GRAINS RESEARCH & DEVELOPMENT CORPORATION

GRDC GROWNOTES

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 3
Nozzle design and function

How nozzle choice impacts on spray application

Bill Gordon

Key points

- **Nozzles are designed to control flow rate and determine the spray pattern**
- **Nozzle design impacts on droplet size, velocity, trajectory and retention on the target**
- **Formulation and tank mix can affect nozzle performance and the droplets produced**

1. Introduction

Nozzles are one sprayer component an operator can change to affect the results of their spray application.

It can be challenging to choose the right nozzle for your spray product, target and conditions. We must consider how different types of nozzles work and some of the things that can affect nozzle and spray performance, including deposition and drift potential.

Applicators should have a range of nozzles ready to use.

Source:Teejet

2. Nozzle design and function

View Module 8: Calibration of the spray system and Module 1: The need for planning

The primary function of a nozzle is to control flow rate and convert the spray liquid into droplets (via atomisation) that are of a suitable size for depositing on the intended target.

- **Flow rate is influenced by the orifice size, operating pressure at the nozzle and, to an extent, by the specific gravity and viscosity of the spray solution (see Module 8: Calibration of the spray system).**
- **Spray quality (the size of the droplets produced) is influenced by nozzle design, operating pressure, the angle of the spray pattern, the properties of the tank mix and (for some nozzles) the inclusion of air into the droplet.**

To consider how all of these factors may interact to influence the results of a spray application we will discuss some properties of droplets that can affect their deposition and retention at the target.

Once these properties have been discussed, we will focus on how variations in nozzle design and operating parameters can impact on this process.

2.1 Nozzle flow rates

The flow rate of ISO (International Organization for Standardization) nozzles is based on US gallons. A 01 orifice produces 0.1 US gallons per minute at 40 PSI (pressure per square inch) (with water), which is equivalent to 0.39 litres per minute at 3.0 bar.

Table 1 ISO nozzle flow rates in litres per minute at 3.0 bar pressure.

01	015	02	025	03	04
0.39 L/min @ 3.0 bar	0.68 L/min @ 3.0 bar	0.79 L/min @ 3.0 bar	0.99 L/min @ 3.0 bar	1.18 L/min @ 3.0 bar	1.58 L/min @ 3.0 bar

The flow rate of each nozzle size is a multiple of the flow rate of 01 at the same pressure. For example, a 03 has three times the flow rate of a 01 at the same pressure.

3. Properties of the droplet that affect its ability to get to the target and stay on the target

Properties such as droplet size, droplet velocity, droplet trajectory and droplet density will affect a droplet's ability to arrive at its target, be deposited and be successfully retained on that target.

3.1 Droplet size

Larger droplets tend to travel and sediment (settle to the ground) faster than smaller droplets, primarily due to their increased mass. Doubling a droplet's diameter increases its mass by a factor of eight.

Table 2 Behaviour of water-based droplets under favourable conditions for spraying.

Approximate droplet size diameter (micrometres or microns)	Expected droplet behaviour in neutral conditons
< 50	Will evaporate quickly and typically be lost before reaching the target.
50–150	Will move with the wind and can present a risk for off-target movement.
< 200	Considered to be 'driftable' as they can reduce in size with evaporation and then move with the wind.
> 350	May bounce or shatter, depending on nozzle type, formulation and leaf surface.
100 to 350–450	Considered most useful for spraying onto foliage.

3.2 Spray quality classifications

Table 3 Spray quality classifications

UC	XC	VC	C	M	F	XF
Ultra coarse	Extra coarse	Very coarse	Coarse	Medium	Fine	Extra Fine

Very good drift control ⟷ Poor drift control

Spray quality is classified according to the range of droplet sizes produced by a nozzle at a given pressure when compared to a set of standard reference nozzles. The Australian Pesticides and Veterinary Medicines Authority (APVMA) recognises two classification systems for determining spray quality on product labels: the American Society of Agricultural Engineers (ASAE) standard S572 or the British Crop Protection Council (BCPC) standard. Nozzle outputs for both are tested using water.

In 2009 the ASAE, now the American Society for Agricultural and Biological Engineers (ASABE), released a new testing standard, S572.1, that requires the addition of a 40 dyne adjuvant to the water prior to testing the drift reduction of pre-orifice nozzle outputs. This addition is likely to make the spray quality classifications for some nozzles appear to be finer than indicated under the old standard.

ASABE standard S572.1 for spray quality classification is important for spray operators to be aware of. In future APVMA will adopt the new standard when referring to spray quality on the product label.

Table 4 A comparison of spray quality classifications for one type of nozzle using ASAE standard S572 (old) and ASABE standard S572.1 (new).

OLD	Hypro Guardian Air™ 110-025	Pressure (bar)	1.5	2	3	4	5	6	7	8
		Spray quality ASAE S572	XC	VC	C	C	C	M	M	M

NEW	Hypro Guardian Air™ 110-025	Pressure (bar)	1.5	2	3	4	5	6	7	8
		Spray quality ASABE S572.1	XC	VC	C	M	M	M	M	M

Under the old standard (S572) pre-orifice and low drift nozzles such as air induction types were tested using water only. Under the new standard S572.1 an adjuvant must be added to the water before testing, which tends to make the spray quality finer than it would be with water alone.

