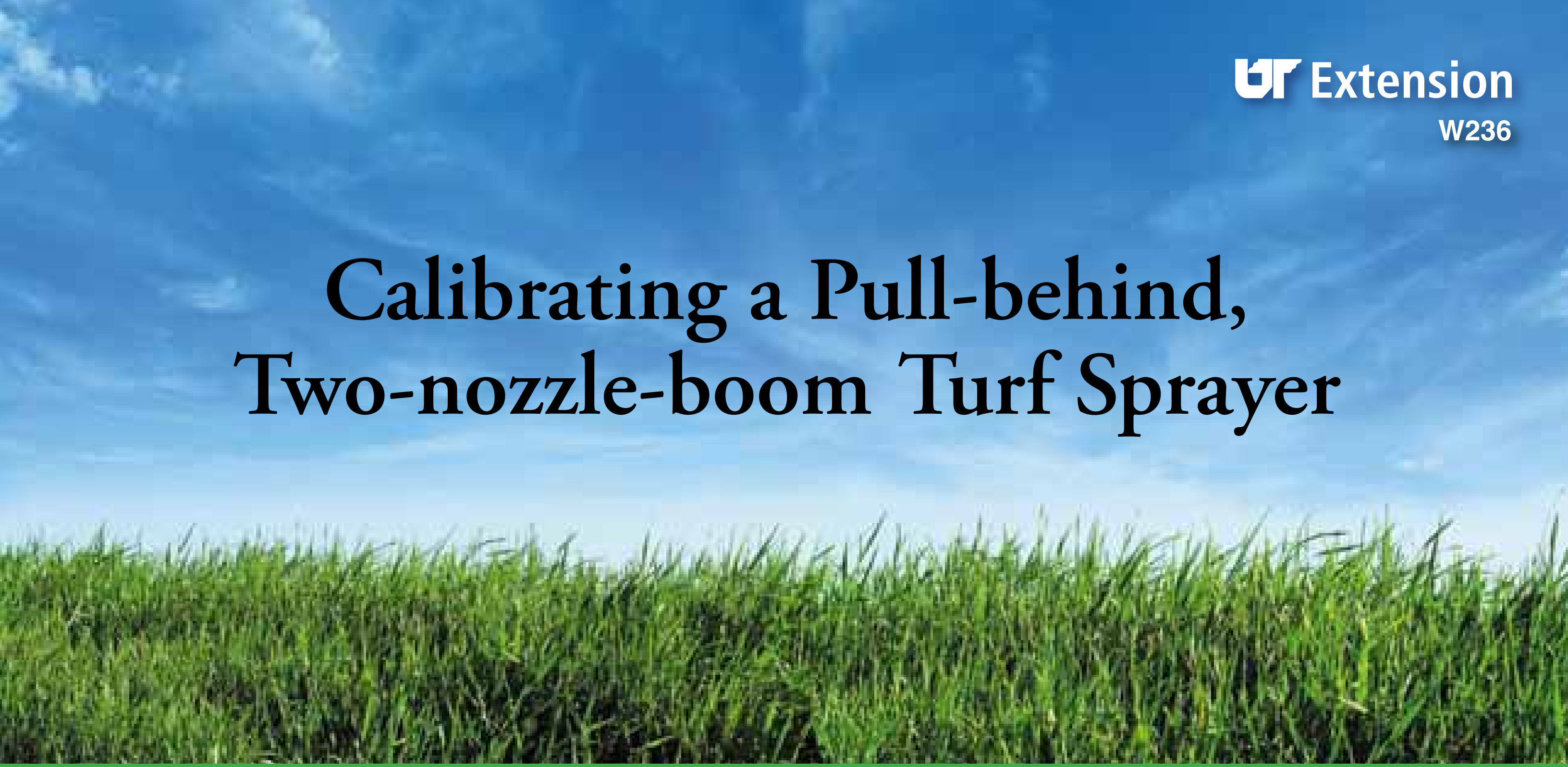

UT Extension
W236

Calibrating a Pull-behind, Two-nozzle-boom Turf Sprayer

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Pesticide and fertilizer solutions and suspensions[1] must be applied to turf uniformly, accurately and according to label directions. This publication is intended to provide a step-by-step guide to assist homeowners in calibrating a pull-behind, boom-type sprayer equipped with two nozzles. The calibration process involves area, time and volume.

