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Reducing Spray Drift

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Spray drift is becoming an increasingly important part of every spraying operation. More diversification of crops, more active and non-selective herbicides, and a greater awareness of pesticides in the environment has caused spray drift management to become every applicator's business. Nozzles play an extremely important part in drift management by having a major affect on determining spray droplet size. They are inexpensive but can be the most important sprayer part regarding spray drift. The spray nozzle and operating pressure determines how effective the spray deposit is and how much spray may drift.

While elimination of all drift is impossible, new nozzle technology is extremely effective in reducing it. Drift can also be kept within reasonable amounts by avoiding spraying at times and places when drift potential is high and by using proven drift-reducing procedures and equipment.

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How Drift Occurs

Spray drift is the movement of a pesticide through the air, during or after application, to a site other than the intended target. Drift is considered to be the most challenging problem facing applicators and pesticide manufacturers. Although drift may occur as vaporized active pesticide from the application site, it is usually the physical movement of very small drops from the target area at the time of application.

Spray drift started with the invention and use of pesticides. Spray drift has become a serious concern because the pesticides used today are more active and many are non-selective. Usually, only a small amount of pesticide is needed to cause injury to nontarget plants and animals that are susceptible to the pesticide.

The use of genetically altered crops that are resistant to non-selective herbicides is growing. When crops produced from conventional seeds are grown next to a field of a genetically altered crop, only a small amount of a non-selective herbicide may be needed to cause damage in the field with a conventional crop.

Drift is likely to occur where liquid sprays are applied. However, under favorable weather conditions, the problem associated with drift can be reduced to a minimum if chemicals are applied with the proper selection and operation of equipment.

Factors Affecting Drift

There are several factors that play a significant part in the creation and reduction of drift. They can be grouped into one of the following categories.

- Spray characteristics, such as volatility and viscosity of the pesticide formulation.
- Equipment and application techniques.
- Weather conditions at the time of application (wind speed and direction, temperature, relative humidity and stability of air at the application site).
- Operator care, attitude and skill.

After wind speed and direction, spray drop size is the second most important factor affecting drift. Good coverage is essential for insecticides and fungicides because of the unusually small size of the target organism. Small-to-medium size droplets are desirable when applying insecticides and fungicides because they usually provide better coverage. Small droplets, however, are difficult to get deposited on the target, so they may remain airborne and drift long distances because of their light weight and small size.

Spray droplet diameters are measured in micrometers. A micrometer is approximately 1/25,000 of an inch and is usually referred to as a micron. For reference, the thickness of a human hair is approximately 100 microns. Drops smaller than 150 microns in diameter generally pose the most serious drift hazard. According to a study, drift is far less likely to be a problem when droplets are 200 microns and larger in size. The same study indicates that spray particles under 50 microns in diameter remain suspended in the air indefinitely or until they evaporate. They should be avoided because there is no way to control deposition of very small drops.

Table 1 provides information on the effect of drop size on coverage. Table 2 provides information on droplet evaporation and the distance various drop sizes will travel before evaporating.

Table 1 shows some characteristics of various size droplets. Decreasing the droplet size from 200 to 20 microns will increase coverage by a 10 fold factor, but table 2 shows that a 20-micron water drop will travel less than 1 inch before it completely evaporates in less than 1 second. Droplets less than 100 microns in size obtain a horizontal trajectory in a very short time and evaporate very rapidly. The pesticides in these droplets become very small aerosols, which will move up into the atmosphere and will not fall out until picked up in falling rain. Droplets over 150 microns in size resist evaporation to a much greater degree than smaller droplets due to their larger volume. From these and other research results, we can conclude that there is a rapid decrease in the drift potential of droplets as their diameter increases to about 150 microns.

Several factors determine if a spray particle will deposit on the surface of a plant.

