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Calibrating Your Sprayer

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Why calibrate? Calibrating your spray equipment not only makes good business sense, but also it is the farmer's community responsibility to apply production inputs safely, carefully, and according to the manufacturer's recommendations.

This document supplements a Sprayer Calibration Template spreadsheet for computers (for details, see pp. 9–11). Steps 1–6 below describe the calculations the template performs. To obtain the program, go to *www.ctahr.hawaii.edu/freepubs* and look under Pesticide Risk Reduction Education.

Farming is a very competitive business. Producing an agricultural commodity requires growers to utilize farm inputs, including seeds, fertilizers, insecticides, and herbicides, to produce economically competitive yields. Applying the right amounts of inputs and producing competitive yields go hand in hand. Applying too much of something could mean that either the yields could have been achieved by applying lesser amounts, or the excess amount of input may reach toxic levels and contribute to lower yield. Applying too little of something could mean that expected production levels are not achieved.

"Shooting in the dark" usually leads to wasting time and resources and puts the farmer in a less-than-competitive position. Knowing that you have the capability to deliver and apply the amounts of inputs you planned will give you peace of mind. Calibrating your application equipment will help you deliver the amounts of farm inputs you planned, achieve production results that you expected, and improve your capacity to manage and economically sustain your farm business.

Your farm is part of a larger community. More than 95 percent of the people in our communities are not involved in producing agricultural commodities. Communities have developed and voiced standards that define the "quality of life" they want to maintain. These standards can be seen in laws that govern communities and in the behavior of their citizens. Farmers are not exempt from these standards. Farmers need to be aware of environmental, health, and labor laws that affect the way they conduct their business. Communities will no longer tolerate wasted farm inputs that enter our environment. As part of the larger community, farmers need to contribute to the "quality of life" defined by their community. Farmers need to be responsible users of the production inputs and avoid turning those inputs into environmental pollutants. Calibrating the application equipment used to apply farm inputs will help farmers conform and contribute to community standards.

Calibrating your spray equipment means adjusting your sprayer so that the amount of chemical you want to apply to your crop and the amount that is actually applied to the crop is the same. Your equipment is not calibrated if in the middle of applying an insecticide on your crop your spray tank is empty, when you thought you made enough tank mixture for the whole field. Likewise, your equipment is not calibrated if you sprayed your whole field and find half the tank still filled with tank mixture, when it should have been used up. Your equipment is calibrated if your sprayer empties as you complete spraying the target area you planned to cover.

Once your equipment is calibrated, you can use it to deliver accurate amounts of chemicals on any size area. You will know how many gallons of tank mixture you would need to spray 1 acre of your crop. You should be able to say, "I apply ___ gallons of tank mixture per acre when I use this sprayer." When you know the output of your sprayer in *gallons per acre*, you can do the following things.

You can calculate how much water to use to make the tank mixture.

For example, suppose the instruction on the pesticide's label says to apply a dosage of 2 pounds of the pesticide

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per acre but it does not say how much water to mix with the 2 pounds. If you calibrated your sprayer and found that you would need 50 gallons of tank mixture to spray 1 acre, you would know that you should mix 2 pounds of pesticide into 50 gallons of water. You could make just 25 gallons of tank mixture by adding 1 pound to 25 gallons of water. Or you could make 100 gallons of tank mixture by adding 4 pounds to 100 gallons of water.

You can estimate how much tank mixture you need for a job.

Suppose you calibrate your sprayer and find that you need 50 gallons of tank mixture to spray 1 acre. If your job is to spray half an acre, you can estimate that you need only 25 gallons of tank mixture. Knowing this is important, because if you were to make more than 25 gallons of tank mixture, you would not use it all, and you would have mixture left over. Tank mixtures of most insecticides and fungicides lose potency quickly and may not be suitable for use even the day after mixing. Excess tank mixture eventually must be disposed of according to label instructions, which for some pesticides involves complicated or expensive methods.

