Nozzle Selection Guidelines for Optimum Efficacy and Least Drift

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What are the best nozzles to use?

By far the most common question applicators ask is: Which nozzle should I put on my sprayer? Such a question is not as easy to answer as it may seem, and the question is best answered with more questions such as:

- What are your application priorities (efficacy, drift control, canopy penetration, etc.)?
- What crops, pests, and types of pesticides do you use (insecticides, contact modes of action, or grassy targets require finer sprays or higher carrier volumes)?
- If interested in low-drift nozzles, what pressure is your sprayer capable of? (There are low- & high-pressure versions, Table 1)
- What carrier volume do you use? (Use conventional, pre-orifice, or low-pressure air-induced tips, for < 6 gpa)
- What is your travel speed range? (Use low pressure nozzles for greater range of speeds)
- What is your tolerance to drift? (High pressure nozzles give better drift control, even at high pressures)

There are a large number of nozzles on the market today, and applicators may have some trouble deciding which specific nozzle is best suited to their needs. The main categories of nozzles are listed below to help with nozzle selection. Within each category, we find a number of manufacturers who make a similar product. Key differences are materials used (plastic, ceramic, steel), pressure ranges, and fan angles. Details on relative droplet sizes and recommended minimum water volume are identified in Table 1.

Nozzle Categories

1. ***Conventional Flat Fan*** - finest spray, reliable performance, can be drift prone, use at 20 to 60 psi, > 3 gpa
2. ***Pre-Orifice*** - reduce drift about 50%, reliable efficacy at low volumes, use at 30 to 60 psi or higher, > 5 gpa
3. ***Low-Pressure Air Induced*** - reduce drift about 50 to 70%, use at 30 to 60 psi or higher, > 5 gpa
4. ***High Pressure Air Induced*** - reduce drift 70 to 90%, use at 60 to 80 psi or higher, > 7 gpa

Nozzle Basics

1. The higher the nominal flowrate of a nozzle, the coarser the droplet size.
2. The higher the spray pressure, the finer the droplet size.
3. For any given flowrate, wider fan angles have finer droplets.
4. Reducing spray pressures below the rated minimum decreases fan angles, resulting in poor patterns.
5. Always operate any nozzle in the middle of its recommended operating range. If an air-induced nozzle is recommended between 30 and 100 psi, operate it at 65 psi to get the best performance.

Carrier Volumes

1. At 8 to 10 gpa or higher, can use any nozzle successfully provided you choose the right pressure and boom height.
2. At 4 gpa and lower, limit yourself to Coarse sprays and finer.
   a) nozzle types 1 to 3 above.
   b) make sure pressure and boom height sufficient to generate good overlaps.

Table 1: Nozzle Choices, Pressures and Volume Recommendations

Nozzle	*Type*	*Air-Induced*	*Smallest Size Available*	*Optimal Pressure (psi)*	*Relative Droplet size*	*Minimum Volume (gpa)*
TeeJet XR	Conventional	No	0067	20 to 60	Smallest (*)	3
Hypro TR, VP, Albuz AXI	Conventional	No	01, 015, 015	20 to 60	*	3
Hardi FF	Conventional	No	0075	20 to 75	*	3
ComboJet ER	Conventional	No	0067	20 to 60	*	3
Turbo TeeJet	Pre-orifice	No	01	15 to 90	**	3-5
Hardi LD	Pre-orifice	No	01	20 to 70	**	3-5
Hypro LD, Albuz ADI	Pre-orifice	No	015, 01	30 to 60	**	3-5
ComboJet MR	Pre-orifice	No	0067	30 to 60	***	5-7
Air Bubble Jet	Low Pressure Air Induced	Yes	01	30 to 60+	***	5-7
Greenleaf AirMix	Low Pressure Air Induced	Yes	005	30 to 60+	***	5-7
Lechler IDK	Low Pressure Air Induced	Yes	015	30 to 60+	***	5-7
Hypro Ultra Lo-Drift	Low Pressure Air Induced	Yes	015	30 to 60+	***	5-7
Greenleaf TurboDrop, XL	High Pressure Air Induced	Yes	005	60 to 80+	****	7-9
Albuz AVI	High Pressure Air Induced	Yes	015	60 to 80+	****	7-9
TeeJet AI	High Pressure Air Induced	Yes	015	60 to 80+	****	7-9
Lechler ID / Hardi InJet	High Pressure Air Induced	Yes	01	60 to 80+	****	7-9
ComboJet DR	Pre-orifice	No	0067	60 to 80+	*****	10
Delavan RainDrop Ultra	Very High Pressure Air Induced	Yes	015	80 to 120+	*****	10

