Choosing drift-reducing NOZZLES

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"What nozzle should I use?" That's as hard a question as "What tractor should I buy?" You wouldn't buy a 300 hp tractor to mow your ditches. The answer to either question depends upon your needs.

Some of the many nozzles on the market can reduce pesticide drift. Would these be right for you?

Whether a particular low-drift nozzle fits your program depends upon your spraying needs and how you currently operate. Larger droplets reduce drift potential, but they may also reduce the effectiveness of the pesticide application. One nozzle will seldom be the best choice for all situations.

Consider your priorities before making your nozzle choices. Nozzles are relatively inexpensive, but they can be the most important sprayer component you buy.

Should you be concerned about spray drift?

- Are you, or your neighbors, planting a greater diversity of drift-susceptible crops?
- Are you using more highly active or nonselective herbicides?
- Are you planting more herbicide-resistant crops?
- Are you able to make applications at the right crop growth stage or do you need a wider window in which to spray?
- Are there sensitive areas (shelterbelts, neighboring fields, rural homes) close by that you should protect from drift?
- Are you concerned about the effect of pesticide drift on the environment?
- Are you trying to avoid future drift problems?

These concerns have made drift management everybody's business. Adopting drift management strategies is a timely and appropriate move for all pesticide applicators.

Whatever nozzle you choose, the chemical label is still the law and must be followed. If a pesticide label states that the pesticide should not be applied above a specific wind velocity and you go ahead, even with low-drift nozzle technology you will be breaking the law. Be aware also that drift-reducing nozzles do not eliminate all drift, they only reduce it. Spraying when susceptible plants are downwind may still cause damage.

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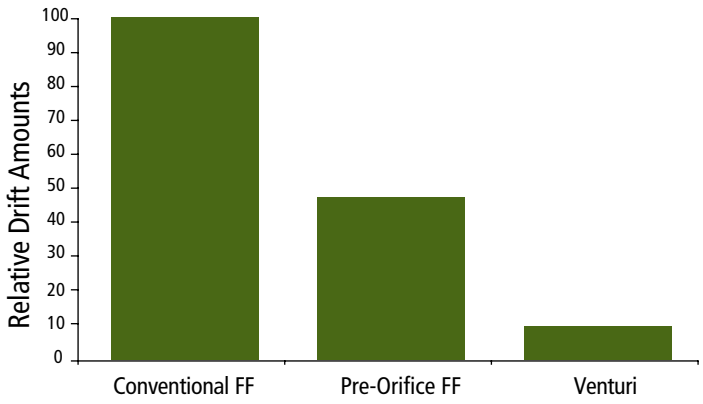


Figure 1. Drift comparison. (Wolf)

Figure 2. Conventionalflat fan spray tips at 40 psi. (Wolf)

Figure 3. Air induction nozzles at 70 psi. (Wolf)

This publication summarizes some characteristics of low-drift nozzle technology and shows the nozzle with a picture of the spray deposit it produces. The deposits were made using water volumes of approximately 8 gal/acre for all nozzles at their standard or optimum pressures.

Figure 1 shows a comparison of relative drift produced from the standard flat fan, the pre-orifice flat fan, and the venturi nozzle. The venturi nozzles show a 90% or more reduction in drift as compared to the flat fan at standard pressures. Figures 2 and 3 indicate the visual difference in drift between a commonly used flat fan nozzle and the newer drift-reducing venturi nozzle.

Research with spray shields has also shown excellent drift reduction. Using venturi nozzles with spray shields will reduce the drift potential even more but still will not reduce it to zero. You still must use care when spraying upwind of a susceptible crop.

Low-drift nozzles

Low-drift nozzles are designed to produce larger spray droplets with fewer driftable fines. The bigger droplets are produced in a pressure-reducing chamber inside the nozzle and, with some nozzles, by the incorporation of air into the spray droplets. These nozzles are excellent at reducing drift, but they do not eliminate all drift. Caution must still be used when susceptible crops are downwind.

When drift is reduced, spray coverage may be reduced or may stay about the same as with finer droplets. Spray coverage is usually less because fewer large droplets will be deposited on the plant. There will be larger spaces between the spray droplets even when the same application rate is used.

Systemic pesticides are generally recommended for use with low-drift nozzles. Pesticides that move within the plant usually do not need to cover the entire plant compared to a contact pesticide. Low-drift nozzles may only provide moderate or poor control with contact-type pesticides and are usually not recommended for these uses. Consult the pesticide label for specific restrictions.

