PRINCIPLES OF VINEYARD CANOPY SPRAYING

A general guide and checklist for grape growers

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Introduction
Spraying is one of the most important tasks performed in a vineyard. It involves application of the correct control agents to the correct target, at the correct rate, at the correct time. Many of the control agents used in viticulture are expensive, as are the resulting costs of inadequate control. This information sheet is intended to provide growers with background information to assist with the general concept of canopy spraying. With all types of spray application the target, timing and technique of spraying should be considered.

Target
Is the spray hitting the target? If not and if spray is drifting away from the target, there will not only be waste but potential legal issues with spray drift. The following picture shows an example where much of the applied chemical appears to be missing the intended target.

Any grower applying spray has a duty of care to ensure that chemical does not have any adverse impact away from the spray target.

Some considerations to minimise spray drift include:
• Weather conditions – Avoid spraying during strong winds, or at times when an inversion layer may be present; which is usually in very calm conditions. An inversion layer may cause some volatile chemicals to be deposited off target. It is better to spray in a light breeze than in dead calm conditions.
• Droplet size – Larger droplets will drift less than smaller droplets in liquid state.
• Droplet Type – Air – filled droplets such as those produced by air inductions nozzles tend to drift less;
• Use of adjuvants and drift retardants – This may reduce the surface tension of droplets that hit the target, and reduce the droplet bounce and subsequent drift. Some drift retardants may encourage a more uniform spray pattern, and reduce the number of very fine “escape” droplets that are more prone to drift.

Rate
• Is the amount of spray being applied appropriate to the target and the chemical being used? If inadequate volume or inadequate dose of chemical is applied, control of pests or disease will be compromised. Application of systemic chemicals in very high volumes of water can cause run-off, potential environmental risks, and poor disease control.

Note that the chemical label is a legal document. The instruction on the chemical label must be followed for legal as well as technical reasons.

**Timing**

Is the correct chemical being used to combat the disease or pest at that time? Good timing includes application of control agents when environmental conditions are most favourable, and at times when pest or disease is susceptible to attack. Examples of poor timing include:

- Application of a pre-infection fungicide (e.g., copper or mancozeb) *after* a downy mildew primary infection;
- Application of *Bacillus thuringiensis* insecticide against large light brown apple moth larvae, when they will be too big for effective control.
- Spraying a systemic chemical during hot, dry conditions when the target plant is stressed, and the uptake of the chemical is compromised.

**Evaporation and Delta T**

During periods of low relative humidity and high temperature the spray that is deposited on the leaf of the target plant will evaporate rapidly. This can be addressed with the addition of adjuvants, by selecting nozzles that produce more suitable spray patterns (see further in this article), and it can also be addressed in considering the conditions that are prevalent at the time of spraying. Translaminar and systemic chemicals (e.g., DMI fungicides and nutrient sprays) that rely on absorption into leaf tissue may have their effectiveness compromised if the chemical evaporates too rapidly from the leaf surface before it can be absorbed by the plant.

These conditions can be determined by the delta T (\(\Delta T\)) value. Put simply, \(\Delta T\) is the difference between the wet bulb and dry bulb thermometer readings at that time. Conditions where \(\Delta T\) is between 2 and 8\(^0\)C are considered ideal for spraying. \(\Delta T\) between 8 and 10\(^0\)C is considered marginal; and \(\Delta T\) above 10\(^0\)C is considered poor for spraying. These conditions can be shown in the following chart (below):

CCW has a Delta T calculator on its website where growers can enter the relative humidity and temperature at a particular time, and find out the suitability for conditions of spraying. There may be times when impending weather conditions determine that spraying needs to be done and the conditions may be marginal or poor. If the delta T is known, then some measures such as adjusting the droplet size or adding adjuvants may be justified.

(Chart Courtesy of Nufarm Australia Ltd: [http://www.nufarm.com/AU/Home](http://www.nufarm.com/AU/Home))
**Technique**

Effective canopy spraying usually involves two main facets:
- **Displacing the air within the vine canopy with the chemical – laden air**;
- **Effectively covering the target surfaces with the chemical being applied**.

