Pome fruit case study and orchard system

Bart Heijne
WageningenUR/Applied Plant Research (WUR/PPO), the Netherlands
> Partners

- 9 countries
  - BE, CH, DK, DE, ES, FR, IT, NL, SE
- 11 major European pome fruit production area

Andrea Patocchi    Frank Hayer    Jörg Samietz
Andreas Naef       Franz Bigler   Jörn Strasssemeyer
Aude Alaphilippe   Gabriele Mack  José Hernandez
Bart Heijne        Gérard Gaillard Heinrich Höhn
Benoit Sauphanor   Isabelle Haynes Jan Buurma
Burghard Golla     Jesus Avilla   Ursula Aubert
Claire Lavigne     Joan Solé     Marko Bohanec
Daniel Cassado     Jan Buurma     Patrik Mouron
Ester Bravin
> Introduction

- integrated control well established
  - corner stones
    - spider mites – predatory mites
    - pear psylla – predatory bugs
    - wooly aphids – parasitoids and predators
    - codling moth – mating disruption
    - apple scab – warning system
- IPM practices known versus used
  - inventory on state of the art of IPM methods used
    - questionnaire
    - self expanding network
    - analyses
- orchard system assessment
  - future development
• long history - non-the-less: high pesticide use
• a lot of questions
  – what tools are available?
  – to what extent used in practice?
  – bottlenecks
    o why not used?
    o economic, practical, technical
• 3 pomefruit problems with high pesticide demand
  – codling moth (*Cydia pomonella*)
  – apple scab (*Venturia inaequalis*)
  – brown spot of pear (*Stemphylium vesicarium*)
Innovative control of codling moth

- warning systems (DSS)
  - further development
- pheromone disruption
  - RAK, Isomate
- virus
  - granulosis virus
- other techniques
> Innovative control of apple scab

- resistant cultivars
- warning systems (DSS)
  - Rimpro
  - further development ongoing
- sanitation
  - survival on fallen leaves
  - leaf shredding
  - urea
  - removing leaves from orchards
- antagonists
  - *Microsphaeropsis*
Brown spot of pear

- *Stemphylium vesicarium*
  - problem since 1980\textsuperscript{th} and increasing
  - north Spain, north Italy, Rhone valley, France, Belgium, Netherlands

- leaf drop and fruit rot
Results questionnaire

- only “ready to use” IFP (IPM) methods
  - no method “still under development”
- get realistic data
  - sometimes easy, difficult
  - very variable: difficult to summarise
- judgement
  - lighter color: positive for integrated system
  - darker color: negative
<table>
<thead>
<tr>
<th>IFP tool</th>
<th>no. regions</th>
<th>use in practice</th>
<th>obstacles</th>
</tr>
</thead>
<tbody>
<tr>
<td>pheromone traps</td>
<td>all</td>
<td>5 – 100</td>
<td>none</td>
</tr>
<tr>
<td>monitoring damage S</td>
<td>all</td>
<td>1 – 100</td>
<td>none</td>
</tr>
<tr>
<td>monitoring damage H</td>
<td>all</td>
<td>5 – 100</td>
<td>none</td>
</tr>
<tr>
<td>corrugated cardboards</td>
<td>none</td>
<td>1</td>
<td>labour</td>
</tr>
<tr>
<td>dss – adults</td>
<td>90</td>
<td>100</td>
<td>none</td>
</tr>
<tr>
<td>dss – oviposition</td>
<td>90</td>
<td>90</td>
<td>none</td>
</tr>
<tr>
<td>dss – larval emergence</td>
<td>all</td>
<td>100</td>
<td>none</td>
</tr>
<tr>
<td>dss – generations</td>
<td>90</td>
<td>90</td>
<td>none</td>
</tr>
<tr>
<td>dss – thresholds</td>
<td>50</td>
<td>70</td>
<td>none</td>
</tr>
<tr>
<td>IFP tool</td>
<td>no. regions</td>
<td>use in practice</td>
<td>obstacles</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>non chemical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sanitation</td>
<td>90</td>
<td>0 – 50</td>
<td>labour</td>
</tr>
<tr>
<td>mating disruption</td>
<td>100</td>
<td>25</td>
<td>labour, economic, practical</td>
</tr>
<tr>
<td>granulosis virus</td>
<td>90</td>
<td>10 – 100</td>
<td>practical</td>
</tr>
<tr>
<td>combinations</td>
<td>90</td>
<td>variable, low</td>
<td>labour, economic</td>
</tr>
<tr>
<td>chemical control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>priority IGR ´s</td>
<td>50</td>
<td>20</td>
<td>none</td>
</tr>
<tr>
<td>alternation IGR ´s</td>
<td>80</td>
<td>80</td>
<td>none</td>
</tr>
</tbody>
</table>
## Summary brown spot of pear

