

# HYDRAULIC NOZZLES FOR BOOM SPRAYERS

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The spray nozzle is one of the critical components of the field sprayer. Proper equipment and chemicals are keys to profitable and environmentally sound pesticide and fertilizer application, and nozzles make the difference. In general, a spray nozzle is a device through which liquid is pumped, broken into droplets, and transported through air over short distances. Specifically, the nozzle regulates the flow rate, atomizes the spray solution, and distributes droplets in a definite pattern.

Through droplet formation, nozzles also influence spray coverage and spray drift. Spray coverage is the degree to which the target surface, the ground, plant, or fruit, is covered. The spray coverage is also influenced by the travel speed and wind speed and direction. Spray drift is the off-target movement of spray materials. Droplet size and weather conditions are the most important factors in determining the amount of spray drift. Spray drift may reduce the effectiveness of the application as well as harm off-target areas.

The most commonly used boom sprayer nozzles are hydraulic nozzles. A hydraulic nozzle is designed so that liquid under pressure is forced through the nozzle orifice with sufficient energy to spread out the liquid into a thin sheet which then breaks into droplets.

## Nozzle Selection

Several types of nozzles are available, so you must match the nozzles to the specific chemical and pest situation. The most important factors to

consider when choosing nozzles are droplet size, spray pattern, spray volume, and nozzle life. Different pest control situations require differences in spray coverage and spray targeting. Droplet size and spray distribution determine the effectiveness of the pest control. Smaller droplets make more efficient use of the spray volume, providing more complete spray coverage, but they are more susceptible to drift. Increasing the application rate can improve spray coverage with larger droplets.

Some nozzles wear quickly and soon produce a poor spray pattern. Nozzle wear rates are primarily influenced by the nozzle material, abrasiveness of the spray formulation, and operating pressure. Of the most readily available materials for nozzles, brass is the least expensive and tends to wear the most quickly. Ceramic nozzles are the most expensive and the most durable, but some can be chipped or cracked if they are mishandled or overtightened. Polymer and hardened stainless steel nozzles have good and very good

wear lives respectively. Consult nozzle catalogs to determine the best nozzle based on these factors.

Once you select the type of nozzle to use, you must determine which size or flow rate you need. To determine nozzle flow rate, you need to know the application rate in gallons per acre (GPA), nozzle spacing or band width in inches (width), and the travel speed in miles per hour (MPH). These operating factors can then be substituted into the following formula to determine the gallons per minute (GPM) flow rate required through each individual nozzle.

$$GPM = \frac{GPA \times MPH \times width}{5,940}$$

- GPM = gallons per minute
- GPA = gallons per acre
- MPH = miles per hour
- 5,940 = a constant to make units consistent
- Width = Nozzle spacing in inches for broadcast spraying
- OR = Spray width in inches of one band nozzle
- OR = Row spacing ÷ number of nozzles per row in directed spraying

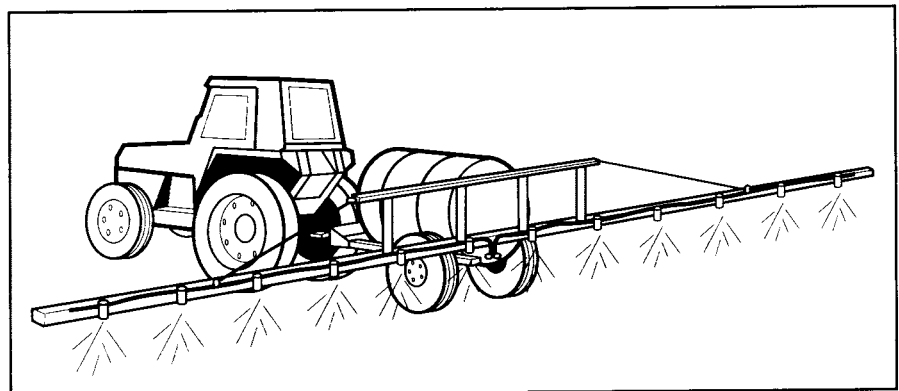


Figure 1. Tyco boom sprayer

Once you know the required nozzle flow rate, consult nozzle manufacturers' catalogs to select the nozzle that provides the required output within the operating pressure range of the sprayer. Changing the pressure changes the nozzle flow rate, but adjusting the pressure affects spray droplet size and drift as well as the spray pattern. Adjust pressure to make only small changes in nozzle output; this will avoid significant changes in spray characteristics. Pressure must be increased four times to double the nozzle flow rate, and the change in pressure significantly affects nozzle performance.

