From direct injection to deposition indicator
– a 45 year retrospective

Dr. Andrew Landers

Faculty Fellow
Cornell University, NYSAES, Geneva, NY, USA
Effective Spraying, Bluff Point, NY, USA
Reducing operator exposure and environmental pollution

Designing an improved sprayer

Precision spraying in fruit growing

Airflow characteristics – improving deposition and reducing drift

Fixed sprayline spraying


Presentations at the same ANPP-BCPC Strasbourg symposium in 1992 were made by: Paolo Balsari, Tom Bals, Jerry Cross, Greg Doruchowski, Emilio Gil, Jan Langenakens, Erdal Ozkan, Peter Walklate and others.

Hand-held direct injection unit, research project for the Fountainhead Group, Utica, NY
HSE funded research study to investigate engineering controls in California

ChemLok  Closed Transfer System developed with Dominic Robinson at The Royal Agricultural College 1990-94
Sir Winston Churchill Memorial Trust grant to study engineering solutions to farm waste products

Used, rinsed pesticide container collection site in KY, USA. 1995

A report to the Winston Churchill Memorial Trust. February.
On-farm Rinsed Pesticide Container Shredder
Student project at Harper Adams College 1996
Opti-sciences SprayScan fluorimeter device
2007
Fixed spray system
Microsprinkler arrangement for applying pesticides

1999: Initial trials using fixed spray method at Cornell Orchards
Fixed Spray System for High Tunnels

- Rears Nifty Pul Tank greenhouse sprayer
- 3 HP motor
- 25 gal tank

- Netafim DAN 7000 series microsprinklers
- 8-mm orifice, flat circular pattern spreader (6 ft diam spray profile)
- 20 psi check valve

High Tunnel trial site, raspberries, 3 sites

SWD Population & Infestation Assessment

- Early August: Weekly samples taken of maturing fruit, held at room temp to rear out any larvae to adult stage
  - 8-13 samples collected per site
  - 10-20 berries (50-100 g total)
  - both Fixed Spray planting and Check planting sampled

- Stephentown (ripe fruit picked daily): no difference in # of adults from different treatments

- Geneva & Ithaca: ~2.5X as many flies from Fixed Spray as from Check plantings
  - fruit not harvested as frequently
  - blackberry planting much more vigorous; coverage not as good
CU orchard trial with rtkGPS at Singer Farms, Appleton, NY

NYSAES Vignoles Vineyard Block

<table>
<thead>
<tr>
<th>GPM</th>
<th>Line color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.77-3.5</td>
<td>Green</td>
</tr>
<tr>
<td>1.5-1.76</td>
<td>Blue</td>
</tr>
<tr>
<td>.51-1.49</td>
<td>Yellow</td>
</tr>
<tr>
<td>0-.5</td>
<td>Red</td>
</tr>
</tbody>
</table>

Target Flow- 1.65gpm

Leica Mojo RTK and CORS Track produced 2-5-2010
Stated Accuracy < 1cm
Target-zone sprayer fitted to the Hazlitt 1852 CIMA
<table>
<thead>
<tr>
<th></th>
<th>TREATMENT ONE</th>
<th>TREATMENT TWO</th>
<th>TREATMENT THREE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DYE IN BOTRYTIS TANK</td>
<td>DYE IN MAIN TANK ONLY</td>
<td>DYE IN BOTRYTIS TANK ONLY</td>
</tr>
<tr>
<td></td>
<td>WATER IN MAIN TANK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOP</td>
<td>0.000887</td>
<td>0.022628</td>
<td>0.01191</td>
</tr>
<tr>
<td>MIDDLE</td>
<td>0.033889</td>
<td>0.179071</td>
<td>0.327976</td>
</tr>
<tr>
<td>BOTTOM</td>
<td>0.037266</td>
<td>0.027183</td>
<td>0.006148</td>
</tr>
<tr>
<td>CENTER</td>
<td>0.003403</td>
<td>0.093168</td>
<td>0.146484</td>
</tr>
</tbody>
</table>

**FRUIT DEPOSITION AVERAGES**

(PPM/cm³)