<table>
<thead>
<tr>
<th>IFP tool</th>
<th>no. regions</th>
<th>use in practice</th>
<th>obstacles</th>
</tr>
</thead>
<tbody>
<tr>
<td>population monitoring</td>
<td>75</td>
<td>75 – 90</td>
<td>economic</td>
</tr>
<tr>
<td>decision support</td>
<td>all</td>
<td>5 – 100</td>
<td>none</td>
</tr>
<tr>
<td>sanitation</td>
<td>all</td>
<td>0 – 5</td>
<td>labour</td>
</tr>
<tr>
<td>non chemical methods</td>
<td>none</td>
<td>0</td>
<td>technical</td>
</tr>
<tr>
<td>chemical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>protectant fungicides</td>
<td>all</td>
<td>100</td>
<td>none</td>
</tr>
<tr>
<td>alternation</td>
<td>all</td>
<td>90</td>
<td>none</td>
</tr>
<tr>
<td>resistant cultivars</td>
<td>none</td>
<td>0</td>
<td>economic, practical</td>
</tr>
</tbody>
</table>
### Summary apple scab

<table>
<thead>
<tr>
<th>IFP tool</th>
<th>no. regions</th>
<th>use in practice</th>
<th>obstacles</th>
</tr>
</thead>
<tbody>
<tr>
<td>cultural methods</td>
<td>50</td>
<td>0 – 10</td>
<td>economic, technical</td>
</tr>
<tr>
<td>monitoring</td>
<td>90</td>
<td>10 – 70</td>
<td>labour</td>
</tr>
<tr>
<td>decision support</td>
<td>all</td>
<td>50 – 100</td>
<td>none</td>
</tr>
<tr>
<td>sanitation</td>
<td>all</td>
<td>0 – 70</td>
<td>labour</td>
</tr>
<tr>
<td>chemical control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>protectant fungicides</td>
<td>all</td>
<td>100</td>
<td>none</td>
</tr>
<tr>
<td>alternation</td>
<td>all</td>
<td>90</td>
<td>none</td>
</tr>
<tr>
<td>resistant cultivars</td>
<td>none</td>
<td>0</td>
<td>none</td>
</tr>
</tbody>
</table>
> Conclusions questionnaire

- knowledge IFP methods: quickly and well spread
- spreading: governmental or private
  - extension services or advisors
- decision support systems: widely used
  - information by modern communication (SMS, e-mail, website)
- ready to use IPF tools: used everywhere in Europe
  - no differences between northern or southern regions
- resistant cultivars: not used!
  - except organic growers
- lack of selective pesticides
- registration of products is tedious and costly

- hindrances to implement: e.g. economic & labour
  - development: assessment methodology orchard systems
Background

- directive 2009/128/EC « sustainable use of pesticides »
  - integrated pest management
    - careful consideration of all methods
    - discourage harmful organisms
    - keep intervention at economically and environmentally level
    - minimise risk to human health & environment

- Orchard system case study
  - goal:
    - develop methodology to assess possible future orchard systems
      - in line with 2009/128/EC
      - quantitative
SustainOS methodology

System description
Context, Target and Crop protection parameters

Quantitative assessment methods
- Life Cycle Analysis (LCA)
- Environmental Risk Assessment (SYNOPS)
- Full cost calculation (Arbokost)

Rating aggregated attributes

Overall Sustainability

Rating basic attributes of ecological and economic sustainability

Hierarchical attribute tree

(a) System description
(b) Quantitative assessment methods
(c) Rating basic attributes
(d) Rating aggregated attributes
(e) Overall Sustainability
Orchard systems

- 4 apple orchard systems defined
  - base line system (BS)
  - advanced system 1 (AS1)
  - advanced system 2 (AS2)
  - innovative system (IS)

- Base line system (BS)
  - good practices
    - resistance management
    - beneficial organisms
  - pesticides allowed in 2009
    - only synthetic
  - common (susceptible) apple cultivars
  - no drift reduction other than 3 m buffer zone
Advanced systems

- Advanced system 1 (AS1)
  - good and best practices
  - apple scab resistant cultivars
  - mating disruption (codling moth), more hail nets, predatory mites, bio control (e.g. fire blight), cover crop
  - pesticides with low ecotoxicity (more antagonists)
  - drift reduction: 45 % of area

- Advanced system 2 (AS2)
  - similar to AS1 + . . .
  - mechanical weeding, exclosure netting, natural fungicides after bloom - no residues
  - drift reduction: 80 % of area
Innovative system (IS)

- like AS2 + . . .
  - cultivars with multiple resistance
    - apple scab
    - powdery mildew
    - fire blight
    - aphids
  - new pesticides, with
    - selective
    - no effects on non target organisms
Parameters

- context parameters
  - overall quality parameters
  - orchard quality
  - infrastructure quality
  - drift reduction
  - decision support systems (dss)
  - labour