Costs

Nozzle prices vary widely. Nozzle tips made from stainless steel or ceramic will usually cost more than plastic tips but generally last longer and may be worth the extra expense. Newer designs in

Table 1. Nozzle selection guidelines.

Conditions when coarser sprays could be considered:	Conditions when finer sprays could be considered:
(larger orifice / lower pressure conventional nozzles or drift reduction nozzle technology)	(smaller orifice / higher pressure conventional nozzles)
Non-selective herbicides	Insecticides/fungicides, contact herbicides
Easy-to-wet broadleaf weeds (pigweed, smartweed, thistles, etc.)	Difficult-to-wet broadleaf weeds / grassy weeds (lambsquarters, kochia / wild oat, foxtail etc.)
Cereal canopy penetration	Open broadleaf canopy penetration
Outside rounds and windy conditions	Favorable weather conditions
Adjacent sensitive crops or non-target areas	

Table 2. Nozzle droplet size classification (microns).

Droplet size	Very fine	Fine	Medium	Coarse	Very coarse	Extremely coarse
Dv 0.5*	less than 182	183-280	281-429	430-531	532-655	greater than 655
% of spray volume under 141 microns**	57	20-57	6-20	3-6	Less than 3	--
Color code	Red	Orange	Yellow	Blue	Green	White

* ASAE standard S-572 and Kirk, USDA–Southern Plains Ag Research Center
** BCPC (British Crop Protection Council) estimate

nozzles incorporating air induction technology will also cost more than standard flat fan nozzles, but again the extra cost may be worth the extra expense if they prevent drift injury. A drift problem can cost thousands of dollars, so a few extra dollars for a set of nozzles may be a good investment.

After you decide on a nozzle, be sure to check with several suppliers, since there may be considerable difference in price.

Drift management strategies
The most important factor in reducing drift is the size of the droplets produced by the nozzle.

For conventional flat fan nozzles, the best approach to reducing fine droplets is to increase the nozzle orifice size and to drop the spray boom pressure.

Consider using a 110° nozzle. This will allow you to lower your boom height and give the wind less opportunity to catch the spray. Booms should be set as low as possible above the target, based on nozzle discharge angle and nozzle spacing, while maintaining uniform coverage. Check with your nozzle manufacturer to match proper boom height and overlap.

Droplet size classification
Droplet size classification is new; manufacturers are beginning to list ASAE (American Society of Ag Engineers) categories that range from very fine to extremely coarse. This standard is based upon the average size droplet, known as the volume mean diameter (VMD), measured in microns, that is produced at a particular operating pressure. One micron is 1/1000 millimeter, or approximately 1/25,000 inch.

The volume median diameter (VMD) is a droplet size diameter which indicates that half of the spray volume is in droplets smaller than this number and half of the spray volume is in droplets larger than this size. It is also often indicated by Dv0.5.

Two other values are also important. They are the 10% volume and 90% volume droplet size and are indicated by Dv0.1 and Dv0.9. These are listed next to the spray droplet samples along with the Dv0.5 number. The Dv0.1 value indicates that 10% of the spray volume is in droplets smaller than this value and may be a major part of the driftable fines. The Dv0.9 value indicates that 90% of the spray volume is in droplets smaller than this value (10% of the spray volume is in droplets larger than this value).

The chart (Table 2) lists the VMD of the droplet size and the percentage of the spray volume in droplets smaller than 141 microns for those categories. Droplets smaller than 141 microns are usually considered to be very susceptible to drift.

The recommended droplet size category to use with a particular pesticide may be listed on the product label. Nozzle selection and pressure can then be based on the nozzle manufacturer's droplet size category charts. Typically, low-drift nozzles will produce spray droplets that fall in the medium to extremely coarse range.