Nozzle Orientation

1. At slow travel speeds, orient nozzle forwards.
2. At fast travel speed (15 to 20 mph), we don't have enough information to make recommendation, but in recent tests:
   a) coarse sprays oriented forward had the best deposition on vertical targets.
   b) coarse sprays oriented backwards improved patterns at fast speeds.
3. Double nozzles (one pointed forward, the other backward such as in the Lurmark TwinCap) are a good idea to improve coverage on vertical targets such as wheat heads (for fusarium headblight control) or grassy weeds. In lab tests, using coarser sprays with these double nozzles significantly improved coverage, but in field tests, this did not result in a yield advantage with fungicides.

Travel Speeds

1. Fast travel speeds have both advantages and disadvantages, but the most important advantage is greater work rates. Disadvantages are greater dust generation, less uniform deposition (especially behind the tractor unit) and less canopy penetration.

2. On the whole, slower speeds are better. Travel as slowly as you can afford to given your workload.

Boom Heights

1. Lower boom heights are almost always preferable over high heights. Nozzles with 80 degree fan angles can go as low as 18" above target, 110 degree nozzles 14". Lower heights reduce drift and improve overall targeting.
2. High booms increase nozzle overlap, which can be useful for maintaining good pattern uniformity for low-drift nozzles and when pressures are low and patterns begin to collapse. But high booms can increase drift potential significantly. Use the lowest boom height you can that still offers you sufficient overlap given your boom movement.
3. Automatic boom levelers are available and have been useful for suspended booms under uneven terrain.

Canopy Penetration

1. Droplet size does not have as much impact on canopy penetration as carrier volume.
2. Penetration improves with slower travel speeds and higher carrier volumes for any nozzle.
3. Air assist is one of the best ways to improve penetration, more effective than the above methods.

Top Questions Asked by Producers about Nozzles

1) Do the air-vents on venturi nozzles ever get plugged, and if they do, what happens?

- They rarely plug. If they do, the spray pattern gets a bit narrower and the spray gets a bit finer. Neither change is dramatic and spraying can continue. Normal nozzle inspection and cleaning is sufficient.

2) Many of the new nozzles are plastic and ceramic. How do these compare to steel for wear?

- There are many different types of plastic materials used in nozzles. They wear at least as well and usually significantly better than steel. Care should be taken when cleaning, as they can deform irreversibly. Ceramic is the most wear-resistant material available, and can last 10-times longer than steel.

3) Do I need air-induction or can I just use low-pressure conventional sprays?

- Air-induction provides much more drift reduction than any comparable technology, even at high pressures. A very low pressure conventional spray is not as coarse as an air-induced spray and many of the pre-orifice sprays. Nonetheless, lower pressures are still a good way to reduce drift. Air induction seems to improve spray retention on grassy weeds compared to same-sized droplets without air.

4) Should I get shrouds or low-drift nozzles to control drift?

- Nozzles are less expensive than shrouds per foot of boom (about half). With shrouds, finer conventional nozzles can be used if the user is nervous about the efficacy of pesticides with coarser sprays. Air-induced nozzles provide similar drift control, depending on the shroud and the nozzle. Both can be used together. Air assist, when done right, can also give you decreased drift, allow use of reduced water volumes, and improve coverage and penetration.

5) Don't coarser droplets reduce coverage?

- Yes, they can, but the effect is not very important at reasonably high water volumes. In most cases, coverage is very similar, and efficacy is the same for broadleaf herbicides and fungicides at 10 gpa. Grassy herbicides require some caution – don't use a combination of very coarse sprays and low carrier volumes, and do maintain higher pressures. Droplet number per square inch can be more important than droplet size for determining efficacy. Pressure and volume should be adjusted to maintain at least 300 - 500 drops / square inch on water-sensitive paper, or 10-15% coverage.

6) Some nozzle manufacturers advertise that their nozzles give larger and more uniform droplets, better coverage, and can be used at lower volumes than other nozzles. Is this true?