Before adding a pesticide or fertilizer into the sprayer tank, the operator must know the volume of solution that will be applied per unit area, which is typically expressed as 1,000 square feet (ft.^{2}) of turf. The volume of pesticide or fertilizer solution applied depends on the amount of product and water added to the tank, the type of spray nozzle tips (spray tips), the number and spacing of nozzles on the boom, the sprayer operating pressure, and the speed of travel.

Part 1. Sprayer Parts and Operation

Spray Nozzle Tips

A spray nozzle is the last spraying system component the solution flows through before exiting the sprayer. A spray nozzle consists of a spray tip, strainer, cap and hollow nozzle body. The cap, which screws on to the nozzle body, holds the spray tip and strainer in place (Figure 1). Typically manufacturers equip new sprayers with appropriate spray tips for the intended use. Spray tips are engineered to disperse liquid in a specific pattern and within a

Figure 1. Spray nozzle tip and strainer are held in place by a nozzle body cap.

1 From this point, the term solution in this publication refers to both a homogeneous mixture of substances in liquid phase; for example, liquid particles in water (emulsion) or a suspension. Particles in suspension are larger than those found in solution and, without mechanical or hydraulic agitation, will settle out.

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recommended range of pressures. The rate at which the solution flows through the spray tip increases with increasing pressure. Spray tips used for boom-type, broadcast applications are designed to operate with pattern overlap from adjacent tips. Each spray tip manufacturer specifies the appropriate amount of spray overlap. Spray tip pattern overlap is dependent on boom height, and spray tip type, spacing and discharge angle.

Filtration and Tip Wear

Turf boom-type sprayers often come with a large basket-type screen (Figure 2) that fits directly into the tank filler opening. This screen is intended to keep debris out of the tank as water or product is being added. Before reaching the spray tips, the solution must flow

Figure 2. Basket-type screens prevent debris from entering sprayer tank during fill-up.

from the tank through an in-line strainer to the pump, and pass through the pressure control regulator and a second strainer inside the nozzle body. Another strainer may be installed on the pressure side of the pump, depending on the type of pump and valves installed on the sprayer. In-line strainers capture particulate matter that can damage pumps and valves, clog spray tips or restrict solution flow (Figure 3).

Figure 3. In-line strainers capture particulate matter that may clog tips or restrict solution flow and are plumbed between tank and positive-displacement pumps.

Some product formulations (e.g., wettable powders and fertilizer suspensions) may be abrasive and cause accelerated tip wear. Spray tips should be routinely monitored for wear. Replace worn tips when the flow rate at a particular operating pressure exceeds the flow rate of a new tip of similar size and type by 10 percent.

Sprayer Operating Pressure

The system operating pressure is typically measured using pressure gauges (dry or wet) or transducers (for electronic systems). The pressure gauge is usually mounted in a prominent location easily viewed by the sprayer operator (Figure 4). Spraying system pressure gauges should be full scale (approximately 1½ to 2 times the working pressure of the system) and may be filled with liquid

Figure 4. The main pressure gauge is most often located where it is easily viewed by the operator.

