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Calibration of Herbicide Applicators [1]

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There are two primary reasons to calibrate a sprayer: 1) to ensure that the correct amount of solution is applied, and 2) to determine the amount of herbicide and water needed to correctly apply the herbicide to the desired area.

Herbicides are usually recommended at certain rates per acre. In order to apply a herbicide correctly, the application rate, in gallons per acre (gal/A) or pounds per acre (lb/A), must be determined. Since most herbicides are applied as sprays, the following discussion of calibration is directed specifically toward spraying.

FACTORS TO CONSIDER IN CALIBRATION

The amount of liquid that a sprayer applies to a given area can be varied by changing one or more of the following: (1) pressure that forces liquid through the nozzle tip, (2) nozzle orifice (tip opening) size, (3) sprayer ground speed, and/or (4) spacing of nozzles on the boom or width of spray pattern.

1. **Pressure:** Adjusting the nozzle pressure is a good way to make small changes in sprayer output. Increasing the pressure will increase the nozzle output, but the increase is only proportional to the square root of the pressure increase (e.g., the pressure would have to be increased four times to double the output of the nozzle). Since herbicide spraying should be done in a pressure range of 20 to 50 psi, it is obvious that only minor changes in nozzle flow can be achieved by varying the pressure. Low pressures are recommended for herbicide spraying in order to reduce the drift potential of the spray.

2. **Nozzle Orifice:** Large changes in spray output are made by changing the nozzles. Nozzles are rated as to capacity in gallons per minute (gal/min) at a certain pressure (40 psi). Manufacturers' data sheets give the discharge of various nozzles at different pressures. This information should be used when selecting the nozzle for a sprayer to apply the desired rate, at a selected tractor speed and operating pressure. After selecting the nozzle, it is often necessary to make small adjustments in the pressure during calibration to get the exact gal/A desired. All nozzles should spray within 5% of the expected GMP and within 10% of the other nozzles on the boom. If a nozzle(s) does not fall within these

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ranges, replace the nozzle and then recheck. It is often necessary to replace all nozzles at one time.

3. **Sprayer Ground Speed:** The speed of the tractor while spraying is generally governed by the terrain, safety, or by some other operation done at the same time as the spraying. Proper nozzles should be used to get the desired application rate at the speed best suited to the operation or field conditions.

4. **Spacing of Nozzles:** The amount of spray depends on the number of nozzles per row, or on the boom. The application rate in a band-treated area decreases with a given nozzle as the band width increases.

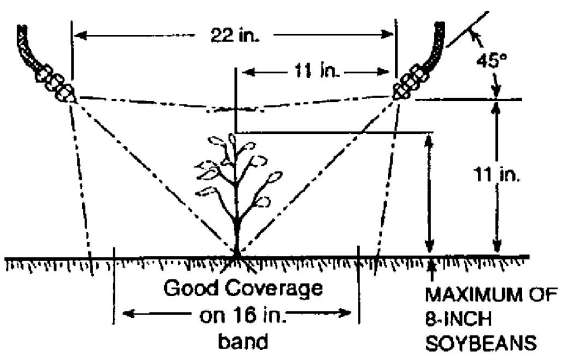

Figure 1. Two-nozzle arrangement for over-the-top applications.

TYPICAL CALIBRATION PROBLEMS

There are two primary types of calibration problems encountered by an applicator of herbicides. One type of problem is where a given application rate is to be applied and the sprayer nozzles must be selected to achieve the desired rate. The other type is where the sprayer is already nozzled and its application rate must be determined. This section discusses both situations.

Selecting Nozzles for a Desired Application Rate

The simplest method to demonstrate how problems of this type are solved is with a typical example.

Example: A grower has a boom sprayer 30-feet long that has 18 nozzles spaced on 20-inch centers. The grower wishes to broadcast a herbicide in a pasture at an application rate of 15 gal/A. Field conditions dictate a tractor speed of 6 mph. What size nozzles should be selected, if the sprayer pressure used is 30 psi?

