Sprayer Calibration

Dr. Wonsuk “Daniel” Lee
Professor
Agricultural & Biological Engineering
University of Florida
Gainesville, FL

LIQUID CHEMICALS

Liquid chemicals

- Learn how to calibrate farm sprayers:
  - Uniformity check
  - 1/128th of an acre method
  - Tank refill method

Calibration method 1: Uniformity check

UF UNIVERSITY of FLORIDA

Uniformity check

- Check whether all the nozzles in a boom are putting out the same amount of pesticide
- Nozzle catch test
- Any nozzle that is greater than 10% above or below the average should be replaced with another nozzle.

Uniformity check – steps

1. Catch output from each nozzle for a pre-determined period of time
2. Calculate average GPM per nozzle
3. Examine each nozzle output to see whether it is within ±10% of the average GPM

Uniformity check - Example

Nozzle	15 sec flow (oz)	Nozzle	15 sec flow (oz)
1	9.30	6	8.96
2	7.95	7	8.52
3	9.57	8	10.65
4	9.27	9	9.13
5	8.86	10	9.30
Average = 9.15			

Uniformity check - Example

Nozzle	60 sec flow (gal)	Nozzle	60 sec flow (gal)
1	0.291	6	0.280
2	0.248	7	0.266
3	0.299	8	0.333
4	0.290	9	0.285
5	0.277	10	0.291
Average = 0.286 GPM			

1. Calculate ±10% of the average flow

   0.286 x 0.9 = 0.257

   0.286 x 1.1 = 0.314

2. All nozzles should be between 0.257-0.314 GPM.
3. Nozzles #2 and #8 should be replaced.

Calibration method 2:
1/128th of an acre calibration

1/128th of an Acre Calibration

- Basis: The spray volume in *ounces* applied to an area equal to 1/128th of an acre is equal to the gallons per acre rate being applied per nozzle.
- 1 gallon = 128 oz

$$\boxed{\frac{1\,\text{gallon}}{\text{ac}} = \frac{128\,\text{oz}}{\text{ac}} = \frac{1\,\text{oz}}{\left(\frac{1}{128}\,\text{ac}\right)}}$$

1/128th of an Acre Calibration

$$\frac{1}{128}\text{ ac has }\frac{1}{128}\text{ gal} = 1\text{ oz}$$

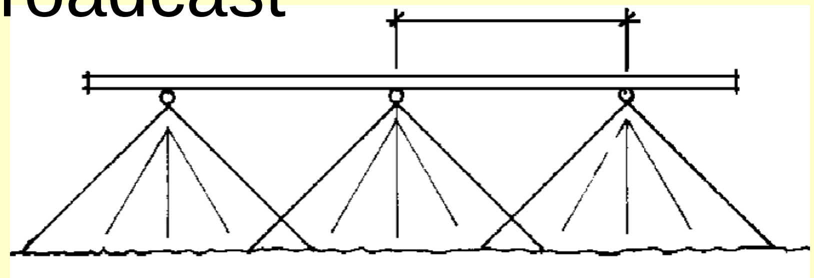
$$\boxed{1\,\text{GPA} = \frac{1\,\text{gal}}{1\,\text{ac}} = \frac{\left(\frac{1}{128}\text{gal}\right)}{\left(\frac{1}{128}\text{ac}\right)} = \frac{1\,\text{oz}}{\left(\frac{1}{128}\text{ac}\right)}}$$

1 gallon

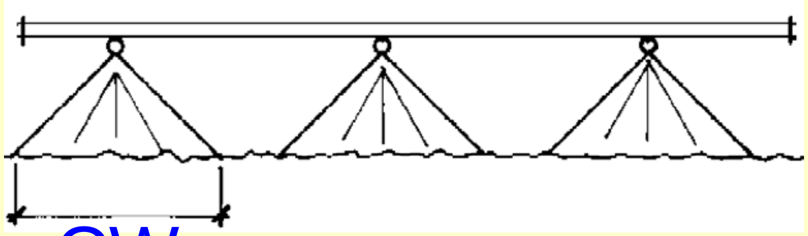
Course width (CW) (ft)

