Section VI

New Mexico Pesticide Applicator Training
Agricultural Pests and Agricultural Weeds

Calibration

Adapted with permission from the
Arizona Study Guide for Agricultural Pest Control Advisors (1991)

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CALIBRATION
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I. CALIBRATION OF SPRAYERS

A. Preliminary Servicing

Before you go to the field, service the entire sprayer in the following manner:

Strainers: Clean all screens and strainers. Check to be sure that all strainers are 50 mesh or coarser and are in place.

Tank: Is tank clean and free of scale and sediment?

Operating Condition: Check overall system operation.

Pressure Gauge: Check operation; occasionally remove and check against a known pressure to be sure it is working properly.

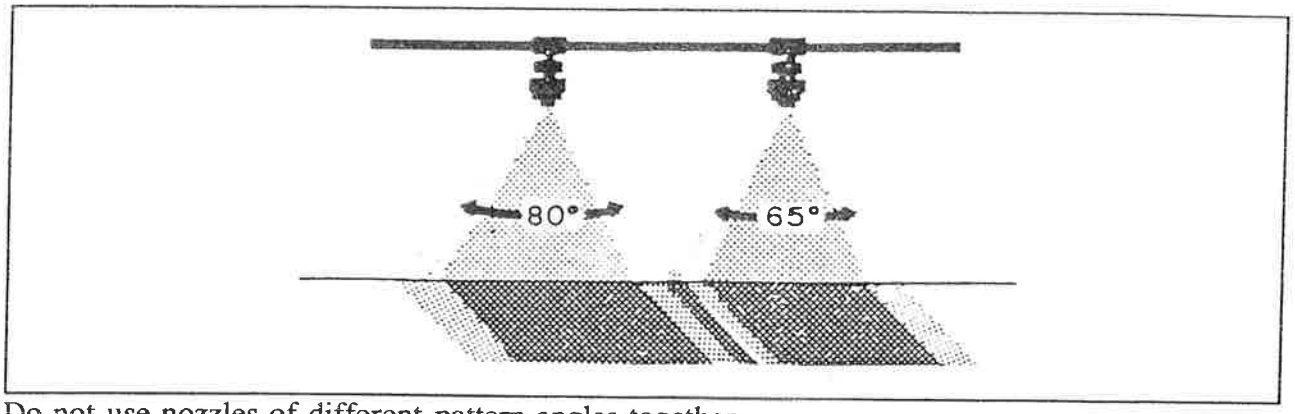
Nozzles: Check nozzles to be sure they are clean and free from blockage.

WARNING

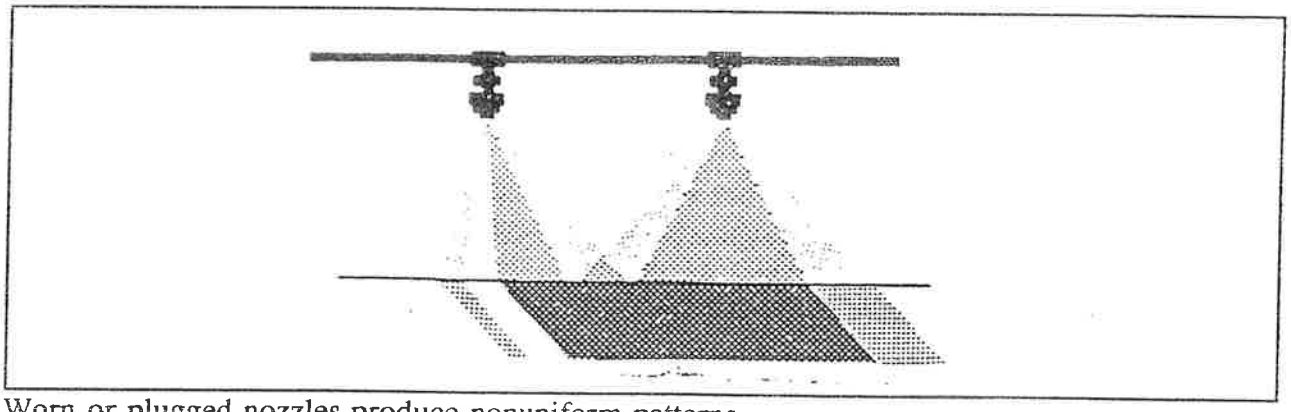
Never use a pocket knife or other metal object to clean a nozzle. It will damage the precisely finished nozzle edges and ruin the performance. A round wooden toothpick is much better. Better still, remove the nozzle tip and back-flush it with air or water first before trying anything else. **Don't blow through it with your mouth...chemicals are poisons!**

Boom: Adjust boom height and nozzles for correct application pattern. Refer to the following illustrations for particular details that affect spray patterns.