Table 1. Spray droplet size and its effect on coverage

		1 gal/Acre application	
Droplet diameter (microns)	Type of droplet	Coverage Droplets per sq. inch (number)	relative to a 1,000 micron drop
5	Dry fog	9,220,000	200
10	Dry fog	1,150,000	100
20	Wet fog	144,000	50
50	Wet fog	9,222	20
100	Misty rain	1,150	10
150	Misty rain	342	7
200	Light rain	144	5
500	Light rain	9	2
1,000	Heavy rain	1	1

Table 2. Spray droplets: evaporation and distance traveled*

Droplet diameter (microns)	Terminal velocity (feet per second)	Droplet diameter after water evaporates (microns)	Time to evaporate (seconds)	Distance traveled from nozzle (inches)
20	0.04	7	0.30	Less than 1
50	0.25	17	1.80	3
100	0.91	33	7.00	9
150	1.70	50	16.0	16
200	2.40	67	29.0	25

* Conditions assumed: Temperature at 90^0F; Relative humidity: 36%; Spray pressure: 25 pounds per square inch; Pesticide solution: 3.75%

These include:

- The size and content of the droplets.
- The size, shape and density of the target.
- The wind speed and other meteorological conditions.
- The nature of the deposition surface.

Very small droplets (less than 50 microns) are collected efficiently by insects or by needles on coniferous plants but tend to remain in the airstream and are carried around stems and leaves of weeds. Medium size droplets applied when there is some air velocity will deposit more efficiently on stems and narrow vertical leaves such as grasses, while large droplets will deposit most efficiently on large flat surfaces such as broadleaved plants.

Be sure to review the pesticide label regarding droplet size requirements because of the usually reduced coverage with large drops. Usually, systemic herbicides work very well with large drops. When applying contact type fungicides for disease control, a smaller drop may be needed due to the need for better coverage.

A Range of Sizes

In reality, you need a range of droplet sizes to effectively deposit pesticides on the variety of plant types, sizes, and shapes that you encounter. For instance, here is how different size droplets vary in their effectiveness:

- To effectively control pests, the actual range of droplet sizes will depend on the specific pesticide being used, the kind and size of the target plant, and weather conditions. Some new nozzles are specifically designed to reduce drift by reducing the amount of small, driftable fines in the spray pattern.
- Insecticides and fungicides generally require smaller droplets than herbicide applications to obtain adequate coverage of the target. Experimental results with foliar herbicides suggest that droplet sizes in the range of 100 to 400 microns do not significantly differ in weed control, unless application volumes are extremely high or very low. Exceptions to this guideline may exist for specific herbicides.

Spray Volume and Pressure for Foliar Herbicides

Some applicators are reducing the spray volume of foliar herbicides. When you reduce spray volume, the herbicide concentration will increase to maintain the same dose of active ingredient. But as spray volume is reduced, the droplet size will decrease, and this means greater drift potential.

Research has also shown that control of some broadleaf weeds with contact herbicides is usually reduced when you cut back on spray volume. However, reduced volumes have little effect on weed control with most systemic herbicides, as long as the chemical is applied properly at the recommended rate.

To compensate for the reduced spray volume, some applicators will increase spray pressure from 30 to 40 pounds per square inch (psi) to 50 to 60 psi. They believe they can “drive” small droplets into the crop canopy to increase coverage. But a large number of small droplets will quickly lose their velocity and evaporate before they reach the plant. In addition, the small droplets have low momentum and insufficient energy to be driven into the plant canopy. Therefore, increasing pressure should not be used as a substitute for spray volume. It is recommended to maintain pressures below 40 psi, and if you need coverage, increase spray volume.

Equipment and Application Methods
to Reduce Drift

Application Parameters

The equipment you choose to reduce drift and the way you use it makes a difference. For example:

Lower spray nozzle height. You can reduce drift by mounting the spray boom closer to the sprayed surface without sacrificing the uniformity of the spray pattern as long as nozzle discharge angle is increased from 80º to 110º. That's because wind speed increases with elevation. The correct spray height for each nozzle is determined by the nozzle spacing and the spray angle. Wide-angle nozzles also produce smaller droplets, offsetting some of the advantage of a lower boom height.