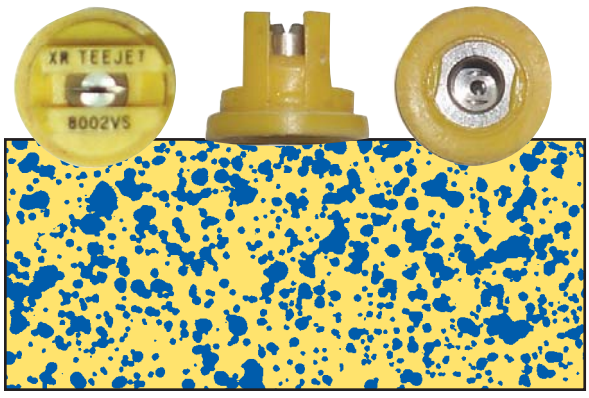
Conventional Nozzles

Extended range flat fan. The extended range flat fan is considered the standard nozzle for pesticide application in the Northern Plains. Variations of this design are available from several manufacturers. The design is available in a wide range of flow rates and fan angles to fit many application needs. A nozzle with an 80° discharge angle produces a larger spray droplet than a 110° angle nozzle at the same flow rate.

Spray quality is considered to be fine- to medium-size droplets for small nozzles. Larger nozzles (larger than 0.3 gpm) operating at 15 to 20 psi are considered to be coarse to very coarse. These nozzles produce a uniform spray pattern when patterns are overlapped 30 to 50% and when operated at 15 to 60 psi.

Lower pressures and higher flow rates produce coarser sprays that are resistant to drift while higher pressures above 30 to 40 psi produce finer droplets that may be susceptible to drift.

Extended Range Flat Fan



Drift-Reduction Nozzles

Pre-orifice flat fan. A pre-orifice nozzle reduces the operating pressure internally in the nozzle, producing a larger spray droplet than a standard flat-fan nozzle at 40 psi operating pressure. The pre-orifice design contains a metering orifice (pre-orifice) that restricts the amount of liquid entering the nozzle. This is what drops the pressure within the nozzle.

Pre-orifice nozzles are available in 80° and 110° discharge angles with a pressure range from 30 to 60 psi. This produces the same number of driftable fines as an extended range flat fan nozzle operating at 15 to 25 psi. A flat fan nozzle at 15 to 20 psi gauge may cause reduced spray application at the end of the boom, due to pressure loss. A pre-orifice nozzle with its higher operating pressure should eliminate this problem.

The pre-orifice nozzle produces a medium to coarse droplet size. The nozzle has a narrower pressure operating range as compared to a conventional extended range flat fan tip; pressure should not drop below 30 psi due to the internal pressure drop in the nozzle or exceed 60 psi, as considerable fines will be produced that contribute to drift. The optimum pressure for this nozzle is 40 psi. These nozzles can reduce drift by 50% over extended range flat fan nozzles but are more difficult to clean due to the metering orifice.

Turbo TeeJet Nozzle. This is a unique flood-type nozzle with a pressure-reducing turbulence chamber. It produces a wide, uniform spray pattern of 150° and should be mounted 15 to 18 inches above the spray surface when using a 20-inch nozzle spacing. This will provide about a 30 to 50% overlap over the adjoining nozzle spray pattern.

This nozzle produces a medium to a coarse droplet at moderate operating pressures. It is capable of operating over a wide pressure range (15 to 90 psi), which makes it an excellent choice for use with automatic rate controllers that use pressure to adjust flow rate in response to a change in travel speed. The optimum pressure is about 40 psi.

With medium to coarse spray, spray drift can be reduced by 50% compared to an extended range nozzle at equal flow rates. Turbo-TeeJet nozzles are an excellent choice for drift reduction compared to extended range flat fan. But these nozzles are difficult to clean, so carry a few extra when spraying. You will often need compressed air to clean the nozzle due to its design.

Venturi Air Induction Nozzles

Eight different brands of venturi nozzles are currently on the market in North America. They are also known as "air induction" nozzles. All have the same basic design feature—two orifices, one to meter liquid flow and the other larger orifice to form the pattern. Between these two orifices is a venturi or jet, used to draw air into the nozzle body. In the body, air mixes with the liquid and forms an air-entrained spray pattern at a lower pressure. The coarse spray contains large, air-filled droplets and very few drift-susceptible droplets. Venturi nozzles differ from conventional low-pressure spray nozzles by producing coarse droplets with few fines.

Dramatic drift reductions have been observed with these tips while good spray coverage has generally been maintained. The reason, the manufacturers say, is that the droplets are filled with air bubbles that cause the droplets to shatter on impact with the leaf, providing better coverage. Getting the maximum benefit from these nozzles, however, requires careful selection of the right nozzle for your needs and proper operation. You need to be aware of differences in pressure operating ranges, ease of cleaning, and the ability to fit into existing nozzle caps.