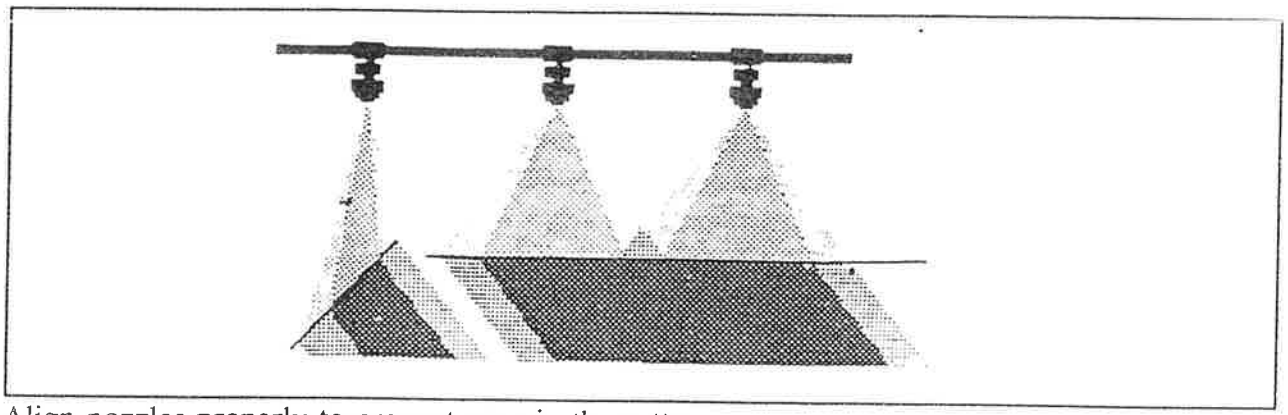
Flow Rate: During the calibration procedure, check each nozzle flow for uniformity by catching flow in a measuring cup marked in fluid ounces. Replace nozzles if uneven flow is noted. A maximum of 5 percent variation between nozzle output is recommended.



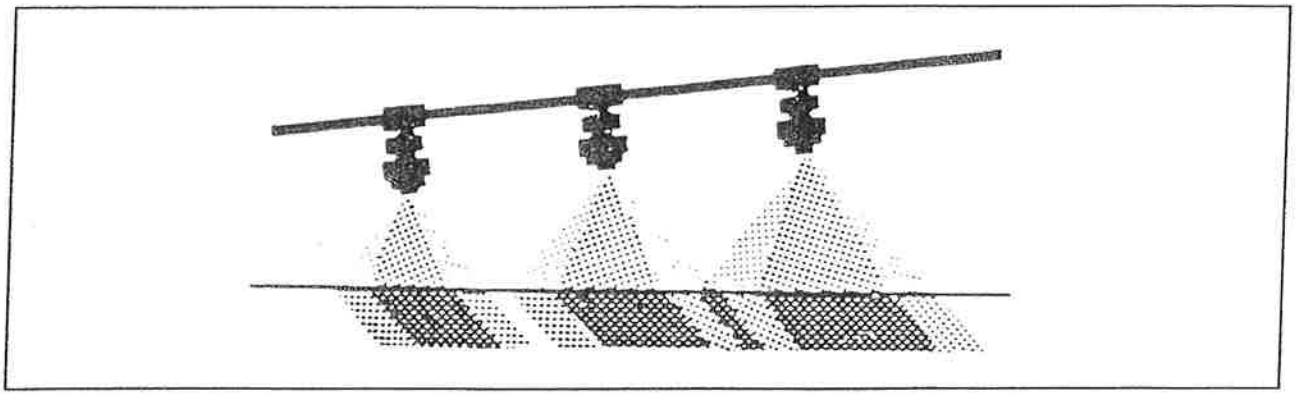
Do not use nozzles of different pattern angles together.