When to calibrate

Calibrate your sprayer when you want to apply a specific dosage of a pesticide. Also, calibrate the sprayer if you apply a different pesticide, or if you change spraying pressure, speed of travel, nozzles, or the distance between nozzle and target. From time to time the sprayer should be re-calibrated because changes can occur when, for example, the sprayer pressure regulator fluctuates or malfunctions, or nozzles get worn, causing higher output rates.

Prepare to calibrate

You will need the following for gathering information to use in the worksheet:

- a stopwatch or wristwatch for counting seconds
- a measuring container for measuring liquid sprayed from a nozzle
- a measuring tape.

Step 1a. Service your sprayer

Clean the sprayer nozzles, screens, and filters. Spray some water and fix any leaks. If your pesticide's label specifies a maximum pressure, ensure that your sprayer pressure does not exceed it. If the nozzles are set on a boom, ensure that they are the proper height above the ground, that they are evenly spaced, and that their output is uniform. Consult the nozzle manufacturer's catalog or sales representative if necessary.

Step 1b. Choose a spraying pressure

Load your sprayer with some water and spray a sample of the area you plan to treat. Note the operating pressure, then stop and inspect the sprayed plants to see if the spray coverage is adequate. Adjust the pressure if necessary. If small adjustments in pressure do not improve spray coverage quality, you may need to use different nozzle tips, or adjust your speed of travel, or try a different spraying technique. Where spray drift into nearby sensitive areas is possible, it is important to find an acceptable balance between the quality of spray coverage and the effectiveness of drift control.

Step 2. Determine "feet per minute" travel speed of sprayer

To estimate the travel speed of your sprayer, do three spray time trials, spraying water, in a typical part of your field. (The field terrain will influence your speed.) If you spray your field while walking, mark off a length of 100 feet in your trial area and write this length on page 3 in the right column under *Your Worksheet*, Part a. For each trial, keep the spraying pressure as close as possible to the pressure you chose in Step 1b, and walk at a speed you can maintain for the whole spray job. If you spray from a tractor, mark off a length of 250 feet in your trial area and write this length on page 3 in the right column under Part a. Set your tractor to run at the same RPM and gearing you used in Step 1b.

For spray time trial 1, spray the marked length of your trial area while using your watch to count the number of seconds it takes. Write this number on the first line in Part b. Repeat the operation for spray time trials 2 and 3 until you have three counts recorded.

Finally, do the calculations shown for Parts c and d on *Your Worksheet*.

Example Worksheet

a. What is the travel distance?

Answer: **200** ft

b. How long (in *seconds*) did it take to travel the distance? Measure several times.

Answers:
Trial 1: **67** seconds
Trial 2: **63** seconds
Trail 3: **65** seconds

c. What is the average time it took to travel the distance?

Calculation: $67 + 63 + 65 = 195$

$$\frac{195}{3} = 65$$

Answer: **65** seconds

d. What is the tractor speed in feet per minute?

Calculation:

[1] $$\frac{? \text{ ft}}{60 \text{ sec}} = \frac{200 \text{ ft}}{65 \text{ sec}}$$

[2] $? \times 65 = 60 \times 200$

[3] $? \times 65 = 12{,}000$

[4] Divide both sides by 65:

$$\frac{? \times 65}{65} = \frac{12{,}000}{65}$$

[5] $$? = \frac{12{,}000}{65}$$

[6] $? =$ **184.6**

Answer: **184.6** ft traveled in 1 minute

Your Worksheet

a. What is the travel distance?

Answer: _____ ft

b. How long (in *seconds*) did it take to travel the distance? Measure several times.

Answers:
Trial 1: _____ seconds
Trial 2: _____ seconds
Trail 3: _____ seconds

c. What is the average time it took to travel the distance?

Calculation:

Answer: _____ seconds

d. What is the tractor speed in feet per minute?

Calculation:

Answer: _____ ft / min

Step 3. Determine "gallons per minute" (output of sprayer)

To determine the volume output of the sprayer, fill about half of the tank with water. Then, operate the sprayer at the pressure you used in Step 2 and collect water discharging from the nozzles for a specific number of seconds. For a multiple-nozzle sprayer such as a boom sprayer, collect water discharged from each nozzle separately. Repeat the collection several times for each nozzle.

