Crop-Adapted Spraying

optimizing apple orchard pesticide rates

Dr. Jason Deveau  ●  OMAFRA Application Technology Specialist  ●  2016
• Most pesticide label rates reflect the area of the planting (e.g. L/ha), not the area-density of the plant canopy

• A fixed, prescribed spray volume and/or rate is insufficient to match Ontario’s apple orchard variability

• A hectare of corn is a hectare of corn, but a hectare of apple trees...
Most orchards are soaked at ~2,000 L/ha.

Once a leaf is saturated, the threshold has been reached and the rest pours off.

Apogee

Coverage
The spray should be directed to the portion of the tree where growth control is desired. To achieve good coverage, use sufficient water, proper spray pressure, nozzles, nozzle spacing, spray volume per hectare, and tractor speed.

Tree Size: Calculate the Apogee rate per hectare based on tree size. The application rate should be based on the volume of water needed to spray the trees to drip (i.e., dilute spray or Tree Row Volume).
Are orchard label rates relevant?

- With no standard application method, tree spacing, tree structure or coverage pattern required for registration, we have to admit that labels aren’t as relevant as they could be.

- Evidence: Excellent work by Cross & Walklate (U.K.) demonstrated that a fixed rate across variable orchards provides suitable coverage <50% of the time.
Possible impacts

<table>
<thead>
<tr>
<th>Over Spraying</th>
<th>Under Spraying</th>
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<tbody>
<tr>
<td>&gt; Money in chemicals/time</td>
<td>&lt; Efficacy</td>
</tr>
<tr>
<td>&gt; Unnecessary contamination</td>
<td>&gt; Pest resistance over time</td>
</tr>
<tr>
<td></td>
<td>&gt; Spraying to compensate</td>
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</table>
In 2010, we started developing a model to address the issue

Based on international methods, the CAS model adjusts the amount of pesticide per unit ground area to achieve consistent foliar coverage for canopies of varying shape and density.

When achieved with sufficient accuracy, pesticide efficacy is maintained.
The method

- First, the operator has to calibrate the sprayer — basically, whatever “misses” is recovered and any excess is eliminated.

- The calibration is performed on for each significantly different block at the beginning of the season (and again around petal fall for semi dwarf).
Before calibration: as much as 75% of spray is wasted & coverage can be inconsistent.
Calibration (aiming)

- After calibration: waste is greatly reduced and coverage is more consistent

- The process is simple & qualitative: adjust travel speed, fan speed, air direction and nozzle #
Spray volume / distribution

- Orchard parameters & sprayer settings are entered into the calculator.

- The calculator (based on TRV, PACE+ and other models) proposes the ideal rate & nozzle distribution and saves to a spray record.

- The grower then confirms coverage with water-sensitive paper and makes a few tweaks to turn theory into reality.
Research & experience suggest a minimum of 85 medium sized droplets per cm$^2$ and a total area of 10-15% coverage is sufficient for most foliar insecticides / fungicides.
• Generally, pesticide rates take care of themselves, as long as the grower mixes the tank the same way they always have.

• This is no different than what most growers already do – we’ve just standardized the *ad hoc* process.

• Dose should be about concentration and coverage, not pesticide per planted area.
• Picture three different apple trees
The label rate works out to 1 g active / L

e.g. 1 g active / L
The applicator uses 1,000 L spray mix / ha

1,000 L / ha at 1 g active / L

e.g. 1 g active / L
e.g. 1 g active / L

1,000 L / ha at 1 g active / L

500 L / ha at 1 g active / L

250 L / ha at 1 g active / L

same coverage, same protection, different rates

Carrier

Active Ingredient
To be clear, the primary objective of this process is to achieve the same coverage in each block, no matter the size.

Reducing environmental loading and saving water / pesticide are wonderful secondary effects.
Preliminary Trials (2011)

• Based on CAS, one orchard applied \(~35\%\) less Mancozeb\(^\text{©}\) than label rate for one season (no control)
Saved $4,140.00 that year just for one fungicide
Surplus Pesticide
Harvest Quality
2012 – RIP Ontario apple blossoms

- Full trials included 2 orchards (year 1), 3 orchards (year 2) and 4 orchards (year 3)
- Sprayer operators used the optimized settings and rates for the CAS (treatment) block, and their typical methods for the control blocks
- Students scouted weekly for 13-15 weeks and apples were collected at harvest
### Full Trials (2013-2015)

<table>
<thead>
<tr>
<th>Orchard</th>
<th>Typical spray volume (Control)</th>
<th>CAS spray volume (Treatment)</th>
<th>% Savings</th>
<th>Varieties (age)</th>
<th>Orchard Structure</th>
<th>Years in study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchard 1</td>
<td>486 L/ha</td>
<td>373 L/ha</td>
<td>23%</td>
<td>Gala + g. Del (~10 yr)</td>
<td>High density</td>
<td>3</td>
</tr>
<tr>
<td>Orchard 2</td>
<td>748 L/ha</td>
<td>478 L/ha &amp; 608 L/ha = 543 L/ha</td>
<td>28%</td>
<td>Macs + Empires (~30 yr)</td>
<td>Semi dwarf</td>
<td>3+</td>
</tr>
<tr>
<td>Orchard 3</td>
<td>577 L/ha (660 L/ha)</td>
<td>407 L/ha</td>
<td>29%</td>
<td>Gala + Fuji (~20 yr)</td>
<td>High density</td>
<td>2</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>544 L/ha</td>
<td>416 L/ha</td>
<td>33%</td>
<td>Jonogold (~10 yr)</td>
<td>High density</td>
<td>1+</td>
</tr>
</tbody>
</table>
Sample CAS calibration
(Orchard 3, 2014)