- target parameters
  - target yield
  - target price
  - impact on arthropods
  - impact on diseases
  - impact on beneficial organisms
Comparison

- context parameters are region specific
  - no comparison possible between European regions
  - comparison between future orchard systems within a region
- basic quantitative information to describe and assess orchard systems
  - methods to control pests
    - synthetic pesticides
    - non chemical methods
  - date of application
  - dose
  - drift
  - etc.
### Example

#### Available alternative methods

<table>
<thead>
<tr>
<th>Options</th>
<th>BS chosen options</th>
<th>target organisms</th>
<th>AS1 chosen options</th>
<th>target organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mating disruption</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2 attract and kill</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3 sanitary methods</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>4 massstrapping</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5 enclosure netting</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6 EPN (Nematodes)</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td>7 predators/parasitoids</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8 resistant varieties/rootstocks</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9 push and pull plants/cultivars (attractance and repellance)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### Insecticides / Acaricides

<table>
<thead>
<tr>
<th>Insecticide group</th>
<th>Active ingredient</th>
<th>kg/l product per ha</th>
<th>% active ingredient</th>
<th>g a.i. per ha</th>
<th>Number of applications</th>
<th>g AI per ha and season</th>
<th>BS chosen options</th>
<th>target organisms</th>
<th>AS1 chosen options</th>
<th>target organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pheromones</td>
<td>codlemone a.o.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>16</td>
<td>0</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2 granulovirus</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>16</td>
<td>0</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>3 IGR's (moulting inhibitors)</td>
<td>novaluron</td>
<td>0.96</td>
<td>10%</td>
<td>96</td>
<td>0,5</td>
<td>22</td>
<td>48</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
</tr>
<tr>
<td>4 IGR's (ecdysone mimics)</td>
<td>methoxefenozid</td>
<td>0.64</td>
<td>24%</td>
<td>153.6</td>
<td>1</td>
<td>27</td>
<td>153.6</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
</tr>
<tr>
<td>5 IGR's (Jh mimics)</td>
<td>fenoxycarb</td>
<td>0.96</td>
<td>25%</td>
<td>240</td>
<td>0.5</td>
<td>20</td>
<td>120</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
</tr>
<tr>
<td>6 various</td>
<td>indoxacarb</td>
<td>0.37</td>
<td>30%</td>
<td>81</td>
<td>1</td>
<td>31</td>
<td>81</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
</tr>
<tr>
<td>7 neonicotinoids</td>
<td>flicamid</td>
<td>0.16</td>
<td>50%</td>
<td>80</td>
<td>1</td>
<td>25</td>
<td>80</td>
<td>x</td>
<td>x</td>
<td>1</td>
</tr>
<tr>
<td>8 neonicotinoids</td>
<td>thiacloprid</td>
<td>0.32</td>
<td>40%</td>
<td>128</td>
<td>1</td>
<td>20</td>
<td>128</td>
<td>x</td>
<td>x</td>
<td>1</td>
</tr>
<tr>
<td>9 organophosphates</td>
<td>chlorpyrifos-ethyl</td>
<td>2.4</td>
<td>23%</td>
<td>552</td>
<td>0.5</td>
<td>17</td>
<td>276</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
</tr>
<tr>
<td>10 acaricides</td>
<td>tebufenpyrad</td>
<td>0.32</td>
<td>20%</td>
<td>64</td>
<td>1</td>
<td>20</td>
<td>64</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
</tr>
<tr>
<td>11 oil</td>
<td>32</td>
<td>95%</td>
<td>30400</td>
<td>0.25</td>
<td>12</td>
<td>7600</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
<td>12</td>
</tr>
<tr>
<td>12 novel insecticide without non-target effects</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>x</td>
<td>x</td>
<td>0.33</td>
<td>12</td>
</tr>
</tbody>
</table>

**Necessary number of sprays (drive trough orchard):**

- **AS1:**
  - codling moth: 1
  - other lepidopteres: 1
  - aphids: 1
  - mites: 1
  - Other pests: 0

- **BS:**
  - codling moth: 2
  - other lepidopteres: 2
  - aphids: 2
  - mites: 2
  - Other pests: 1

---

**Notes:**

- IGR's (ecdysone mimics): Insect growth regulators that mimic the ecdysteroid hormone, leading to dysregulation of the insect's growth and development.
- EPN (Nematodes): Entomopathogenic nematodes, which inject viral or bacterial pathogens into the insect's body, leading to its death.
- Active ingredient: The chemical compound in the pesticide that is responsible for killing the target organism.
• parameters chosen
  – adequate to describe apple orchard systems
  – useful for quantitative data collection
  – collected data
    o can be changed for different situations/conditions, European regions
    o are valid now, but should be renewed, if an assessment is made e.g. 10 years from now

• results
  – apple orchards
  – can be adapted for other crops (PURE)
  – direct policy makers and decision makers

  – detailed results in next presentations