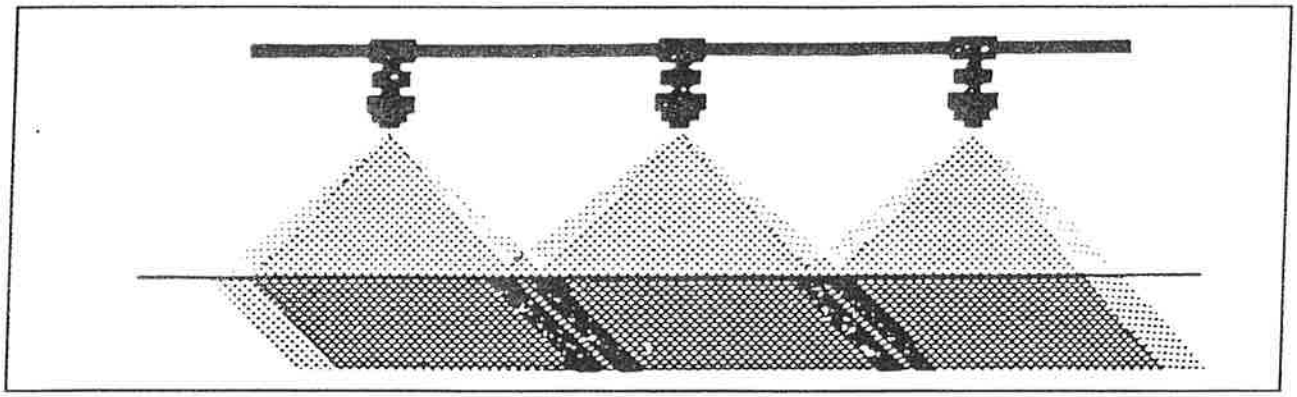
Worn or plugged nozzles produce nonuniform patterns.



Align nozzles properly to prevent gaps in the pattern.



Boom must be level (when moving) to maintain uniform nozzle height and pattern.



Nozzles must be correct height for right amount of overlap to produce uniform pattern. A good way to test-spray a short distance on hot blacktop in the sun and watch the drying rate. Adjust the height to eliminate excessive streaking.

B. Calibration Procedure

Proper calibration of a sprayer is essential to applying the correct amount of chemical. Calibration is the process of determining (or adjusting) the amount of liquid that the sprayer is applying when operated with certain constants. These constants are:

-Ground speed
-Spray pressure
-Nozzle (orifice) size
-Nozzle spacing (spray width)

Sprayer output is expressed as the amount of water applied to given area, usually in gallons per acre or fluid ounces per 1,000 sq.ft. Once output has been determined, the recommended amount of the chemical product is added to the proper amount of water for uniform spray at the correct dosage. Sprayer calibration is done using only water and not with the pesticide/water mixture.

ADJUSTING SPRAYER OUTPUT

Often the applicator needs to adjust the output of a sprayer in order to apply more or less water to a given area. If, for example, a sprayer is equipped with a 50 gallon tank, and the sprayer is calibrated to apply 25 gallons per acre, the sprayer is capable of treating 2 acres before re-filling. However, if the applicator needs to spray 3 acres in one application, there are methods by which the sprayer output can be changed by adjusting one of the constants. *Every time a constant is changed the sprayer must be re-calibrated.*

Sprayer output can be adjusted by changing the ground speed or the nozzle orifice size. An increase in speed will decrease output, while a decrease in speed will increase output. Conversely, an increase in nozzle orifice size will increase the output, but a decrease in nozzle orifice size will decrease the sprayer output. This is true only when the other constants (pressure and spray width) are not changed.

Sprayer output can also be changed by adjusting spray pressure. An increase in pressure will increase output. However, spray pressure has recommended limits. A spray pressure of 25-40 psi is commonly recommended by most experts. Pressures of over 40 psi are not recommended because of finer mist, loss of chemical due to wind drift, and other factors.

