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WILLIAM E. STEINKE
Extension Agricultural Engineer

University of California
Biological & Ag Engineering
One Shields Avenue
Davis, California 95616-5294

Phone: (530) 752-1613
Fax: (530) 752-2640
E-Mail: westeinke@ucdavis.edu

Calibrating Vine Sprayers

Calibrating a vine sprayer is simple whether it is a high-volume, low-volume, air-carrier, or herbicide boom sprayer. Often, each sprayer operation has certain knowns, and a little arithmetic and a nozzle chart will provide all the factors needed for proper calibration.

Typically known:
(1) gpa (gallons per acre) desired
(2) psi (pounds pressure per square inch) desired
(3) mph (miles per hour) desired
(4) number of nozzles on sprayer
(5) vine row spacing

Typically unknown:
(6) gpm (gallons per minute) needed
(7) nozzle sizes and placement
(8) simple measurement for speed

Travel Speed

Travel speed must be measured under field and tractor operating conditions. Values read from engine tachometers on the tractor can have significant errors due to tire size and inflation differences and wheel slip due to soil characteristics, tractor weighting, and sprayer loads. Before doing the calculations associated with nozzle selection and placement, measure actual travel speed.

Mark out a known distance, such as 100 or 200 feet, preferably in the vineyard to be sprayed. If that is not possible, duplicate such conditions as soil tilth, cover, and soil moisture between the vineyard and the marked course. Connect the tractor-sprayer combination to be used, and fill to one-half to two-thirds with water. Engine-operating rpm and gear selection should be that used for pesticide application.

Start from several yards before the marked course and drive the tractor just as during the application. The sprayer should be operating. Measure the time required to pass through the known distance with a stopwatch or a watch with a second hand or seconds digits. Repeat the procedure at least two times, traveling in both directions, and average the resulting time.

Travel speed is then calculated from:

$$\frac{100 \text{ feet}}{x \text{ seconds}} \times \frac{1 \text{ mile}}{5{,}280 \text{ feet}} \times \frac{3{,}600 \text{ seconds}}{1 \text{ hour}} =$$

Example: Two passes are made on a 100-foot course, one at 26 seconds, and the other at 27 seconds. Average pass = 26.5 seconds.

$$\frac{100 \text{ feet}}{26.5 \text{ seconds}} \times \frac{1 \text{ mile}}{5{,}280 \text{ feet}} \times \frac{3{,}600 \text{ seconds}}{1 \text{ hour}} = 2.57 \text{ mph}$$

You can also use vine spacing to calculate the mph speed of travel on the basis that 1 mph = 88 feet per minute.

Example:

$$\text{Vines/min.} = \frac{3 \text{ mph} \times 88 \text{ ft/min}}{8\text{-ft vine spacing}}$$

$$= \frac{264}{8}$$

$$= 33 \text{ vines per min } (= 3 \text{ mph})$$

Or use table 2, which shows the number of vine spaces you must pass in 1 minute, to obtain your desired (mph) travel speed in relation to the planting distance between vines.

Table 2. Travel speed relative to planting distances

	Number of vine spaces passed per minute		
		Planting distances	
Miles per hour (mph)	6 feet	7 feet	8 feet
2	30	25	22
2.5	37	31	28
3	44	38	33
3.5	51	44	39
4	59	50	44
4.5	66	57	50
5	73	63	55

Following are calibration examples for different vine sprayers:

Example A. An over-the-vine, high-pressure boom sprayer covers two complete rows per pass. (See fig. 1.)

Known:

(1) gpa = 200. Desired application rate per acre
(2) psi = 300. Pounds pressure per square inch at nozzle
(3) mph = 3. Selected travel speed
(4) number of nozzles = 20 nozzles on sprayer (10 per side)
(5) vine row spacing = 24 feet (Although row spacing is 12 feet, to spray two rows, use a 24-foot spray swath; for a 10-foot planting, spray swath is 20 feet.)

