Sprayer Calibration for Pecan Orchards

The application of pesticides is the most commonly used method for controlling arthropod pests and diseases on pecan trees. Because of the size of the pecan tree, pesticides are primarily applied with large spray machines known as air-assisted sprayers. Spray is delivered to different parts of the tree by a high speed air current produced by a radial fan. Air-assisted sprays vary considerably in size, volume, air speed capacity, pressure and nozzle arrangement. Sprayers can be engine-driven or PTO-driven.

Pesticide applications are costly. Whether the application is designed to be preventative or curative of a disease or insect infestation, the objective of the farmer is to do the job once and get his money's worth. Chemical control failure, generally tied to misapplications is very expensive because the farmer will not get the control he expects, another application may be required (bringing more costs), yield or fruit quality will be negatively affected, and, consequently, net return.

Spray Volume (GPA)

Good spray coverage and droplet distribution, as well as chemical efficiency, are directly related to volume of spray used, most commonly referred to as "gallons per acre or GPA." In the past, trees were sprayed to the point of runoff and volumes of up to 400 gallons per acre were used. Spray was delivered by hand-held hydraulic sprayers. Improvements in application technology have allowed spray volume to be reduced to less than 200 gallons per acre, but there is still no consensus about optimum spray volume. According to tree size, age and row spacing, volumes used generally vary from 50 GPA up to 200 GPA. Noteworthy to remember is that water is only the carrier of the product. Regardless of the amount of water used per acre, chemical use per acre should remain constant.

Before you start

Agricultural sprayers are used daily in the delivery of chemicals to our crops, ensuring a productive yield. Misuse of chemicals, however, is a potentially dangerous situation. Some chemicals used in agriculture are highly toxic, and proper safety equipment has to be used during application. During calibration procedures, even though no chemical is being used, safety should still be our primary concern. Never use your mouth to clean clogged nozzles or strainers. Use chemically resistant gloves, protective clothing and goggles when manipulating nozzles, strainers, fittings, etc. Use only water during calibration.

Sprayer calibration is the key

Why do we have to calibrate sprayers?

- To ensure that the correct volume is being delivered per unit of area.
- To ensure that mixture of water and active ingredient is being done correctly.

Sprayer speed (MPH) – Misapplications and lack of coverage are generally linked to sprayer speed. Growers tend to drive the sprayer too fast and fail to achieve the desired coverage. The chemical won't work if it is not present. Sprayer speed should be limited to 2.5 mph. To illustrate the importance of proper speed, a sprayer calibrated to deliver 100 GPA at 2 MPH will deliver only 80 GPA (20 GPA less) if sprayer speed is changed from 2.0 to 2.5 MPH.

Speed calibration: Calibrate sprayer speed by marking 100 to 200 feet and timing the sprayer as it runs the course. Don't forget to add water to the tank so that the sprayer is as heavy as it is when spraying. Do this at least three times and take an average. Enter the value in the formula:

$$\text{MPH} = \frac{\text{feet}}{\text{second}} \times 0.682$$

If you measured 200 feet and timed the sprayer at 66 seconds, then speed is:

$$\text{MPH} = \frac{200}{66} \times 0.682 = 2.0$$

Effective swath width (W) – Effective swath width is the distance at which the sprayer will be driven through the orchard. Whether spray is delivered by both sides, or each row will be travelled twice with a one-sided spray, normally W will be equal to tree row spacing divided by 2.

Volume per minute (GPM) – The amount of spray delivered by the sprayer at a given time, usually expressed by "gallons per minute, or GPM."

The formula used to calibrate the sprayer is

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{W}}{495}$$

Make sure the units match! For this formula to work out, volume should be expressed in gallons, area in acres, speed in miles per hour and width in feet. The number 495 is just a conversion factor.

EXAMPLE #1

150 GPA should be delivered at a speed of 2.0 MPH. Trees are spaced at 50 feet. Calculate the volume in gallons that the sprayers should deliver per minute.

