Selecting the Correct Nozzle to Reduce Spray Drift

Avoiding excessive spray drift is a key objective for pesticide applicators. With increasing acreage planted to herbicide-resistant crops and a shift to more postemergence spraying, the potential for off-target plant damage, surface and groundwater contamination, and occasional risks to humans and livestock have increased. Off-site damage is often apparent in adjacent farmland and rural acreages. However, it is important to remember that **all** pesticide drift, not just drift that results in visible plant injury, is illegal. Applicators are responsible and legally liable for drift to off-target areas as a result of their applications.

Several factors in spray equipment setup and operation affect spray movement outside the target area. Boom height, nozzle spacing, and pressure all play a role in a comprehensive drift management plan. However, nozzle selection and the resulting droplet size are the most important factors in keeping spray drift in check.

What is drift?

Pesticide drift is the physical movement of spray particles through the air from the target site to any non- or off-target site at the time of application. Vapor drift, or movement of pesticide in vapor or gas form, can occur at or **after** the time of application. It is common with 2,4-D and dicamba.Vapor drift is more a function of the product and environmental conditions rather than equipment used and is not discussed herein.

Wind speed greatly influences the amount of drift that occurs. Although applicators have little control over weather, closely monitoring environmental conditions and making sound application decisions are critical. Pesticide labels may provide guidance, and in some cases mandatory requirements, on wind speed limits and buffer zones. Each application is made under different conditions and should be evaluated as such. Proximity to urban areas, sensitive vegetation, well sites, and surface streams could limit applications to wind speeds lower than what the label allows.

After wind speed and direction, spray droplet size is the most important factor influencing drift. Large droplets are heavier and less likely to move off-target because they fall to the ground faster than small droplets. Selecting the correct nozzle is a compromise between generating larger droplets that are less likely to drift or smaller droplets that provide more thorough coverage of the weed, insect, or disease target.

Importance of droplet size

Applicators must understand the principles of droplet size to select nozzles that provide adequate coverage yet have sufficient drift reduction properties.

Spray droplets are measured in microns. One micron equals approximately 1/25,000 inch. For comparison, the diameter of a paper clip is 850 microns and the diameter of a human hair is 100 microns. The human eye can see objects down to approximately

Match nozzle selection to product, application type, and environmental conditions.

Table 1. Movement of spray particles.

Droplet diameter (microns)	Size classification (ASAE* equivalent)	Time required to fall 10 feet	Lateral movement in 3 mph wind
5	Fog	66 minutes	3 miles
20	Very fine	4.2 minutes	1,100 feet
100	Very fine	10 seconds	44 feet
240	Fine/medium	6 seconds	28 feet
400	Coarse	2 seconds	8.5 feet
1,000	Extremely coarse	1 second	4.7 feet

*American Society of Agricultural Engineers.
Source: Akesson and Yates, Annual Review of Entomology, 1964.

100 microns without magnification. An important point is that drift isn't what you can see during an application, but what you cannot see. Visual estimates of off-target movement of spray particles are not an accurate representation of the actual drift that is occurring.

Research shows that droplets smaller than 150–200 microns are more likely to move off-target and should be avoided for most applications. Because of their light weight for the droplet surface area, these droplets take much longer to fall and can move greater distances. Particles less than 50 microns in diameter can remain suspended in air for long periods until they evaporate.

All nozzles produce a range of droplet sizes. To measure the range of droplets produced by a nozzle, the term volume median diameter, or VMD, is used. The VMD represents the droplet size where half of the spray volume is contained in droplets larger than the VMD, and half of the volume is in droplets smaller than the VMD.

Table 2. Droplet classification system.

Category	Symbol	Color Code	VMD (0.5)
Very fine	VF	Red	< 150
Fine	F	Orange	150 - 250
Medium	M	Yellow	250 - 350
Coarse	C	Blue	350 - 450
Very coarse	VC	Green	450 - 550
Extremely coarse	XC	White	> 550

Source: ASAE Standard S-572.