Example Worksheet

a. What is the sprayer operating pressure?

Answer: **45** psi

(Note this for your records, not for calculation)

b. What is the time period (seconds) used to collect water discharged from the nozzle?

Answer: **15** seconds

c. How many nozzles does the sprayer have?

Answer: **3** nozzles

d. In the time period, how much water does each nozzle discharge?

Nozzle 1	**13.5**	fl oz
	14.0	fl oz
	15.0	fl oz
Nozzle 2	**12.5**	fl oz
	15.5	fl oz
	13.0	fl oz
Nozzle 3	**12.0**	fl oz
	16.0	fl oz
	13.5	fl oz

e. In the time period, what is the average nozzle discharge rate?

Calculation:

$$13.5 + 14 + 15 + 12.5 + 15.5 + 13 +$$

$$12 + 16 + 13.5 = 125 \text{ fl oz}$$

$$\frac{125 \text{ fl oz}}{9} = 13.9 \text{ fl oz}$$

Answer: **13.9** fl oz per **15** seconds

Your Worksheet

a. What is the sprayer operating pressure?

Answer: _____ psi

(Note this for your records, not for calculation)

b. What is the time period (seconds) used to collect water discharged from the nozzle?

Answer: _____ seconds

c. How many nozzles does the sprayer have?

Answer: _____ nozzles

d. In the time period, how much water does each nozzle discharge?

Nozzle 1	_____	fl oz
	_____	fl oz
	_____	fl oz
Nozzle 2	_____	fl oz
	_____	fl oz
	_____	fl oz
Nozzle 3	_____	fl oz
	_____	fl oz
	_____	fl oz

e. In the time period, what is the average nozzle discharge rate?

Calculation:

Answer: _____ fl oz per _____ seconds

Example Worksheet (continued)

f. For the number of nozzles on the sprayer (Step 3c) and in the time period (Step 3b), what is the average rate of all nozzles on the sprayer?

Calculation: 13.9 fl oz × 3 nozzles = 41.7 fl oz

Answer: **41.7** fl oz

g. What is the water discharge per minute of the sprayer?

Calculation: *(Note:* 60 seconds = 1 minute)

$$\frac{?\ \text{fl oz}}{60\ \text{sec}} = \frac{41.7\ \text{fl oz}}{15\ \text{sec}}$$

$$? \times 15 = 41.7 \times 60$$

$$\frac{? \times 15}{15} = \frac{2500}{15}$$

$$? = \frac{2500}{15}$$

$$? = \mathbf{166.7}$$

Answer: **166.7** fl oz per minute

h. Convert fluid ounces per minute to gallons per minute.

Calculation: *(Note:* 128 fl oz = 1 gallon)

$$\frac{1\ \text{gal}}{128\ \text{fl oz}} = \frac{?\ \text{gal}}{166.7\ \text{fl oz}}$$

$$? \times 128 = 1 \times 166.7$$

$$\frac{? \times 128}{128} = \frac{166.7}{128}$$

$$? = \frac{166.7}{128}$$

$$? = \mathbf{1.3}$$

Answer: **1.3** gallons per minute

Your Worksheet (continued)

f. For the number of nozzles on the sprayer (Step 3c) and in the time period (Step 3b), what is the average rate of all nozzles on the sprayer?

Calculation: _____ fl oz × ____ nozzles = _____ fl oz

Answer: _____ fl oz

g. What is the water discharge per minute of the sprayer?

Calculation: *(Note:* 60 seconds = 1 minute)

Answer: _____ fl oz per minute

h. Convert fluid ounces per minute to gallons per minute.

Calculation: *(Note:* 128 fl oz = 1 gallon)

Answer: _____ gallons per minute

Step 4. Determine width of spray pattern

Determine the width of spray coverage of the sprayer (width of the wet zone). Over a hard dry surface, hold the nozzle at operating height and pressure, and turn on sprayer. Measure the length of the wet line of the spray. This will give you the width of your spray coverage.