Unknown:

$$(6)\ \text{gpm} = \frac{\text{gpa} \times \text{mph} \times \text{row spacing}}{495 \text{ (conversion factor)}}$$

$$= \frac{200 \times 3 \times 24}{495}$$

$$= \frac{14{,}400}{495}$$

$$\text{gpm} = 29$$

(7) For 20 nozzle positions you will need a discharge of 29 gpm.

$$\frac{29}{20} = 1.45 \text{ gpm/nozzle}$$

Because vines are not as thick or as dense uniformly from bottom to top, it is necessary to use two or three different nozzle sizes (S = small, M = medium, L = large) to place more spray in the shoulder area (fig. 13). To do this, select some nozzles that discharge more and some less than 1.45 gpm. Nozzle calculations are more easily made if based on one row or one side and then later duplicated for the other row or side. Accordingly, aim for a 10-nozzle arrangement and a total discharge of 14.5 gpm (10 × 1.45 gpm per nozzle) (fig. 14).

Nozzle charts for the type of nozzles on your sprayer (as the following chart in table 3 shows) will give the gpm discharge of different size tips. *Note:* If you use swirl plates in your nozzles, use the nozzle chart corresponding to swirl place size.

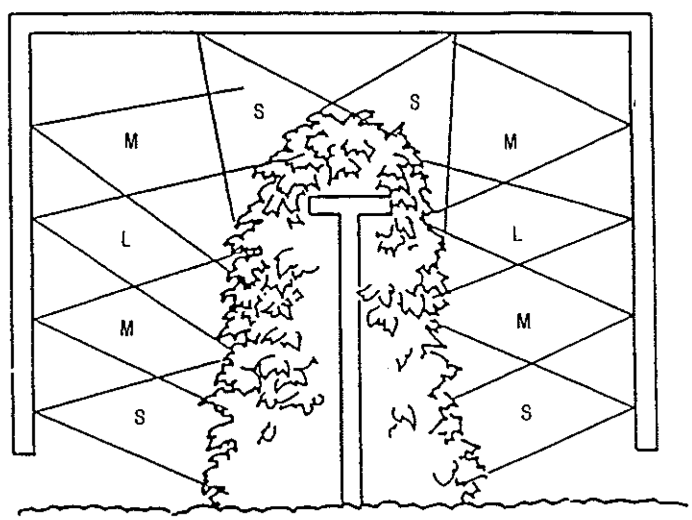

Fig. 13. Spray boom on one side of an over-the-vine, high-pressure boom sprayer showing relative nozzle sizes.

Table 3. Hollow-cone nozzle chart

Disc-core number	Gallons per minute (gpm) 40 psi	100 psi	200 psi	300 psi
4-25	.29	.45	.62	.75
5-25	.35	.54	.75	.90
6-25	.44	.70	.97	1.19
7-25	.52	.81	1.18	1.37
8-25	.61	.97	1.36	1.68
10-25	.76	1.21	1.71	2.10

For the sprayer in this example, using a spray pressure of 300 psi, check the 300 psi column to find the gpm for each different size nozzle tip. You will need an average output per nozzle of 1.45 gpm, but because of the variations needed for proper vine coverage, you will probably want four nozzles smaller than 1.45 gpm, four nozzles approximately 1.45 gpm, and two nozzles larger than 1.45 gpm, placed as shown in the diagram to provide greatest coverage to the densest part of vine rows. Therefore, by selecting four No. 6 tips, four No. 7 tips, and two No. 10 tips you can arrive at an acceptable nozzle arrangement.

4 No. 6-25 disc-core = 4 × 1.19 = 4.76 gpm
4 No. 7-25 disc-core = 4 × 1.37 = 5.48 gpm
2 No. 10-25 disc-core = 2 × 2.10 = 4.20 gpm

14.44 gpm

14.44 gpm is satisfactorily close to the 14.5 gpm desired. (Obtaining the exact nozzle gpm output is seldom possible.)