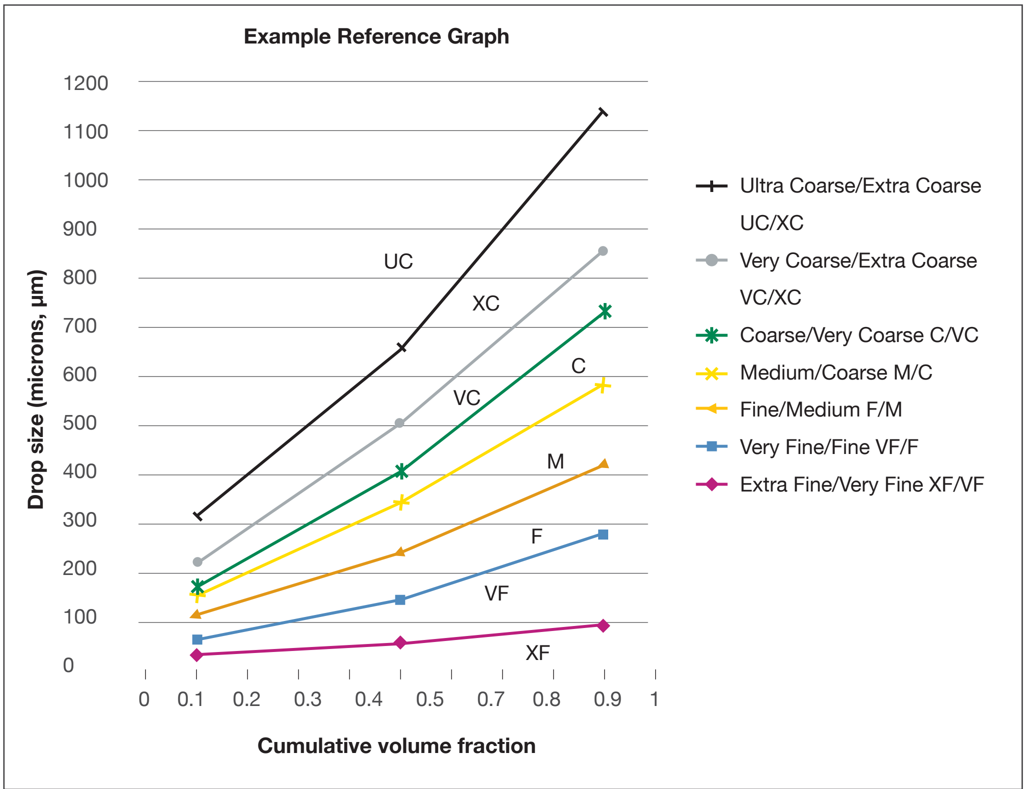
3.3 Spray quality and droplet size

Nozzles are assigned a spray quality classification (Table 3) by comparing their output (range of droplet sizes) at a given pressure to the output of standard reference nozzles.

Note: 0.1 as a cumulative volume fraction is equal to 10 per cent.

Figure 1 shows the average output of the standard reference nozzles as measured by several laser instruments, as an example of how nozzles are assigned a spray quality classification. The actual measurements would be performed through a single instrument, hence actual droplet sizes produced by a nozzle may differ from this graph.

Figure 1 An example of a reference graph used to assign spray quality classifications.



Source: ASABE Standard S572.1

The cumulative volume fraction (CVF) is the percentage of a spray volume that exists as droplets less than a given droplet size (microns) (see Figure 1).

For example, if we consider 0.5 CVF for the line separating coarse and very coarse (C–VC) it is about 400 microns. Therefore, half of the spray volume would exist as droplets less than 400 microns and half would be greater in diameter than 400 microns. The 0.1 CVF for the C–VC cut-off is about 180 microns; this means about 10 per cent of the volume would exist as droplets less than 180 microns.

As a general rule, each time you move to a coarser spray quality, you approximately halve the fraction of the spray that exists as droplets less than 150–200 microns in diameter (the fraction considered 'driftable').

A fine spray quality could have between 40 and 50 per cent of its volume existing as droplets less than 150 microns, a medium spray quality about 20 per cent and a coarse spray quality less than 10 per cent of its volume existing as droplets less than 150 microns.

3.4 Impact of spray quality on the number of droplets produced and spray coverage

The number of droplets produced per litre of spray decreases as spray quality becomes coarser. You can see this by depositing droplets onto water-sensitive paper – use an equivalent application volume and nozzles representing the cut-off of each spray quality classification.

For more information on using water-sensitive paper to look at spray coverage go to Module 21: Assessing spray deposits

Figure 2 Water-sensitive paper spray quality cut-offs.

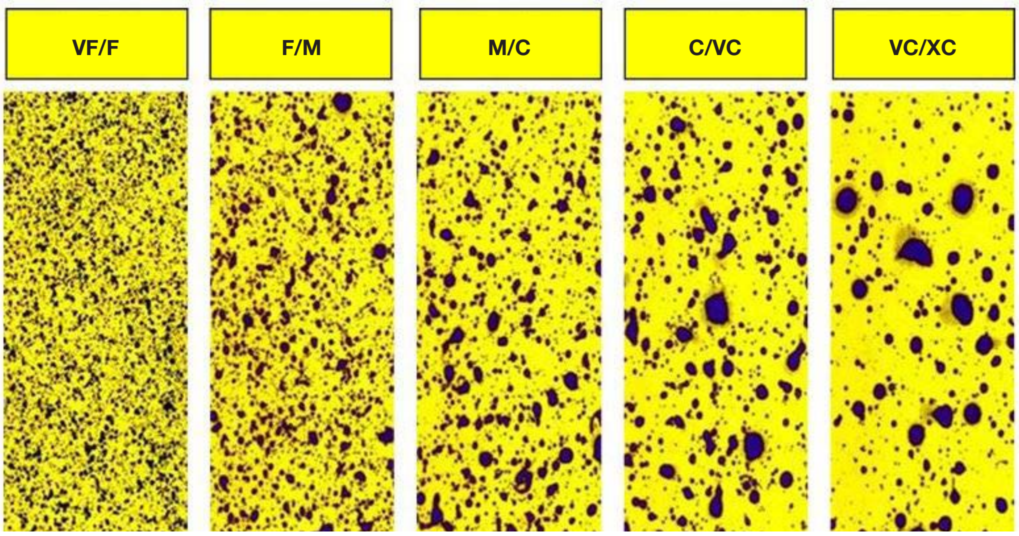
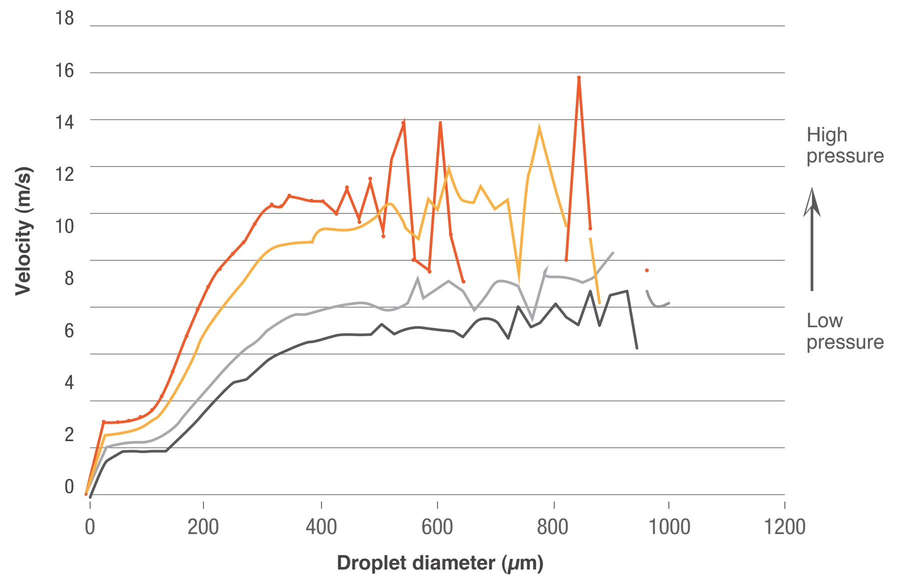


