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G89-955 Nozzles – Selection and Sizing (Revised February 2003)

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Nozzles — Selection and Sizing

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This NebGuide covers nozzle description, recommended uses and orifice sizing for sprayers.

The proper selection of a nozzle type and size is essential for proper pesticide application. The nozzle is a major factor in determining the amount of spray applied to an area, the uniformity of application, the coverage obtained on the target surface, and the amount of potential drift.

Nozzles break the liquid into droplets, form the spray pattern, and propel the droplets in the proper direction. They determine the amount of spray volume at a given operating pressure, travel speed, and spacing. Drift can be minimized by selecting nozzles that produce the largest droplet size while providing adequate coverage at the intended application rate and pressure.

Spray Particle Size

The size of the spray particle is important because it affects both efficacy and spray drift of the pesticide. If the size of the spray particle (for example 300 to 600 microns) is doubled and the application volume stays the same, you have only 1/8 as many spray droplets. For optimum efficacy and 10 to 20 gallon spray volumes, a medium droplet size is suggested for contact non-translocating herbicides and a coarse droplet size for contact translocating herbicides. Concern for drift may cause you to consider larger droplet sizes and higher spray volumes.

Nozzle Description

Nozzle types commonly used in low-pressure agricultural sprayers include: flat, flood, air induction, raindrop, hollow-cone, full-cone, and others. Special features, or subtypes such as “extended range,” are available for some nozzle types.

Flat-Fan

Flat-fan nozzles are widely used for broadcast spraying of herbicides. These nozzles produce a tapered edge, flat-fan spray pattern (*Figure 1*). These nozzles have several subtypes, such as standard flat-fan, even flat-fan, low pressure flat-fan, extended range flat-fan, and some special types such as off-center flat-fan and twin-orifice flat-fan.

The *standard* flat-fan normally operates between 30 and 60 psi, with an ideal range between 30 and 40 psi. The *even* (E) flat-fan nozzles apply uniform coverage across the entire width of the spray pattern. They are used for *banding* pesticide over the row and should not be used for broadcast applications. The band width can be controlled with the nozzle height and the spray angle.

The *extended range* (XR or LFT) flat-fan nozzle provides fair drift control when operated between 15 and 25 psi. This nozzle is ideal for an applicator who likes the uniform distribution of a flat-fan nozzle and wants lower operating pressures for drift control. Since extended range nozzles have an excellent spray distribution over a wide range of pressures (15-60 psi), they can be used on sprayers equipped with flow controllers.

The special feature flat-fan nozzles, such as the *off-center* (LX) flat-fan, are used for boom end nozzles so a wide swath projection is obtained. The *twin-orifice* (TJ) flat-fan produces two spray patterns — one angled 30 degrees forward and the other directed 30 degrees backward. The droplets are small due to the atomizing by two smaller orifices. The two spray directions and smaller droplets improve coverage and penetration, a plus when applying postemergence contact herbicides. Because of the small spray droplets, drift is a concern. To produce fine droplets, the twin-orifice usually operates between 30 and 60 psi.

Flat-fan nozzles are available in several spray angles. The most common spray angles are 65, 73, 80 and 110 degrees. Recommended nozzle heights for flat-fan nozzles during broadcast application are given in *Table 1*.

