Pesticide Sprayer Calibration 13

(updated September 2008)

Calibration helps ensure good pest control. It also helps prevent potential crop damage, high pesticide residues, and environmental contamination. All application equipment should be calibrated to ensure that pesticides are applied accurately and uniformly at the recommended rate. Calibration involves preparing the equipment so it is working properly, measuring the delivery rate, adjusting the equipment to change the delivery rate, and calculating how much pesticide to add to the sprayer tank. Calibrate equipment regularly, at least once per year, to make sure the output is not changing. Also calibrate equipment when it is new and when making changes that affect the delivery rate. Proper calibration will minimize, if not eliminate, left-over pesticide solutions in the sprayer tank that can be very difficult to dispose of properly.

There are four basic procedures to be carried out when calibrating almost any sprayer. Details on these procedures are given below. (Also refer to the *Pesticide Applicator Course for Agricultural Producers*.) Use the *Calibration Worksheet* in Appendix H to follow these four procedures when applying pesticides to your crop.

1. Set-up
2. Measuring delivery rate
3. Adjusting delivery rate (if different from recommended rate)
4. Calculating how much pesticide to add to the spray tank

Calibration of backpack sprayers, boom sprayers, and specialized greenhouse sprayers will be discussed. All spraying equipment should be calibrated using the same basic steps; more complex equipment may require more set-up.

Set-Up

Set-up is often the most neglected component of calibration and without proper set-up the likelihood of good spray coverage and uniformity is greatly diminished. The reason why set-up is often neglected is that it takes time, lots of time, if the sprayer is not well maintained. During sprayer set-up, check that the sprayer nozzles, forward speed, and spray pressure suit the pesticide, the weather, and the crop conditions. Check the equipment to ensure all parts are in good condition, clean, and working properly. Refer to the sprayer's operating manual for specific operational information. The sprayer must emit the pesticide solution uniformly across the width of the boom or spray swath to properly cover the application area. The Calibration Worksheets in Appendix H give a thorough checklist to use for boom sprayer set-up, whether it is a tractor operated system in the field or a stationary or cart based sprayer with a hand boom in greenhouses.

All sprayers should be properly set-up before you move on to the second step in calibration, measuring the delivery rate. The last page of the worksheet gives formulas for checking the speed of your tractor gears. Knowing the speed of each gear will help to make adjustments in the sprayer's delivery rate. To use the calibration formulas you must also determine your sprayer's swath width.

Select Spray Volume

Most pesticides used for floriculture crops are given as dilution rates where the crop is to be sprayed thoroughly. Spraying a test area of the crop with water will allow the operator to determine the amount of water required to adequately cover an hectare or given area. This technique is useful to determine the amount of pesticide needed per hectare when labels only provide dilution rates. The same technique can be used to identify a spray volume to use when the label rate is expressed as a certain amount of pesticide active ingredient per area. The spray volume (and amount of water) may depend on crop, stage of growth, the pest, the pesticide, weather and soil conditions, and the method of application.

For herbicides, spray volumes range from 50 to 1,000 L/ha. Refer to the product label for specific recommendations. Pesticide application rates and spray volumes for herbicides are normally given as a broadcast treatment as if the entire field is sprayed. However, in some crops, herbicides are often

applied in bands along the rows spraying only a part of the field. Therefore, to spray only bands and not the entire field, the amount of area actually treated must be calculated to determine how much herbicide to add to the sprayer.

For fungicides and insecticides, volumes of 300 to 1,000 L/ha are typically used. For foliar sprays, just enough water should be used to obtain thorough coverage of the leaves without run-off. Early in the season when growth is light, 300 L/ha of water may be adequate. In situations where foliage is dense and coverage is critical, at least 1,000 L/ha of water should be used. For drenches (high-volume, low-pressure sprays directed to the soil for control of soil-borne pests), usually at least 2,000 L/ha is used.

Use of drop pendants in tall, leafy field crops will permit lower spray volumes and better coverage than a conventional straight boom. To maintain effective coverage of the foliage with lower spray volumes, finer droplets are required to cover the same area. Finer droplets will be more prone to drift in windy conditions. In hot, dry weather, low ambient relative humidity may cause the water in fine droplets to evaporate before the pesticide reaches the target. This is another cause of drift. Sprayer operators should carefully monitor the foliage including the lower stems and undersides of lower leaves to ensure thorough coverage. Water sensitive spray cards are available to assist in carrying out this task. Also monitor spray drift.

