ORCHARD SPRAYERS

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Air delivery or air blast sprayers are used to apply pesticides, plant growth regulators, and foliar nutrients to orchard trees by applying these materials as liquids carried in large volumes of air. Air blast sprayers have adjustments in the fluid and air delivery systems that permit tailoring of applications to fit a wide range of orchard conditions.

The efficiency and cost effectiveness of orchard pest management programs are influenced by the skills of managers and sprayer operators who evaluate orchard conditions and alter machine settings and operating techniques to optimize performance of sprayers. A combination of operational skill, equipment performance, timing, and chemical selection is necessary for optimal results.

SPRAYER SELECTION

A sprayer must be adequate for the worst of orchard conditions; one that is adequate only under favorable conditions is a liability under adverse conditions. Sprayers should at least meet the demands of spraying large, thick trees under the poorest conditions allowable for spraying. Reliability, maintenance history, and the ability to cover the projected acreage should be considered in selecting spray equipment.

Tractor horsepower requirement is a very important consideration because the air delivery fans must move a considerable volume of air and materials. Sprayer manufacturers provide a recommended tractor horsepower range, but reliability and equipment longevity are often enhanced by selecting from the upper range of suggested tractor horsepowers.

HOW TO CHOOSE A SPRAYER

When selecting an orchard sprayer, observe its performance under orchard conditions that are similar to your most difficult to spray blocks. Examine spray coverage in a setting where tree size, row spacing, weather, speed, application volume, etc. are challenging. Request dealer demonstrations and ask for names and locations of customers who are operating models of interest. Consult with university personnel, pesticide industry representatives, and growers or custom applicators who operate sprayers. When observing a demonstration, it is important to relate conditions and operating techniques such as speed, pressure, nozzle output volume, etc. to those normally occurring during actual orchard spraying conditions.

SPRAYER COMPONENTS

An air blast sprayer should have a minimum of a tank, pump, pressure regulator, pressure gauge, control valve, manifolds, nozzles, and fan. These basic components are shown in Figure 1.

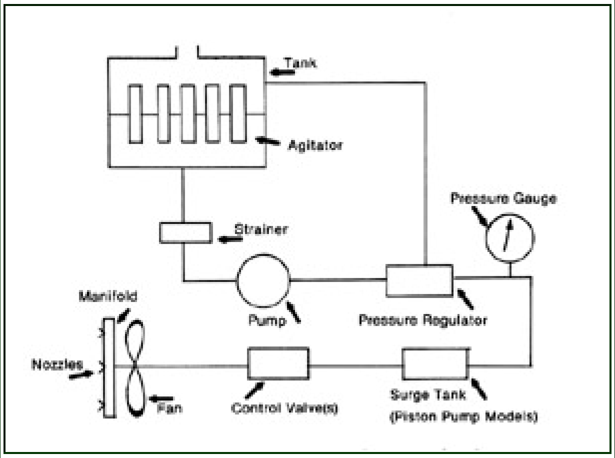

Figure 1. Basic components of an air sprayer. (Adapted from Cromwell, R. P. 1975. Citrus growers guide to air spraying. Florida Cooperative Extension Service Circular 351. 31 p.).

Tanks for sprayers should be corrosion-resistant and designed for ease in filling, adding pesticides, and for rapid, complete drainage to facilitate cleaning. Agitation should be sufficient to keep all materials uniformly distributed throughout the tank. Wettable powder pesticide formulations require vigorous agitation. Paddle or propeller type mechanical agitators and hydraulic jet agitators are common. Regardless of design, thorough agitation is required, both when trees are being sprayed and when spray nozzles are shut off. Settling of pesticides in tank mixtures may cause spray equipment problems and reduce pesticide effectiveness.

Pumps for orchard sprayers are usually piston or centrifugal type units. Centrifugal pumps move a high volume of liquid at low to medium pressure. Piston pumps are usually selected for high pressure applications.