Answer: GPA and MPH are given, W in this case is 25 feet (50 ft ÷ 2). Entering the numbers in the formula you get:

$$\text{GPM} = \frac{100 \times 2.0 \times 25}{495} = 15.1$$

In order for the sprayer to deliver 150 GPA at 2.0 MPH, it should deliver 15.1 gallons per minute (GPM). You can turn the sprayer on and spray clean water for a minute and then measure how much was sprayed. If you are not achieving the desired GPM, you should adjust sprayer pressure.

EXAMPLE #2

A sprayer is set up to deliver 12 GPM. Trees are spaced 40 feet (W is 20), and sprayer speed was measured at 2.5 MPH. What is the GPA?

Answer: We can rearrange the equation above to calculate GPA:

$$\text{GPA} = \frac{\text{GPM} \times 495}{\text{MPH} \times \text{W}}$$

and calculate GPA as

$$\text{GPA} = \frac{12 \times 495}{2.5 \times 20} = 118.8$$

Maintenance is critical

Keep your sprayer and nozzles clean – Make sure your sprayer is free of leaks and clogged nozzles. Nozzles deliver high volumes of spray. A partially clogged nozzle will reduce volume being delivered and directly affect GPA and coverage.

Recalibrate often – Recalibrate your sprayer at least three times during the growing season. Nozzles get worn, different operators may drive the tractor differently and all these factors will affect GPA and coverage.

Use clean water – Water quality will affect spray quality. Use a basket filter to pre-filter the water when filling up the sprayer.

Check water pH daily – When water pH is too high (above 7) some pesticides break down and lose efficiency (especially insecticides). This is called *alkaline hydrolysis*. Some chemicals will start breaking down 30 minutes after being mixed to very alkaline water (pH 8 or higher). Use a pH buffer to keep pH around 5.

Droplet size will define coverage

Droplets that are fine to medium in size are best for good coverage, especially for contact products. Large droplets are too heavy and will not reach the top of the trees. Use water sensitive cards to check on droplet size and coverage on different parts of the tree.

Set up the sprayer to reach the trees

Direct the spray towards the trees. It is not uncommon to see sprayers delivering spray too high or too low for a particular tree size. Shut off nozzles if needed. Direct ⅔ of the spray to the top half of the tree.

Watch the weather when you spray

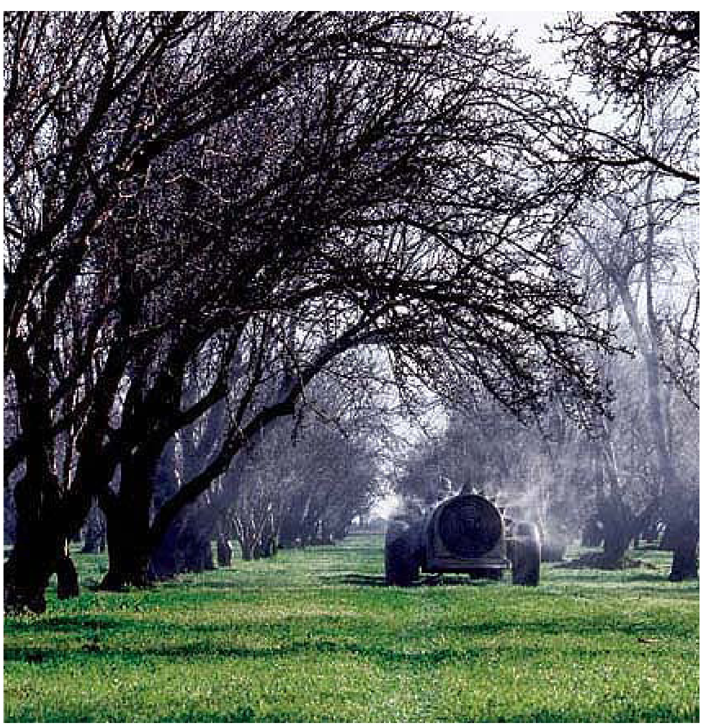
Watch for both wind direction and speed before spraying. Wind speed should be less than 10 mph (14.7 ft/s) during spraying. Spray when the wind is blowing towards the orchard and not away from it. Strong winds will carry droplets away instead of allowing them to deposit onto the trees. Try not to spray immediately before it rains; the product will be washed away from the trees.