DETERMINING THE CONSTANTS

Speed - Sprayer ground speeds of 2-5 miles per hour are most commonly used. The speed which is chosen should be comfortable and safe for the type of terrain that will be traveled. Once the speed is determined (usually by selecting a certain gear at a given engine RPM), that speed should be strictly maintained during calibration and subsequent spraying.

Nozzle Orifice Size - There is a wide range of nozzle sizes. In general, nozzle size should be chosen to apply a minimum of 10 gallons per acre. More output will increase wetting distribution, but some products are recommended to be used with less output per acre.

Nozzle Spacing (spray width) - The number of nozzles used and the spacing between nozzles will determine **effective spray width**. Most general purpose nozzles are spaced 20 inches apart and held 18 inches above the ground. This arrangement will provide a uniform coverage with about 50 percent overlap of the spray pattern, particularly with flat fan or even flat fan nozzles.

Pressure - As mentioned previously, sprayer pressure should be kept between 25 and 40 psi. Thirty psi is an ideal pressure. Remember, the pressure of a power take-off driven pump will increase with engine RPM. Therefore a pressure regulator is an essential part of any sprayer unit.

Step 1 - Determine effective spray idth (ESW)
For broadcast sprayers:
ESW = nozzle spacing in inches X number of nozzles
Example: ESW = 20" X 6 nozzles
=120" or 10 feet

For band spraying:
ESW = band width X number of nozzles
Example: 6" band X 8 nozzles = 48" or 4 feet

Step 2 - Measure off a test area. (Use a tape measure. Do not measure by paces.)
ESW X any convenient length
Example: 10 feet X 50 feet = 500 square feet

Step 3 - Determine the number of test areas (TA) in one acre.
Number of square feet per acre
Number of square feet per TA = TAs per acre

Example: 43,560 sq ft per acre
500 sq ft per TA = 87.1 TAs per acre

Step 4 - Determine the time require to cover test area.
Operate sprayer with speed and pressure at field operating conditions.
Bring spray rig up to speed before entering the course.
Take an average time over three course runs.
Use a stop watch or seconds sweep hand and time from the same place on the spray rig when entering and exiting the measured test area.

Step 5 - Calculate sprayer output for test area.
Use same pressure that will be used in the field.
Using a measuring cup calibrated in fluid ounces, catch individual nozzle output for the same amount of time required to cover the test area.
Determine total output for the test area:

Fluid ounce output per nozzle X number of nozzles = total fluid ounces per test area
Example: 6 fluid oz per nozzle X 6 nozzles = 36 fl oz per test area

Step 6 - Determine sprayer output per acre.
fl oz per TA X number of TAs per acre = fl oz per acre
Example: 36 fl oz per TA X 87.1 TAs per acre = 3135.6 fl oz/acre

To convert to gallons per acre:

$$\frac{\text{fl oz per acre}}{\text{fl oz per gallon}} = \text{gallons per acre}$$

Example:

$$\frac{3135.6 \text{ fl oz per acre}}{128 \text{ fl oz per gallon}} = 24.4 \text{ gallons per acre}$$

II. APPLICATION TECHNIQUES

A. Adding Material

Read the manufacturer's label or recommendation, then add the correct amount of material. If the recommendation is two pounds per acre, and the tank holds five acres worth of water, and 10 pounds (5 x 2) of material. You need to know whether the recommendation calls for the commercial material as it comes from the bag, or whether it means the active ingredient. If the material is not pure active ingredient such as an 80 percent wettable powder, for example, some extra material must be added to provide two full pounds of active ingredient per acre.

Suppose you have a material that is 100 percent pure active ingredient, and the recommendation says to apply it at two pounds per acre. From your calibration you know that your spray rig will put out 50 gallons of water per acre, and you have a 200-gallon tank. How much will a tankful cover?

Example:

$$\frac{200 \text{ gallons}}{50 \text{ gallons per acre}} = \frac{200}{50} = 4 \text{ acres}$$

We now understand that we can cover four acres with a tankful, and we need two pounds of active ingredient per acre. If our pesticide is 100 percent pure active ingredient, calculations are simple: 2 lb/acre x 4 acres = 8 lb/tankful. We know, however, that the material we usually buy is purposely provided with only part of the total as pure active ingredient. If the label specifies it is an 80 percent mix, what now?