April 17, 2014, 10:00-12:30 am, 14°C, ~65% RH, Wind 7-10 km/h

660 L/ha
18 nozzles

Control
22.3% / 161 d/cm²
57.7% / 68 d/cm²
23.3% / 150 d/cm²
50.2% / 150 d/cm²

400 L/ha
18 nozzles

Trial 1
17.8% / 175 d/cm²
45.2% / 136 d/cm²
9.3% / 128 d/cm²
39% / 172 d/cm²

400 L/ha
16 nozzles

Trial 2
4.5% / 54 d/cm²
36.5% / 167 d/cm²
25.8% / 195 d/cm²
32.7% / 194 d/cm²

400 L/ha
14 nozzles

Trial 3
17.6% / 141 d/cm²
56.6% / 94 d/cm²
17.6% / 127 d/cm²
21.6% / 140 d/cm²

(Ideal coverage: 10-15% / 85 drops / cm²)
Sample CAS calibration (Orchard 2, pre petal-fall 2014)

May 2, 2014, 9:00-10:30 am, 9°C, ~95% RH (drizzle), Wind 9-14 kmh

748 L/ha
20 nozzles

748 L/ha
20 nozzles

(Ideal coverage: 10-15% / 85 drops /cm²)
Sample CAS calibration (Orchard 2, post petal-fall 2014)

June 11, 2014, 1:30 pm, 24.5°C, ~65% RH (drizzle), Wind 5-10 kmh

608 L/ha
20 nozzles

61% / n/a d/cm²

24% / 148 d/cm²

Position 1

100% / n/a d/cm²

11% / 161 d/cm²

Position 3

Position 4

Position 5

80% / n/a d/cm²

35% / 205 d/cm²

49% / n/a d/cm²

4% / 128 d/cm²

51% / n/a d/cm²

(Ideal coverage: 10-15% / 85 drops /cm²)
• **Students were not aware which condition was which** (blind scouting)

• **Scouting was ~weekly for each condition**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Method</th>
</tr>
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<tbody>
<tr>
<td>Number of trees</td>
<td>10 weekly</td>
</tr>
<tr>
<td>Tapping</td>
<td>2.5 taps per tree (25 total)</td>
</tr>
<tr>
<td>Leaves</td>
<td>5 leaves per tree (50 total)</td>
</tr>
<tr>
<td>Spurs/Terminals</td>
<td>10 per tree (100 total)</td>
</tr>
<tr>
<td>End-of-season Fruit</td>
<td>5 per tree at harvest (50 total)</td>
</tr>
</tbody>
</table>
Data analysis

"79.48% of all statistics are made up on up on the spot."

– John A. Paulos

- Data was non-parametric.

- Used the statistical software package “r” to run Kruskal-Wallis rank sum tests (an ANOVA that does not assume normalized data).

- P values above 0.05 mean populations are significantly different.
- Nova Scotia ran their own independent trials & reported no difference between blocks
• Sometimes counts were higher in the CAS block and sometimes in the control

• Of 128 block comparisons, only 3 were significantly different and CAS had the lowest counts in 2 of them

• Here are the 3 significantly different data sets:
Orchard 1, Year 2
European Red Mite (Active nymphs and adults)

Spray Threshold:
Early season: 5-7 active mites / leaf
Late season: 10-15 active mites / leaf

Highest count in a bag of 5 leaves: 130

Average Count per Leaf
(5 leaves per bag, from 10 trees per condition)
Results

Orchard 1, Year 3
European Red Mite (Active nymphs and adults)

Spray Threshold:
- Early season: 5-7 active mites / leaf
- Late season: 10-15 active mites / leaf

Highest count in a bag of 5 leaves: 124
Results

Orchard 1, Year 2
Two Spotted Spider Mite (Active nymphs and adults)

Spray Threshold:
- Early season: 5-7 active mites / leaf
- Late season: 10-15 active mites / leaf

Highest count in a bag of 5 leaves: 12

Average Count per Leaf
(5 leaves per bag, from 10 trees per condition)

Week

Bars indicate SEM
Destructive apple sampling

Jason Deveau

Tara Wiedeman

Kristy Grigg-McGuffin
• I’m not saying differences were significant, but they are intriguing…
Conclusions

• CAS worked in both high density and semi-dwarf orchards… whether I was there to help or not.

• Growers reported that these methods were intuitive and that they would be willing to expand their use of use CAS

• …in fact, I struggled to preserve the control blocks!
Conclusions

• There are 16,000 acres of commercial apple orchard in Ontario (Stats Canada, 2010)

• An acre needs $\sim1,000.00$ of insecticide and fungicide each year (2010 OMAFRA Economic Report on Apple Production)

• CAS has the potential to improving overall coverage while reducing inputs by a conservative 20%

• That’s a savings of $3,200,000.00$ per year!
• Labeled application rates should be structured as a ratio of formulated product to carrier, should state an ideal coverage standard, and state maximum allowances by time or by area (to cover REI & residue)

• Crop-Adapted Spraying (CAS) should become a recognized method for optimizing dosages (like tree-row-volume in the 60’s)
• Inventory your orchard airblast sprayers
• Inventory of your orchard blocks
• Optimal sprayer settings
• Propose a pesticide dose (water & product(s)/tank)
• Spray record emailed to user
**New Resource**

- **AB101** – A Handbook of Best Practices in Airblast Spraying
- >200 pages, >200 illustrations
- ebook, interactive PDF, spiral-bound
Thanks to

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- Lingwood Orchards (ON)
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