Fourth European Workshop on

Standardized Procedure for the Inspection of Sprayers in Europe -SPISE 4-

27 to 29 March 2012 – Lana (Italy)
Session 2: Member States may apply different timetables and inspection intervals with exceptions following a risk assessment and exempt handheld pesticide application equipment or knapsack sprayers.
The trials on the influence of knapsack sprayer technical condition on operator exposure as an input to the risk assessment for human health

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Question

Should we inspect knapsack sprayers?

Maybe it is so simple equipment, that no damages influence on the effects of the spraying and safety of the operator?
The aim of the trials

- The assessment of the influence of knapsack sprayer technical condition on its operator exposure during spraying of three different types of crops
- The tests were carried out for:
  - undamaged efficient knapsack sprayer
  - the sprayer with damaged nozzle (scraped outlet)
  - the sprayer with damaged gun valve (permanently opened)
- Tests were carried out in:
  - low crop (strawberries)
  - medium loose crop (young orchard)
  - high dense crop (bearing fruits orchard)
Material and methods

Knapsack sprayers

- **Kwazar - Neptune 15** (Kwazar Corporation, Poland)
- **Solo 425** (SOLO Kleinmotoren GmbH, Germany)

Nozzle: Lechler LU 120-04 1.55 l/min @ 3 bar; medium drops: VMD 240 µm
Material and methods

crops

- **Low crop (strawberries):**
  - row distance: 1.0 m
  - spraying of two neighboring rows – plot 40 m long

- **Medium loose crop (young apple orchard):**
  - height to 1.80 m, row distance 4.0 m
  - spraying of one row – plot 30 m long

- **High dense crop (bearing fruits apple orchard):**
  - height to 3.0 m, row distance 4.0 m
  - spraying of one row – plot 20 m long
## Material and methods

**crops**

<table>
<thead>
<tr>
<th>Low crop</th>
<th>Medium-loose crop</th>
<th>High-dense crop</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="Low_crop.png" alt="Image" /></td>
<td><img src="Medium-loose_crop.png" alt="Image" /></td>
<td><img src="High-dense_crop.png" alt="Image" /></td>
</tr>
<tr>
<td><img src="Low_crop_2.png" alt="Image" /></td>
<td><img src="Medium-loose_crop_2.png" alt="Image" /></td>
<td><img src="High-dense_crop_2.png" alt="Image" /></td>
</tr>
</tbody>
</table>

*Images show different crop densities with workers applying treatments.*
Material and methods

operators

- Height ca 175-180 cm:
  - operator 1 – experienced (aged 57 years)
  - operator 2 – inexperienced (aged 27 years)
Material and methods

**spray liquid**

- Water solution of BSF fluorescent tracer (0.3%)
  - (Brilliant Sulfoflavin, WALDECK-GmbH & Co KG DIVISION CHROMA – Germany)
- Spray volume: 5 or 10 l for one trial
Material and methods

- Technofil filter fiber (5 x 10 cm) Technofil B.V., NL
- Protective gloves (nitryl) Ansell Healthcare, BE
### Samples location

<table>
<thead>
<tr>
<th>Location</th>
<th>Area (cm²)</th>
<th>Sample no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>3550</td>
<td>1</td>
</tr>
<tr>
<td>Back</td>
<td>3550</td>
<td>Mean for 2, 3, 4</td>
</tr>
<tr>
<td>Shoulder R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper arm R</td>
<td>1455</td>
<td>5</td>
</tr>
<tr>
<td>Upper arm L</td>
<td>1455</td>
<td>6</td>
</tr>
<tr>
<td>Forearm R</td>
<td>605</td>
<td>7</td>
</tr>
<tr>
<td>Forearm L</td>
<td>605</td>
<td>8</td>
</tr>
<tr>
<td>Thigh R</td>
<td>1910</td>
<td>9</td>
</tr>
<tr>
<td>Thigh L</td>
<td>1910</td>
<td>10</td>
</tr>
<tr>
<td>Lower leg R</td>
<td>1190</td>
<td>11</td>
</tr>
<tr>
<td>Lower leg L</td>
<td>1190</td>
<td>12</td>
</tr>
<tr>
<td>Head</td>
<td>1300</td>
<td>13</td>
</tr>
<tr>
<td>Glove R</td>
<td>Whole area rinsed</td>
<td>14</td>
</tr>
<tr>
<td>Glove L</td>
<td>Whole area rinsed</td>
<td>15</td>
</tr>
</tbody>
</table>
Material and methods

how we did it

- Operators in protective overals (Tyvek® by DuPont™)
- Samples placed on overals in 13 locations + gloves
- In each location two samples
Material and methods

how we did it

- Samples were taken off in two steps:
  - a set of 15 samples each time
  - after spraying of 5 l of BSF solution
  - after spraying of following 10 l of BSF solution
Material and methods