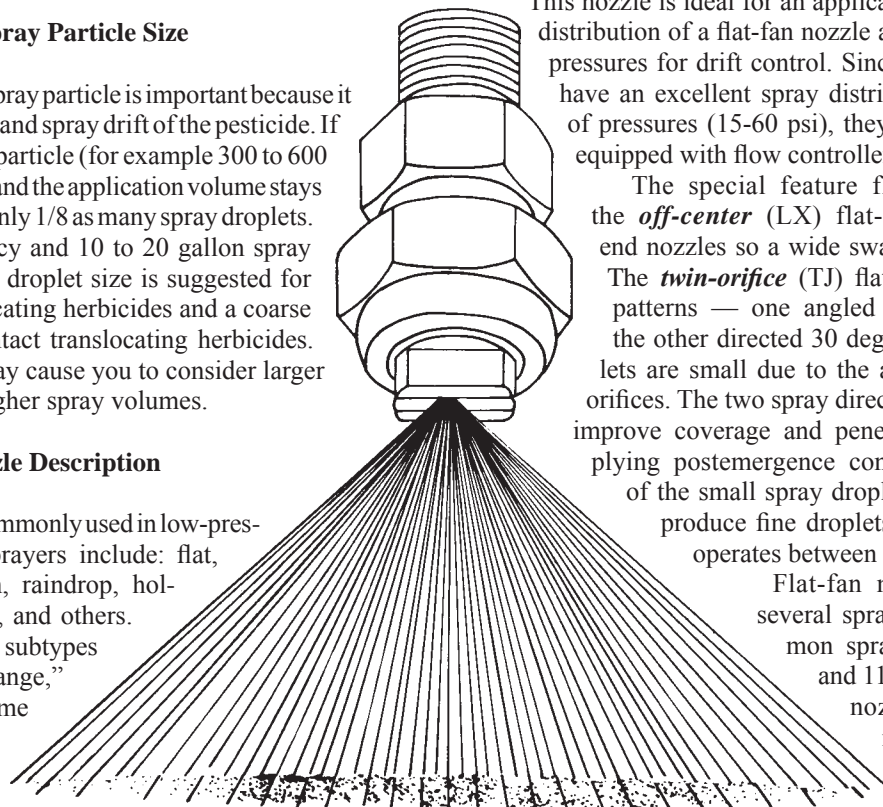


Figure 1. Flat-fan spray nozzle.

Table I. Suggested minimum spray heights.

Spray Angle (degrees)	Spray Height (in.)			
	20" Spacing Overlap		30" Spacing Overlap	
	30%	100%	30%	100%
65	22-24	NR	NR	NR
73	20-22	NR	29-31	NR
80	17-19	26-28	26-28	37-39
110	10-12	15-17	14-18	25-27

NR = Not recommended.

The correct nozzle height is measured from the nozzle to the target, which may be the top of the ground, growing canopy, or stubble. Use 110 degree nozzles when booms are less than 30 inches high with a 30-inch nozzle spacing, and 80 degree nozzles when the booms are higher.

Although wide-angle nozzles produce smaller droplets, which are more prone to drift, the lower boom height reduces the drift potential more than the corresponding decrease in droplet size. The nozzle spacing and orientation should provide for 100 percent overlap at the target height. Nozzles should not be oriented more than 30 degrees back from vertical.

Spraying Systems Company¹ identifies its flat-fan nozzles with a four or five digit number. The first numbers are the spray angle and the other numbers signify the discharge rate at rated pressure. For example, an 8005 has an 80 degree spray angle and will apply 0.5 gallons per minute (GPM) at rated pressure of 40 psi. An 11002 nozzle has a 110 degree spray angle and will apply 0.2 GPM at rated pressure of 40 psi. Additional designations are "BR" - brass material; "SS" - stainless steel; "HS" - hardened stainless steel; "VP" - polymer with color coding; "VK" - ceramic with color coding; "VH" - hardened stainless steel with color coding; and "VS" - stainless steel with color coding.

Some nozzles are identified by "LF" or "LF-R," which reflect the standard and extended range flat-fan nozzles. The first numbers are the spray angle followed by a dash, and then the discharge rate at rated pressure. For example, an LF 80-5R is an extended range nozzle with an 80 degree spray angle that will apply 0.5 GPM at the rated pressure of 40 psi.

The *turbulence chamber nozzle* is an updated nozzle design that incorporates a pre-orifice concept with an internal turbulence chamber. These design improvements have resulted in larger, less driftable droplets and improved spray pattern uniformity. Turbulence chamber nozzles are available in flood and flat-fan tip designs.

The *Turbo TeeJet* has the widest pressure range of the flat-fan nozzles — 15 to 90 psi. It produces larger droplets for less drift and is available only in 110 degrees.

