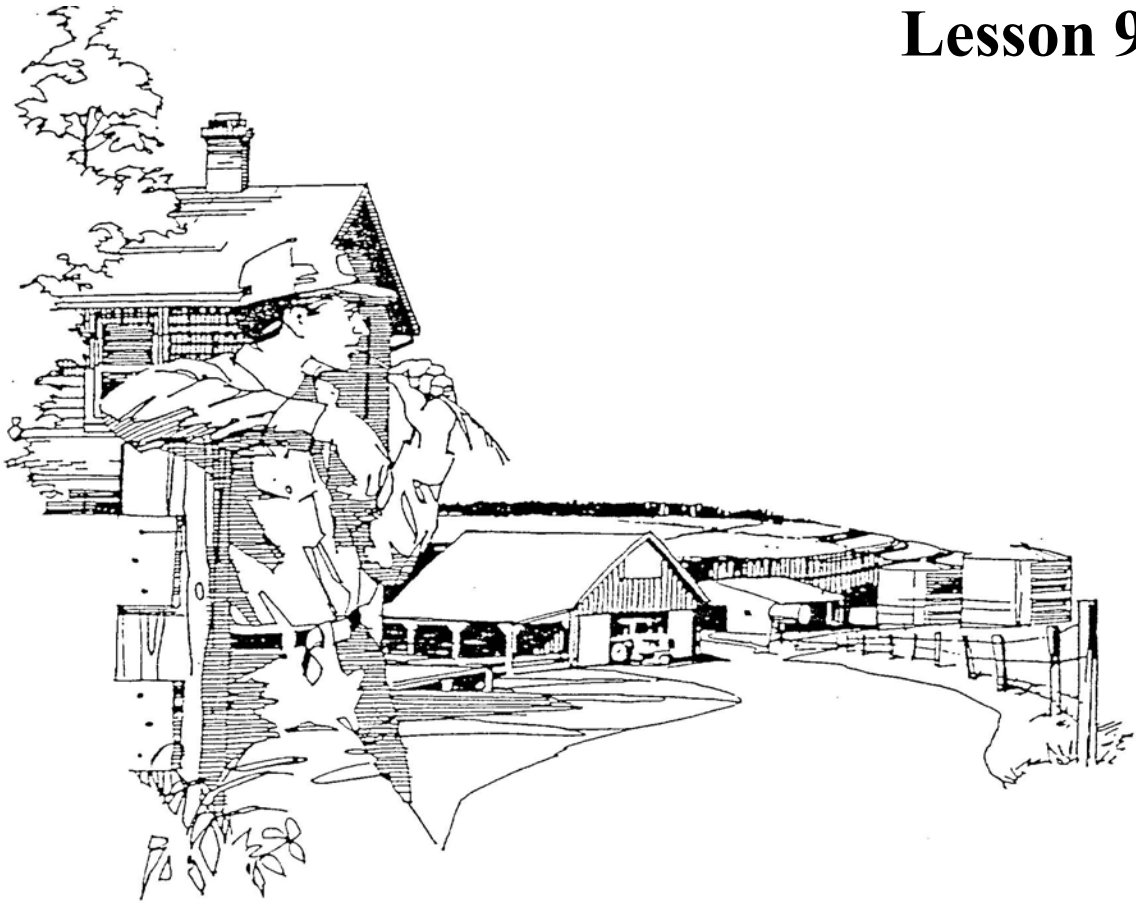


Pesticide Applicator Course for Agricultural Producers

Lesson 9



Calibrating Pesticide Application Equipment

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Lesson 9

Calibrating Pesticide Application Equipment

What You'll Learn!

The purpose of this lesson is to explain what calibration is, why it is required and how to calibrate the pesticide application equipment used in your commodity group. You will also learn how to calculate the amount of pesticide to buy for a season.

You will only be tested on parts of this lesson. All growers will be tested on the sections **Introduction to Calibration and Hand-Operated Sprayers**. You will also be tested on the sections for equipment commonly used by your commodity group, as shown below.

ALL GROWERS	Introduction to Calibration Hand-Operated Sprayers
	PLUS
Commodity Group	Additional Sections You Need to Know
- Field Crops	Boom Sprayers
- Vegetables (field)	Granular Applicators
- Nursery	
- Tree Fruits	Air-Blast Sprayers
- Greenhouse Vegetables	
- Greenhouse Ornamentals	Boom Sprayers Foggers, Misters, and Smoke Fumigators
- Berries	Boom Sprayers

By the time you complete this lesson, you should be able to:

- explain terms used in equipment calibration;
- describe how to inspect, set up, test, adjust, and calibrate pesticide application equipment that may be used in your commodity group;
- calculate the amount of pesticide to add to a spray tank mix;
- calculate the amount of pesticide to buy for a specified field size and application rate.

Introduction to Calibration

You know that to control a pest it's important to select the right pesticide and apply it at the right time. But equally important is applying the right amount. That's why calibration is essential.

Calibration is a procedure for checking and adjusting the delivery rate of application equipment. Calibration is done to ensure a pesticide will be applied accurately and uniformly at the recommended application rate.

Why Calibrate?

Time spent calibrating is a necessity! If you're not applying a pesticide at the recommended application rate you can suffer some serious problems:

If less than the correct application rate is actually being applied:

- **Your crop may suffer pest damage which could have been avoided.**
- **Money spent on pesticide and application may be wasted.**

If more than the correct application rate is actually being applied:

- **Your crop could be injured.**
- **Excess pesticide residues may make your crop unmarketable or harmful to livestock eating it.**
- **Leaching or excess runoff of pesticides may be harmful to the environment.**
- **Future crops can be affected by excessive amounts of some herbicides.**

Most pesticide application equipment comes with charts or tables to help when first setting up the equipment or making adjustments. These should only be used as guides. You must still calibrate your equipment to check that it is applying pesticide accurately and uniformly.

Calibrating for Accurate Application

There are many factors which affect the delivery rate (the rate at which pesticide is actually applied by your equipment). These include:

- **Spray or granule output - sprayer nozzles or granule metering devices may not have the exact output specified by the manufacturer, and they gradually wear over a period of use.**
- **Speed - sprayer delivery rate is directly affected by speed. Tractors often do not travel at the speed shown by the speedometer or tachometer due to wheel slippage, inaccurate meters, or change of tire size.**
- **Pressure - actual pressure at the nozzle may be lower than indicated by the line pressure gauge due to hydraulic friction losses. This will result in a delivery rate which is lower than expected.**

Calibrating for Uniform Application

Calibration also includes steps to ensure that the pesticide is being applied uniformly. Constant spray pressure and speed, and an even spray pattern from nozzles, are needed for an overall uniform application.

If pesticide application is not uniform, part of your crop may be over-dosed while the rest may not receive enough. Even when calibration shows that, on average, your field is receiving the right amount, much of your crop could be getting too much or too little.

When Should You Calibrate?

Calibration of equipment should be done:

- **before new or altered equipment is used;**
- **when making changes that affect the delivery rate ;**
- **at regular intervals to see if wear is affecting output.**

What Does Calibration Include?

Calibration involves three and possibly four procedures. Later sections in this lesson describe how these are followed for specific types of equipment.

- 1. Set-up:** making sure all parts of the equipment are set up and working properly and that output is being evenly distributed by the spray or granule pattern.
- 2. Measuring Delivery Rate :** finding the actual amount of spray or granules being applied by the equipment under typical operating conditions. Two common methods are described here:

Method #1 - Test Area: measuring the amount actually applied to a test area;

Method #2 - Timed Output: measuring the actual output/minute and speed of equipment.

You may use either of these or any method you prefer as long as you get an accurate result. (All are essentially the same if you closely examine the math involved.)

- 3. Adjustment:** changing the delivery rate , if necessary, so that it is the same as the recommended rate on the pesticide label. If adjustments are made, it will be necessary to repeat Step 2 to measure the new delivery rate.

For granular pesticides, concentrate sprays, and some fumigants, this is the final procedure. A fourth is required when the pesticide is mixed with water.

- 4. Calculating Amount of Pesticide to Add to a Spray Tank:** determining the area which one spray tank will cover and the amount of pesticide concentrate to add to a tank of spray mixture.

Terms Used in Calibration

Application rate is the recommended amount of pesticide for a specified area, row length, greenhouse volume, or plant surface. You can find the application rate on the pesticide label. Sometimes a range will be given.

- Examples:**
- apply at 1.1 L/ha (440 mL/acre)
 - apply at 4.5 kg/ha (1.8 kg/acre)
 - apply one can per 100 m³
 - apply at 0.6 to 1.0 kg/1,000 m of row

Spray volume is the recommended amount of spray mixture to be applied to a specified area. This spray mix is usually a pesticide concentrate diluted in water. You can find the spray volume on the pesticide label together with the application rate. Sometimes a range will be given.

Example: apply pesticide at 2.5 L/ha in 400 to 600L of water

The spray volume in this example is 400 to 600 litres per hectare. The application rate is 2.5 litres of pesticide per hectare.

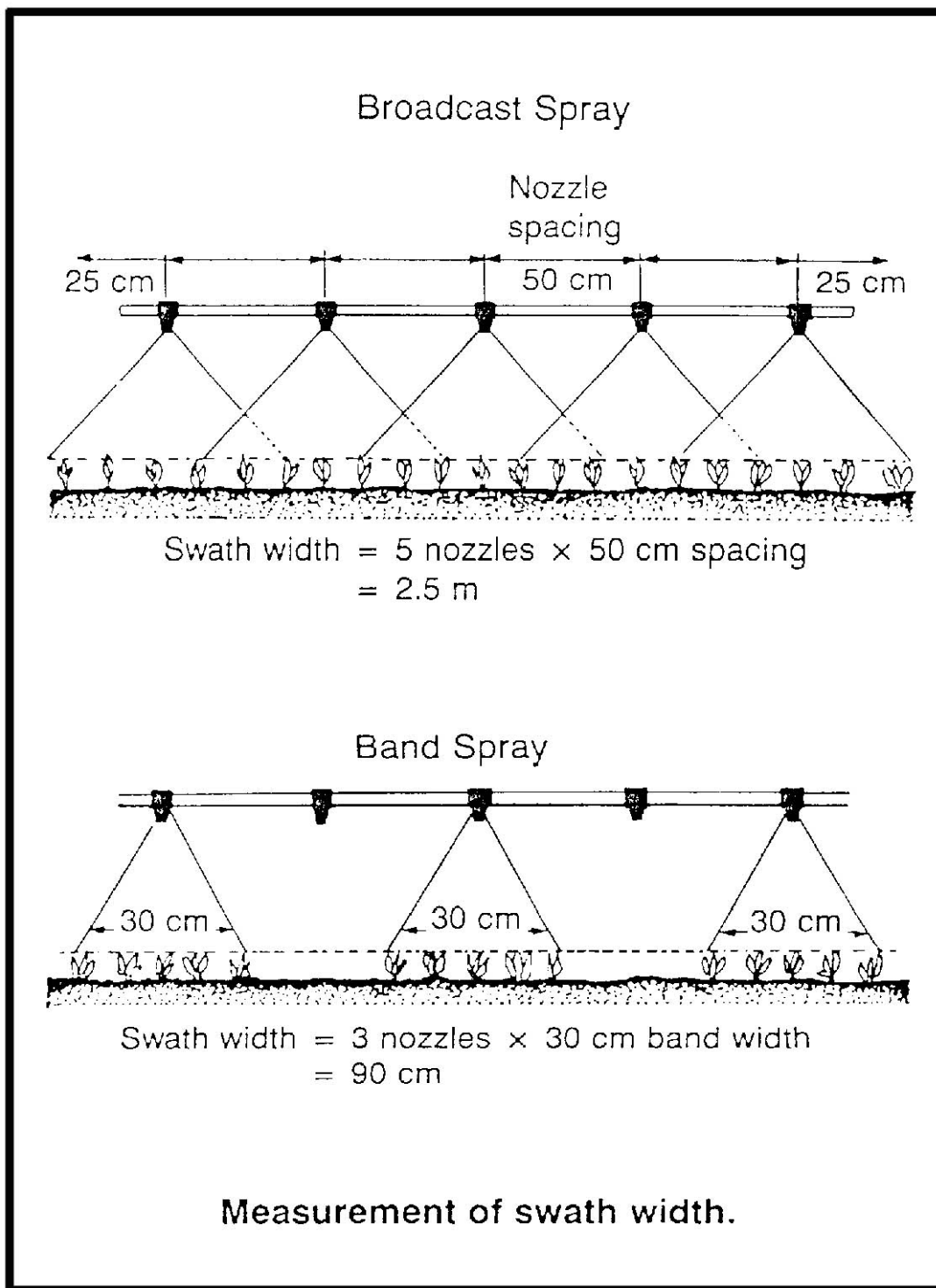
Delivery Rate is the amount of spray or granules which the equipment actually applies to a specified area, distance, or volume. During calibration you are trying to ensure that the actual delivery rate is the same as the recommended rate on the pesticide label.

Output is the amount of spray or granules which the equipment discharges during a measured period of time.

**Example: 16 L/min
 200 g/min**

Speed is the speed of the application equipment over the ground expressed in kilometres or miles per hour (km/h or mph).

Test strip or test area is an accurately measured distance or area which has conditions similar to the field to be treated. It is used to measure the delivery rate or forward speed of the application equipment.



Swath width is the width over which spray droplets or granules are distributed in one pass of the applicator. In orchards and other crops it may be the row spacing. For band treatments it is the sum of the treated band widths.

Metric or Imperial Measure?

You may do your calculations in either metres (m) and hectares (ha) or in feet (ft) and acres since recommended application rates in the production guides are currently provided in both.

Formulas are provided that will work with either measurement system. Examples are given for both systems. Whichever system you select, be consistent - use metres, kilometres, and hectares or use feet, miles, and acres. Don't mix them. Many formulas rely on ratios between two measurements so they must be in the same units.

Only kilograms (kg) and grams (g) are used for granules and powders, and only litres (L) and millilitres (mL) are used for liquid measure since they are standard in labels and production guides.

Measuring Tank Size and Levels

If you have a spray tank you will need a way to measure how many litres are in a partially-full tank. Some tanks have an outside clear tube which shows the level of tank liquid; make sure this gauge is accurate. If a tank does not have an accurate gauge, make a calibrated dip stick by adding a measured amount of water at a time (e.g., 20 L) and marking the stick as the level rises.

You may also find it easier to work in litres. To convert from gallons to litres:

1 imperial gallon = 4.54 litres 1 U.S. gallon = 3.78 litres

Abbreviations for Commonly-Used Measurements

cm	=	centimetres	in	=	inches
m	=	metres	ft	=	feet
m ²	=	square metres	ft ²	=	square feet
m ³	=	cubic metres	ft ³	=	cubic feet
ha	=	hectares	acre	=	acres
kPa	=	kilopascals	psi	=	pounds per square inch
km/h	=	kilometres/hour	mph	=	miles per hour
mL	=	millilitres	sec	=	seconds
L	=	litres			

Useful Numeric Values

1 kilometre	=	1,000 m	1 mile	=	5,280 ft
1 hectare	=	10,000 m ²	1 acre	=	43,560 ft ²
1 litre	=	1,000 mL	1 imperial gallons	=	4.54 L
1 kilogram	=	1,000 g	1 U.S. gallon	=	3.78 L

Conversion tables between metric and imperial measures are provided in most production guides.

Tips on Doing Formulas

Remember that this will be an open book exam. You don't have to memorize formulas or constants you only have to know how to use them (and where to find them). And yes, you can use a calculator.

The math used in these formulas is very simple. If you're not sure about which parts to do first, here are some guidelines:

- First do everything above a fraction line and below a fraction line.
- Then solve the fraction... the top is divided by the bottom.
- Then do any remaining multiplication (shown as X).
- Round off numbers up or down to the closest useful number (for example, 2.666666 may become 2.67 or even 2.7). Don't round off if you need the accuracy (for example, 0.0127 should not be rounded to 0.01).

How Much Pesticide to Purchase

Before you begin calibration, you should know what pesticide you will use and the recommended application rate. One of the first calculations you'll need to perform is figuring out how much pesticide to buy.