Image: Tom Wolf, Agriculture and Agri-Food Canada, Research Centre

4. Droplet velocity

Nozzle design can impact on droplet velocity. Generally, increasing orifice size or operating pressure will result in increased droplet velocities as the droplets leave the nozzle.

Figure 3 Droplet velocity distributions.



Source: Tom Wolf, Agrimetrix, Canada

Consider the impact of nozzle design on droplet velocity (close to the point where the sheet breaks up to form droplets): for nozzles of equivalent size and operating pressure, extended range flat fans normally produce the highest droplet velocities, followed by pre-orifice nozzles and then air-induction nozzles.

Small droplets tend to slow down rapidly after leaving the nozzle. Most will reduce the velocity by more then 90 percent before traveling less than half a metre.

Higher droplet velocities can be useful when using fine-to-medium spray qualities. The velocity can increase travel distances from the nozzle for smaller droplets (before losing momentum) and improve droplet impact and retention (provided the nozzle height is not too far from the target).

Larger droplets tend to have higher velocities when they arrive at the target, only reducing in velocity by about 50 per cent from where they leave the nozzle to reaching the target. This means they could still be travelling at 20 to 30 kilometres per hour when they hit the target.

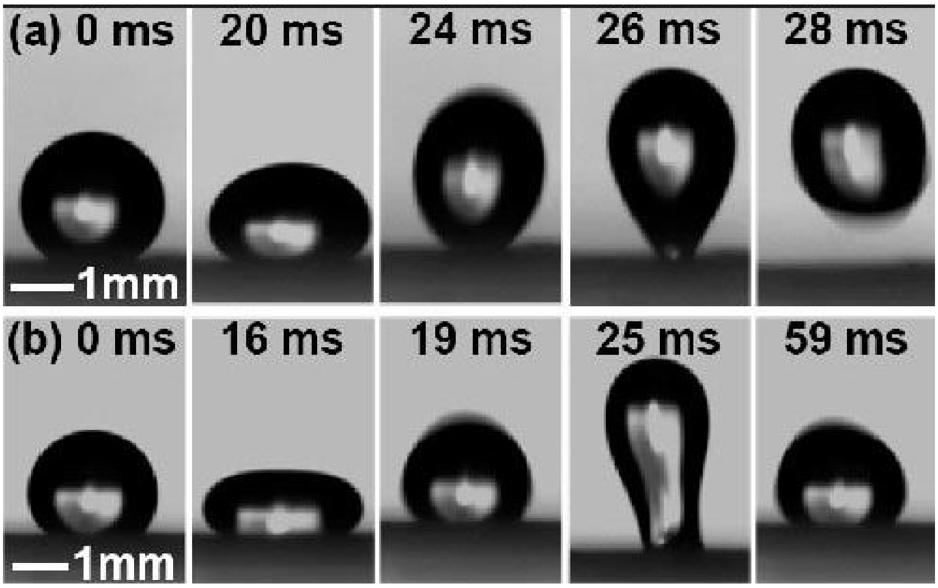
High droplet velocities can be detrimental in some situations (target and product combinations) if using coarse to very coarse spray qualities or larger.

Large droplets travelling at high speeds tend to have a lot of energy when they hit the target and may bounce or shatter on impact. The extent to which a droplet will bounce or shatter depends on the formulation type and the characteristics of the leaf or target surface.

Image of water droplet bouncing from lotus leaf (hydrophobic surface)

Photo: physicsworld.com

Figure 4 Larger water-based droplet bouncing from a hydrophobic leaf surface.



Generally, larger droplets that contain products with a high dynamic surface tension, such as crop oils or water, will tend to bounce more. Larger droplets containing products with a low dynamic surface tension, such as an organosilicone-based adjuvant, will tend to shatter more when hitting the target surface at high speeds.

Some formulation types will tend to shatter more on hairy leaf surfaces, while others will tend to bounce more on smooth leaf surfaces, particularly once the droplet size becomes too large, too fast, or both.