Nozzle manufacturers specify how to set up their nozzles to provide a uniform spray distribution. The instructions vary by nozzle type, size, and manufacturer, so different nozzle types should not be mounted on the same boom. Manufacturers code nozzles by type, flow rate, fan angle, operating pressure range, and nozzle material. Each manufacturer has its own codes and descriptions, so it is important to know the meaning of codes when comparing nozzles or selecting replacements. Consult nozzle manufacturers' catalogs to determine the best operating parameters, such as pressure, height, and spacing, for specific nozzles.

## Nozzle Types

The nozzles most commonly used on boom sprayers are the regular flat fan, even flat fan, hollow cone, solid cone, flooding, and twin fan nozzles. Each nozzle type except the even flat fan nozzle requires overlap with adjacent nozzle spray patterns for uniform application.

### Regular Flat Fan Nozzles

The regular flat fan nozzle is a good general-purpose nozzle for broadcast spray operations (figure 2). The spray stream from a regular flat fan nozzle has an ellipsoid shape—spray distribution forms an oval pattern on the ground under the nozzle. A single regular flat fan nozzle depos-

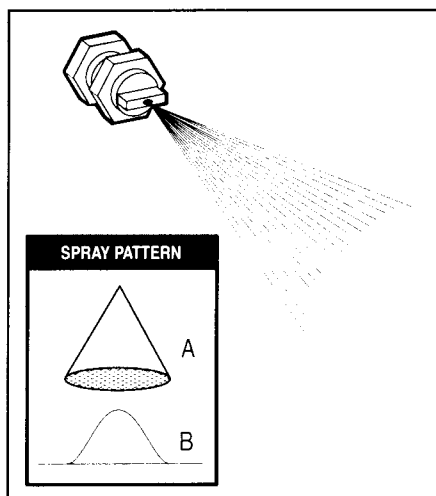


Figure 2. Regular flat fan nozzle spray pattern (A) and spray distribution (B).

its more spray material directly under the nozzle than on either side of the spray pattern. Regular flat fan nozzles are available with operating pressures of 30 to 75 psi.

Generally, flat fan nozzles produce a wide range of droplet sizes, including many small and large droplets. The percentage of small droplets decreases as the operating pressure decreases. Flat fan nozzles should be operated within their recommended operating pressure range to avoid distorting the spray pattern.

Unlike most flat fan nozzles, extended range fan nozzles are designed to provide similar spray patterns over a wide or extended range of pressures (15 to 60 psi). The extended range nozzle should be used in situations where nozzle pressure is adjusted significantly during normal sprayer operation; for example, when large pressure changes are made to change nozzle output.

Flat fan nozzles are generally used for herbicide or insecticide applications where deep foliage penetration is not required. Spray distribution is influenced by the nozzle spacing, nozzle height above the target area, and the angle of the spray pattern (figure 3). Nozzles should be slightly slanted so that adjacent patterns do not interfere with each other.

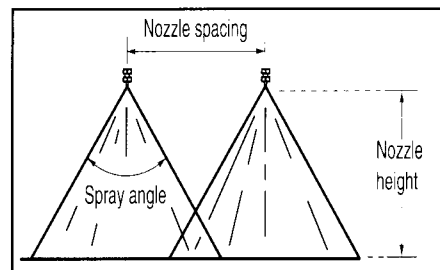


Figure 3. Setup of flat-fan nozzles.

Several fan nozzles are available to produce different spray angles. Wide-angle flat fan nozzles produce smaller droplets than regular flat fan nozzles at the same flow rates. However, they can be operated closer to the ground than regular flat fan nozzles, which reduces the drift hazard.

