Sprayer Calibration

Introduction

A dilute application is when the volume of spray water is sufficient to make all foliage surfaces wet enough so that the water begins to drip off the leaves. If the spray will not be a dilute application (as is usually the case), then the amount of pesticide formulation to add to each 100 gallons of tank mix depends on the spray concentration.

Spray concentration is the ratio between number of gallons of water per acre needed for a dilute application, compared to the number of gallons of water that are actually sprayed per acre.

This section describes how to calculate the dilute gallons of water per acre for each group of similar orchard blocks, how to choose or calculate spray concentration, and how to set up the sprayer to deliver a specified volume of water per acre. By using this simple "Gallons per Minute" method, you know precisely at what concentration you are spraying. With this method, the accuracy of pesticide dosage does not depend on estimating how many acres are being sprayed per tank load.

Another way to estimate the amount of pesticide to add to the tank is to estimate how many acres of orchard will be sprayed by a tank load. This "Acres per Tank" way of estimating how much spray material to use is subject to error if the acreage is not accurately measured. The number of acres to be sprayed per tank load is then multiplied by the amount of pesticide to be used per acre. The amount of pesticide to use per acre depends on the size of trees. As with the "Gallons per Acre" method, accurate pesticide dosage using the "Acres per Tank" method depends on adjusting the dosage to tree size. For example, if the tree size and spacing is such that the dilute gallons per acre is 250 gallons, then (in most cases) the amount of a pesticide to use per acre would be 2.5 times the rate per 100 gallons. If you feel that orchard and application conditions allow it, pesticide dosage can also be further adjusted for concentrate spray application.

Tree Row Volume

Orchard blocks with different size trees and row spacings have different requirements for dilute gallonage per acre, and thus pesticide dosage per acre. By making a couple of simple measurements and using the tree row volume (TRV) formula, growers can estimate how much water would be needed to make a dilute spray to the block. By comparing the actual spray volume to the estimated dilute spray volume, growers have measure of the pesticide concentration to use. For example, if estimated dilute gallonage is 4 times greater than the volume of water sprayed per acre, then the amount of a pesticide to add to each 100 gallons of tank mix would be 4 times the dilute rate per100 gallons.

This concept is not new, most growers already take tree size into account as they mix and apply pesticide sprays.

The tree row volume method is much more accurate than making rough estimates of spray concentration by comparing spray volume per acre to a fictitious "standard" of 300 or 400gallons. A grower who sprays at 50 gallons per acre and assumes that a dilute spray would require 300 gallons would calculate that he/she is spraying at 6X (1/6 dilute volume). Thus, the grower would put roughly 6 times the recommended dilute pesticide rate in each 100 gallons of spray mix.

Many orchards are now planted on semi-dwarf and dwarf rootstocks, and comparing the actual spray volume to a hypothetical dilute volume of 300 gallons per acre is no longer accurate. For example, if the tree size in the block is such that a dilute application would only require 200 gallons water per acre, then an application made at 50 gallons per acre is a 4X spray, nota 6X spray. If the grower had used the 6X rate, he/she would have applied50% more pesticide than necessary.

For larger trees, 300 gallons per acre may be an underestimate of the dilute gallonage.

Accurate dosage for pesticide, thinning, growth regulator, and calcium sprays is too important (and mistakes too costly) to leave to guesswork. With a folding carpenter's ruler or tape measure, and a pocket calculator, a grower can have a relatively precise estimate of the dilute gallonage required for a block in just a few minutes.

Definition of Terms

- Tree Height = Distance from the ground to the top of the canopy. (Except for trees trained to high clearance.)
- Tree Width = Looking down a row from one end, the average maximum tree width.
- Row Length per acre = 43,560 square feet divided by distance between rows.
- Tree Row Volume (TRV) = Tree Height x Tree Width x Row length per acre.
- Dilute Gallons per acre (DG/A) = TRV x 0.7 gallons divided by 1,000.
- Concentrate Gallons per acre (CG/A) = Dilute gallons per acre divided by Concentration (or "X") factor.