Broadcast

CW

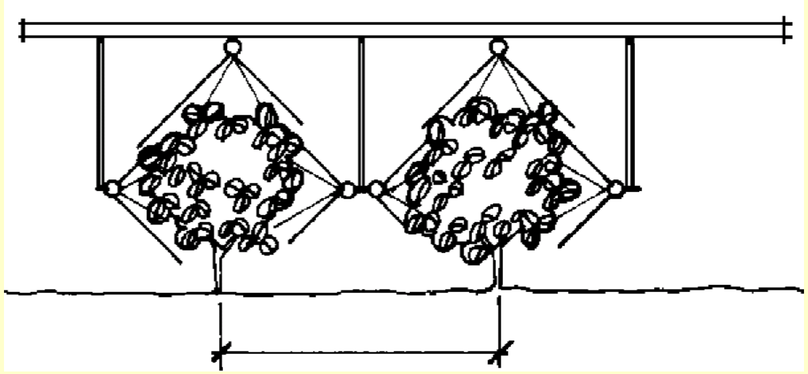


Band



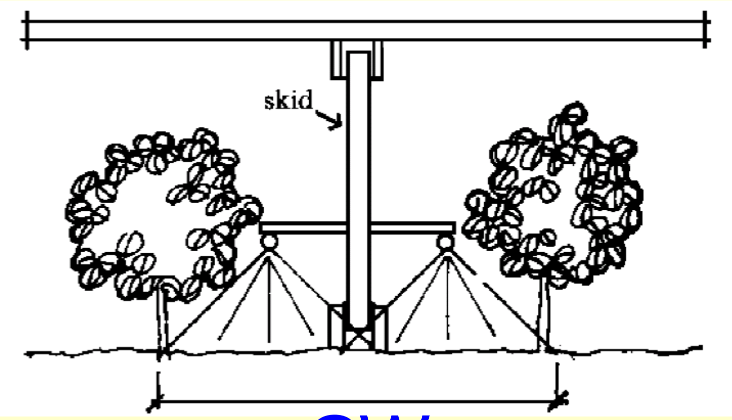
CW

Crop foliage



CW

Broadcast directed



CW

Course Length (CL) (ft)

Course length (CL)