Often the main focus toward achieving good coverage focuses only the volume of liquid applied. Coverage comprises many interacting factors, including:

- **Water rate**
  - Number of spray jets
  - Size of Jets
  - Pump Pressure

- **Ground Speed**

- **Volume and direction of air carrier stream**
  - Air pressure
  - Air velocity

- **Canopy Density and Configuration**

Coverage with air-assisted canopy sprayers requires **both air penetration and liquid coverage to be maximised**.

**Air Volume**

There are many different types of commercially available vineyard canopy sprayers, with different configurations of fans and spray jets. Some rely on high velocity air at moderate volumes, while others use high volumes of lower velocity air.

There are units that can simultaneously spray multiple rows.

- **Most of these spray plants will do a good job of spraying vines under normal conditions if they are set up and used well.**
- **ALL of these spray plants will do a poor job if they are not well set up, and are used without due care.**

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The critical aspect of application of air volume is for the sprayer to **replace the air within the canopy with chemical – laden air**. In this diagram a single row air blast sprayer is being used so that the chemical laden air is forced through the vine canopy and out the opposite side. This gives a high chance that the majority of surfaces will be covered after application of spray from adjacent rows, when leaf and bunch surfaces are sprayed from the opposite direction. When this type of sprayer is viewed in operation, there should be a small amount of spray penetrating through the canopy to the opposite side, as shown above. This means that sufficient air is moving through the canopy. If this is not occurring it is unlikely that leaf surfaces are being adequately covered.

As the vine canopy grows during the season, more air will be required to carry the spray into a denser canopy. At the start of the season when shoot length is very short, little or no air will be needed to carry the spray chemical to the target. At this stage blowing the canopy with excessive volume or velocity of air may blow most of the spray off target. In calm conditions the first one or two fungicide applications may be applied with the sprayer fan disengaged. Alternatively, lower air volumes may be applied by using the following methods:

- Operating the fan in low speed – if a low speed gear box is fitted;
- Operating the tractor PTO at lower RPM if the torque load of the tractor will allow;
- Restricting the fan intake, as with the “Cornell Donuts” (see right) picture from Dr. Andrew Landers, “Improved Pesticide Application Technologies”

Some allowance may be needed for the rotary air pattern that can emit from the axial fan commonly found on air blast sprayers. If there are no straightening vanes in the unit, the air typically comes out in a “rolling pattern” that may cause the vine canopy on one side to be forced upward, and forced downward on the other. The spray jets may need to be altered to allow for the different airflow on opposite sides of the spray plant. Better still, straightening vanes could be retrofitted to give a linear spray pattern.
A sprayer with straightening vanes is more likely to achieve more even coverage.


**Ground Speed**

This is mainly a function of the air volume produced by the sprayer. As ground speed increases the time available for the air to penetrate the canopy and cover the target decreases. As mentioned above, single row sprayers should penetrate the canopy with the spray in each pass.

Some multi-row sprayers can create very turbulent conditions, as the canopy is sprayed in two directions. Leaves and canes are moved around vigorously, and it *may* be possible to achieve adequate coverage without forcing the air stream entirely through the canopy in each direction.

Generally speaking, slower is better with ground speed; especially late in the season. There is a point where excessive spray run-off can cause losses and ineffective coverage, but in most cases spraying a full canopy should be done at a controlled speed.

<table>
<thead>
<tr>
<th>Sprayer and fan type</th>
<th>Claimed Air Volume Output (m³/hr)</th>
<th>Theoretical maximum speed to displace all air in 0.75m x 1.0m canopy (kph)</th>
<th>Theoretical maximum speed to displace all air in 1.5m x 1.5m canopy (kph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single row air shear, 500mm Turbine fan</td>
<td>7550</td>
<td>4.7</td>
<td>1.6</td>
</tr>
<tr>
<td>2 Row air shear, 570mm Turbine fan</td>
<td>10300</td>
<td>6.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Single row ducted output 500mm Turbine</td>
<td>7550</td>
<td>4.7</td>
<td>1.6</td>
</tr>
<tr>
<td>2 Row ducted 550mm Turbine</td>
<td>14000</td>
<td>8.75</td>
<td>3.0</td>
</tr>
<tr>
<td>Single row conventional air blast 900mm axial fan</td>
<td>85500</td>
<td>53.4</td>
<td>19.0</td>
</tr>
<tr>
<td>4 x 500mm boom-mounted fan heads per row, 2 entire rows sprayed</td>
<td>96000</td>
<td>60.0</td>
<td>21.3</td>
</tr>
</tbody>
</table>

