Integrated pest management in pip fruit orchards and the challenge to control stink bugs (Pentatomidae)

Integrated Pest Management in horticulture: research for practice
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Pip fruit growing: A lot of potential pest outbreaks

APPLE

PEAR
Integrated Pest Management (IPM)

• “The rational application of a combination of biological, biotechnical, chemical, cultural or plant-breeding measures, whereby the use of plant protection products is limited to the strict minimum necessary to maintain the pest population at levels below those causing economically unacceptable damage or loss”.

• From “calendar (preventive) sprayings” with broad-spectrum products to “economic threshold sprayings” with selective products

• Beneficial arthropod populations increase and redress the balance between pests and their natural control agents, resulting in fewer catastrophic occurrences of crop damage

• EC Directive 2009/128: 2014, all pest control activity in agriculture in EU Member States should be conducted within an IPM framework

• In Belgian pip fruit growing: **IPM adoption already in 90-ties**
Integrated Pest Management (IPM)

Key principles of IPM in pip fruit growing

• Apple: key beneficial: predatory mite *Thyphlodromus pyri* for control of spider mites (*Panonychus ulmi*, *Tetranychus urticae*) and rust mites (*Aculus schlechtendali*)

• Pear: key beneficial: predatory bugs (*Anthocoris*, *Orius* sp.) for control of pear suckers (*Psyllids*, *Cacopsylla pyri*)
Life cycle pear sucker

<table>
<thead>
<tr>
<th>Overwintering adults</th>
<th>First generation</th>
<th>Second generation</th>
<th>3rd - 4th generation</th>
<th>Last generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Februar-April</td>
<td>May-June</td>
<td>Septem-October</td>
<td>Novem-Decem-Jan</td>
</tr>
</tbody>
</table>

- **Overwintering adults**
- **First generation**
- **Second generation**
- **3rd - 4th generation**
- **Last generation**

- Adults
- Eggs
- Larvaes
Controlling pear sucker spring

<table>
<thead>
<tr>
<th>Overwintering adults</th>
<th>First generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>March</td>
</tr>
<tr>
<td>April</td>
<td>May</td>
</tr>
</tbody>
</table>

- adults
- eggs
- larvae

- pyrethroids
- kaolin (multiple)
- oil
- thiacloprid

Min. 200 adults /100 beatings
Summer control pear sucker

<table>
<thead>
<tr>
<th>First generation</th>
<th>Second generation</th>
<th>3rd-4th generation</th>
<th>Last generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>June</td>
<td>July</td>
<td>August</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- First generation
  - May: adults
  - June: eggs
  - July: larvae

- Second generation
  - June: adults
  - July: eggs
  - August: larvae

- 3rd-4th generation
  - July: adults
  - August: eggs
  - September: larvae

- Last generation
  - August: adults
  - September: eggs
  - October: larvae

- Predatory bugs
  - Spirodiclofen
  - Abamectin/(spinosad)
  - Spirotetramat
  - Potassium bicarbonate
  - Thiamethoxam / Thiacloprid / Potassium bicarbonate
Preflowering treatments
Consequences for IPM system?

– 1st generation, before flowering (pyrethroid against adults, oil or repellent, thiacloprid on young larvae)

+ Anthocoris sp.
Field trials: Determining of side effects

Materials & Methods

- Random block design, macroplots (min. 40 trees) (mobile insects), 4 replicates
- Treatments with knapsack sprayer, Leaf Wall Area (LWA) dose expression
- Sampling of Anthocorids larvae and adults by fixed number of beatings per plot (10-20): One beating = 3 short solid beatings per branch, on 3 randomly chosen branches in centre of plot. Predatory bugs caught in beating tray (min. 40 cm x 50 cm) + counted for each plot. Number of larvae/adults registered separately.

Assessment of mortality (side effect):
Formula Abbott (%): Side effect = (\(C - T\)/\(C\)) * 100
\(C\) = average degree of beneficial population in untreated object
\(T\) = average degree of beneficial population in treated object

Statistical analysis: homogeneity of variances test(transformations), ANOVA: multiple comparisons (Duncan, Newman–Keuls) or Friedman (two-way ANOVA)

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>1st gen eggs (Ref Appl. A)</th>
<th>1st gen larvae (Ref. Appl. B)</th>
<th>2nd gen hatching eggs (Ref. Appl. C)</th>
<th>2nd gen larvae (Ref. Appl. D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>-</td>
<td>-</td>
<td>spirodiclofen (+ adjuvant)</td>
<td>spirodiclofen (+ adjuvant)</td>
</tr>
<tr>
<td>2.</td>
<td>-</td>
<td>pyrethroid</td>
<td>spirodiclofen (+ adjuvant)</td>
<td>spirodiclofen (+ adjuvant)</td>
</tr>
<tr>
<td>3.</td>
<td>-</td>
<td>thiacloprid</td>
<td>spirodiclofen (+ adjuvant)</td>
<td>spirodiclofen (+ adjuvant)</td>
</tr>
<tr>
<td>4.</td>
<td>kaolin(^a) or mineral oil</td>
<td>-</td>
<td>spirodiclofen (+ adjuvant)</td>
<td>spirodiclofen (+ adjuvant)</td>
</tr>
<tr>
<td>5.</td>
<td>kaolin(^a) or mineral oil</td>
<td>-</td>
<td>spirodiclofen (+ adjuvant)</td>
<td>abamectin(^b)</td>
</tr>
</tbody>
</table>

