An update on the intelligent spraying system development for fruit and nursery crop applications

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A concept-proven laser-guided sprayer developed in 2013
Major components of the Intelligent Sprayer

- Laser sensor
- Speed sensor
- PWM flow control valve
- Flow controller
- Laptop Computer
- Algorithms
Field tests

**S1** (Intelligent Sprayer)

**S2** (Intelligent sprayer with automatic rate control turned off)

**S3** (Conventional air blast sprayer)
Field tests

- Mean spray coverage inside tree canopies
- Mean spray deposition inside tree canopies
- Spray deposition on the ground
- Spray deposition beyond tree canopies
- Airborne drift
- Spray mixture consumption
Initial Results – Phase I
Intelligent Sprayer vs. Conventional Sprayer

• Equally good spray coverage inside tree canopies
• Uniform, sufficient spray deposition inside tree canopies
• Less spray deposition on the ground
• Less spray deposition beyond tree canopies
• Less airborne drift
• Much less spray mixture (pesticide) consumption (L/ha)
An apple orchard

A nursery

A nursery sprayer in action

An orchard sprayer in action
We have been conducting biological efficacy tests at 9 Ohio Nurseries since 2013
Intelligent Sprayer -- Phase I completed

Question yet to be addressed:

- Can we make the fruit growers as excited about this technology as the nursery crop growers are?
Intelligent Sprayer -- Phase I

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• Can we make the fruit growers as excited about this technology as the nursery crop growers are?

ANSWERS:

➢ Conduct more performance tests in fruit fields
➢ Conduct more biological efficacy tests
➢ Highlight economic benefits of using the intelligent system.
Diversity of specialty crops requires specific spray equipment to achieve effective pest control.
Can we retrofit growers’ existing sprayers with components of intelligent system?
Phase 2: Development of universal automatic control system to retrofit on a wide range of sprayers in use
Specific Objectives of Phase 2 Research

- Retrofit existing sprayers with the intelligent functions
- Compare their performances with conventional constant-rate applications in terms of:
  - Spray deposition and coverage inside the tree canopy
  - Spray loss on the ground
  - Airborne spray drift
  - Biological efficacy
Current Situation:
Total 11 growers’ conventional sprayers have been retrofitted with the Universal intelligent control system.

- 3 apple growers
- 1 Blubery grower
- 1 Peach grower
- 1 Pecan grower
- 3 Nursery growers
An AgTec apple orchard sprayer retrofitted with the laser-guided spray control system.
Peach orchard

Pecan orchard

Pear orchard

Nurseries
A conventional radial air-assisted sprayer retrofitted with intelligent spray control system to achieve variable-rate applications.

- A - seven-blade fan
- B - nine PWM-coupled hollow cone nozzles
- C – flow rate controller
- D - laser scanning sensor
- E - embedded computer
- F - Doppler speed sensor
- G – flow meter

PWM valve attached to nozzle fitting

Original nozzle disc
Air-blast sprayer in apple orchard trials
Top view of the apple orchard
Test plan and Procedure

Drift Sampling

Spray Direction

Under canopy

Wind Direction (± 30°)

The Last row

Row Center

Rep 3 Rep 2 Rep 1

8 plants

Plastic plate - Ground

WSP - Ground

Tower - Airborne
Spray deposition sample locations inside canopy

Total 29 locations

60 mesh, 3.8 cm diameter SS screen

a- Top view  

b- Side view  

SS Screen  
WSP  

Travel direction  
Spray direction  
Vertical  
Travel direction
## General Information

- **Row Spacing:** 4.60 m
- **Plant spacing:** 2.6 m
- **Plant height:** 2.90 m (avg.)
- **Fluorescent tracer:** BSF 2 g/L
- **Travel speed:** 5.1 km/h
- **Test dates:** 5/23/2018, 6/28/2018

### Sprayer Nozzle Flow Rate

<table>
<thead>
<tr>
<th>Sprayer</th>
<th>Nozzle flow rate GPM (L/min)</th>
<th>Active nozzle/total nozzle</th>
<th>Application rate (L/ha) (Alternate row)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D5-DC25 nozzle @ 100 psi</td>
<td><strong>Intelligent</strong> 0-0.542 (0 - 2)</td>
<td>Depending on Canopy (Max. 8)</td>
<td>0-416</td>
</tr>
<tr>
<td></td>
<td><strong>Conventional</strong> 0.542 (2)</td>
<td>8/9</td>
<td>416</td>
</tr>
</tbody>
</table>
Collecting and analyzing samples

