Low-Loss Spray Application
A Concept for More Efficiency and Safety in Top Fruit Crop Protection

The Scientific Basis

Verlustarm Sprühen
Pflanzenschutz mit optimaler Applikationstechnik und minimaler Abdrift im Sinne eines nachhaltigen Obstbaus

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The Goals of Spray Application in Fruit and Vine

The history of spray application techniques at Lake Constance area

Since the late 1980ies low volume spray application (< ~250 l/ha) is standard in top fruit production at Lake Constance area and other European fruit growing regions

Reasons: ● a high work rate, ● no visual deposits on fruit, ● lower risk for phytotoxicity, ● reduced pesticide dose rates, ● less fillings, ● less chances of contamination with concentrated pesticides, ● lower costs

The problem: The high drift POTENTIAL! of small droplets

To preserve the benefits of small droplet/low volume spray application for professional fruit growing, classical drift reduction by big droplets had to be extended by methods for small droplets

Reasons: Without officially registered means of drift reduction growers cannot make use of reduced buffer zones to surface waters when applying pesticides

The solution: To avoid a lot of drift from small droplets, the high drift potential of small droplets needs to be kept under control by hardware and methods
Spray Drift Reduction with Small Droplets: The Status Quo
Spray drift from an axial fan with hollow cone nozzles "Albuz ATR purple" and standard settings of forward speed and fan speed (6 km h\(^{-1}\), 540 min\(^{-1}\) PTO) is 4.1 x above the reference values.

**Particle Drift Deposits, Relative Values**

compared to german reference values

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Spray Drift Reduction with Small Droplets: The Status Quo
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A changeover from axial fan to a tower sprayer, operated at the same setting (6 km h\(^{-1}\), 540 min\(^{-1}\) PTO) reduces spray drift by ~40%
Spray Drift Reduction with Small Droplets: The Status Quo

Particle Drift Deposits, Relative Values*
compared to german reference values

- Reference Values
- Reference Values - 50%
- Reference Values - 75%
- Reference Values - 90%
- N36 ATR purple 7,5 540 6
- SZA32 ATR purple 7,5 540 6
- SZA32 ATR purple 7,5 420 6
- SZA32 ATR purple 7,5 300 6
- SZA32 ATR purple 7,5 330 9
- SZA32 ATR purple 7,5 420 12

* = with full downwind air stream

Average 3 - 50 m
Changing fan type and adapting fan speed to the canopy (e.g. 300 min$^{-1}$ PTO) without changing forward speed (6 km h$^{-1}$), reduces spray drift from small droplet nozzles by $\sim$95%
Spray Drift Reduction with Small Droplets: The Status Quo

Adapting fan power to canopy width, spray drift from small droplet hollow cone nozzles (Albuz ATR purple) is about the same irrespective of the forward speed. Even now spray drift is still above the reference values!
Spray Drift Reduction with Small Droplets: Method #1
Spray Drift Reduction with Small Droplets: Method # I

Particle Drift Deposits, Relative Values*
compared to german reference values

- Reference Values
- Reference Values - 50%
- Reference Values - 75%
- Reference Values - 90%

SZA32 ATR purple 7,5 300 6
SZA32 ATR purple 7,5 330 9
SZA32 ATR purple 7,5 420 12
SZA32 ATR purple + AVI 8001 7,5 300 6
SZA32 ATR purple + AVI 8001 7,5 330 9
SZA32 ATR purple + AVI 8001 7,5 420 12

* = with full downwind air stream
Spray Drift Reduction with Small Droplets: Method # I

Tower sprayers equipped with a mixed nozzle set (ATR purple / AVI 8001 or IDK9001) reduce spray drift by >75% at any forward speed when operated at canopy adapted fan speed.

Particle Drift Deposits,
Relative Values* compared to german reference values

Reference Values
Reference Values - 50%
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- SZA32 ATR purple 7,5 300 6
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* = with full downwind air stream
Spray Drift Reduction with Small Droplets: Method #1

Tower sprayers equipped with a mixed nozzle set (ATR purple / AVI 8001 or IDK 9001) reduce spray drift by >90% at any forward speed when operated at canopy adapted fan speed under hail net.
Spray Drift Reduction with Small Droplets

- **Fans with cross flow characteristics at any forward speed** (Method # I)
  + canopy adapted fan speed
  + mixed nozzle set (ATR purple + 2 x 2 AVI 8001 / IDK 9001)
  - reduce particle drift deposits by >75% (officially registered in Germany and Austria)
  + hail net
  - reduce particle drift deposits by >90% (officially registered in Austria, pending in Germany)

- **Fans with cross flow characteristics at any forward speed** (Method # II)
  + canopy adapted fan speed
  + air flow control
  + active deflection air stream
  + full hollow cone nozzle set (ATR purple)
  - reduce particle drift deposits by >95%
By optimizing the air support (crossflow characteristics, adjustment of working height to tree height and adaptation of fan speed to canopy width) spray drift from small droplet nozzles may be reduced as much as with air induction nozzles!
Why are axial fans using small droplets unusable for an efficient spray application with low spray drift?