Most venturi nozzles are designed to be disassembled for cleaning, but you may need a needle-nosed plier, small screwdriver, or a piece of fine wire. It may be best to carry two or three extra nozzles along while spraying if some get plugged. Trying to clean venturi nozzles in the field will be difficult, as they contain some very small pieces that could be easily lost.

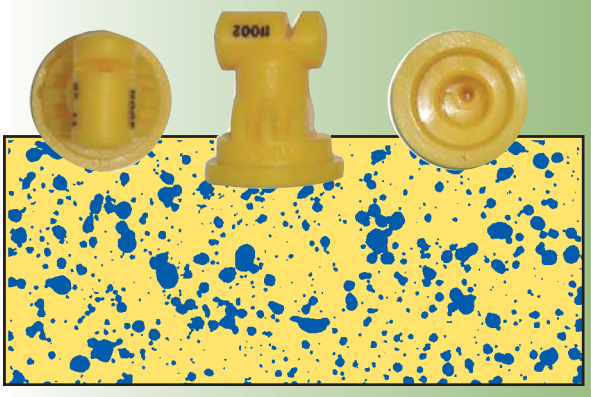
All brands of venturi nozzles can usually be installed on a standard spray boom. Some nozzles may require a different nozzle cap, so be sure to check this out when making a purchase.

Greenleaf TurboDrop. The first and most proven venturi nozzle is the Greenleaf TurboDrop. The exit tip is separate from the nozzle body and can be exchanged with other tips to fit specific needs.

Drift Guard Flat Fan

Dv0.1= 241
Dv0.5 =462
Dv0.9 =635
40 psi
8 gpa

Turbo TeeJet



Dv0.1 =187
Dv0.5 =366
Dv0.9 =578
40 psi
8 gpa

For example, a Turbo TeeJet exit tip can be used to increase spray coarseness, widen the spray angle, and improve pressure operating range. Exit tips must conform to the manufacturer's flow rate recommendations and should be a 110° angle. The TurboDrop nozzle produces droplets of intermediate spray coarseness as compared to other venturi tips. Good patterns are achieved between 30 and 150 psi, while optimum pressures for pesticide effectiveness are 60 to 80 psi.

Integrated nozzle caps fit Spraying Systems QuickJet nozzle bodies. The nozzle contains a long-lasting ceramic metering orifice that is easily detachable for cleaning. Be careful to match the spray exit orifice with the metering orifice.

Greenleaf TurboDrop XL. The Turbo Drop XL is a lower-pressure, all-plastic version of the TurboDrop. Good patterns are produced between 15 and 120 psi. Pressures up to 75 psi provide a coarser spray than the original TurboDrop, while pressures over 75 psi create a somewhat finer spray. Optimum pressures are 60 to 80 psi.

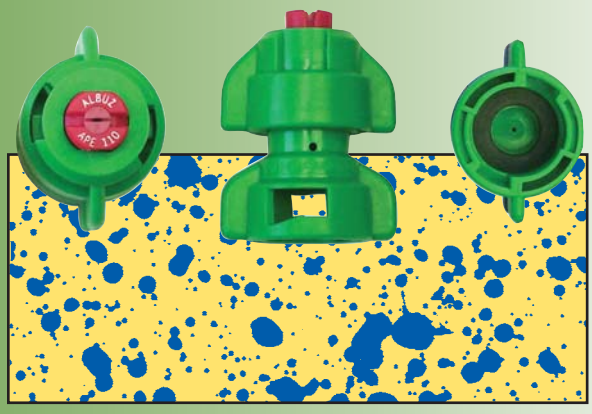
These nozzles contain integrated nozzle caps that fit Spraying Systems QuickJet nozzle bodies. They are best suited for a lower, wider pressure range.

Greenleaf - AirMix. The Greenleaf AirMix nozzle is a relatively new nozzle in the U.S. It is a two-piece, all-plastic design that separates easily for cleaning. It operates at a lower pressure than most venturi nozzles, with a suggested range of 15-90 psi. Optimal pressure ranges are from 25-60 psi. At these pressures, this nozzle produces moderate sized droplets that are generally finer than those produced by most venturi nozzles. The spray angle is rated at 110°. Pressures below 20 psi result in rapid pattern narrowing. The nozzle fits standard Spraying Systems QuickJet nozzle caps.