Select Nozzle Pressure

Herbicides are generally applied at low pressures, 100 to 275 kPa, or 15 to 40 psi, to keep drift to a minimum. Do not use higher pressures unless they are specifically recommended. Some new nozzles are available that work over extended pressure ranges. Insecticides and fungicides are applied at pressures up to 2,000 kPa (300 psi) in conventional spraying equipment depending upon the pest to be controlled, the type of pesticide, and the density of the foliage. For non-systemic pesticides and high, dense plant canopies, high nozzle pressures should be used to penetrate and cover the foliage. Systemic pesticides and plants with open canopies can be sprayed at lower nozzle pressures, generally 550 kPa or 80 psi and higher, to avoid spray drift. Commercial quality backpack sprayers will produce sprays up to 1,000 kPa (150 psi). These units should be equipped with a pressure gauge and pressure regulator just like powered sprayers. Some manufacturers supply kits to convert backpack sprayers that do not have these components.

Many nozzle manufacturers have chosen to report nozzle outputs with pressures in “bars” not kilopascals (kPa). The bar unit is equal to 100 kPa. Pesticide labels report pressures in kPa. Use a pressure gauge on the sprayer marked in both psi and kPa (or bar) so both units can be read directly from the gauge. The maximum pressure on the pressure gauge for powered sprayers should be twice the maximum spray pressure used to protect the gauge from damage and allow it to be read accurately.

Determine Sprayer Swath Width (Boom Sprayers)

Swath width is the width of treated area over which spray droplets are distributed in one pass of the applicator. See Figures 13.1 to 13.4. In a broadcast spray, it is the nozzle spacing multiplied by the number of nozzles and for band treatments it is the sum of the treated band widths. For row crops it is the row spacing (from center-to-center) multiplied by the number of rows. When crops are grown in beds, usually the plant canopy covers the whole field area. The sprayer swath width is the bed spacing (from center to center of wheel tracks) multiplied by the number of beds.

The swath width is used in sprayer calibration to calculate the sprayer’s delivery rate. As the sprayer swath width is based on the treated area, the delivery rate will also be based on the treated area when band spraying herbicides.

When sprayers are set-up during calibration, check to make sure that the driving pattern used in spraying does not cause skips – areas where portions of the crop are not sprayed between successive passes of the sprayer. The sprayer boom may also overlap the first pass when spraying the next strip or swath. Skips and overlaps can be caused by not matching the nozzles on the boom to the driving pattern of the sprayer. Sometimes different nozzles are needed at the end of the boom when spraying beds or row crops to get a uniform spray coverage of the crop. With skips and overlaps, either pests will go uncontrolled or high spray residues can occur which may be dangerous to humans, plants and the environment. *While spraying, the true swath width of the sprayer is determined by the driving pattern of the sprayer through the field.*