STEP 1 : Write the basic equation which is applicable for any type of calibration problem.

$$Gal/acre = \frac{GPM}{acres/\min}$$

In this problem the gal/A or GPA was given as 15, so the gal/min or GPM can be determined, if the acres per minute being treated are known. The volume of product added should be included with the carrier to equal the total volume of spray mixture.

STEP 2 : Determine acres per minute.

$$Acres/\min = \frac{Swath\ (ft) \times Speed\ (mph)}{495}$$

Example : The swath is 30 feet and the speed is 6 mph or 528 ft/min.

$$Acres/\min = \frac{30 \times 6}{495} = 0.364\ or\ 0.36$$

STEP 3 : Determine the GPM required to have an application rate of 15 GPA when treating 0.36 acres per minute.

$$\begin{aligned} GPM &= GPA \times Acres/\min \\ &= 15 \times 0.36 \\ &= 5.4 \end{aligned}$$

STEP 4 : Determine the nozzle capacity needed. The capacity rating per nozzle at 30 psi is:

$$\begin{aligned} GPM/nozzle &= \frac{Total\ GPM}{Number\ of\ nozzles} \\ &= \frac{5.4}{18} \\ &= 0.3\ at\ 30\ psi \end{aligned}$$

Another method used to determine the nozzle capacity needed:

$$GPM = \frac{GPA \times nozzle\ spacing\ (in) \times mph}{5940}$$

$$GPM = \frac{15 \times 20 \times 6}{5940} = 0.3$$

A nozzle would be selected from the nozzle manufacturer's catalogs that delivers close to 0.3 GPM when operating at 30 psi. After selecting the nozzle and nozzling the boom, the grower should conduct a calibration test like that outlined in the following section, because many factors tend to make the flow different from what was determined mathematically. Spraying materials more viscous than water (the catalogs are based on spraying water), and having less pressure at the nozzle than shown at the gauge due to friction loss tend to make the nozzle flow less than figured. Installing used and worn nozzles tend to make the flow greater than expected because the catalog performance data is based on new orifices.

Calibrating the Already-Nozzled Sprayer

A. The Tank Refill Method

1. Set two stakes, 330 feet apart, in a field that is typical of the field or fields to be sprayed. The sprayer is to be operated through one round trip between these stakes, or a distance of 660 feet.

2. Partially fill the sprayer tank with water.

3. Operate the sprayer unit to see that all of the parts are operating properly, and adjust the pressure regulator to achieve the desired pressure with the engine turning at the RPM to be used while spraying. Shut off the sprayer.

4. Fill the sprayer tank completely, or to some measurable point with water. A measuring stick or gauge on the tank may be used if the water is likely to splash out of the tank as the unit moves.

5. Beginning 20 to 30 feet from the first stake, drive the tractor toward this stake at the desired speed with the sprayer cutoff valve closed.

6. Upon passing the first stake, open the cutoff valve or turn the sprayer "on" for spraying.

7. Upon passing the second stake, turn off the sprayer, and turn the unit around. Spray the course again on the return trip. Be sure to maintain uniform speed and pressure throughout the course.

8. Measure, to the nearest quart, the amount of water required to refill the tank, or to restore the original level. When refilling, be sure that the sprayer is in the same location as for the first filling, or is resting level in both instances to avoid possible error.

9. Determine application rate by use of the following equation:

$$GPA = \frac{Gallons\ to\ refill\ tank \times 66}{Spray\ Width\ (feet)}$$

Example : Assume that it took 6.75 gal to refill the tank and that the swath width was 30 feet:

$$GPA = \frac{6.75 \times 66}{30} = 14.85\ or\ 15$$

10. Add the recommended amount of chemical to the sprayer tank. The amount is dictated by the application rate (GPA), and the volume of spray in the tank. For example, if you want to apply 2 lb of chemical per acre and you are applying 15 gal of water per acre, add 2 lb of chemicals to every 15 gal of water to make up the spray mixture for the sprayer. The volume of product added should be included with the carrier to equal the total volume of spray mixture.