EXAMPLE A:

If the trees are 13 feet high, 12 feet wide, and planted with 20 feet between rows, then:

Row Length = 43,560/20 = 2,178 feet/acre.

TRV = 13 x 12 x 2,178 = 339,768 cubic feet/acre.

DG/A = TRV x 0.7 gallons divided by 1,000

= 339,768 x 0.7/1,000 = 238 gallons/acre.

If you want to spray at 3X, then: CG/A = 238/3 = 79.3 = 80 gallons per acre.

Comments: A pocket calculator will never replace grower judgment. Where tree size is variable, TRV should be estimated for the average of the larger trees. For late summer sprays or very dense canopies, the estimated dilute gallonage may need upward adjustment. Unless experience has proven otherwise, estimate the dilute gallonage per acre to be at least 150 gallons even if TRV calculations indicate a lower amount. Be aware that sterol inhibitor fungicides (Nova, Rubigan) and possibly other pesticides have a minimum dose per acre, regardless of tree size.

Even though the TRV method is highly recommended, growers should experiment with one or two blocks to gain experience before using an unfamiliar method for the whole orchard.

Sprayer Setup

Being able to calculate the appropriate spray volume per acre is only useful if the spray equipment can be set to deliver that volume. This takes a little more time than figuring TRV and DG/A, but is still based on fairly simple calculations.

Every sprayer should be calibrated before the beginning of each season. A mid-season calibration checkup is also recommended. Here are a few items for a preseason calibration checklist:

- Check tractor operation and PTO mechanism.
- Have a current nozzle chart and owner's manual for your sprayer.
- Clean sprayer thoroughly, flush out tank and lines to remove rust particles and sludge, clean or replace screens or filters. Check and replace worn parts as necessary, especially nozzles.
- Check pump and pressure regulator. Have an extra pressure regulator and pressure gauge on hand. Pressure gauges often go bad, usually by reading too low.
- Obtain a stop watch, and use a tape measure to measure off an 88 foot long tractor course.
- Before setting up the sprayer and calibrating it, figure out how much water per acre is needed to treat individual blocks at 3X and 6X (or whatever spray concentrations you will use during the season). This can be done by calculating the TRV and DG/A for each block. For example, the 3X spray volume equals DG/A divided by 3. In choosing the desired spray volume(s) for each block, take into account cultivars and what you know about pest problems in that block.

Now you are ready to begin calibrating. With a moving start, and while pulling a tank half filled with water in the gear and at the RPM used for normal spraying speed, time how long it takes to cover the 88 foot course. It is much more accurate to determine this by timing the sprayer over the 88 foot course than to rely on a speedometer reading. Repeat the time trial going the other way to check your results, take the average of the two runs.

Definition of Terms

- Travel Speed (TS) in miles per hour = 60 divided by the number of seconds required to travel 88 feet.
- Swath (S) (for spraying every row) = the distance between rows. (For alternate row spraying, swath would be twice the row spacing if you want the full pesticide rate per acre. It would be only the distance between rows if you want half of the full pesticide rate per acre, applied more frequently.)
- Gallons per minute (GPM) = the gallons of water pumped out of the sprayer each minute.
- Gallons per minute (GPM) = (Concentrate gallons per acre x Swath x Travel Speed) divided by 495.
- GPM = (CG/A x S x TS) divided by 495.

EXAMPLE B:

A grower is calibrating the sprayer which will be used to treat the block described in Examples A. It takes an average of 25 seconds to run the measured tractor course at normal operating speed.

TS = 60/25 = 2.40 miles per hour

S = 20 feet

CG/A = 80 gallons/acre (see Example A).