Since two pounds of material from the sack would not equal two pounds of active ingredient per acre, you obviously will have to add more than two pounds of the commercial powder to each "acre's worth of water" in your tank to end up with two pounds of active ingredient. You can make an easy calculation:

$$2 \text{ lb} \times \frac{100\%}{80} = 2 \text{ lb} \times \frac{100}{80} = 2 \text{ lb} \times 1.25 \ (1\ 1/4) = 2.5 \text{ lb}$$

Look at the problem again:

You want:	2 pounds active ingredient per acre
Your have:	80 percent wettable powder
Your tank holds:	200 gallons
Your system puts out:	50 gallons of water per acre
So, with a tankful, you can cover:	$\frac{200}{50}$ or 4 acres

For 4 acres you will need: 2 pounds active per acre x 4 acres = 8 pounds active
For the tankful, then you will need to add:

$$8 \times \frac{100}{80} = 8 \times 1.25 = 10 \text{ pounds of material}$$

Usually, things do not come out that evenly, and the numbers don't work out as well; but if you remember the basic principle and don't let odd numbers bother you, the problem remains nearly as simple. Let's try another example:

You want:	2.5 pound of active per acre
You have:	75 percent wettable powder
Your tank holds:	255 gallons
Your system puts out:	47 gallons per acre
So, with a thankful, you can cover:	$\frac{255}{47} = 5.43$

Round it off to 5.4 acres; we can round off a small amount like this because the whole operation is certainly not any more accurate that this.

For 5.4 acres, you will need:
2.5 pounds active per acre x 5.4 acres = 2.5 x 5.4 = 13.5 pounds active

But the material itself is only 75 percent pure active ingredient, so for the full tank you will need:
13.5 pounds active x $\frac{100}{75}$ = 13.5 x 1.33, or 18 pounds of the commercial material.

If, for some reason, the material had to be mixed at a prescribed rate of water per pound of powder, the problem would have to have some refinement.

B. Mixing Methods

If the material to be used is a liquid, simply mix as directed by the label or manufacturer's instructions. A wettable powder, on the other hand, requires more care and a special technique. If a sack of wettable powder is simply dumped into a tank, the chunks produced may be very hard to mix adequately. The proper technique is to:

- Fill tank one-third to one-half full with water, to equal the number of acres to be sprayed, at a predetermined gallonage per acre.
- Premix (or slurry) the wettable powder in a five-gallon can or similar container, making a smooth slurry free of chunks or dry material.
- Add the slurry to the tank, with the agitation system running. Continue with further batches of slurry until all the required amount of powder is in the tank.
- Add the rest of the water, and keep the agitation system going until the spray job is complete.
- Do not premix more material than the job at hand requires.
- Do not shut off the agitator while you go to lunch or allow the mix to stand overnight or over the weekend. Remixing powder that has settled out and caked on the tank bottom is very difficult and, in some cases, impossible. If this type of situation should happen inadvertently, work up the caked material on the tank bottom carefully by hand, using an appropriate paddle, before starting the agitator. If a tankful is not thoroughly mixed, the application rate will be incorrect, and the next tankful may also be affected. An even greater problem that may occur if a mix is left in the system is that the powder may settle and cake in the pump, strainers, lines, and nozzles.
- You can expect the flow rate to change somewhat after mixing, because calibration was done with water alone, and the nature of the material changes when a chemical is added. Compare the flow rate at one of the nozzles with the first test, and adjust the pressure regulator setting slightly to compensate for any change (this will usually be small).
- If the chemical is an oil, with a viscosity considerably different from water, a rather substantial change may occur and greater adjustment may be necessary. Therefore, if an oil is to be used, it is wise to make the final calibration with oil, although the first general operational system checkouts can be done with water.

C. Need For Accuracy

When it comes right down to the question, "how much do I put into the tank?," accuracy is required. You want to apply a precise amount of active ingredient to the crop or acreage in question.