Timing is critical

Time your application correctly. A preventative product needs to be sprayed before the pest/disease infects the tree. Scouting to determine pest presence is very important.

Make use of technology

Some sprayer manufacturers offer sensor technology that will shut the sprayer off if trees are missing, or if too large of a gap is present. This can significantly impact the amount of pesticide use in the farm.



Calculating number of nozzles and spray distribution

It is a good idea to direct a larger part of the spray volume to the top of the trees. Usually recommendations are made to direct ⅔ of the spray to the top ⅓ of the tree. A grower wants to set up his one-sided sprayer equipped with 26 nozzles (8 nozzles in the volute and 18 nozzles around the fan) to deliver 100 GPA at a speed of 2.0 mph. Tree row spacing is 40 feet. How to distribute the flow in the sprayer?

We first calculate GPM using the formula:

$$\text{GPM} = \frac{100\ \text{GPA} \times 2\ \text{MPH} \times 20\ \text{FEET}}{495} = 8.1$$

To direct ⅔ of the spray to the top ⅓ of the tree, we need to divide the GPM. Two-thirds of 8.1 GPM is 5.4, and the remaining 2.7 makes up for the remaining one-third (5.4 + 2.7 = 8.1). Eight nozzles in the volute make up about one-third of the n# of nozzles. Dividing 5.4 GPM (two-thirds of the volume) by 8 nozzles (top one-third of the nozzles) we get 0.675 GPM. Dividing the remaining 2.7 GPM by the remaining 18 nozzles, we get 0.15 GPM.

Using a nozzle manufacturer's catalog, we begin by selecting the type of nozzle to use. For this example, we've selected the AITX ConeJet nozzle from Teejet (page 44 of Teejet's catalog 50A). Now, looking at the different flow rates under constant pressure, we try to select nozzle sizes that can give us flow close to the flow we desired (0.675 and 0.15). Nozzles AITX 8004VK and AITX 8001VK yield 0.684 GPM and 0.168 GPM respectively at 120 PSI. Remember that all nozzles will be operated under the same pressure, therefore, they have to be selected under constant pressure conditions.

Eight AITX 8004VK will give us a flow of 5.472 (8 x 0.675) and 18 AITX8001VK will give us a flow of 3.024 GPM (18 x 0.15) when operated at 120 PSI, a total of 8.496 GPM, slightly above the 8.1 GPM desired. What would be the GPA using these nozzles at 120 PSI? We can calculate GPA rearranging the formula:

$$\text{GPA} = \frac{\text{GPM} \times 495}{\text{MPH} \times \text{W}} = \frac{8.496 \times 495}{2 \times 20} = 105.1$$

The final volume per acre of 105.1 is only 5.1 percent higher than the desired 100 GPA.

Field Acres versus Treated Acres

If large gaps are present among trees, or if several trees are missing and the farmer decides to shutoff the sprayer between trees to save chemical, treated acres will not be the same as field acres. That does not mean that the sprayer is not calibrated it means that only areas that are being sprayed are currently receiving the correct dose per area.

Example of Field Acres versus Treated Acres

Figure 1 represents one acre containing 16 trees and it is going to be completely sprayed by the farmer. The shaded area in gray represents the area that received a full dose of chemicals. Figure 2 represents one acre where ¼ of the trees are missing and the farmer decides not to spray that area, since there are no trees there. The shaded area in gray represents the area that received a full dose of chemicals while the area enclosed by a red dashed line represents the area that did not receive any chemical. Therefore ¾ of that acre received chemical while ¼ did not.