Pressure regulators are variable orifice devices that are opened or closed to change system pressure. With air blast sprayers, pressure regulators are primarily used to divert varying amounts of the pump output back to the tank. They are often referred to as pressure relief valves or unloading valves. Actual spray output is seldom governed by pressure regulators on air blast sprayers. Spray pressure is sometimes regulated by varying pump speed. It can also be regulated by varying engine RPM. Accordingly, it is very important to maintain consistent engine speed so the RPMs of the sprayer PTO remain in the range needed.

Pressure gauges are monitors of spray system operation. Experienced operators will quickly observe spray system malfunctions that visibly reduce spray output and pattern. However, malfunctions that result in 10 to 20 percent changes in spray output may easily go unnoticed. Pressure gauges indicate spray manifold pressure. Because a sprayer is set up to operate within a specified pressure range, the pressure gauge should alert the operator when a malfunction has changed manifold pressure. Malfunctions can arise from restricted or clogged strainers (particularly line strainers), restricted or leaking lines, changes in pump output, pressure regulator malfunctions, etc. Test pressure gauges annually. They tend to become inaccurate after a few years.

Control valves may simply be an off/on valve but, most often, they provide manifold selection options. Valves may be manually operated or operated by electric solenoids. Valve controls should be mounted within easy reach of the operator.

Manifolds deliver spray to nozzles and typically allow selective nozzle placement to achieve the desired spray pattern.

Spray nozzles meter spray liquid and atomize the spray (influencing droplet size and the number of droplets obtained from a given volume of liquid). Nozzle type and location also influence spray pattern. Nozzles usually have several components, including a body, cap, strainer, disc and core (orifice and whirl plate). The disc and core, or tip, are quite susceptible to wear. Wear resistant and chemical corrosion resistant materials, such as hardened stainless steel, tungsten carbide, or ceramic material, are usually selected. Even so, nozzle output should be checked periodically and adjustments made for nozzle wear, as even a small amount of wear can significantly increase flow. For example, the flow rate of a D6 disc is increased 36 percent with only 0.005 of an inch of wear.

Fans, both axial and centrifugal, are used on air blast sprayers. The airstream's major function is moving spray into trees and enhancing the uniformity of pesticide deposition on fruit, foliage, and wood. Chemical and air mixture displaces the volume of dead air space within the tree canopy, which aids spray penetration and increases the exposure of surfaces to spray. The airstream assures spray droplet velocity, which increases impingement (sticking) of very small spray droplets to the target. Some systems depend on the airstream for atomization, although most sprayers depend primarily on nozzles. The effect of the airstream on spray droplet size is proportional to the relative velocity difference between the liquid spray and the airstream. The greater the velocity difference, the greater the atomization. Thus, if the nozzle injects spray into the airstream moving in the same direction (parallel) as the air, the spray droplet break-up caused by the air forces will be minimal. Injecting spray directly into (perpendicular) the air stream produces the maximum degree of atomization.

Airstream characteristics that influence coverage include air volume (CFM: cubic feet per minute) and velocity (FPM: feet per minute). These parameters are influenced by fan type and speed, size, volute design, and so on. As these and previous comments indicate, a number of factors, most being interactive rather than independent, are involved in air delivery sprayer performance. Performance data concerning many of these factors for specific sprayers are not generally available.

SPRAYER SETUP

Setup of an air blast sprayer includes selection and placement of nozzles, orienting air director vanes and other air control devices, and setting pressure, throttle, and engine speed, etc. that have major effects on spray volume, spray droplet size, and spray placement and coverage.

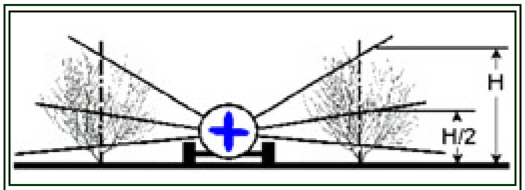

Figure 2. Recommended proportioning of a sprayer.

