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Spray Application

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Australian Government
Grape and Wine Research and Development Corporation

Introduction

Research and education in spray application, in Australia and overseas, has shifted during the last 20 years from being focussed on issues of efficiency (more effective deposition, finer spray quality, better sprayer set up, multi-row sprayers) to focussing now on risk minimisation. In Europe, UK, USA and elsewhere, the recent research, technological advances and policy discussions have been directed in particular at minimising spray drift.

In Australia, the Australian Pesticides and Veterinary Medicines Authority (APVMA) manage the registration of pesticides, and make sure that wording on each product label is appropriate to ensure that the use of each pesticide poses minimum risk of off-target damage, to people, markets or the environment. Changes internationally have put the APVMA under pressure to similarly address the issue of spray drift.

In July 2008 the APVMA published new ***Operating Principles In Relation To Spray Drift Risk***. They subsequently announced a review process that is leading to new chemical labels.

While the focus on drift risk minimisation has driven innovations in nozzles and spray technology, the major implication is that chemical users now have greater responsibilities to minimize spray drift risk.

New chemical labels will include new restraints and mandatory no spray zones

Two new headings may appear under the DIRECTIONS FOR USE section of a chemical label.

SPRAY DRIFT RESTRAINTS include **'DO NOT ...'** statements, and also prescribe some conditions of use (nozzles, record keeping, weather conditions).

MANDATORY NO-SPRAY ZONES are buffer zones imposed to protect human health, the environment or international trade. The widths required for Mandatory No-Spray Zones will vary between products from zero to over 200 metres, according to the risks associated with each product formulation.

If the restraints or mandatory no-spray zone on a label seems impractical, then growers need to select a different product with a narrower no-spray zone or more suitable restraints.

Restraints to prevent build up of persistent chemicals

Labels may limit the number of times you can use a product per year, or impose a minimum time interval between applications. This is to protect the environment or protect people from risks associated with residue persistence or repeat exposures.

Restraints related to stage of crop development

'DO NOT ... ' restraints on labels may limit the crop size or developmental stages that can be sprayed. During dormancy or early in the season it may be inappropriate to spray a particular product using a fine atomizing nozzle or with the fan on, due to the high drift risk when there is no canopy (or only sparse canopy) to capture fine droplets of spray. The risk of drift decreases as the canopy grows.

Restraints on spray machinery

The **APVMA** have clear expectations of vineyard spraying operations:

- Spray must be directed sideways into the vines or, with tunnel-type equipment, sideways and down into the vines.
- Spray must be directed into the foliage and not above or below the canopy where there is no foliage to intercept the spray.
- Shut-off controls may be required on air-blast sprayers.
- Minimum application volumes may be required.
- Use of shielded booms and drift-reduction agents may be required.

Spray release height (height of the nozzle above the canopy) is a major factor affecting spray drift risk: the higher the release height, the greater the potential for off-target drift. At this stage however the APVMA will not specify release heights for vineyard spraying on labels, in most cases.

Restraints on weather conditions during spraying

Wind speed & wind direction

An increase in wind speed from 1-7 km/hr doubles the proportion of drift landing 500m downwind. The APVMA has begun to include restrictions on product labels prescribing wind speed permitted during spraying. Labels may also stipulate how wind speed is recorded.

Kestrel anemometer
Source: KestrelWeather.com.au

Temperature & Humidity

Drift risk increases as temperature increases. Drift risk decreases as relative humidity increases. Delta T (△T) is a measure that captures

the combined effects of temperature and humidity, and indicates whether conditions are suitable for spraying. As air becomes drier (and △T increases), moisture evaporates more quickly. If △T > 8, droplets will evaporate too quickly to reach the target effectively.
Options to reduce evaporation rates include:

- Spray when Delta T is between 2 and 8.
- Increase the droplet size spectrum using a coarser nozzle.
- Apply a greater water volume to increase droplet coverage and humidity within the canopy.
- Add a non-volatile adjuvant to slow evaporation of droplets.
- Decision support is available to help growers assess weather conditions before spraying, from the Bureau of Meteorology, SILO and other web sources by subscription.

Interaction between temperature and humidity – 'Delta T'

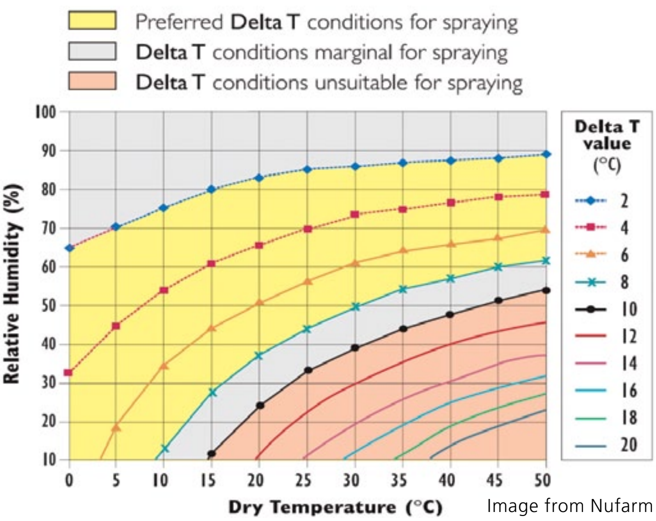
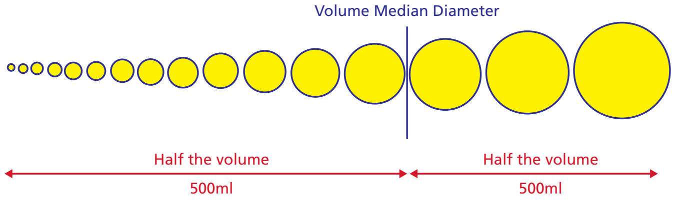