Figure 13.1: Broadcast Swath Width

= # of nozzles x spacing
= 5 nozzles x 50 cm
= 250 cm
= 2.5 m

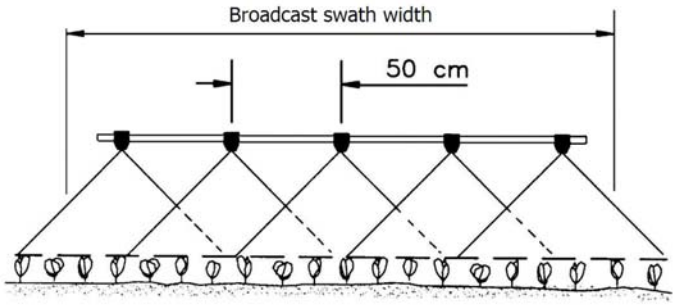


Figure 13.2: Broadcast Swath Width

= # of beds x bed width
= 2 * x 180 cm
= 360 cm
= 3.6 m

*****Note that the number of beds
= ½ bed + 1 bed + ½ bed = 2 beds

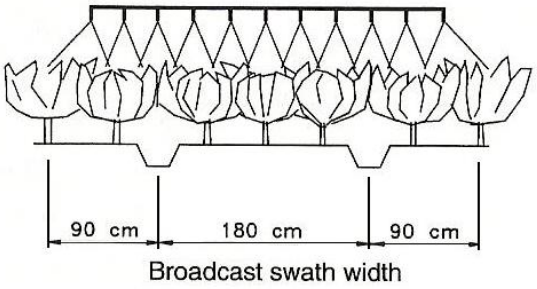


Figure 13.3: Band Swath Width

= # of bands x band width
= 3 bands x 30 cm
= 90 cm
= 0.9 m

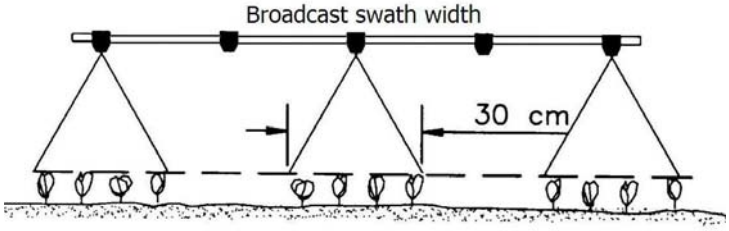
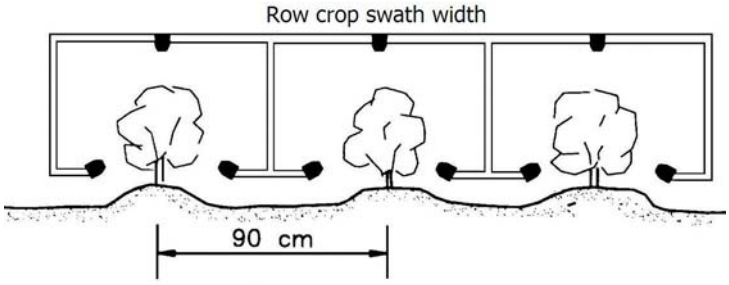


Figure 13.4: Row Crop Swath Width

= # of rows x row width
= 3 rows x 90 cm
= 270 cm
= 2.7 m



The swath width is used in sprayer calibration to calculate the sprayer's delivery rate. As the sprayer swath width is based on the treated area, the delivery rate will also be based on the treated area when band spraying herbicides.

When sprayers are set-up during calibration, check to make sure that the driving pattern used in spraying does not cause skips, i.e. areas where portions of the crop are not sprayed between successive passes of the sprayer. The sprayer boom may also overlap the first pass when spraying the next strip or swath. Both skips and overlaps can be caused by not matching the nozzles on the boom to the driving pattern of the sprayer. Sometimes different nozzles are needed at the end of the boom when spraying beds or row crops to get a uniform spray coverage of the crop. With skips and overlaps, either pests will go uncontrolled or high spray

residues can occur that may be dangerous to humans, plants and the environment. *While spraying, the true swath width of the sprayer is determined by the driving pattern of the sprayer through the field.*

Measure Delivery Rate (Boom Sprayers)

There are two basic methods used to measure sprayer delivery rates, the test area method and the timed output method.

1. The test area method uses fewer calculations, however, it can take longer to carry out. If an entire acre or hectare is used as the test area, then the measured discharge of water is the delivery rate per acre or hectare and no further calculations are required. The most common problem with the test area method is measuring the amount of spray water discharged. If too small a test area is used or it is not covered with enough passes, the actual amount of water discharged will be too small to accurately measure in the tank. The tractor and sprayer tank should be parked in the exact same location and the water must settle in the tank after stopping, before measuring the tank level after spraying.
2. The timed output method can avoid these problems, however it will require more calculations. It involves using forward speed and output per minute.

By using both the test area and timed output method, the accuracy of your sprayer calibration can be checked.

Adjust Delivery Rate (All Portable Sprayers)

If the measured delivery rate of the sprayer is different than the spray volume listed on the pesticide label or recommended in the production guide, it can be adjusted in three ways:

1. Nozzle size should be changed before making large changes in delivery rate. Check with the nozzle supplier or agricultural advisor. Obtain a catalogue listing nozzles and nozzle outputs in litres per minute (L/min).
2. Forward speed changes will adjust the delivery rate. Slower speeds increase the amount sprayed in a field, and faster speeds reduce the amount. If the delivery rate is 112 L/ha at 6 kph, then by halving the speed to 3 kph, the delivery rate is doubled to 224 L/ha. Speed changes are usually made by using a different gear in order to keep tractor RPM's and spray pressure constant and within the range recommended for the sprayer pump.
3. Spray pressure should be set for the correct droplet size. Changing pressure is recommended only for very small changes in delivery rates. Otherwise the droplet size will change and cause drift or run-off problems. Since pressure must be increased four times to double the delivery rate, this is not a good way to adjust delivery rate.