Nozzle arrangement and air guide or director vane settings should place most of the spray in the top half of trees, where most of the foliage and fruit are located. Air blast sprayers are typically set up to apply 2/3 to 3/4 of the spray to the top half of trees, and 1/3 to 1/4 to the bottom half (Figure 2). This targeted spraying is accomplished by placing more or larger nozzles on manifolds in the area that supplies spray to the upper half of trees and setting the air directors on the fan outlet to direct the airstream accordingly. Tree growth and target pest habits should be considered in determining the setup for specific applications. Dormant oil sprays for scale may be slightly more effective when spray distribution is shifted down to a less top-heavy pattern.

Nozzle selection decisions influence the gallons of spray per acre that will be applied and sprayer speed. Orchard spray volumes vary from 30 to 150 gallons per acre (GPA). In peaches, a range of 80 GPA for large trees to 40 GPA for newly planted trees is a good standard. Sprayer speeds range from 1.5 to 4 miles per hour (MPH). Better coverage is obtained at the lower speeds, particularly at wind speeds above 5 miles per hour.

Other items that must be determined are spray system pressure (PSI), the number of nozzles on the sprayer, and the tree row spacing. Manufacturers usually recommend operation within a specified pressure range, normally 60 to 260 PSI for sprayers with conventional hydraulic nozzles. Many manufacturers also provide nozzle setup suggestions.

Sprayer setup decisions are made using information from pesticide labels, operator manuals, extension recommendations, anticipated orchard conditions, and experience. Factors can be listed as knowns and unknowns. Knowns will include:

(1) GPA (gallons per acre) desired
(2) PSI (pounds per square inch) pressure desired
(3) MPH (miles per hour) desired
(4) Number of nozzles on sprayer
(5) Tree row spacing (feet)

The information that needs to be determined and set for the machine can be listed as unknowns:

(1) GPM (gallons per minute) output needed
(2) Nozzles (sizes and placement)

Gallons per minute output for a sprayer traveling between each row and spraying from both sides can be calculated with the following equation:

$$GPM = \frac{GPA \times MPH \times \text{Row Spacing (ft)}}{500}$$

Nozzle sizes can be selected from the manufacturer's catalogues using the calculated GPM, the selected pressure (PSI), and number of nozzle positions on the sprayer. Arrange nozzles so that 2/3 to 3/4 of the spray will be applied to the top half of trees, with the residual applied to the bottom half. Calculating the average nozzle output will help in making nozzle selections from the manufacturer's tables.

Example:

Knowns

(1) GPA = 50
(2) PSI = 100 at the manifold
(3) MPH = 3 (selected travel speed)
(4) Number of nozzles = 10 on sprayer @ 5 per side
(5) Tree row spacing = 18 feet

Unknowns

(1) Gallons per minute output needed

$$GPM = \frac{GPA \times MPH \times \text{Row Spacing (ft)}}{500} = \frac{50 \times 3 \times 18}{500} = \frac{2700}{500} = 5.4 \text{ gal/min total for 2 sides}$$

$$= 2.7 \text{ gal/min/side}$$

(2) Nozzles (sizes and placement). There are 10 nozzles, five on each side. Select 5 nozzles that have a combined output of 2.7 GPM/side. Arrange nozzles to provide the desired volume in the top half of trees for one side, then duplicate the selection and arrangement on the other side.

Determine the average nozzle output as a starting point for making nozzle selections from the manufacturer's tables. This can be calculated as follows:

$$\frac{2.7 \text{ GPM on each side}}{5 \text{ nozzles on each side}} = 0.54 \text{ GPM/nozzle}$$

To place 2/3 of the spray volume in the top half of trees, the nozzles placed on the top half of each manifold will need a combined output between 2/3 x 2.7 GPM = 1.8 GPM and 3/4 x 2.7 = 2.25 GPM.