Droplet bounce or shatter may not produce a poorer outcome if the crop canopy can recapture the satellite droplets, which have less energy on impact. Droplet bounce and shatter are more likely to cause problems with efficacy for herbicide applications in fallow situations or where there is limited foliage to recapture droplets not initially retained by the target.

Some adjuvants, such as Dead Sure®, can improve the retention of large droplets by reducing droplet bounce, even with higher droplet velocities. Dead Sure® has also demonstrated drift-reduction properties.

5. Droplet trajectory

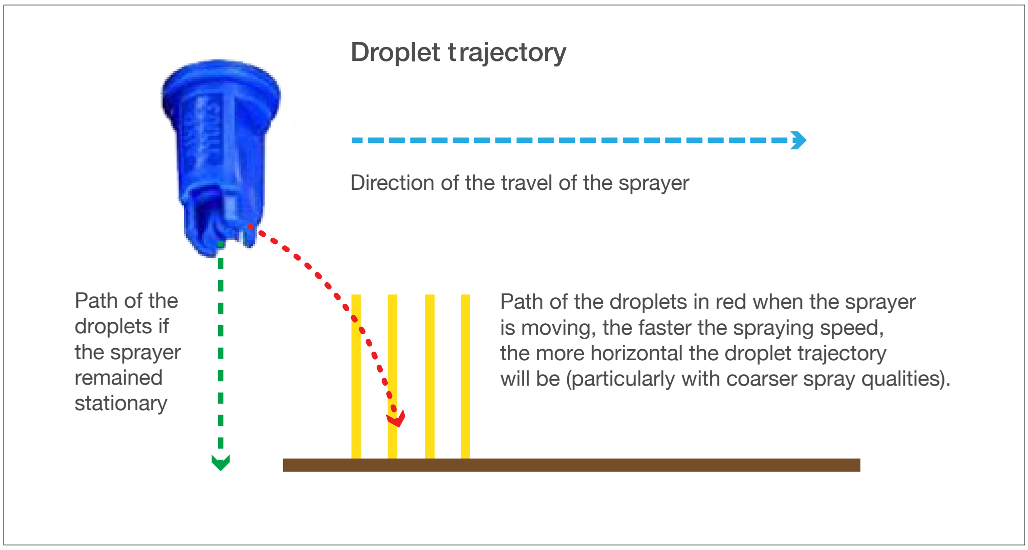
Nozzle design, droplet size and travel speed can interact to affect the direction that droplets travel after they exit the nozzle. The resulting direction of travel is referred to as the 'droplet trajectory'.

Higher forward-spraying speeds have a greater impact on the trajectory of large droplets, which tend to hold their direction of travel more readily than smaller droplets. Increased travel speeds increase the horizontal movement of the droplets in the direction of travel. This can increase the deposition of larger droplets onto vertical targets, but also onto 'false' targets (such as standing stubble).

At higher speeds larger droplets will travel on a more horizontal trajectory.

Source: Bill Gordon

Figure 5 Droplet trajectory.



The angle at which a droplet strikes its target surface can affect retention. Generally, the sharper the angle of impact relative to the surface, the less likely a droplet is to be retained on the target, particularly as the droplet size increases.

5.1 Angled nozzles and twin nozzles

Many angled nozzles and nozzles with twin patterns ('twin nozzles') have become available in recent years. Forward-facing patterns can be useful for increasing deposition onto vertical targets; rear-facing patterns can help to overcome the effects of shadowing that may occur with some targets, provided the travel speed does not exceed the speed of the droplets leaving the nozzle.

As with any claim that is made about things that will improve efficacy, look at the evidence provided and consider the source of the data. For example, a herbicide manufacturer that recommends a particular type of nozzle for a specific product will normally have good efficacy data to support that recommendation.

Generally, nozzles will provide better efficacy at slower spraying speeds or with increased application volumes. Decide how relevant the application parameters used in a trial are compared to how they will operate in your commercial practice, especially when it comes to speed and application volume.

6. Droplet density (mass)

Droplet density affects droplet mass, which then influences the rate of droplet sedimentation. When mass is combined with droplet velocity it can also affect the energy of the droplet at impact and the ability of the droplet to be retained on the target.

Increased specific gravity (weight per unit volume of the spray solution) increases droplet density, which can then increase the rate of sedimentation and the energy at impact.

This can result in reduced drift and can also lead to reduced retention of larger droplets, depending on the properties of the formulation and the characteristics of the leaf surface.

Go to Module 8: Calibration of the spray system

Droplet density can also be reduced with some formulation types (for example, crop oils) or may be reduced when air is included in the droplet. Reduced droplet density leads to a reduced rate of sedimentation and can lessen the energy at impact. This potentially improves retention – but an increased risk of spray drift is the trade-off.

7. The process of making droplets using hydraulic pressure

There are several ways to convert spray solution into droplets. For broadacre applications, the most common method is to force liquid under hydraulic pressure through an orifice (opening) or onto a deflector plate (anvil) to produce a fan-shaped pattern.

Broadacre spray applicators tend to use hydraulic nozzles to produce fan-shaped spray patterns.

The most common pattern is the tapered fan used on booms to achieve a uniform overlap. However, it is possible to get nozzles that produce an even fan pattern, often utilised for applying bands, under shielded sprayers or on target-selectable sprayers such as the WeedSeeker®.

Figure 6 Tapered pattern (left) vs even pattern (right).

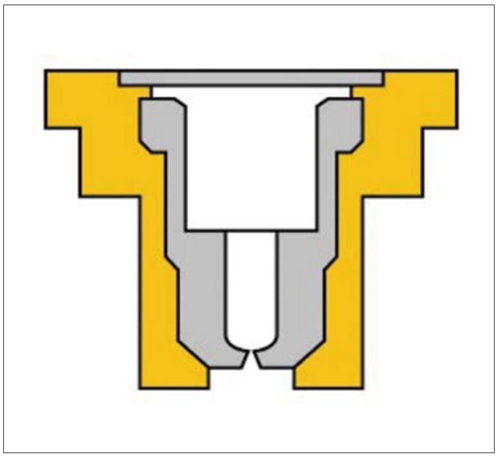
Source: Teejet®

Tapered patterns are designed for use on booms where the nozzle spray patterns are overlapped. Even fans are designed for band spraying where the nozzle patterns do not overlap.

