

Spray Application: grapevines

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Spray application is a critical activity for grape and wine businesses – spanning the issues of food safety, environmental stewardship, community welfare and profitability.

Efficient spray application requires equipment that is matched to the grapevine target, an appropriate dose of agrochemical and minimal loss of spray to the ground or to drift. The efficacy of spray application depends on various elements including:

- Sprayer type
- Nozzle type and sprayer set-up
- Tank mix and adjuvants
- Sprayer technologies
- Buffer vegetation
- Weather conditions

Sprayer Type

A wide range of spraying units are available in Australia. Some of the main types include:

- Airblast sprayers (axial fan type)
- Directed air duct sprayers
- Multihead axial fan sprayers
- Cross-flow fan sprayers
- Air-shear sprayers
- Tunnel and recycle sprayers



Angle row airblast sprayer with large rear axial fan.

Photo: J.Kitt

Airblast sprayers (axial fan): Airblast sprayers use an axial fan to generate a large volume of air that is forced towards the canopy in a circular pattern.

Single-row airblast sprayers are more common than multi-row airblast sprayers and are limited to treating the canopy on either side of the mid-row (requiring travel up every row).

Airblast sprayers produce a large air volume and there is a greater risk of spray drift if the spray trajectory is above the height of the canopy.

Air velocity should also be considered when spraying small canopies with airblast sprayers. If the velocity is too high, inadequate coverage may result. To avoid this, fan speed can be reduced, the pitch of the blades changed, the travel speed increased or the air intake reduced (e.g. by installing a 'donut' baffle).

Multi-head (axial) fan sprayer: Multihead fan sprayers require far less power to move significant volumes of air (as air is pushed directly through the fan). In addition, the use of multiple small axial fans with hydraulic, electric or cable drive systems allows treatment of multiple rows in a single pass.



Multi-head sprayer with axial fan.

Photo: J.Kitt

Cross-flow fan sprayers: These sprayers usually feature a vertical fan that produces a curtain of air that is blown horizontally toward the canopy. The fan type reduces the chance of spray being directed over the height of the canopy, reducing drift risk. This sprayer type is well-suited to thin wall VSP canopies, but may not produce sufficient air volume for large or dense sprawl canopies.

The sprayer types mentioned above all use hydraulic pressure to force spray mix through nozzles to generate droplets and air is used to assist delivery to the grapevine, usually at speeds between 20-30 m/s (at the nozzle).

Air shear sprayers: Air shear sprayers use very high velocity air (>90m/s) to break a low-volume spray liquid stream into fine or very fine spray droplets. Air shear sprayers are usually considered to produce high speed air at low volumes, in contrast to the other sprayers described which produce a higher volume of low speed air.

Air shear sprayers require significant torque to create the high velocity air and, due to the power required, the volume of spray liquid that can be efficiently broken into fine spray droplets is limited. As a result, these sprayers usually perform best when used to deliver low volume concentrate spray applications. Air shear sprayers can be calibrated to deliver high volume sprays although coverage performance will often be compromised by the formation of large droplets at high volumes.

Tunnel and recycle sprayers: These sprayers straddle the vine row and use shrouds to capture excess spray (see 'sprayer technologies'). Simple and inexpensive tunnel sprayers can be built using a set of non-air assisted nozzles although most commercially available units feature some kind of air assistance.

Nozzle type + sprayer setup

There are several key considerations for sprayer unit selection and optimised coverage. These include:

- nozzle types and positions/angles
- air speed and volume output
- air direction
- special features e.g: on-board weather read-out, sonic sensors.

Nozzles: With a few exceptions, such as air shear equipment, spray units utilise high pressures (6 to 25 bar) through small orifice cone nozzles (e.g: disc-core, hollow cone or full cone designs) to create 'fine' (~100-150 µm) and 'very fine' (<100 µm) droplets. This can provide excellent coverage on leaves and bunches, however, the smaller, lighter nature of 'very fine' droplets makes them highly susceptible to drift.



Various nozzles used in spraying viticulture.

