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Calibrating Combination Boom/Boomless Sprayers

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Introduction

Sprayer technology in forage and pasture systems has evolved quickly in recent years. Traditional boom sprayers with evenly spaced nozzles, while common in row-crop agriculture, are often impractical in the rougher terrain where much of Arkansas cattle and hay production occurs. In these systems, cluster or boomless nozzles have been far more common. Boomless nozzles let you spray broad swaths in pastures while keeping sensitive components (i.e., nozzles and plumbing) safely tucked behind the tractor or sprayer chassis. That protection comes at a cost; boomless nozzles often sacrifice application uniformity and product coverage compared with closer-to-target, evenly spaced boom nozzles.

A third option—one that has become increasingly popular—keeps most benefits of both systems. Hybrid (or combination) sprayers consist of a narrow boom, roughly the width of or just slightly wider than the tractor or sprayer chassis and typically narrower than the gates the sprayer will travel through. On each end of this boom are fence-row or extender nozzles (Figure 1), a modern version of boomless cluster nozzles. When set up and calibrated correctly, these "boom extenders" overlap the last boom nozzle, spray 8–15 ft beyond it, deliver the same volume of product, and more closely match the droplet size and coverage of the boom nozzles than traditional boomless nozzles do. The key, however, is getting that setup and calibration right—a bigger challenge than with either system alone. This factsheet serves as a practical guide to correctly calibrating hybrid boom/boomless sprayers and offers suggestions for situations when calibration is not possible with your current nozzle setup.

Figure 1. Example fence-row or extender nozzles. From left to right , Boom Buster roadside nozzle, Hypro Boom X-Tender, TeeJet XP BoomJet, and Udor Boominator.

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Initial considerations

One of the simplest ways to approach this process is to recognize that you are essentially calibrating two separate sprayers. Calibrate the boom nozzles first as a standalone boom sprayer and carefully record the settings. Then calibrate the "boomless system" (both extender nozzles together) as a separate boomless sprayer, using several measurements from the boom calibration. As an example, both systems are on the same chassis, so they share the same travel speed. In many cases there are no separate valves or regulators for the boomless side; once you set pressure for the boom, that same pressure is shared and therefore controls flow to the extender nozzles as well.

With this in mind, the following sections walk through the steps and special considerations for matching the two systems, so they deliver the same output volume. For greater detail on calibrating each system individually, consult University of Arkansas Division of Agriculture fact sheets FSA2212 "Calibrating Boom Sprayers" and FSA2197 "Calibrating Single Nozzle Boom-less Sprayers". Those publications cover the specific measurements needed for each type. Here we focus on how to optimize the two systems together, so they produce matching gallons per acre (GPA). As with any sprayer calibration, this requires measuring equipment speed, nozzle spacing (boom) or swath width (boomless), and nozzle flow rate.

Equipment Speed

Both the boom and boomless systems share the same equipment speed, so a single accurate measurement serves both calibrations. Many tractor speedometers are not precise enough for spray calibration, so they should be used with caution.

Verify your actual speed using one of these reliable methods: a GPS guidance system, a smartphone speedometer app, or by measuring a known distance, timing how long it takes to travel it, and calculating speed from those values. Detailed explanations of each method are provided in the University of Arkansas Division of Agriculture fact sheets FSA2212 "Calibrating Boom Sprayers" and FSA2197 "Calibrating Single Nozzle Boom-less Sprayers." Use at least one of these methods to confirm your tractor speed before performing calibration calculations and setting application rates.

Nozzle Output

Accurately measuring the output or flow rate from each spray nozzle is essential for proper sprayer calibration. To perform a catch test, you will need a stopwatch and a container large enough to collect the flow from a single nozzle for 30–60 seconds. A graduated quart container (marked in ounces or milliliters) works well for most boom nozzles. However, boomless extender nozzles often deliver 1–5 gallons per minute or more, so you may need to catch the output in a 5-gallon bucket and then measure the volume in a smaller graduated container for accuracy.

Perform all catch tests using clean water only. Before testing, make sure all screens, strainers, and filters are clean and free of obstructions, so every nozzle delivers a uniform flow rate. With water in the tank, engage the pump, set the tractor to the desired RPM, turn the nozzles on, and adjust the pressure to match the nozzle manufacturer's recommendation. Observe each nozzle pattern for irregularities and correct any problems before measuring flow.

Important pressure note

Most boom nozzles operate well at lower pressures, but boom extender (fence-row) nozzles typically require a minimum of 30 psi and perform best at 40 psi. Operating below these pressures produces narrow, poorly developed patterns that are too coarse for good coverage. Detailed instructions for performing catch tests on boom nozzles versus boom-less extender nozzles are provided in University of Arkansas Division of Agriculture fact sheets FSA2212 and FSA2197.