Droplets 100 microns may move as far as 44 feet and take 10 seconds to fall to the ground. When droplet size is increased to 400 microns, the droplets fall in 2 seconds and lateral movement is decreased by more than 80 percent (Table 1).

Droplet size classification

Droplet-size information is useful for determining the correct nozzle for an application and pesticide. However, this information is not always readily available to the applicator. Instead, a classification system is often used to define nozzle output (Table 2). Nozzle manufacturers use this standardized system to indicate the droplet size of their nozzles for different size and pressure combinations. Product labels sometimes use the system to recommend appropriate droplet sizes to be used with their products.

For example, the herbicide label recommends using a nozzle producing **medium**-sized droplets. From the nozzle manufacturer's chart (Table 3), the applicator can select any nozzle and pressure combination with the **M** or **yellow** classification. This system allows the applicator to use many different combinations of nozzles and pressure settings, achieve the desired droplet size, reduce drift, and provide adequate coverage required for control of the pest.

Pressure effects

One of the simplest methods to increase droplet size with any nozzle is to reduce nozzle pressure.

Table 3. Use droplet size classification to select nozzle size and pressure (Spraying Systems Co. Wheaton, IL).

XR TeeJet

	PSI						
	15	22	29	36	44	51	58
XR8001	M	F	F	F	F	F	F
XR80015	M	M	M	F	F	F	F
XR8002	M	M	M	M	M	F	F
XR8003	M	M	M	M	M	M	M
XR8004	C	C	C	M	M	M	M
XR8005	C	C	C	C	C	M	M
XR8006	C	C	C	C	C	C	C
XR8008	VC	C	C	C	C	C	C

Operating a nozzle at a lower pressure increases the VMD of spray droplets (Table 4). Spray output is also reduced for a given nozzle, which means that a larger nozzle may be needed if application rate is to remain the same at a specific travel speed. Also, care should be taken not to operate a nozzle outside of its recommended pressure range or a distorted pattern develops, resulting in poor coverage.

Table 4. Effect of nozzle type and pressure on droplet size.

	40 psi		60 psi	
-	VMD (0.5)	% volume <100 microns	VMD (0.5)	% volume <100 microns
XR11002	142	25	129	32
XR11004	166	20	156	26
TT11002	181	15	160	21
TT11004	258	8	182	15
TD02	473	2	400	4
TD04	444	3	376,	5

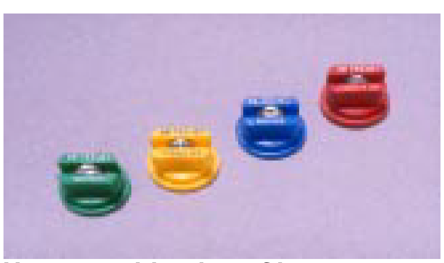
[a]XR, extended range flat fan; TT, Turbo TeeJet; TD = TurboDrop
Source: Derksen et al., USDA-ARS, 1997.

The effect of pressure on droplet size should be kept in mind when a pressure-compensating controller is used to vary flow on the go. For example, a controller is calibrated to deliver the proper application rate when traveling at 10 miles per hour (mph) and nozzle pressure of 42 pounds per square inch (psi). If the ground speed slows to 6 mph, nozzle pressure drops to 15 psi and droplet size increases. If the ground speed increases to 12 mph, the nozzle pressure rises to 60 psi, thus decreasing droplet size and increasing the opportunity for drift. In an area with sensitive vegetation, one strategy to decrease drift is to decrease travel speed even if field conditions allow higher speeds.

Nozzle types

Standard flat-fan

Major nozzle tip manufacturers produce broadcast flat-fan nozzles able to operate in a 15–60-psi pressure range. By maintaining their pattern at lower pressures, these low-pressure or extended-range nozzles offer more flexibility than older style flat-fan tips designed to operate in a 30–60-psi range. When operated at lower pressures, these tips reduce drift. If any type of controller is being used to vary application rate with speed, these tips should be considered a minimum level of quality to use because of their increased operating pressure range over that of a standard older flat-fan tip.



Use a combination of larger nozzles and lower pressure to reduce drift with standard flat-fan nozzles.