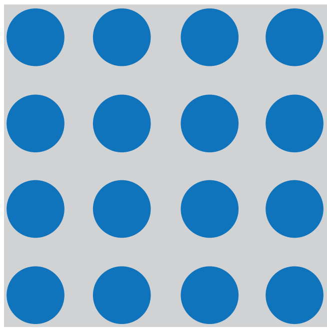


Figure 1. An acre that received a complete dose of chemical

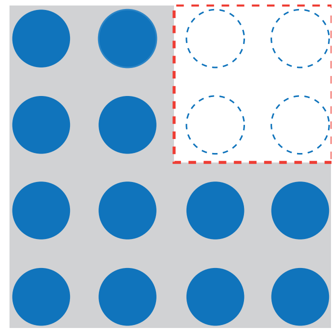


Figure 2. ¾ of this acre received chemical and ¼ did not. The dosage in gallons per acre is the same for the areas that received chemical.

The Tree Row Volume Concept (TRV)

The TRV concept is one of the systems suggested to adjust application volume (GPA) to tree size. It may be better understood through an example. A farmer needs to spray pecan trees that are 35 feet tall (crown height), and their width at ½ crown height is about 6 feet. The orchard is 100 acres in size and trees are spaced 40 feet. We need to calculate the linear row length.

$$\text{Row length (feet)} = \frac{100 \text{ acres} \times 43{,}560 \text{ feet}}{40 \text{ feet}} = 108{,}900 \text{ feet}$$

Therefore there are 108, 900 feet of linear row length in 100 acres of pecan trees spaced at 40 feet. Air volume (AV) to be treated can be calculated as:

$$\text{AV} = \text{Crown height (ft)} \times \text{Tree width} \times \text{lenght of row (ft)}$$

$$\text{AV} = 35 \times 6 \times 108{,}900 = 22{,}869{,}000 \text{ ft}^3$$

If the speed of travel is 2.0 miles per hour, how long will it take to cover all 100 acres?

$$\text{Time} = \frac{108{,}900 \text{ feet}}{2 \text{ mph} \times 5{,}280} = 10.31 \text{ hr}$$

The volume of air necessary per hour that the sprayer should deliver is calculated by dividing the total air volume required by the estimated time it will take to travel the area:

$$\text{Sprayer Air Volume} = \frac{22{,}869{,}000}{10.31} = 2{,}218{,}138 \frac{\text{ft}^3}{\text{hr}} \text{ or } 37{,}000 \text{ cfm}$$

Use this number to make adjustments in the sprayer in order to get the necessary air flow. We need now to calculate the volume of the trees. Trees are 35 feet high and 6 feet wide and are spaced 40 feet, therefore:

$$\text{Tree volume} = 35 \text{ ft} \times 6 \text{ ft} \times \frac{43560 \text{ ft}^2}{40 \text{ ft}} = 228{,}690 \text{ ft}^3 \text{ per acre}$$

Recommendations are to use up to 1 gallon of spray for every 1,000 cubic feet of tree volume for correct coverage without run-off. Selecting 0.5 gallon per 1,000 cubic feet then volume to be sprayed (GPA) per acre is:

$$\text{GPA} = 228{,}690 \frac{\text{ft}^3}{\text{ac}} \times 0.5 \frac{\text{gal}}{1{,}000 \text{ ft}^3} = 114.3$$

Specific Gravity of the Solution

Solutions are made up of water and chemicals to be sprayed. Since they are not made up of pure water, attention has to be given to the specific gravity of the mixture. Nozzle catalogs bring information on nozzle flow based on spraying water. If the solution has a specific gravity different from the water's, misapplications will occur. Specific gravity (SG) is the comparison between the solution's density and water density. It can be calculated as:

$$SG = \frac{\text{Mass (lb)}}{\text{Volume (gal)}} \div 8.34$$

Water has a specific gravity of 1 (1 gallons of water weighs 8.34 lbs.). For solutions with a different specific gravity, a conversion factor has to be applied. To do that, weigh in a known volume of the solution to be sprayed and calculate its specific gravity according to the formula above. The conversion factor (CF) is:

$$CF = \sqrt{SG}$$

Table 1 lists values of several specific gravities and their corresponding conversion factors:

Solution's Weight (lbs/gal)	Specific Gravity (SG)	Conversion Factor (CF)
7	0.84	0.92
8	0.96	0.98
8.34[a]	1	1.00
9	1.08	1.04
10	1.2	1.10
10.65[b]	1.28	1.13
11	1.32	1.15
12	1.44	1.20
13	1.55	1.25
14	1.68	1.30
15	1.79	1.38

[a]water.

