Current Trends and Developments in Pesticide Application

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Efficacy
• Sole reason to spray
• Depends on characteristics of deposit
• Needs critical timing, pest populations and stage of development
• Effective application can enable use of reduced-risk materials

Increased efficacy allows us to reduce rate of use, use lower-risk materials, time application

Productivity
– timely, economical and efficient application
• Lower volumes to reduce refill / ferry times
• High ground speeds
• Tank mixes
• Wider weather windows
• Timeliness for stage of pest

Higher productivity allows more effective IPM, lower rates, use of reduced-risk materials

Off-site protection
Airborne drift mitigation
• Classic method to mitigate: larger droplets, higher volumes
• May reduce efficacy
• Ground deposit and runoff
• Aggravated by some drift mitigation techniques

Mitigating off-site effects is a result of application, lower a.i. rates and use of reduced-risk materials

Agrochemical application in California
Proximity to sensitive areas, either natural or man-made is common.
Tools for higher quality applications:

- Improved nozzles
  - Droplet size management

- Adjuvants
  - Reduce liquid rates
  - Small droplet deposition with larger droplets

- Targeted application
  - Sensors and controllers
  - Focused application
  - GPS for mapping and monitoring

Nozzle Technology

- Trend toward larger droplets
- Using air induction
- Manipulating droplet velocities

Air induction nozzle

- A passive air flow
- Reduces small droplets
- Can create bubbles in droplets

Air induction nozzle

- Water

Air induction nozzle

- Water + 0.5% surfactant

Effects of changing surface tension of spray mix
Effects of changing surface tension and viscosity of spray mix

Water
0.508 mm orifice
5 cm distance
70 kPa
100 ms pulse

Water + surfactant
0.508 mm orifice
5 cm distance
70 kPa
100 ms pulse

Water + surfactant + polymer
0.508 mm orifice
5 cm distance
70 kPa
100 ms pulse

Spray to run off?

Good tracer and registered for use, OMRI* listed:
Surround™
A kaolin clay

* Organic Materials Research Institute
**Surround™ for assessing dormant spray application**

Clay material shows runoff and overspray

Or … use drip line woven into canopy to show spray patterns…

**Miller et al. (2003) concluded:**
“Most of the spray movement out of the tree canopy was in the spaces between trees…”

“One way to reduce drift may be to turn off the spray between tree crowns…”

**Spray deposit partitioning in orchards**

<table>
<thead>
<tr>
<th>Author</th>
<th>Condition</th>
<th>Ground</th>
<th>Target</th>
<th>Drift</th>
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<tbody>
<tr>
<td>Seiber</td>
<td>Dormant</td>
<td>25 – 45%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cross</td>
<td>Both</td>
<td>43 - 63%</td>
<td>-</td>
<td>16%</td>
</tr>
<tr>
<td>Vercruysse</td>
<td>Both</td>
<td>-</td>
<td>56 – 68%</td>
<td>-</td>
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<tr>
<td>Pergher</td>
<td>In season</td>
<td>-</td>
<td>37 – 62%</td>
<td>-</td>
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<tr>
<td>Fox</td>
<td>“Sparse”</td>
<td>57%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Miller</td>
<td>In season</td>
<td>22%</td>
<td>57%</td>
<td>4.6 (16%)</td>
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</table>

**Ultrasonic measurement of trees for control of spray sections.**

Savings depends on orchard age, size, gaps, etc.

Some trials have shown 50 - 70 % savings.

**Field test – dormant plums**

January 2003 - Chico, CA, USA

Air-O-Fan 2D48 engine-driven sprayer

“Smart Spray” ultrasonic control system (retrofit)
Field test – dormant walnuts
March 2003 - Davis, CA, USA
Durand-Wayland AF500CPS PTO-driven sprayer
Nozzle configuration was “center-weighted” spray

Field test – dormant almonds
January 2004 - Ceres, CA USA
Durand-Wayland AF500 Smart Sprayer
Nozzle configuration was “center-weighted” spray
0.5 kg/ha Lorsban (chlopyrifos)

Performance results
3 crops, 3 chemicals, 3 sprayers,
3 locations, 3 operators …
Use of system had no significant effect on target deposition
• Plum orchard –
  – 15% reduction in a.i. rate
  – 5% less ground deposit
• Walnut orchard –
  – 45% reduction in a.i. rate
  – 58% less ground deposit
• Almond orchard –
  – 22% reduction in a.i. rate
  – 71% less ground deposit

Field test – sampling

Deposition sampling - almonds
5 m height, 240 trees/ha

Field test – dormant plums
November 2005 - Gridley, CA
Durand-Wayland Smart Spray
Field test – dormant plums  
November 2005 - Gridley, CA

Durand Wayland Smart Spray

Ground deposit and runoff monitored

39% reduction in applied pesticide

54% reduction in ground deposit

44% reduction in diazinon in runoff water

Yield loss of over 80% reported in processing tomatoes for weeds left in the seedline the entire season.

Conventional Processing Tomato Field

Tomato Seedline

A typical target scene within the row

Cotton

Nutsedge

These weeds are usually very competitive with and damaging to the crop.

Conventional control through selective herbicides...

... or hand hoeing

A typical target scene within the row

Process for image analysis
Generating a precise spray micro-map (10 cm x 15 cm)
Replacing chemical selectivity with spatial selectivity

The concept..
“Leaf-specific” agriculture

Process for spatially selective application of non-selective herbicide

Micro boom and micro boom sections of micro nozzles
One micro boom section per cell
Fast valves for flow control
Micro-nozzles for dosing
Target plants

Visual Occlusion
Complicates these shape-based algorithms

What do these plants have in common?
Ground Cherry    Black Nightshade
They are in the same taxonomic family (Solanaceae)
Hairy Nightshade    Tomato
### Narrowband Hyperspectral (10 bit)

<table>
<thead>
<tr>
<th>λ (nm)</th>
<th>Nightshade Error</th>
<th>Tomato Error</th>
<th>Total Error</th>
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<tbody>
<tr>
<td></td>
<td>Black</td>
<td>Hairy</td>
<td>Heinz</td>
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<tr>
<td>400-480</td>
<td>6%</td>
<td>7%</td>
<td>4%</td>
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<tr>
<td>700-1100</td>
<td>20%</td>
<td>17%</td>
<td>14%</td>
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<tr>
<td>1580-1680</td>
<td>43%</td>
<td>34%</td>
<td>42%</td>
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<tr>
<td>1700-1900</td>
<td>5%</td>
<td>3%</td>
<td>4%</td>
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<tr>
<td>2120-2320</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
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</table>

### GPS mapping, environmental sensing and novel application

Conventional Application

Drift Avoid Zone

Pulse-Width Modulation (PWM) for Spray Rate Control and for Droplet Size Control

- Low-frequency (10-20 Hz) pulsing of spray.
- Independent pressure control for droplet size management.
- Vary length of pulse for rate control.
- Digital control system.

### Pulsed Emissions from Nozzles

Spraying near a sensitive area with weather, efficacy and time demands
Accountability map for Field run 7 - wind speed and wind direction

Data from on-board weather sensor

Real time record of sprayer location and droplet size