Use the manufacturer's table to find 5 nozzles having a combined capacity of approximately 2.7 GPM that can be mounted on the sprayer manifold, with between 1.8 and 2.25 GPM applied to the top half of trees.

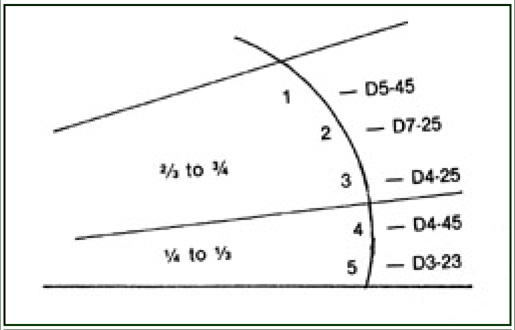

Figure 3. Nozzle placement for proportioning spray material.

Most spray nozzle manufacturers publish tables showing the GPM capacity of various nozzle sizes for various pressures. Table 1 is part of a manufacturer's nozzle capacity table.

Two or more nozzle sizes are normally required to produce the desired spray volume and pattern. A variety of nozzle arrangements can be used to achieve the volume and spray distribution needed. A good selection would be as follows (Figure 3).

(1) D3-45 tip = (1 x 0.36) = 0.36 GPM
(2) D4-25 tips = (2 x 0.45) = 0.90 GPM
(2) D5-45 tips = (2 x 0.71) = 1.42 GPM
2.68 GPM/side

With (2) D5-45 nozzles and (1) D4-25 nozzle supplying spray to the top half of trees, the volume supplied would be:

(2) D5-45 nozzles = (2 x 0.71) = 1.42 GPM
(1) D4-25 nozzle = (1 x 0.45) = 0.45 GPM
1.87 GPM or 70%

Another option would be:

(1) D7-25 nozzle = (1 x 0.81) = 0.81 GPM
(1) D5-45 nozzle = (1 x 0.71) = 0.71 GPM
(1) D4-45 nozzle = (1 x 0.56) = 0.56 GPM
(1) D4-25 nozzle = (1 x 0.45) = 0.45 GPM
(1) D3-23 nozzle = (1 x 0.18) = 0.18 GPM
2.71 GPM/side

With this nozzle combination, the nozzles placed to spray the top half of trees would be:

(1) D7 - 25 = (1 x 0.81) GPM
(1) D5 - 45 = (1 x 0.71) GPM
(1) D4 - 25 = (1 x 0.45) GPM
TOTAL 1.97 (See Figure 3)

This would place 73 percent of the spray in the upper half of trees.

CALIBRATION

Calibration is the process of measuring and adjusting the gallons per acre of spray actually applied. Sprayers need to be calibrated to meet the coverage needs of the orchards to be sprayed and to facilitate precise dosing of each material. A sprayer should be set up to apply a gallon per acre rate at a desired speed and pressure. In-orchard calibration frequently indicates a need for adjustments to achieve the target gallonage per acre.

Step 1. Determine the proper speed of travel for your sprayer.

Driving too fast for orchard conditions is a major cause of poor coverage. Time spent figuring out proper sprayer speed can make the biggest improvement in both spray coverage and spray material performance. Matching sprayer output to tree surface that must be covered takes time. As the growing season progresses, and leaf and shoot growth add to the density of the trees, you may have to recalibrate. For any given sprayer, you will have to drive more slowly as the season progresses.

How fast should you drive?

There is no one proper speed to fit all conditions. You must drive slowly enough to obtain coverage in the upper central portion of the tree. For most sprayers, this means driving from 1.0 to 2.5 miles per hour (mph), depending on conditions.

How can you tell when the speed is right?