To assess the impact of nozzle design and other parameters on the nozzle output, it is useful to consider how a standard flat-fan nozzle or an extended range flat-fan nozzle (which contains a single orifice at the exit) works compared with other nozzle designs.

8. Standard or extended range flat fans

Figure 7 Cross-section of an extended range nozzle.

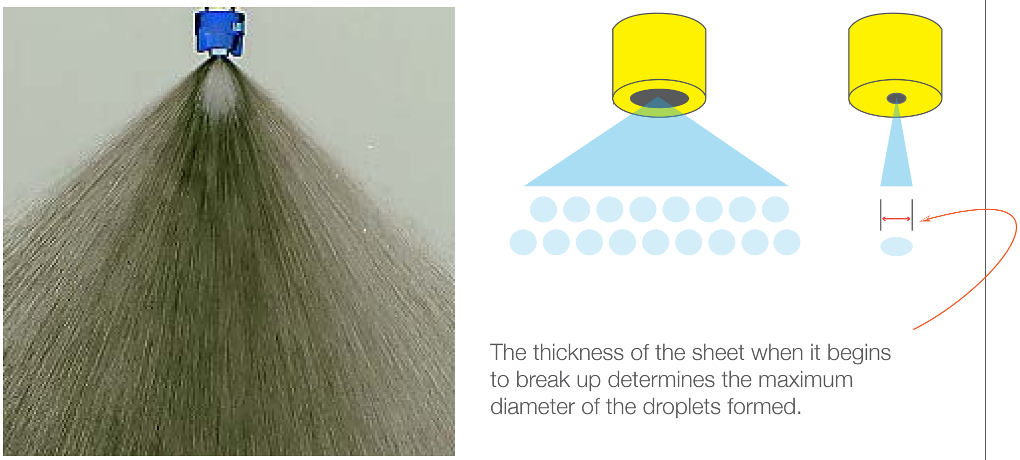


Source: Teejet®

Standard flat fans or extended range flat-fan nozzles contain a single orifice that controls flow rate and determines the spray pattern.

As the spray solution leaves the orifice it forms a sheet. Droplets are formed when that sheet becomes unstable and breaks apart. Several things affect how the sheet is formed and how and when it begins to break up.

Figure 8 Sheet break-up into droplets from a flat-fan nozzle.



Source: F.R.I New Zealand

8.1 Thickness of the sheet at break-up influences droplet size

The thickness of the sheet helps to determine the size (diameter) of the droplets produced. The thicker the sheet is when it begins to break up, the larger the diameter of the droplets produced.

8.2 Orifice size and shape (angle of the pattern)

At equivalent pressures, single orifice nozzles, such as the standard and extended range flat-fan nozzles, with larger orifice sizes tend to produce thicker sheets, which result in larger droplets than the same nozzle type with smaller orifice sizes.

The shape of the orifice or fan angle can affect droplet size. Compare two extended range flat-fan nozzles with the same orifice size (02): at the same operating pressure, one produces an 80-degree pattern and the other produces a 110-degree pattern. The orifice shape can change to produce different fan angles – the 110-degree nozzle will have a longer and thinner shaped orifice than the 80-degree nozzle.

Figure 9 Different orifice shape of two different fan angles of the same size.

Source: Bill Gordon

At equivalent pressures, a 110-degree nozzle will typically produce a thinner sheet and smaller droplets than an 80-degree nozzle.

There are additional things to consider if you are using a narrower fan angle.

- **Narrower fan angles tend to increase droplet velocity. This means that the droplets can impact on the target at higher speed. This can affect droplet retention (better for small droplets, but possibly worse for large droplets).**
- **Narrower fan angles generally require narrower nozzle spacing or an increased release height to achieve suitable overlaps of the pattern.**
- **Narrower fan angles tend to become blocked less than wider fan angles due to the shape of the exit orifice.**
- **Narrower fan angles tend to allow more air movement between spray patterns across the boom, which can reduce the escape of small droplets (detrainment) from the spray pattern. This has the potential to reduce spray drift.**

8.3 Impact of operating pressure on droplet size

When pressure at the nozzle is reduced, the angle of the spray pattern tends to collapse; this normally causes the sheet to become thicker when it breaks apart and droplet size increases.

As the pressure at the nozzle is increased, the fan pattern tends to open up and the angle of the spray pattern widens; this causes the sheet to become thinner when it breaks. For many nozzles this is particularly noticeable on the edges of the sheet.

Summary of standard or extended range flat-fan nozzles

- **Increased pressure reduces droplet size**
- **Wider fan angles reduce droplet size**
- **Reducing surface tension (through surfactants) reduces droplet size**
- **Smaller orifice sizes reduce droplet size**
- **Droplet velocity is relatively high – there is potential for poor retention of large droplets**
- **Best for fine to medium spray qualities**

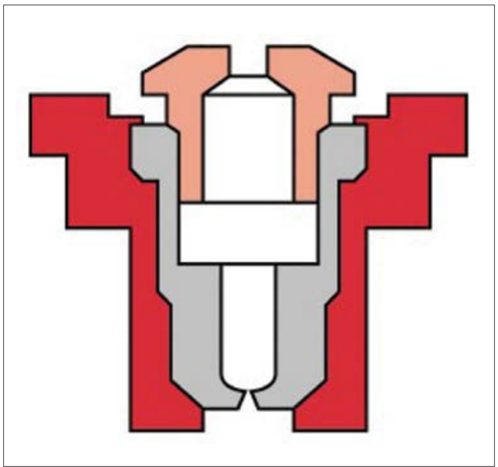
9. Variations on the standard flat-fan nozzle design

9.1 Pre-orifice nozzles

Many pre-orifice nozzles (often referred to as ‘low drift’ nozzles) look similar to standard flat fans, but can be identified by a plug or a plate near the inlet of the nozzle.