- No. Low-drift nozzles are designed to reduce drift, and they do this by eliminating many of the finer droplets and adding some larger ones. Therefore, a low-drift spray reduces the number of droplets available for coverage, even if they are 'more uniform'. In practice, this is offset by maintaining a higher carrier volume and optimizing pressure for the specific nozzle. If you want to reduce water volumes, you need to use finer sprays to keep droplet number up. But you can compromise and get the best of both options. Use a reasonable water volume (5 to 7 gpa) and an intermediate low-drift nozzle.

7) How fast should I travel when spraying?

- Although faster speeds reduce canopy penetration, increase dust, and can cause drift problems, there is really no concern below 10 mph. Once you're above that, you will generally do a better job the slower you go. The problems are three-fold:
  - At faster speeds, you need a larger nozzle which creates a coarser spray, and that can reduce coverage;
  - At faster speeds, spray gets swept backwards, decreasing canopy penetration and increasing spray drift potential;
  - At faster speeds there is more air turbulence from the tractor unit or the boom. Spray patterns can become non-uniform, and that's hard to diagnose and correct.
- On the positive side, faster speeds can improve coverage of vertical surfaces.
- Faster speeds also cause greater variations in travel speed, for example when you climb a hill or slow down to make a turn. This will reduce your spray pressure and can cause pattern problems if you go below the recommended nozzle pressure. There is no specific nozzle that is designed for fast speed spraying, but nozzles with wide pressure ranges will probably work best.
- Consider a wider boom to increase work rates.

8) Is air assistance any good?

- Yes, air assistance is great for increasing dense canopy penetration. This means it can be especially useful for fungicides and insecticides – benefits for herbicides are harder to demonstrate. When done properly, air-assist can decrease drift even when fine sprays and lower water volumes are used.

9) If aerial application can get away with 2 to 4 gpa for fungicides, why do I have to use 10 to 15 gpa with a ground sprayer?

- For fungicides, more water is usually better. Both aerial and ground sprays use as much water as economically and practically justifiable in each case. Aircraft can apply sprays in a more timely manner under some conditions, which can be more important than carrier volume.

10) How do I get rid of sprayer tracks?

- Poor weed control in the sprayer tracks is hard to improve. Fast travel speeds, heavy sprayers, and dusty conditions appear to be the culprits. Some strategies involve placing higher flow-rate nozzles behind the wheels, moving the boom back away from the wheels, adding nozzles behind the wheels, or travelling slower.

11) How far can spray drift move?

- Fine spray droplets can move for many miles under some conditions. They move farthest during temperature inversions (night or early morning) because high humidity keeps them from evaporating and the inversion keeps them from dispersing. Topography is also important, as drift will follow low-lying areas. Windy conditions actually help disperse the spray. When it's windy, a greater proportion of the spray will drift, but it also gets diluted rapidly. Actual drift amounts vary greatly with weather conditions, topography, crop stage,

spray quality, boom height, etc., and the damage cuased also depends on the sensitivity of the downwind area and the toxicity of the active ingredient.

12) How low can I go with water volumes and still get good results?

- The secret to using low water volumes is that coverage is maintained. Since lower volumes result in less water available per square inch, applying in smaller droplets compensates. That is fine as long as drift can be managed. Low water volumes typically reduce the effect of natagonism caused by hard water ions. Unfortunately, canopy penetration and overall consistency can be reduced when water volumes are reduced too low. I would not recommend that less than 5 gpa be used for any product other than glyphosate. Remember, water is a relatively cheap input and it offers significant returns in terms of a quality job.

13) Can I use low drift nozzles with all my chemicals?

- Yes, as long as all the other guidelines (appropriate product rate, water volume and spray pressure) are followed. Among herbicides and weeds, broadleaf weeds and Group 2 and 4 herbicides have sometimes worked better with coarser sprays. Grassy weeds and Group 1 herbicides prefer finer sprays. A Group 1 and Group 2 tank-mix can be applied with a Coarse to Very Coarse spray but water volume should be kept above 7 gpa.
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14) How do I know what droplet size my nozzles are producing?

- All nozzle manufacturers now publish spray quality charts that identify either the ASAE spray quality or the actual VMD. These charts are available in catalogues or on-line. For examples, see
  - www.teejet.com/techcent/catalog_english/techinfo.pdf
  - www.hypropumps.com/Agriculture/AG_Spray_Products.cfm
  - www.hardi-us.com/html/_spray_quality_chart.html
  - www.turbodrop.com/dropsize.html