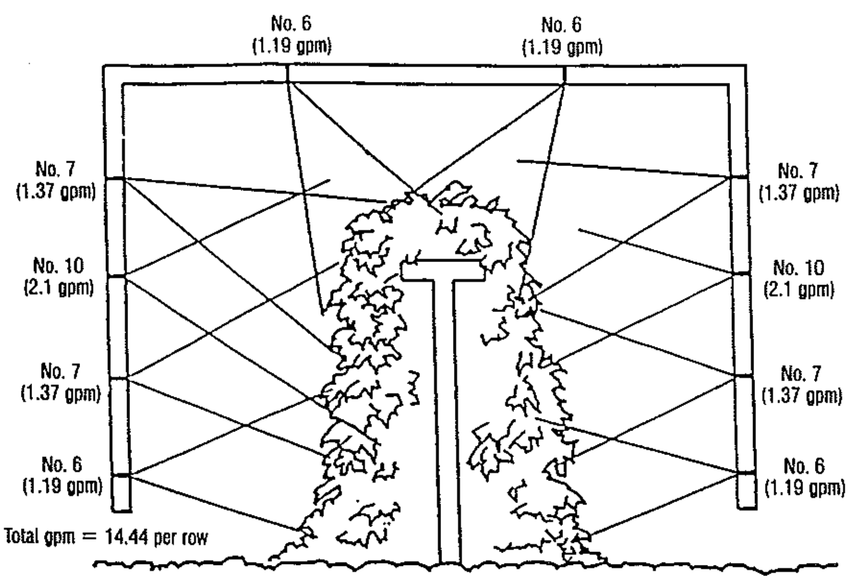

Fig. 14. Spray boom on one side of an over-the-vine, high-pressure sprayer, showing actual disc using a No. 25 swirl plate. This same nozzle arrangement can be duplicated on the other side of the sprayer.

Example B. An air-carrier sprayer travels each row and sprays two half rows. (See fig. 2.)

Known:

(1) gpa = 50. Desired application rate per acre
(2) psi = 100. Pounds pressure per square inch at nozzle
(3) mph = 3. Selected travel speed
(4) number of nozzles = 10 nozzles on sprayer (5 per side)
(5) vine row spacing = 12-foot row (or swath)

Unknown:

(6) $\text{gpm} = \dfrac{\text{gpa} \times \text{mph} \times \text{row spacing}}{495}$

$$= \frac{50 \times 3 \times 12}{495}$$

$$= \frac{1{,}800}{495}$$

gpm = 3.6

(7) For 10 nozzle positions you will need a discharge of 3.6 gpm.

$$\frac{3.6}{10} = .36 \text{ gpm/nozzle}$$

Because vines are not as thick or as dense uniformly from bottom to top, it is necessary to use two or three different nozzle sizes (S = small and L = large) to place more spray into the shoulder area (fig. 15). To do this, select some nozzles that discharge more and some less than .36 gpm. For one side of the sprayer and ease of calculation aim for a five-nozzle arrangement. Therefore, the five nozzles are required to discharge only one half of the necessary 3.6 gpm, or 1.8 gpm per side.

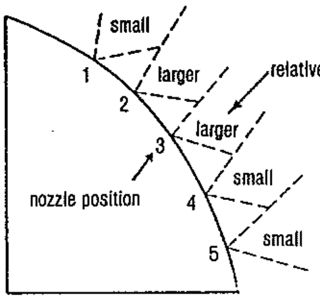

Fig. 15. One side of an air-carrier sprayer showing relative nozzle sizes.

Using a nozzle chart for the type of nozzles on your sprayer, as the following example shows in table 4, check the column headed by the pressure (psi) you will use to get the gpm discharge for each different-sized nozzle tip. This example uses a pressure of 100 psi. *Note:* For nozzles with swirl plates, use the nozzle chart corresponding to the swirl plate size.