Special flat fan nozzles produce a spray pattern with the spray deflected away from the center of the nozzles. The "off-center" nozzle may be used on the end of a boom to treat hard-to-reach areas adjacent to the spray swath.

Low-pressure flat fan nozzles are designed to provide the same spray distribution characteristics as other flat fan nozzles while operating at pressures of under 20 psi. These nozzles produce a spray made up of fairly large droplets which are less susceptible to drift.

### Even Flat Fan Nozzles

Even flat fan nozzles are similar to regular flat fan nozzles but apply a more even volume of spray material across the spray pattern (figure 4). They are designed for applying spray solution in a band or narrow strip under the nozzle and do not need to be overlapped with other nozzles (figure 5).

Even flat fan nozzles generally produce a wide droplet spectrum that includes many small and large droplets. The width of the spray band can be changed by raising or lowering the nozzle height. Increasing the operating height of the even flat fan nozzle increases the effective spray width. Increasing the width of the

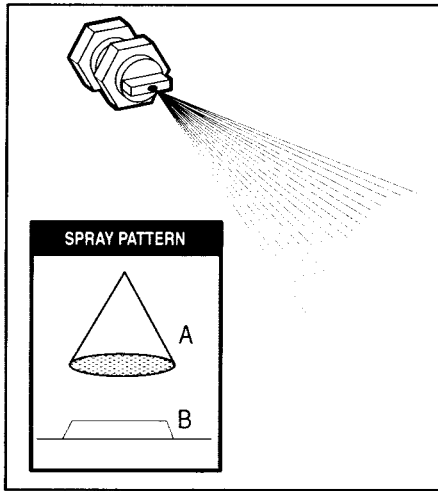


Figure 4. Even flat fan nozzle spray pattern (A) and spray distribution (B).

spray band decreases the effective application rate because the same volume of spray is spread over a larger area.

Even flat fan nozzles have operating characteristics, such as droplet size, similar to those of regular flat fan nozzles. They are designed for use at pressures below 60 psi.

In many crops, band spraying is an efficient way of reducing chemical use. Even flat fan nozzles are mounted on a planter box and used to apply preemergence materials over the crop row. They can also be mounted on a row-crop cultivator to apply postemergence materials over or between crop rows.

### Hollow Cone Nozzles

A hollow cone nozzle produces a spray pattern where the liquid is concentrated on the outside of the conical pattern (figure 6). More of the spray material is deposited on the edges of the hollow cone spray pattern with less directly under the nozzle. One- or two-piece hollow cone nozzles are available from manufacturers. Two-piece cone (disc and core) nozzles are available with operating pressures from 20 to 500 psi and usually have higher flow capacities than one-piece nozzles. One-piece hollow cone nozzles are available with operating pressures

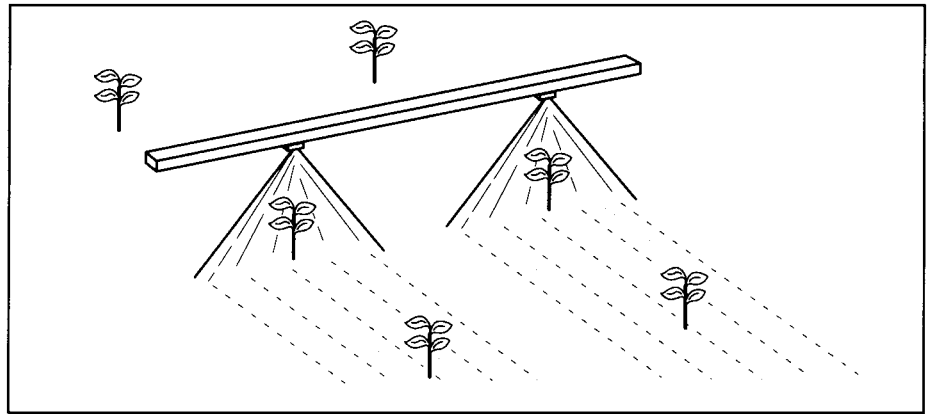


Figure 5. Band spraying.

