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Orchard Spraying With An Air-Blast Sprayer

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The reason for spraying any orchard is to protect it from pests that will decrease the yield and quality of the fruit being produced. This can only be accomplished when the recommended pesticide is applied at the correct time, in the correct amount, and to the correct target area.

To apply a pesticide in the correct amount and to the correct target area requires that the application equipment is the proper type and size, that it is functioning properly, that it is properly calibrated, and that the operator is trained in the proper operation of the equipment and understands the importance of the job he or she is doing.

Components Of An Air-Blast Sprayer

The basic components of an air-blast sprayer are diagrammed in Figure 1.

Tanks. Like any type of sprayer tank, the air-blast sprayer tank should be corrosion resistant and designed for easy filling, cleaning, and draining. Agitation should be sufficient in the tank to keep all pesticides distributed uniformly throughout the tank mixture when spraying the orchard or when the spray nozzles are shut off. Two types of agitation systems that are common are (1) the paddle or propeller type mechanical system or (2) the hydraulic jet system. Both should be designed to keep pesticides thoroughly mixed in the tank solution.

Pumps. Pumps used in air-blast sprayers are usually piston or centrifugal pumps. The piston pumps are usually selected for when applications require high pressures (450-600 psi). Centrifugal pumps are considered for applications requiring a high volume of liquid at low to medium pressures (50-200 psi).

Pressure Regulators. The pressure regulator is a variable orifice device that can be opened or closed to change the system's pressure. It is not, however, commonly used for this purpose on an air-blast sprayer. Some regulators are spring loaded; some are simply valves that direct varying amounts of pump output back to the tank. These are referred to as pressure relief or unloading valves.

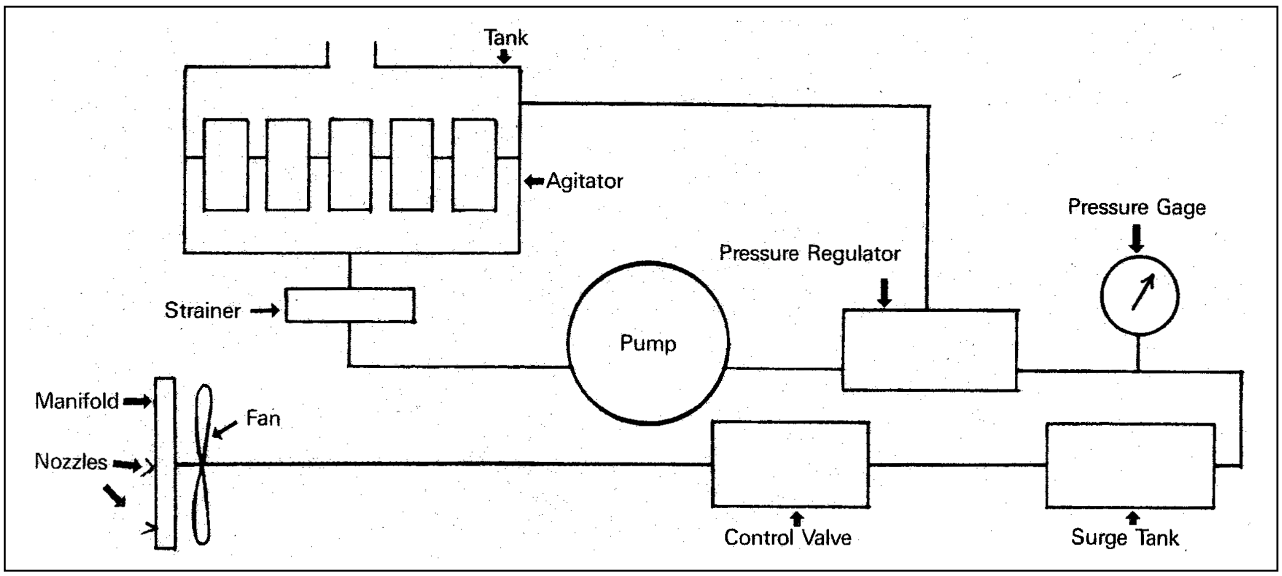

Fig. 1. Components of air-blast sprayer (after Cromwell 1975).

Spray pressure in air-blast sprayers may be set by regulating the pump speed on models with a centrifugal pump. This can be done by varying the engine RPM on engine-driven models. It is very important that the operators maintain engine speed at the RPM required to produce the desired pressure. If the engine speed changes it will change the pressure and the spray volume output.