B. Alternate Method

Mathematical calculations have resulted in a formula that can be used as a quick and easy method of checking or rechecking the calibration of ground equipment. The formula is :

$$ml\ per\ 30\ \text{sec} = \frac{21.7 \times nozzle\ spacing\ (in) \times GPA\ desired}{Speed\ (\text{sec}/\ 100\ ft)}$$

This formula will provide the volume in milliliters to catch when you know the gal/A that you

want to apply, and you have already measured the nozzle spacing and determined the travel speed in a field or area typical of that to be sprayed. An example is :

$$\frac{21.7 \times 20 \textit{ in nozzle spray} \times 20\, GPA}{17 \text{ sec}/\ 100\, ft} = 510\, ml \textit{ per } 30 \text{ sec } nozzle$$

Therefore, you should collect 510 ml in 30 seconds at each nozzle to achieve an application of 20 gal/A. If you do not have metric equipment, the milliliters can be divided by 29.6 to give the answer in ounces (i.e., 510 divided by 29.7 equals 17.2 oz per 30 seconds). Be sure to check each nozzle to assure uniformity. If you do not collect the amount of spray needed for the GPA desired, you can adjust pressure, change nozzle size, change speed, or adjust nozzle spacing.

To determine the amount of pesticide to add to the spray tank, especially when the recommendation is only given in lb of active ingredient per acre, another short formula may be utilized.

For liquid :

$$\begin{matrix} ml \textit{ of pesticide} \\ \textit{to add to one gal} \\ \textit{of spray mix} \end{matrix} = \frac{\dfrac{\textit{what you want}}{\textit{what you have}} \times 3785}{GPA}$$

Where: what you want is lb of active ingredient to apply per acre and what you have is the formulated pesticide. The volume of product added should be included with the carrier to equal the total volume of spray mixture.

Example : Apply Prowl at 1.0 lb ai and Prowl is a 3.3 lb/gal material:

$$\frac{\dfrac{want\ \ 1.0}{have\ \ 3.3} \times 3785}{GPA} = \frac{1147}{20} = 57.4\, ml/gal \textit{ of spray mix}$$

To convert milliliters to ounces, divide by 29.7.

For powders, dry flowables or other non-liquids the formula is changed slightly; i.e., 454 must be substituted for 3,785 to give grams of pesticide to add per gallon of spray mix. The adjusted formula is :

$$\begin{matrix} \textit{Grams of pesticide} \\ \textit{to add to one gal} \\ \textit{of spray mix} \end{matrix} = \frac{\dfrac{\textit{what you want}}{\textit{what you have}} \times 454}{GPA}$$

Example : Apply 1.0 lb active ingredient of Zorial 80DF per acre at 20 GPA.

$$\frac{\dfrac{want\ 1.0}{have\ 0.80} \times 454}{20\, GPA} = \frac{567.5}{20} = \begin{matrix} 28.4\, gr \textit{ of Zorial} \\ \textit{to be added per} \\ \textit{gal of spray mix} \end{matrix}$$

Grams may be converted to ounces by dividing grams by 28.4.

SPOT TREATMENT

Herbicide labels will sometimes allow for spot treatments. In this case, the recommended amount of herbicide is given in % v/v solution. This often results in confusion and in an excess amount of herbicide being applied. To determine the correct amount of herbicide to add to the spray tank, see the following example:

Ex. A grower wants to apply glyphosate at 1.5% v/v to a 20 gallon tank.

$$\begin{array}{r} 20 \text{ gal} \\ \times 1.5\% \\ \hline 0.30 \text{ gal} \end{array} \quad \left(\begin{matrix}\text{remember a \% means moving} \\ \text{the decimal place to multiply}\end{matrix}\right)$$

$$0.30 \text{ gal} \times \frac{128 \text{ oz}}{\text{gal}} = 38.4 \text{ oz of glyphosate should be added to a 20 gallon spray tank.}$$

1/128TH ACRE METHOD

Another simple calibration method is the 1/128th Acre Method.