Use the lower end of the pressure range. Higher pressures generate many more small droplets (less than 150 microns). Extended range flat fan nozzles are designed to produce a uniform spray pattern down to 15 to 20 psi, and at this pressure, fine spray drops are reduced considerably. It is recommended to not use operating pressures that exceed 35 to 40 psi or significant fine drops will be produced.

Increase nozzle size. Larger nozzle sizes create larger droplets, which are less likely to move off-target. If you use nozzles that put out 5 to 10 gallons per acre (gpa), increase the size to nozzles that put out 10 to 12 gpa.

Drift reducing nozzles. Recent developments in spray nozzles have been aimed at reducing spray drift. Almost all major nozzle manufactures have introduced a "low drift" nozzle. Several nozzles utilize a pressure-reducing chamber in the nozzle, which will help create larger drops at the same flow rate and operating pressure as a comparable flat-fan nozzle. This has been accomplished by adding a pre-orifice to the nozzle assembly just ahead of the conventional discharge orifice (Figure 1).

The new low-drift design allows liquid flow through a small orifice into a pressure-reducing chamber. The liquid flows from this chamber out the outer orifice. The pre-orifice reduces liquid velocity and pressure at the exit orifice, creating larger drops to reduce drift significantly. According to one manufacturer, their low-drift nozzle tip reduces the number of droplets smaller than 200 microns by 50 to 80 percent.

Air Induction Drift Reducing Nozzles

Several different designs of air-induction/ venturi nozzles are currently available (Figures 2 and 3). They are designed to "entrap" air into the spray drop inside the spray nozzle. Air is introduced into the nozzle through a small opening in the nozzle as a result of a venturi effect. The reduced

Figure 1. "DriftGuard," a low-drift nozzle. (Source: Spraying Systems Co.)

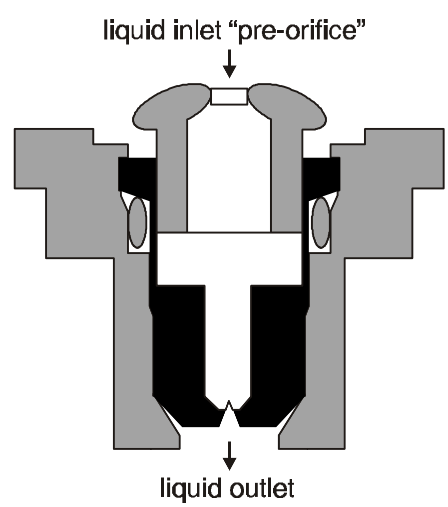


Figure 2. TurboDrop Nozzle.
(Source: Greenleaf Technologies, Covington, LA)