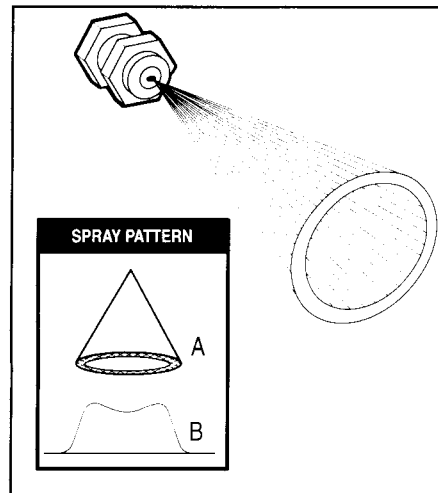


Figure 6. Hollow cone nozzle spray pattern (A) and spray distribution (B).

from 40 to 120 psi and typically produce smaller size droplets than other hydraulic nozzles at the same operating pressures.

Hollow cone nozzles are typically best suited for applying materials like contact insecticides, fungicides, and growth regulators that require good spray coverage on the plant or target surface. Two or three low-volume hollow cone nozzles may also be used in a banding or directed spray operation where the spray streams from the nozzles are directed around or at the same target (figure 7).

Because they produce small droplets, hollow cone nozzles are more apt to produce spray drift. Some

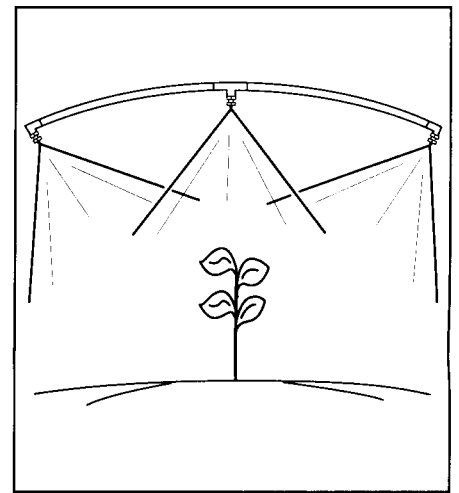


Figure 7. Directed spraying operation using hollow cone nozzles.

manufacturers do make special hollow cone nozzles which produce fewer small droplets when used at recommended pressures. Unless operated at high pressures or with additional velocity provided by an airstream, hollow cone nozzles usually cannot provide good spray penetration through deep or dense canopies.

### Solid (Full) Cone Nozzles

The solid cone nozzle, like the hollow cone nozzle, produces a circular spray pattern, but the spray from a solid cone nozzle is greatest in the center of the pattern (figure 8). Two-piece solid cone nozzle systems are available with operating pressures from 10 to 500 psi and can provide greater spray output than one-piece

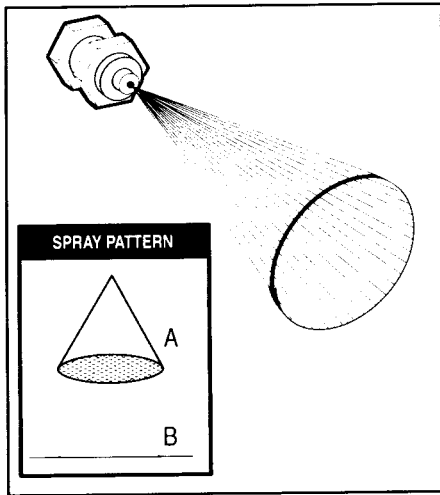


Figure 8. Solid (full) cone nozzle spray pattern (A) and spray distribution (B).

cone nozzles. One-piece nozzles are available with operating pressures from 20 to 60 psi. Although the solid cone nozzle produces more large droplets than a hollow cone nozzle, it still produces a number of small droplets which may cause a drift hazard.

Solid cone nozzles are commonly used for soil incorporation operations or broadcast application of systemic pesticides. Solid cone nozzles are suited to applications requiring high flow rates of spray solution. They are not suited for applications such as fungicides, miticides, or insecticides that require good coverage. Narrow-angle solid cone nozzles are better suited to situations that require spraying through a deep or dense canopy than hollow cone nozzles. Wide-angle solid cone nozzles may be operated closer to the ground than regular solid cone nozzles, which helps minimize drift.