Generally it is a good idea to buy only as much pesticide as will be used in one year.

Broadcast Treatments

Broadcast treatments apply a solid swath so that all of an area is covered. A simple calculation will tell you how much to buy: multiply the application rate times the area to be treated times the anticipated number of applications.

**Amount to buy
for broadcast
treatment = application rate x area x number of applications**

Example: The pesticide you need has an application rate of 2 L/ha, your field is 20 ha, and you expect to make two applications during the year.

**Amount to buy = 2 L/ha x 20 ha x 2 applications
 = 80 L**

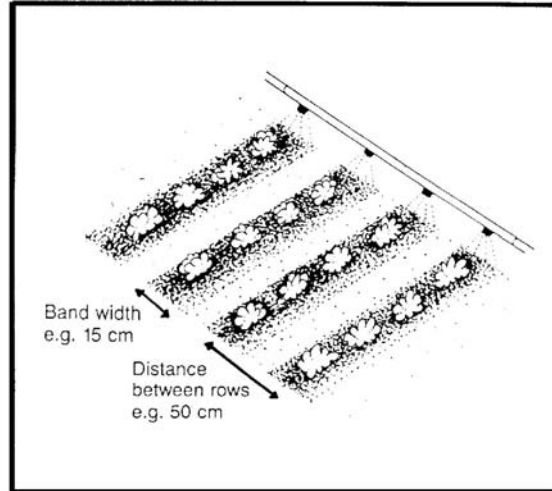
Example: The pesticide you need has an application rate of 1.5 L/acre, your field is 40 acres, and you expect to make one application during the year.

**Amount to buy = 1.5 L/acre x 40 acres x 1 application
 = 60 L**

Band Treatments

With a band treatment the equipment leaves untreated strips between treated bands. You do not need as much pesticide for a band treatment as for a broadcast treatment of the same field.

You can calculate the reduced amount of pesticide you'll need to buy by using the following formula. Row spacing is the distance from the centre of one row to the centre of the next.



Amount to buy for band treatment = **application rate (broadcast rate)** x **area (total)** x **number of applications** x $\frac{\text{band width}}{\text{row spacing}}$

Example: Your pesticide must be applied at 2 L/ha when sprayed as a broadcast treatment. You have decided to apply it in bands over crop rows. Crop rows are 76 centimetres apart and you will use 20 centimetre bands. The field is 20 hectares and you plan two applications this year.

Amount to buy for band treatment = 2 L/ha x 20 ha x 2 times x $\frac{20 \text{ cm}}{76 \text{ cm}}$
 = 2 L x 20 x 2 x 0.263
 = 21 L

Example: Your pesticide must be applied at 1.5 L/acre when sprayed as a broadcast treatment. You have decided to apply it in bands over the rows of your crop. The crop rows are 30 inches apart and you have decided to use eight inch bands. The field is 40 acres and you are planning one application this year.

$$\begin{aligned} \text{Amount to} & & & & & \mathbf{8 \text{ in}} \\ \text{buy for band} & = & 1.5 \text{ L/acre} & \times & 40 \text{ acres} & \times & 1 \text{ time} & \times & 30 \text{ in} \\ \text{treatment} & & & & & & & & \\ & = & 1.5 \text{ L} & \times & 40 & \times & 1 & \times & 0.267 \\ & = & 16 \text{ L} & & & & & & \end{aligned}$$

Pre-calculated Rates for Band Treatments

Some production guides provide tables showing pre-calculated pesticide amounts to use for certain band treatments. The use of pre-calculated rates is not shown in this course and you will not be tested on them.

Example: The rate recommended for broadcast treatment is 800 mL/ha. For band treatment of rows spaced at 120 cm, the rate for 30 cm bands (one quarter of the total field area) is 200 mL and the rate for 60 cm bands (one half of the total field area) is 400 mL.

While this can be very convenient, it is important to watch carefully for pre-calculated rates. You must know that the rate you are using in these formulas is the recommended label rate for broadcast treatment (total field coverage). In the example above you would choose 800 mL/ha to use in these formulas.

Quiz 9.1 - Introduction to Calibration

1. What is meant by equipment calibration?

2. List three reasons why a sprayer delivery rate may be different than dealer specifications, therefore making calibration necessary.

3. List three situations when you should calibrate.

4. What is the "application rate"? How does it differ from "spray volume"?

5. What is the difference between "delivery rate " and "output"?

6. What are the four main procedures of calibration?

7. How much pesticide should you buy for a broadcast treatment if:

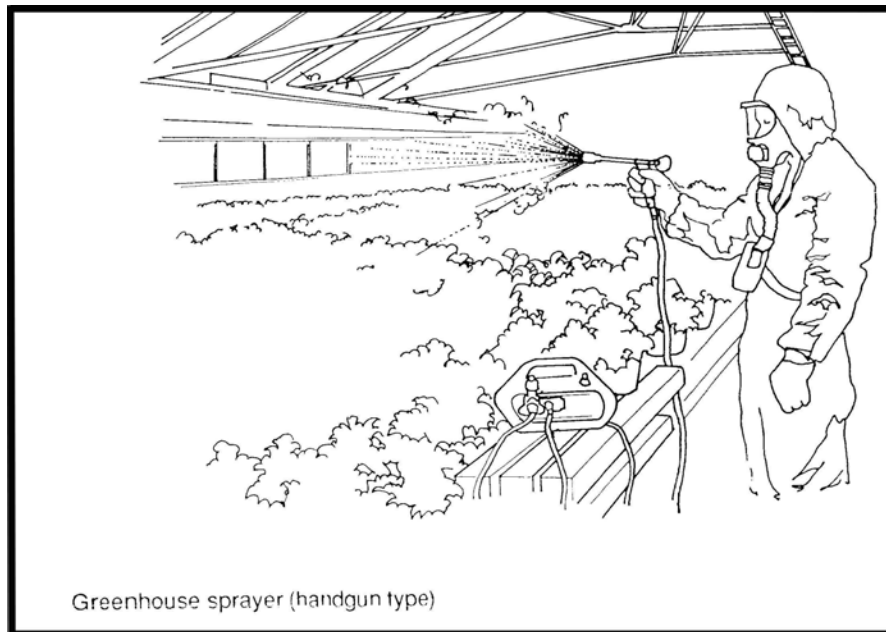
- **The application rate is 3 kg/ha.**
- **Your field is ten hectares.**
- **You expect to do two applications this year and two the next.**

8. How much pesticide would you need for a band treatment if:

- **The application rate is 3 L/ha.**
- **Your field is 20 hectares.**
- **You expect to do three applications this year.**
- **Each band is 60 cm wide.**
- **Bands (crop rows) are spaced 120 cm apart.**

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

Hand-Operated Sprayers



(This section is required for all commodity groups.)

Hand-operated sprayers include hand-carried compressed air sprayers and backpack sprayers. They may be used for spot treatment in fields and orchards, for weed control around buildings, and for many applications in nurseries and greenhouses.

When the Application Rate Is Given as a Dilution Rate

Frequently, hand-operated sprayers are used for situations where the application rate is given as an amount of pesticide to mix (dilute) with a measured quantity of water and the amount applied is judged by eye.

Example: 175 g/100 L water, spray to runoff

(Runoff is the point where the spray begins to drip off the foliage.)

You do not need to follow all the calibration steps for these types of applications, but you should set up the sprayer as described later in this lesson.

You will also need to calculate how much pesticide to mix with the water in the spray tank. Use the following formula when the application rate specifies a dilution rate only:

Amount of pesticide to add to tank = $\frac{\text{application rate}}{\text{dilution rate}} \times \text{volume of spray mixture in tank}$

Example: The label application rate specifies a mixture of 175 grams of pesticide per 100 litres of water (175 g/100 L). Your tank holds 12 litres, but you decide that 10 litres of spray mix is all you need to prepare for now. The amount of pesticide to add is calculated as follows:

$$\begin{aligned} \text{Amount of pesticide} &= \frac{175 \text{ g} \times 10 \text{ L}}{100 \text{ L}} \\ &= 17.5 \text{ g} \end{aligned}$$

When the Application Rate Is for an Area

Hand-operated sprayers may also be used in cases where the application rate specifies an amount of pesticide per unit area.

Example: apply 2.5 litres per hectare (2.5 L/ha)

In such cases, you must follow all the steps in calibration as shown in this lesson, just as you would for a large piece of field equipment, in order to ensure that the sprayer will deliver the recommended rate. All four procedures are required: set-up, measuring delivery rate, making adjustments, and calculating how much pesticide to add to a tank.

Sprayer Set-up

Hand-operated sprayers should be checked to make sure there are no leaks, especially where the hose enters the tank and around the trigger valve. The nozzle should deliver a uniform spray pattern. Many nozzles can be adjusted to produce the desired droplet size. Adjust the nozzle to produce a coarse spray (larger droplets) for herbicides and a medium to fine spray (smaller droplets) for insecticide and fungicide applications. For uniform spray application it is important that you maintain constant spray pressure and co-ordinate your walking speed with uniform back and forth movements of the nozzle.

Measuring Sprayer Delivery Rate

Hand-operated sprayers are calibrated by measuring the volume of water applied to a test area.

- Step 1 Measure and mark a conveniently-sized test strip, for example, 20 metres (or 65 feet). Walking conditions should be similar to where you are going to spray.**
- Step 2 Find the spray swath by accurately measuring the width that you spray; for example, 1.5 m (or 5 ft). Calculate the area of the test strip: length times swath width times number of runs.**
- Step 3 Fill the sprayer tank about half full with water and record the level. (Half full represents average pressure and weight conditions.) Pump a hand-held tank to the pressure level you'll be using.**
- Step 4 Carefully spray the measured test strip while maintaining a steady forward speed and, for a backpack sprayer, a steady pumping pace. If you vary either of these you will vary your output.**
- Step 5 Measure the amount of water needed to refill the spray tank to its starting level. Use an accurate measuring container. The amount needed to refill is the amount sprayed on the test strip. For example, if you need 5.5 litres to refill to the starting level, then 5.5 L is the amount sprayed on the test area.**

Step 6 Calculate sprayer delivery rate per hectare (10,000 m²) or per acre (43,560 ft²) using the following formula. (In rare cases where an application rate might be given for an area of 100 m² or 100 ft², substitute that value instead of the hectare or acre numbers.)

$$\text{Delivery Rate L/ha} = \frac{\text{amount sprayed in test (L)}}{\text{test area (m}^2\text{)}} \times \frac{10\,000\text{ m}^2}{\text{test area (m}^2\text{)}}$$

$$\text{Delivery Rate L/acre} = \frac{\text{amount sprayed in test (L)}}{\text{test area (ft}^2\text{)}} \times \frac{43\,560\text{ ft}^2}{\text{test area (ft}^2\text{)}}$$

Example: The test strip is 20 m long, the swath width is 1.5 m, and you spray it one time so the test area is 30 m² (20 x 1.5 x 1). The amount of water sprayed during the test is 3.5 L. The delivery rate is:

$$\begin{aligned} \text{Delivery Rate L/ha} &= 3.5\text{ L} \times \frac{10\,000\text{ m}^2}{30\text{m}^2} \\ &= 1\,167\text{ L/ha} \end{aligned}$$

Example: The test strip is 65 ft long, the swath width is 5 ft, and you spray it one time so the test area is 325 ft² (65 x 5 x 1). The amount of water applied during the test is 3.5 L. The delivery rate for an acre is:

$$\begin{aligned} \text{Delivery Rate L/acre} &= 3.5\text{ L} \times \frac{43\,560\text{ ft}^2}{325\text{ ft}^2} \\ &= 469\text{ L/acre} \end{aligned}$$

Calculating the Amount of Pesticide to Add to a Spray Tank

When your delivery rate is known you can calculate how much pesticide to add to the spray tank. This requires two steps.

Step 1 Find the area sprayed by one tank. Divide the volume of spray you are mixing (it may be a full tank or a partial one) by the delivery rate .

$$\text{Area sprayed by one tank} = \frac{\text{volume of spray mixture in tank}}{\text{delivery rate}}$$

Example: You want to make up 12 L in a tank. The delivery rate was found to be 1,167 L/ha. The area one tank will spray is:

$$\begin{aligned} \text{Area sprayed by one tank (ha)} &= \frac{12 \text{ L}}{1\,167 \text{ L/ha}} \\ &= 0.0103 \text{ ha} \end{aligned}$$

There are 10,000 m² in a hectare. If you wish to convert 0.0103 ha to square metres, multiply by 10 000:

$$10,000 \text{ m}^2 \times 0.0103 \text{ ha} = 103 \text{ m}^2$$

Example: You want to make up 12 L in a tank. The delivery rate was found to be 469 L/acre. The area one tank will spray is:

$$\begin{aligned} \text{Area sprayed by one tank (ha)} &= \frac{12 \text{ L}}{469 \text{ L/ha}} \\ &= 0.0256 \text{ acre} \end{aligned}$$

There are 43,560 ft² in an acre. If you wish to convert 0.0256 acre to square feet, multiply by 43,560:

$$43\,560 \text{ ft}^2 \times 0.0256 \text{ acre} = 1,115 \text{ ft}^2$$

NOTE: When doing calculations for hand-operated sprayers you will find that one spray tank covers only a small part of a hectare or acre. For accuracy, you should use four figures after the decimal point, as shown above, when working with decimal fractions of hectares or acres.

Step 2 Find the amount of pesticide to add to a spray tank. Multiply the pesticide application rate by the area sprayed by one tank (remember to use the same units).

$$\begin{array}{l} \text{Amount of pesticide} \\ \text{to add to a tank} \end{array} = \begin{array}{l} \text{application} \\ \text{rate} \end{array} \times \begin{array}{l} \text{area sprayed} \\ \text{by one tank} \end{array}$$

Example: The application rate on the label is 4 L/ha and you calculated that one 12 L spray tank will cover 0.0103 ha. The amount of pesticide to add for 12 L of spray would be:

$$\begin{array}{l} \text{Amount of} \\ \text{pesticide to add} \\ \text{to a full tank} \end{array} = 4 \text{ L/ha} \times 0.0103 \text{ ha}$$
$$= 0.0412 \text{ L}$$

There are 1,000 millilitres in a litre. If you wish to convert 0.0412 L to millilitres, multiply by 1,000:

$$1,000 \times 0.0412 \text{ L} = 41.2 \text{ mL}$$

Example: The application rate on the label is 1.6 L/acre and you calculated that one 12 L spray tank will cover 0.0256 acre. The amount of pesticide to add for 12 L of spray would be:

$$\begin{array}{l} \text{Amount of} \\ \text{pesticide to add} \\ \text{to a full tank} \end{array} = 1.6 \text{ L/acre} \times 0.0256 \text{ acre}$$
$$= 0.041 \text{ L}$$

There are 1,000 millilitres in a litre. If you wish to convert 0.041 L to millilitres, multiply by 1,000:

$$1,000 \times 0.041 \text{ L} = 41 \text{ mL}$$

Quiz 9.2 - Hand-Operated Sprayers

Now try this quiz.

1. The pesticide application rate says you are to add 66 mL per 100 L of spray and wet the foliage. How much pesticide would you add to make 15 L of spray in a tank?

2. Describe the five steps you would follow to find how much spray was applied to a test area in preparation for calculating delivery rate .

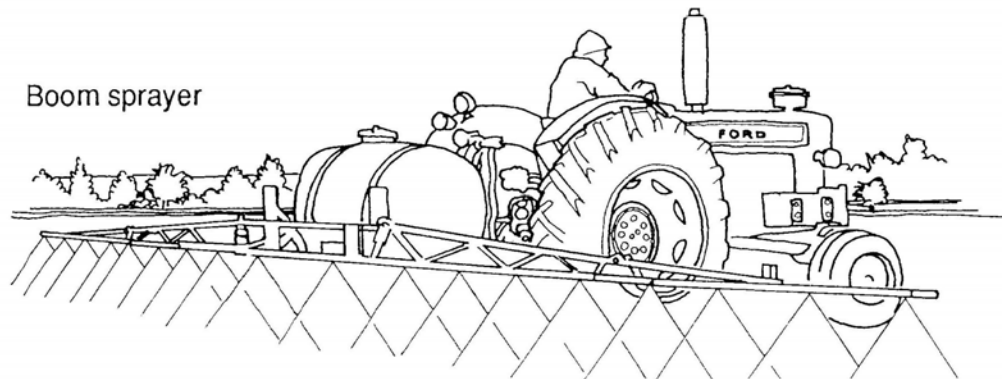
3. Your equipment yard has a large number of broadleaved weeds. You identify the weeds and choose a herbicide spray which must be applied at 5 kg/ha (2 kg/acre). You test your hand-operated sprayer on a 10 m (33 ft) strip which is 2.5 metres (8 ft) wide. In spraying the strip twice, you use up 2 L of water. What is the sprayer's delivery rate per hectare?