(* Assuming all air volume is directed at the canopy with veloutes)

Note the following:

- These are the *theoretical* maximum speeds. As discussed previously, coverage may be adequate on multiple row sprayers without having to spray entirely through the canopy due to turbulence gains;
• The ground speed relates entirely to air volume output;
• Clearly spraying at 53 to 60 kph is not practical! This suggests that a slower fan speed or spraying without air assistance when canopies are smaller may be appropriate. For most conventional air blast sprayers a ground speed of 6 – 8 kph may be used early in the season; and slower speeds of 4 – 5 kph are more common as canopies become larger and denser later in the season. Growers should test their own coverage and observe what setting achieve the desired coverage
• Allowance for not only liquid volume but also air volume should be made as the canopy size increases.

Leaf Shingling
This term refers to the effect that often happens later in the season when vines approach full canopy. When air and liquid is directed straight at the vine canopy, often the leaves can flatten, and resemble shingles on a roof. In the same way roof shingles resist water penetration, vine leaves in this pattern will resist chemical spray from entering the canopy. This effect is most pronounced where the air stream is perpendicular to the travel direction.

In the example left, the travel direction of the spray plant is shown with the black arrow, and spray direction shown in red. The perpendicular air blast has flattened and “shingled” the leaves, effectively shielding the internal area of the vine canopy.

Apart from a focus on canopy management, another method of reducing the shingling effect is to alter the direction that the spray air stream hits the canopy. If the angle of air and liquid is directed slightly behind square (as shown left) there is a greater chance that leaves will be blown aside, and a chance that spray coverage will improve.

In the example shown left, the stream is angled back thus giving less leaf shingling and a higher chance that spray will reach the inner part of the canopy. Travel direction is shown with black arrow; spray direction is shown with the red arrow.

With spray plants that allow the air and spray direction to be set differently for high and low jets (eg multi-head fans, directed air blast sprayers) there may be benefit in setting the high and low jet to impact on the canopy from different directions. In the following example overleaf, the high jets have been directed forward and the low jets are directed backwards.

High and low air streams and jets directed to hit the canopy from different directions. Direction of ground travel is shown with the black arrow; direction of liquid and air stream is shown with the red arrow.
Leaf shingling can also be reduced by slowing the velocity of air. It is important that the volume of air is good, but that velocity of air is not so great that leaves are shingled. With a traditional air blast sprayer this may be addressed by enlarging the air outlet vent. If any modifications are made, the changes should be tested with coverage strips (or similar) in the canopy to evaluate the changes. Some modifications may make coverage worse.

**Liquid**

**Droplet Size**

A large number of small droplets will cover better than a small number of large droplets. The distribution of droplet size is more relevant than the total volume of liquid applied per hectare. Note the following picture:

Clearly the most complete spray coverage is achieved with the fine droplets. The coverage at 45 L/ha with fine nozzles is far superior to that achieved at 125 L/ha with coarser nozzles. However, fine droplets will be much more prone to drift, especially as wind increases, so often a compromise between coverage and drift management is required.

Smaller droplets also evaporate much faster than medium and coarse droplets. Application of translaminar or systemic chemicals (such as nutrient sprays, or DMI fungicides) potential effectiveness may be lost if the spray evaporates in the air on the way to the target, or evaporates from the leaf surface before it can be adequately absorbed by the plant. Again, a compromise may be needed to achieve the best result.

The type of product being used will also influence the choice of spray nozzle and the resulting spray pattern.

- Fungicides that require coverage such as copper and sulphur products will usually achieve the best coverage with fine to medium nozzles. These products are not subject to major concerns in regard to evaporative losses; as long as the chemical is evenly deposited on the leaf.
- *Translaminar* or *Systemic* fungicides are best if evaporation is limited. They are also more forgiving in regard to coverage, as the chemical is absorbed into leaf tissue. For this reason medium to coarse nozzles may be better for this type of chemical. There are also advantages of adding a suitable adjuvant to help in this regard, but that is a complex topic for another paper.