Billericay Farm Systems - Air Bubble Jet - ABJ. This nozzle is all plastic, has a 110° spray angle, and contains a removable metering orifice for easy cleaning. Good patterns are produced between 20 and 90 psi and the nozzle is suited for applications requiring a lower, wider pressure range. Unlike many other venturi nozzles, optimum pressures are 30 to 45 psi. This brand emits a finer spray than most other venturi nozzles, but still offers good drift protection. Integrated nozzle caps fit Spraying Systems QuickJet nozzle caps.

Hardi Injet. This nozzle is all plastic with a removable venturi insert, a 110° spray angle, and 20-inch optimum boom height. Good spray patterns are produced between 40 and 100 psi. The

Greenleaf TurboDrop

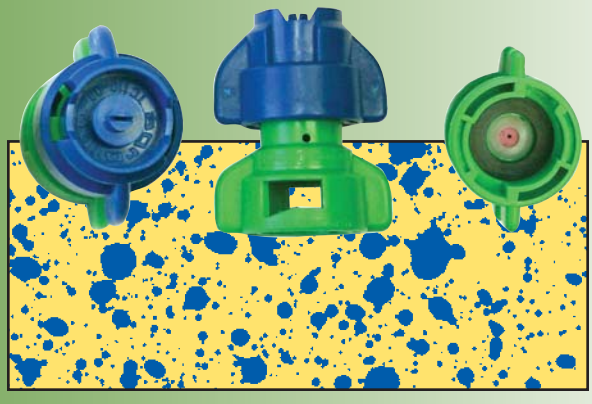


Dv0.1=244
Dv0.5=506
Dv0.9=712
80 psi
8 gpa

Greenleaf - AirMix

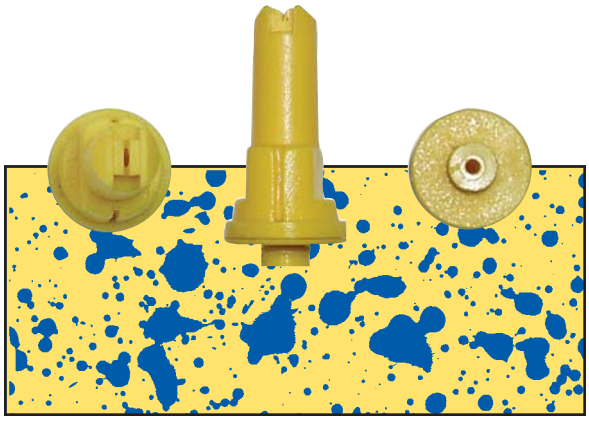
Dv0.1=213
Dv0.5=458
Dv0.9=692
80 psi
8 gpa

Greenleaf TurboDrop XL



Dv0.1=211
Dv0.5=461
Dv0.9=627
80 psi
8 gpa

Billericay Farm Systems - Air Bubble Jet - ABJ



Dv0.1=261
Dv0.5=537
Dv0.9=750
40 psi
8 gpa

nozzle produces an intermediate spray coarseness droplet as compared to other venturi nozzles, and its optimum pressures are 60 to 80 psi. It has a wider body than a standard nozzle and requires a special nozzle cap. Removal of the insert requires needle-nosed pliers.

TeeJet Air Induction (AI). This nozzle is similar in design to the Hardi Injet but has a stainless steel exit tip. It is also available in an "even" pattern for banding applications. Good patterns are produced between 40 and 100 psi; optimum pressures are 60 to 80 psi. The nozzle generates an intermediate to a slightly coarser spray droplet than other venturi nozzles. It requires a special nozzle cap to accommodate its wider body. Removal of the venturi insert requires needle-nosed pliers or a short piece of fine wire.

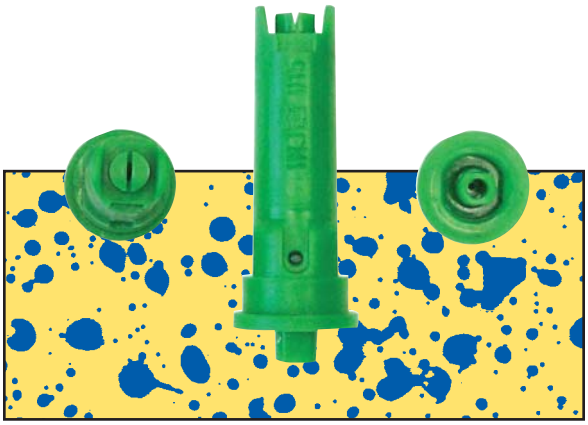
Delavan Raindrop Ultra. This nozzle contains an all-plastic body with a stainless steel exit tip of 110°. Good patterns are produced between 30 and 100 psi; optimum pressures are 60 to 80 psi. This nozzle generates a coarse spray droplet and spray patterns need close attention to maintain proper pattern overlap. The venturi orifice is removable for cleaning and fits Spraying Systems nozzle caps.

