2016 Spring Ranchers' Forum

Boom Sprayer Calibration Notes

Mark Warren, Agriculture Agent
UF/ IFAS Extension Flagler & Putnam Counties

*Agriculture is the **Science** and **Art** of producing plants and animals beneficial to mankind.*

Science/ Math

What is calibration?

- In terms of agricultural applications, calibration is the process of measuring and adjusting application equipment to deliver a defined quantity of product to a defined area. E.g. gallons/ acre, pounds/ 1000 ft^2

Why calibrate?

- Pesticides are expensive
- Too much is illegal & potentially damaging to crops and environment
- Too little doesn't get the job done

It is estimated that >60% of all agricultural application equipment has a calibration error greater than 10%

What factors cause calibration errors?

- Equipment performance (obstructed or worn nozzles/ screens/ pumps, design features, improper adjustment)
- Operator error (improper speed, poor operation patterns, carelessness to settings, equipment proficiency)

Operators should be well trained and familiar with application equipment prior to activity to ensure safe accurate applications.

In addition to basic operation skills. Applicators need to be aware and trained in basic pesticide safety and take into account important variables such as wind speed/ direction, chemical risks, and potential non-target impacts.

- Use hand throttle to set RPMs and choose the right gear to start with.
- Hydrostatic equipment needs to have stop blocks in-place.
- Groundspeed has the greatest effect on sprayer output.
- Proper agitation is important with many products
- Equipment should be in sound working order.

The four variables required to properly calibrate a broadcast sprayer are operating pressure, swath width, equipment speed, and nozzle flow rate (output/ minute.)

The result will be rate/ area (gallons per acre).

- Boom sprayer calibration is fairly straight forward; distribution patterns and swath width are easily calculated as part of the process without the need for manufacturer guides.
- Boom-less sprayers have some of the same challenges associated with granular spreaders in relation to effective swath width and recommended overlaps. Manufacturer guides **are** important.
- Since most sprayers being used on farms are boom sprayers, this will be the focus of this demonstration.

How to measure equipment speed?

- Don't rely on speed charts or even speedometers to determine speed. They are typically wrong.
- First, determine a comfortable operating speed based on field conditions and operator preferences.
    - If necessary drive the equipment through the area to be treated (booms out, tank full of water)
        - Do this at proper engine RPM (typically 540 RPM)
        - Note safe comfortable gear selection
    - This is also a good time to think about driving patterns
    - In pastures with numerous obstacles or uneven terrain (trees, fences, mineral boxes…), slower speeds may be needed for wider booms.
- Do this first, to avoid making decisions that may compromise comfort and safety

Once the proper gear selection is made:

- Layout a 200' driving course (two survey flags along a long driveway will work) and drive in the selected gear at 540 RPM.
    - Do this a couple of times from a rolling start and record time.

RPM:		Gear:			
Test #	Distance (ft.)	Time (sec.)			Speed (MPH)
1					
2					
3					

- Calculate speed using the following formula.
    - 88ft./ minute equals 1 MPH

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

- **Example**

$$\frac{200\ ft \times 60}{34\ sec.\ \times 88} = \boxed{4\ \text{MPH}}$$

Evaluate nozzle performance and output

- Nozzle performance is closely connected to operating pressure. Operating pressures will affect output.
- Follow manufacturer recommendations to properly adjust pressure at 540 RPM.
- Using a stop watch and measuring device, collect and record the output of each nozzle for a predetermined period of time (15 sec.).

Time Interval: 15 sec.						Nozzle #: TJ 8004							Date: 10/2/15				
Tip # (L-R)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Avg.	+/- 10%
Output (oz.) **Example:**	12	12	13	15	14	14	12	15	15	14	11	16				13.6	12.2 15.0
Corrected:	12	12	13	15	14	14	12	15	15	14	14	14				13.6	
Output (oz./ min.)																	

- Replace any nozzles that do not meet 10% margin criteria.

Calculate combined output (gals./ minute)

- Add together measured values or multiply the calculated average by the number of nozzles.
- Be sure to adjust for collection time interval.
    - **Example:**

13.6 oz. per nozzle/ 15 sec. x 4 (adjustment to per minute) x 12 nozzles = 652.8 oz./ min.

Calculate the effective swath width using the following formula.

$$\frac{(Number\ of\ Nozzles + 1)\ \times\ Spacing\ Between\ Nozzles\ (in.)}{12\ in.} = Effective\ Swath\ Width\ (ft.)$$

- **Example**

$$\frac{(12+1) \times 30\ (in.)}{12} = \text{32.5 ft Effective Swath Width}$$

How to calculate sprayer output per acre (Gallons/ Acre, *GPA*)

- First, keep in mind that some product labels have recommendations for product carrier delivery rates (e.g. Apply at 2 pts. Dibrom per acre using 15-20 gallons of water to ensure uniform coverage)
    - So the initial calibration is really a process of determining the delivery rate of the carrier (water).
    - Chemical adjustments will be made based on calculated carrier rates.
- Calculate minutes required to treat 1 acre
    - Using speed in MPH and the calculated effective swath width in feet.
    - Calculate time (in minutes) to treat 1 acre using the following formula.