When spraying in windy conditions or near sensitive areas, larger droplets (>250 µm) are preferred to reduce the risk of off-target drift. The use of air induction (AI) nozzles, which produce large spray droplets (typically 300-600µm), can mitigate spray loss in these situations.

1 µm = microns and is the usual unit for measurement of droplet diameters.
1mm = 1000 µm.

AI nozzles produce droplets containing small air bubbles which reduce the mass of the droplets and assists with coverage (compared to droplets of the same size produced by other nozzles). Despite the advantages of AI nozzles in avoiding drift, the increase of spray droplet size will almost always compromise spray retention and coverage (compared to application of finer droplets).

Table 1: Classification scheme for nozzles used in agricultural spraying in accordance with (ASABE) s572 (American society of agricultural and biological engineers). (Formerly known as ASAE s572).

Classification Category	Symbol	Color Code	Approximate VMD
Very Fine	VF	Red	<100
Fine	F	Orange	100-175
Medium	M	Yellow	175-250
Coarse	C	Blue	250-375
Very Coarse	VC	Green	375-450
Extremely Coarse	KC	White	>450

Air speed and volume: Most spray units utilise air to transport spray from the nozzle to the vine canopy. The speed, volume and angle of air are critical in the effectiveness of spray deposition:

- When air speed and volume are inadequate, only outer leaves will be sprayed
- With sufficient air speed and volume, all leaf surfaces will receive adequate coverage and spray will penetrate the canopy
- As excess air speed and volume can push spray through or around the canopy and past the target. This results in poor coverage, wasted chemical and high drift risk. Excessive air can cause outer leaves to "shingle" together and close off the inner canopy from spray deposits.

Best practice spray application involves ensuring air volume and speed are matched to canopy size to achieve most efficient spray deposition without overspray or drift.

Air direction: Direction of air is an important factor for effective spray deposition. If air is poorly directed, especially over the height of the canopy, spray loss to ground or aerial drift is likely.

Tank mix and adjuvants

The combined ingredients of agrochemicals in the spray mixture affect droplet formation, physical properties (droplet bounce, spread or sticking), evaporation rates and the efficacy of active ingredient of each product.

Adjuvants are used to influence properties of the spray solution and improve the performance of active ingredient on the grapevine. There are many different types of adjuvants which include surfactants, emulsifiers, oils, salts and buffers. They will perform one or a range of functions including increasing droplet size, spread or adherence and some influence water quality. Most agrochemicals have an adjuvant premixed with the active ingredient - check the label for instructions on adjuvant addition.

Grape bunches present an application target that is more repellent to wetting from spray droplets than grape leaves; there is a challenge to maximize droplet adhesion and coverage on bunches at all growth stages. In general, a spray mixture that is optimised for bunch coverage will often show full wetting with runoff losses on the upper surfaces of leaves. For a simple test dip a bunch into the spray mixture and observe how the spray liquid behaves on berries. Consider adding an adjuvant if the liquid tends to break and form drip points with little liquid retention on the berry surface.

Sprayer technologies

Several technologies are now available that can facilitate improved spray deposition including:

- sensor systems
- electrostatic sprayers and
- tunnel and recycle sprayers

Sensor systems: Detecting the presence or absence of vine canopy, these systems automatically adjust spray outputs accordingly.

The most common sensor system, the 'electronic eye', detects any gaps between vines and row ends and automatically turns off spray using in-line solenoids. This system is reported to reduce spray application by up to 40% early in the season and in vineyards with uneven growth (e.g. young vines).

Electrostatic sprayers: Using electrostatic energy to 'charge' spray droplets, the 'attraction force' is increased as droplets seek to be 'earthed' in order to neutralise the charge. However, electrostatic sprayers rely on the production of extremely fine droplets, which can drift if they escape from the canopy spraying target. Electrostatic spraying systems have been previously used on winegrapes, however, their reliability is questionable and they are difficult to maintain.