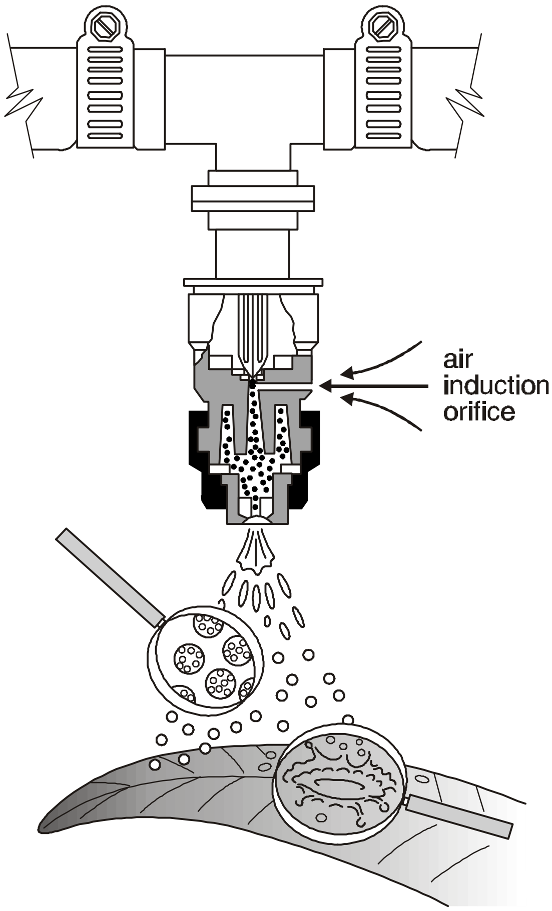
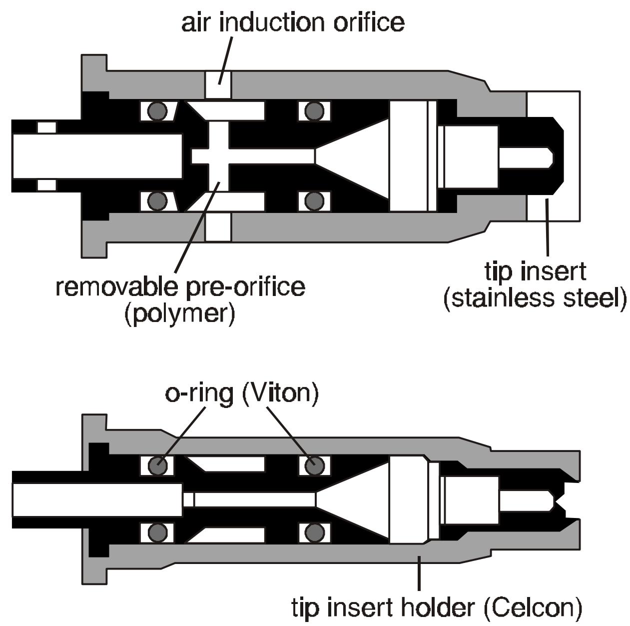


Figure 3. AI TeeJet Air Induction Nozzle. (Source: Spraying Systems Co., Wheaton, IL)



pressure or vacuum created within the nozzle will draw air into the spray solution, forming air bubbles. The air and liquid exit the nozzle as a larger spray droplet with the potential to get more pesticide product to the target and reduce drift.

Air-induction/venturi nozzle systems appear to be very promising for improved application efficiency and reduced drift, especially for use with systemic herbicides. These nozzles are relatively new, so more research and experience is needed to verify this concept. These nozzles produce large drops, so coverage may be reduced in the case of their use in applying insecticides and fungicides. Be sure to read the label for recommendations regarding nozzle use. Some pesticides require small drops for good coverage, and the air-induction type design may not produce the best results.

Table 3 lists volume median diameter (VMD) drop size information for several types of nozzles. The larger the number, the more resistant it is to drift.

Pre-orifice, turbulence chamber nozzles.

Another relatively new concept in nozzle design combines the pre-orifice concept with an internal turbulence chamber (Figures 4 and 5). The turbulence chamber absorbs energy, again reducing the exit pressure from the nozzle. This not only creates larger droplets but also improves the uniformity of the spray pattern.

Turbulence chamber nozzles are available in a turbo flood tip and the turbo flat-fan design. The turbo flat-fan design shows considerable improvement in reducing the percentage of driftable droplets over the extended range flat fan nozzle under a wide range of pressures. Both of the turbo designs are designed for use on the boom to spray straight down with a 50 percent overlap.