The *drift guard* flat-fan has a pre-orifice that controls the flow. The spray tip is approximately one nozzle size larger and therefore produces larger droplets and reduces the small, drift-prone droplets.

The *venturi type* nozzle produces large air-filled drops through the use of a venturi air aspirator for reducing drift. These include the Delavan Raindrop Ultra, Greenleaf Turbo Drop and

Airmix, Lurmark Ultra Lo-Drift, Spraying Systems AI Teejet, ABJ Agri. Air Bubble Jet, and Wilger's Combo-Jet.

Flood

Flood nozzles are popular for applying suspension fertilizers where clogging is a potential problem. These nozzles produce large droplets at pressures of 10 to 25 psi. The nozzles should be spaced less than 60 inches apart. The nozzle orientation and height should be set for 100 percent overlap.

Nozzle spacing between 30 to 40 inches produces the best spray patterns. Pressure influences spray patterns of flooding nozzles more than flat-fan nozzles. However, the spray pattern is not as uniform as with the flat-fan nozzles, and special attention to nozzle orientation and correct overlap is critical. The new turbo flood nozzles which have a pre-orifice and turbulence chamber have excellent spray patterns. Besides fertilizer suspensions, these nozzles are used with soil incorporated herbicides, preemergence without contact herbicides, and with spray kits mounted on tillage implements.

Flooding nozzles are designated "TK" or "TF" by Spraying Systems and "D" by Delavan. The value following the letters is the flow rate divided by 10 at a rated pressure of 10 psi. For example, TK-SS2 or D-2 are flood nozzles that apply 0.2 GPM at 10 psi.

TurfJet®

The TurfJet® is a new nozzle designed for the turf industry. It is modeled after the Turbo® flood nozzle, which is used extensively in the application of crop protection products for agricultural field crops. The major difference is that the TurfJet® nozzle incorporates a larger orifice to accommodate heavier application volumes, which are common in the turf industry.

Hollow-Cone

Hollow-cone nozzles generally are used to apply insecticides or fungicides to field crops when foliage penetration and complete coverage of the leaf surface is required. These nozzles operate at pressures ranging from 40 to 100 psi. Spray drift potential is higher from hollow-cone nozzles than from other nozzles due to the small droplets produced.

Full-Cone

The wide-angle full-cone nozzles produce large droplets. Full-cone nozzles, which are recommended for soil-incorporated herbicides, operate at pressures between 15 and 40 psi. Optimum uniformity is achieved by angling the nozzles 30 degrees and overlapping the spray coverage by 100 percent.

Nozzle Materials

Nozzles can be made from several materials, including brass, nylon, stainless steel, hardened stainless steel and ceramic. Stainless steel nozzles last longer than brass or nylon and generally produce a more uniform pattern over a longer time. Nylon nozzles with stainless steel or hardened stainless steel inserts offer an alternative to solid stainless steel nozzles at a reduced cost. Ceramic nozzles have the longest life and are usually worth the added cost. Thermoplastic nozzles have good abrasion resistance, but swelling can occur with some chemicals. They are easily damaged when cleaned.

Do not mix nozzles of different materials, types, spray angles, or spray volumes on the same spray boom. A mixture of nozzles produces uneven spray distribution.

¹Mention of trade and company names does not imply endorsement or preferential treatment of the product names by the University of Nebraska-Lincoln.

Nozzle Selection

It is important to select a nozzle that develops the desired spray pattern. The specific use of a nozzle, such as broadcast application of herbicides or spraying of insecticides on row crops, determines the type of nozzle needed. Examine current and future application requirements and be prepared to have several sets of nozzles for a variety of application needs. In general, do not select a nozzle that requires a nozzle screen less than 50 mesh. Nozzles requiring 80-100 mesh screens plug too easily.

Follow the steps below to determine the correct nozzle type and capacity needed.