4. To apply a herbicide to a small area you plan to use a backpack sprayer which has been calibrated and has a delivery rate of 1,185 L/ha (480 L/acre). The sprayer tank holds 15 L. How much of a hectare (acre) will a full tank cover?

5. You have a sprayer with a 10 L tank. You have measured its delivery rate and calculated that a full tank will cover 0.022 hectares (0.054 acres). If your herbicide should be applied at 3 L per hectare (1.2 L/acre), how many millilitres (mL) of herbicide must be added to a full tank?
-

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

Boom Sprayers (Broadcast and Band Applications)



(Most commodity groups need to know how to calibrate boom sprayers for the exam. The exception is tree fruit producers who may instead go directly to the section on air-blast sprayers.)

The most common type of sprayer used in Newfoundland and Labrador is the field boom sprayer. It applies pesticide either by broadcasting it evenly or placing it in bands. For broadcast applications nozzles are typically spaced at 50 cm (20 in) intervals; for band applications they are placed according to row spacing.

The four basic procedures you used for hand sprayers are also followed when calibrating boom sprayers, although with more to consider:

- **set-up**
- **measuring delivery rate**
- **adjustment**
- **calculating how much pesticide to add to a spray tank**

Calculations for broadcast or band applications are done in exactly the same way with only one difference - the swath width.

Finding Swath Width - Broadcast and Band

Swath width for broadcast spraying includes the entire spray width (less any overlapping spray at the boom ends). Swath width for band spraying is the total of the individual band widths. Review the previous diagram in the section "Terms Used in Calibration." Don't use the boom length for your calculations - the actual swath width may differ because of nozzle placement, end-of-boom gaps, or overlaps, or because of untreated areas between bands.

Use the following formulas to determine swath width:

Broadcast swath width = space between nozzles x number of nozzles

Band swath width = width of each band x number of bands

Example: For a broadcast application you have 14 nozzles spaced 20 inches apart on a 25 foot boom. What is the swath width?

Broadcast swath width = 20 inches apart x 14 nozzles
= 280 inches
= 23.33 feet (280 in divided by 12)

Example: For a band application you have eight nozzles spaced 76 cm apart. Each nozzle sprays a band 20 cm wide. What is the swath width?

Band swath width = 20 cm wide x eight nozzles
= 160 cm
= 1.6 metres (160 cm divided by 100)

Note that band treatment is only partial coverage. The treated area is NOT the same as the total field area.

Example: If you apply 60 cm bands to rows that are 120 cm apart, you're really treating only half the field.

Set-up

During set-up you check that the sprayer nozzles, speed, and spray pressure are correct for the application. Then the equipment is inspected to ensure all parts are in good condition and working properly. Finally, nozzle spray patterns and output are checked.

Selecting Nozzle Tips

For effective spraying you need a set of nozzle tips which produce the required spray pattern and volume at the desired speed and spray pressure. Nozzle manufacturers' charts can help you find a set to match your requirements. (See the section on selecting nozzles in Lesson 8.) Consult your equipment dealer, agricultural rep, or Crops Specialist for help in selecting the correct nozzle tips for the job.

Selecting Speed

The speed selected depends on the type of equipment being used and on ground conditions. Typical speeds for boom sprayers are between 5 and 10 km/h (3 to 6 mph). Driving too fast over rough ground will result in bouncing of booms and uneven spray or granule application.

When changing speed, it is important to note that doubling the speed will result in half the amount of spray being applied.

Example: At a speed of 3 km/h your delivery rate is 200 L/ha. To decrease the delivery to 100 L/ha at the same pressure, your new speed must be 6 km/h.

Selecting Spray Pressure

Pressure is measured in kilopascals (kPa) or pounds per square inch (psi). Low-pressure boom sprayers usually operate at 100 - 275 kPa (15 - 40 psi) for herbicide application and 345 - 620 kPa (50 - 90 psi) for insecticide applications. High-pressure sprayers may range up to 4,200 kPa (600 psi) or more.

Large adjustments to output should not be made by increasing pressure. You would have to increase the pressure four times just to double the spray output.

Example: At a certain speed and pressure of 30 psi your spray output is 100 L/ha. If you tried to increase the spray output to 200 L/ha by changing only pressure, you would need 120 psi.

Increased pressure results in more potential for drift from small spray droplets. Reducing pressure may alter the spray pattern and result in uneven coverage. When adjusting sprayer output it is usually better to adjust speed or change nozzle size.

Check manufacturers' charts to make sure you operate within the recommended operating pressure range for your sprayer. Using lower pressures will help extend pump life and reduce drift. Nozzle manufacturer charts give the pressure recommended for each type of nozzle to produce the output you need.

Inspection Before Sprayer Start-up

Check that:

- **Tire pressures of both the tractor and sprayer are correct.**
- **All hoses are in good condition and of the proper pressure rating.**
- **All filters, strainers, and screens are clean and in place.**
- **Nozzles are the correct type and size for the job (e.g., flat fan for herbicides).**
- **Nozzles are properly aligned and clean.**

Inspection with Sprayer Running

Fill the tank about half full with clean water for an operating test:

- **Start the sprayer operating at the recommended rpm for the pump (usually 540 rpm)**
- **Open the valve to the boom to fill the lines and begin spraying.**
- **Once all nozzles are spraying, adjust the pressure regulator to the recommended operating pressure.**

Check that

- **There are no leaks in the system.**
- **All ON/OFF valves are working.**
- **Pressure gauges are accurate (see Lesson 8).**
- **The agitation system is working properly.**

Checking Nozzle Spray Pattern

Set the proper spray pressure and visually check that each nozzle has a uniform spray pattern. Nozzles which do not produce a uniform spray pattern should be cleaned using a soft brush. If they still produce streaking or distortion after being cleaned, replace them. (Remember to wear rubber gloves when handling and testing sprayer nozzles.)

Measuring Nozzle Output

Check that nozzle output is uniform across the boom using the following method. (This test can also provide you with output per minute for the timed output method of finding delivery rate .) You will need a measuring container calibrated in millilitres and a stopwatch or watch which shows seconds.

- Step 1 Place a collecting cup under each nozzle for an exact time (such as 30 seconds or 1 minute).**
- Step 2 Measure and record the volume of spray collected from each nozzle.**

Step 3 **Add the output for all nozzles to get the total output. Divide the total output by the number of nozzles to find the average nozzle output.**

$$\text{Average output per nozzle} = \frac{\text{total output of all nozzles}}{\text{number of nozzles}}$$

Step 4 **If average output is more than 10% higher than (i.e., over 1.10 times) the manufacturer's specifications, replace the whole set of nozzles.**

Step 5 **Compare each nozzle's output to the average. Replace any nozzle if its output is 10% above average (i.e., over 1.10 times the average output). Clean any nozzle which is 5% below average (i.e., under 0.95 times the average output).**

Step 6 **Retest if any nozzles have been changed or cleaned.**

Measuring Sprayer Delivery Rate

Delivery rate is the amount of spray your equipment actually applies per unit area (e.g., L/ha). You need to check that the delivery rate is within the recommended range of spray volume for the pesticide you are using. You also need to know the delivery rate in order to determine tank coverage and calculate how much pesticide to add to your spray tank.

There are two basic methods for measuring delivery rate of a boom sprayer: using a test area and using timed output. Both methods are described below. You only need to know one method - choose whichever you prefer. You can work in either litres per hectare (L/ha) or litres per acre (L/acre); be sure to use the appropriate units and constants.

Measuring Delivery Rate : Method 1 - Using a Test Area

In this method, you find sprayer delivery rate by measuring spray applied to a test area.

Step 1 **Accurately measure a reasonably long test strip (e.g., 60 metres or 200 feet - the longer the test strip, the more accurate the calibration). Mark it with two stakes. Write down the measurements for your records.**

Step 2 **Fill the sprayer half full of water and measure the amount in the tank (e.g., with a calibrated measuring stick). Write down the amount. Half a tank is used because that's the average sprayer weight. Note exactly where your sprayer is parked so you can return to the same position to accurately measure how much spray was applied to the test strip.**

Step 3 **Check the pressure setting and select the gear and rpm for the speed you want. As you approach the test strip, ensure that the tractor has reached the desired speed and that the pressure is correct.**

Step 4 **Open the boom valve as you pass the first stake and close it as you pass the second stake. Do the same for a second run.**

Step 5 **Return to the filling site and set the sprayer in the same spot you marked when filling. Determine the litres of water used to spray the test area by either:**

a) measuring how much is needed to refill the sprayer tank to the starting level in Step 2 (use an accurate measuring container);

or

b) measuring the litres used with an accurately calibrated stick.

Step 6 **Calculate the test area as follows:**

Test area = length x swath width x number of runs

Step 7 Determine the sprayer delivery rate in either litres per hectare (L/ha) or litres per acre (L/acre) depending on the spray volume units you are using. A hectare is 10,000 m², an acre is 43,560 ft².

$$\text{Delivery Rate (L/ha)} = \frac{\text{amount sprayed in test (L)}}{\text{test area (m}^2\text{)}} \times 10,000 \text{ m}^2$$

$$\text{Delivery Rate (L/acre)} = \frac{\text{amount sprayed in test (L)}}{\text{test area (ft}^2\text{)}} \times 43,560 \text{ ft}^2$$

Example: You measured a test strip 60 metres long. The width sprayed by your spray boom (swath width) is 8 metres. You started spraying the test strip with a tank that was half full of water and after making two runs you needed 21 litres of water to refill the tank half full. The sprayer delivery rate per hectare (10,000 m²) can be found as follows:

$$\begin{aligned} \text{Delivery Rate (L/ha)} &= \frac{21 \text{ L} \times 10,000 \text{ m}^2}{60 \text{ m} \times 8 \text{ m} \times 2 \text{ runs}} \\ &= \frac{21 \text{ L} \times 10,000 \text{ m}^2}{960 \text{ m}^2} \\ &= 219 \text{ L/ha} \end{aligned}$$

Example: Your test strip is 200 feet long. The width sprayed by your spray boom (swath width) is 26 feet. After two runs you needed 21 litres of water to refill the tank half full. The sprayer delivery rate per acre (43,560 ft²) can be found as follows:

$$\begin{aligned} \text{Delivery Rate (L/acre)} &= 21 \text{ L} \times \frac{43,560 \text{ ft}^2}{200 \text{ ft} \times 26 \text{ ft} \times 2 \text{ runs}} \\ &= 21 \text{ L} \times \frac{43,560 \text{ ft}^2}{10,400 \text{ ft}^2} \\ &= 88 \text{ L/acre} \end{aligned}$$

Calculating for Band Applications

Delivery rate for band applications is measured the same way except that band swath width is the sum of the individual band widths.

Example (band application): You measured a test strip 60 metres long. The eight nozzles on your sprayer are spaced at 76 centimetres intervals and each nozzle sprays a band 20 centimetres wide. After making two runs you needed 5.5 litres of water to refill the tank half full.

First you must determine the swath width (combined width of all the bands):

$$\begin{aligned}\text{Band swath width} &= \text{width of each band x number of bands} \\ &= 0.20 \text{ m x } 8 \text{ bands} \\ &= 1.6 \text{ m}\end{aligned}$$

The sprayer delivery rate for the treated area (within the bands) can then be calculated as above:

$$\begin{aligned}\text{Delivery Rate} &= 4.2 \text{ L} \quad \times \quad \frac{10,000 \text{ m}^2}{60 \text{ m} \times 1.6 \text{ m} \times 2 \text{ runs}} \\ &= 4.2 \text{ L} \quad \times \quad \frac{10,000 \text{ m}^2}{192 \text{ m}^2} \\ &= 219 \text{ L/ha}\end{aligned}$$

Measuring Delivery Rate : Method 2 - Timed Output

In this method, you find sprayer delivery rate by using speed and output per minute. Knowing the exact speed is critical to accuracy. Test speed for various gears as follows:

Step 1 Accurately measure a test strip which is reasonably long (at least 60 metres or 200 feet) and which represents typical field driving conditions.

- Step 2** **Fill your tank about half full - you won't be spraying now, but this gives an average weight load. Move to the test strip.**
- Step 3** **Select a gear and a tachometer setting which will give you a speed you want. If you use a power take off (PTO) for your sprayer, set engine speed to give 540 rpm at the PTO. Reach and hold your speed before entering the test strip.**
- Step 4** **Using a stopwatch or watch with a second hand, determine the exact time in seconds required to travel the measured distance. Write it down. Do the same for a second pass and add the two times together.**
- Step 5** **Calculate speed using one of the following formulas for km/h or mph. (If you are curious about the source of the constants 3.6 and 0.68, they are explained in Appendix 1,p.326)**

$$\text{Speed (km/h)} = \frac{\text{total distance travelled (m)}}{\text{total time required (sec)}} \times 3.6 \text{ (for km/h)}$$

$$\text{Speed (mph)} = \frac{\text{total distance travelled (ft)}}{\text{total time required (sec)}} \times 0.68 \text{ (for mph)}$$

Example: **A 60 metre test strip took 27 seconds for the first run and 27 seconds for the second run, so total time was 54 seconds and total distance was 120 metres (60 x 2).**

$$\begin{aligned} \text{Speed (km/h)} &= \frac{120\text{m}}{54 \text{ sec}} \times 3.6 \\ &= 8 \text{ km/h} \end{aligned}$$

Example: A 200 foot test strip took 27 seconds the first run and 27 seconds the second run, so total time was 54 seconds and total distance was 400 feet (200 x 2).

$$\begin{aligned}\text{Speed (mph)} &= \frac{400 \text{ ft}}{54 \text{ sec}} \times 0.68 \\ &= 5 \text{ mph}\end{aligned}$$

Step 6 Determine sprayer output per minute using either of two methods:

- a) One method is to use the total output figure from the nozzle check described earlier. When you checked nozzle output, you measured the output of each nozzle per minute and added them to get a total sprayer output per minute. (If you used 30 seconds, double the result to get a 1 minute rate.)
- b) Another method is to fill the sprayer tank half full and measure the water level. Spray in a stationary or moving test for a measured time such as 10 minutes. Measure how much water was used by refilling the tank half full or by using a calibrated dip stick. Divide the amount of spray used by the length of time of the spray test to get output per minute.

Step 7 Use one of the following formulas to determine sprayer delivery rate in either litres per hectare (L/ha) or litres per acre (L/acre), depending on the units you are using. (If you are curious about the source of the constants 600 and 495, they are explained in Appendix 1 p326).

$$\text{Delivery Rate (L/ha)} = \frac{\text{output (L/min)} \times 600}{\text{speed (km/h)} \times \text{swath width (m)}}$$

$$\text{Delivery Rate (L/acre)} = \frac{\text{output (L/min)} \times 495}{\text{speed (mph)} \times \text{swath width (ft)}}$$

Example: In calculations you found the speed to be eight kilometres per hour and the total sprayer output to be 44 litres per minute. Swath width is 15 metres.

$$\begin{aligned} \text{Delivery Rate (L/ha)} &= \frac{44 \text{ L/min} \times 600}{8 \text{ km/h} \times 15 \text{ m}} \\ &= 220 \text{ L/ha} \end{aligned}$$

Example: In calculations you found the speed to be 5 miles per hour and the total sprayer output to be 44 litres per minute. Swath width is 30 feet.

$$\begin{aligned} \text{Delivery Rate (L/acre)} &= \frac{44 \text{ L/min} \times 495}{5 \text{ mph} \times 30 \text{ ft}} \\ &= 145 \text{ L/acre} \end{aligned}$$

Band applications can be calculated in exactly the same manner. The only difference is that swath width is the total of individual band widths.