After making the adjustments, measure the delivery rate again!

Calculate How Much Pesticide to Add to the Spray Tank

Once the sprayer delivery rate is known, then calculate how many hectares can be sprayed by a full tank and how much pesticide to add to the spray tank. Formulas to use when spraying only a partial tank are given in the Calibration Worksheets in Appendix H. Be very careful to accurately measure the area to be covered by the last tank to minimize left-over spray solution.

Calibrate Hand Operated Sprayers

Sprayer Set-up

Hand operated sprayers should be checked to make sure that there aren't any 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 with large droplets for herbicides, and medium to fine spray with small droplets for insecticide and fungicide applications.

For uniform spray application it is important to maintain a constant spray pressure. Some manufacturers offer pressure regulators and pressure gauges as optional accessories that enable the operator to set specific pressures depending on the spraying job. Commercial quality backpack sprayers should have these options as standard equipment. Uniform spray application also requires the operator

to co-ordinate the walking speed with uniform sweeping movements of the nozzle. The back and forth movements determine the swath width.

Most pesticide labels give instructions as a specific amount of pesticide per unit area (e.g., apply 2.4 L/ha). Some pesticides give directions to dilute an amount of pesticide in water and apply with thorough and complete coverage.

Application Rate Given as a Dilution with Water

When the application rate is given as a dilution rate, then the amount of pesticide to mix in a full tank can be calculated directly.

Also estimate how much spray mixture is needed so pesticide solutions are not left over. Do this by applying water to a measured test area to determine the total solution needed. If large areas are being sprayed (more than one backpack tank-full), then a full tank of pesticide can be sprayed and the area measured to determine how many tanks are needed for the whole area. If smaller areas are to be sprayed, then use the same procedures as for pesticide application rates given as an amount of pesticide per unit area to determine how much pesticide to add to the tank.

Example:

A label recommends mixing 1 L of pesticide in 100 L of water and applying to foliage with thorough coverage. A 12-litre backpack will be used. How much pesticide will be needed per tank?

Method - The amount of pesticide to add to the tank can be calculated with the following formula:

Amount of pesticide = label rate (product amount ÷ water volume) X sprayer volume

Amount of pesticide = 1 L product ÷ 100 L water X 12 L tank = 0.12 L product/tank

If only a partial tank full (e.g. 8 L) of pesticide mix is required, use that figure as the "sprayer volume" in the formula.

Application Rate Given as Amount of Pesticide per Hectare

Measuring delivery rate of the hand-operated sprayer follows the same basic steps as with the tractor mounted boom sprayer but on a smaller scale. Remember during set-up of the sprayer that a steady walking speed and swath width must be used.

1. Mark out a measured length of test strip at least 60 feet long.
2. Fill the tank about half full with water and record the volume or level of water. Pump the tank to the pressure level that will be used.
3. Carefully spray the measured test strip while maintaining a steady forward speed and pumping action. Repeat enough runs over the test area until at least 10% of a full tank has been sprayed.
4. Measure the volume of water sprayed in the test strip by refilling the tank to the starting level.

Follow these steps to determine the application rate:

1. Calculate the test area:

   Test area (ft^2) = strip length (ft) X swath width (ft) X # runs

1. Calculate the delivery rate:

   Delivery rate (L/acre) = water sprayed (L) ÷ test area (ft^2) X 43,560 ft^2/acre

   Adjust the delivery rate as necessary by changing the walking speed.

2. Calculate the amount of area sprayed by a full tank:

   Area sprayed (by full tank) = tank volume (L) ÷ delivery rate (L/acre)

3. Calculate how much pesticide to add to the spray tank:

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

Example:

A grower wants to apply a foliar spray at a rate of 0.5 kg/800 L of water per ha. A test strip of 20 m long and 1 m wide is sprayed with one pass of water to measure delivery rate. To refill the spray tank, 1.7 L of water is required. What is the delivery rate, area sprayed by a full tank, and the amount of pesticide to add to a 12 L tank?