Pressure Gauges. Pressure gauges are used to monitor the system pressure. They should indicate the sprayer manifold pressure. The spray system is usually set to operate at a certain pressure to assure a particular output of the system. The pressure gauge will indicate any change in that preset pressure. Any change will alert the operator that there is a malfunction in the system. These malfunctions may be caused by various things, such as clogged filter screens, change in pump output, or regulator malfunction. It is, therefore, very important that the sprayer has a pressure gauge and that the gauge is operating properly.

Manifolds. Manifolds deliver the spray material to the nozzles and aid in the placing of the nozzles to achieve the desired spray pattern.

Nozzles. Nozzles on air-delivery sprayers meter the spray material into the air stream. By atomizing the liquid into a spray, the nozzle influences the droplet size and number of droplets obtained from a given volume of liquid. The type and location of the nozzles also influences the spray pattern.

Several parts make up the spray nozzle (Figure 2). These parts are the body, cap, strainer, disc, and core (orifice or whirlplate) or tip. The disc and core are the most susceptible to wear, and those made of resistant materials such as hardened stainless steel, tungsten carbide, or ceramic material are usually selected. Over time the materials will wear; check the disc and core and recalibrate the sprayer to adjust for this wear.

Fans. Both axial and centrifugal fans are used on air-delivery sprayers. The function of the air stream created by the fan is to atomize the spray material and deliver it into the canopy of the tree or crop.

Most sprayers depend on the nozzle for atomization of the spray. The effect of the air stream on spray droplet size is proportional to the velocity difference between the liquid spray and the airstream. The greater the velocity difference, the greater the atomization. The spray droplet break-up will be minimal if the nozzle injects the spray into the air stream moving in the same direction as the air. Likewise, if the spray is injected into the air stream directly against the air flow, the atomization will be maximum.

The major function of the air stream is to move the pesticide into the tree canopy and uniformly deposit it on the fruit and foliage and on other parts of the tree or crop.

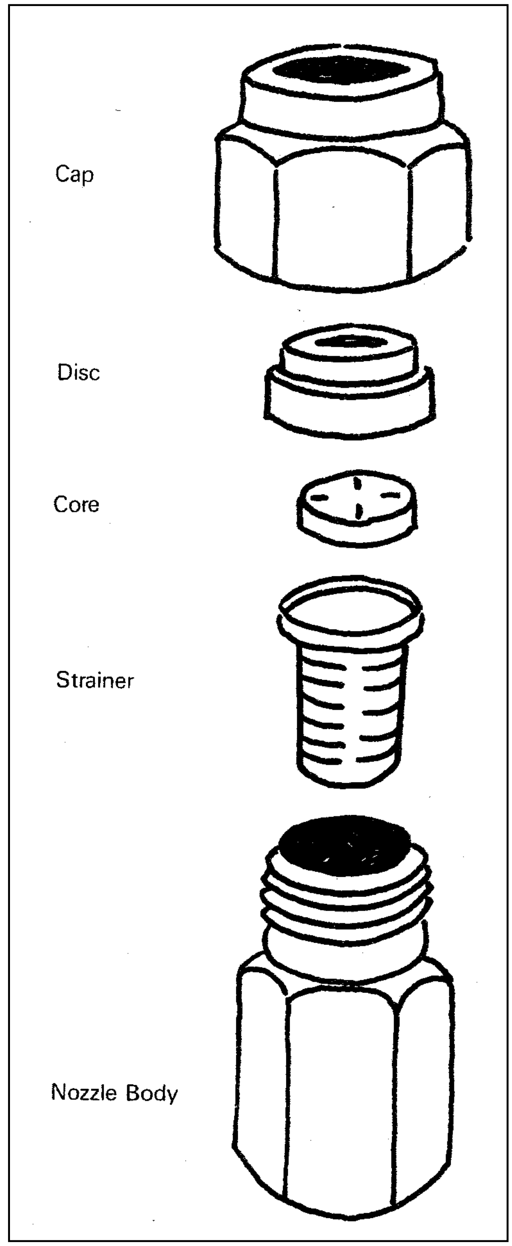

Fig. 2. Components of spray nozzle.