Adjusting Sprayer Delivery Rate

If the measured delivery rate is not what is required, it will be necessary to make adjustments. Remember that large adjustments to delivery rate are best made by changing nozzle sizes, and that changing pressure is suitable only for very small adjustments. Most small adjustments can be made by changing speed.

Use the following formula to calculate a new speed:

$$\text{New speed} = \text{present speed} \times \frac{\text{present delivery rate}}{\text{required delivery rate}}$$

Example: At a certain pressure and a speed of 6 km/h your delivery rate is 100 L/ha. To increase the delivery to 200 L/ha at the same pressure, what must be your new speed?

$$\begin{aligned} \text{New speed} &= 6 \text{ km/h} \times \frac{100 \text{ L/ha}}{200 \text{ L/ha}} \\ &= 3 \text{ km/h} \end{aligned}$$

If you change nozzles, pressure, or speed you will need to test the new settings and recalculate the delivery rate .

Calculating the Amount of Pesticide to Add to a Spray Tank

When your delivery rate is known, you can calculate how much pesticide to add to the spray tank. This requires two steps:

Step 1 Find the area that can be sprayed by one tank. Divide the volume of spray in the tank by the delivery rate as follows:

$$\text{Area sprayed by one tank} = \frac{\text{volume of spray mixture in tank}}{\text{delivery rate}}$$

Step 2 Calculate the amount of pesticide you need to add to your tank:

$$\text{Amount of pesticide to add to a tank} = \frac{\text{application rate}}{\text{rate}} \times \text{area sprayed by one tank}$$

Example: You have found that the sprayer delivery rate is 219 L/ha, the tank capacity is 900 L, and your pesticide must be applied at 5 L/ha. First calculate the area that can be sprayed by one tank as follows:

$$\begin{aligned} \text{Area sprayed by one 900 L tank (ha)} &= \frac{900 \text{ L}}{219 \text{ L/ha}} \\ &= 4.11 \text{ ha} \end{aligned}$$

Now you can find out how much pesticide to add to the spray tank:

$$\begin{aligned} \text{Amount of} \\ \text{pesticide to add} &= 5 \text{ L/ha} \times 4.11 \text{ ha} \\ \text{to one 900 L tank} &= 20.5 \text{ L} \end{aligned}$$

Example: Your sprayer delivery rate is 88 L/acre, the tank capacity is 900 L and you are using a pesticide that must be applied at 2 L/acre. First calculate the area that can be sprayed by one tank as follows:

$$\begin{aligned} \text{Area sprayed by one 900 L tank (acre)} &= \frac{900 \text{ L}}{88 \text{ L/acre}} \\ &= 10.2 \text{ acres} \end{aligned}$$

Now you can find out how much pesticide to add to the sprayer tank:

$$\begin{aligned} \text{Amount of} \\ \text{pesticide to add} &= 2 \text{ L/acre} \times 10.2 \text{ acres} \\ \text{to one 900 L tank} &= 20.4 \text{ L} \end{aligned}$$

Band Treatments

The formulas above work for either broadcast or band treatments. The band swath width automatically adjusts for the partial coverage.

However, you should always keep in mind that the area in the delivery rate and the area sprayed by a full tank refers only to the treated area. In band treatments only part of a field is treated.

Example: If you apply 40 cm bands to rows that are 120 cm you're really treating only one third the field. If your delivery rate shows that one tank will treat ten acres (within the bands), that means you will be able to do a total field size of 30 acres.

In this example the ten acres treated will be within the bands and 20 acres will be untreated between the bands.

(You may wish to review earlier sections "Terms Used in Calibration," "How Much Pesticide to Purchase," and, "Finding Swath Width - Broadcast and Band.")

Quiz 9.3 - Boom Sprayers

1. What are the three factors that affect sprayer delivery rate ?

2. Which three of the following would double your delivery rate ?

- a) increasing the speed to twice as fast**
- b) slowing the speed to half as fast**
- c) doubling the pressure**
- d) increasing the pressure by four times**
- e) changing nozzles to ones designed for twice the output**

3. Which of the three is the best way to double output? Why?

4. When testing spray nozzles, what two things are you checking for?

5. Your boom has ten nozzles manufactured to output 140 mL/min. In a one-minute test you collect the following amounts from each nozzle: 150 mL, 145 mL, 145 mL, 150 mL, 147 mL, 165 mL, 142 mL, 150 mL, 155 mL, 151 mL.

a) What is the average output per nozzle? _____

b) Should the set be replaced yet? _____

**c) Should any individual nozzles be replaced now?
If so, which? _____**

6. Your boom is 7.3 m (24 ft) wide. You are using overlapping flat fan sprays. You have 14 nozzles spaced 50 cm (20 in) apart. What is your exact spray swath width in metres (or feet) for calibration purposes?

7. Your band sprayer has ten nozzles, each spraying a band 15 cm (6 in.) wide. You make two passes over a test strip 200 m (660 ft) long. What is the test area sprayed in m² (or ft²)?

8. **Your boom sprayer has a swath width of 10 m (33 ft). On two passes over a 50 metre (150 ft) test strip you use 20 litres of water. What is the sprayer delivery rate per hectare (or acre)?**
-

9. **Your pesticide must be applied at 2 L/ha (810 mL/acre) in 100 to 200 L/ha (40 to 80 L/acre) of water. You have calculated the delivery rate of your boom sprayer to be 150 L/ha (61 L/acre) and tank capacity to be 1,200 L.**

- a) **How many hectares (or acres) will a full tank cover?**
b) **How much pesticide must you add to a full tank of spray?**
-

10. **To test speed you measure a test strip of 60 metres (200 ft). The time to travel it was 29 seconds the first pass and 31 seconds the second pass. What is the speed in either km/h or mph?**
-

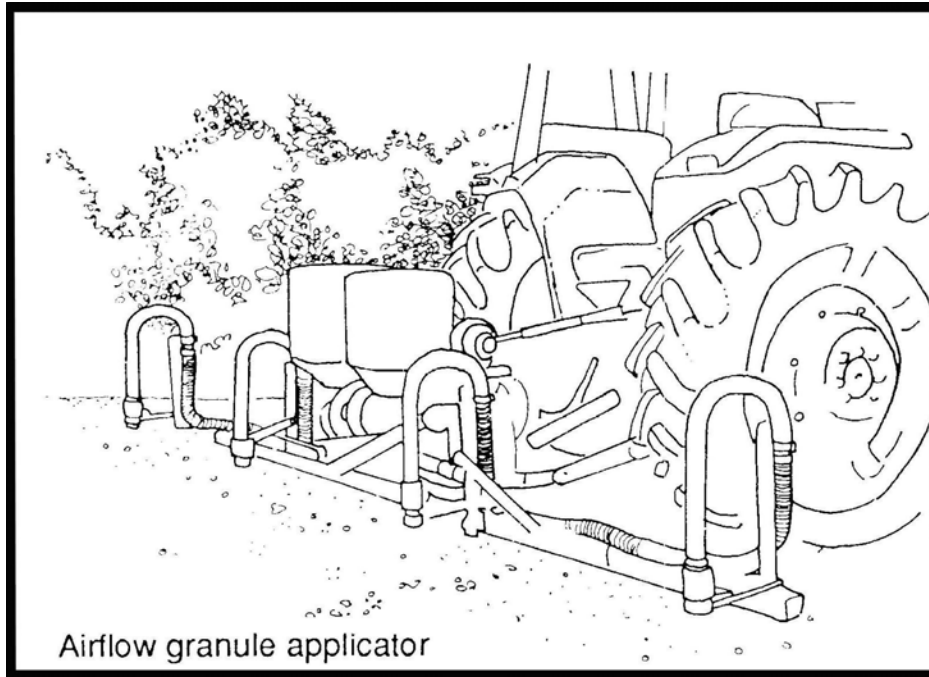
11. **Your sprayer's speed is 8 km/h (5 mph), its swath width is 10 m (33 ft), and its total output is 40 litres per minute. What is the delivery rate per hectare (or acre)?**
-

12. **You have just calibrated your boom sprayer. You calculated the speed to be 8 km/h (5 mph) and the sprayer delivery rate to be 100 L/ha (40 L/acre). However, the pesticide you are using must be applied in 120 L/ha (48 L/acre) of water. Calculate a new speed that will give you a sprayer output of 120 L/ha (48 L/acre).**
-

- 13. To reduce the amount of pesticide used and to save money, you decide to band-apply a herbicide to weeds in your carrots and to cultivate between the rows. The rows of carrots are 76 cm (30 in) apart and the ten nozzles each spray a band 20 cm (8 in) wide. You set your rig up, and on four passes of a 65 metre (200 ft) test strip you use five litres of water. What is the sprayer delivery rate per treated hectare (or acre)?**
-

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

Granular Applicators



(This section is required for field crop, vegetable (field) and nursery producers.)

Granular applicators include broadcast, band, and in-furrow type applicators. Calibration involves three basic procedures:

- **set-up**
- **measuring delivery rate**
- **adjusting delivery rate if it differs from the recommended application rate.**

Several factors can cause a variation in output. These include:

- **Size of the metering openings. With most equipment adjustment of the metering opening is used to change output. Output does not usually change in direct proportion to opening size.**
- **Roughness of the field. Differences in field roughness can affect the output. When moving between fields, or if conditions change, it is important to recalibrate to maintain the proper delivery rate. (It is also important not to travel too fast on rough fields; if the equipment bounces, application will not be uniform.)**

- **Speed. Measurement of delivery rate must be done at the same speed as will be used during application. Gravity flow metering hoppers use a rotating agitator that varies with speed. However, the flow of granules through the adjustable opening does not change in direct proportion to speed. It is quite possible to find a 50% variation in the output when changing speed only slightly.**
- **Granule flowability. Granules differ in rates of flow depending on the type, size, and density of granule and on the temperature and humidity. Although granules may look very much the same, they may actually be metered out at quite different rates. You should recalibrate when changing to a different type of granule.**

Set-up

The following items should be checked to ensure that equipment is maintained and ready for a calibration test.

On a regular basis:

- **Don't leave granules in the applicator overnight or for prolonged periods, especially during high temperatures and excessive moisture. This will help to prevent moisture absorption and product caking.**
- **Lubricate all moving parts frequently (granular material is very abrasive).**

Before testing delivery rate , check that:

- **Tire pressures of both the tractor and applicator are correct**
- **Hopper bottom, metering system, and delivery pipes are free of moisture, dust, chaff, stones, etc. (partially plugged pipes can dramatically affect the flow rate - check at least once daily during application)**
- **A hopper screen is in place to prevent foreign material (paper, dirt, straw, etc.) from entering and plugging or damaging the metering system**
- **The hopper lid is closed to prevent moisture and debris from entering.**

Use the equipment manual to find the approximate setting to supply the recommended application rate of granules. Remember, these settings may not be accurate for your field conditions; this is why you must measure your actual delivery rate .

Calculations for broadcast or band applications are each done in the same way except for determining band swath width. Swath width for broadcast applications includes the entire width of one pass. Swath width for band applications is the total of the individual band widths for one pass.

In-furrow applications are a special case. The application and delivery rates are expressed per length of row. Examples of calculations for both band and in-furrow applications are shown later in this lesson.

Measuring Delivery Rate

Delivery rate is generally determined by measuring the amount of granules discharged while the applicator is run over a test area. It is usually necessary to capture the output and weigh it. Since granules tend to settle in the hopper, refilling to a previous level does not provide accurate measurement of the amount used in the test.

Step 1 Accurately measure a reasonably long test strip (e.g., 60 metres or 200 feet). If you are calibrating for an in-furrow application, use a test strip which is the length specified in the application rate.

Mark the test strip with two stakes. For accurate calibration, the test strip should have conditions similar to those of the field to be treated. Be sure to write down all the measurements.

Step 2 Fill the applicator hopper(s) about half full of granules. A half load approximates average weight conditions. (Always wear rubber gloves when handling pesticide granules.)

Step 3 Attach bags or other containers under each downspout to catch the granules during calibration. For granular equipment that uses air flow for distribution, either use porous mesh bags (e.g., nylons) or shut off the air flow and catch the granules from directly under the metering device.

- Step 4** **Move the applicator to the test strip. Select a gear and tachometer setting that will give the speed you want. Before entering the test strip, bring the tractor up to the desired speed. Turn on the applicator metering system as it passes the first stake and turn it off as it passes the second stake. Do the same for a second run. (The more runs, the greater the accuracy.)**
- Step 5** **Weigh the granules from each bag or container and record the amounts. Since the granules collected may only be a few grams, it is very important to use a scale that accurately measures very small quantities. DO NOT use a scale that is used for food. Add the individual amounts to get the total.**
- Step 6** **If your equipment permits, check for uniform distribution across the swath. Several adjustments may be necessary. Retest after each.**
- Step 7** **The test area is calculated using the following formula. (Remember that for band applications swath width is the sum of the individual band widths.)**

$$\text{Test area} = \text{length} \times \text{swath width} \times \text{number of runs}$$

- Step 8** **Determine the applicator delivery rate in either kilograms per hectare (kg/ha) or per acre (kg/acre), depending on the application rate units you are using. A hectare is 10,000 m², an acre is 43,560 ft².**

$$\text{Delivery Rate (kg/ha)} = \frac{\text{amount collected in test area (kg)}}{\text{test area (m}^2\text{)}} \times 10,000 \text{ m}^2$$

$$\text{Delivery Rate (kg/acre)} = \frac{\text{amount collected in test (kg)}}{\text{test area (ft}^2\text{)}} \times 43,560 \text{ ft}^2$$

Example: You make two runs of a test strip 60 metres long. Swath width is 8 metres. You collect 2.5 kilograms of granules from the metering system. The applicator delivery rate in kg/hectare can be found as follows:

$$\begin{aligned}\text{Delivery Rate (kg/ha)} &= 2.5 \text{ kg} \times \frac{10,000 \text{ m}^2}{60 \text{ m} \times 8 \text{ m} \times 2} \\ &= 26 \text{ kg/ha}\end{aligned}$$

Example: You make two runs of a test strip 200 feet long. Swath width is 26 feet. You collect 2.5 kilograms of granules from the metering system. The delivery rate in kg/acre can be found as follows:

$$\begin{aligned}\text{Delivery Rate (kg/acre)} &= 2.5 \text{ kg} \times \frac{43,560 \text{ ft}^2}{200 \text{ ft} \times 26 \text{ ft} \times 2} \\ &= 10.5 \text{ kg/acre}\end{aligned}$$

Calculating for Band Applications

Band application calculations are done the same way as for broadcast except when determining swath width.

$$\text{Band swath width} = \text{width of each band} \times \text{number of bands}$$

Example (band application): You make two runs of a test strip 60 metres long. The eight bands on your applicator are spaced at 76 centimetre (0.76 m) intervals. Each band is 20 centimetres (0.20 m) wide. You find that a total of 0.5 kilograms of granules were collected from the downspouts. First you must determine the swath width (combined width of all the bands) as follows:

$$\begin{aligned}\text{Band swath width} &= 0.20 \text{ m} \times 8 \text{ bands} \\ &= 1.6 \text{ m}\end{aligned}$$

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Now, find the delivery rate in kilograms per treated area (within the bands):

$$\begin{aligned} \text{Delivery Rate (kg/ha)} &= 0.5 \text{ kg x } \frac{10,000 \text{ m}^2}{60 \text{ m x 1.6 m x 2}} \\ &= 26 \text{ kg/ha} \end{aligned}$$

Calibrating Granular In-Furrow Applications

A granular in-furrow applicator applies pesticide granules in a narrow band underground. The application rate for in-furrow treatments is recommended per length of row.

Example: Apply at 50 grams per 100 metres of row length.

Measuring delivery rate for this type of application is very simple. Use a test strip which is the same length as the application rate distance. Follow the same procedure as described previously for measuring delivery rate. The weight of the granules for the total test distance should be the same as recommended on the label application rate. If not, adjust and recalibrate.