As the name suggests these nozzles have a pre-orifice as well as an exit orifice.

Figure 10 Cross-section of a pre-orifice nozzle



Source: Teejet®

Pre-orifice nozzles contain a metering orifice close to the inlet that is used to control flow rate. The exit orifice is used to create the spray pattern.

The exit orifice is usually larger than the metering orifice. This creates a pressure drop within the nozzle so the pressure at the exit of the nozzle will be lower than that in the spray line or at the inlet of the pre-orifice.

The combination of the internal pressure drop and the larger size of the exit orifice cause the sheet to be thicker than equivalently sized standard or extended range flat fans.

Droplet sizes produced by pre-orifice nozzles tend to be larger than standard or extended range flat fans and have lower exit velocities when operated at the same pressure.

Table 5 A comparison of spray quality classifications for TeeJet® XR 110-025 and TeeJet® DG 110-025 nozzle types under ASAE standard S572

TeeJet® XR 110-025	Pressure (bar)	1	2	3	4	5
	Spray quality ASAE S572	M	F	F	F	F
TeeJet® DG 110-025	Pressure (bar)		2	3	4	5
	Spray quality	NA	C	M	M	M

Pre-orifice nozzles such as the DG tend to larger droplets than equivalent sizes XR nozzles.

Larger droplets with lower velocities from a pre-orifice nozzle are more likely to be retained on the surface target than those of a standard or extended range flat-fan nozzle, which create higher droplet velocities.

The internal pressure drop within pre-orifice nozzles means they will generally have a higher minimum pressure requirement than equivalently sized standard flat-fan nozzles. This can have implications for the practical range of application volumes or range of travel speeds that pre-orifice nozzles can be used at compared to extended range flat-fan nozzles. That is unless the pre-orifice nozzle has an equivalent range of flow rates at its operating pressure range.

Pre-orifice nozzles are usually more difficult to block than equivalently sized standard or extended range flat-fan nozzles as the metering orifice is usually round rather than tapered and the exit orifice is normally larger. The only exception may be some pre-orifice nozzles that have more than one metering device or inlet (where each one may be quite small in diameter).

Pre-orifice summary

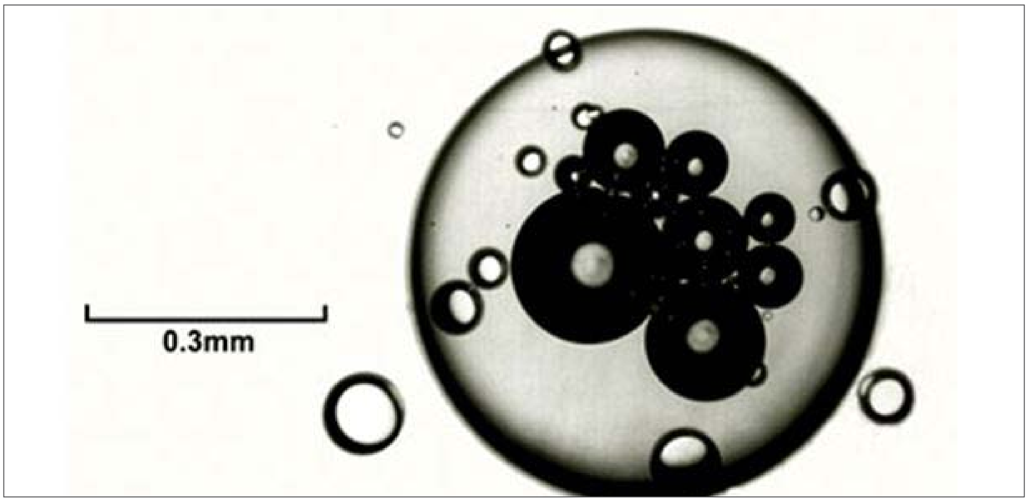
- **Good for medium to coarse spray qualities due the improved retention of slower droplets compared to standard or extended flat-fan nozzles.**
- **Potentially less blockages than standard or extended flat-fan nozzles of the same size and angle.**
- **Higher minimum pressure may reduce speed or volume range compared to extended flat fan nozzles.**

10. Air-induction nozzles

Air-induction nozzles also have a pre-orifice, but in addition to this they also have air intakes after the pre-orifice and a mixing chamber before the exit orifice.

As the liquid passes through the pre-orifice a pressure drop occurs within the nozzle and air can be drawn into the nozzle by the Venturi action. Liquid and air mix, and when the sheet forms it may contain air inclusions (bubbles) that can be present in the droplets after the sheet breaks.

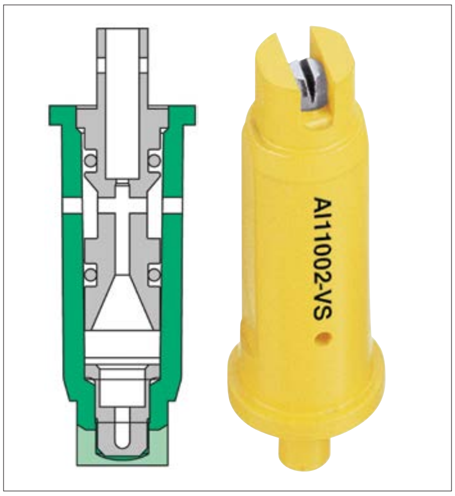
Figure 11 Air inclusions shown within a very coarse to extra coarse droplet



Source: Unkown

The pressure required to efficiently operate an air-induction nozzle depends on the size of the exit orifice relative to the size of the pre-orifice. Nozzles with a large difference in size between the pre-orifice and exit orifice, and large mixing chambers, will generally require higher pressures to operate and generate the Venturi.