GPM = (80 x 20 x 2.40)/495

= (3,840)/495 = 7.76 gallons per minute

For high pressure sprayers, use the nozzle chart for your sprayer, choose a pump pressure and design a nozzle set up where the total output of the nozzles at the pump pressure is as close as practical to 7.76 gallons per minute (in this example).

Designing a Nozzle Setup for a High Pressure Sprayer

A general guideline that has been used in some orchards is: For trees over10 feet high, direct 2/3 of the sprayer output to the upper half of the tree, and 1/3 of the output to the lower half of the tree. However, be aware that a general guideline such as this may not be appropriate for every orchard. Adjust nozzles and air vanes to obtain the desired spray pattern. Water sensitive paper is a useful tool to evaluate the spray deposit delivered by your sprayer to different areas of the canopy.

High pressure nozzles deliver the appropriate range of droplet sizes at200 psi, and possibly down to 100 psi. The proportion of superfine droplets (those less than 100 microns diameter) increases with nozzle pressure over200 psi. Superfine drop lets are prone to off-target drift and overly quick evaporation. Pressure above 200 psi not only increases the amount of spray lost to drift, it also puts more wear on the pump. Another benefit of setting pressure no higher than 200 psi is to reduce nozzle clogging. This is because for the same out put, a larger nozzle orifice is used at a lower pressure.

Two ways to use flip over nozzle bodies are:

1. Set up the sprayer for applications of the same tank mix to two groups of blocks that have different spray volume and spray pattern requirements, or
2. Set up the sprayer for applying tank mixes of different concentration to the same blocks (e.g. one set for 3X applications, the other set for6X applications).

Measuring Sprayer Output

Once the nozzles are in place, measure the actual sprayer output in gallons per minute. Relatively inexpensive flow meters for both high and low pressure sprayers are commercially available. When pressed onto a nozzle (or manifold line for low pressure, air shear sprayers), the meter indicates the flowrate in gallons per minute. While not as easy as using a flow meter, individual nozzles can also be checked by collecting their output into a measured container for a measured time. Checking individual high pressure nozzles will reveal those that are misfiring because of a partial plugging or because of a worn orifice. A nozzle that varies by more than 10% from its rated output at a given pressure should be replaced because as the orifice enlarges with wear, spray pattern and droplet size can also be affected.

To measure overall output, fill the tank to the top with water, and operate the sprayer for 3 minutes. After 3 minutes, turn off the sprayer and measure how much water it takes to refill the tank. A 5 gallon bucket marked like a measuring cup is useful for this. Calculate the gallons per minute output. For large adjustments, change cores or nozzles. For small adjustments (to vary gallons per minute by roughly 10% or less), set the pump pressure up or down as needed to bring the total output as close as possible to the desired gallons per minute.

How close is close enough? Consider this: if the yearly expense for pesticide, foliar nutrients and growth regulators is $250 per acre for a 50 acre orchard, then improving calibration accuracy by 10% represents $1,250 in spray materials. The benefits of precise calibration include: better crop protection; reduced risks from poor control, russeting or overthinning; lower application costs by getting the job done right the first time; accurate estimation of spray costs per block; less chance of neighbor problems and proof that you are a skilled applicator; less guesswork and more peace of mind.

As a final check, fill the sprayer with water and spray a known acreage. Measure how much water is needed to replace the water sprayed out, calculate the rate per acre, and compare it to the desired output per acre.

Adjustments for Different Blocks

Often the same sprayer and tank mix is used to treat orchard blocks with different tree size and row spacing. When moving from one block into another one that has different spray pattern and spray volume requirements, the sprayer can be quickly adjusted to provide optimal spray delivery for the second block. While each block is unique, for simplicity of planning and adjustments, blocks with similar spray requirements can be lumped into groups.

As long as the range of difference among blocks combined in a group are minor, the spray requirements for the group can be defined by the block with the highest spray volume requirement. The following example shows how a grower plans the adjustments to make for a block (or group of similar blocks) called Block C.

