Exclusion nets: a step towards pesticide-free apple growing in North America
Growing organic apples is difficult in NE North America…
But how about growing without pesticides?

- If key pests can be controlled
- If diseases do not flare up
- If climate extremes are not too challenging
- If pollination can be achieved

Codling moth  Plum curculio  Tarnished plant bug  Apple maggot

©Photo : B. Drouin
Exclusion systems exist for tree fruit

- IRDA
- McGill
- Chouinard
- Severac
- Charlot
- Lefsrud
7-yr study 2012-2018

• Assess the effectiveness of a *complete* exclusion system for the prevention of apple fruit damage
  – Without using any pesticide or other sprays
  – On a ‘Honeycrisp’ high-density planting
  – Exclusion nets in place from bud-break to harvest

• Improve our knowledge of:
  – Primary and secondary pests and diseases, non-parasitic disorders
  – Photosynthesis and fruit quality
  – Pollination within / below nets
  – Nets and structure: strength, durability, ease of opening
Setup

- Cv. Honeycrisp / B9 (planted 2006)
- Zero sprays (no pesticides, growth regulators, fertilizers)
- Each plot: 10 m (12 trees)
- Compared treatments (6X):
  1) nets*
  2) No nets

*ProtekNet 60g/m clear HDPE
  - mesh: 0,95x1,9mm
  - light transmission: 93%
Collected data

- Fruit damage (insects, diseases and non-parasitic)
- Foliar pests populations
- Temperature and photosynthesis
- Fruit load and quality (color, size, firmness, sugars, etc.)
Installation - spring
Complete exclusion
Opening (for summer work)
Opening (for pollination)

2012: 40 h
2013: 24 h
2014: 19 h
2015: 20 h
2016: 24 h
Visited flowers

- Opened nets do not affect pollination behavior

**2015**

![Visits per 100 flowers](chart_2015)

**2014**

![Visits per 100 flowers](chart_2014)

- **Apis mellifera**
- Other hymenopteran pollinators
- Other pollinators

**Visit rates per 100 flowers**

- Two open nets
- Open Exclusion net
- Check (no nets)
Fruit pests (2012-2016)
(120 apples/unit, picked < 1 week from harvest)

Leafroller damage – 2012-2016

(Choristoneura rosaceana, Obliquebanded leafroller)

Average % damage at harvest

- 2012
- 2013
- 2014
- 2015
- 2016

Nets
No nets
Summer arthropods (2012-13-16)
(Various population indices, pests and beneficials)

- Leafhoppers
- Twospotted mite
- Red mite
- Rust mites
- Aphids
- Stigmaeid mites
- Phytoseid mites
- Aphid predators
- Ants

Average population levels

- No nets
- Nets

* Significant difference
Fruit and foliar diseases (3-5 years)

(Various indices)

<table>
<thead>
<tr>
<th>Disease</th>
<th>Average Level</th>
<th>Nets</th>
<th>No nets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire blight</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foliar rusts</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foliar scab</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit scab</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBFS</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Asterisk indicates significant difference between Nets and No nets.
Relative humidity – May-August

2015, 1 dot = 5-min average
Non-parasitic damage (2012-2016)
(120 apples/unit, picked < 1 week prior to harvest)

Average % damage at harvest

<table>
<thead>
<tr>
<th></th>
<th>Nets</th>
<th>No nets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Russeting</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Asymmetry</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hail</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

* * * *** *

Outil de formation du cueilleur de pomme
Photosynthesis and fruit quality (3-5 years)

(Various indices)

<table>
<thead>
<tr>
<th></th>
<th>No nets</th>
<th>Nets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits/cluster set</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maturity</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Firmness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeds/fruit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brix</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Average levels of various indices under different conditions.
Crop load vs pollination time

# average fruitlets / cluster

2015

<table>
<thead>
<tr>
<th>Time</th>
<th>0h</th>
<th>3h</th>
<th>2x3h</th>
<th>6h</th>
<th>2x6h</th>
<th>12h</th>
<th>18h</th>
<th>&gt; 100h</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>A</td>
<td>AB</td>
<td>AB</td>
<td>ABC</td>
<td>ABC</td>
<td>BC</td>
<td>CD</td>
<td>D</td>
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</tbody>
</table>

2014

<table>
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<tr>
<th>Time</th>
<th>0h</th>
<th>3h</th>
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<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>
Photosynthesis and fruit quality (3-5 years) (various indices)

- Chlorophyll/10
- Fluorescence (Fv/Fm)
- % red color
- Removed fruits/tree
- Fruit size (mm)
- Fruit weight (g)
- Yield (kg/tree)

Average levels

- Nets
- No nets
Air temperature – May-August

Average temperature in netted plots

Average temperature in un-netted plots

2015, 1 dot= 5-min average
Air temperature – May-August

- May
- June
- July
- August
- September
- October

Graph showing average temperature over time of day with two conditions: Nets and No nets.
Air temperature - July

Temperature (°C)

No nets
Nets

2013, 1 dot= 6-h average
Seven years of pesticide-free Honeycrisp:

• Requires investment (11$/m/10yr)
• Requires additional labour for pollination (0,60$/m/open day)
• Complicates thinning / other sprays
• Protects fruit from insects - except for OBLR
• Protects from birds / mammals
• Protects from mechanical injuries and hail
• Does not result in scab epidemic
• Does not significantly affect tree physiology
• Produces high-quality fruit
• May slow down fruit maturity by up to ca. 1 wk
First catch in Québec apple orchards: June 2014

Protection from BMSB

First established population detected in Montreal, August 2016
Acknowledgments

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  - IRDA - Quebec Apple Network
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  - Polytechnique Montreal

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  - Organic science cluster II (AAAC)
  - Innov’action (MAPAQ)
  - Québec Apple Growers
  - Dubois Agrinovation (nets)