Table 4. Hollow-cone nozzle chart

	Gallons per minute (gpm)				
Disc-core number	40 psi	100 psi	150 psi	200 psi	300 psi
2-25	.16	.25	.29	.34	.41
3-25	.19	.29	.35	.40	.48
4-25	.29	.45	.54	.62	.75
5-25	.35	.54	.65	.75	.90

Check the 100 psi column for the gpm for each different nozzle tip. In this example you will need an average output per nozzle of 0.36 gpm, but because of the nozzle size difference for proper vine coverage you will probably want three nozzles smaller than 0.36 gpm and two nozzles larger than .36 gpm. By selecting three No. 3-25 disc-cores and two No. 4-25 disc-cores you can arrive at an acceptable nozzle arrangement sufficiently close to the required 1.8-gpm discharge requirement (fig. 16).

3 No. 3-25 disc-core = 3 × .29 = .87 gpm
2 No. 4-25 disc-core = 2 × .45 = .90 gpm

1.77 gpm

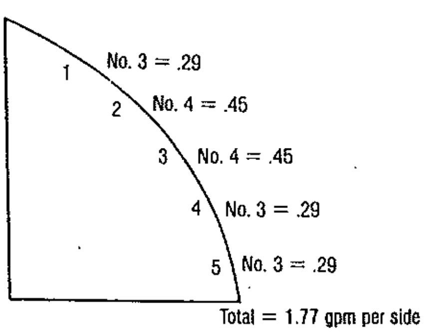

Fig. 16. One side of an air-carrier sprayer showing actual nozzle size selection and placement. This same nozzle arrangement can be duplicated on the other side of the sprayer.

(8) Sprayers that use air-shear nozzles and are calibrated on the basis of gallons per hour would be calibrated as 3.6 gpm × 60 minutes = 216 gph. Since they use low-pressure, air-shear-type nozzles rather than conventional nozzles with different size orifices and cores, nozzle pressure is not important. Therefore, follow a simple calibration step of merely setting a valve pointer at the desired gph. Still, where adjustment of individual nozzle flow is possible, try directing the greatest flow to the densest part of vines (fig. 17).

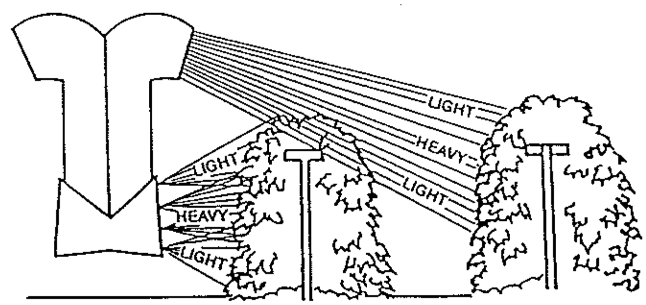

Fig. 17. One side of an air-carrier sprayer that travels every other row and sprays four half rows.

Example C. An air-carrier sprayer travels every other row and covers four half rows per pass. (See fig. 3.)

Known:

(1) gpa = 50. Desired application rate per acre
(2) psi = 100. Pounds pressure per square inch at nozzle
(3) mph = 3. Selected travel speed
(4) number of nozzles = 14 nozzles on sprayer
(5) vine row spacing = 24 feet (Although row spacing is 12 feet, to cover the equivalent of two rows, use a 24-foot spray swath 2 rows × 12 feet.)

Unknown:

$$(6)\ \text{gpm} = \frac{\text{gpa} \times \text{mph} \times \text{row spacing}}{495}$$

$$= \frac{50 \times 3 \times 24}{495}$$

$$= \frac{3{,}600}{495}$$

$$\text{gpm} = 7.27$$

(7) This system employs two air heads per side (each head having its own set of nozzles), one low head for the row adjacent to the sprayer, and a high-level head directed at the next row beyond the adjacent row (fig. 3 and 17). In this example you could use three nozzles on the low head and four on the high head. Therefore, for actual nozzle selection, be guided by the visual pattern shown in preceding figures and by Example B.

Sprayers that use air-shear nozzles and are calibrated on the basis of gallons per hour should be calibrated as follows: 7.27 gpm × 60 minutes = 436.2 gph. Because they use low-pressure, air-shear-type nozzles, rather than conventional nozzles with different size orifices and cores, nozzle pressure is not important. Therefore, follow their simple calibration steps, which may consist of merely setting a valve pointer at the desired gph. Still, where adjustment of individual nozzle flow is possible, try to direct the greatest flow to the densest area of the vine.