Spray at various speeds, using plain water as a test product, until a visual check shows that you have adequately covered the hard-to-reach areas of the tree. Write down the gear and revolutions per minute (rpm) used. Then measure the number of seconds it takes to drive 88 feet at this speed. Divide the seconds into 60. This measure gives you miles per hour. You will need this accurate measurement of mph to adjust the sprayer's per acre application rate properly. Do *not* trust your tractor's speedometer.

For power take-off (pto) driven sprayers, select the speed based on the gear and rpm range that operate the sprayer. Choose the ground speed that both runs the sprayer at the correct pto rpm and provides adequate tree coverage. Although this speed may be slower than you would like to drive, proper coverage will save you more than you will spend on increased labor costs. Reducing your travel speed by 1/2 mph adds only 3 to 5 minutes to the time it takes to spray an acre of orchard.

After choosing a speed that will give you good coverage, you can set the sprayer to apply your preferred gallons per acre rate.

Step 2. Sprayer Output

The gallons per minute output required for a sprayer traveling between each row spraying from both sides for a desired gallon per acre rate can be calculated with the equation.

$$GPM_{(req)} = \frac{GPA \times MPH \times \text{Row Spacing (ft)}}{500}$$

To check actual output:

Now that your sprayer is set up for your spraying conditions, write down the size and position of the nozzle discs, the core sizes, the speed of travel (gear and rpm for the tractor used), and the total gallon per minute output you measured by following the next exercise.

- Fill sprayer with water to overflowing.
- Without moving the sprayer, run both sides for 3 minutes at operating pressure.
- Using a calibrated bucket, refill the sprayer and measure gallons sprayed.
- Divide gallons sprayed by 3 to determine output.

- Compare actual sprayer output with calculated output (Step 2). If necessary, alter pump pressure slightly to adjust sprayer output.
- Record pump and manifold pressure necessary to operate new nozzles and cores at the correct output per minute.
- Recheck your gallons per minute output regularly. If the output rises by 5% at a constant pressure, the nozzles are wasting more money than it takes to replace them.

Useful Calibration Formulas

A. To determine the number of gallons per minute (GPM) to spray, spraying from both sides.

$$GPM = \frac{GPA \times MPH \times \text{Row Spacing (ft)}}{500}$$

B. If you know the gallons per minute output of the sprayer and have an accurate measurement of the speed of travel and wish to determine the gallons per acre output.

$$GPA = \frac{GPM\ \text{(2 sides)} \times 500}{\text{Row Spacing} \times MPH}$$

C. If you know the gallons per minute output (2 sides) and the gallons per acre you wish to apply, then want to determine the speed to drive (note: check the coverage at that given speed!).

$$MPH = \frac{GPM\ \text{(2 sides)} \times 500}{GPA \times \text{Row Spacing (ft)}}$$

D. To accurately determine your speed in mph, time equipment over an 88-foot length. Divide seconds elapsed into 60.

$$MPH = \frac{60\ \text{(seconds)}}{\text{Seconds (required for sprayer to travel 88 ft)}}$$

Table 1. Nozzle capacity data.

Disc and Core Nozzles	Liquid Pressure in P.S.I.	Capacity in G.P.M. Per Nozzle
D3-23	40	.12
	60	.14
	80	.16
	100	.18
	150	.21
	250	.26
	400	.32
D3-25	40	.19
	60	.23

	80	.26
	100	.29
	150	.35
	250	.44
	400	.55
D3-45	40	.23
	60	.28
	80	.33
	100	.36
	150	.44
	250	.56
	400	.71
D4-25	40	.29
	60	.35
	80	.40
	100	.45
	150	.54
	250	.68
	400	.86
D4-45	40	.36
	60	.43
	80	.50
	100	.56
	150	.68
	250	.86
	400	1.11
D5-45	40	.45
	60	.55
	80	.64
	100	.71
	150	.86
	250	1.11
	400	1.40
D7-25	40	.53
	60	.63
	80	.73
	100	.81
	150	.98
	250	1.27
	400	1.59