= Length (ft) of 1/128th of an acre course

$$= \frac{340\ (ft^2)}{\text{course width (ft)}}$$

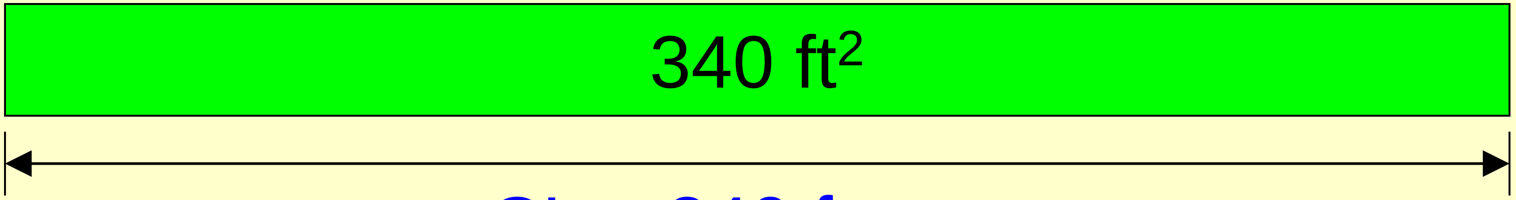
since,

$$\frac{1\,ac}{128} = \frac{43560\ ft^2}{128} = 340\ ft^2 \qquad (340.3\ ft^2)$$

CL (ft) - Examples

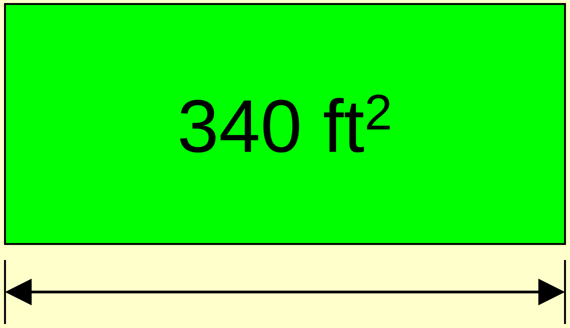
CW

1 ft



CL = 340 ft

3 ft



CL = 113.3 ft

$$\boxed{CL = \frac{340\ ft^2}{CW}}$$

Example

- A grower is applying an herbicide broadcast with a sprayer that has nozzles spaced 20 inches on the boom. How would he calibrate using the $1/128^{th}$ of an acre method?

Step 1. Determine the course length (CL)

For broadcast spraying,

CW = nozzle spacing = 20 in = 1.67 ft

So, CL = $\dfrac{340\ \text{ft}^2}{\text{CW}} = \dfrac{340\ \text{ft}^2}{1.67\ \text{ft}} = 204\ \text{ft}$

Step 2. Stake out the course length

- Stake out the 204-ft course.

Step 3. Determine the time required to travel the course length

- Using the same gear and RPM that will be used when spraying, determine the time required to travel the course length.

Step 4. Conduct a nozzle uniformity check

- Conduct a nozzle uniformity check.

UNIVERSITY of FLORIDA

Step 5. Catch the flow from one nozzle for the same time as in step 3

- With spray pressure system set at the same pressure as will be used when spraying, catch the flow from one nozzle for the same period of time it took to travel the course length.

Step 6. Determine GPA

- The number of ounces caught in Step 5 is equal to the number of GPA being applied to the sprayed area.
- If 15 ounces were caught in the time it took to travel the course length, the GPA applied is 15 GPA.

Optional confirmation step

$$\frac{15\ \text{oz}}{340\ \text{ft}^2} = \frac{15\ \text{oz x } 128}{340\ \text{ft}^2\ \text{x } 128} = \frac{15\ \text{x } 128\ \text{oz}}{43560\ \text{ft}^2} = \frac{15\ \text{gallon}}{1\,\text{ac}} = 15\ \text{GPA}$$

Calibration method 3: Tank refill test

UF | UNIVERSITY of FLORIDA

Tank refill test

1. Fill the spray tank to a known level
2. Run the sprayer for a period of predetermined duration
3. Measuring as you fill, refill the tank with water to the original level
4. The gallons of refill water needed equal to the gallons sprayed during the test
5. Calculate the actual GPM by dividing the total gallon sprayed during the test by the total time required for the test.

Tank refill test

- Main problem: *uncertainty of water level*
- Avoid low gallonage (short time) tests
- A tank refill test should spray out minimum 25 gallons of water (more is better).
- A test that uses only a few gallons is much more prone to error.

Tank refill test: Example

- Suppose 26 gallons were sprayed in 10 minutes, then the sprayer's GPM will be:

$$\text{GPM} = \frac{\text{Gallons sprayed during the test}}{\text{Time required for the test}}$$

$$= \frac{26 \text{ gal}}{10 \text{ min}}$$

= 2.6 GPM (Ans)

Useful formula

$$GPA = \frac{Gallon}{Acre} = \frac{GPM}{ac/min} \quad ; \quad \#/ac = \frac{\#/min}{ac/min}$$

$$ac/min = \left(\frac{ft^2}{43560}\right)/\min = \left(\frac{ft \text{ x } (ft/min)}{43560}\right) = \frac{swath\,(ft) \text{ x } speed\,(ft/min)}{43560}$$

$$ac/min = \frac{swath\,(ft) \text{ x } speed\,(ft/min)}{43560} \text{ x } \left(\frac{88\ mi/hr}{ft/min}\right) = \frac{swath\,(ft) \text{ x } speed\,(mi/hr)}{495}$$