EXAMPLE C:

The grower with the 13 foot high trees described in Example A is planning the sprayer adjustments that will be made so that the same sprayer and tank mix can be used to treat Block C. The trees in Block C are16 feet high, 15 feet wide, and with 23 feet between rows.

Row length= 43,560/23 = 1,894 feet

TRV=16 x 14 x 1,894 = 424,256 cubic feet

DG/A=424,256 x 0.7 gallon/1,000 cubic feet

=297 gallons per acre.

The block in Example A was sprayed at 3X, so in order to use the same tank mix for Block C, it will also have to be sprayed at 3X.

CG/A = 297/3 = 99 gallons per acre.

Because the trees in Block C are taller than in Block A, the grower will turn on an additional nozzle on each side of the manifold. For this example, let's say that the added nozzles are rated at 0.60 gallons per minute at the operating pressure chosen for Block A. By adding the two nozzles, the total output becomes 7.76 (see Example B) + 1.20 = 8.96 gallons per minute.

The grower knows that after spring calibration, the sprayer output with the top nozzles on will be close to 8.96 gallons per minute. To calculate what the travel speed will have to be to get the desired 99 gallons per acre in Block C, the grower uses this formula (for DEFINITION OF TERMS see Example B):

Travel speed = (Gallons per minute x 495) divided by (Swath x Concentrate gallons per acre)

TS = (GPM x 495) / (S x CG/A)

TS = (8.96 x 495) / (23 x 99)

TS = (4,435) / (2,277) = 1.95 miles per hour.

Thus, by adding the two top nozzles and slowing the travel speed to 1.95mph, the grower can use the same tank-mix to make 3X applications to both Block A and Block C. Flow monitors for sprayers are commercially available. They account for manifold output, travel speed, and row spacing to give a running report of the gallons per acre being sprayed. This can help the driver detect calibration errors, plugged nozzles, and other problems during the application.

There are several ways to vary sprayer output for different block. Methods can be combined to get the desired result. Adding or subtracting nozzles is the simplest and most common method. As long as the sprayer operator knows what happens to pesticide delivery by adding or subtracting nozzles, it is also probably the best. Other ways include: adjusting travel speed, adjusting pump pressure (within a limited favorable range of roughly 100to 200 psi on high pressure sprayers), changing the manifold flow meter settings (low pressure, air shear sprayers), or by switching nozzle size or disc/core selection at one or more nozzle positions. Caution is advised in adjusting travel speed. Research trials have indicated that going slower than 1.5 mph or faster than 2.5 mph can cause problems with air blast spray penetration into tree canopies and affect spray coverage. For power take-off driven sprayers, the gear and RPM settings needed to properly operate the sprayer may limit the options for adjusting travel speed.

Continuing with the example of Block C, what if the grower wants to go no slower than 2.1 mph? The grower can use the Gallons per Minute formula from Example B to calculate the necessary Gallons per Minute output if the sprayer will be used to make a 3X spray to Block C at 2.1 mph.

GPM = (CG/A x S x TS) divided by 495

GPM = (99 x 23 x 2.1) / 495

GPM = (4782) / 495 = 9.66 gallons per minute

In this case, the grower will have to boost output from 8.96 to 9.66 gallons per minute, either by adjusting pressure and/or substituting one or more pairs of nozzles.

Sprayer Setup Chart

With this preseason planning, one result can be a sprayer setup plan which records the following: Blocks to be sprayed with this setup, Spray concentration, Nozzle positions used, Nozzle orifice/disc/core selection for each position, Pump pressure, Travel speed.

It is very important to verify the output of each setup by doing a preseason sprayer calibration, find the adjustments needed to get the desired output, and record them.

Finally, the different setups can be recorded in a small durable notebook kept with the tractor. This will insure that the person operating the sprayer will have the information they need to make quick adjustments to the sprayer when moving between blocks with different spray requirements.

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