Tunnel and recycle sprayers: This over-row spraying system involves shields that hang on either side of the vine row to capture at least some of the overspray. The main advantage of this system is that ambient wind is less likely to adversely affect spray deposition or cause drift due to the protection of the shrouds. Loss of spray to ground, while not prevented by tunnel sprayers, can be reduced by using recycle sprayers that capture excess spray in collection trays at the base of each shield and pump it back into the tank for reapplication.

Buffer Vegetation

Densely planted trees or shrubs within the vineyard or on property boundaries can form useful barriers to prevent spray drift. The higher the shelter the better, but established vegetation of approximately 1-2m wide and 3m high can capture up to 60-90% of low-level spray drift. Plantings of various tree and shrub species (with differing growth habits), spaced 4-5m apart, with long, thin and rough foliage from the base to the crown are recommended. Selection of variety will vary according to region.

Artificial netting with porosity of 25-60% can also be effective; results indicate that it catches up to 50% of spray drift.

Influence of weather on spraying

Temperature and humidity: High air-temperature and low relative humidity result in high evaporation rates which reduce droplet survival times in the air and on the target. Delta T values provide a guide for droplet survival based on evaporation rates.

As air becomes drier, and Delta T increases, spray droplets evaporate more quickly. If Delta T >8, droplets will evaporate dramatically reducing in size. These very fine droplets may not be able to reach the target effectively, reducing spray efficacy and resulting in a greater risk of spray drift.

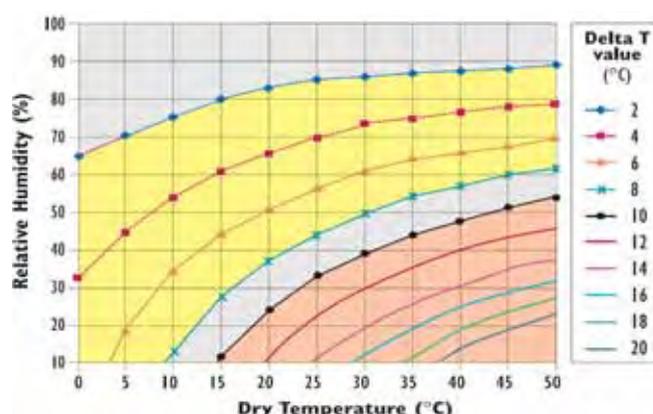


Fig 1: Delta T conditions for spraying.

Source: Nufarm

Options to reduce evaporation rates include:

- spray when Delta T is between 2 and 8
- use a coarser nozzle type to increase the droplet size spectrum
- apply higher water volume to increase droplet coverage and humidity within the canopy
- add a non-volatile adjuvant to slow evaporation of droplets and
- utilise web-based spray decision support tools such as:
 - Bureau of Meteorology: www.bom.gov.au
 - SILO climate database: <http://www.longpaddock.qld.gov.au/silo>
 - Spraywise: www.spraywisecisions.com.au

Surface temperature inversion: Surface temperature inversion can have a significant impact on the efficacy of spraying and spray drift.

Under normal conditions (ie where air is unstable near the ground) airborne droplets tend to rise and disperse in the atmosphere. Where there is surface temperature inversion, (ie the atmosphere is very stable near the ground) the airborne droplets can be 'trapped'. When this occurs, droplets may float away from the target resulting in unexpected drift.

For more information on surface temperature inversion visit:

<http://www.bom.gov.au/info/leaflets/Pesticide-Spraying.pdf>

http://www.grdc.com.au/uploads/documents/GRDC_FS_Spray%20drift%0temp%29inversions1.pdf

Wind: Spraying should usually be done where wind speeds are between 3 and 15 km/h.

At wind speeds below 3 km/h there may be a local surface temperature inversion (see previous). In these conditions, it is recommended that spraying not be conducted (unless there is continuous heavy cloud cover) and, consequently, a low risk of a surface temperature inversion.