to reduce needle vibration due to pump pulsations. An adjustable pressure control regulator is most often located nearby. To ensure a uniform spray pattern and to minimize the potential for spray drift (off-target movement of the spray solution), the pressure at which the sprayer is operated must be within the spray-tip manufacturer's recommended operating range. When a sprayer is operated at a pressure below manufacturer's specifications, tips no longer produce the desired pattern and coverage is poor. Excessive pressure causes small droplets to form. Small droplets have a much greater potential to drift than large droplets. The pressure at the nozzle is the actual sprayer operating pressure, and may be slightly lower than that registered by the system pressure gauge. Depending on the type of spray tip installed, a pressure range (at the spray tip) of 10 to 30 pounds per square inch (psi) is usually appropriate for herbicides, while a range of 30 to 50 psi is most often appropriate for insecticides and fungicides. Although not intended to be used to make major changes in the rate at which a product is applied, operating pressure can be used to make minor adjustments in sprayer output.

Sprayer Tanks

The sprayer tank is usually mounted above the pump. This arrangement minimizes the energy required to move solution from the tank to the pump (Figure 5). Tanks should have a large filler opening equipped with a basket-type screen and must be vented to the atmosphere. They usually have a sight gauge that allows the operator to monitor solution levels inside the tank. A suction line

Figure 5. The spray tank is usually mounted above the pump to improve priming.

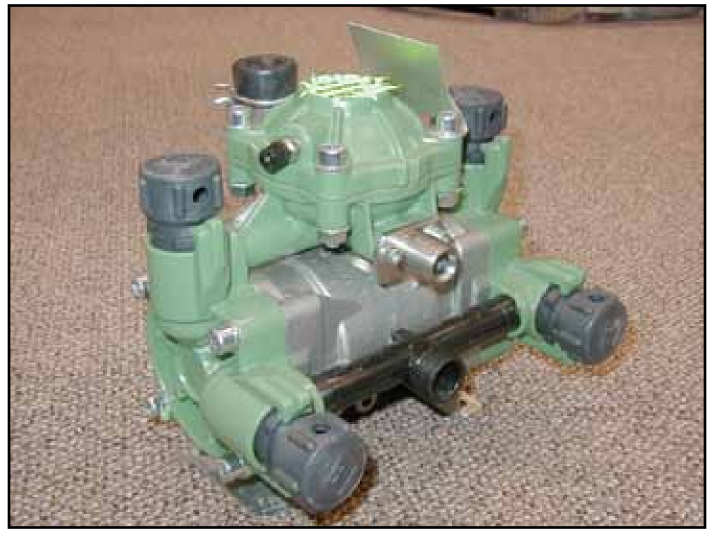

Figure 6. A diaphragm pump is classified as a positive-displacement pump with low-to-medium flow and medium-to-high pressure capacities.

Figure 7. Another type of positive-displacement pump is a piston pump, which has low flow and medium-to-high pressure capacities.

Figure 8. A roller pump is classified as a semi-positive displacement pump and is considered to have medium flow and pressure capacities.

(hose) from the pump input port is often connected to a small box (sump) located directly on the bottom of the tank. This set-up reduces the amount of solution remaining in the tank after the pump loses prime. Sprayer tanks are typically constructed from fiberglass, polymers, high-density polyethylene or stainless steel.

Sprayer Pumps

Pumps used to move solution from the tank to the spray tips are broadly classified as either positive or non-positive displacement. Output from a positive-displacement pump, such as a diaphragm (Figure 6), piston (Figure 7) and roller (Figure 8) pump, is directly proportional to the operating speed. Output from a positive-displacement pump is relatively independent of the sprayer operating pressure. The output from a non-positive-displacement pump, such as a centrifugal pump, is also dependent on operating speed, but is also influenced by operating pressure. Centrifugal pumps (Figure 9) are most often used to deliver large volumes of liquid at low-to-moderate pressure.

Figure 9. A centrifugal pump is classified as a non-positive displacement pump with medium-to-high flow and low-to-medium pressure capacities.