Image from Nufarm

Restraints on nozzles, to reduce the risk of drift.

The diameter of a droplet is expressed in microns (μm). One micron is equivalent to 0.001 mm.

Droplet size is the most important single factor in spray drift risk. Fine droplets have greater potential for drifting off-target than large, higher mass droplets. As droplet size increases from 100μm to 400μm, the proportion of drift landing 500 metres downwind is reduced from around 4% to almost zero.



Source: GWRDC

Every nozzle actually produces a range of droplet sizes, so nozzles are classified according to the spectra (range of droplet sizes) they produce. Two nozzle classifications systems are used internationally (British Crop Protection Council classification and the US Standard ASABE 572.1).
In both systems, the names of the nozzle categories ('fine/medium/coarse) describe the Volume Median Diameter (VMD) of the spray plume produced by a nozzle (half of the spray volume produced by a nozzle exists in droplets with diameters equal to or smaller than the VMD, and half the volume exists in droplets with diameters larger than the VMD).

Spray plumes used in canopy spraying in viticulture typically have VMDs in the range 100μm - 250μm, which is a size range at risk of drifting. Whether that poses any threat to the environment depends on the toxicity of the droplets; a separate important consideration in assessing overall risk.

New labels may recommend using a nozzle with a larger VMD than has been used previously in vineyard spraying. While coarser nozzles will reduce the risk of drift, they will also reduce the spray coverage in the canopy. To minimise drift risk but maintain efficacy, growers might consider an alternative product that does not require use of a coarse nozzle.

New product labels may include detail about the type of nozzle that growers must use to apply that product. This is to ensure that droplets are not too fine.

> A product requiring a particular range of droplet sizes will have a DO NOT … statement to specify nozzle size.

The APVMA base their drift risk assessment for each product on the nozzle size stipulated on the label. However they recognize that the VMD actually tells us nothing about the proportion of fine, driftable droplets that will be produced in a spray plume. A new international ISO standard for spray droplet sizes is being developed to replace the BCPC and ASAE standards. The new ISO standard will classify nozzles according to the proportion of spray plume that is in fine droplets, not according to VMD. In this respect, the new

ISO standards will be a better guide to drift risk, and will be adopted by the APVMA.

Changes to chemical registrations in 2010, and more changes to come

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has an ongoing program to review registered chemicals if there are concerns about their use or safety. Twenty-four chemicals of relevance to viticulture are currently under review, or are pending review, under the program. Five chemicals have already undergone review. Four active ingredients previously used in viticulture have had all uses removed from grapes as a consequence of the review process. Nine active ingredients have also been nominated for review under an APVMA priority list for Spray Drift Label Reviews.

The 2010-2011 list of Registered Agrochemicals produced by the AWRI includes some new products while some old products have been removed. Growers should refer to the current AWRI 'Dog Book' for the current list.

Spray additives (spreaders, stickers, penetrants, drift retardants)

Tank mixing can change the physical and chemical properties of a spray solution, with significant effects on atomization and droplet evaporation, for example the spray quality from a nozzle may change from medium to coarse due to tank mixing and the influence of a particular formulation. When a new product is registered, the APVMA now require data showing how the product formulation will atomize through different nozzles, and the chemical industry has been funding research to explore this relationship. Of all the adjuvants currently registered by the APVMA more than 25% claim that they will slow evaporation. These are oil-based products. They are non-volatile materials that impose a minimum mass on each droplet, and as the droplet shrinks the non-volatile material slows any further evaporation. If droplets can settle before they evaporate to a driftable size, drift risk is reduced. Note that the APVMA cautions chemical users against relying on products advertised as 'drift retardants', to achieve the correct droplet spectrum, because there is no consistent data supporting the efficacy of these.

The Entwine program for environmental stewardship

Through the Entwine program, the Australian wine industry promotes use of the Freshcare Environmental Viticulture code of practice. Spraying requirements within Freshcare (Freshcare™ Environmental, June 2009) are not detailed, requiring spray operators merely to follow label requirements. However, good sprayer set-up is implied: if a label requires that no spray is directed above or below the canopy then compliance with the Freshcare Environmental Viticulture code of practice requires that spray operators have configured their equipment appropriately. At minimum growers need to be:

- **Assessing canopy spray requirements.** As the canopy grows, more volume is required to cover foliage. There are several systems for calculating the canopy volume requirement.