- The air stream of an axial fan cannot be adapted to the canopy!
- Because of the diverging air stream a lot of air with a steep angle is required to reach the top of the tree, producing high spray drift and poor coverage.
- High fuel consumption and high noise emission at low forward speed!
Why are only fans with cross flow characteristics using small droplets suitable for an efficient spray application with low spray drift?

- Optimized fans with crossflow characteristics produce an air stream with a uniform horizontal reach over working height which may very easily be adapted to canopy width!
- Very little air is needed to transport the droplets into the canopy and not through!
- Low fuel consumption and low noise emission at high forward speed!
A key to improve spray cover and reduce spray drift from small droplets:

Adapting forward speed and fan speed to canopy width increases spray droplet deposition and reduces spray drift significantly.
Low Loss Spray Application: The Effect on Spray Cover

Comparison of two methods of sprayer operation (with the same sprayer)

New: spray liquid volume, forward speed and fan speed adapted to canopy width

(240 – 115 l ha\(^{-1}\), 4 – 12 km/h, 300 – 460 PTO I)

Versus

Old: constant spray liquid volume, full fan speed and widely constant forward speed

(200 l ha\(^{-1}\), 7 – 9 km/h, 540 PTO II)

Parameters compared:

Spray deposit: \(\mu g\ cm^{-2}\) per liter of liquid sprayed

Relative coverage: % coverage per liter of liquid sprayed

Droplet deposit density: number of droplets cm\(^{-2}\) per liter of liquid sprayed

<table>
<thead>
<tr>
<th>Changes in efficiency</th>
<th>3-row Bed</th>
<th>Slender Spindle</th>
<th>Super Spindle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray deposit (entire leaf)</td>
<td>+14%</td>
<td>+29%</td>
<td>+35%</td>
</tr>
<tr>
<td>Relative Spray Cover (upper leaf surface)</td>
<td>-29%</td>
<td>+26%</td>
<td>+67%</td>
</tr>
<tr>
<td>(lower leaf surface)</td>
<td>-27%</td>
<td>-3%</td>
<td>+7%</td>
</tr>
<tr>
<td>Droplet Deposit Density (upper leaf surface)</td>
<td>-5%</td>
<td>+27%</td>
<td>+55%</td>
</tr>
<tr>
<td>(lower leaf surface)</td>
<td>+17%</td>
<td>+28%</td>
<td>+27%</td>
</tr>
</tbody>
</table>

Excessive fan speed (not adapted to the canopy) has NO positive effect on spray cover, but reduces spray deposition efficiency and increases negative side effects (spray drift, fuel consumption, noise)
Energy consumption: How much is necessary?

The fraction of the non-usuable air stream may exceed 50% of the total air stream.
Energy consumption: How much is necessary?

Specific energy consumption per m³ h⁻¹ of usable air volume varies by a factor of 5!
Adapting fan speed to the canopy reduces fuel consumption

Reducing PTO speed from 540 min⁻¹ high fan gear to 300 min⁻¹ low fan gear reduces Diesel consumption by up to >80%
Adapting fan speed significantly reduces noise emissions.

Reducing PTO speed from 540 to 380 min⁻¹ reduces noise emissions by 50%.
Spray drift from small droplets is reduced by

Key #1: An air stream as horizontal as possible, adjusted to farm specific tree height
Key #2: The adaptation of the horizontal reach of the air stream to canopy width during spray application

Keys #1 and #2 additionally

- minimize the useless air stream (increase energy efficiency)
- minimize the amount of air required (increase energy efficiency)
- minimize fuel consumption (improves CO₂-footprint)
- minimize CO₂-emissions (improves CO₂-footprint)
- minimize noise emissions (improves acceptance at stakeholders)
- improve deposition on the target (increase pesticide usage efficiency)
- improve quality of the spray deposit (increase pesticide usage efficiency)
- reduce pesticide consumption by canopy related dosing models
- reduce costs for crop protection

but…
A uniform rectangular vertical air distribution is essential for high quality and efficient spray application, reducing spray drift, fuel consumption, \( \text{CO}_2 \)-emissions and noise.

Up to now many growers use ways too much air and try to compensate a defective vertical air distribution by high fan speed!

It is not very progressive to compensate a defective air distribution by increased fuel consumption and noise emission!
Vertical air distribution generally needs to be improved!

Before purchasing a sprayer, air distribution needs to be adjusted to farm specific maximum tree height and straightened!

A reduction of fan speed of an unadjusted sprayer may result in a reduced horizontal reach at certain sections of the air stream, reducing the penetration of the canopy and leading to stripes with poor spray cover.
Low Loss Spray Application

- Optimization of air and spray liquid distribution,
- Individual sprayer testing and adjustment with air and spray liquid test benches,
- Canopy adapted, low loss / low volume spray application

is a module of

Low Loss Crop Protection

The other modules:

Canopy Adapted Pesticide Dosing and Spray Application

(Electronic fieldbooks for canopy adapted pesticide dosing, canopy adapted spray application and documentation)

+ Education and Training

(Growers, dealers of sprayers and manufacturers of sprayers)
Low-Loss Spray Application

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THANK YOU FOR YOUR KIND ATTENTION