Spray International. This nozzle has not been widely used in North America. It is sometimes called the "Kematal" tip because of the material it is made of. Good spray patterns are produced between 40 and 100 psi, with optimum pressures between 60 and 80 psi. The nozzle is similar in appearance to the Air Bubble Jet, produces a coarse spray and has the narrowest fan angle of the venturi tips. Patterns and overlaps must be watched closely to ensure good coverage. This nozzle contains a removable back plate and a non-removable venturi that fits a Spraying Systems nozzle cap.

Hypro Ultra-Lo-Drift. This is the most compact of the venturi tips and closely resembles a conventional spray nozzle. It is of all-plastic construction with two pre-orifice holes to meter the liquid through the body of the nozzle.

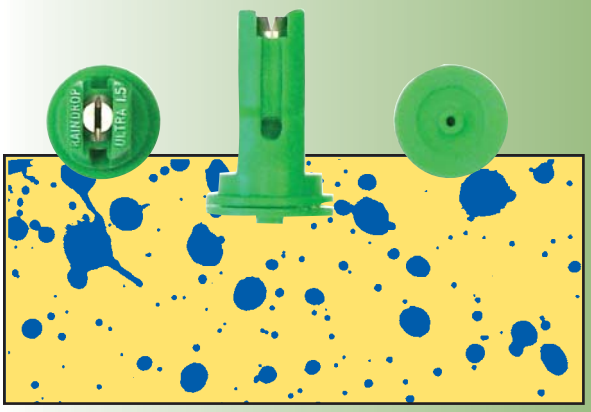
Good patterns are produced at pressures of 30 to 100 psi; optimum pressures are 60 to 80 psi. Spray droplet size is intermediate compared to other venturi nozzles. The nozzle produces a wider angled spray and operates at a slightly wider pressure range than most other venturi tips. It may have more problems with plugging due to the two small metering orifices. Good nozzle screens, properly sized for the nozzles, should eliminate this problem.

Hardi Injet



Dv0.1=246
Dv0.5=511
Dv0.9=714
80 psi
8 gpa

Delavan Raindrop Ultra

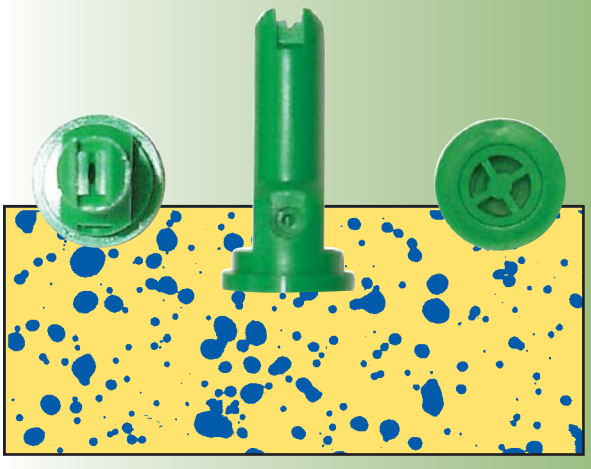


Dv0.1=256
Dv0.5=510
Dv0.9=678
80 psi
8 gpa

TeeJet Air Induction (AI)

Dv 0.1=233
Dv0.5=501
Dv0.9=688
80 psi
8 gpa

Spray International



Dv0.1=245
Dv0.5=498
Dv0.9=705
80 psi
8 gpa

Hypro AVI, Air-Inducing Venturi. This nozzle has a two-piece pressure-reducing design that contains a ceramic metering orifice along with a ceramic outer orifice that produces the spray pattern. Ceramic provides for long life and uniform flow rate.

Uniform spray patterns are produced over a wide pressure range of 30 to 100 psi. This nozzle produces a 110° spray angle that should be mounted at an optimum height of 20 inches with a 20-inch nozzle spacing.