Example Worksheet

a. What is the width of spray coverage?

Answer: **70** inches

b. Convert inches to feet.

Calculation: (*Note:* 12 inches = 1 foot)

$$\frac{70}{12} = 5.8$$

Answer: **5.8** feet

Your Worksheet

a. What is the width of spray coverage?

Answer: _____ inches

b. Convert inches to feet.

Calculation: (*Note:* 12 inches = 1 foot)

Answer: _____ feet

Step 5. Your sprayer calibration

Calibrate the sprayer using the three values calculated above: speed in feet per minute, water discharge in gallons per minute, and width of spray coverage in feet.

Example Worksheet

a. How many square feet can the sprayer cover at the calculated discharge rate per minute?

Note:
Speed is 184.6 feet per minute (from Step 2d).

Spray width is 5.8 feet (from Step 4b).

Calculation:

$$\frac{184.6 \text{ ft}}{1 \text{ min}} \times 5.8 \text{ ft} = \frac{1071 \text{ sq ft}}{1 \text{ min}}$$

Answer: **1071** square feet

b. How many gallons per acre would you apply with your sprayer?

Note: Discharge rate is 1.3 gallons per minute (from Step 3h).

Calculation:

$$\frac{1.3 \text{ gal}}{1 \text{ min}} \times \frac{1 \text{ min}}{1071 \text{ sq ft}} \times \frac{43{,}560 \text{ sq ft}}{1 \text{ acre}} =$$

$$\frac{1.3 \times 1 \times 43{,}560}{1 \times 1071 \times 1} =$$

$$\frac{56{,}628}{1071} = 53$$

Answer: **53** gal per acre

So you can say, "I apply 53 gallons of tank mix per acre when I use this sprayer."

Your Worksheet

a. How many square feet can the sprayer cover at the calculated discharge rate per minute?

Note:
Speed is _____ feet per minute (from Step 2d).

Spray width is _____ feet (from Step 4b).

Calculation:

Answer: _____ square feet

b. How many gallons per acre would you apply with your sprayer?

Note: Discharge rate is _____ gallons per minute (from Step 3h).

Calculation:

Answer: _____ gal per acre

So you can say, "I apply _____ gallons of tank mix per acre when I use this sprayer."

Step 6. Determine the correct amount of pesticide to add to a tank mixture

a. Study your pesticide label and determine the dosage allowed for your pest and crop.
b. Measure the target area to be sprayed and determine its size.
c. Calculate the amount of pesticide to use to spray the target area. Three examples are shown below.

Dosage allowed (from pesticide label)	Size of target area to be sprayed	Formula to be solved	Calculation
Example 1 2 pints per acre	0.33 acre	$\frac{?\text{ pt}}{0.33\text{ acre}} = \frac{2\text{ pt}}{1\text{ acre}}$	$? \times 1 = 2 \times 0.33$ $? = 2 \times 0.33$ $? = 0.66$ *Answer:* 0.66 pt for 0.33 acre
Example 2 12 pounds per acre	5.45 acres	$\frac{?\text{ lb}}{5.45\text{ acre}} = \frac{12\text{ lb}}{1\text{ acre}}$	$? \times 1 = 12 \times 5.45$ $? = 12 \times 5.45$ $? = 65.4$ *Answer:* 65.4 lb for 5.45 acres
Example 3 5 fluid ounces per 1000 sq ft	11,000 sq ft	$\frac{?\text{ fl oz}}{11{,}000\text{ sq ft}} = \frac{5\text{ fl oz}}{1000\text{ sq ft}}$	$? \times 1000 = 5 \times 11{,}000$ $? \times 1000 = 55{,}000$ Divide both sides by 1000: $\frac{? \times \cancel{1000}}{\cancel{1000}} = \frac{55{,}000}{1000}$ $? = 55$ *Answer:* 55 fl oz for 11,000 sq ft

Sprayer calibration calculator spreadsheet

A facsimile of the computer spreadsheet appears on pages 10–11. Although this facsimile is a black-and-white image, on the computer it will display in color. The spreadsheet is written for the Microsoft Excel® computer program. With a computer connected to the Internet, go to <http://www.ctahr.hawaii.edu/freepubs> and look under Pesticide Risk Reduction Education to download the Sprayer Calibration Template to your computer. You must have Excel installed on your computer to use the spreadsheet.