The 1/128th acre, baby bottle, and 100-foot methods of calibration are based on spraying 1/128th acre. There are 128 ounces per gallon; therefore, ounces sprayed per 1/128th acre equal gallons sprayed per acre. This procedure results in a treated acre calibration.

1) Determine nozzle spacing or swath width. (Note: if you are making **band** applications and use nozzle spacings, you will figure the gallons of spray per planted acre.)

2) Refer to Table 1 for length of calibration course and mark calibration course in the field or 340 ft^2/nozzle swath width (feet) course length.

3) Record time required to drive length of calibration course at gear, engine rpm, and implement settings to be used while spraying.

4) Park sprayer, maintain engine rpm used to drive course, and turn on sprayer.

5) Collect all spray from one nozzle for time equal to that required to drive the calibration course.

6) Measure the **ounces** caught. Ounces caught equal gallons per acre of spray applied.

7) Repeat Steps 5 and 6 for several other nozzles.

*NOTE: If multiple nozzles are used per row use the width of area treated by all nozzles as the swath width for step 1 and catch the flow from all nozzles directed to the row in Step 5.

CHECKLIST BEFORE FIELD OPERATION OF SPRAYERS

A little time and effort spent checking and preparing the sprayer will ensure a more effective and trouble-free spray operation.

1. Clean the supply tank and fill it with clean water. Sand or other small particles will cause excessive wear of the pump and nozzles and results in clogged screens.
2. Clean suction and line strainer.
3. Remove all nozzle tips, nozzle strainers, and boom endcaps.
4. Start the sprayer, and flush the hoses and boom with plenty of clean water.
5. Inspect nozzle tips and strainers for defects and cleanliness, and make sure all tips are the same type and size. Mixed nozzle tips along the boom will give uneven spray distribution.
6. Replace the nozzles and strainers, and check for proper operation and alignment.
7. Check all connections for leaks.
8. Adjust the pressure regulator to desired operating pressure. Operate sprayer with water, and check nozzle discharge for uniformity. This can be done by placing containers under each nozzle, operating sprayer for a few minutes, and then checking to see if the same amount of water is in each container. This will detect worn, defective, or incorrect nozzles.
9. Calibrate sprayer. Check calibration figures.
10. Add chemical to tank to correct ratio for desired rate of application.

GUIDE TO FIELD OPERATION OF SPRAYERS

The following information should be used as a guide for operating a sprayer in the field.

1. Check wind. Excessive wind will affect the uniformity of spray application and could result in spray drift. Do not spray until winds are calm.
2. Operate the tractor at a uniform speed. This must be the same speed and gear that were used in calibrating the sprayer.
3. Strive to keep the spray boom parallel to the ground.
4. Maintain proper height of boom. The height of the nozzle above the spray surface determines the width of the spray pattern at the surface. On a boom sprayer, with nozzles spaced for complete broadcast coverage, the nozzle must be at the correct height to obtain uniform coverage across the boom width. Manufacturers' data sheets list the correct height for each type of nozzle.
5. Make regular observations of the operation pressure while spraying. Maintain pressure as determined by calibration.
6. Observe nozzle patterns continuously to detect clogged nozzles, or nozzle position changes that might arise. Clogged nozzles or nozzle strainers are common problems affecting spray distribution. By using only clean water, selecting and using proper nozzle strainers, and cleaning

nozzles and strainers daily, this problem will be reduced to a minimum. A toothbrush is excellent for cleaning nozzles.

7. Stop the pump immediately when the liquid is gone. Pumps can be seriously damaged when operated without liquid.

8. Always completely flush the entire system with clean water after completing the spraying job. With some spray materials, the system should be cleaned every night. Dispose of rinse water as directed on the pesticide label.

MAINTENANCE, CARE AND CLEANING OF SPRAYERS

The owner's instruction manual, furnished by the sprayer manufacturer, is a good reference and guide to operation, care, and maintenance of a sprayer. All owners should have a manual for their sprayer, study it thoroughly, and keep it for future reference.