Example: The recommended rate is 50 g/100 m. You mark a test strip 100 metres long and make one run. The average amount collected per downspout was 40 grams. Your delivery rate is 10 grams per 100 metres too low. You make adjustments and test again.

Adjusting the Delivery Rate

If you find the equipment is not delivering at the application rate needed, then you will have to adjust the metering system and recalibrate.

If there are several separate metering units on the applicator, they must be adjusted individually. Do not assume that similar settings will deliver at the same rate, or that similar adjustments will achieve the same change.

Separate metering units on row applicators must be adjusted individually. When all units are adjusted to a similar setting, large differences may occur between row units on the same planter.

Quiz 9.4 - Granular Applicators

1. **List four things that can cause granular output to vary.**

2. **What are the reasons you need to recalibrate your granular applicator when changing to a different type of granule?**

3. **Why should granules not be allowed to remain in the applicator overnight or for prolonged periods before calibrating (or any time)?**

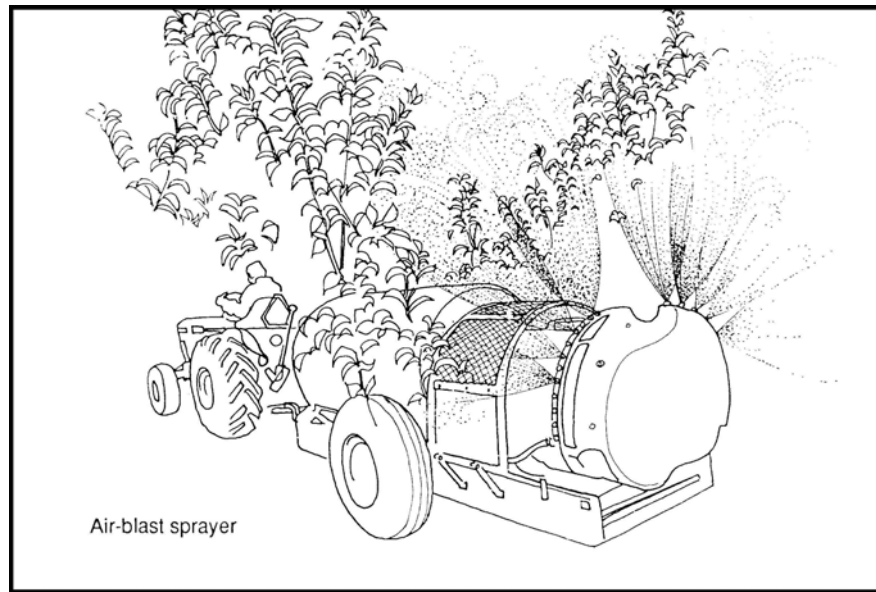
4. **When measuring delivery rate why is it better to fill the hoppers only half full of granules? (Circle the correct answer below.)**

- a) **The tractor will be able to pull the applicator.**
- b) **The applicator wheels will not damage the field.**
- c) **You'll have average weight conditions during calibration.**
- d) **The applicator will be easier to clean out at the end of the day.**

5. **You make two runs of a test strip 100 metres (330 feet) long. The swath width is ten metres (33 feet). You find that five kilograms of granules were collected from the metering system. What is the applicator delivery rate per hectare (or per acre)?**

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

Air-Blast Sprayers



(This section is required for tree fruit producers.)

Air-blast sprayers use a high-speed, fan-driven airstream to disperse spray from the nozzles through the foliage. Calibration of air-blast sprayers involves four basic procedures:

- **set-up**
- **measuring delivery rate**
- **adjustment**
- **calculation of the amount of pesticide to add to a spray tank**

With the introduction of varying sizes of fruit trees, some growers are now using Tree Row Volume (TRV) spraying in which the amount of pesticide applied is adjusted according to the volume of foliage per hectare or acre. At present, you are not required to know TRV principles or calculations for this course.

The procedures described in the following pages have long been the standard method of calibration to ensure pesticide is applied at the recommended amounts per hectare or acre. Whether you use traditional spray methods or adopt TRV techniques, these calibration procedures will continue to ensure that you are actually applying the amount of pesticide intended.

If you need further advice about set-up, nozzle selection, or calibration, or for further information on Tree Row Volume spraying, contact your Crops Specialist or local agricultural representatives.

Set-up

For this course you should know the basic activities involved in setting up an air-blast sprayer. These include:

- 1. inspecting the equipment**
- 2. adjusting the airstream**
- 3. adjusting spray pressure**
- 4. selecting spray volume**
- 5. measuring speed**
- 6. calculating required output per side**
- 7. selecting a set of nozzles**

Each of these is described in more detail below. All of them should be done when setting up a new sprayer or adapting a sprayer to different sizes of trees. However, for a routine calibration to check for nozzle wear, you may only need to make an inspection before proceeding to measure delivery rate .

1. Inspecting the Equipment

Inspection before start-up check:

- Tire pressures of both the tractor and sprayer are correct.**
- All hoses are in good condition and of the proper pressure rating.**
- All filters, strainers, and screens are clean and in place.**
- Nozzles are clean and are the intended type and size.**

Inspection with sprayer operating:

Fill the tank about half full of clean water. Start the pump and set the tractor engine speed to obtain the rpm recommended for the pump (usually 540 rpm). Open the valve to the manifold to fill the lines and begin spraying. Once all nozzles are spraying, adjust the pressure regulator to the operating pressure recommended for your pump and spraying operation (using the lowest pressure recommended will extend pump life and reduce the amount of small droplets that may drift).

Then, with the sprayer running:

- **Check that each ON/OFF valve is working.**
- **Test pressure gauges for accuracy (see Lesson 8).**
- **Check that the agitation system is working properly.**
- **Make sure there are no leaks in the spray system.**

2. Adjusting the Airstream

The airstream created by the sprayer fan carries the spray mixture into the trees and distributes it throughout the foliage. To reach all leaf surfaces and obtain complete pesticide coverage, all of the air around the foliage must be replaced by the spray-laden airstream. Both the speed of the air and the volume of the air from the fan outlet are important.

- **Speed of airstream - For sprayers with cone nozzles the minimum airspeed at the fan outlet should be at least 160 km/h (100 mph). For air-shear nozzles this velocity should be at least 240 km/h. Air speed gauges are available from packing house reps or equipment dealers.**
- **Volume of airstream - Large trees require a greater volume of air than small ones. Airstream volume is determined by the size of the fan housing opening and by air speed. Make adjustments and use air volumes as recommended in equipment manuals or by agricultural representatives.**

3. Adjusting Spray Pressure

The spray pressure affects both the volume of spray output and the size of spray droplets. As pressure increases, spray output increases but droplet size gets smaller. Excessive pressure can result in too many small droplets which are prone to drift far away from the target. Excessive pressure also increases wear on the pump, hoses, and nozzles.

As pressure decreases, spray output decreases but droplet size gets larger. Too low a pressure can cause spray so coarse that it does not penetrate foliage properly. For low-volume spraying with hollow cone nozzles, adequate spray breakup can be obtained at a pressure of 690 kPa (100 psi). For medium-and high-volume spraying, lower pressure can be used because spray breakup is not as critical.

For low-volume spraying with air-shear nozzles, a lower pressure is used, usually about 105 kPa (15 psi). With these nozzles the spray breakup depends on the high velocity of the airstream.

4. Selecting Spray Volume

Spray volume is the amount of diluent (usually water) in which a pesticide is mixed and sprayed for a specified area. The choice of spray volume depends on the type of pesticide, the pest being controlled, the application equipment, and to some extent, on the operator's preferences.

Most insects and diseases of fruit trees can be controlled with low-volume sprays (560 to 840 litres/hectare; 225 to 340 litres/acre). Some pests may require medium-volume spraying (1,100 to 2,200 litres/hectare; 440 to 880 litres/acre) or high-volume spraying (2,800 to 5,600 litres/hectare; 1,120 to 2,240 litres/acre). High-volume spraying is characterized by considerable runoff and may be required for control of fruit tree scale insects.

5. Measuring Speed

Speed must be slow enough to allow the airstream to completely replace the air in the foliage, but not so slow that excessive blow-through results. The choice of speed for orchards depends on tree size and spacing, density of foliage, and airstream speed and volume. The recommended range of speeds is from 1.6 to 4.8 km/h (1 to 3 mph).

The sprayer speed selected for use during application must be accurately measured in order to select nozzles and to calculate sprayer delivery rate . Generally two or three speeds (i.e., different tractor gears) are measured so that you can select the speed most suitable for field conditions.

Measure speed for various gears as follows:

- Step 1** **Mark off a test strip which is reasonably long (at least 60 metres or 200 feet) and which represents typical field driving conditions. Make sure tire pressures are correct. Fill your tank about half full - you won't be spraying now, but this gives an average weight load.**

- Step 2** **Select a gear and a tachometer setting which will give you a speed you want. If you use a power take off (PTO) for your sprayer, set engine speed to give 540 rpm at the PTO. Be sure that the blower is going without discharging water. Reach and hold your speed before entering the test strip.**

- Step 3** **Use a stopwatch or watch with a second hand to measure the exact time required to travel the test strip. Write it down.**

- Step 4** **Do several passes for each gear/tachometer setting - the greater the total distance, the more accurate the results. Add up the total time (in seconds) and calculate the total distance travelled (in metres or feet).**

- Step 5** **Calculate speed using the following formula. Choose the formula for the units you are using. (If you are curious about the source of the constants 3.6 and 0.68, an explanation is provided in Appendix 1,p328).**

$$\text{Speed (km/h)} = \frac{\text{total distance travelled (m)}}{\text{total time required (sec)}} \times 3.6 \text{ (for km/h)}$$

$$\text{Speed (mph)} = \frac{\text{total distance travelled (ft)}}{\text{total time required (sec)}} \times 0.68 \text{ (for mph)}$$

Example: A 100 metre test strip took 112 seconds the first run and 113 seconds the second run, so total time was 225 seconds and total distance was 200 metres (100 x 2).

$$\begin{aligned} \text{Speed (km/h)} &= \frac{200 \text{ m}}{225 \text{ sec}} \times 3.6 \\ &= 3.2 \text{ km/h} \end{aligned}$$

Example: A 300 foot test strip took 102 seconds the first run and 104 seconds the second run, so total time was 206 seconds and total distance was 600 feet (300 X 2).

$$\begin{aligned} \text{Speed (mph)} &= \frac{600 \text{ ft}}{206 \text{ sec}} \times 0.68 \\ &= 2 \text{ mph} \end{aligned}$$

6. Calculating Required Output per Side

Air-blast spray nozzles are sold on the basis of their output per minute. Since air-blast sprayers are traditionally calibrated using output for only one side of the manifold (half the sprayer output), to select the correct nozzles you must first calculate the required output for one side of your sprayer. Then you can select a set of nozzles whose individual outputs, added together, equal the required output per side.

Choose either of the following formulas, depending on the units you are using:

$$\begin{array}{ccccccc} \text{Output per side} & & \text{recommended} & & & & \text{row} \\ \text{(L/min/side)} & & \text{spray volume} & \times & \text{speed} & \times & \text{spacing} \\ & & \text{(L/ha)} & & \text{(km/h)} & & \text{(m)} \\ & & \hline & & & & 1200 & & \hline \end{array}$$

$$\text{Output per side (L/min/side)} = \frac{\text{recommended spray volume (L/acre)} \times \text{speed (mph)} \times \text{row spacing (ft)}}{900}$$

(If you're curious about the constants 1,200 and 990, the derivation of this formula is shown in Appendix 1,p328).

Example: What should the output be for all the nozzles on one side of an air-blast sprayer where the desired output is a spray volume of 560 L/ha, the speed is 3.2 km/h, and the space between the rows of trees is 6 m?

$$\begin{aligned} \text{Output per side (L/min/side)} &= \frac{560 \text{ L/ha} \times 3.2 \text{ km/h} \times 6 \text{ m}}{1,200} \\ &= 8.96 \text{ L/min/side} \end{aligned}$$

Example: What should the output be for all the nozzles on one side of an air-blast sprayer where the desired output is a spray volume of 227 L/acre, the speed is 2 mph, and the space between the rows of trees is 20 ft?

$$\begin{aligned} \text{Output per side (L/min/side)} &= \frac{227 \text{ L/acre} \times 2 \text{ mph} \times 20 \text{ ft}}{990} \\ &= \frac{9,080}{990} \\ &= 9.17 \text{ L/min/side} \end{aligned}$$

Feet or Metres? Gallons or Litres?

You can use either hectares, km/h, and metres, or acres, mph, and feet as long as you use the same set of units throughout and use the appropriate constant as shown in the preceding formula. If you need to convert speed:

$$\text{mph} = 1.61 \times \text{km/h}$$

$$\text{km/h} = 0.621 \times \text{mph}$$

The formulas shown above use only litres, not imperial gallons. If you are accustomed to using a spray volume in imperial gallons/acre, convert it to litres/acre for the formula.

One litre = 0.22 Imperial gallons

Example: 227 L/acre = 227 x 0.22 = 49.9 imperial gallons/acre

Most nozzle manufacturers have catalogues which specify nozzle output in both metric (L/min) and imperial (gallons/min) units. If you want to use imperial units, convert the L/min output you obtained in the calculations above to imperial gallons/min.

**Example: 9.17 L/min/side = 9.17 x 0.22 = 2.02 imperial
gallons/min/side**

However, working with litres is strongly recommended. Litres are standard on labels and fractions are simple to calculate (1 L = 1,000 mL). Do a one-time conversion from imperial or U.S.gallons for your tank, tank gauge markings, and measuring dip stick.

Litres = 4.54 x imperial gallons Litres = 3.78 x U.S. gallons

7. Selecting a Set of Nozzles

You can now select a set of nozzles to give you the required sprayer output (L/min/side) at the selected operating pressure. They are chosen not only to give a correct total output, but also to produce the desired spray pattern.

Nozzles of different outputs may be placed in appropriate locations on the sprayer manifold in order to achieve the desired spray pattern. Usually most of the spray volume is directed at the thickest foliage. For vineyard spraying, nozzles may be placed only in the lower half of the manifold.

If you set up your manifold for mature or nearly mature trees, a typical spray pattern is to apply approximately two third (67%) of the spray material through the upper half and about one third (33%) through the lower half of the manifold. This means nozzles in the lower part will be much smaller than those in the upper part. Most air-blast sprayers use seven nozzles on the manifold when applying low-volume sprays, so half the output of the middle (4th) nozzle is included in both upper and lower outputs.

Example: Your required sprayer output is 8.96 litres per minute per side. About 6 litres per minute (67% of the spray output) must come from the upper half of the manifold and about 3 litres per minute (33% of the spray output) from the lower part. You have seven nozzles, so half the output of the middle (fourth) nozzle will be allocated to the upper part, half to the lower part. At a pressure of 690 kPa (100 psi), one possible set-up would be as follows:

	Manifold Nozzle	Nozzle Size	Core No.	Litres /min	litres/min /side
Output of upper half about 67%	1	D4	24	1.22	5.63
	2	D6	24	1.90	
	3	D6	24	1.90	
	half of 4	D4	24	0.61	
Output of lower half about 33%	half of 4	D4	24	0.61	3.31
	5	D3	24	0.90	
	6	D3	24	0.90	
	7	D3	24	0.90	
Total output per minute per side (L/min/side)					8.94

Measuring Delivery Rate

In theory, the sprayer has been set up to deliver a certain output per side. In fact, the output may be different than expected. This is true both of new nozzles and of ones which may have worn through use. You must measure the actual output per minute in order to calculate the delivery rate. You need to know the delivery rate to determine how much pesticide to add to the spray tank and to ensure it is within the range of recommended spray volumes (e.g., 560 to 840 L/ha).

First you measure actual sprayer output per minute. Then, having already tested your true speed, you can calculate the delivery rate.