Table 3. Drop size comparisons
(Data provided by Spraying Systems Company, 1996)

Nozzle Type*	Drop Size (in microns) at different spray volumes and pressures Volume Median Diameter (VMD)			% of spray volume under 200 microns
Nozzles that operate at low pressure	40 psi 0.2 gpm	40 psi 0.5 gpm	60 psi 0.50 gpm	40 psi 0.5 gpm
Extended range nozzles				
• XR flat-fan 80⁰	270	370	300	11
• XR flat-fan 110⁰	224	310	250	22
Pre-orifice nozzles				
• Drift Guard flat fan 80⁰	340	410	330	8
• Drift Guard flat-fan 110⁰	330	390	320	11
Pre-orifice, turbulence chamber				
• Turbo flat-fan	340	450	400	6
• Turbo flood flat-fan	—	710	650	Less than 1
Other Nozzles				
• Flat-fan 80⁰	270	370	300	11
• Flood flat-fan	—	450	410	3

*All nozzles are Spraying Systems gpm = gallons per minute psi = pounds per square inch

Figure 4. Turbo TeeJet Nozzle.
(Source: Spraying Systems Co.)

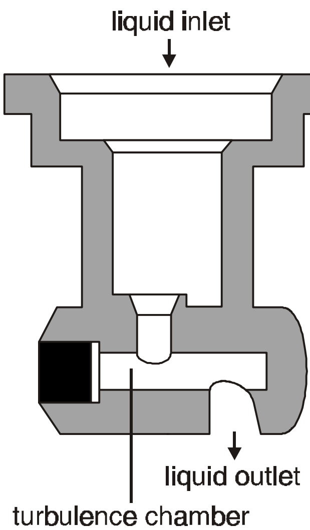
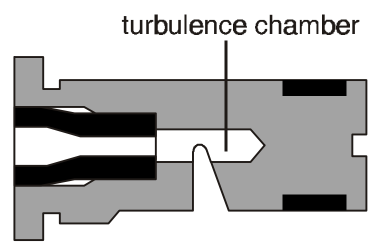


Figure 5. Turbo Flood Nozzle.
(Source: Spraying Systems Co.)



Air-Assist Sprayers

Air-assist technology uses high velocity airflow to improve the atomization, transportation, penetration, and deposition of spray products. There are two basic styles of air-assist systems – one type uses an air curtain and the other uses air atomizing or air shear nozzles.

The Air-Curtain or Air-Shield Boom

Air-curtain or air-shield booms are designed to use an external fan. This creates a high air velocity that will entrain and direct the spray solution toward the target. Some sprayers provide a shield in front of or behind the conventional spray pattern, protecting the spray from being blown off-target.

This concept is designed to increase the effectiveness of pest-control substances, provide better coverage to the underside of leaves, promote deeper penetration into the crop canopy, make it easier for small droplets to deposit on the target, cover more acres per load, and reduce drift. But, the initial purchase price and operational cost will be higher. More equipment and considerable horsepower is needed to move large volumes of air.

An NDSU study on potatoes found air-assist sprayers improved spray coverage 3 to 5 percent at the same application rate as compared to conventional sprayers. Increasing the application rate with conventional sprayers 1 to 2 gallons per acre can usually make up this difference.

Studies conducted by the USDA-ARS in Stoneville, Mississippi, have shown that conventional sprayers provide adequate control in the top of the crop canopy, while the air-assisted sprayers tended to show improved control in the mid to lower part of the canopy. The air stream tended to open the canopy and help spray particles penetrate deeper in the plant canopy.

Mid- to lower-canopy penetration and coverage is important when working with insecticides and fungicides, but may not be as critical when applying systemic herbicides.

Another finding in the USDA-ARS study (supported by a Canadian study) was that air-assisted boom sprayers can decrease drift when there is a crop canopy, but can increase drift when applying to small plant growth or bare ground. When there is a crop canopy, the plants absorb the extra energy created by the fan's air stream. When the ground is bare, the increased air velocity can cause more drift by rebounding air flow, which will carry small drops up into the air.