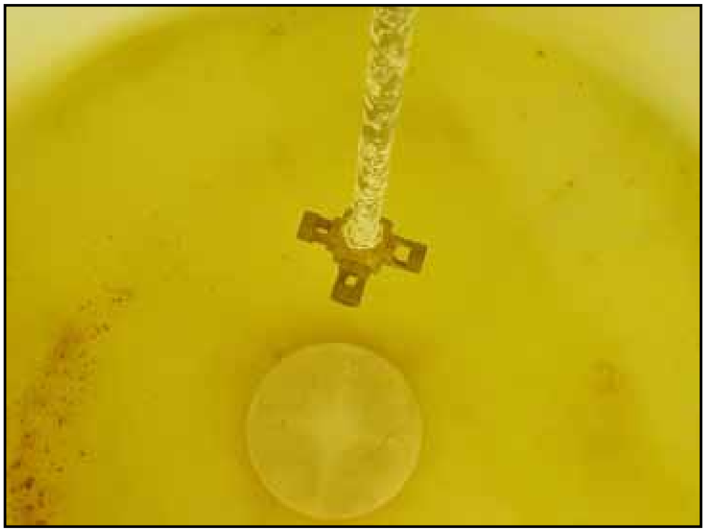

Figure 10. Hydraulic agitators stir solutions by re-circulating flow back to the tank.

Figure 11. A dry boom supports hoses that carry solution to the spray tips.

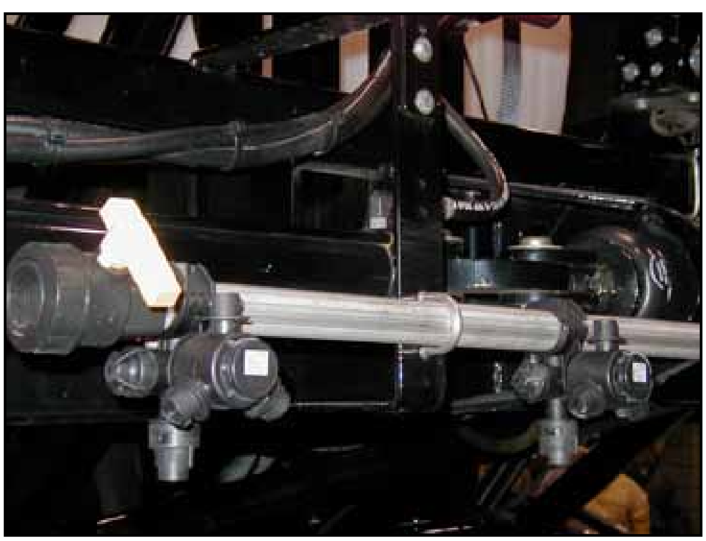

Figure 12. A wet boom is hollow and carries solution directly to spray tips.

Agitation of the Spray Solution or Suspension

Once added to the sprayer tank, products are constantly agitated or stirred either mechanically by the action of a moving paddle or hydraulically (sometimes referred to as jet or hydraulic agitation, Figure 10), as some of the solution reaching the main pressure manifold is directed back into the tank. The amount of stirring is dependent on the rotational speed of the mechanical agitator or the amount of solution returned to the tank through the agitator. Stirring of a product in solution or suspended in water is critically important, whether the sprayer is stationary or is moving across the turf. Too little stirring usually results in very poor product mixing, while too much stirring can cause excessive foaming.

Sprayer Booms

The boom of a turf sprayer may be classified as either dry or wet. As the name implies, dry booms support hoses that carry solution to the spray tips that are suspended above the turf (Figure 11). Wet booms (Figure 12) are hollow and carry solution to the spray tips that are mounted directly to them.

Sprayer Hoses

Sprayers use both suction- and pressure-type hoses to carry solution from the sprayer tank to the spray tips (Figure 13). A suction hose carries solution from the tank to the suction-side inlet of the pump. The inside diameter of the suction hose is at least as large as that of the pump inlet port. It is reinforced to prevent hose collapse, which results in flow restriction, cavitations and excessive pump wear.