10.1 High-pressure air-induction nozzles



Source: Teejet®

Figure 12 High-pressure air-induction nozzle (right) and cross-section diagram (left).

High-pressure air-induction nozzles are generally larger in appearance, have larger mixing chambers and typically have a greater increase in size between the pre-orifice and exit orifice. High-pressure air-induction nozzles usually require a minimum pressure of 3.0 to 4.0 bar for the Venturi to work effectively.

TIP

High-pressure air-induction nozzles are designed to operate at pressures up to 8.0 bar.

10.2 Low-pressure air-induction nozzles

Source: Teejet®

Figure 13 A low-pressure air-induction nozzle.

Low-pressure air-induction nozzles normally appear to be more compact than their high-pressure counterparts. Low-pressure air-induction nozzles tend to have smaller mixing chambers and a smaller difference in size between the pre-orifice and the exit orifice. Low-pressure air-induction nozzles usually require minimum pressures above 2.0 to 3.0 bar to get the Venturi to work effectively.

10.3 Ratio between pre-orifice and exit orifice sizes in air-induction nozzles

The ratio between the size of the pre-orifice and the size of the exit orifice is usually kept fairly constant across the range of nozzle sizes produced by each nozzle manufacturer. This means that as you move to larger nozzle sizes the spray quality generally becomes progressively coarser.

However, some manufacturers change this ratio for different size nozzles. In these instances, the spray quality of a larger nozzle may be finer than the spray quality of a smaller nozzle from the same range.

Table 6 A comparison of spray quality classifications for Agrotop Airmix® 110-015 and Agrotop Airmix® 110-02 nozzle types under ASAE standard S572

Agrotop Airmix® 110-015	Pressure (bar)	2	3	4	5	6
	Spray quality ASAE S572	XC	C	C	C	M
Agrotop Airmix® 110-02	Pressure (bar)	2	3	4	5	6
	Spray quality	C	C	M	M	M

10.4 High surfactant loading and air-induction nozzles

There can be an increase in the amount of air inclusion within the droplets produced where surface tension is decreased (with the addition of wetters and spreaders) and where operating pressure is relatively high.

Increased air inclusion can lead to lower droplet density, which can result in lower sedimentation velocities and lower energy at impact. This can increase the retention of large droplets; however, in smaller droplets it may lead to greater drift potential. Smaller droplets that have high levels of air inclusion will take longer to settle to the ground compared with droplets without air inclusion (‘solid droplets’).

Where surface tension is increased (through the addition of some oil-based products) and the operating pressure is relatively low, air inclusion can be reduced or completely absent from the droplets produced by an air-induction nozzle. This lack of air inclusion, combined with the effect of the oil causing the sheet to be thicker at break-up, means that the resulting droplets may be too large for some spray jobs.

For more information go to Module 10: Weather monitoring for spray applications

TIP

If you are considering using air-induction nozzles for oil-based products (or products that require the addition of an oil-based adjuvant) try to avoid very coarse or larger spray qualities, particularly on small vertical targets. Where the label or tank-mix requires a coarse spray quality aim to operate at the lower end of the coarse spectrum (towards the medium spectrum). When targeting small grasses be aware that lower speeds could result in the minimum pressure at the nozzle causing the spray quality to become too coarse.

Summary of air-induction nozzles

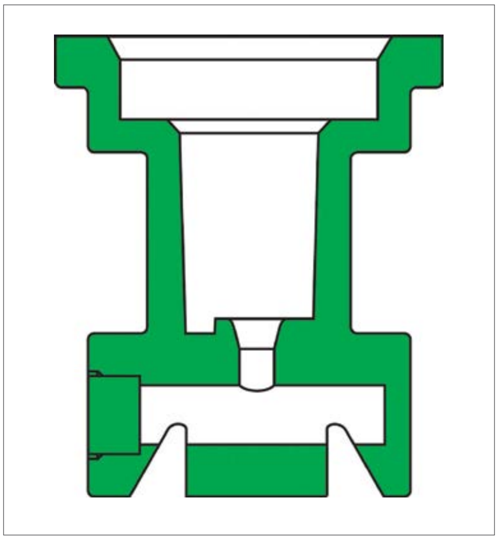
- **Always check what spray quality the nozzle produces at various pressures before you make a purchase.**
- **Formulation or adjuvant may affect air inclusion in the droplets.**
- **Check what minimum pressure is required to run the nozzle effectively on your machine, particularly with different tank mixes.**
- **Good for using coarse spray qualities and larger (depending on the target).**
- **Medium droplets with high levels of air inclusion may drift more than medium droplets from some extended range or ‘low drift’ nozzles.**
- **Check the spray angle – it is not uncommon for an air-induction nozzle to spray at a narrower angle than the nominated spray angle.**

11. Anvil and hybrid anvil nozzles

Anvil nozzles use a deflector or plate rather than an exit orifice to produce a spray pattern.

There are several variations of this nozzle type.

Anvil nozzles use a pre-orifice to control the flow rate and deflectors and make the spray pattern. Examples of anvil nozzles include TeeJet®'s Turbo FloodJet®, Turbo TeeJet® (TT), and Turbo TwinJet (TTJ60).



Source: Bill Gordon

Figure 14 Cross-section of a twin-jet with anvil deflectors.

There are also hybrid anvil nozzles that include air-induction, such as the Turbo TeeJet® Induction (TTI) and the Air-induction Turbo TwinJet (AITTJ60) that draw air into the nozzle by Venturi.

Source: Teejet®

Figure 15 A hybrid air-induction Turbo TeeJet® Induction (TTI1100015) nozzle.

Other hybrid versions have air forced into them via a compressor, such as the nozzles fitted to several twin-fluid sprayers, including Airtec, Agrifac, Optispray® and Airmatic.