After testing

- All nozzles on the boom should have flow rates within 10% of the boom average.
- The two extender nozzles should produce nearly identical output to each other.

Record each nozzle's flow rate. This helps you calculate the average and quickly identify any nozzles on the boom that fall outside the 10% range. Attempt to make the extender nozzles' flow rates as close as possible.

Troubleshooting Flow

- If a boom nozzle flows more than 10% below the average, verify it is the correct nozzle size and check for obstructions.
- If a boom nozzle flows more than 10% above the average, confirm it matches the size of the others.
- If the two extender nozzles do not match each other, inspect for kinked hoses, restrictive fittings, different filter sizes, or clogged screens.

Nozzle Spacing (Boom) and Swath Width (Extender Nozzles)

Consistent overlap between boom nozzles and proper overlap between the extender nozzles (and between passes) is critical for uniform pesticide application. As detailed in UA fact sheet FSA2197 "Calibrating Single Nozzle Boom-less Sprayers," a common starting point for most boomless nozzles is to take 70% of the total (observed) swath width. This allows for a 30% overlap between passes and is often a safe minimum for extender nozzles in hybrid systems as well. However, in hybrid setups we frequently reduce the effective swath width even further. This is the primary adjustment used to match application volumes (GPA) between the boom and the extender nozzles. Total system swath width is calculated by simply combining the total boom width with the effective swath width of both extenders.

Boom Nozzle Spacing

Measure the distance from the center of one nozzle to the center of the adjacent nozzle in inches (Figure 2). Although this measurement is usually straightforward, spacing is often inconsistent across the boom. Correct any large deviations before mixing or applying pesticides.

Extender Nozzle Swath Width

Determining the effective swath width for the pair of extender nozzles is more involved. First, understand the difference between total swath width and effective swath width.

Figure 2. Catch test on a boom nozzle using a catch container.

- **Total swath width** is the full distance droplets are thrown to either side of the nozzle and is often the width listed by the manufacturer.
- **Effective swath width** is the portion of the total swath used in calculations after accounting for the necessary overlap between passes to ensure good coverage. A safe effective swath width is 70% or less of the total (observed) swath width.

Important clarification: Reducing the effective swath width is done only in the calibration calculations — it does not require physically repositioning or re-angling the nozzles to shorten their actual spray pattern.

Determining Nozzle Heights

Nozzle heights are not used in calculating application volume or mixing ratios, but spraying at the recommended height is critical for uniform pesticide applications. In hybrid systems, the optimal nozzle heights for the boom and extender nozzles are usually different.

Boom Nozzle Height

Boom nozzle height depends on nozzle spacing and the nozzle's spray pattern (fan angle). Most modern broadcast nozzles used on booms are tapered flat-fan nozzles. These deliver more spray near the center of the pattern that

gradually tapers toward the edges. Uniform coverage is achieved by overlapping adjacent patterns, so the heavy center of one nozzle compensates for the lighter edges of the next.

A practical way to set proper boom height and overlap is to position the boom so the center of one nozzle's pattern just meets the outer edge of the adjacent nozzle's pattern (see Figure 3). For 20-inch nozzle spacing, this typically results in a boom height of 20–24 inches for 110° nozzles and 28–32 inches for 80° nozzles.

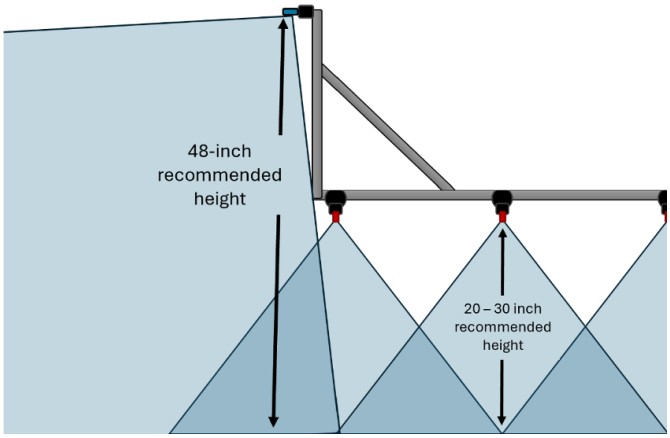

Figure 3. When setting nozzle heights in hybrid boom/extender systems, it is important to note the recommended height for each separately. Most extender nozzles should be approximately 48 inches above the application target, and boom nozzles should be mounted between 20 and 30 inches above the application target depending on nozzle fan angle.