First, read and thoroughly understand the written recommendation. Then read the label thoroughly. It may have a great deal of fine print, these details are there for an express purpose. They are as important as the fine print on any contract.

After you have read the label thoroughly, ask yourself if you understand what you are doing. If not, study some more; above all, ask questions if you don't understand. Don't be embarrassed to ask.

Note also that the basic principles of calibration apply equally well to application equipment used with all chemicals, although some types of compounds may call for more precise measurements and careful calculations.

D. Sample Problems

The question, "how much do I put in the tank?" may have to be answered in other ways. For instance, a recommendation may call for a tank mix in terms of pounds per amount of water (2 pounds per 100 gallons), percent solution, or ppm (parts per million). A recommendation may also call for wettable powder when you have only emulsifiable concentrate available.

The approaches you can use can best be understood by working through some sample problems (given below), but first the following definitions might be helpful:

ppm - parts per million, expressed in either units of weight or of volume, but never simultaneously expressed;

% or percent solution - parts per hundred, expressed in either units of weight or of volume, but never both at once;

pounds of material - this can be either pounds of material as it comes from the container, or pounds of active ingredient (ai). You must first make sure which it is!

As an illustration of the difference of units of weight versus volume, consider four pounds per 100 gallons of water versus four gallons per 100 gallons (total volume):

Example:
4 pounds per 100 gallons is not a 4% mixture by weight, since 100 gallons of water weighs 834 pounds; therefore $\frac{4}{834} = 0.48\%$ by weight;
If 4 gallons of oil are added to 96 gallons of water to make 100 gallons total volume, this is $\frac{4}{100} = 4\%$ by volume.

Problem: Emulsifiable concentrate versus wettable powder, or EC vs. WP

If your recommendation calls for one formulation and you have only the other, first figure the amount of active ingredient (ai) to determine the amount to use:

Assume your recommendation calls for 2 pounds of 25 percent WP per 100 gallons of mix, and you have EC at 4 pounds ai/gallon. How much ai is called for?

2 pounds at 25% = 2 x 0.25 = 0.5, or 1/2 pound ai/100 gallons

You have EC that contains 4 pounds ai/gallon. How would you get 1/2 pound ai?

EC = 4 pounds ai per gallon
= 1 pound ai per quart
= 1/2 pound ai per pint

Therefore, you need 1 pint of EC per 100 gallons.

Remember, in going from one formulation to another, you must determine how much active ingredient the recommendation calls for.

Problem: Material available is 2 pounds ai per gallon EC. Recommendation is 1/4 pound ai per 100 gallons. Sprayer tank holds 225 gallons. How much EC do you use.

EC = 2 pounds ai per gallon
= 1/2 pound ai per quart
= 1/4 pound ai per pint
you need 1 pint per 100 gallons

Load will require 1 pint x $\frac{225}{100}$ = 2-1/4 pints/load

Problem: Spreader-sticker, adjuvant, or emulsifier

Suppose recommendation calls for some material to be added in small proportion, such as adjuvant at 1/2 percent concentration (by volume):

Sprayer capacity is 300 gallons.

If 1 percent of 100 gallons is 1 gallon, or 100 x .01 = 1.00 gallons, then 1/2 percent of 100 gallons is 1/2 gallon, or 2 quarts.

Therefore, use 2 quarts per 100 gallons x 3 (for 300 gallons) = 6 quarts per 300 gallons.

Problem: How much chemical should be used to produce a solution of given percent strength (by weight)?

$$\text{Pounds to use} = \frac{\text{(gallons water to be mixed) 8.34) (\% desired)}}{\text{strength of chemical to be used}}$$

(Remember: one gallon of water weighs 8.34 pounds)

You need the following:

Amount desired = 100 gallons
Percent final mix = 0.25%
Wettable powder = 40% WP = 40% ai

$$\text{Pounds to use} = \frac{(100)\ (8.34)\ (0.25)}{40} = 5.21 \text{ pounds}$$