Another option to consider in regard to the spray droplet distribution is the use of air induction (AI) nozzles. These nozzles draw air into the side of the nozzle as the droplets are forced out, making air–filled droplets. The resulting droplets are heavier and are less prone to drift.

**Targeting Spray**

A spray plant should be set up to apply spray depending on the target in question. The sprayer shown right is set up to spray the vine...
foliage, as would be the case in spraying fungicide on leaves and bunches.

If spraying to control botrytis or light brown apple moth in bunches, the sprayer should be configured to ensure the bulk of the spray is aimed at the bunch zone; as shown at right. Note that trying to cover bunches late in the season may be an impossible task. The best chance at achieving good coverage in this type of operation is to have as many spray nozzles as possible operational, direct the spray at the bunch zone, and travel at a ground speed slow enough to allow for coverage.

**Total Spray Volume**
After the air volume has been addressed, the total water volume is the next critical factor. The amount of water required will depend on the size of the target. When spraying leaves and fruit the total amount of water applied per hectare will depend on the leaf surface area and crop load per hectare.

**More crop and heavier canopy = larger target = more water required.**

**DILUTE SPRAYING** assumes the total plant surface is covered with spray solution to the point of runoff. The dose rate of chemical (per 100L rate) is enough to control disease or pest due to the volume of water. The amount of water needed to achieve point of runoff is often referred to as the theoretical volume.

**CONCENTRATE SPRAYING** involves applying an amount of water less than the point of runoff, but a sufficient volume to achieve acceptable coverage. Acceptable coverage may be achieved at a lower volume of water if the air volume is high enough, and is well-directed. Adequate coverage at lower volume may be possible with smaller droplet sizes. If the diameter of a droplet is halved, it can produce 8 droplets of the same total volume. So if droplet size is halved, it is possible to achieve better coverage at half the total spray volume per hectare:
Note however, that as total volume of spray per hectare is reduced the risk associated with the spraying operation increases.

The choice of droplet size and consideration of drift is a trade-off. Fine nozzles and in particular air-shear spray units tend to produce a greater percentage of fine droplets than large hydraulic nozzles.

When the amount of water applied is lower than the theoretical volume, the dose rate of chemical must be adjusted so that the same amount of chemical is applied to make sure the pest or disease is controlled. The amount this must be adjusted is the concentration factor.

Eg A canopy requires 1000 L to achieve the point of run off. The grower has a spray unit that will still achieve good coverage at 750 L/ha, and decides to apply this total volume of spray. Wettable sulphur is to be applied at 600 g/100L. This means that:

<table>
<thead>
<tr>
<th>Theoretical Volume 1000 L/ha</th>
<th>Chosen Volume 750 L/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration factor ((A) / (B))</td>
<td>(= 1000 / 750 = 1.33)</td>
</tr>
<tr>
<td>so 1.33 x 600g</td>
<td>so 800g wettable sulphur added per 100L</td>
</tr>
</tbody>
</table>

allowing for the concentration factor.

The rate of wettable sulphur per hectare is the same whether spraying by the dilute or concentrate method (see table).

<table>
<thead>
<tr>
<th>Water Volume Litres per ha</th>
<th>Dilute Spray</th>
<th>Concentrate Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Label Rate per 100L</td>
<td>600 g</td>
<td>600 g</td>
</tr>
<tr>
<td>Concentration factor (cfi)</td>
<td>1</td>
<td>1.33</td>
</tr>
<tr>
<td>Chemical needed per 100 L of spray</td>
<td>600 g</td>
<td>600 g</td>
</tr>
<tr>
<td>Chemical dose per ha</td>
<td>6 kg</td>
<td>6 kg</td>
</tr>
</tbody>
</table>

Failure to adjust the dosage rates when using a spray volume lower than the appropriate volume may result in poor control of diseases and pests. This is particularly important during high pressure situations. Not only can the disease or pest control be compromised, but application of inappropriate rates of agrochemical may encourage the development of resistance (see CCW fact sheet about chemical resistance for more information).