Example D. Multiple-air fan (over-the-vine), two-row sprayers cover two complete rows per pass and travel every other row. (See fig. 4.)

If the sprayer is an over-the-vine, two-row, air-carrier sprayer utilizing four to six small fans per row, calculate the gpm as shown in Example A. However, because you are not dealing with high-pressure, conventional nozzles adjust the spray flow per fan so that the bulk of the spray discharge is directed at dense shoulder areas of vines. This, as previously mentioned, is where the greatest leaf growth and number of fruit bunches are located. Because these sprayers have adjustable angle fans and may have four to six fans per row, trial-and-error adjustments are necessary for optimum deposition.

New Application Techniques

Nonconventional spray application devices have been evaluated for their ability to improve pest control over existing methods, to benefit integrated pest management goals, or to lessen operational costs. Such interest is primarily directed at suppressing arthropods and diseases. Evaluations have been made principally by observing the deposition of spray containing colored dye on target cards, evaluating plant tissue residues, or making mite counts.

Use of electrostatic sprayers in vineyards has been found to be less effective compared with their use in fruit trees.

Controlled droplet application, as tested, shows good potential for short-range targets. Using air-ducting arms traveling underneath grapevines has proved superior in obtaining inside vine deposition because spray-laden air is forced up into fruit clusters. This type of application is especially valuable for combating OLR, orange tortrix, mildew, and bunch rot.

Vineyard Floor Sprayers

Vineyard floor sprayers are used to either cover the entire soil surface between vine rows (fig. 18) or to treat vine row berms only (fig. 19). Such sprayers can be constructed simply and economically. Small pumps are satisfactory because of the low gallon-per-acre (10 to 100 gpa) and pressure requirements (20 to 60 psi). Booms, set parallel to the ground, transfer pesticides and allow proper spacing and support for the nozzles, which are usually flat-fan types. Because the target (the ground) is relatively flat and at a uniform distance from each nozzle, the same-size nozzle is used across the boom to maintain an even pattern. These nozzles should be set a uniform distance apart and height above the ground so that they properly overlap at the edges of their fan pattern. Nozzle catalogs have charts showing the proper relationship between nozzle angle, height, and spacing.

The boom, for safety, should be hinged so that it will swing away and not be damaged if it hits a vine. Hinged booms can also be folded back during transportation. With a simple spring attachment the boom can be designed to return and hold to normal position after retraction.

Calibrating boom sprayers is simple and similar to calibrating vine sprayers. Therefore, if the gpm, psi, mph, number of nozzles, and swath width (usually the same as the boom width and/or row width) are known, the unknown can be accurately and quickly determined.

For example:

Known:

(1) gpa = 40
(2) psi = 30 or 40
(3) mph = 3
(4) number of nozzles = 7
(5) swath width = 11.67 feet

Unknown:

$$(6)\ \text{gpm} = \frac{\text{gpa} \times \text{mph} \times \text{swath width}}{495}$$

$$= \frac{40 \times 3 \times 11.67}{495}$$

$$= \frac{1{,}400}{495}$$

$$\text{gpm} = 2.8$$

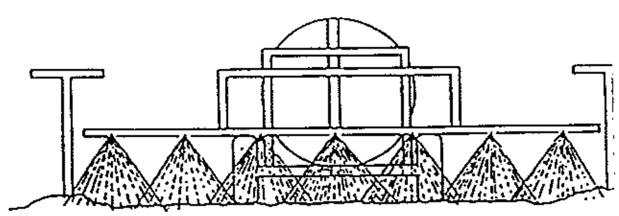

Fig. 18. Vineyard floor sprayer with complete coverage boom.