20 x 20 cm Nylon screens
2017-2018 intelligent sprayer tests in a vineyard
Samplers – Vineyard tests

15x33 cm Nylon plate
Canopy Deposit Sample locations

14 positions on each plant

- Overlapped area
- Trunk Centerline
- Side view of the vineyard row
  - Travel direction
  - Front @ Middle elevation
  - Back @ Middle elevation
  - After Center @ Middle elevation
  - Before Center @ Middle elevation
  - Trunk center @ 3 elevation (Top, Middle, Bottom)

- 60 mesh, 3.8 cm diameter SS screen
- 2.5x7.5 cm WSP
- Trunk center @ 3 elevation
Airborne and ground deposit sample locations

Total 15 towers to collect airborne drift
9 targets to collect ground loss under 3 plants

20x20 cm nylon screen (Tower)
15x33 cm plastic plate (Ground)
Collecting samples
Results
Conventional Constant rate

Intelligent variable rate

Total spray volume used for the test row

Constant-rate application: 12.60 L
Variable-rate application: 8.06 L

36% reduction
Canopy Deposition

No significant difference
Canopy deposition

No significant difference
41% reduction in off-target loss under trees
Airborne Ground Deposition

44% reduction in spray drift loss on the ground
Airborne spray drift at different heights and different distances from the sprayed row

65.5% reduction in total spray drift loss
Vineyard tests
Variable Rate vs. Constant rate

**Biological efficacy:** No significant difference

**Spray drift:** Less drift with variable rate Intelligent system
# Economic Analysis

## 2017 Spray Program - At-a-Glance

The fungicides listed in this program are **recommendations only** and this figure does not include all of the fungicides currently registered for use on grapes.

<table>
<thead>
<tr>
<th>Spray No.</th>
<th>Dormant</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Stage</td>
<td>Dormant</td>
<td>Bud Break</td>
<td>1 inch</td>
<td>3-5 inch</td>
<td>10-12 inch</td>
<td>Pre-bloom To Early Bloom</td>
<td>Fruit set (First post-bloom)</td>
<td>Pea-size (Second post-bloom)</td>
<td>Pea-size (Third post-bloom)</td>
<td>Berry touch (Fourth post-bloom)</td>
<td>Berry touch (Fifth post-bloom)</td>
<td>Veraison</td>
<td>Pre-harvest</td>
<td></td>
</tr>
</tbody>
</table>

- **Critical Period For Clusters**

1. **Anthracnose**
   - Sulfurix
   - Mancozeb

2. **Phomopsis**
   - Mancozeb

3. **Powdery mildew**
   - Quintec
   - Revus Top

4. **Downy mildew**
   - Mancozeb
   - Revus Top

5. **Black rot**
   - Mancozeb
   - Revus Top

6. **Botrytis bunch rot**
   - (Tight cluster varieties only)
   - Vangard

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Economic comparison of conventional and Intelligent spray applications in terms of seasonal costs of spraying fungicides and Insecticides.

52% reduction in fungicide consumption  
$566 / ha savings

43% reduction in insecticide consumption  
$132/ha savings

TOTAL Savings = $668/ha
Overall SUMMARY
Compared to conventional sprayers, the laser-guided variable-rate intelligent sprayers:

1. Minimized off-target losses
   - 40-87% reduction in spray loss beyond tree canopy
   - Up to 87% reduction in airborne spray drift
   - 68-93% reduction in spray loss on the ground

2. Reduced pesticide use by 47-70%

3. Provided annual chemical savings of:
   - $345 - $694 per hectare in ornamental nurseries
   - $668 per hectare in ornamental nurseries.

With comparable control of insects and diseases
Conclusions
Sprayers retrofitted with the laser-guided intelligent spray system performed satisfactorily the duties they were expected to accomplish:

- Automatically apply the amount of sprays to match presence, size, shape, and foliage density of target tree canopies and sprayer travel speed in real time
- Reduce pesticide use by more than 50% without losing efficacy, thereby offering sustainable and environmentally responsible approach to protecting crops.

Smart Guided Systems, LLC in Indianapolis is commercializing the intelligent spray control system (https://www.smartguided.com/).
Future work:
Continue conducting Performance and Biological Efficacy tests using retrofitted sprayers

Focus:
- Apple orchards
- Grape vineyard
ACKNOWLEDGEMENTS

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