\(^{a}\) 1 or 3 applications, \(^{b}\) 1 or no application
Anthocoris nemoralsis & Cacopsylla pyri population dynamics
7 locations

FLOWERING
First flowers open: 07/04
Full bloom: 14/04
End of flowering: 05/05

Psylla pyri adults
Psylla pyri eggs
Psylla pyri larvae

Anthocoris adults
Anthocoris Larvae
Orius adults

Numbers per 10 shoot/clusters or beatings
Example of results for one location

No statistical differences!

Mean number of Anthocoris larvae or adults

Check / spirodiclofen + adjuvant (D)
pyrethroid (C) / spirodiclofen + adjuvant (D)
thiacloprid + adjuvant (C) / spirodiclofen + adjuvant (D)
kaolin (AB) / spirodiclofen + adjuvant (D)
kaolin (AB) / spirodiclofen + adjuvant (D), abamectin (E)

Zoology department

IPM symposium BNL-SHS 07/03/2013
Conclusion for IPM system pear

• No statistical differences between check and thiacloprid objects in larvae of *Anthocoris* sp. in 5 large scale trials

• When statistical differences are found in the number of adults, no differences are found between thiacloprid and the selective IPM references

• thiacloprid can be used on a selective way when applied before flowering, before appearance of *Anthocoris* sp. in the orchard

= Selectivity based on timing of application
IPM in pear orchards

Only selective plant protection products
New challenges: increasing populations of secondary pests → economic threshold
IPM in pear orchards

Only selective plant protection products

New challenges: increasing populations of secondary pests

→ economic threshold

**Stink bug damage!**

- *Peribalus strictus*
- *Pentatoma rufipes*
- *Rhaphigaster nebulosa*
- *Palomena prasina*
- *Asopinae*: beneficial!

**Timing treatments /selectivity: which is causing main damage? How is life cycle?**
Stink bugs in pear orchards

Which species is mainly responsible for increasing damage?

→ *P. rufipes* correlation - damage pears
IPM control method: beat and kill

<table>
<thead>
<tr>
<th>Location</th>
<th>Method</th>
<th>Total</th>
<th>P. Rufipes stink bugs</th>
<th>Other stink bugs</th>
<th>% damage</th>
<th>Mean % damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huldenberg</td>
<td>Beat and kill</td>
<td>17</td>
<td>15</td>
<td>2</td>
<td>9.12</td>
<td>11.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>8.86</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>10.18</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>19.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>7.44</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>5.92</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>7</td>
<td>4.83</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>12.85</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meensel</td>
<td>Beat and kill</td>
<td>24</td>
<td>17</td>
<td>7</td>
<td>7.44</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13</td>
<td>5.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27</td>
<td>4.83</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54</td>
<td>12.85</td>
<td></td>
</tr>
</tbody>
</table>

Abbott control

- 29.9 %
- 5.4 %

→ Very labor intensive: variable efficacy results
Stink bugs in pear orchards

Population dynamics of *Pentatoma rufipes*?

### Dynamica van *P. rufipes* (2011, Huldenberg)

<table>
<thead>
<tr>
<th>Life stage</th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Huldenberg</td>
<td>Ezemaal</td>
</tr>
<tr>
<td>N1</td>
<td>16/7*</td>
<td>15/9</td>
</tr>
<tr>
<td>N2</td>
<td>&lt;15/9</td>
<td>&lt;15/9</td>
</tr>
<tr>
<td>N3</td>
<td>15/9</td>
<td>15/9</td>
</tr>
<tr>
<td>N4</td>
<td>29/5</td>
<td>16/4</td>
</tr>
<tr>
<td>N5</td>
<td>5/5</td>
<td>5/5</td>
</tr>
<tr>
<td>adult</td>
<td>16/7*</td>
<td>15/9</td>
</tr>
<tr>
<td>total</td>
<td>70/7*</td>
<td>70/7*</td>
</tr>
</tbody>
</table>

**Methods**

March-November, population of true bugs in pear orchards (cv. Conférence) was monitored by beating 3 times on 3 shoots of 50 trees twice a month. Collected bugs were identified (species, life stage, sex) and counted. Overwintering as nymph!
Stink bugs in pear orchards

Field trial: control efficacy sprayings

**Methods**
- Randomized microplot block design (6 trees/plot, 4 plots/treatment) in two pear orchards (cv. Conférence) using a motorized knapsack sprayer
- Assessments of *P. rufipes* in May and in June,
- Assessments of damaged fruit (%) in July
- Efficacy calculated as corrected mortality (%) according to Abbott (1925).