UNIVERSITY of FLORIDA

Conversion factors

- 1 gallon = 4 quarts = 8 pints = 128 oz
- 1 mile = 5280 ft
- 1 acre = 43560 ft^2
- 1 sq. mi = 640 ac
- ft/min ÷ 88 = mi/hr

DRY CHEMICALS

Calibration of granule applicators

- Calibrating granule applicators is very similar to spray equipment (same formula)
- One important difference: Granular (and other dry pesticides) products are measured in units of U.S. weight

Caution for using ounces!

- In the U.S. liquid system:

  1 ounce = 1/128 gallon
- In the U.S. weight system:

  1 ounce = 1/16 pound
- The best thing to do, when working calibration problems, is not to use *ounces*, or use it carefully.

Two major groups of granule-applying devices

- Group I: devices for which product delivery per unit area is not influenced by travel speed
- Group II: devices for which product delivery per unit area is influenced by travel speed

UF UNIVERSITY of FLORIDA

Group I devices

- The granule-distributing mechanism is driven by the equipment’s ground wheels.
- The faster the equipment travels, the faster the granules are released.
- The amount of granules per unit area always stays the same.

Group II devices

- The granule-distributing mechanism is driven by the equipment's independently-energized mechanism (whirl plate, blower, etc.)
- The equipment can put out granules even when standing still
- Examples:
  - A hand-cranked bag spreader
  - A tractor-mounted spreader that uses a PTO-driven whirl plate

Calibration of granule applicators

Calibrating granule applicators

- Two questions
  - How much product is the equipment actually putting out per unit area?
  - Is the amount of product actually applied per unit area within ±10% of the amount indicated by the pesticide labeling?

Initial step of calibration

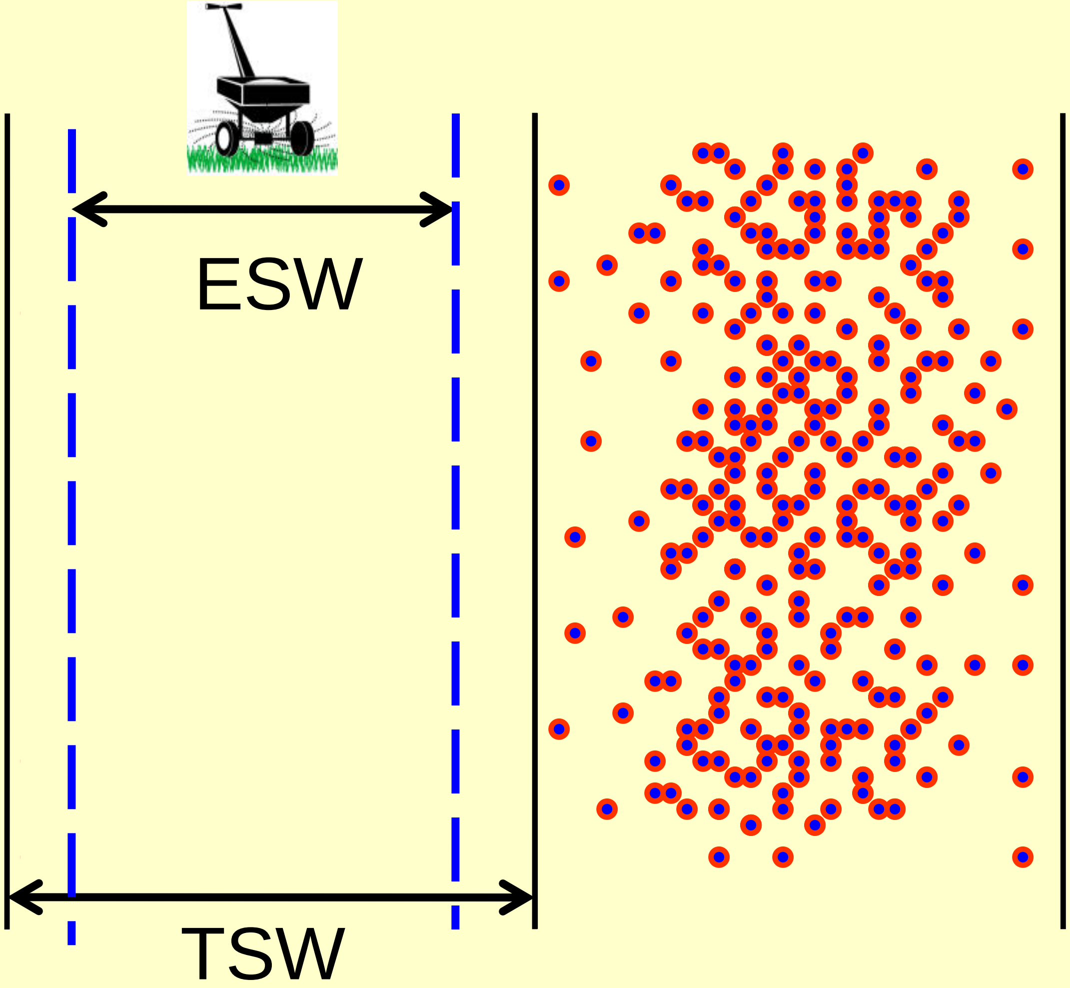
- Determine total swath width (TSW) in feet