- Step 1 Position the sprayer on a level location and fill it approximately half full of water. Measure the water level in the tank (use a calibrated measuring stick). Write down the water level.**
- Step 2 Start the sprayer pump operating. Set the pressure to that used when selecting nozzles.**
- Step 3 Spray out water for a measured time such as ten minutes (the longer, the more accurate). You do not have to be moving - a stationary test works well.**
- Step 4 Measure the amount sprayed by either measuring the amount of water left in the tank with a calibrated stick or accurate tank gauge, or by refilling the tank to the original level with an accurate measuring container.**
- Step 5 Calculate the sprayer output per minute for the sprayer (two sides).**

$$\text{Sprayer output (L/min, 2 sides)} = \frac{\text{amount sprayed (L)}}{\text{time of test (min)}}$$

If you wish to find the output/min per side, divide the total two-sided sprayer output/min by two.

Example: After ten minutes you have sprayed 185 litres.

$$\begin{aligned}\text{Sprayer output (L/min, 2 sides)} &= \frac{185 \text{ L}}{10 \text{ min}} \\ &= 18.5 \text{ L/min}\end{aligned}$$

$$\begin{aligned}\text{Sprayer output (L/min/side)} &= \frac{18.5 \text{ L/min}}{2 \text{ sides}} \\ &= 9.25 \text{ L/min/side}\end{aligned}$$

Step 6 Calculate the delivery rate in litres per hectare (L/ha) or litres per acre (L/acre) using one of the following formulas. Note: these formulas use total sprayer output, not output/side as in some publications. (To use output/side, just double the 600 constant in the L/ha formula to 1200 or the 495 constant in L/acre formula to 990.)

$$\text{Delivery Rate (L/ha)} = \frac{\text{sprayer output (L/min/2 sides)} \times 600}{\text{speed (km/h)} \times \text{row spacing (m)}}$$

$$\text{Delivery Rate (L/acre)} = \frac{\text{sprayer output (L/min/2 sides)} \times 495}{\text{speed (mph)} \times \text{row spacing (ft)}}$$

Example: Your speed was 3.2 km/h and the space between the rows in your orchard is six metres. You found the actual sprayer output for two sides to be 18.5 litres/minute.

$$\begin{aligned}\text{Delivery Rate (L/ha)} &= \frac{18.5 \text{ L/min} \times 600}{3.2 \text{ km/h} \times 6 \text{ m}} \\ &= 578 \text{ L/ha}\end{aligned}$$

Example: Your speed was 2 mph and the space between the rows in your orchard is 20 feet. You found the actual sprayer output for two sides to be 18.5 litres/minute.

$$\begin{aligned} \text{Delivery Rate L/acre} &= \frac{18.5 \text{ L/min} \times 495}{2 \text{ mph} \times 20 \text{ ft}} \\ &= 229 \text{ L/acre} \end{aligned}$$

Adjusting Output

If the delivery rate is in the acceptable range for spray volume, you can proceed to find how much pesticide to add to your spray tank. If not, you will need to adjust the output and re-measure until a satisfactory delivery rate results.

If there is a significant difference between actual output and that calculated from nozzle specifications, check the system for possible causes (for example, spray pressure may not have been maintained) and make corrections where necessary. If older nozzles are no longer producing a proper output they may need replacement. Minor differences can be adjusted by slight pressure changes, but this should be done in moderation.

After any adjustments, repeat the output test if needed and calculate the delivery rate until results are within the range recommended.

- If you change pressure or nozzles, you must retest output first.
- If you change speed to an untested gear or rpm, forward speed should be retested first.

Changing nozzle size is the only way you should make large changes in output.

Changing speed for PTO-driven sprayers must only be done by making a full gear change (for example, by moving from second low to third low) so that PTO speed and engine rpm are maintained. If the spray unit has an independent engine, this is not a problem.

Changing pressure is a way to get a small change in output. It is not advisable for large changes. (Remember, to double sprayer output you would have to increase spray pressure four times.)

Adjusting for Different Row Spacing or Tree Size

What if row spacing differs from place to place? To maintain the same delivery rate you must change either output (pressure and/or nozzle sizes) or speed.

Variations in tree size may also require adjustments. For example, speed may be changed when you reduce air speed to spray dwarf trees.

For advice on making these types of adjustments to suit your particular situation, contact your agricultural representative or Crop Specialist.

Calculating the Amount of Pesticide to Add to One Tank

When your delivery rate is known you can determine how much pesticide to add to the spray tank. This is done by first finding the area of your field that can be sprayed per tank.

$$\text{Area sprayed by one tank} = \frac{\text{volume of spray mixture in tank}}{\text{delivery rate}}$$

Then calculate the amount of pesticide you need to add to your tank:

$$\text{Amount of pesticide to add to a tank} = \text{application rate} \times \text{area sprayed by one tank}$$

Example: Your sprayer delivery rate is 544 L/ha the tank capacity is 1,500 L and you are using a pesticide that must be applied at 5.5 L/ha. First calculate the area that can be sprayed by a full tank as follows:

$$\begin{aligned}\text{Area sprayed by one tank} &= \frac{1,500 \text{ L}}{544 \text{ L/ha}} \\ &= 2.76 \text{ ha}\end{aligned}$$

$$\begin{aligned}\text{Amount of pesticide to add to a full tank} &= 5.5 \text{ L/ha} \times 2.76 \text{ ha} \\ &= 15.2 \text{ L}\end{aligned}$$

Example: Your sprayer delivery rate is 217 L/acre, the tank capacity is 1,500 L, and you are using a pesticide that must be applied at 2.2 L/acre. First calculate the area that can be sprayed by a full tank as follows:

$$\begin{aligned}\text{Area sprayed by one tank} &= \frac{1,500 \text{ L}}{217 \text{ L/acre}} \\ &= 6.9 \text{ acres}\end{aligned}$$

$$\begin{aligned}\text{Amount of pesticide to add to a full tank} &= 2.2 \text{ L/acre} \times 6.9 \text{ acres} \\ &= 15.2 \text{ L}\end{aligned}$$

Quiz 9.5 - Air Blast Sprayers

1. **In a test to find speed you make two passes of a 100 metre (330 ft) test strip. One takes 148 seconds, the other 152 seconds. What is the speed in either km/h or mph?**

2. **What three pieces of information do you need to calculate the required output per minute for nozzle selection?**

3. **For mature trees, what fraction of the sprayer output typically comes from the top half of the nozzles?**

4. **You need to select nozzles for your air-blast sprayer. You want to use a pesticide in your orchard which must be applied in 500 L/ha (200 L/acre) of water. You have calculated your tractor speed to be 2.8 km/h (1.75 mph) and the tree rows in your orchard are 6 m (20 ft) apart.**

- a) **What output, in L/min/side, should your sprayer produce?**

- b) **You do a ten minute stationary test and find that a total of 150 L was sprayed with both sides spraying. What is the actual output in L/min/side?**

- c) **Given the information above, if you used the output in (b) what would be the delivery rate per acre or hectare?**

5. **What is the preferred way to make a large change in output? What is usually an acceptable way to make a small change in output?**

6. **What are three possible consequences of changing pressure to make major output changes?**

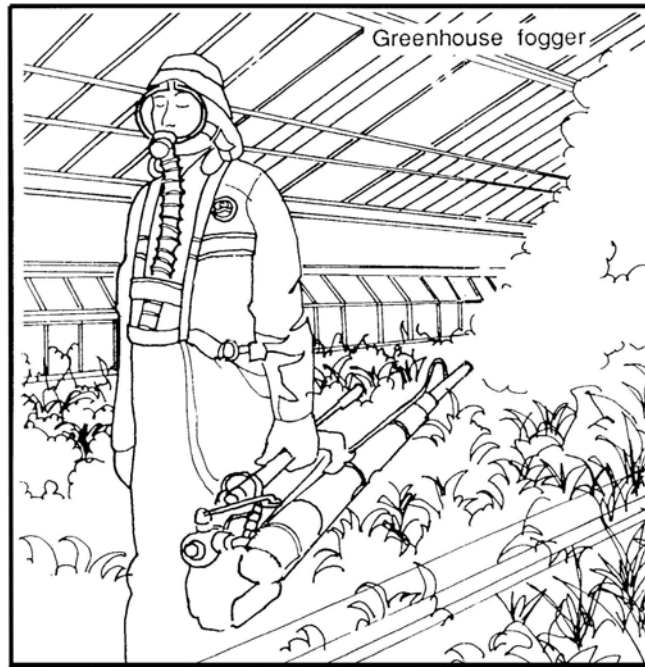
7. **Your sprayer delivery rate is 560 L/ha (224 L/acre) and the tank capacity is 1,200 L, and you are using a pesticide which must be applied at 5.5 L/ha (2.2 L/acre).**

- a) **What area in hectares or acres can be sprayed by a full tank?**

- b) **How much pesticide should you add to a full tank?**

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

Greenhouse Application Equipment



(This section is required for greenhouse vegetable or greenhouse ornamental producers.)

Many types of equipment are being used for pesticide application in greenhouses. The technology is changing rapidly, making it necessary to continue learning about the latest innovations. Your agricultural representative or Crops Specialist is a good source of information about new equipment.

There are some application rates unique to greenhouses such as those based on pot sizes or soil fumigation injection patterns.

Example: 0.10 grams per 15 cm pot

Example: inject 2.5 3 cm³ at 25 cm centres

Careful reading of the label instructions is recommended for such cases.

Greenhouse Area and Volume

Some application rates are based on area to be treated. Area is found by multiplying length times width. Triangular areas are found by multiplying length times width and dividing by two. If the layout is irregular, find the area of the whole by adding the area of each part. If plants are on racks you may need to treat each level as an area.

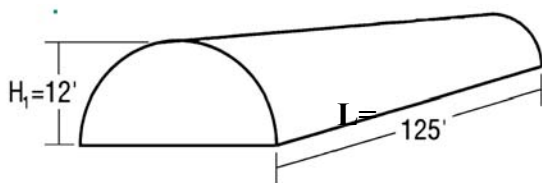
Remember that 1 hectare = 10,000 m². Recommended rates are usually stated in hectares.

Many greenhouse application rates are based on volume of the enclosed space. Volume of a flat-roofed structure is its area times its height. However, most greenhouses have sloping or Quonset roofs, so the total volume is found by finding the volume of the lower wall-height shape and the volume of the roofed shape above it and adding them together.

Volume of a Quonset Hut

If length of a quonset hut is 125 feet and the height is 12 feet. What is the volume under the quonset hut? Note: the height of 12 feet is really the radius (r) of a circle.)

Hint: Try to imagine the quonset as half a cylinder lying on it's side. Then all you need to do is figure out the volume of a cylinder and get half that amount!



Quonset Hut

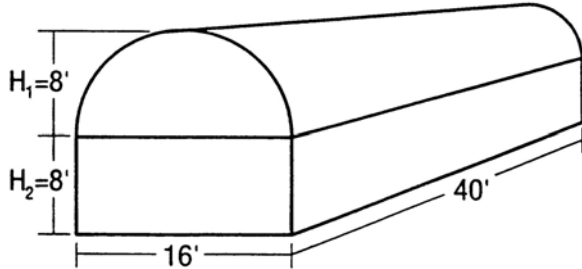
$$\begin{aligned}\text{Cylinder Volume} &= \text{area of a circle} \times \text{height} \\ &= \pi r^2 \times \text{height} \\ \text{where } \pi &= 3.14\end{aligned}$$

Since the cylinder is lying on the side, height in the formula will now be the length of the greenhouse. The volume will be divided by 2 since it is only half a cylinder!

$$\text{Quonset Volume} = \pi r^2 \times \text{height} \div 2 \quad \text{where } \pi \text{ is } 3.14$$

$$\begin{aligned}&= (3.14 \times (12' \times 12') \times 125') \div 2 \\ &= 28,260 \text{ ft}^3\end{aligned}$$

Now if your greenhouse looks like this:



You need to figure out the volume of the quonset roof as above, then figure out the volume of the rectangle below.

$$\text{Rectangle Volume} = \text{length} \times \text{width} \times \text{height}$$

$$\text{Volume} = 40' \times 16' \times 8 = 5,120 \text{ ft}^3$$

The volume of the quonset roof would be

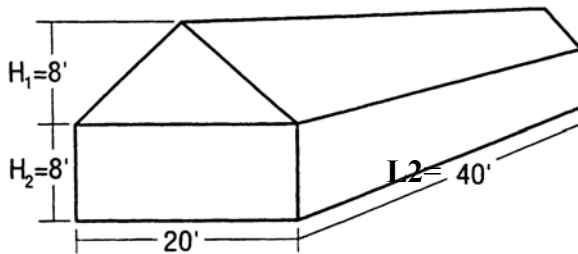
$$\text{Quonset Volume} = \pi r^2 \times \text{height} \div 2$$

$$\begin{aligned} &= 3.14 \times (8 \times 8) \times 40 \div 2 \\ &= 4,019.2 \text{ ft}^3 \end{aligned}$$

Don't forget to add the top and bottom parts together!

$$5,120 \text{ ft}^3 + 4019.2 \text{ ft}^3 = 9,139.2 \text{ ft}^3$$

Volume of an Even or Uneven Span Greenhouse



The formula for the volume of an even span greenhouse is the same as it is for an uneven span. Volume is the area of a triangle which is $\frac{1}{2}$ the width x the height multiplied by the length.

$$\text{Even Span Roof Volume} = \frac{1}{2} (\text{width} \times \text{height} \times \text{length})$$

Even Span Greenhouse

$$\begin{aligned} \text{Even Span Roof Volume} &= \frac{1}{2} \times (\text{width} \times \text{height} \times \text{length}) \\ &= \frac{1}{2} (20' \times 8' \times 40') \\ &= 3200 \text{ ft}^3 \end{aligned}$$

Length x width x length²

20' x 8' x 40' = 6400 ft³

Add the 2 sections together

Total Volume = 6400 ft³ + 3200 ft³ = 9600 ft³

Sprayers

For information on the calibration of hand-held sprayers and boom sprayers, refer back to those sections.

Many greenhouse applications are based on a "spray-to-wet" application rate which requires a well-trained eye rather than calibration for an area rate. A spray mixture dilution rate is usually all that's provided.

Example: apply at 60 g/100 L

However, you will still need to know how much spray mixture to prepare. This can be found by using a small test area as described for handsprayer calibration.

Thermal Foggers

Thermal foggers are usually gasoline-powered portable backpack or wheel-mounted units that are moved throughout the greenhouse as they are operating. Some thermal foggers have a dial to select the output in mL per minute.

The pesticide is sprayed onto a hot element and evaporates. As it condenses it produces a heavy fog which drifts through the greenhouse. The fog effectively penetrates thick foliage.

The pesticide used with this equipment is purchased either as a ready-to-apply product or may require mixing with an oil-based carrier.

Amount of Pesticide for Greenhouse Area

First find the floor area of your greenhouse. Calculate how much pesticide is needed for that area. To change litres to millilitres, multiply by 1,000 (1 litre = 1,000 millilitres). Remember also that 1 hectare = 10,000 m².

$$\text{Amount of pesticide} = \text{application rate} \times \frac{\text{greenhouse area (m}^2\text{)}}{10,000 \text{ m}^2}$$

Example: Your greenhouse is 30 m by 10 m. The pesticide application rate is 5 L/ha.

$$\begin{aligned} \text{Greenhouse area} &= 30 \text{ m} \times 10 \text{ m} = 300 \text{ m}^2 \\ \text{Application rate in mL} &= 5 \text{ L/ha} \times 1,000 = 5,000 \text{ mL}/10,000 \text{ m}^2 \\ \text{Amount of pesticide} &= 5,000 \text{ mL} \times \frac{300 \text{ m}^2}{10,000 \text{ m}^2} \\ &= 5,000 \text{ mL} \times 0.03 \\ &= 150 \text{ mL} \end{aligned}$$

Example: Your greenhouse is 30 m by 10 m. The pesticide application rate is shown as 50 mL/100 m².

$$\begin{aligned} \text{Greenhouse area} &= 30 \text{ m} \times 10 \text{ m} = 300 \text{ m}^2 \\ &= 300 \text{ m}^2 \\ \text{Amount of pesticide} &= 50 \text{ mL} \times \frac{300 \text{ m}^2}{100 \text{ m}^2} \\ &= 50 \times 3 \\ &= 150 \text{ mL} \end{aligned}$$

Calculating Output Setting

To find the output setting (mL/min) for your fogger you need to find how long it takes (in minutes) to walk with your equipment through the greenhouse. Do a preliminary walk through the greenhouse to determine this time. Use the same route and walking speed that you will use for the actual application.

$$\text{Output (mL/min)} = \frac{\text{pesticide needed for greenhouse (mL)}}{\text{time to move equipment through greenhouse (min)}}$$

Example: As in the preceding example, 150 mL of a pesticide is needed to treat the greenhouse. You find that it takes three minutes to move your equipment through the area. Now you can find the output setting for your fogger as follows:

$$\begin{aligned} \text{Output (mL/min)} &= \frac{150 \text{ mL}}{3 \text{ min}} \\ &= 50 \text{ mL/min} \end{aligned}$$

Low Volume Misters (LVM)

Mist formed by this equipment is usually very effective in penetrating dense foliage and achieving good pest control.