Air stream characteristics that influence the coverage include air volume (cubic feet per minute: CFM) and velocity (feet per minute: FPM). These are influenced by fan type, size; speed, volute design, etc.

Several factors are involved in an air-delivery sprayer's performance. Most of these factors interact rather than act independently. Therefore, performance data concerning many of these factors for specific sprayers are not generally available.

Sprayer Preparation

If spray material is to be evenly distributed during a spraying operation, the spray-laden air must overcome and replace the residual air in the tree. If the sprayer is moved past the tree too fast or if the tree is too dense or if the sprayer output is insufficient, the resident air will not be displaced and poor coverage will result.

Some factors affect coverage that we cannot control, such as humidity and wind. Extremely low humidity will cause rapid evaporation of spray droplets, preventing them from reaching parts of the tree. Spraying when the humidity is above 50 percent will help reduce this problem. Winds that blow across spray patterns will prevent good coverage, so spraying should be done during the calm periods of the day whenever possible.

Other factors affecting coverage such as ground speed, pressure, timing, nozzle and nozzle placement, air speed and direction, and spray volume must be controlled by the operator to get complete coverage.

Sprayer speeds are usually from 2 to 5 MPH with the most common speed between 3 and 4 MPH. Better coverage can be obtained at the lower speeds.

Pressure in the spray system also affects coverage. Manufacturers recommend a pressure range for their machines, usually in the range of 60 to 260 psi.

Manufacturers also provide nozzle arrangement set-ups. The number of nozzles may vary from 5 to 10 nozzles per side.

Nozzles should be arranged on the sprayer manifold so that 2/3 to 3/4 of the sprayer output is directed to the top half of the tree and 1/3 to 1/4 is directed to the lower half (Figure 3).

Proper positioning of the air guide or director will aid in the proper placement of the spray on the target.

Nozzle size, pressure, and speed all determine spray volume. First, select your desired spray volume and speed, and then determine your nozzle size and pressure. Spray volume may vary from 15 to 250 gallons per acre. The most common range is 50 to 150 gallons per acre.

Using information from pesticide labels, operators' manuals, Extension pest control recommendations, orchard measurements, and experience, decisions can be made concerning the factors affecting spraying.