Method

Test area	= 20 m X 1 m X 1 run = 20 m^2
Delivery Rate	= 1.7 L ÷ 20 m^2 X 10,000 m^2/hectare = 850 L/ha
Area sprayed (by full tank)	= 12 L ÷ 850 L/ha = 0.0121 hectare
Amount of pesticide to add to one tank	= 0.5 kg/ha X 0.0141 ha = 0.007 kg = 7 mg

Calibrate Granular Applicators

Calibration of granular applicators involves the same first three steps as a liquid pesticide sprayer:

1. Set-up
2. Measuring delivery rate
3. Adjusting delivery rate

Granular pesticide formulations may be applied by broadcast, band, or in-furrow methods. Granular pesticides used in the floriculture industry are typically broadcast in the field. There are several factors that can cause variation in output including, size of meter openings, roughness and slope of the field, forward speed, and granule flowability.

Set-up

Set-up includes inspecting the equipment to make sure it is cleaned, lubricated, and operating properly according to the operator's manual. Set the equipment to the approximate settings to deliver the recommended application rate. Swath width on tractor mounted spinning disc and oscillating spout spreaders is dependent on the PTO (and engine) RPM. Proper spreading width, overlap of tapered patterns, and swath width will require several test runs to determine settings that will work in your field. Pneumatic spreaders that use air to carry the granules through hoses to individual distributing nozzles will drop the granules directly over the target. On a smaller scale, gravity drop granular pesticide applicators are available with in-furrow applications or with distributing nozzles for broadcast applications.

Measuring Delivery Rate

Delivery rate is generally determined by measuring the amount of granules discharged while the applicator is run over a test area or test length for in-furrow applications. It is usually necessary to capture the output and weigh it.

1. Mark out a measured test strip at least 60 m or 200 ft long.
2. Fill the applicator hopper(s) about half full of granules.
3. Choose a tractor gear and throttle setting.
4. 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.
5. Drive towards the first stake at the correct speed and discharge granules over the test strip only.
6. Repeat until enough granules are discharged to allow for accurate weights to be measured. Record the number of runs.
7. Weigh the granules from each bag or container and record the amounts. Compare the individual weights for uniformity across the swath. If outputs are uniform, then add them together. Otherwise, make adjustments and retest.

Determine the delivery rate (kg/acre) using the following formula:

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

Adjusting Delivery Rate

Increase the meter opening to discharge more granules or decrease the meter opening to discharge less granules and retest.

Calibration Example – Boom Sprayers

Refer to the Calibration Worksheet (Boom Sprayers) in Appendix H when working through the following example.

A grower has set-up a 1,000 L sprayer to spray foliage with a fungicide at the recommended rate of 2.5 kg/ha in 500 L/ha of water. The sprayer boom uses 11 nozzles spaced at 50 cm. After spraying a 100 m test strip with four runs (to discharge enough water from the spray tank to accurately measure it), 105 L of water were required to refill the tank.

What is the sprayer swath width?

From Calibration Worksheet under Set-up - Swath Width

Row crop swath width = 11 nozzles X 50 cm = 550 cm = 5.50 m

What is the delivery rate (litres per hectare) of the sprayer?

Follow Steps 1 - 8, *Measuring Delivery Rate – Test Area Method*, from the Calibration Worksheet

Test area = 100 m X 5.50 m X 4 runs = 2,200 m^2

Follow Step 9, *Measuring Delivery Rate - Test Area Method*, from the Calibration Worksheet

Delivery rate = 105 L ÷ 2,200 m^2 X 10,000 m^2/ha = 477 L/ha

The sprayer is operating at a delivery rate of 477 L/ha. The delivery rate is close enough to the desired spray volume of 500 L/ha. Use the delivery rate of 477 L/ha when calculating how much pesticide to add to the tank.

How many hectares will be covered with one full tank of spray?

Follow *Calculating How Much Pesticide to Add to the Tank – Full Tank*, from the Calibration Worksheet

Area = 1,000 L ÷ 477 L/ha = 2.10 ha

One full tank of spray will cover 2.10 ha.

How much pesticide must be added to a full tank of water?

Follow *Calculating How Much Pesticide to Add to the Tank – Full Tank*, from the Calibration Worksheet

Pesticide = 2.5 kg/ha X 2.10 ha = 5.25 kg

Add 5.25 kg of pesticide to make one full sprayer tank of spray mixture.