Calibration of portable misters is carried out in a similar manner to thermal foggers although output rates are usually lower.

Stationary misters require no calibration. However, you do need to calculate the amount of pesticide required for the greenhouse area or volume, as was shown for thermal foggers. The pesticide is then placed in the stationary mister and the mister is run until all the pesticide is used up. At that time the mister will shut itself off.

Smoke Fumigator Cans

Smoke fumigator cans or "smoke bombs," as they are sometimes called, are a convenient but relatively expensive method of controlling greenhouse insect pests. They provide "contact" kill of a number of insects, but have no residual action. Each can will treat a certain volume of greenhouse (for example, 300 cubic metres or 10,600 cubic feet).

To find the number of cans required, first find the volume of your greenhouse as shown previously in this section. Then divide the greenhouse volume by the can treatment volume.

Example: Your greenhouse is 600 m³. One can will treat 300 m³. Therefore for one treatment you will need two cans (600 m³ divided by 300 m³).

Safe Procedures

Please review the procedures for setting out smoke fumigators on page 215 and general safety procedures for greenhouse application on page 179.

Quiz 9.6 - Greenhouse Application

1. A greenhouse is 10 m wide and 30 m long with side walls which are 2.5 m high. Its roof is a gable (a typical house shape, high in the middle and sloping down each side) which is 1.5 m high in the peaked section. What is the volume of the greenhouse in m³?

2. The area you are going to treat with a thermal fogger is 25 m by 12 m. The pesticide application rate is 5 L/ha. How much pesticide will you need to treat that area?

- 3. For the area described in Question 2, you walk your portable fogging equipment through the route you are going to take and find it takes you 2.5 minutes. To what output setting will you set your fogger?**

- 4. A quonset hut greenhouse is 5 m wide and 25 m long. What is the volume of the greenhouse in m³?**

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, proceed to the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

Appendix 1 - Source of Formulas (Optional)

This information is provided for your interest, or as background for instructors. You do NOT need to study it.

Calculating Speed

The formula to calculate speed is:

$$\begin{array}{l} \text{Speed} \\ \text{Speed} \\ \text{(km/h or mph)} = \end{array} \frac{\text{total distance travelled (m or ft)}}{\text{total time required (sec)}} \times \frac{60 \text{ min} \times 60 \text{ sec}}{1000 \text{ m or } 5280 \text{ ft}}$$

To make your calculations easier, this formula has been restated below showing a constant of 3.6 (for km/h) or 0.68 (for mph). This constant represents the value of 3,600 seconds (60 x 60) divided by either 1,000 metres (a kilometre) or 5,280 feet (a mile).

$$\begin{array}{l} \text{Speed} \\ \text{(km/h)} \end{array} = \frac{\text{total distance travelled (m)}}{\text{total time required (sec)}} \times 3.6 \text{ (for km/h)}$$

$$\begin{array}{l} \text{Speed} \\ \text{(mph)} \end{array} = \frac{\text{total distance travelled (ft)}}{\text{total time required(sec)}} \times 0.68 \text{ (for mph)}$$

Example: A 60 metre test strip took 27 seconds the first run and 27 seconds the second run, so total time was 54 seconds and total distance was 120 metres (60 x 2).

$$\text{Speed (km/h)} = \frac{120 \text{ m}}{54 \text{ sec}} \times 3.6$$

$$= 8 \text{ km/h}$$

Example: A 200 foot test strip took 27 seconds the first run and 27 seconds the second run, so total time was 54 seconds and total distance was 400 feet (200 x 2).

$$\begin{aligned}\text{Speed (mph)} &= \frac{400 \text{ ft} \times 0.68}{54 \text{ sec}} \\ &= 5 \text{ mph}\end{aligned}$$

Source of the Timed Output Formula

This is provided for information only. You do NOT need to study it.

The formula to calculate delivery rate is:

$$\text{Delivery Rate (L/ha)} = \frac{\text{output (L/min)} \times 10,000 \text{ m}^2 \times 60 \text{ min}}{\text{speed(km/h)} \times \text{swath width(m)} \times 1,000\text{m}}$$

Solving for all the constant numbers into one constant value of 600 gives you the final formula for metres, hectares, and km/h.

$$\text{Delivery Rate (L/ha)} = \frac{\text{output (L/min)} \times 600}{\text{speed (km/h)} \times \text{swath width (m)}}$$

If you're working in feet, acres, and mph, the constant is 495. Here's the math behind the constant; 43,560 ft² is the area of one acre.

$$\text{Delivery Rate (L/acre)} = \frac{\text{output (L/min)} \times 43,560 \text{ ft}^2 \times 60 \text{ min}}{\text{speed(mph)} \times \text{swath width(ft)} \times 5,280\text{ft}}$$

$$\text{Delivery Rate (L/acre)} = \frac{\text{output (L/min)} \times 495}{\text{speed (mph)} \times \text{swath width (ft)}}$$

Note that when this same formula is shown for air-blast sprayers, in some publications where output per side is used, the constants are doubled to 1,200 for the L/ha formula and to 990 for the L/acre formula. See the following comments about air-blast sprayers. Swath width is also renamed "row spacing".

Calculating Required Sprayer Output per Minute (Air-Blast)

The timed output formula to find delivery rate is based on output.

$$\text{Delivery Rate (L/ha or L/acre)} = \frac{\text{output (L/min) x 600 (for ha) or 495 (for acres)}}{\text{speed (km/h or mph) x swath width (m or ft)}}$$

If you know the desired delivery rate, you can alter this formula to solve for output as follows:

$$\text{Sprayer output (L/min)} = \frac{\text{delivery rate (L/ha or L/acre)} \times \text{speed (km/h or mph)} \times \text{row spacing (m or ft)}}{600 \text{ (for ha) or } 495 \text{ (for acres)}}$$

Nozzle selection and calibration for air-blast sprayers are traditionally done using output for only one side of the manifold. This is half the total sprayer output, so output/side can be found by dividing the above answer by two.

Commonly, however, the above formula is modified to solve for output per side. This is done by doubling the denominator constants to 1,200 and 990.

For use with air-blast sprayers swath width is renamed "row spacing".

$$\text{Output per side (L/min/side)} = \frac{\text{recommended spray rate (L/ha or L/acre)} \times \text{speed (km/h or mph)} \times \text{row spacing (m or ft)}}{1,200 \text{ (for ha) or } 990 \text{ (for acres)}}$$

Answer Key

Quiz 9.1 - Introduction to Calibration

1. What is meant by equipment calibration?

Checking and adjusting the equipment to make sure it is applying pesticide uniformly and at the correct application rate.

2. List three reasons why a sprayer delivery rate may be different than dealer specifications, therefore making calibration necessary.

1. Spray nozzles may not have the output specified.
2. Speed may not be accurately shown by the speedometer or tachometer.
3. Spray pressure may not be accurately shown by the gauge.

3. List three situations when you should calibrate.

1. before new or altered equipment is used
2. when changing delivery rates, air speed (for airblast sprayers), granular sizes (for granular applicators), etc.
3. at regular intervals to see if wear is affecting output

4. What is the "application rate"? How does it differ from "spray volume"?

Application rate is the recommended amount of pesticide for an area (field) or volume (greenhouse). Spray volume is the recommended amount of a mixture of pesticide and water or other liquids for an area.

5. What is the difference between "delivery rate" and "output"?

Delivery rate is the amount the equipment applies to an area. Output is the amount it applies in a given time.

6. What are the four main procedures of calibration?

1. set-up
2. measuring the delivery rate
3. adjustment
4. calculating how much pesticide to add to the spray tank

7. How much pesticide should you buy for a broadcast treatment if:

- The application rate is 3 kg/ha.
- Your field is ten hectares.
- You expect to do two applications this year and two the next.

You would only buy enough for this year for only two applications, not four.

Amount to buy
for broadcast
treatment = application rate x area x number of applications

Amount to buy = 3 kg/ha x 10 ha x 2 applications
= 60 kg

8. How much pesticide would you need for a band treatment if:

- The application rate is 3 L/ha.
- Your field is 20 hectares.
- You expect to do three applications this year.
- Each band is 60 cm wide.
- Bands (crop rows) are spaced 120 cm apart.

Amount to buy for band treatment = application rate (broadcast rate) x area total field x number of applications x band width row spacing

Amount to buy = 3 L x 20 ha x times x $\frac{60\text{cm}}{120\text{ cm}}$
= 90 L

Quiz 9.2 - Hand-Operated Sprayers

1. The pesticide application rate says you are to add 66 mL per 100 L of spray and wet the foliage. How much pesticide would you add to make 15 L of spray in a tank?

$$\begin{aligned} \text{Amount of pesticide} \\ \text{to add to tank} &= \text{application} \\ & \text{dilution rate} \quad \times \quad \text{Volume of spray} \\ & \text{mixture in tank} \\ &= \frac{66 \text{ mL}}{100 \text{ L}} \times 15 \text{ L} \\ &= 10 \text{ mL (rounded to nearest mL)} \end{aligned}$$

2. Describe the five steps you would follow to find how much spray was applied to a test area in preparation for calculating delivery rate .

- Measure a convenient test strip, e.g., 20 m by 1.5 m (65 ft by 4 ft).
- Find the spray swath width and calculate the test area.
- Half fill the tank with water and record the level.
- Carefully spray the test strip while maintaining a steady speed and pumping pace.
- Measure the amount of water used to spray the test strip.

3. Your equipment yard has a large number of broadleaved weeds. You identify the weeds and choose a herbicide spray which must be applied at 5 kg/ha (2 kg/acre). You test your hand-operated sprayer on a 10 m (33 ft) strip which is 2.5 metres (8 ft) wide. In spraying the strip twice, you use up 2 L of water. What is the sprayer's delivery rate per hectare?

$$\begin{aligned} \text{Area} &= \text{length} \times \text{swath width} \times \text{number of runs} \\ &= 10 \text{ m} \times 2.5 \text{ m} \times 2 \text{ passes} \\ &= 50 \text{ m}^2 \end{aligned}$$

$$\begin{aligned}\text{Delivery Rate L/ha} &= \text{amount sprayed in test (L)} \quad \times \quad \frac{10\,000 \text{ m}^2}{\text{test area (m}^2\text{)}} \\ &= 2 \text{ L} \times \frac{10\,000 \text{ m}^2}{50 \text{ m}^2} \\ &= 400 \text{ L/ha}\end{aligned}$$

$$\begin{aligned}\text{Area} &= \text{length} \times \text{swath width} \times \text{number of runs} \\ &= 33 \text{ ft} \times 8 \text{ ft} \times 2 \text{ passes} \\ &= 528 \text{ ft}^2\end{aligned}$$

$$\begin{aligned}\text{Delivery Rate (L/acre)} &= \text{amount sprayed in test (L)} \times \frac{43\,560 \text{ ft}^2}{\text{test area (ft}^2\text{)}} \\ &= \frac{2 \text{ L} \times 43\,560 \text{ ft}^2}{528 \text{ ft}^2} \\ &= 165 \text{ L/acre}\end{aligned}$$

4. To apply a herbicide to a small area you plan to use a backpack sprayer which has been calibrated and has a delivery rate of 1,185 L/ha (480 L/acre). The sprayer tank holds 15 L. How much of a hectare (acre) will a full tank cover?

$$\begin{aligned}\text{Area sprayed by one tank (hectares)} &= \frac{\text{volume of spray in tank}}{\text{delivery rate (L/ha)}} \\ &= \frac{15 \text{ L}}{1,185 \text{ L/ha}} \\ &= 0.0126 \text{ ha}\end{aligned}$$

$$\begin{aligned}\text{Area sprayed by one tank (acres)} &= \frac{\text{volume of spray in tank}}{\text{delivery rate}} \\ &= \frac{15 \text{ L}}{480 \text{ L/acre}} \\ &= 0.0312 \text{ acres}\end{aligned}$$

5. You have a sprayer with a 10 L tank. You have measured its delivery rate and calculated that a full tank will cover 0.022 hectares (0.054 acres). If your herbicide should be applied at 3 L per hectare (1.2 L/acre), how many millilitres (mL) of herbicide must be added to a full tank?

$$\begin{aligned}\text{Amount of pesticide} \\ \text{to add to a tank} &= \text{application rate (L/ha)} \times \text{area sprayed by} \\ & \hspace{15em} \text{one tank (ha)} \\ &= 3 \text{ L/ha} \times 0.022 \text{ ha} \\ &= 0.066 \text{ L}\end{aligned}$$

$$\begin{aligned}\text{Amount of} \\ \text{pesticide to} \\ \text{add to a tank} &= \text{application rate (L/acre)} \times \text{area sprayed by} \\ & \hspace{15em} \text{one tank (acres)} \\ &= 1.2 \text{ L/acre} \times 0.054 \text{ acre} \\ &= 0.065 \text{ L}\end{aligned}$$

There are 1,000 millilitres in a litre. To convert litres to millilitres, multiply by 1,000:

$$1,000 \text{ mL} \times 0.066 \text{ L} = 66 \text{ mL}$$

Quiz 9.3 - Boom Sprayers

1. What are the three factors that affect sprayer delivery rate ?

Nozzle size, pressure, and forward speed.

2. Which three of the following would double your delivery rate ?

- b) slowing the speed to half as fast
- d) increasing the pressure by four times
- e) changing nozzles to ones designed for twice the output

3. Which of the three is the best way to double output? Why?

Changing nozzles. Changing speed may cause uneven distribution due to bouncing, and higher pressure may result in more drift and pump wear.

4. When testing spray nozzles, what two things are you checking for?

a uniform spray pattern and that the output of each nozzle is satisfactory.

5. Your boom has ten nozzles manufactured to output 140 mL/min. In a one-minute test you collect the following amounts from each: 150 mL, 145 mL, 145 mL, 150 mL, 147 mL, 165 mL, 142 mL, 150 mL, 155 mL, 151 mL.

- a) What is the average output per nozzle?

150 mL (sum of 1500 mL divided by 10 nozzles)

- b) Should the set be replaced yet?

No. The set average is not 10% higher than specifications (1.10 x 140 = 154 mL).

- c) Should any individual nozzles be replaced now? If so, which?

Yes. The nozzles delivering an output of 165 and 155 ml are more than 10% above average (1.10 x 150 = 154.4). The nozzle with output of 142ml should be cleaned and rechecked, because it is less than 95% of average output 0.95 x 150 = 142.5).

6. Your boom is 7.3 m (24 ft) wide. You are using overlapping flat fan nozzles. You have 14 nozzles spaced 50 cm (20 in) apart. What is your exact spray swath width in metres or feet for calibration purposes?

7 metres (14 x 50 cm = 700 cm = 7 m) or 23.3 feet (14 x 20 in = 280 in). You didn't use boom width 7.3 m (24 ft) because the boom width isn't necessarily the same as the spray width. (Note there will be some overlap with the two outer nozzles on return passes.)