Climatic Conditions

Wind Speed

Wind speed and direction, temperature, relative humidity, and atmospheric stability all affect spray drift. Wind speed, however, is usually the most critical meteorological condition. The greater the wind speed, the farther off-target small droplets will be carried. Although there is no maximum wind speed to serve as a guideline in all situations, try to spray when the wind speed is between 2 and 10 miles per hour. Wind speeds less than 2 MPH may be approaching temperature inversion conditions, which can be as damaging as excessive winds. (Inversions are explained further in the next section.)

North Dakota law does not specify a maximum wind speed allowable for spraying. State law requires applicators to follow the label and all pesticide labels have drift statements, so the label is the law.

To minimize the damage done by drift, it is also important to determine the wind direction relative to sensitive crops. To greatly reduce damage to sensitive plants, leave a buffer zone at the downwind edge of the spray area. After the wind has died down or changed direction, you can then safely spray the buffer zone.

Temperature and Inversions

Temperature and humidity affect the amount of drift that occurs through evaporation of spray particles. Although some spray is lost through evaporation under all atmospheric conditions, the losses are lower in cool, damp conditions.

Temperature also influences atmospheric stability, as well as the presence of air turbulence and "inversions." An inversion can occur when the air is very calm with very little air mixing. A temperature inversion occurs when the air temperature is coolest at ground level, warms with an increase in elevation, then gets cooler again. This condition makes it easy for spray drops to remain suspended in the air and to move slowly downwind. In other words, extremely calm conditions can pose a serious risk of drift; it doesn't necessarily have to be excessively windy. Usually, if you have a cloud free night and no wind, you will encounter an inversion the next morning. This may not be the best time to spray your crop. You can recognize an inversion by observing a column of smoke. If the smoke does not dissipate, or if it moves downwind without mixing vertically, conditions are not good for spraying.

The best way to avoid the kind of drift associated with atmospheric conditions is to eliminate the formation of very small droplets in the spray. Once you do this, you can essentially negotiate around most weather stability factors.

Drift Control Additives

Another way to minimize drift is to use spray additives that increase spray droplet size. Tests indicate that, in some cases, drift control additives can reduce downwind drift deposits by 50 to 80 percent.

Drift control additives are a specific class of chemical adjuvant that should not be confused with such products as surfactants, wetting agents, spreaders, and stickers.

A number of drift control additives are commercially available. Many of these products are extremely rate sensitive, so follow the mixing directions closely. Increased rates may further reduce drift but can also cause nozzle distribution patterns to become distorted. Increased rates of drift control additive can also cause build-up inside the sprayer plumbing system that may be very difficult to remove.

The new types of nozzles provide excellent control of drop size and eliminate driftable fines. Nozzles have developed to the point of being able to reduce driftable fines as well as drift control agents, plus they eliminate the cost and disadvantages of the additives.

Drift control additives vary in cost, depending on the rate and formulation, but they are comparatively inexpensive for the amount of control they provide. They do not eliminate all drift, however. Common sense is still required.

Sprayer Shields

Shielded sprayers have become very popular for broadcast spraying on the prairies. Research studies have shown that drift is usually reduced by 50 percent or more under a full shield, compared to an unshielded spray boom with the same nozzle and operating pressure. Individual nozzle shields have shown a reduction in drift that is almost as good. If the newer drift reducing nozzles are used in conjunction with shields, spray drift can be reduced substantially. But, caution must still be used when highly active pesticides are used upwind of sensitive crops or around trees and gardens.

The use of shields does not allow applicators to ignore label statements about drift. If the label states a wind speed limit, that limit must be followed.

Summary

A number of drift control methods are available to applicators. They include new drift reducing nozzles, shielded spray booms and drift control additives. The new nozzles and additives increase drop size and reduce the fine drops while the shields contain the fine drops inside the shield.

The most important part to reducing drift is the applicator. He/she must make the decision to either do the job or to postpone it until a more opportune time. Taking a chance of doing the spraying job in conditions that may cause drift could be very costly.

Additional Information

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For more information on this and other topics, see: www.ag.ndsu.nodak.edu

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