Step 1. Consult the label. The most important source of information is the pesticide label. Not only will the label specify the application rates, controllable pests and conditions needed to apply the pesticide, it often will provide information concerning the gallons per acre, nozzle type and spacing. Follow the guidelines outlined on the pesticide label. If nozzle recommendations are not stated on the label, use *Table II* to select a nozzle type best fitted to the application.

Step 2. Select operating conditions. Select or measure ground speeds in miles per hour (mph). Select the desired nozzle spacing and spray volume. For most broadcast applications, a 30-inch spacing is preferred. If the label doesn't recommend nozzle spacing or spray volume, follow university and chemical company recommendations.

Correct selection of a spray volume is important. It will influence several spray characteristics such as drift potential, coverage, droplet size, acres per tank, and pesticide efficacy. Generally the greater the operating pressure or spray angle, the smaller the droplets. Smaller droplets increase the drift potential. As the orifice opening becomes larger, the droplets increase in size.

Step 3. Calculate required nozzle discharge. To select a specific orifice size, the spray volume, nozzle spacing, and travel speed are needed for the following calculation:

$$\text{Nozzle discharge (GPM)} = \frac{\text{Travel speed} \times \text{Nozzle spacing} \times \text{Spray volume}}{5940}$$

where: Travel speed = miles per hour (mph)
Nozzle spacing = inches (in)
Spray volume = gallons per acre (GPA)

Step 4. Consult a nozzle catalog. Once the nozzle discharge (GPM) has been determined, consult a nozzle catalog for a specific nozzle number or size. Using the nozzle type selected from the application guide (*Table II*), review the specification of these nozzles in the discharge capacity column. Several consecutive nozzles may meet your needs, but select a nozzle that operates at a low pressure and gives the desired particle size and still gives a range for "fine-tuning." Remember, most nozzles only perform well over a limited pressure range.

A linear relationship does not exist between pressure and flow discharge. If the discharge rate is not found in the catalogs, calculate the operating pressure using known catalog conditions:

$$\text{psi}_1 = \text{psi}_2 \times \left[\frac{\text{GPM}_1}{\text{GPM}_2} \right]^2 \quad [1]$$

where: subscript "1" is the desired condition, and
subscript "2" is the known catalog condition.

Avoid high pressures for the nozzle used. Higher pressures increase the drift potential and put strain on the sprayer components. Conversely, avoid pressures less than the recommended minimum pressure because spray patterns begin to distort and cause poor spray uniformity.

Table II. Spray nozzle selection guide for broadcast applications.

	<i>Herbicides</i>				<i>Fungicides</i>		<i>Insecticides</i>		<i>Liquid Fertilizer</i>
	<i>Soil Incorporated</i>	<i>Pre-Emerge</i>	<i>Post-Emerge</i>		<i>Contact</i>	<i>Systemic</i>	<i>Contact</i>	<i>Systemic</i>	
			<i>Contact</i>	<i>Systemic</i>					
Turbo TeeJet	Good	Good	Good	Good+	Good	Good+	Good	Good+	Good
Air induction	Good+	Good+	Good	Good+	Good	Good+	Good	Good+	Good+
Extended range flat fan	—	—	Good+	Good	Good+	Good	Good+	Good	Good
Pre-orifice flat fan	Good+	Good+	Good	Good+	Good	Good+	Good	Good+	Good
Standard flat fan	—	—	Good	Good	Good	Good	Good	Good	—
Twin orifice flat fan	—	—	Good+	—	Good+	—	Good+	—	—
Turbo FloodJet	Good+	Good+	—	Good	—	Good	—	Good	Good+
TurfJet	Good+	Good+	—	Good	—	Good	—	Good	Good+
Solid cone	—	—	—	Good	—	Good	—	Good	Good+

— Information not available or not applicable.

Step 5. Calibrate the sprayer. Once the nozzles are selected, purchased, installed and flushed, calibrate the spray system. Nozzle catalogs provide tables to show spray volumes for various nozzles, spacing, pressures, and ground speeds. Use these tables to initially set up the sprayer, and then use the “ounce” calibration method to evaluate and adjust the sprayer for accurate application.