  → TSW: width *being covered* by the equipment per pass

- Determine effective swath width (ESW) of the device, considering overlap

  → ESW: width *actually* being treated per pass

TSW – Overlap = ESW



Calibration of Group I devices

- ✓ Catch-pan method
- ✓ Volume output method

Catch-Pan method of calibration

- Fit a catch-pan underneath the hopper outflow gate, and operate the device over a test area.
- After the test run, weigh the total amount of granules in the catch pan.
- Then divide the weight of the captured granules by the test area.

Ex: Catch-pan calibration of a Group I device

- A strip of 300 ft long is staked and flagged as a test site for a tractor-towed “drop spreader”. Its effective swath is 6.75 ft. The device is moved to one end of the strip and a catch-pan is installed. After filling the hopper with the pesticide product, opening the feed gate to setting #6, and making a single-pass test run, the catch-pan is found to contain 11.5 lb of granules. If the label rate calls for 300 lb/ac, can this device be used “as is” to make the broadcast application?

UF | UNIVERSITY of FLORIDA

Ex: Catch-pan calibration of a Group I device

(Solution)

1. Determine the acreage of treated area

   : 6.75 ft x 300 ft = 2025 ft^2 = 0.0465 ac

2. Determine the actual application rate (lb/ac)

   : 11.5 lb / 0.0465 ac = 247.3 lb/ac

3. Calculate the ±10% tolerance interval for the label rate

   : 300 lb/ac ± 10% = from 270 lb/ac to 330 lb/ac

4. The device is under-applying. (Ans)

Volume output method

- Use your experience to set the hopper gate to deliver a certain application rate. Record the setting.
- Fill the hopper with a known amount of the pesticide.
- Operate the device over a test area.
- Empty the hopper to find how much actually were applied.
- Calculate the actual application rate per unit area.

Ex: Volume output calibration of a Group I device

- A strip 300 ft long is staked and flagged as a test site for a tractor-towed “drop spreader”. Its effective swath is 6.75 ft. The device is moved to one end of the strip and exactly 100 lb of product is put into the hopper. After the feed gate is set to position #8 and a single-pass test run is made, the hopper is emptied and found to contain 65 lb of granules. If the label calls for 500 lb/ac, can this device be used “as is” to make the broadcast application?