A pressure hose carries solution under pressure either from the pump outlet to the boom, or back to the tank. Pressure hoses are selected on the basis of flow rate, length, operating pressure and chemical resistance. The greater the length of pressure hose, the more the resistance to solution flow and the greater the pressure drop between pump and spray tips.

Figure 13. Both suction- and pressure-type hoses are used on sprayers to deliver solution from the tank to the spray tips.

Figure 14. A variety of valve types are used on sprayers to control system pressure, flow direction and flow rates.

Figure 15. A pressure relief/regulating valve is a required component for sprayers equipped with positive displacement pumps.

Figure 16. A manual throttling valve is usually located between the pump and jet agitator, mounted inside the tank, providing independent control of the amount of hydraulic agitation.

Pressure and Flow Control Valves

A variety of valve types are used to control the sprayer operating pressure and the direction and rate of flow (Figure 14). A pressure relief/regulating valve (Figure 15) is a required component for a sprayer equipped with a positive-displacement pump. This valve allows the operator to regulate, or adjust, the operating pressure by directing excess pump flow back to the tank. This prevents the flow from the pump from being completely blocked off. The placement and sizing of a pressure relief/regulating valve are essential for the safe and accurate operation of a sprayer.

A manual throttling valve on the main output hose is typically used to control flow for a non-positive-displacement pump. A second manual throttling valve (Figure 16) may be located between the pump and jet agitator, which is mounted inside the tank. This valve allows for independent control of the amount of hydraulic agitation.

Other types of flow control valves include ball; plunger; and multi-section, boom-control (TeeValve) valves. These valves can be operated manually or can be purchased with electrical controls (e.g., electric ball and electric solenoid).

Speed of Travel

To apply a turf care product according to the label rate, the operator must know the speed at which the sprayer is traveling across turf. With a given solution output or flow rate, changing speeds can substantially change the product application rate. At a fixed sprayer travel speed, changing flow by installing different spray tips or increasing the sprayer operating pressure will vary the application rate. A spray tip rated for a specific flow rate in gallons per minute (gpm), or gallons per acre (gpa), will apply that rate only under very specific conditions [e.g., a speed of 4 miles per hour (mph), a pressure of 30 psi, and a spray tip spacing of 20 inches (in.)]. Since some sprayers and lawn tractors use speed-measuring devices that are based on gear selection and/or the actual rotational speed of drive wheels, speed readings may be inaccurate due to wheel slippage, worn tires or excessively low or high tire pressures. It is always best to precisely determine the speed of travel through a sprayer calibration course of measured length.

Part 2. Calibrating the Sprayer

The trailer-mounted turf sprayer (Fimco Industries, North Sioux City, South Dakota, Figure 17) used in this calibration demonstration has the following features.

Sprayer tank:	15 gal. polyethylene with full length drain sump
Pump:	12-volt (demand) diaphragm pump with an operating pressure range of 0 to 60 psi and output capacity of 2.1 gpm
Boom:	Dry; with two flood jet nozzles
Spray tip spacing on boom:	40 in.
Boom height:	18.25 in. from surface to tips
Spray tips:	Polymer, flood jets

A 10-Step Calibration Procedure

Figure 17. The lawn tractor and pull-behind turf sprayer used in this calibration demonstration.

1. Perform a pre-calibration check, inspecting all sprayer components and correcting obvious problems (e.g., hose cracks, loose fittings, improper or unmatched tips) before filling the tank.

   a. Remove and clean all spray tips and strainers. It may be necessary to soak spray tips and screens in soapy water or a dilute ammonia solution for several minutes. A toothbrush or a wooden toothpick can be used to clean clogged nozzles without damaging the nozzle opening(s) or screens. Do not use metal objects such as pocket knives or wire brushes to clean spray tips, since they can damage screens and alter the size of the screen openings.

   b. Rinse and fill the sprayer tank with clean water.