The standard flat-fan tip can still be used effectively for many pesticide applications. However, care must be taken to reduce pressure and use a larger orifice nozzle to maintain larger droplet sizes and reduce drift-prone particles. These tips are useful for applications of insecticides and fungicides that require greater target coverage.

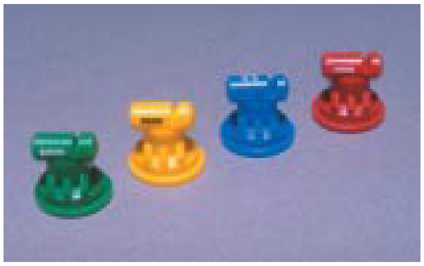
Pre-orifice

For many years, Delavan, Inc. (Monroe, NC) has marketed Raindrop nozzle tips that produce large droplet sizes relatively independent of operating pressure. Nozzle design limits the release of small droplets and pressure is reduced internally within the nozzle. These tips have been popular for soil-applied herbicides. The Drift Guard nozzle (Spraying Systems Co., Wheaton, IL) uses a pre-orifice to reduce pressure within the nozzle. Such nozzle tips are often called drift-reduction flat-fan nozzles and are commonly used to obtain larger droplets at a given operating pressure.

Pre-orifice nozzles, such as the Drift Guard, combine the coverage of regular flat-fan nozzles while reducing droplet size. However, newer nozzles, such as the Turbo TeeJet, can provide even greater drift reduction at a similar cost.

Turbulence chamber

Recent designs in nozzles have added the use of a turbulence chamber to further absorb energy within the tip and increase droplet size. Examples include Turbo



Turbo TeeJet nozzles reduce drift-prone particles yet provide adequate coverage for many herbicides.

Teejet (Spraying Systems Co.) in a small, flat-fan tip design and Turbo Floodjet in a flooding tip design. Both produce larger droplet sizes than similar nozzles operated at a specific pressure without the turbulence chamber. Because the Turbo Teejet maintains its pattern over a wide pressure range, 15–90 psi, it is an excellent choice to use with a spray controller that is varying flow rate (and pressure) with travel speed. Turbulence chamber nozzles provide a good compromise of larger droplets while maintaining adequate coverage for many herbicide applications.

Venturi

Venturi nozzles produce larger droplets by inducing air into the liquid stream inside the nozzle body. After spray flows through a metering pre-orifice inside the nozzle body, an inlet port introduces air into the liquid by venturi action. The droplets containing entrained air are generally larger than those produced by similar sized nozzles using only a pre-orifice or turbulence chamber. Most venturi nozzles are designed to operate at higher pressures than conventional flat-fan or turbulence chamber nozzles and to maintain a uniform droplet size throughout the pressure range.

Examples of venturi nozzles (clockwise from left): Greenleaf TurboDrop, TeeJet Air Induction (AI), Lurmark DriftBETA.

Blended-pulse

A recent technology (Capstan Ag Systems, Topeka, KS) uses solenoid-controlled valves within each nozzle body to rapidly start and stop flow. If the valve is only open 50 percent of the time (50 percent duty cycle) then only half as much spray solution is applied. Such technology allows the formation of larger droplets by using larger nozzle tips with lower operating pressures without requiring high volumes of spray solution. Alternatively, spray pressure can be increased to create finer droplets for coverage, but total spray volume can be held constant by reducing the amount of time the nozzle solenoid is open.

Conclusion

Nozzle selection is the most important factor in reducing pesticide drift. Take time to match application needs to the nozzle best suited to the situation. All the nozzles mentioned in this publication can be used under different conditions to reduce drift. They also can be used improperly. Be sure to pay attention to pressure, product, and pest before you spray. Coarser sprays are adequate for many herbicide applications. However, contact-type herbicides, such as Gramoxone, Buctril, or Cobra, require good coverage for maximum weed control. Finer sprays are more appropriate for insecticide and fungicide applications. Always consult the product label for further guidance on selecting the correct nozzle, pressure, and spray volume combination.

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Reference to products or trade names in this publication does not imply endorsement and exclusion does not imply nonapproval.

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