11.1 Key differences between anvil nozzles and orifice nozzles

Anvil nozzles tend to produce wider fan angles than standard flat-fan nozzles.

Pre-orifice versions tend to have lower droplet velocities than equivalently sized standard flat fans. Spray quality at a given pressure appears to be less affected by changes in formulation than nozzles that use an exit orifice to produce the spray pattern.

The pre-orifice versions tend to reduce droplet size quite rapidly as the pressure to the nozzle is increased, so they usually have a lower range of operating pressures to maintain the desired spray quality. This makes them quite useful for manual pressure systems, but can be limiting when running an automatic rate controller.

The hybrid air-inducted versions tend to produce very large droplets over their entire pressure range.

Pre-orifice and the hybrid air-induction versions are useful for coarse to medium spray qualities.

TIP

Most anvil nozzles have an offset pattern. Rather than directing the pattern towards the ground, the pattern is typically offset by 10 to 15 degrees from the vertical. If using anvil nozzles to apply medium or fine spray qualities, align the nozzles on the boom so that the offset patterns are facing in the same direction as the direction you are travelling. Forward-facing pattern alignments result in more spray arriving at the target and less spray remaining airborne compared with backward-facing pattern alignments.

12. Fenceline nozzles and offset nozzles

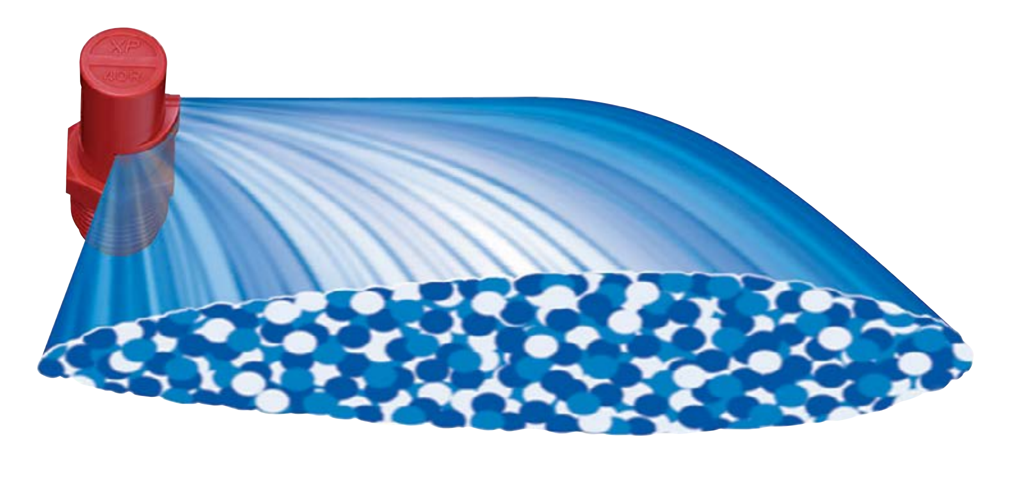
See Module 8: Calibration of the spray system

It is possible to get nozzles that produce an offset pattern, or produce half a full pattern, to give a sharp cut-off at the ends of the spray pattern to minimise overlap. Often these are best suited to ends of the boom in row crop situations where the nozzle spacing and boom width don't match other implements. These generally require good GPS accuracy. As with other nozzles they must produce an appropriate spray quality for the job

Weed control along fencelines is critically important to prevent green bridges acting as a source of weed seed and a potential host for pests and disease. Standard boom set-ups usually do not allow the spray operator to spray the fencelines without risking boom strikes.

See Module 11: Pumps, plumbing and components

Figure 16 The XP Boomjet® Boomless pattern is often used at fencelines



Source: Teejet®

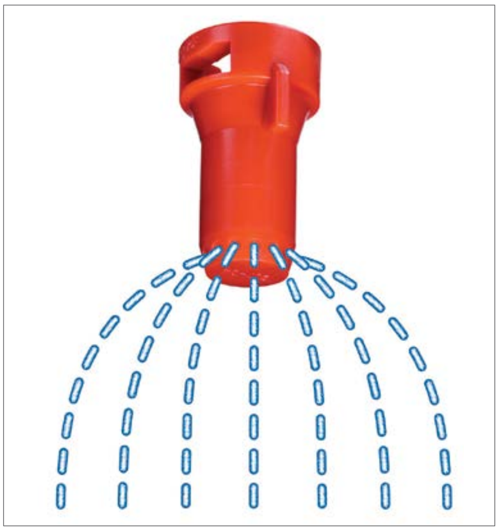
Fenceline nozzles have a wide offset pattern that may extend for up to 4 or 5 metres, helping operators to avoid travelling too close to obstacles. The orifice size for some may be listed as 01, but because of the width of the spray pattern the flow rate is usually 10 times greater than a standard 01 orifice and the spray quality is usually very coarse or extremely coarse.

Careful consideration of plumbing and calibration is required to set up fenceline nozzles.

13. Streaming nozzles

The application of some liquid fertilisers directly onto your crop canopy as spray droplets can cause damage (phytotoxicity); a stream of liquid directly onto the soil may be preferred in these instances.

Figure 17 Liquid fertilisers are often applied with streaming nozzles.



Source: Teejet®

There are several streaming nozzles available that can produce single or multiple streams in a variety of spray widths. As with other hydraulic nozzles streaming nozzles come in a range of sizes to achieve different flow rates at a range of pressures.

Resources

- GRDC Back Pocket Guide: Nozzle selection for boom, band and shielded spraying
- A3 nozzle selection chart
- TeeJet® nozzle selection app

More information

- Module 14: Boom stability and height control
- Module 17: Pulse-width modulation systems
- Module 18: Single line and multi-step systems
- Module 20: Target-selectable sprayers
- Module 21: Assessing spray deposits

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 4 Drift management strategies Minimising and managing spray drift risk

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