Other Drift Reduction Technologies

Syncro Blended Pulse Spraying System. Capstan Ag System's Syncro Blended Pulse Spraying System is designed to provide independent control over nozzle pressure and flow rate. This is accomplished by using a rapidly pulsing solenoid within each nozzle body to vary the amount of time spray is flowing to the nozzle. Nozzles are paired so that when one nozzle is off the nozzles on either side are on, preventing skips.

Drift reduction benefits come from using larger orifice nozzles to produce larger droplets at lower pressures, while allowing lower application rates by varying the duty cycle of the solenoid. Systems are available which may be manually operated or used in conjunction with a rate controller that allows a constant application rate and droplet size over varying travel speeds. Case IH offers this system (AIM Command) as a factory option on some models of spray equipment.

Issues to Consider

Venturi Tip Spray Pressure

Although most venturi tips are rated at minimum pressures of 30 to 40 psi, they may need to be operated at higher pressures to give optimum performance over a range of conditions. The exceptions are the Air Bubble Jet and Air Mix nozzles, which are designed to work at conventional pressures.

Even at pressures of 60 to 80 psi, the remaining venturi nozzles still provide excellent drift protection. Using lower than the recommended pressures may cause the pattern to narrow and may reduce the activity of the air-induction mechanism. Without the inclusion of air in the droplets, the ability to maintain proper coverage may be reduced. Check the operating pressure of your sprayer and the ability of your pump to operate at higher pressures. If your system has trouble exceeding 50 psi, consider the Turbo TeeJet, Air Bubble Jet, Greenleaf Air Mix, or the Greenleaf TurboDrop XL nozzles.

When using an automatic flow regulator, monitor boom pressure and sprayer output closely when you change speeds. Poor spray patterns are often the number-one reason for performance complaints.

Nozzle Size Selection

Since venturi nozzles should be operated at higher pressures, you may need to choose a nozzle with a lower application rate as compared to conventional nozzles to maintain the correct spray volume without increasing travel speed.

For example, if you currently use a flat fan 0.2 gpm size nozzle at 40 psi, a venturi 0.15 gpm tip operated at 70 psi will provide the same flow rate, drift less, and give you some pressure flexibility if you need to slow down. If you use a flat fan 0.3 gpm tip at 40 psi, conversion to a 0.25 gpm nozzle at 60 psi, or a 0.2 gpm nozzle at 90 psi all will give the same flow rate.

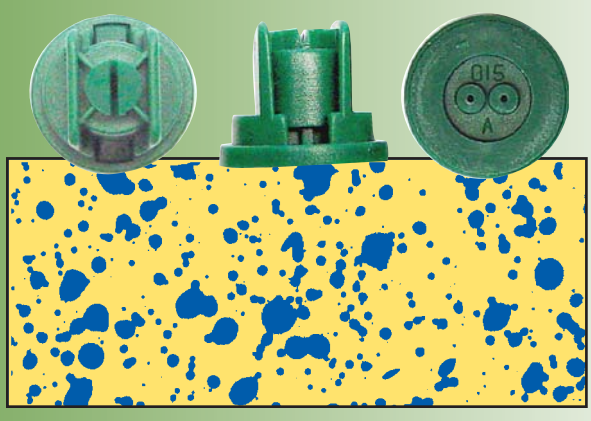
The smallest size for most venturi nozzles is 0.15 gpm, except for the Greenleaf TurboDrop and TurboDrop XL, which come in sizes as small as 0.1 gpm. Check the manufacturer guidelines for recommended pressures, and calibrate your sprayer at the start of every season.

Boom Height

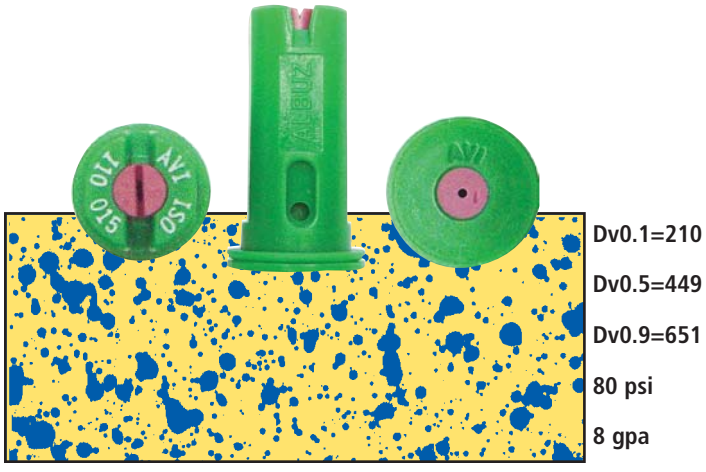
Proper boom height allows uniform overlap and coverage of the spray pattern, and your spraying equipment should be easily adjustable to meet changing conditions. Check with the particular nozzle manufacturer to insure proper boom height.