### Flooding Fan Nozzles

The flooding fan nozzle sprays a stream of solution at a surface which breaks the stream into a wide pattern of droplets (figure 9). The volume of spray produced is greatest directly under the nozzle and on the edges of the spray pattern. The nozzle, which operates at

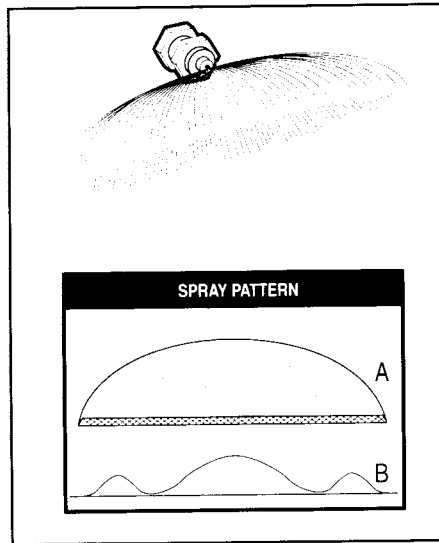


Figure 9. Flooding fan nozzle spray pattern (A) and spray distribution (B).

lower pressures of 10 to 25 psi, produces larger droplets than other nozzle types of similar capacities, and its large orifice resists plugging. The uniformity of the spray distribution and the droplet sizes that flooding nozzles produce at higher pressures are equivalent to those of regular flat fan nozzles.

Flooding fan nozzles are best suited to the application of herbicides and fertilizer spray solutions in preemergence broadcast or soil incorporation operations. They are generally not used in applications that require good spray coverage. Unless the spray pattern is deflected up into the air rather than down to the ground, the flooding fan nozzle produces very little risk of spray drift when operated at low pressures. Some research suggests that these nozzles can be operated at higher pressures which reduce the size of the spray droplets and improve spray coverage; increasing the pressure may also increase the size of the spray pattern. Changing the angle of the nozzle relative to the ground changes the size of the spray pattern. Nozzle position may have to be changed to compensate for pressure changes and ensure a uniform spray distribution.

### Turbo FloodJet™ Nozzles

Turbo FloodJet nozzles, available from Spraying Systems Company, are similar to standard flooding fan nozzles except they produce a different spray pattern and fewer driftable droplets (figure 10). Spray droplets are formed when the spray strikes a surface which deflects the stream into a wide spray pattern, breaking it up into droplets. Under similar operating conditions, the Turbo FloodJet produces droplets 30 to 50% larger than standard flooding fan nozzles. These nozzles operate at pressures from 10 to 30 psi.

The Turbo FloodJet nozzle also produces a spray pattern more similar to a flat fan pattern except it is much wider due to the wide-angle discharge. The spray pattern does not distribute higher volumes of spray on the edges of the pattern as the standard flooding fan nozzle does.

Because of the large droplets they produce, Turbo FloodJet nozzles are not recommended for use in situations that require good coverage. They are best suited for application of preemergence herbicides or application of postemergence systemic herbicides. The size of the spray pattern can be adjusted slightly by varying the orientation of the nozzle.

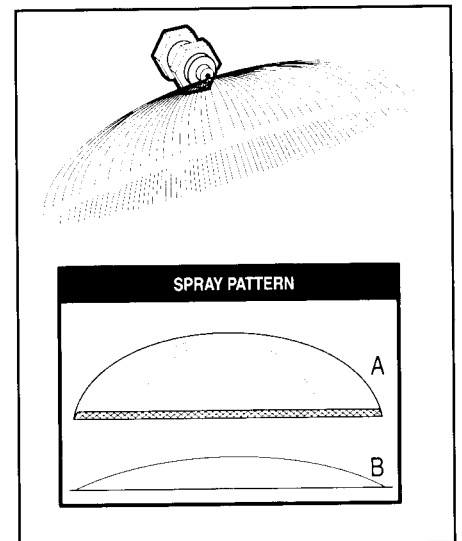


Figure 10. Turbo FloodJet nozzle spray pattern (A) and spray distribution (B).