**analysis**

- **Rinsing with deionized water:**
  - Technofil filter fiber: 100 ml, protective gloves: 300 ml

- **Shaking for 15 min**
  - frequency: 162 cycles·min⁻¹, amplitude: 40 mm

- **Measurement of the BSF concentration**
  - spectrofluorometer PerkinElmer LS 55
Material and methods

calculation of the operator exposure

• Taking into account:
  • concentration of rinsed BSF
  • rinsing volume: 100 or 300 ml
  • fiber sample area: 50 cm$^2$
  • body surface area: depending on location
  • the amount of BSF tracer sprayed out in the trial (15 or 45 g)

• As:
  • TOTAL exposure (13 locations on overal + 2 gloves)
  • PARTIAL exposure (without deposition on lower legs and gloves)

• Expressing in w ppm of the dose applied
Results

Achieved spray volumes

- **Trial duration:**
  - (5 l) 3-5 min
  - (10 l) 6-11 min
  - (5+10 l) 10-15 minutes

- **Achieved spray volumes:**
  - Low crop: 280÷660 l·ha⁻¹
  - Medium crop: 110÷220 l·ha⁻¹
  - High crop: 150÷370 l·ha⁻¹
Results
mean exposure of body parts (ppm)

- **Low crop**
- **Medium crop**
- **High crp**
Exposure (ppm)
Low crop

- Total Experienced
  - A
  - B
  - AB

- Total Unexperienced
  - A
  - B
  - AB

- Partial Experienced
  - a
  - a
  - a

- Partial Unexperienced
  - a
  - a
  - a

Legend:
- Efficient
- Damaged valve
- Damaged nozzle

Note: Exposures are shown in ppm (parts per million).
Exposure (ppm)
Medium-loose crop

- Efficient
- Damaged valve
- Damaged nozzle

- Total Experienced
- Total Inexperienced
- Partial Experienced
- Partial Inexperienced

1,80 m
Exposure (ppm)
High-dense crop

- Total Experienced
- Total Inexperienced
- Partial Experienced
- Partial Inexperienced

Efficient
Damaged valve
Damaged nozzle

A A A A
A A A A
A A A A
A A A A

3,00 m
Let me remind some definitions

- **AOEL** – Acceptable Operator Exposure Level:
  - The maximum amount of the active ingredient (a.i.) of PPP on which the operator may be exposed, without any adverse effects on his health. Expressed in mg/kg of body weight.

- **BBA model** – BBA mathematic model used to assess the predicted operator exposure level (dermal and inhalation exposure during mixing/loading and spraying), expressing in mg/kg bw/day.

- **UK-POEM model** – Predictive Operator Exposure Model, British Model, expressing in mg/kg bw/day.
**BBA model vs. UK-POEM model**