<table>
<thead>
<tr>
<th>Obj</th>
<th>Product</th>
<th>Active ingredient</th>
<th>Dose rate</th>
<th>App</th>
<th>Application time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check (untreated)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tracer 480 EC Spinosad</td>
<td>0.3 l/LWA</td>
<td>1</td>
<td>March 15 (early season)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tracer 480 EC Spinosad</td>
<td>0.3 l/LWA</td>
<td>1</td>
<td>April 1 (before bloom)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Tracer 480 EC Spinosad</td>
<td>0.3 l/LWA</td>
<td>2</td>
<td>March 15 + April 19</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>naturabell Bio insect 180 EC Pyrethrum + Piperonylbut</td>
<td>3 l/LWA</td>
<td>1</td>
<td>March 15 (early season)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>naturabell Bio insect 180 EC Pyrethrum + Piperonylbut</td>
<td>3 l/LWA</td>
<td>1</td>
<td>April 1 (before bloom)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>naturabell Bio insect 180 EC Pyrethrum + Piperonylbut</td>
<td>3 l/LWA</td>
<td>1</td>
<td>April 19 (after bloom)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>naturabell Bio insect 180 EC Pyrethrum + Piperonylbut</td>
<td>3 l/LWA</td>
<td>2</td>
<td>March 15 + April 19</td>
<td></td>
</tr>
</tbody>
</table>
Stink bugs in pear orchards

Field trial: control efficacy sprayings

Presence of *P. rufipes* (Huldenberg 9/5/2011)

Mean number *P. rufipes* (4 trees)

Check

spinosad (Tracer)

pyrethroid (Compo Naturabell Bio Insect)

mid-March (early)

before flowering

mid-March + after flowering

after flowering (late)

mid-March (early)

before flowering

mid-March + after flowering

after flowering (late)
Stink bugs in pear orchards

Field trial: control efficacy sprayings

Stink bug mediated fruit damage (Huldenberg, 26/7/2011)

- Check
- Spinosad (Tracer)
- Pyrethroid (Compo Naturabell Bio Insect)

Mean fruit damage (4 trees)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>mid-March (early)</th>
<th>before flowering</th>
<th>mid-March + after flowering</th>
<th>after flowering (late)</th>
<th>mid-March (early)</th>
<th>before flowering</th>
<th>mid-March + after flowering</th>
<th>after flowering (late)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>35</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>35</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Spinosad (Tracer)</td>
<td>25</td>
<td>20</td>
<td>12</td>
<td>7</td>
<td>25</td>
<td>20</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Pyrethroid (Compo Naturabell Bio Insect)</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Abbott efficacy

% Abbott efficacy

mid-March (early)
before flowering
mid-March + after flowering
after flowering (late)
Stink bugs in pear orchards

Field trial: control efficacy sprayings

Field trial: treatments after harvest 2011 and before flowering 2012

<table>
<thead>
<tr>
<th>Damage fruits / control efficacy (%)</th>
<th>Treatment</th>
<th>% damage unsellable</th>
<th>% damage sellable</th>
<th>% Abbott</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Check</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>after harvest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>spinosad</td>
<td>a</td>
<td>ab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>after harvest +</td>
<td>a</td>
<td>ab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>before flowering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pyrethrum</td>
<td></td>
<td>b</td>
<td></td>
</tr>
</tbody>
</table>

- % damage unsellable
- % damage sellable
- % Abbott
Conclusion stink bug control pear (IPM/organic)

- Forest bug *Pentatoma rufipes* is main stink bug pest species in pear
- In contrast to many other stink bugs, *P. rufipes* overwinters on the fruit trees as small nymphs → become active early in the spring and cause damage to the fruits before and after bloom.

- Timing treatments crucial: directed on (more sensitive) nymphs!
- Control efficacy is depending on timing and products used.
  - Spinosad: best efficacies around/after flowering
  - Pyrethroid: best efficacies after harvest and before flowering

- IPM system: differences in side effects (pyrethroid = broad spectrum) on beneficial arthropods (predatory bugs etc..) have to be considered in timing of the treatments.
  → Timing of treatments = crucial aspect in IPM
Thanks to

- Colleagues pcfruit vzw
- CRA-W
- FOD Volksgezondheid RF 10/6231 PENTA-in-TOMIDAE
- IWT LA/110778
- CCBT

- Phytopharmaceutical companies for support field trials / product development
- Fruit growers for trial orchards
- And you for your attention!