## Twin Fan Nozzles

The twin fan nozzle operates as a regular flat fan nozzle but applies material through two orifices, producing two fan patterns (figure 11). Spray distribution from the twin fan nozzle is very similar to that from the regular flat fan nozzle where most of the spray is distributed directly under the nozzle. This nozzle is usually mounted so that one fan pattern operates forward in the direction of travel and one fan pattern operates away from the direction of travel. The twin fan spray pattern allows targets to be treated from different directions, thus improving spray coverage. Different twin fan nozzles are available with two spray streams set at different angles. The recommended spraying pressure is 30 to 60 psi.

Twin fan nozzles should be used with caution since they apply half of the spray volume of a regular fan nozzle out of each orifice. They produce more small droplets than a regular flat fan nozzle applying the same flow rate of spray solution. Finer screens or strainers should be used with these nozzles to prevent plugging of the small orifices. Twin fan nozzles are best suited for application of contact pesticides that require good spray coverage. The twin

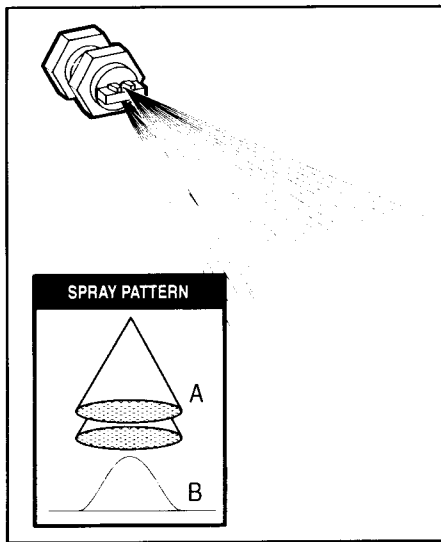


Figure 11. Twin fan nozzle spray pattern (A) and spray distribution (B).

fan spray pattern improves spray penetration through dense foliage and crop residue.

## Reducing Spray Drift

Spray drift can result in uneven application of spray material and contamination of off-target areas. Most spray drift is caused by small droplets that do not reach the target area. Increasing droplet size reduces the drift hazard. Nozzles of similar flow ranges can have very different droplet size characteristics (table 1). The spray angle, pressure, flow rate, nozzle type, and spray formulation affect droplet size and influence the amount of spray drift. Other factors include weather conditions, the nozzle orientation, nozzle height, and travel speed.

The drift hazard must be balanced with the droplet size and spray pattern required for the application. Use larger nozzles with higher flow rates at lower pressures to reduce the potential for spray drift. If this does not provide adequate coverage, using a higher spray volume will help improve spray coverage. Keep pressure high enough to maintain the spray angle and spray distribution.

Nozzle manufacturers offer several new nozzles and replacement components designed to reduce spray drift without changing sprayer settings (see table 1). The new designs use additional chambers, orifices, or restrictors to decrease pressure within the nozzle and reduce the number of small droplets that are produced. Other designs use additional chambers to alter the swirling action of the liquid so fewer small droplets are produced. These nozzles and components that reduce the drift hazard do not alter the overall spray pattern or spray distribution from similar components. Minimizing spray drift may compromise spray coverage. Ask sales representatives or cooperative extension agents for information on new designs that reduce the potential for drift.

Nozzle type	Percent of spray in small droplets	
	20 psi	60 psi
XR8004, extended range, fan	8	24
XR8008, extended range, fan	3	15
XR11004, extended range, fan	18	24
XR11008, extended range, fan	10	21
DG8004, drift reduction, fan	2	18
DG11004, drift reduction, fan	5	21
TF-2, drift reduction, flood	0.5	1.75
TK-2, flood	1	8

Adapted with permission from Pearson, S. L., T. Reed, and B. Göbel, "New Developments in Spray Tips to Reduce Drift." ASAE Paper No. 931081.

Table 1. Percent of spray volume in droplets less than 200 microns in diameter

## Effective Nozzle Use

In addition to selecting the correct nozzle, accurate chemical application requires periodic checks of sprayer performance. Sprayer operation should be checked using only water. Sprayer calibration includes checking nozzle pressure, nozzle output, effective spray width, and travel speed. Accurately mixing the spray formulation also helps to ensure accurate spray application.