   c. Start the sprayer and flush all hoses and spray tips with plenty (e.g., 5 gal.) of water.

   d. Replace strainers and spray tips, making sure that all tips are of the same type and capacity, and that each is properly aligned.

   e. With spray tips and strainers installed, and the spray boom at the proper height (e.g., the distance from the base of the tips to the soil surface on this demonstration sprayer was 18.25 in.), turn the pump on and check all connections for leaks.

   f. Adjust the pressure relief/regulating valve to deliver an appropriate operating pressure (for this demonstration, the sprayer operating pressure was set at 21 psi) and check all components again, verifying that each is operating properly.

   g. Determine pattern uniformity and spray nozzle wear. Before conducting this step, many sprayer operators prefer to move the sprayer to an impervious surface. With the spray boom turned on, observe spray tip discharge pattern uniformity. Collect the output from each spray tip for a specific amount of time and compare it to the manufacturer's published flow rate. If the collected output varies more than 10 percent and/or discharge patterns are not uniform, replace the spray tips with new ones.

   h. Turn the sprayer off.

Figure 18. Determining the total width of the boom spray pattern.

2. Determine the total width of the boom spray pattern (Figure 18).

In this example, the total width of the boom spray pattern is 2 nozzles x 40 in. = 80 in. or 80 in. divided by 12 in. per foot (ft.) = 6.6 ft.

3. Determine the appropriate length of the calibration course.

In this example, the calibration course will have a total area of 1,000 ft.^{2}. Since the total width of the boom spray pattern is 6.6 ft., and the area of the calibration course will be 1,000 ft.^{2}, the length of the calibration course is 1,000 ft.^{2} divided by 6.6 ft. = 151 ft. long.

4. Using a measuring tape and markers (e.g., flags, stakes, cones, etc.), lay out the calibration course (Figure 19). The course should be located on turf rather than driveways and sidewalks.

In this example, wire flags were installed in all four corners of the calibration course and were spaced 25 ft. apart along each side to assist the operator in maneuvering the sprayer through the course in a straight line.

5. Determine the speed of travel of the tractor + sprayer.

Figure 19. Measuring and marking the calibration course.

Figure 20. Recording the amount of time required for the tractor and attached sprayer to move through the calibration area.

Figure 21. Collecting the amount of water from one tip for the amount of time in seconds required to complete the calibration course.

Figure 22. Measuring the amount of water collected from one tip for the amount of time in seconds required to complete the calibration course.

a. Record the amount of time required for the tractor (with sprayer attached) to move linearly, from one end of the calibration area to the other (Figure 20). To improve the accuracy of this measurement, this step should be repeated at least three more times. The measured time to complete the course should then be averaged over the total number of passes.

In this example, pass 1 required 35 seconds (sec.), pass 2 required 35 sec., pass 3 required 35 sec. and pass 4 required 35 sec.

The average time (in sec.) required to complete the 151-ft.-long course was (35 + 35 + 35 + 35) divided by 4 = 140 sec./4 passes = 35 sec.

b. Calculate the number of ft. the tractor + sprayer move per sec.

Since the tractor + sprayer traveled 151 ft. linearly in 35 sec., the tractor + sprayer move at a speed of 151 ft. divided by 35 sec. = 4.3 ft. per sec. or 2.9 mph (1 ft. per sec. = 0.682 mph).

6. Turn the sprayer on.

7. Determine the flow rate of the spray tips.

Collect and measure the amount of water from one tip for the average amount of time in sec. recorded in Step 5a (Figures 21 and 22). This step should be repeated at least three times to improve the measurement precision.

Individual tip output was very consistent in this example, as 1,000 milliliters (mL) of water were collected in 35 sec. the first, second, third and fourth time water was collected. Individual tip output per 1,000 ft.^{2} = 1,000 mL in 35 sec.