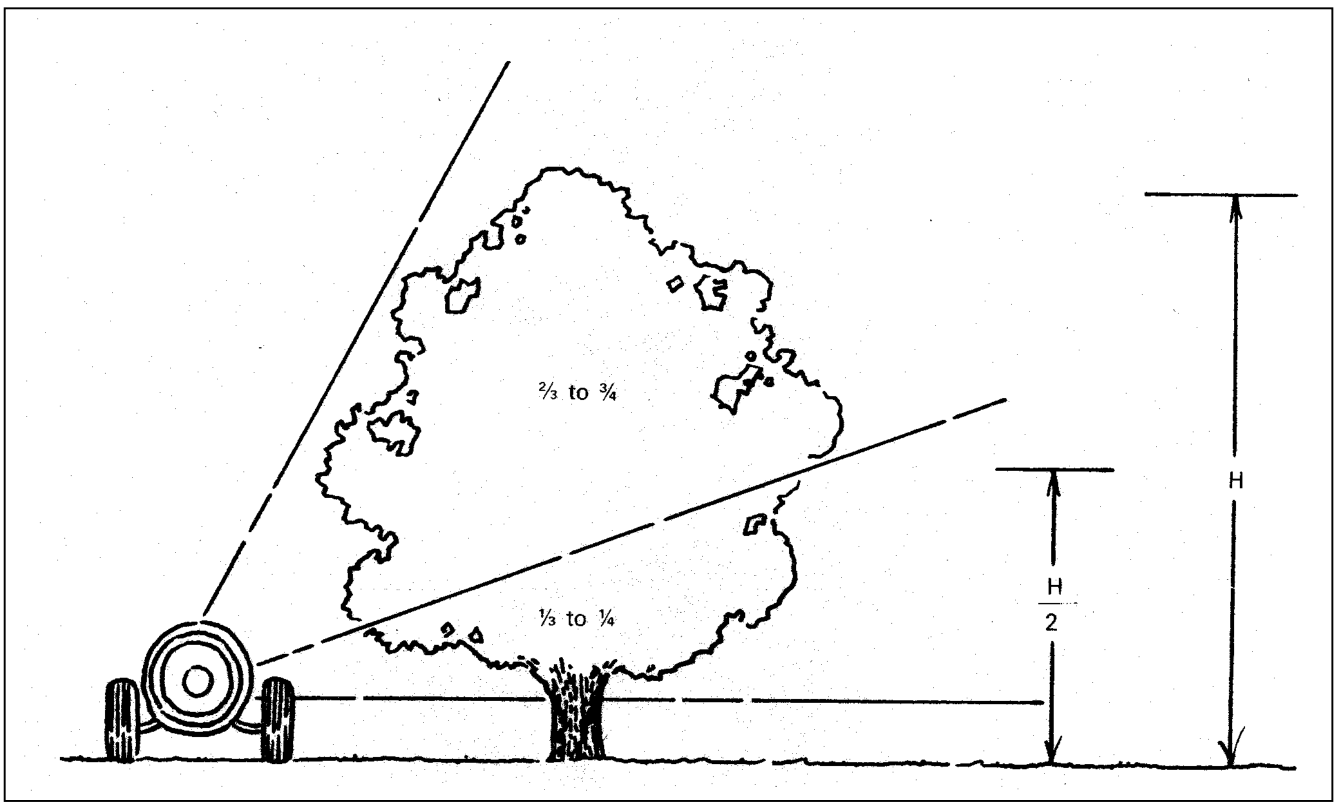

Fig. 3.Components of air-blast sprayer (after Cromwell 1975).

Calibration

The present rate of application of the sprayer can be determined by calibrating it before any changes are made. This is sometimes known as a **trial calibration.** It is performed after the sprayer has been checked to make sure it is functioning properly and all parts are in good condition.

During the trial calibration two things are determined: the gallon per acre output of the sprayer and the travel speed of the sprayer.

The gallons per acre output is obtained for a two sided sprayer by determining the unknowns in the following formula

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

Row spacing of the orchard is determined by measuring the distance between the rows.

Speed and gallons per minute output can be determined by the following procedure.

1. Fill the sprayer tank to a known level and mark. If a material with considerably different flow characteristics than water is to be used, fill the sprayer with this material.
2. In the orchard to be sprayed, lay out a course of several hundred feet (200 feet or more).
3. With the tractor RPM set where you plan to operate during spraying, start pulling the sprayer beyond the first flag of the course to make sure the sprayer is at operating speed when it enters the course. As the front tractor wheel passes the first flag, start spraying, and start timing.
4. As the front wheel passes the flag at the end of the course, turn off the sprayer and record the time it took to travel the course.
5. Return the sprayer to the same position where you filled the tank and refill it to the marked level, recording the gallons required to refill.

Now the speed and gallons per minute output of the sprayer can be determined.

Speed

$$\text{(MPH)} = \frac{\text{Distance of the course (feet)}}{\text{Time to travel course (seconds)}} \times 0.682$$

$$\text{GPM} = \frac{\text{Gallons to refill} \times 60 \text{ seconds/minute}}{\text{Time to travel to course (seconds)}}$$

Example: Course 200 feet long;
time to travel—44 seconds;
gallons to refill tank—36.4;
and row spacing—40 feet

Speed

$$\text{(MPH)} = \frac{200 \times 0.682}{44} = 3.1$$

$$\text{GPM} = \frac{36.4}{44} \times 60 = 49.6$$

Now the actual gallons per acre output of the sprayer can be determined

$$\text{GPA} = \frac{49.6 \times 500}{3.1 \times 40} = 200$$

If you are satisfied with 200 gallons per acre output, then the chemicals can be mixed based on this output. But if you desire, say, 120 gallons per acre, you can determine the nozzle sizes and placement required to obtain this output by the following procedure.

Factors that affect the sprayer output can be listed as knowns and unknowns:

Knowns will include:

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

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 (size 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:

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

Example:

Known:

1. Desired GPA—120 gallons.
2. PSI—150 pounds at the manifold.
3. MPH—3 (selected travel speed).
4. Number of nozzles—16—on sprayer; 8 per side.
5. Tree row spacing—60 feet.

Unknown:

1. Gallons per minute output needed—

$$\text{GPM} = \frac{120 \times 3 \times 60}{500} = 43.2 \text{ gal. per min.}$$

$$\text{On each side } \frac{43.2}{2}$$

= 21.6 gallons per minute.