Extender Nozzle Height

Extender nozzles have a manufacturer-recommended height that is commonly 48 inches above the target. This extra height gives droplets more time to travel horizontally and fully develop the desired swath width. Mount the extender nozzles as close as practically possible to this recommended height.

Why Separate Mounting Is Needed

Because the recommended heights differ, mounting extender nozzles directly on the boom forces a compromise: either the boom sits too low (greatly reducing the extender's effective swath) or too high (dramatically increasing drift potential). Proper separate mounting, as shown in Figure 3, is essential for good drift mitigation and for maximizing the hybrid system's overall spray swath.

Calculating Matching GPA

Once you have determined equipment speed, nozzle output (flow rate), and nozzle spacing or effective swath width, you can calculate application volume in gallons per acre (GPA). Higher spray volumes generally provide better coverage and improved product performance. For hybrid boom/extender systems, a minimum of 15 GPA is recommended; higher volumes may be needed for optimal results.

Use the formulas shown in Figure 4 to calculate GPA for each system. The only difference between the two formulas is the units for nozzle spacing versus effective swath width (inches for boom nozzles, feet for extender nozzles). This affects the constant in the formula and is done purely for measurement convenience. Always use the correct constant that matches your units.

Calculating Boom GPA

MPH = miles per hour
GPM = gallons per minute
W = nozzle spacing (in.)
GPA = gallons per acre
5940 = constant

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

Calculating Extender GPA

MPH = miles per hour
GPM = gallons per minute
W = effective swath in ft.
GPA = gallons per acre
495 = constant

$$GPA = \frac{(GPM \times 495)}{(MPH \times W)}$$

Figure 4. Calculating GPA output for boom nozzles and extender nozzles.

When calibrating the extender nozzles, it is important to remember that the formula is asking for the individual nozzle values (One extender nozzle's output (GPM), speed (MPH), and width (ft.)). The individual nozzle values should be nearly identical. If not, make adjustments as described above, but for calculation purposes, simply use a single nozzle's measurements for determining extender nozzle GPA.

The resulting GPA for each nozzle system represents the volume applied per acre when speed, nozzle output, and spacing/swath width remain constant. After calculating both systems independently, the GPA values often do not match. The goal is then to make practical adjustments, so both systems deliver the same GPA.

Adjustment Options

- **Speed** cannot be changed independently because both systems are mounted on the same chassis.
- **Nozzle output (pressure/flow):** In some setups the boom and extender nozzles have separate regulators or valves. If so, you can adjust boom pressure slightly to change its GPA. Do not exceed the nozzle manufacturer's recommended pressure range—high pressures increase drift, while pressures below 20 psi often cause poor boom nozzle patterns. After any pressure change, re-measure nozzle output and recalculate GPA. If both systems share the same pump and have no separate controls, pressure adjustments will affect both sides equally and usually will not help.
- **Effective swath width (extenders):** This is the most practical and effective adjustment for hybrid systems. Nozzle spacing on the boom is difficult to change, but you can easily modify the effective swath width used in calculations for the extender nozzles. Reducing the effective swath width increases the calculated GPA and also increases overlap between passes, which improves uniformity and reduces the risk of skips. You can safely reduce it below the standard 70% of total observed swath. Increasing effective swath width is possible but should not exceed 70% of the total observed swath, as wider settings risk skips or streaks, especially in marginal wind conditions.

Example Adjustment

Suppose your boom system calibrates at 15 GPA. For the extender nozzles, you measure an observed swath of 16.5 ft per side. Using the common 70% rule gives an effective swath of about 11.5 ft per side. With a travel speed of 5 mph and 1.5 GPM per extender nozzle, the calculated GPA is only 13—two gallons short of the boom.

Because a single line from the pump feeds both the boom and extenders, independent flow adjustments are not possible. The best solution is to reduce the effective swath width used in calculations (increasing overlap). After testing 11 ft, 10.5 ft, and then 10 ft, you find that a 10 ft effective swath per side delivers exactly 15 GPA. No changes to flow or speed were needed.

The total system swath width is then simply the boom width plus the effective swath of both extenders (boom width + 10 ft + 10 ft). Both systems now apply a uniform 15 GPA when operated at the calibrated pressure, speed, and effective swath width. Using a GPS guidance system makes this easiest—you can simply program the total calibrated swath width into the display.

It is worth noting that some sprayers on initial calibration have nozzles that cannot be calibrated with matching volume. In this case either the boom or the extender nozzles will need to be replaced with a different size. Contact your local county extension office for assistance in the proper sizing of these nozzles.