Wind speeds of above 15 km/h can result in high loss of spray from the target area and should be avoided. For more information, download the free 'weather essentials for pesticide application' fact sheet from www.grdc.com.au/Resources/Bookshop/2012/02/Weather-essentials-for-pesticide-application

Spray volumes and chemical application rates

Historically, spray volumes and chemical rates were based on 'per hectare' calculations but these did not take into account the variations in vine canopy height, density and row spacing. Best practice spray calibration is use of 'litres per 100 metres per row per metre of canopy height' (L/100m/m). The volume is calculated by:

- measuring 100m of vine row
- measuring the height of canopy and
- height of the band of spray emitted by the sprayer

"Per row" means spraying the one row from both sides or spraying sides of two rows from the mid-row.

The 'point of first run-off' for grapevines is between 20 – 30 L/100m/m.

This range allows for adjustments according to canopy size. With sparse canopies a lower figure is used, for larger, dense canopies a higher figure is used.

The point of first runoff can be calculated as follows:

Litres per 100m – Litres/100m/m of canopy height x canopy height (m)

For dilute sprayer calibrations:

1. Add up the output of all nozzles for 2-sided spraying at the output pressure to be used (charts are available to read off the L/100m based on the total flow rate of your nozzles per row and your travel speed.)
2. Ensure that the L/100m delivered by your sprayer matches, or slightly exceeds the L/100m for the point of first run-off for your vineyard.

For concentrate spraying calibrations:

1. Add up the output of all nozzles for 2-sided spraying at the output pressure to be used. Look up from the chart the L/100m delivered by your sprayer as for dilute spraying.
2. Calculate the concentration factor (CF) where
 $CF = L/100m \text{ for the point of first run-off divided by the L/100m applied by the sprayer}$
3. Then calculate the amount of chemical to put into the tank:
 $Tank \text{ concentration (amount per 100L) = Label rate (amount per 100L for dilute application) } \times CF$

Spray deposition assessment

Assessment of spray deposition is a critical component of spray application and should be done on various trellis types and canopy sizes to ensure adequate spray coverage. Spray deposition can be assessed using the following tools:

Assessment method	Advantages	Disadvantages
Water-sensitive papers	Easy to use Good indication of spray droplet size range Excellent to use during sprayer setup Provides a record of sprayer output	Does not show very fine droplets Does not show droplet spread and coverage potential (adjuvant effects)
Kaolin clay	Easy to observe Shows spreading and coverage on all plant surfaces Excellent to use during sprayer setup	Messy to use Needs to be dry to be visible (Check with winery before use)
Fluorescent dye	Shows spreading and coverage on all plant surfaces Identifies off-target spray losses Shows spray deposits even at very low deposition level	Need UV light to assess Can only observe in very low light or dark conditions Assessment can be difficult

Other calibration tools include 'spot-on' sprayer calibrator and freeware on coverage assessments at www.remssp.com/Stainalysis/

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Best Practice Spray Application

Despite the large number of variables and decisions that need to be made, spraying is simple. There are four basic rules to sprayer setup and spray optimisation:

Direct the spray output towards the target canopy

Ensure adequate spray hits the target canopy.

Assess by observing the spraying in operation and adjust nozzle output and air volume and speed to hit the target.

Adjust your agrochemical application rate to match different target canopies

To achieve the same chemical dose, large canopies and/or close row spacings need higher application rates than smaller canopies and/or wider row spacings.

A simple row-length based sprayer calibration system can be used to make these adjustments.