Sprayer pump and nozzle wear, caused by the abrasive particles in the spray material, or water and sprayer deterioration from chemical corrosive action are the most costly maintenance problems affecting sprayers. The wear can be held to a minimum by always using clean water for the spray mixture, using care in selecting less abrasive spray materials, making sure the spray, chemicals and water have been well mixed before starting the pump, keeping the proper strainers in place at all times, and never operating the pump without liquid in the tank.

Corrosion can be reduced by thoroughly cleaning the sprayer after each period of use. An ordinary field sprayer should never be used for applying liquid fertilizers, because these fertilizers are very corrosive to metals other than stainless steel.

Before storage at the end of the season, and after thoroughly cleaning the sprayer, run a few gallons of fuel oil through the sprayer to help prevent rust. Store nozzle tips and all strainers in a can of light machine oil. Gear and piston pumps should be filled with oil. Roller and diaphragm pumps should be flushed with rust inhibitor, and then all openings should be capped.

Herbicide sprayers should be thoroughly washed and cleaned after each use. The sprayer should first be flushed with water, then cleaned with one of the following materials in 50 gal of water by flushing the mixture through the sprayer.

- 1/2 gal of household ammonia (let stand in sprayer overnight)
- 4 lb trisodium phosphate cleaner
- 2 1/2 lb sal soda
- 2 lb activated charcoal (leave in sprayer and lines 10 minutes)

As a rule, sprayers used with chemicals to kill weeds should not be used in spraying chemicals for insects or diseases on extremely susceptible crops.

Table 1. Distance for each nozzle to spray 1/128 acre.

Effective Swath Width (in)	Course Distance (ft)
6	681
8	510
10	408
12	340
14	292
16	255
18	227
20	204
22	186
24	170
30	136
36	113
38	107
40	102
42	97
48	85

Table 2. Nozzle Types, Spray Patterns and Suggested Uses.

Type	Spray Pattern	Pressure (psi)	Suggested Use/Comment
Flat Fan	Fan-like pattern of medium droplets. Not uniform across width.	20-40 (15-40 psi for LP nozzle)	Pre- and postemergence, broadcast booms. Available in low pressure tips that reduce clogging and drift potential. Requires 30% overlap for uniform distribution.
Even Fan	Fan-like pattern. Uniform volume across entire width.	20-40	Pre- and postemergence. Good for banding.
Flooding Fan	Wide, flat pattern of coarse droplets.	10-30	Broadcast booms, chemical-fertilizer mixture, layby. Requires 100% overlap for uniform distribution.
Off-Center Flat Fan (up to OCO8)	Flat-fan pattern. directed to one side of tip. Swath width 20-144 inches.	20-40	Post-directed, low-profile spraying. Larger drops and increased volume deposited on the top of pattern. Reasonably uniform deposits are not expected.
Large Off-Center Flat Fan	Swath directed to one side from 12 to 33 feet width.	30-40	Herbicide application to ditches and roadsides. Reasonably uniform deposits are not expected.
Cone	Circular, with heavy concentration on outside. Small droplets.	40-60	Complete coverage of foliage. Insecticide, fungicide, and growth regulator four applications, and Basagran rigs. Use where slight drifting is not hazardous.

Table 2. Nozzle Types, Spray Patterns and Suggested Uses.

Type	Spray Pattern	Pressure (psi)	Suggested Use/Comment
Whirl Chamber (Raindrop™)	Hollow cone pattern.	5-20	Used on incorporation equipment.
Rotary Atomizers	Flat plane similar to hollow cone. More nearly uniform droplet size.	Device dependent	Low-volume application of herbicides and insecticides.
Boomless Nozzle Cluster	Wide swath (up to 60 feet). Pattern easily distorted by wind. High spray trajectory.	20-40	Pastures and broadcast spraying where obstructions to booms exist. High drift potential. Not suitable for orchard spraying. Reasonably uniform deposits are not expected.