- **Monitoring** deposition, using tracers (fluorescent dye, water sensitive papers, particle film technology etc) so that the air volume, air direction and air speed can be adjusted to maximize deposition.

Sprayer designs offer increasing scope for adjustment to air volumes and directions, nozzle type and nozzle direction. Most sprayer manufacturers offer **Controllers** that adjust application rates as forward speed varies, to maintain the dose per 100/m. Several **Crop sensors** appear in mainstream spray catalogues. Crop sensors are designed in most cases to turn nozzles on when there is canopy to intercept the spray but turn the nozzles off again when the sensor detects a gap in the canopy. Other sensors relay more detailed information into models that record and map the crop to make detailed predictions about spray requirements; for example to produce diagrams of canopy density.

Can we maintain or improve efficacy yet reduce drift risk?

Decreasing droplet size increases drift risk, which is bad. However decreasing droplet size also improves coverage, which is good. Each time the diameter of a droplet is halved, the number of available droplets from the equivalent volume increases 8-fold. Wetters that cause droplets to spread will improve coverage of a liquid film across a bunch or leaf surface, but do not overcome the coverage limitations of large droplets.

Advances in nozzle technology to improve efficacy and reduce drift

Above: A) Hollow cone nozzles can have a narrow droplet spectrum.
B) Examples of air induction nozzles, designed to reduce drift yet retain efficacy.

Cone jets remain the main nozzle used for air assisted spraying in viticulture.

Air induction (AI) nozzles attract much interest and have been promoted as an option to reduce drift. They have proven to be effective for boom applications, particularly of herbicides. There is only limited research data showing the effectiveness of AI nozzles in air-assisted sprayers and in orchard or vineyard canopies. Some data is appearing from preliminary research in New Zealand where AI nozzles are being trialed together with adjuvants for use in row crops (kiwifruit and vines). AI nozzles vary in how they atomize the liquid film, but in general, air is drawn by venturi from the side of the nozzle into a chamber within the nozzle where it mixes with the liquid, forming air-entrained droplets as the liquid atomises. The liquid+air mix is expelled from the orifice at low pressure and low speed, creating very coarse droplets that contain air. Depending on the nozzle orifice and pressure, the resultant droplets may vary in size.

Adjuvants will influence the amount of air held within droplets. Surfactants that reduce dynamic surface tension of droplets, to enhance spray coverage in vines, may assist droplets to include air. However, the adjuvant may also increase droplet shatter by a fast airstream.

If large, slow droplets formed by air induction nozzles are then projected into the fast airstream of an air-assisted sprayer, the droplets may shatter, defeating their purpose.

Additives that increase surface tension will reduce shatter from air, but will also reduce droplet adhesion to grape surfaces, reducing efficacy.

Do not use AI nozzles with oily formulations. Instead, use an alternative low drift nozzle eg a TurboTeeJet for herbiciding with an oily formulation or if an oil additive is being used.

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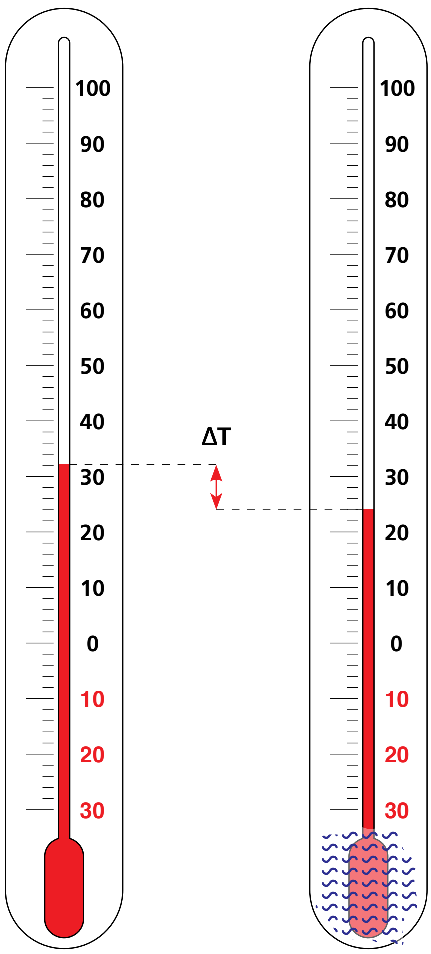
CRC for Viticulture

Interaction between temperature and humidity – 'Delta T'

Dry Bulb Temperature (T_{db}) is not affected by moisture in the air, only by heat in the air



Delta T (ΔT) is the difference between the dry and wet bulb temperatures ($\Delta T = T_{db} - T_{wb}$)

Wet Bulb Temperature (T_{wb}) is indicated by a moistened thermometer bulb exposed to air flow. Evaporation of water has a cooling effect, so a "wet bulb temperature" is lower than the "dry bulb temperature" of the air.

Source: A MacGregor 2010

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