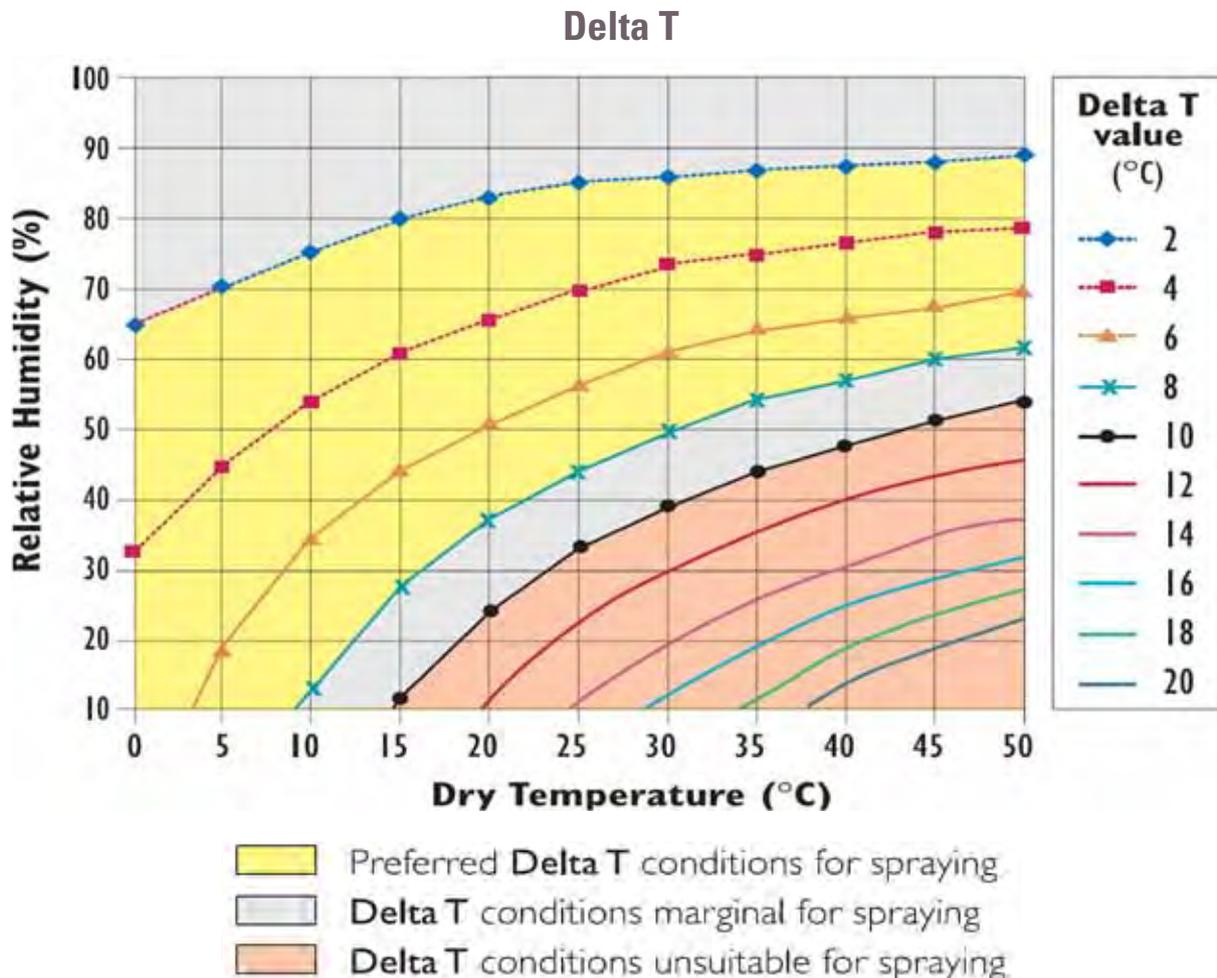
Achieve coverage of the spraying target

Altering sprayer output for the target canopy significantly improves coverage. Simple coverage-monitoring tools include water sensitive papers or tracers such as kaolin clay.

Watch the weather

Keep an eye on the weather forecast. On the day of spraying, record relevant weather conditions over the period of spray application. Consider Delta T and surface temperature inversions.

Conditions for spraying



Surface temperature inversion

Visual clues

A surface temperature inversion is likely to be present if:

- mist, fog or dew are present or a frost have occurred
- smoke or dust hangs in the air and moves sideways, just above the surface and
- cumulus clouds that have built up during the day collapse towards evening.

Other clues

A surface temperature inversion is likely to be present if:

- wind speed is constantly less than 11km/h in the evening and overnight
- cool, off-slope breezes develop during the evening or overnight
- distant sounds become clearer and easier to hear and
- aromas become more distinct during the evening than during the day.

Extract taken from "Surface temperature inversions & spraying." (2011) Reproduced with kind permission of GRDC.