Although venturi nozzles are sold as 110° fan angles, their spray pattern is often closer to 80° and quickly becomes narrower at lower pressures. This is because the exit tip has a greater flow rate

Hypro Ultra-Lo-Drift



Hypro AVI, Air-Inducing Venturi



than the metering orifice, causing a significant pressure drop. Even at a gauge pressure of 80 psi, the exit tip pressure may only be 20 to 30 psi. The lower spray pressure at the exit tip causes a narrowing of the fan.

Watch patterns carefully, and set your boom at the height needed to achieve proper overlap.

Nozzle Wear
Most venturi nozzles are plastic. Plastic has very good wear characteristics and sometimes can outlast stainless steel. Plastic is, however, prone to deformation if cleaned with hard objects such as fine wire or a knife tip. A soft bristled brush, such as a nozzle cleaning brush or a toothbrush, should be used.

Nozzle Plugging
Even with clean water and screens, nozzles will occasionally plug. A venturi nozzle should present less plugging problems than conventional nozzles because the metering orifice is round, allowing larger particles to pass through.

The exit orifice typically has about twice the flow rate of the metering orifice, reducing the likelihood of plugging. If this orifice plugs, the nozzle will have to be taken apart for cleaning. Venturi nozzles are sometimes difficult to disassemble, especially in the field. It may be best to carry extra nozzles and disassemble and clean the plugged ones at the shop.

Adjuvants
Air inclusion in spray droplets is a function of formulation and pressure. Air bubbles may not form without a surfactant or at lower pressures. Remember that almost all postemergence pesticides sold in North America either have surfactants in the formulation or the manufacturers recommend them to be added. No special additives are required.

Low-drift adjuvants such as Nalcotrol or 38-F should not be used with venturi tips, as the spray may not atomize and form droplets properly. Always check your spray pattern after adding any adjuvant.

Efficacy
Venturi tips are best known for their dramatic ability to reduce drift. Many of these tips are new and information on pesticide efficacy is still scarce. Initial data suggest that these tips perform well at conventional carrier volumes, travel speeds, and product rates when used with systemic herbicides. Situations such as low carrier rates, reduced pesticide rates, contact pesticides, and small weeds under heavy canopies may reduce effective control with venturi nozzles.

Some weeds are more difficult targets than others, particularly the difficult-to-wet weeds, such as lambsquarters, wild oats, and green foxtail, or small weeds under dense canopy. These weeds generally require finer sprays to maintain effective coverage. When using venturi nozzles on these weeds, make sure your pressure is high enough to achieve good coverage. Larger weeds and reduced product rates typically make chemical control more difficult, and these conditions may also reveal some performance differences between nozzles.

Check with your chemical representative to see if the manufacturer supports the use of low-drift nozzles with the products.

The Bottom Line

As with any new technology, venturi nozzles should be used with caution. They have tremendous promise for reducing drift while maintaining good efficacy and have been used successfully by many applicators under a wide range of conditions. But they can be used improperly—make sure you pay attention to pressure and your herbicide/weed combination before you spray.

You may not want to or need to use venturi nozzles under all conditions. Think in terms of using the "right spray for the condition." This means that you may want to use conventional tips under good conditions but slow down and drop pressure or choose low-drift tips for the outside rounds or when winds come up. Always remember that the label is the law, and if the label states a maximum wind speed for spraying, it should be followed even when using drift-reducing nozzles.

Finer sprays are more appropriate for most insecticides and fungicides and for grassy weeds. Coarser sprays will work well for broadleaf weeds and when penetrating a small-grain canopy. You may also want to consider having two different flow rates available—for example, 5 to 7 gallons/acre will improve performance for glyphosate, and 10 gallons/acre or more may be required for other herbicides and most contact products.

Nozzles are the most important part of your sprayer. It makes sense to invest in the proper nozzle to make sure the job gets done right.

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