How Much Product to Add to the Sprayer Tank?

Once both systems are calibrated to deliver the same application volume, it is time to calculate the tank mix. Assume the sprayer is calibrated to 15 gallons per acre (GPA) and the tank holds 150 gallons (Figure 5). Divide the tank volume by the GPA to find the acres covered by one full tank: 150 gallons ÷ 15 GPA = 10 acres per tank.

Next, check the product label or contact your county extension office for the recommended rate per acre. In this example, the rate is 1 quart per acre. Multiply the acres per tank by the product rate per acre: 10 acres × 1 quart per acre = 10 quarts of product to add to the tank. Fill the tank with water, add the measured product (and any other tank-mix partners), agitate thoroughly, and you are ready to spray. Always follow the label for proper mixing order and any restrictions.

Calculating Mix

1. $\frac{\textit{Tank Volume}}{\textit{Sprayer Output}} = \textit{ac./tank}$ **Ex.** $\frac{150\ \textit{gal.}}{15\ \textit{GPA}} = 10\ \textit{ac./tank}$
2. *(ac./tank) × (rate/ac.) = product per tank*
   Ex. 10 *ac./tank* × 1 *qt./ac.* = 10 *qt. per tank*
3. Mix water and product.
   Ex. 150 gal of water with 10 qt. of product.

Figure 5. Calculating pesticide mixes using calibrated GPA output.

Conclusion

Hybrid boom/extender spray systems combine the best features of traditional boom and boomless nozzles. They are becoming increasingly popular in Arkansas forage and hay production because they offer good coverage while protecting sensitive components in rough terrain.

Proper calibration is especially important with these more complex setups to achieve accurate, uniform applications and successful pest control. Once you have completed the initial calibration and recorded your settings (speed, pressure, nozzle outputs, effective swath widths, and total system swath), future checks become much simpler.

Perform a full calibration check at least once per season and anytime you change nozzles, pressure, speed, or the intended application volume. Regularly inspect hoses, tanks, connections, and nozzles for leaks, obstructions, or worn parts. Always conduct these checks using only clean water in the tank — it is far safer and less expensive to correct problems before adding pesticide.

When calibrated correctly, hybrid systems deliver consistent gallons-per-acre across the entire swath, reduce the risk of under- or over-application, and help you get the most from every pass. Take a few minutes to document your final calibrated settings so you (or another operator) can quickly return to them. Accurate calibration is one of the simplest ways to improve product performance and protect your forage, hay, and bottom line.

References

Davis, J. A. (2024). Calibrating boom sprayers (FSA2212). University of Arkansas System Division of Agriculture. https://www.uaex.uada.edu/publications/pdf/FSA2212.pdf

Davis, J. A. (2021). Calibrating single nozzle boom-less sprayers (FSA2197). University of Arkansas System Division of Agriculture. https://www.uaex.uada.edu/publications/PDF/FSA2197.pdf

Hybrid Boom-extender Sprayer: Calibration Worksheet

Tractor Range: _____ Gear: _____ RPM: _____

Equipment Speed: _____ *Sprayer pressure (PSI):* _____

Boom Nozzle Output (GPM): _____ Extender Nozzle Output (GPM): L _____ R_____

Nozzle Spacing (in.): _____ Extender Observed Width (ft): L _____ R_____

Extender Effective Width (ft): L _____ R_____

Boom gallons per acre (GPA): _____ Extender gallons per acre (GPA): _____

Mix = _____ gallons of water and _____ product per tank.

Simplified Steps for calibrating a hybrid boom-extender sprayer:

1. Calibrate the boom sprayer for 15 or more GPA by measuring speed, nozzle flow, and nozzle spacing and using the provided calibration formula.
2. Calibrate the boomless sprayer using the same pressure and speed as the boom.
3. The effective swath width should be approximately 70% or less of the observed total swath.
4. If the boom and the extender nozzles GPA do not match and there are separate regulator valves controlling each system
   - Adjust regulators accordingly
   - Recatch flow rates for adjusted system
   - Recalculate GPA for adjusted system
   - Repeat until values match or pressures are outside of manufacturer recommended range.
     - Boom nozzles vary by design but should be between 20 and 60 psi
     - Extender nozzles should remain between 30 and 45 psi
5. If flow is all on one hose and regulator, recompute effective swath for extender nozzles.
6. If the extender nozzle GPA is too high, increase the effective width (up to 70%) and recalculate.
7. If the extender nozzle GPA is too low, decrease the effective width and recalculate.
8. If no practical effective spray swath is found (calculated GPAs for systems too far apart), replace one set of nozzles to achieve a minimum 15 GPA for both systems.

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