Nozzle Selection and Sizing Example

Suppose a postemergence herbicide is to be broadcast at 15 GPA at a speed of 5 mph. Using *Table II* as a guide, the “best” choice is a Turbo TeeJet. The recommended nozzle spacing is 30 inches. Calculate the required nozzle discharge:

$$\text{Nozzle discharge} = \frac{5 \text{ mph} \times 30 \text{ in} \times 15 \text{ GPA}}{5940} = 0.38 \text{ GPM}$$

Consult a nozzle catalog. The selected nozzle must have a flow discharge of 0.38 GPM when operated within the recommended range for the nozzle. A nozzle performance table shows the discharge rate at various pressures for several nozzle sizes. *Table III* shows that four nozzles listed in the catalog are possible choices. The TT11003, TT11004, TT11005, or TT11006 nozzles may be purchased for this application, but the TT11004 gives the most flexibility with a wide pressure range for “fine-tuning.”

Table III. Nozzle data and comparison of pressure and discharge

Nozzle	Catalog Calculated		Eq. [1]	
	psi	GPM	psi	GPM
TT11003	60	0.37	64	0.38
TT11004	30	0.35	36	0.38
TT11005	20	0.35	24	0.38
TT11006	15	0.37	16	0.38

Nozzle Manufacturers

Several principal spray nozzle manufacturers supply local equipment dealers. Each manufacturer distributes nozzle catalogs. These can be obtained from the local dealer or ordered from the following addresses:

Century Engineering
P.O. Box 3018
Cedar Rapids, IA 52406
Phone: 800-472-4624

HD Ceramics
475 Steamboat Rd
Greenwich, CT 06836

CP Products Co., Inc.
418 S. Price Road
Tempe, AZ 85281
Phone: 866-303-0600
Web: www.cproductsinc.com

Hardi Inc.
1500 West 76th St.
Davenport, IA 52806
Phone: 563-386-1730
Web: www.hardi-US.com

Greenleaf Technologies
P.O. Box 1767
Covington, LA 70434
Phone: 985-892-3870
Web: www.greenleaftech.com/

HYPRO
375 Fifth Avenue NW
New Brighton, MN 55112-3288
Phone: 800-424-9776
Web: www.hypropumps.com/Agriculture/

Lurmark, U.D.
Smyra, GA 30080
Phone: 404-435-4627
Web: www.lurmark.com/agriculture

Wilger Inc.
16549 Highway 194N
Lexington, TN 38351
Phone: 877-968-7695
Web: www.wilger.net

Spraying Systems Co.
P.o. Box 7900
Wheaton, IL 60189-7900
Phone: 630-665-5201
Web: www.spray.com

Reference

Grisso, R. and R. Klein. *Fine Tuning a Sprayer with the “Ounce” Calibration Method.* University of Nebraska–Lincoln Extension NebGuide G865.

Weight and Measures Conversions

Weight

16 ounces = 1 pound = 453.6 grams
1 gallon water = 8.34 pounds = 3.78 liters

Liquid Measure

1 fluid ounce = 2 tablespoons = 29.57 milliliters
16 fluid ounces = 1 pint = 2 cups
8 pints = 4 quarts = 1 gallon

Length

3 feet = 1 yard = 91.44 centimeters
16.5 feet = 1 rod
5,280 feet = 1 mile = 1.61 kilometers
320 rods = 1 mile

Area

9 square feet = 1 square yard
43,560 square feet = 1 acre = 160 square rods
1 acre = 0.405 hectare
640 acres = 1 square mile

Speed

88 feet per minute = 1 mph
1 mph = 1.61 km/h

Volume

27 cubic feet = 1 cubic yard
1 cubic foot = 1,728 cubic inches = 7.48 gallons
1 gallon = 231 cubic inches
1 cubic foot = 0.028 cubic meters

Common abbreviations and terms used

GPM = gallons per minute
GPA = gallons per acre
psi = pounds per square inch
mph = miles per hour
RPM = revolutions per minute
GPH = gallons per hour
FPM = feet per minute

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