Liquid flow and air flow

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Improving pesticide application via engineering methods

Comparative testing of novel sprayers

Developing methods to improve deposition and reduce drift

Extension demonstrations of novel sprayers
## Droplets

<table>
<thead>
<tr>
<th>ASAE Standard</th>
<th>Comparative Size</th>
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<tr>
<td>Symbol</td>
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<tr>
<td>VF</td>
<td>Very Fine</td>
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<tr>
<td>F</td>
<td>Fine</td>
</tr>
<tr>
<td>M</td>
<td>Medium</td>
</tr>
<tr>
<td>C</td>
<td>Coarse</td>
</tr>
<tr>
<td>EC</td>
<td>Extremely Coarse</td>
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Spray droplets are measured in microns and expressed as Volume Median Diameter (VMD).

One micron ($\mu$m) = 1/1000 mm
VMD or NMD?
1/2 of spray volume = smaller droplets

1/2 of spray volume = larger droplets

Credit: Tom Wolf
Laser Droplet Analyzer
Halving droplet size results in eight times the number of droplets.

- 1 x 500 Micron
- 8 x 250 microns
- 64 x 125 Microns
Droplets appear as streaks whose length is controlled by the shutter speed of the camera.
A large water droplet bouncing on a pea leaf

Diameter: 650 μm
Velocity: 1.5 m/s
A smaller water droplet bouncing on a pea leaf

Water droplet impact and bounce on pea leaf

Eight frames combined
Four bounces to retention (1 to 4)
First impact speed 0.93m/s
Diameter 375 μm
Select the correct nozzles:

- **Fine (F)** for contact products
- **Medium (M)** for herbicides
- **Coarse (C)** for pre-emergent herbicides

**Note:** 3rd column states spray quality
## Nozzle catalogue – hollow cone

### ALBUZ

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<th>Brown</th>
<th>Yellow</th>
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Nozzle selection - smartphone apps

- **TeeJet Technologies SpraySelect Tip Selector**
  - Start

- **Lechler Nozzle Calculator**
  - Choose your calculator:
    - Arable Crops
    - Vine & Orchard Crops
  - Website
  - Settings

- **Greenleaf Technologies Nozzle Calculator**
  - Application Reference
  - Contact Greenleaf

- **CoorsTek Website**
  - Volume (l/ha): 1
  - Row Spacing (m): 1.0
  - Number of Nozzles: 1

- **ALBUZ Website**
  - Calculate
Calibration
Calibration

Calibration of airblast sprayers for vineyards

- Part 1 selecting and changing nozzles (metric version)
- Part 2 measuring liquid flow (metric version)

8 film clips on calibrating liquid flow and nozzle selection

Distance learning courses
(Cornell University)
Electronic nozzle tip testers
Patternator
Improved setting for the canopy: adjusting nozzle orientation
Patternator for growers to build

Patternator assembly instructions
Drift poles to determine nozzle/plume direction
Air induction nozzles

- Spray liquid enters nozzle through metering orifice
- Air is drawn into venturi through side port
- Air and liquid mix in nozzle body
- Spray is emitted through exit orifice forming pattern devoid of fine droplets

Droplets contain air bubbles, causing them to shatter on impact with the target.
Air induction nozzles

Drift Reduction - Air Induction Nozzles Fitted On A Berthoud Sprayer

% area covered on drift cards

Rows from target

- Hollow cone
- Air Induction
Precision application to the target zone

- Botrytis sprays to the fruit zone
- Grapevine Berry Moth sprays to the fruit zone
- Insecticide for Japanese Beetle at the top of the canopy
Target-zone sprayer

2-diaphragm pump/pressure regulator: $900
Hydraulic motor: $200
Motor to pump connector: $150

(Prices approx.)
Target-zone sprayer

Fitted to a Hazlitt 1852 CIMA sprayer

Low pressure, two diaphragm pump - 12 volt electric: $400 (approx.)
Dilution: water and agrochemical
Induction bowls and closed chemical transfer

Reduce operator exposure and environmental contamination
Why care about the air?

We change liquid flow rate with different size canopies including:
  - Vine Row Volume
  - Leaf Wall Area
  - Dosavina
  - Unit Canopy Row

Why not change airflow to match the developing canopy?
Airflow

Direction of the air
The speed of the air
The volume of air
The answer is blowing in the wind

- Transports droplets from the sprayer to the target
- Protects droplets against wind effects
- Droplet production (pneumatic sprayers)
- Provides shaking of the leaves in the canopy
- Provides good coverage on the target

- Transports droplets through & past the target
- Excessive shaking of the canopy resulting in removing droplets already present on the target
Air direction

Deflectors and towers fitted to airblast sprayers to change air direction
Adjust airflow direction – park the plume
Air direction

Source: Balsari, P., Marucco, P. and Tamagnone, M. Workshop on spray application techniques in fruit growing, Barcelona 2005, pp.101-106
Air direction

*Figure 4. Spray deposits registered on the artificial collectors displayed within the canopy spraying both sides of the row simultaneously or not simultaneously.*

Source: Balsari, P., Marucco, P. and Tamagnone, M. Workshop on spray application techniques in fruit growing, Barcelona 2005, pp.101-106
Air direction

Figure 2. Schematic view of the sprayer configurations examined: A) spray distribution not simultaneous on the two side of the rows; B) spray distribution simultaneous on the two sides of the row with three different nozzles and air outlets orientation

Source: Balsari, P., Marucco, P. and Tamagnone, M. Workshop on spray application techniques in fruit growing, Barcelona 2005, pp.101-106
Park the plume
Air speed – grapes are the target

Good coverage

Poor coverage
Wind tunnel observations
The classic horseshoe vortex

Ludwig Prandtl
1875 - 1953
Adjusting the air volume intake

Cornell Doughnut (2002)

ISAFUIT project Europe (2002-07)
Early season – Air flow reduced
Mid season – Air flow adjusted
Full canopy – Air flow fully open

Adjustable Cornell louvre system

Table 2. FMC tower sprayer. Drift reduction and deposition increase in V. vinifera cv. Vignole vineyard

<table>
<thead>
<tr>
<th>Season</th>
<th>Early</th>
<th>Mid</th>
<th>Late</th>
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<tbody>
<tr>
<td>Louvre position</td>
<td>Fully open</td>
<td>Adjusted</td>
<td>Fully open</td>
</tr>
<tr>
<td>Drift reduction (%)</td>
<td>0</td>
<td>71</td>
<td>0</td>
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<tr>
<td>Deposition increase (%)</td>
<td>0</td>
<td>82</td>
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Drift measurements in *Vitis sp.* GR 7 vineyard 2010

- **Pole1 T1**
- **Pole2 T1**
- **Pole3 T1**
- **Pole1 T2**
- **Pole2 T2**
- **Pole3 T2**

**Dye concentration**
- (mL dye/ L /pipe cleaner)

**Top**
- Pipe cleaner position on pole
  - P1
  - P2
  - P3
  - P4
  - P5
  - P6
  - P7
  - P8

**Bottom**
- Adjusted air volume
- Airflow maximum

T1 = Louvres Adjusted
T2 = Louvres Open
Conclusions

Select the correct nozzle to provide the right size droplets

  Calibrate the nozzles and spray plume

  Reduce the airflow to match the canopy