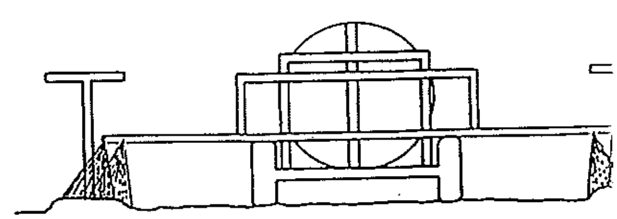

Fig. 19. Vineyard floor sprayer for berm-only coverage.

(7) For seven nozzle positions you will need a discharge of 2.8 gpm.

$$\frac{2.8}{7} = .40 \text{ gpm/nozzle}$$

Because all nozzles can be the same size for this type of spraying, look at flat-fan nozzle charts (table 5), as per the following example, and read the output for 40 psi. From this chart select the nozzle size that most closely discharges .40 gpm. Place seven of these nozzles on the boom, spaced as recommended at 20 inches apart and 17 to 19 inches above the ground. This would be an 80-degree fan nozzle with a flow rate of 0.40 gpm at 40 psi.

Note: If spraying only vine row berms (fig. 19) and you wish to use two nozzles per berm, follow the same procedure.

For example:

Known:

(1) gpa = 15. Three acres of vineyard are treated with this amount since only 4 feet of each 12 are treated.
(2) psi = 30
(3) mph = 3
(4) number of nozzles = 4
(5) swath width = 4 feet

Unknown:

$$\text{(6) gpm} = \frac{\text{gpa} \times \text{mph} \times \text{swath width}}{495}$$

$$= \frac{15 \times 3 \times 4}{495}$$

$$= \frac{180}{495}$$

$$\text{gpm} = .36$$

Table 5. Flat-fan nozzle chart

Nozzle tip no.	psi	gpm
1	30	.09
	40	.10
2	30	.17
	40	.20
3	30	.26
	40	.30
4	30	.35
	40	.40
5	30	.43
	40	.50

(7) For four nozzle positions you will need a total discharge of .36 gpm

$$\frac{0.36}{4} = .09 \text{ gpm/nozzle}$$

Because all four nozzles can be the same size with this type of application, look at a flat-fan nozzle chart and read down the 30 psi column. From this chart select the nozzle that most closely discharges .09 gpm (no. 1's). Place four of these nozzles on the boom, two at each end for proper berm coverage. *Note:* To eliminate double coverage, off-center nozzles may be more desirable at the end of the boom.

Spray Check

Finally, to check your calibration:

(1) Spray out an area of vines with plain water to check the spray pattern and the total gpa output; rearrange or change nozzles as needed.

(2) If the gpa is incorrect, check whether your original pressure reading (necessary for proper nozzle size selection) was wrong, whether your nozzle size selections were incorrect, or whether speed of travel was too slow or too fast.

(3) The best method for checking sprayer deposition visually is to spray a water-soluble dye that will not injure vines and is permissible to use on grapes. Water-soluble food-color dyes used in the baking industry are available in different colors at food supply houses.

For foliage-applied materials, staple 3- by 5-inch file cards at 1-foot intervals on a 7-foot lath. Place one to three of these laths inside the vines on each side of the travel row against the support wire. Operate the calibrated sprayer past the test area and observe the spray deposit on the cards. Deposits not only show hits and misses, but also the sprayer's spray-droplet pattern. It is wise, however, to make an initial run outside the vine row to see how the pattern looks unobstructed. Here, you simply anchor the laths 12 feet apart (if 12 feet is the row spacing) and drive the sprayer between the two laths. After reading the results and making minor corrections, repeat the operation in the vine rows. This type of spray check is often revealing and may help visualize problems with an existing sprayer setup. Water-sensitive paper may also be used. Water-sensitive paper eliminates the need for using colored dye, but is more expensive.

All spray equipment should be double- or triple-rinsed after use. This involves running clean water through the entire system and nozzles, followed with a rich horticultural oil/water spray mix. After the tank has been emptied, leave drain and fill holes open so that tank and lines can dry.

Never treat vineyards with spray equipment in which hormone-type herbicides (2,4-D) have been used; residues can build up in rubber hoses and fittings, leading to contamination and vine damage.