<table>
<thead>
<tr>
<th></th>
<th>Treatment One</th>
<th>Treatment Two</th>
<th>Treatment Three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.004212</td>
<td>0.004127</td>
<td>0.00427</td>
</tr>
</tbody>
</table>

**FLOW RATE IN FRUIT ZONE**

(GPA)

|                   | 51 | 16 | 35 |
Infra red sensors to monitor growth stage/gaps in the canopy
Solenoid valves operate individual nozzles

Landers, A.J. (2010). *Developments towards an automatic precision sprayer for fruit crop canopies*. Presented at the 2010 ASABE Annual International Meeting, Pittsburgh PA, Paper No. 1008973, ASABE, 2950 Niles Road, St Joseph, MI 49085-9659
Reduction in spray use with Infra-red sensors
*c.v* Vignoles, NYSAES, Geneva
2009 & 2010

<table>
<thead>
<tr>
<th>Trials in 2009</th>
<th>Reduction in spray use</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd June</td>
<td>40%</td>
</tr>
<tr>
<td>17th June</td>
<td>18%</td>
</tr>
<tr>
<td>6th July</td>
<td>0.3%</td>
</tr>
<tr>
<td>Trials in 2010</td>
<td></td>
</tr>
<tr>
<td>27th May</td>
<td>25%</td>
</tr>
<tr>
<td>11th June</td>
<td>15%</td>
</tr>
</tbody>
</table>
SCRI Grant - Integrated Automation for Sustainable Specialty Crop Farming 2009 -2012

$US 3.9 million grant to develop a fully autonomous tractor with a canopy sprayer for citrus trees using LIDAR

CORNELL PRECISION SPRAYER

- Adjusting airflow louvre
- Adjusting liquid flow
The objective of this work is to validate a method of measuring canopy density.

wave intensity (V) vs. time (µs)

- Start ranging: t1
- Stop ranging: t2
- Time to start up: t2 - t1

Waveform (pin 2)
- Wave emission
- Ranging switch (pin 4)

ROI
Introducing a probe to count the number of leaf layers

- The frames have 4 horizontal bars, matching the ultrasonic sensors’ height.
- Each horizontal bar has 6 marks spaced 10 cm apart

Vineyard (Vignoles) over the 2015 season
var. Macoun
Adjusting liquid flow


Adjusting liquid flow

Airflow and sensor trials, *var.* Aceymac, Lamont Fruit farms 2014 & 2015

Adjust airflow to match canopy size based upon canopy density

NO AIR ADJUSTMENT

CORRECT AIR ADJUSTMENT
branches and
100 of leaves
LAI: 8.17

branches and
35% of leaves
LAI: 2.91

branches and
2% of leaves
LAI: 0.16

reference

ultrasound signal (%)
Air flow regulation system – SARDI fans, Lamont Fruit Farms 2016

![Graph showing wind speed (m/s) vs. fan power (%)](image)

- Optimum for ultrasound at 56%
- Before tree
- After tree
- Reduction
Results of flow rate adjustment

Cornell sensor system: flow rate (from 0.026 to 6.6 gpm at 60 psi, 0.1 to 25 L/min at 4 bar)
### Deposition results

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Configuration</th>
<th>Pressure PSI</th>
<th>Flow rate GPM</th>
<th>Ground speed MPH</th>
<th>Applied Volume GPA</th>
<th>Savings %</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>CONVENTIONAL</td>
<td>101</td>
<td>3.12</td>
<td>2</td>
<td>112.89</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>PROPORTIONAL</td>
<td>93-126</td>
<td>0.68-6.27</td>
<td>2</td>
<td>87.2</td>
<td>22.7</td>
</tr>
</tbody>
</table>

Deposition normalized results (mean ±SE). Different letters indicate that there is a significant difference between treatments for each stage.
Monitoring the sprayer. CU orchard trial with rtkGPS at Singer Farms (Jim Bittner)

**Management**
- Have all the rows been sprayed?
- Why is there disease/insect activity just in this area?

**Traceability**
- How much has been applied?
- Has this row been sprayed twice?
- What products have been applied?
The concept

GPS
Flowmeters
Datalogger
GIS map
4 row Croplands sprayer for spraying the canopy from one-side with adjustable air fans
Fibre wrap plant protection 2008