III. CALIBRATION INFORMATION

A. Useful facts

1 foot band per mile equals 0.1212 acres
5,280 feet equals 1 mile
43,560 square feet equals one acre
1 quart equals 32 ounces
1 gallon equals 128 ounces

$$\text{gal/acre} = \frac{\text{43,560 x gallons applied to the acre}}{\text{area sprayed}}$$

B. Points to remember when calibrating a spray rig

a. Strive for accuracy in all calibrating measurements.
b. The pressure gauge may be inaccurate. (If it is too far from the spray boom, it will indicate a higher pressure than is actually being developed at the nozzle because of friction in the pipe.)
c. The orifice in the nozzle may be worn resulting in an erroneous application.
d. Calibrate nozzles with plain water first. Make final calibration check with the spray solution or mixture being used. Some additives, such as foaming agents, may have a different flow rate from water or oil.
e. Make certain that all nozzle tips on the boom are the same size or different rates will be delivered across the boom.
f. Keep pressure down (40 psi or lower) and the orifice size large, to reduce the danger of drift, whenever feasible.

g. When deciding on the speed for operating a spray rig, do not select such a high speed that bouncing of the boom will result in damage or alter the spray pattern.

IV. CALIBRATION QUESTIONS

The following questions will test your knowledge of calibration. The answers are to be found after the questions for self-evaluation.

1. A spray rig sprayed a width of 20 feet for 5 miles. How many acres were sprayed?

2. If 600 gallons were applied over 25 acres, what was the rate of output in gal/acre (gpa)?

3. It took 40 minutes to apply 300 gallons. What was the rate of discharge from the boom in gal/min?

4. There were 15 nozzles on the boom in question 3. What was the discharge rate per nozzle in gal/min?

5. A spray rig took 25 seconds to travel 176 feet. What was the speed in miles per hour (mph)?

6. A spray rig used 44 gallons of water to cover 32,000 sq ft. How many gal/acre (gpa) were sprayed?

7. A 20-foot width boom sprayed for a distance of 4 miles with 420 gallons of solution. What was the application ratc in gal/acre (gpa)?

8. Decreasing speed will decrease gpa.

   True_____ False_____

9. Doubling pressure will double nozzle discharge rate in gal/min.

   True_____ False_____

10. Doubling nozzle discharge rate, without changing speed or pressure, will double the application rate in gpa.

    True_____ False_____

11. A broadcast rate of herbicide is 2 pounds per acre. How much herbicide will be used on each crop acre when only a 13-inch band is sprayed between the lister points on a 38-inch bed?

Answers to calibration questions are below.

1. 20 ft x 0.1212 = 2.42 acres/miles x 5 miles = 12.1 acres, or 5280 x 5 miles x 20 ft = 528,000 sq ft
2. 600 ÷ 25 = gpa
3. 300 ÷ 40 = 7.5 gal/min
4. 7.5 ÷ 15 = .5 gal/min
5. 120 ÷ 25 = 4.8 mph
6. 43,560 x 4 : 32,000 = 59.9 gpa
7. 20 x 0.1212 x 4 = 9.7 acres, 420 ÷ 9.7 = gpa
8. False
9. False
10. True
11. 13/38 x 2.0 = .68 lbs per crop acre

ABBREVIATIONS

A	acre
ai	active ingredient
approx.	approximately
avdp.	avoirdupois
BP	boiling point
bu	bushel
C	Centigrade
Cu	copper
c	cup
cc	cubic centimeter
cm	centimeter
cwt	hundredweight
EC	emulsifiable concentrate
F	Fahrenheit
fl	fluid
ft	foot
fpm	feet per minute
gal	gallon
gm	gram
gpa	gallons per acre
gpm	gallons per minute
hr	hour
in.	inch
kg	kilogram
L	liter
LC	liquid concentrate
lb	pound
mcg	microgram
mg	milligram
min	minute
ml	milliliter
mm	millimeter
MP	melting point
mph	miles per hour
MW	molecular weight
oz	ounce
ppm	parts per million
psi	pounds per square inch
pt	pint
qt	quart
sec	second
SP	soluble powder
sp.gr.	specific gravity
sq.	square
Tb	tablespoon
temp	temperature
tsp	teaspoon
WP	wettable powder

Abbreviations for the plural are the same as for the singular.