7. Your band sprayer has ten nozzles each spraying a band 15 cm (6 in) wide. You make two passes over a test strip 200 m (660 ft) long. What is the test area sprayed in m² (or ft²)?

$$\begin{aligned}\text{Test area} &= \text{length} \times \text{swath width} \times \text{number of runs} \\ &= 200 \text{ m} \times (10 \times 15 \text{ cm}) \times 2 \\ &= 200 \text{ m} \times 1.5 \text{ m} \times 2 \\ &= 600 \text{ m}^2 \\ &= 660 \text{ ft} \times (10 \times 6 \text{ in}) \times 2 \\ &= 660 \text{ ft} \times 5 \text{ ft} \times 2 \\ &= 6,600 \text{ ft}^2\end{aligned}$$

8. Your boom sprayer has a swath width of 10 m (33 ft). On two passes over a 50 metre test strip you use 20 litres of water. What is the sprayer delivery rate per hectare (or acre)?

$$\text{Delivery Rate} = \text{amount sprayed in test (L)} \times \frac{10,000 \text{ m}^2 \text{ or } 43,560 \text{ ft}^2}{\text{area sprayed in test}}$$

$$\begin{aligned}\text{Delivery Rate L/ha} &= 20 \text{ L} \times \frac{10,000 \text{ m}^2}{50 \text{ m} \times 10 \text{ m} \times 2 \text{ runs}} \\ &= 20 \text{ L} \times \frac{10,000 \text{ m}^2}{1,000 \text{ m}^2} \\ &= 200 \text{ L/ha}\end{aligned}$$

$$\begin{aligned}\text{Delivery Rate (L/acre)} &= 20 \text{ L} \times \frac{43,560 \text{ ft}^2}{165 \text{ ft} \times 33 \text{ ft} \times 2 \text{ runs}} \\ &= 20 \text{ L} \times \frac{43,560 \text{ ft}^2}{10,890 \text{ ft}^2} \\ &= 80 \text{ L/acre}\end{aligned}$$

9. Your pesticide must be applied at 2 L/ha (810 mL/acre) in 100 to 200 L/ha (40 to 80 L/acre) of water. You have calculated the delivery rate of your boom sprayer to be 150 L/ha (61 L/acre) and tank capacity to be 1,200 L.

a) How many hectares (or acres) will a full tank cover?

$$\text{Area sprayed by one tank} = \frac{\text{volume of spray mixture in tank}}{\text{delivery rate}}$$

$$\text{Area sprayed by one tank} = \frac{1,200 \text{ L}}{150 \text{ L}}$$

$$= 8 \text{ ha}$$

$$\text{OR} = \frac{1,200 \text{ L}}{61 \text{ L}}$$

$$= 19.7 \text{ acres}$$

b) How much pesticide must you add to a full tank of spray?

Amount of pesticide to add to a tank = application rate x area sprayed by one tank

Amount of pesticide to add to a full tank = 2 L/ha x 8 ha

= 16 L

OR = 810 mL/acre x 19.7 acre

= 16 L (15,957 mL)

10. To test speed you measure a test strip of 60 metres (200 ft). The time to travel it was 29 seconds the first pass and 31 seconds the second pass. What is the speed in either km/h or mph?

Speed (km/h) = $\frac{\text{total distance travelled (m)}}{\text{total time required (sec)}} \times 3.6$ (for km/h)

Speed (mph) = $\frac{\text{total distance travelled (ft)}}{\text{total time required (sec)}} \times 0.68$ (for mph)

Speed = $\frac{120 \text{ m}}{60 \text{ sec}} \times 3.6$

= 7.2 km/h

OR = $\frac{400 \text{ m}}{60 \text{ sec}} \times 0.68$

= 4.5 mph

11. Your sprayer's speed is 8 km/h (5 mph), its swath width is 10 m (33 ft), and its total output is 40 litres per minute. What is the delivery rate per hectare (or acre)?

$$\text{Delivery Rate} = \frac{\text{output (L/min)} \times 600 \text{ (metric) or } 495 \text{ (imperial)}}{\text{forward speed} \times \text{swath width}}$$

$$\begin{aligned} \text{Delivery Rate} &= \frac{40 \text{ L/min} \times 600}{8 \text{ km/h} \times 10 \text{ m}} \\ &= 300 \text{ L/ha} \end{aligned}$$

$$\begin{aligned} \text{OR} &= \frac{40 \text{ L/min} \times 495}{5 \text{ mph} \times 33 \text{ ft}} \\ &= 120 \text{ L/acre} \end{aligned}$$

12. You have just calibrated your boom sprayer. You calculated the speed to be 8 km/h (5 mph) and the sprayer delivery rate to be 100 L/ha (40 L/acre). However, the pesticide you are using must be applied in 120 L/ha (48 L/acre) of water. Calculate a new speed that will give you a sprayer output of 120 L/ha (48 L/acre).

$$\text{New speed} = \text{present speed} \times \frac{\text{present delivery rate}}{\text{required delivery rate}}$$

$$\begin{aligned} \text{New speed} &= \frac{8 \text{ km/h} \times 100 \text{ L/ha}}{120 \text{ L/ha}} \\ &= 6.7 \text{ km/h} \end{aligned}$$

$$\begin{aligned} \text{OR} &= 5 \text{ mph} \times \frac{40 \text{ L/ha}}{48 \text{ L/acre}} \\ &= 4.2 \text{ mph} \end{aligned}$$

13. To reduce the amount of pesticide used and to save money, you decide to band-apply a herbicide to weeds in your corn and to cultivate between the rows. The rows of corn are 76 cm (30 in) apart and the ten nozzles each spray a band 20 cm (8 in) wide. You set your rig up, and on four passes of a 65 metre (200 ft) test strip you use five litres of water. What is the sprayer delivery rate per treated hectare (or acre)?

$$\begin{aligned}\text{Band swath width} &= \text{width of band} \times \text{number of nozzles} \\ &= 20 \text{ cm} \times 10 \text{ nozzles} \\ &= 200 \text{ cm} \\ &= 2 \text{ m}\end{aligned}$$

$$\begin{aligned}\text{OR} &= 8 \text{ in} \times 10 \text{ nozzles} \\ &= 80 \text{ in} \\ &= 6.67 \text{ ft}\end{aligned}$$

$$\text{Delivery Rate} = \text{amount sprayed in test (L)} \times \frac{10,000 \text{ m}^2 \text{ or } 43,560 \text{ ft}^2}{\text{area sprayed in test}}$$

$$\begin{aligned}\text{Delivery Rate L/ha} &= 5 \text{ L} \times \frac{10,000 \text{ m}^2}{65 \text{ m} \times 2 \text{ m} \times 4 \text{ runs}} \\ &= 5 \text{ L} \times \frac{10,000 \text{ m}^2}{520 \text{ m}^2} \\ &= 96 \text{ L/ha (to treated area)}\end{aligned}$$

$$\begin{aligned}\text{Delivery Rate L/acre} &= 5 \text{ L} \times \frac{43,560 \text{ ft}^2}{200 \text{ ft} \times 6.67 \text{ ft} \times 4 \text{ runs}} \\ &= 5 \text{ L} \times \frac{43,560 \text{ ft}^2}{5,336 \text{ ft}^2} \\ &= 41 \text{ L/acre (to treated area)}\end{aligned}$$

Quiz 9.4 - Granular Applicators

1. **List four things that can cause granular output to vary.**

size of the metering opening
speed
roughness of the field
granule flowability

2. **What are the reasons you need to recalibrate your granular applicator when changing to a different type of granule?**

Granules vary in size and density, and therefore vary in flow rate.

3. **Why should granules not be allowed to remain in the applicator overnight or for prolonged periods before calibrating (or any time)?**

They may absorb moisture and begin to cake.

4. **When measuring delivery rate why is it better to fill the hoppers only half full of granules?**

c) you'll have average weight conditions during calibration

5. You make two runs of a test strip 100 meters (330 feet) long. The swath width is ten metres (33 feet). You find that five kilograms of granules were collected from the metering system. What is the applicator delivery rate per hectare (or per acre)?

$$\begin{array}{l} \text{Delivery Rate} \\ \text{kg/ha} \\ \text{kg/acre)} \end{array} = \text{amount collected in test (kg)} \quad \times \quad \frac{\text{10,000 m}^2 \text{ or } 43,560 \text{ ft}^2}{\text{test area}}$$

$$\begin{aligned} \text{Delivery Rate (kg/ha)} &= 5 \text{ kg} \times \frac{10,000 \text{ m}^2}{100 \text{ m} \times 10 \text{ m} \times 2 \text{ runs}} \\ &= 5 \text{ kg} \times \frac{10,000 \text{ m}^2}{2,000 \text{ m}^2} \\ &= 25 \text{ kg/ha} \end{aligned}$$

$$\begin{aligned} \text{Delivery Rate (kg/acre)} &= 5 \text{ kg} \times \frac{43,560 \text{ ft}^2}{330 \text{ ft} \times 33 \text{ ft} \times 2 \text{ runs}} \\ &= 5 \text{ kg} \times \frac{43,560 \text{ ft}^2}{21,780 \text{ ft}^2} \\ &= 10 \text{ kg/acre} \end{aligned}$$

Quiz 9.5 - Air-Blast Sprayers

1. In a test to find speed you make two passes of a 100 metre (330 ft) test strip. One takes 148 seconds, the other 152 seconds. What is the speed in either km/h or mph?

$$\text{Speed (km/h)} = \frac{\text{total distance travelled (m)}}{\text{total time required (sec)}} \times 3.6 \text{ for (km/h)}$$

$$\text{Speed (mph)} = \frac{\text{total distance travelled (ft)}}{\text{total time required (sec)}} \times 0.68 \text{ for (mph)}$$

$$\text{Speed} = \frac{200 \text{ m}}{300 \text{ sec}} \times 3.6$$

$$= 2.4 \text{ km/h}$$

$$\text{OR} = \frac{660 \text{ ft}}{330 \text{ sec}} \times 0.68$$

$$= 1.5 \text{ mph}$$

2. What three pieces of information do you need to calculate the required output per minute for nozzle selection?

recommended spray volume
speed(s) you will be using
row spacing

3. For mature trees, what fraction of the sprayer output typically comes from the top half of the nozzles?

about two-thirds (about 67%)

4. You need to select nozzles for your air-blast sprayer. You want to use a pesticide in your orchard which must be applied in 500 L/ha (200 L/acre) of water. You have calculated your tractor speed to be 2.8 km/h (1.75 mph) and the tree rows in your orchard are 6 m (20 ft) apart.

- a) What output, in L/min/side, should your sprayer produce?

$$\begin{array}{l} \text{Output} \\ \text{per side} \\ \text{(L/min/side)} \end{array} = \frac{\begin{array}{l} \text{recommended} \\ \text{spray volume} \\ \text{(L/ha or L/acre)} \end{array} \times \begin{array}{l} \text{speed} \\ \text{(km/h or} \\ \text{mph)} \end{array} \times \begin{array}{l} \text{row} \\ \text{spacing} \\ \text{(m or ft)} \end{array}}{1,200 \text{ (for ha) or } 990 \text{ (for acres)}}$$

$$\begin{aligned} \text{Output per side (L/min/side)} &= \frac{500 \text{ L/ha} \times 2.8 \text{ km/h} \times 6 \text{ m}}{1,200} \\ &= 7 \text{ L/min/side} \end{aligned}$$

OR

$$\begin{aligned} \text{Output per side (L/min/side)} &= \frac{200 \text{ L/acre} \times 1.75 \text{ mph} \times 20 \text{ ft}}{990} \\ &= 7 \text{ L/min/side} \end{aligned}$$

- b) You do a ten-minute stationary test and find that a total of 150 L was sprayed with both sides spraying. What is the actual output in L/min/side?

$$\text{Sprayed output (L/min)} = \frac{\text{amount sprayed (L)}}{\text{time of test (min)}}$$

$$\begin{aligned} \text{Sprayed output (L/min/2 sides)} &= \frac{150 \text{ L}}{10 \text{ min}} \\ &= 15 \text{ L/min} \end{aligned}$$

$$\begin{aligned} \text{Output/side (L/min/side)} &= \frac{15 \text{ L/min}}{2 \text{ sides}} \\ &= 7.5 \text{ L/min/side} \end{aligned}$$

- c) Given the information above, if you used the actual output in (b), what would be the delivery rate per acre or hectare?

$$\text{Delivery Rate (L/ha)} = \frac{\text{actual output (L/min/2 sides)} \times 600}{\text{speed (km/h)} \times \text{row spacing (m)}}$$

$$\text{Delivery Rate (L/acre)} = \frac{\text{actual output (L/min/2 sides)} \times 495}{\text{speed (mph)} \times \text{row spacing (ft)}}$$

$$\begin{aligned} \text{Delivery Rate L/ha} &= \frac{15 \text{ L/min} \times 600}{2.8 \text{ km/h} \times 6} \\ &= 536 \text{ L/ha} \end{aligned}$$

OR

$$\begin{aligned} &= \frac{15 \text{ L/min} \times 495}{1.75 \text{ mph} \times 20 \text{ ft}} \\ &= 212 \text{ L/acre} \end{aligned}$$

5. What is the preferred way to make a large change in output? What is usually an acceptable way to make a small change in output?

- Changing nozzles is the preferred way to make a large output change.
- Changing pressure is usually all right for very small output changes.

6. What are three possible consequences of changing pressure to make major output changes?

- Higher pressure produces more fine droplets which could cause drift.
- Too low a pressure can produce too coarse a spray and not penetrate.
- Higher pressure can cause excessive pump and system wear.

7. Your sprayer delivery rate is 560 L/ha (224 L/acre) and the tank capacity is 1,200 L, and you are using a pesticide which must be applied at 5.5 L/ha (2.2 L/acre).

a) What area in hectares or acres can be sprayed by a full tank?

Area sprayed by one tank = $\frac{\text{volume of spray in tank}}{\text{delivery rate}}$

$$= \frac{1,200 \text{ L}}{560 \text{ L/ha}}$$

$$= 2.14 \text{ ha}$$

OR

$$= \frac{1,200 \text{ L}}{224 \text{ L/acre}}$$

$$= 5.36 \text{ acres}$$

b) How much pesticide should you add to a full tank?

Amount of pesticide to add to one tank = application rate x area sprayed by one tank

Amount of pesticide to add to one tank = 5.5 L/ha x 2.14 ha
= 11.8 L

OR = 2.2 L/acre x 5.36 acres
= 11.8 L

Quiz 9.6 - Greenhouse Application

1. A greenhouse is 10 m wide and 30 m long with side walls which are 2.5 m high. Its roof is a gable (a typical house shape, high in the middle and sloping down each side) which is 1.5 m from the bottom of the roof section to the peak. What is the volume of the greenhouse in m³?

Volume of the lower portion (box-shaped) is 10m x 30m x 2.5m = 750 m³. Volume of the upper portion is half of 10m x 30m x 1.5m = 225 m³. Total volume is 750m + 225m = 975 m³.

2. The area you are going to treat with a thermal fogger is 25 m by 12 m. The pesticide application rate is 5 L/ha. How much pesticide will you need to treat that area?

$$\text{Amount of pesticide} = \text{application rate} \times \frac{\text{greenhouse area}}{10,000 \text{ m}^2}$$

$$\begin{aligned} \text{Greenhouse area} &= 25 \text{ m} \times 12 \text{ m} \\ &= 300 \text{ m}^2 \end{aligned}$$

$$\text{Application rate (mL)} = 5 \text{ L} \times 1,000\text{ml/L} = 5,000 \text{ mL}/10,000 \text{ m}^2$$

$$\begin{aligned} \text{Amount of pesticide} &= 5,000 \text{ mL} \times \frac{300 \text{ m}^2}{10,000 \text{ m}^2} \\ &= 150 \text{ mL} \end{aligned}$$

3. For the area described in Question 2, you walk your portable fogging equipment through the route you are going to take and find it takes you 2.5 minutes. To what output setting will you set your fogger?

$$\text{Output (mL/min)} = \frac{\text{Pesticide needed for greenhouse (mL)}}{\text{Time to move equipment through greenhouse (min)}}$$

$$\begin{aligned}\text{Output (mL/min)} &= \frac{150 \text{ mL}}{2.5 \text{ min}} \\ &= 60 \text{ mL/min}\end{aligned}$$

4. A quonset hut greenhouse is 5 m wide and 25 m long. What is the volume of the greenhouse in m³?

$$\text{Area of a circle x length} \div 2$$

$$(\pi r^2 \text{ x length}) \div 2$$

$$(3.14 \times 2.5 \times 2.5 \times 25) \div 2 = 245 \text{ m}^3$$