UF UNIVERSITY of FLORIDA

Ex: Volume output calibration of a Group I device

(Solution)

1. Determine the treated area

   : 6.75 ft x 300 ft = 2025 ft^2 = 0.0465 ac
2. Determine the total weight of granules applied during the test

   : 100 lb – 65 lb = 35 lb actually applied
3. Calculate the lb/ac actually applied during the test run

   : 35 lb / 0.0465 ac = 752.7 lb/ac
4. Calculate the ±10% tolerance interval for the label rate

   : 500 lb/ac ±10% = from 450 lb/ac to 550 lb/ac
5. The device is over-applying. (Ans)

UF | UNIVERSITY of FLORIDA

Thank you!

2011 Class of Pesticide Application Technology at PSREU

EXTRA

Calibration of Group II devices

- ✓ Catch-pan method

Calibrating a Group II device

- Group II devices: devices for which travel speed does influence actual application rate
- The calibration procedure for a Group II device is basically the same as for Group I devices.
- To calibrate a Group II device, you must conduct a speed test.

Calibrating a Group II device

- Important procedural differences which have to do with speed
  - Conduct a speed test to find actual travel speed at the application site
  - Record the throttle and gear settings
  - Record any settings that independently influence the speed of the granule-distributing mechanism (ex. throttle position, PTO rpm, etc.)
  - Adjust speed if you want to change the actual amount of product

Adjusting speed involves…

- Altering device's travel speed (FPM change), or
- Altering the speed of the device's granule-distributing mechanism (RPM change), or
- Altering both (FPM or RPM)

For Group II devices

- Actual travel speed is inversely proportional to actual application rate.
- To increase the actual application rate, decrease vehicle speed.
- To make small change in output, adjust travel speed.

Catch-pan method

- Conduct a speed test, but do not operate the granule-dispersing mechanism.
- With the equipment standing still, run the granule-dispersing mechanism only and record its speed setting.
- Shut off all machinery, and install the catch-pan.
- Operate only the granule-dispersing mechanism for the time it took for speed test
- Remove the catch-pan, weigh the total amount of granules discharged, and calculate application rate.

UF | UNIVERSITY of FLORIDA

Ex. Catch-pan method

A strip 500 ft long is staked as a test site for a PTO-powered “whirl-plate” broadcast spreader. Its effective swath is 28 ft. In a timed test run from a rolling start, the tractor drove the length of the test site in 2.39 min. With the pesticide product in the hopper, the feed gate set to position 6, a catch-pan installed, and the PTO speed set to 2000 rpm, the whirl plate delivered 37.4 lb of granules into the catch pan during a 2.39 min test. If the label calls for 100 lb/ac, can this device be used “as is” to make the broadcast application?

Ex. Catch-pan method

(Solution)

1. Calculate the actual travel speed (in fpm) of the device during the test run

   : 500 ft / 2.39 min = 209.2 fpm

2. Calculate the APM actually being covered by the device during the test run

   : APM = $\dfrac{\text{swath (ft) x speed (fpm)}}{43560} = \dfrac{\text{28 ft x 209.2 fpm}}{43560} = 0.134\ \text{ac/min}$

3. Calculate the pounds of granules actually distributed per minute of whirl-plate operation

   : lb/min = $\dfrac{\text{Pounds of granules in catch} - \text{pan}}{\text{elapsed time of the test}} = \dfrac{37.4\ \text{lb}}{2.39\ \text{min}} = 15.65\ \text{lb/min}$

Ex. Catch-pan method

(Solution - continued)

4. Using the values calculated in steps 2 and 3, determine the actual application rate (PPA or lb/ac) being delivered

$$: \text{PPA} = \frac{\text{Pounds per min (actual)}}{\text{Acres per min (actual)}} = \frac{15.65\ \text{lb/min}}{0.134\ \text{ac/min}} = 116.79\ \text{lb/ac}$$

5. Calculate the ±10% tolerance interval for the label rate.

   Desired rate ±10% = 100 lb/ac ±10% = 90 to 110 lb/ac

6. The device is over-applying and cannot be used “as is”. (Ans)