Inspect nozzles for wear by comparing the flow rate when they are new with the flow rates found in follow-up inspections at regular intervals (figure 12, next page). Replace nozzles when the flow rate of any one nozzle is more than 10% different from the average output of all of the boom nozzles. Periodic nozzle inspection can reveal streaking in a spray pattern, which indicates that the nozzle is damaged or plugged. Clean plugged or dirty nozzles with soft materials such as nylon brushes, which will not damage the nozzle orifice. For most nozzles, a screen or strainer with adequate mesh size is needed to prevent orifice clogging, spray pattern distortion, and resulting spray application failure.

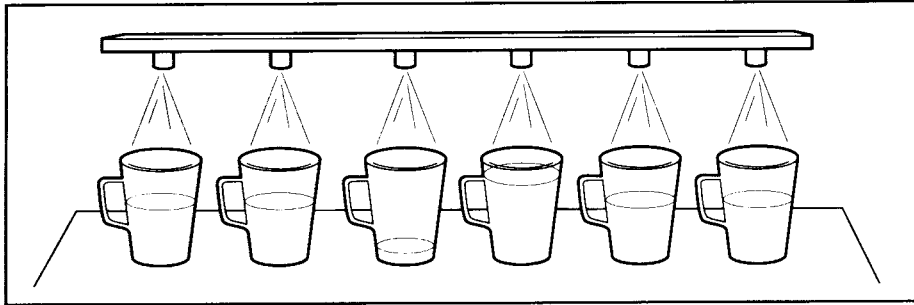


Figure 12. Variation in nozzle output.

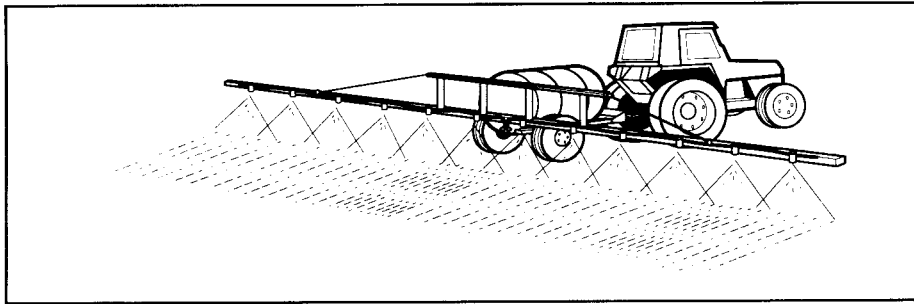


Figure 13. Driving test to check spray pattern.

Check the uniformity of the spray pattern by spraying clean water while driving on dry concrete or asphalt (figure 13). If part of the spray pattern dries more quickly than the rest, the boom height may need to be adjusted to ensure a more uniform application. Excess water under the nozzles indicates that the boom and nozzles should be raised. Excess water between nozzles indicates that the spray patterns overlap too much and that the boom and nozzles should be lowered. Avoid traffic areas when evaluating spray distribution using this technique.

Water-sensitive paper can be used to check the spray coverage or spray pattern (figure 14). Attach paper to leaves with paper clips, clothespins, or staples to check spray coverage and to see whether the spray is reaching all parts of target plants. Lay the paper on the ground to check spray patterns.

Before operating a sprayer, read the operator's manual and chemical labels to review recommended procedures for safe use of the equipment and the chemical. Use the required personal safety protection when working with spray compounds.

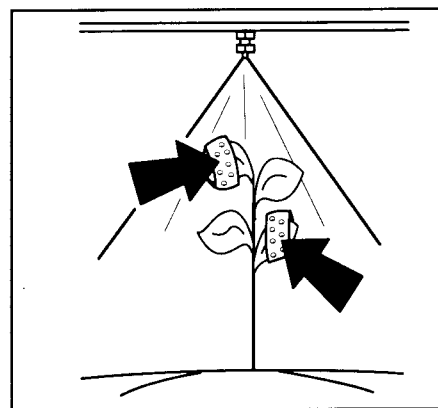


Figure 14. Use of water-sensitive paper to check sprayer operation.

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