<table>
<thead>
<tr>
<th>Factors taken into account</th>
<th>BBA model</th>
<th>UK-POEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application method</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product formulation</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>PPP dose</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Spray volume</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Level of dermal absorption</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Work rate / day - ha</td>
<td>Yes - 1 ha</td>
<td>Yes - 1 ha</td>
</tr>
<tr>
<td>Work rate / day - duration</td>
<td>No</td>
<td>6 hrs</td>
</tr>
<tr>
<td>Operator body weight</td>
<td>70 kg</td>
<td>60 kg</td>
</tr>
<tr>
<td>No</td>
<td>PPP name</td>
<td>A.I.</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td><strong>High-dense crop</strong></td>
<td></td>
</tr>
<tr>
<td>PPP 1</td>
<td>Pirimor 500 WG</td>
<td>pirymikarb</td>
</tr>
<tr>
<td>PPP 2</td>
<td>Sadoplon 75 WP</td>
<td>tiuram</td>
</tr>
<tr>
<td>PPP 3</td>
<td>Redlan 400 EC</td>
<td>chlorpyrifos metylowy</td>
</tr>
<tr>
<td>PPP 4</td>
<td>Pennfluid 420 SC</td>
<td>mankozeb</td>
</tr>
<tr>
<td>PPP 5</td>
<td>Owadofos Extra 480 EC</td>
<td>chlorpyrifos</td>
</tr>
<tr>
<td></td>
<td><strong>Medium-loose crop</strong></td>
<td></td>
</tr>
<tr>
<td>PPP 6</td>
<td>Sparta 250 EW</td>
<td>tebukonazol</td>
</tr>
<tr>
<td>PPP 7</td>
<td>Ammo Super 100 EW</td>
<td>z-cypermetryna</td>
</tr>
<tr>
<td>PPP 8</td>
<td>Bumper 250 EC</td>
<td>propikonazol</td>
</tr>
<tr>
<td>PPP 9</td>
<td>Captan 80WG</td>
<td>kaptan</td>
</tr>
<tr>
<td>PPP 10</td>
<td>Mospilan 20 SP</td>
<td>acetamipryd</td>
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<tr>
<td></td>
<td><strong>Low Crop</strong></td>
<td></td>
</tr>
<tr>
<td>PPP 11</td>
<td>Roundup max 680 SG</td>
<td>glifosat</td>
</tr>
<tr>
<td>PPP 12</td>
<td>Starane 250 EC</td>
<td>fluroksypyr</td>
</tr>
<tr>
<td>PPP 13</td>
<td>Chwastox 750 SL</td>
<td>MCPA-DMA</td>
</tr>
<tr>
<td>PPP 14</td>
<td>Amistar 250 SC</td>
<td>azoksystrobina</td>
</tr>
<tr>
<td>PPP 15</td>
<td>Mythos 300 SC</td>
<td>pirymetanil</td>
</tr>
<tr>
<td>AOEL mg/kg/day</td>
<td>PPP name</td>
<td>Efficient Sprayer</td>
</tr>
<tr>
<td>----------------</td>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>83/17</td>
</tr>
<tr>
<td>0,035</td>
<td>[I] Pirimor 500 WG</td>
<td>2400/315</td>
</tr>
<tr>
<td>0,02</td>
<td>[F] Sadoplon 75 WP</td>
<td>200/50</td>
</tr>
<tr>
<td>0,01</td>
<td>[I] Redlan 400 EC</td>
<td>46/23</td>
</tr>
<tr>
<td>0,035</td>
<td>[F] Pennfluid 420 SC</td>
<td>900/140</td>
</tr>
<tr>
<td>0,01</td>
<td>[I] Owadofos Extra 480 EC</td>
<td>267/10</td>
</tr>
<tr>
<td>0,03</td>
<td>[F] Sparta 250 EW</td>
<td>50/2,5</td>
</tr>
<tr>
<td>0,02</td>
<td>[I] Ammo Super 100 EW</td>
<td>10/0,8</td>
</tr>
<tr>
<td>0,1</td>
<td>[F] Bumper 250 EC</td>
<td>200/30</td>
</tr>
<tr>
<td>0,124</td>
<td>[I] Mospilan 20 SP</td>
<td>15/1,6</td>
</tr>
<tr>
<td>0,2</td>
<td>[H] Roundup max 680 SG</td>
<td>25/5</td>
</tr>
<tr>
<td>0,8</td>
<td>[H] Starane 250 EC</td>
<td>21/1</td>
</tr>
<tr>
<td>0,04</td>
<td>[H] Chwastox 750 SL</td>
<td>200/17,5</td>
</tr>
<tr>
<td>0,1</td>
<td>[F] Amistar 250 SC</td>
<td>40/2,7</td>
</tr>
<tr>
<td>0,12</td>
<td>[F] Mythos 300 SC</td>
<td>92/14</td>
</tr>
</tbody>
</table>
Summary:

- Spraying of higher crops may favour the increase the operator exposure in comparison to low crops (up to 3110 ppm in high crop and up to 1404 ppm in medium one in comparison to 756 ppm in low crop).
- The maximum increase of the operator exposure due to crop type and operator experience ranges from 7x in low crop, thru 15x in medium one to 31x in high crop.
- The maximum increase of exposure for experienced operator due to the technical condition of the knapsack sprayer may occur in higher crops (up to 15x in comparison to <2x in other crops).
- The inexperience of the operator may influence on the 7-fold increase of his exposure in the low crop in comparison to ca 2-fold in other crops.
- On the lower leg there was found up to 94% of the total spray found on the operator overall in comparison to up to 48% in medium crop and up to 23% in high crop. It shows that in low crop. High protective boot may be enough, but in higher crops the operator needs more PPE.
- The in silico modeling showed the influence of sprayer technical condition on operator exposure only for 2/5 PPP’s during applications in high crops.
Thanks
% AOEL acc. to BBA model

High dense crop – efficient sprayer

<table>
<thead>
<tr>
<th>PPP</th>
<th>No PPE</th>
<th>With PPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPP1</td>
<td>83</td>
<td>17</td>
</tr>
<tr>
<td>PPP2</td>
<td>315</td>
<td>200</td>
</tr>
<tr>
<td>PPP3</td>
<td>2400</td>
<td>200</td>
</tr>
<tr>
<td>PPP4</td>
<td>900</td>
<td>140</td>
</tr>
<tr>
<td>PPP5</td>
<td>140</td>
<td>140</td>
</tr>
</tbody>
</table>
% AOEL acc. to BBA model
Medium-loose crop – efficient sprayer

PPP6  PPP7  PPP8  PPP9  PPP10
267   50   10  30   15
10    1    1    2

No PPE
With PPE
% AOEL acc. to BBA model

Low crop – efficient sprayer

![Bar chart showing % AOEL for different PPPs with and without PPE](chart.png)
% AOEL acc. to BBA model

High dense crop – gun valve damaged

<table>
<thead>
<tr>
<th>PPP1</th>
<th>PPP2</th>
<th>PPP3</th>
<th>PPP4</th>
<th>PPP5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1226</td>
<td>254</td>
<td>2960</td>
<td>740</td>
<td>3806</td>
</tr>
<tr>
<td>35520</td>
<td>4662</td>
<td>3806</td>
<td>740</td>
<td>592</td>
</tr>
</tbody>
</table>

- Red: No PPE
- Green: With PPE
% AOEL acc. to BBA model
Medium-loose crop – gun valve damaged
% AOEL acc. to BBA model
Low crop – gun valve damaged

<table>
<thead>
<tr>
<th>PPP</th>
<th>No PPE</th>
<th>With PPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPP1</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>PPP2</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>PPP3</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>PPP4</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>PPP5</td>
<td>92</td>
<td>14</td>
</tr>
</tbody>
</table>
Drift (%) efficient sprayer

![Graph showing drift percentage vs. distance for different levels of experience.]

- Low-experienced
- Medium-Experienced
- High-Experienced
- Low-Inexperienced
- Medium-Inexperienced
- High-Inexperienced

Percent of dose applied (%) vs. Distance (m)
Results
operator exposure (ppm)
Let me remind some definitions

- **AOEL** – Acceptable Operator Exposure Level:
  - The maximum amount of the active ingredient (a.i.) of PPP on which the operator may be exposed, without any adverse effects on his health. Expressed in mg/kg of body weight.

- **BBA model** – BBA mathematic model used to assess the predicted operator exposure level (dermal and inhalation exposure during mixing/loading and spraying), expressing in mg/kg bw/day, taking into account:
  - Application method
  - Product and formulation type, PPP dose
  - Level of dermal absorption from product (typical for product)
  - PPE during mixing/loading and PPE during spraying
  - Work rate /day in ha (here 1 ha)
  - Operator body weight (70 kg)

- **UK-POEM model** – Predictive Operator Exposure Model, British Model, Taking into account:
  - Application method
  - Product and formulation type, PPP dose and spray volume
  - Level of dermal absorption from product (typical for product)
  - PPE during mixing/loading and spraying
  - Work rate /day in ha (here 1 ha) and duration of spraying (here 6 hours)
  - Operator body weight (60 kg)