Before using the spreadsheet, first follow the steps beginning on page 2 to do the measurements and calibration trials in the area you want to treat with a pesticide. Then, return to your computer and enter the measurements and trial results into the blue and yellow boxes in the spreadsheet. Follow the template instructions, reproduced on page 11, as you enter your information. The computer will automatically display the calculated numbers in the white boxes. In the green boxes, you can enter information that does not figure in the computer's calculations but may be useful when you need to calibrate your sprayer again.

Sprayer Calibration Template

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Enter information in the Blue and Green rectangular cells to calibrate your sprayer and determine product dosage/dilution and water measurements.

Blue = Information required for calibration or calculation of a section
Green = Information for your records; entries not figured in calculations (indicated with **)
White = Information automatically calculated
Yellow = Enter value you went to convert

Tractor ID, RPM, transmission gearing, PSI, and sprayer ID

1. RPM =
2. Gear =
PSI =

Tractor and sprayer ID

3. Tractor =
Sprayer =

Travel speed information, tractor or walking

4. Travel distance (ft) = 100.00 ft
5. Time to travel the distance (sec) =
6. Tractor speed in feet per minute (ft/min) =

Volume water output from sprayer nozzle(s) and coverage information

7. Average sprayer output (gal) (use conversion table) = 0.08 gal
8. Time period of measuring output (sec) = 15.00 sec
9. Gallons water per minute output of sprayer = 0.32 gal/min
10. Width of spray coverage (ft) = 3.00 ft
11. Area coverage (sq ft/min) = 562.50 sq ft/min

Calibration of sprayer, on information provided in #1 to #11

12. Calibration of sprayer, volume of water per acre = 24.78 gal/acre

1 ACRE = 43560.00 SQ FT

13. NUMBER OF ACRES SPRAYED PER HOUR (acre/hr) = 0.77 acre/hr

Calculating gallons of water required from known acreage to spray

14. How many acres do you want to spray today? 2.00 acre
15. Gallon(s) water required for 2.00 acre = 49.56 gal

Calculating acreage from known volume of water in sprayer

16. How many gallon(s) water did you put in the sprayer? 200.00 gal
17. The number of acres you can spray with 200.00 gal = 8.07 acre

Calculating product dosage and dilution

18. What product are you applying today?** ROUNDUP
19. What label dosage rate per acre are you applying? 1.00 units/acre
20. What unit of measure are you using (liter, lb, gal, fl oz)?** GAL
21. Product units needed for (#15) 2.00 acre = 2.00 units
22. Product units needed for (#17) 200.00 gal water = 8.07 units

Table 1: Guidelines for diluting water and product for known area to be sprayed.

Your field number	Field width (feet)	Field length (feet)	Square feet	Acres	Gal water required	Liter water required	Units product required
1	40.00	30.00	1200.00	0.03	0.68	2.58	0.03
	20.00	50.00	1000.00	0.02	0.57	2.15	0.02
	3000.00	5500.00	16500000.00	378.79	9386.67	35532.29	378.79
			0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00