**Adjuvants**

This is a complex area and cannot be covered in detail here. There are many facets to the use of adjuvants, and there is a great deal of conflicting advice that is offered in regard to the most suitable adjuvants that can be used with canopy sprays; or even if they should be used at all. Apart from the obstacles to good spray coverage that have already been previously described, plant surfaces are coated with a waxy cuticle which tends to repel water. This tends to be antagonistic to the fungicide sticking to the leaf surface.

It is impossible to give definitive recommendations for every agrochemical, but the following general considerations may help. Generally speaking, if an adjuvant acts to aid the passage of chemical into the plant it is likely to have a disruptive effect on the plant cuticle. This impact does not mean that such adjuvants should be totally avoided; it is, however a good idea to consider the potential impacts when choosing an adjuvant or chemicals for successive sprays.

- Acids (buffers), organosilicone and oil – based adjuvants generally can cause some disruption to plant cuticles.
Addition of some adjuvants may increase the likelihood that the chemical can wash-off in following rain. Oil – based adjuvants and resin – based adjuvants are likely to be more resistant to rain wash-off.

The term “sticker” **may not** mean that the adjuvant is **rain-fast**. It may mean that use of the adjuvant helps the spray droplet to adhere to the waxy plant tissue. Many of these adjuvants will increase the wash off of chemicals in the event of rain.

Some adjuvants are not compatible with some fungicides.

Many fungicides now contain adjuvants as part of the formulation.

Adjuvants that claim to be a “penetrant” are likely to cause disruption to plant cuticles.

### Buffers

Some agrochemical labels recommend that a buffer should be added to the spray solution. Many agrochemicals with the active ingredients *captan* and *iprodione* are unstable at spray solutions higher than pH 8.5, and may degrade before they are applied to the target plant. As with every case – read the label carefully! It is a good practice when using active chemicals that are subject to alkaline instability that the pH of the spray water is tested. Note that pH measurements with low quality pH meters can be very misleading.

Some buffers have inbuilt indicators. The amount of buffer required for the spray tank can be calculated by gradually adding buffer to a known volume of spray water. For example, buffer can be added to water in a one litre jug using a 1ml eyedropper. When the desired colour change is observed, the amount of buffer needed per 100L of spray mix can then be calculated from this test.

### Canopy Management

There is no question that large dense canopies are more difficult to spray than sparse canopies. These canopies are also a more suitable environment for disease to proliferate, as there is usually higher humidity, less air movement and less light as well as less penetration of chemical into the canopy. It may also allow pests such as light brown apple moth to be more protected from attack by beneficial insects. Management to achieve a balanced canopy will not only help in achieving better spray coverage but also discourage disease and pest growth.

In some seasons it may be impossible to control the canopy growth if high rainfall and humidity are commonplace. Wherever possible a grower should try to maintain a balanced canopy, and if possible to direct the growth into a shape that encourages spray penetration and lower humidity. This may mean more than simply trimming a canopy. It may include different pruning treatments, strategic irrigation deficit, shoot removal or positioning, nutrition management as well as trimming.

### Summary

Far from being an onerous task that must be endured, canopy spraying is a vitally important task in a vineyard. Growers should view the spraying for control of diseases or pests in their vines as a technical operation that requires constant diligence and checking to ensure that the best possible job is done. **Every** time a spray is applied, the quality of the job should be constantly assessed and improved wherever possible. “Near enough” is not good enough when it comes to canopy spraying. This is more so during high pressure conditions.
The most expensive spray is one that doesn’t work.

References:
“Spray Application in Viticulture”, GWRDC Innovators Network Module; Alison McGregor, Shcolefield Robinson Horticultlural Services.


Nufarm Australia Limited: http://www.nufarm.com/AU/Home

“Improving Spray Efficiency”; Dr Andrew Landers; Cornell University; www.nysaes.cornell.edu/ent/faculty/landers/pestapp

“Improved Pesticide Application Technologies”; Dr Andrew Landers, Cornell University, www.nysaes.cornell.edu/ent/faculty/landers/pestapp

Pictures:

http://wwwairofan.com

http://www.tornadosprayers.com.au

http://www.hardi-us.com/en-us/Products