2. Nozzles (size and placement)—There are 16 nozzles, 8 on each side. Because both sides will be

alike, we can select 8 nozzles that have a combined output of half the total volume required (21.6 GPM) and that can be arranged to provide the desired volume in the top half of trees for one side, then duplicate the selection and arrangement on the other side.

Knowing the average nozzle output will aid in making nozzle selections from manufacturers' tables. This can be calculated as follows:

$$\frac{21.6 \text{ GPM on each side}}{8 \text{ nozzles on each side}} = 2.7 \text{ GPM/nozzle.}$$

To place two-thirds to three-quarters of the spray volume in the top half of trees, the nozzles placed on the area of the manifold that supplies spray to the top half will need a combined output of 2/3 x 21.6 GPM = 14.5 GPM or 3/4 of 21.6 GPM = 16.2 GPM.

The next step is to find 8 nozzles having a combined capacity of approximately 21.6 GPM that can be mounted on the sprayer mainfold so that approximately 14.5 to 16.2 GPM will be applied to the top half of trees.

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.

A situation where all the desired criteria could be met with one nozzle size would be unusual—two or more nozzle sizes is more common. In the previous example only 8 nozzles can be mounted on each side of the sprayer; then, the average output per nozzle would need to be 21.6/8 = 2.7 GPM.

No single nozzle size listed in the table will provide the exact output needed. The D12-45 disc and core nozzle has an output of 2.69 GPM at 150 psi, which is extremely close.

If six of these were located to supply spray to the top half of trees, the amount supplied would be 16.1 GPM, 74.5 percent of the total. This would be acceptable. Using two D12-45 for the lower part of the tree would provide 5.38 GPM or 24.9 percent, which is also acceptable.

Once the nozzles and their placement have been determined, the sprayer should be calibrated to make sure the actual gallons per acre output is sufficiently close to the required or desired gallons per acre output. The calibration procedure is the same as that used in the trial calibration.

Table 1. Nozzle Capacity Data.

		Capacity GPM At PSI										
Orifice No.	Core No.	10	15	20	25	30	40	60	80	100	150	200
D2	45	—	0.13	0.14	0.16	0.18	0.20	0.25	0.28	0.32	0.38	0.44
D3	45	—	0.14	0.17	0.18	0.20	0.23	0.28	0.33	0.36	0.44	0.51
D4	45	0.18	0.22	0.25	0.28	0.31	0.36	0.43	0.50	0.56	0.68	0.78
D5	45	0.23	0.28	0.32	0.36	0.39	0.45	0.55	0.64	0.71	0.86	0.99
D6	45	0.29	0.35	0.41	0.45	0.50	0.58	0.72	0.83	0.93	1.15	1.33
D7	45	0.33	0.41	0.48	0.54	0.59	0.68	0.84	0.97	1.11	1.35	1.57
D8	45	0.41	0.51	0.59	0.66	0.72	0.84	1.04	1.21	1.35	1.68	1.94
D10	45	0.54	0.66	0.77	0.86	0.94	1.10	1.35	1.57	1.77	2.18	2.50
D12	45	0.67	0.82	0.95	1.07	1.17	1.36	1.68	1.95	2.20	2.69	3.11
D14	45	0.75	0.92	1.07	1.20	1.32	1.53	1.89	2.19	2.45	3.00	3.49
D16	45	0.86	1.08	1.25	1.40	1.54	1.79	2.20	2.57	2.89	3.54	4.11
D2	46	—	—	—	0.22	0.24	0.27	0.33	0.37	0.42	0.50	0.57
D3	46	—	—	0.23	0.25	0.28	0.32	0.39	0.45	0.51	0.61	0.70
D4	46	0.28	0.34	0.39	0.44	0.48	0.56	0.68	0.78	0.88	1.07	1.23
D5	46	0.38	0.47	0.54	0.60	0.66	0.77	0.94	1.10	1.25	1.50	1.73
D6	46	0.55	0.67	0.78	0.87	0.95	1.10	1.35	1.58	1.73	2.16	2.50
D7	46	—	—	0.98	1.10	1.22	1.39	1.72	1.97	2.22	2.73	3.15
D8	46	—	—	—	1.45	1.59	1.84	2.25	2.62	2.93	3.60	4.17
D10	46	—	—	—	—	2.15	2.48	3.05	3.53	3.96	4.83	5.59

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