8. Turn the sprayer off.

9. Determine the total boom output in gal. per 1,000 ft^2.

To convert the volume measured in ml. to gal., divide the number of ml. from one tip (1,000 mL in this demonstration) by 3,785 (3,785 ml. = 1 U.S. gallon, gal.). In this demonstration, the output of each tip on the boom is 0.26 gal. (1,000 mL/3,785 mL per gal. = 0.26 gal.) in 35 sec.

Since the boom is equipped with two nozzles and an individual nozzle applies 0.26 gal. in 35 sec., the total boom output equals 0.26 gal. x 2 = 0.52 gal. Therefore, the application rate through the two-nozzle boom is 0.52 gal. per 1,000 ft.^{2} of coverage.

10. Review calculations to insure that the predicted sprayer output is correct before adding an appropriate amount of product and water to the tank.

In summary for this example, the output of the two-nozzle-boom sprayer at an operating pressure of 21 psi and a traveling speed of 2.9 mph is 0.52 gal. per 1,000 ft.^{2}.

Determining How Much Water and Product to Add to the Sprayer Tank.

Once the sprayer output has been determined, an appropriate amount of water and product can be added to the sprayer tank.

Helpful conversions when calculating how much liquid to add to the sprayer tank are:

1 gal. = 128 fl. oz.; 1 qt. = 32 oz.; 1 liter = 33.8 fl. oz.; 1 pt. = 16 oz. and 1 acre = 43,560 ft.^{2}

Again, when travelling at 2.9 mph and operating at a pressure of 21 psi, this sprayer is now calibrated to deliver 0.52 gal. of spray solution per 1,000 ft.^{2}. When the sprayer tank is completely full (sprayer tank capacity of 15 gal. of spray solution), the sprayer used in this demonstration can treat a total of 28,846 ft.^{2} (15 gal. divided by 0.52 gal. per 1,000 ft.^{2} = 28.846 x 1,000 ft.^{2} = 28,846 ft.^{2}) or approximately 2/3 acre (28,846 ft.^{2} divided by 43,560 ft.^{2} per acre = 0.67 acre).

Example 1. If the label states that the application rate of a selected herbicide is 32 oz. product per acre, or 0.75 oz. product per 1,000 ft.^{2}, and the sprayer operator intends to fill the tank to capacity and treat a total of 2/3 acre (0.67 acre) of turf with herbicide solution, 21.3 oz. (2/3 x 32 oz. = 21.3 oz.) of product would be added to the sprayer tank, along with 14 gal. 106.7 oz. of water.

Example 2. If the sprayer operator intends to treat only 10,000 ft.^{2} of turf with herbicide solution, much less product and water would be added to the sprayer tank than in the previous example. Since the sprayer output in this demonstration is 0.52 gal., or 66.6 oz. of spray solution per 1,000 ft.^{2}, a total of 5.2 gal. (0.52 gal. per 1,000 ft.^{2} x 10 = 5.2 gal.), or 666 oz. of spray solution must be prepared. Since the labeled application rate of the selected herbicide is 0.75 oz. product per 1,000 ft.^{2}, and 10,000 ft.^{2} of turf will be treated, 7.5 oz. of product (0.75 oz. per 1,000 ft.^{2} x 10 = 7.5 oz.) will be added to the sprayer tank along with 658.5 oz. (666 oz. – 7.5 oz. = 658.5 oz.) or 5 gal. 18.5 oz. of water.

Once calibrated, attention to detail before, during and after operating a sprayer like the one used in this example will help ensure the accurate application and effectiveness of lawn care products. Performing timely and preventative maintenance usually extends the life of a sprayer. It is especially important to keep the filters clean, release the system pressure when spraying is complete and avoid consistently operating the sprayer at full capacity (e.g., high rate of speed and pressure). Fertilizer and pesticide residues can build up quickly, clogging filters, limiting solution flow to and from the pump, and damaging spray tips. After each use, rinse the spraying system with clean water and/or an appropriate solvent, according to product label directions and pesticide laws.

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