[b]28% nitrogen.

EXAMPLE

A solution contains a mix of different insecticides and adjuvant and weighs 7.8 lbs. per gallon. Calculate its specific gravity and conversion factor. A nozzle to be used in this application sprays 0.665 GPM at 200 PSI, according to the catalog. How much solution will it spray at 200 PSI?

Let's begin by calculating the specific gravity:

$$SG = \frac{7.8 \text{ lbs}}{1 \text{ gallon}} \div 8.34 = 0.935$$

The conversion factor is calculated as

$$CF = \sqrt{0.935} = 0.967$$

The nozzle delivers 0.665 GPM of pure water at 200 PSI. To find out what flow of the solution with a different specific gravity will be, we divide the flow by the conversion factor

$$\frac{0.667}{0.967} = 0.689$$

This nozzle will deliver 0.689 GPM at 200 PSI instead of 0.667 GPM as rated on the catalog.

Mixing Examples

Often mixing the correct amount of chemicals in the tank is as difficult as calibrating the sprayer. Examples are given here to help understand these procedures.

EXAMPLE

Eight ounces per acre of an insecticide are recommended at a solution rate of 150 GPA. The sprayer tank has a 500-gallon capacity and the field has 175 acres.

- How much product is needed?
- How much water is needed?
- What is the tank mixture ratio?

Insecticide rate is 8 oz/ac and the field size is 175 acres. That means we need 1,400 ounces (8 x 175) of product or 10.9 gallons (1,400 ÷ 128, remember that there are 128 ounces in a gallon). Total gallons of solution (product and water) is 26,250 gallons (175 x 150). Tank size is 500 gallons, so we will need 52.5 tanks (26,250 ÷ 500) to treat the entire area. One tank will treat 3.3 acres (500 ÷ 150). For each tank, mix 26.4 ounces of product (3.3 x 8) and complete with water (499.8 gallons).

What would change in the above problem if the GPA is changed to 75 GPA but the insecticide rate remains 8 oz/ac?

We would still need the same amount of insecticide (rate is 8 oz/ac and field size is 175 acres). That means we need 1,400 ounces (8 x 175) of product or 10.9 gallons. Total gallons of solution will change since now we are spraying 75 GPA instead of 150. Solution total will be 13,125 gallons (175 x 75). Tank size is 500 gallons, so we will need 26.25 tanks (13,125 ÷ 500) to treat the entire area. One tank will treat 6.6 acres (500 ÷ 75). For each tank, mix 52.8 ounces of product (6.6 x 8) and complete with water (499.6 gallons).

Useful Conversions

Length

1 foot = 12 inches = 30.48 cm

1 yard = 3 feet = 36 inches = 91.4 cm

1 inch = 2.54 cm = 25.4 mm

1 meter = 3.281 ft = 39.37 in = 1.09 yd

1 mile = 1,609 m = 5,280 ft

Area

1 acre = 43,560 ft^2 = 0.4047 ha = 4,840 yd^2

1 m^2 = 10.76 ft^2

1 ft^2 = 144 in^2

Volume

1 pint = 2 cups = 16 fl oz

1 gallon = 4 qt = 8 pints = 128 oz = 3.785 liters

1 ft^3 = 7.48 gallons

1 bushel = 1.245 ft^3

1 m^3 = 35.31 ft^3

Weight

1 oz = 0.0625 lb = 28.35 g

1 lb = 16 oz = 454 g

1 kg = 2.205 lb

Speed

1 ft/s = 0.681 mph = 0.304 m/s

1 mph = 1.609 km/hr

Pressure

1 PSI (lb_f/in^2) = 144 lb_f/ft^2 = 0.068 atm = 2.31 ft of H_2O

Temperature

Degrees Celsius (°C) = 5/9 (°F – 32)

Degrees Fahrenheit (°F) = 9/5 °C + 32

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