$$\frac{43{,}560\ ft^2\ (1\ acre)}{Speed\ (MPH)\ \times\ 88ft\ \times\ Swath\ Width\ (ft)} = minutes/\ acre$$

- **Example**

$$\frac{43{,}560\ ft^2\ (1\ acre)}{4\ (MPH) \times 88ft \times 32.5\ (ft)} = \boxed{3.8\ \text{minutes/ acre}}$$

- Using per acre time to treat (min.) and sprayer output per minute (oz.), calculate sprayer output (GPA) using the following formula.

$$\frac{Sprayer\ Output\ per\ Minute\ (oz.)\ \times Minutes\ per\ Acre}{128\ oz.per\ Gallon} = Gallons\ per\ Acre$$

- **Example**
  - 32.5' Sprayer operated at:
    - 60PSI, 12-TJ 8004 Noz., @ 4 MPH
    - Will deliver:

$$\frac{652.8\ (oz.) \times 3.8\ min.per\ Acre}{128\ oz.per\ Gallon} = \boxed{19.4\ \text{GPA}}$$

- What if I want to drive **6 MPH**?
  - Driving faster will dramatically reduce rate per acre.

$$\frac{43{,}560\ ft^2\ (1\ acre)}{6\ (MPH)\ \times\ 88ft\ \times 32.5\ (ft)} = 2.5\ minutes/\ acre$$

$$\frac{652.8\ (oz.)\ \times 2.5\ min.per\ Acre}{128\ oz.per\ Gallon} = \mathbf{12.75\ GPA}$$

- But what if I still want ~**20 GPA @ 6 MPH. You'll need different Nozzles.**

How to calculate required nozzle size

$$\frac{Target\ Application\ Rate\ (GPA)}{Calculated\ minutes\ required\ per\ acre} = Total\ Sprayer\ Output\ (GPM)$$

- **Example**

$$\frac{20\ (GPA)}{2.5\ min.per\ acre} = 8\ gpm. \qquad \frac{8\ gpm.}{12\ nozzles} = .66\ gpm.per\ nozzle$$

- 8004 nozzles deliver ~0.4 gpm. @ 60PSI
- 8006 nozzles deliver ~0.6 gpm. @ 60PSI
  - Slight adjustments to pressure or speed may help fine tune accuracy, but always re-calibrate to confirm changes.

Calculating Chemical Rates

- Based on calculated delivery rates and known field size add products at label rates.
- **Example:**
    - If the field being treated is determined to be 10.3 acres
    - and the sprayer with a 150 gallon tank is calibrated to deliver 19.4 gallons per acre.
    - Each full tank will treat 7.7 acres (150 gal. divided by 19.4 GPA).
        - It will take ~50 additional gallons of mixture to complete the remaining 2.6 acres.

    - If the product label states to apply 2.0 pts./ Acre, you would add 15.4 pts. (1.9 gal) per 150 gal. tank to treat 7.7 acres.
    - The remaining 2.6 acres x 2.0 pts. per acre = 5.2 pts. per 50 gallons

Art

Application Accuracy/ Driving patterns

- Much like granular spreaders, skips and overlaps are still common with boom sprayers in pastures.
- I don't advise double coverage at half rates like would be used with a fertilizer spreader (time, efficacy)
- Planned driving patterns and field markers are more accurate and easier to consider.
- Without a plan, cumulative error can be significant.

Use visual ques of known spacing

- Observe tire tracks from previous passes. This improves with practice, but practice accurately. (get off the tractor occasionally and measure/ pace)
- Lay fields out prior to applications (survey flags, flaggling tied to fences, traffic cones) Can get busy fast with narrower swath widths.
- A light morning dew can help visualize spray coverage and uniformity
- If using spotters consider pesticide exposure risk.

Make a plan for turn rows

- Avoid severe overlapping and heavy applications on turn rows
    - Open and close control valves while moving if possible leaving turn rows untreated.
    - Finish the job by spraying the turn rows last

Develop a plan for refills

- If possible, refill between passes to avoid running out the middle of the field.

Monitor Accuracy

- Calculate accuracy throughout the application
    - How much of the area should have been covered when one quarter or half of the tank volume is gone?
    - Calculate accuracy between refills.

- If:
  - Equipment is properly calibrated,
  - Equipment is being operated properly (Speed, RPM, Gear Selection),
  - Equipment is functioning properly
  - The only variable left to adjust is the distance between passes (too wide, too narrow)

The job isn't over until the paperwork is finished.

Keep Good Records

Speed Calibration

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

RPM:		Gear:			
Test Date	Distance (ft.)	Time (sec.)			Speed (MPH)

Nozzle Evaluation and Output

Time Interval:						Nozzle #:						Date:						Calculated Boom Output/ Min. (gals./ min.)
Tip # (L-R)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Avg.	+/- 10%	
Output (oz.)																		
Output (oz.)																		

Actual Application Rate

$$Actual\ GPA = \frac{Total\ Gallons\ Applied}{Total\ Acres\ Treated} \qquad Actual\ Amount\ of\ Product\ per\ Acre = \frac{Total\ Amt.of\ Product\ Used}{Total\ Acres\ Treated}$$

Date	Acres Treated	Gallons Applied	Actual GPA (Gallons/ Acre)	Amt. of Product Used	Actual Amt. of Product/ Acre