Conversion (miles/hr to feet/min)
MPH = 1.000
FPM = 88.000

Conversion (feet/min to miles/hr)
FPM = 88.000
MPH = 1.000

Volume Conversion

fl oz	to gallon
128.00	1.000

fl oz	to pint
	0.000

pint	to fl oz
1.00	16.000

pint	to cup
	0.000

cup	to pint
	0.000

cup	to fl oz
	0.000

fl oz	to cup
	0.000

ml	to gal
	0.000

gallon	to ml
	0.000

fl oz	to ml
	0.000

ml	to fl oz
	0.000

Mass Conversion

lb	to oz
	0.000

oz	to lb
	0.000

lb	to kg
	0.000

kg	to lb
	0.000

oz	to g
	0.000

g	to oz
1.00	0.035

Area Conversion

sq feet	to acre
	0.000

acre	to sq ft
	0.000

sq feet	sq root
43560.00	208.710

Template Instructions

Tractor RPM and gearing information** **(** = for your information, not used in calculations)**
#1 and #2: Enter the tractor RPM, gearing, and sprayer PSI you will use to operate the tractor and sprayer for your calibration and spraying activities.

RPM = 1500 GEAR = 3rd, Low
PSI = 45

Tractor and sprayer ID**
#3 Enter the tractor and sprayer you will use for this calibration; e.g., Case 695, Gearmore.

Travel speed information: Travel speed of your tractor for mounted sprayer or walking speed for knapsack sprayer.
#4 Enter the distance you will travel for this calibration activity. Measure distance with tape measure; e.g., 150 feet.
#5 Using a watch or stopwatch, record the time in seconds it took to travel the measured distance; e.g., 32 seconds.

#6 Tractor speed measued in feet per minute will be calculated.

gal	to fl oz
	0.000
quart	to pint
1.00	2.000
pint	to quart
2.00	1.000

Sprayer water output from nozzles and coverage information
#7 Using measuring beakers, record the volume of water discharged from the nozzles at the RPM and PSI set in #1 and #2 for a constant period (#8). For multi-nozzle sprayers, such as boom sprayers, measure volume from each nozzle for a constant period. For a boom sprayer, be sure to enter the total volume from all the nozzles; e.g., 300 ml, 2 gal.
#8 Enter the time period used to measure the volume of water discharge; e.g., 15 sec.
#9 Sprayer output measued in gallons per minute will be calculated.
#10 Enter the width of the spray coverage; e.g., 12 ft, 3 ft.
#11 Area coverage measured in square feet per minute will be calculated.

Sprayer output calibration
#12 Water output measured in gallons per acre will be calculated.
#13 The number of acres you can spray per hour will be calculated.

Calculating gallons water required for known acreage to spray
#14 Enter the number of acres you want to spray; e.g., 1 acre, 0.5 acre, 10.657 acre.
#15 The number of gallons water required for the amount of acres you entered in #14 will be calculated.

Calculating acreage for known volume of water in sprayer
#16 Enter the number of gallons water you put in the sprayer; e.g., 5 gal, 36 gal, 222 gal, etc.
#17 The number of acres you will be able to spray with the amount of water you entered in #16 will be calculated.

Calculating product dosage and dilution
#18 Enter the product name you are applying, for your records;** e.g., Admire, GOAL, RoundUp, etc.
#19 Enter the product label rate, in units (amounts) per acre, that you are applying to the crop.
#20 Enter the unit of measure that represents #19;** e.g., gallons, grams, liters, pounds, oz, quarts.
#21 The product units needed for the number of acres entered in #14 will be calculated.
#22 The product units needed for the number of gallons water entered in #16 will be calculated.

Table 1: Guidelines for mixing water and product for a known area to be sprayed
Use Table 1 after completing calibration activities #1 to #22.
Sometimes you have different size fields that are treated with the same prdoduct. Table 1 allows you to identify the field and determine the size of the field, and ir provides calculations that will help you with your spraying operation.

Table 1 Instructions:
Enter your field number.** Enter the width of the field, measured in feet. Enter the length of the field, measured in feet. Repeat this process for the other fields where you are applying the same product.

If you have a circular field and know the acreage, go to the Area Conversion Table to convert square feet into square root.

This will give you a square demension of your circular field. Enter SQ. ROOT from the conversion table in the field width and length.

The square feet of the field, acreage of the field, gallons or liters of water required, and the amount of product required will be calculated for that field. Calculations will be provided for each field for which you enter dimensions.