A generic Decision Support System for integrated weed management

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and:
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Arnd Verschwele (JKI), Germany
Ole M Bojer, IPM Consult, Denmark

Poznan, 15th January 2015
Change of jobs

- Mr Per Rydahl and Mr Ole M Bojer

From 1 October, 2014:
- Owners of IPM Consult Ltd., Denmark (new SME)
- focus on DSS for IWM
- finalize DSS activities in PURE
EU-project ‘ENDURE’

- Analyses of 70 European DSS on IPM
- 9 DSS on weed control
- ‘Best parts’ in 3 DSS:
  1. ‘DecidHerb’
     - Weed Potential Threat (WPT)
  2. ‘CPO-weeds’
     - Target Efficacy (TE)
     - Herbicide dose-response functions
     - Optimization of herbicide tank-mixtures
  3. ‘GestInf’:
     - Economic Net Return (ENR)
New DSS – ideas of potential

- Weeds are not evenly distributed
- Different weeds cause different losses
- Different control measures provide different efficacy
- So, rational weed management is complex!
- Combine:
  - field reports
  - results from weed research and expert knowledge
  - legal restrictions
- Expected results:
  - safe control
  - legal control
  - reduced cost/TFI
  - good compliance with IPM
Decision flow

Field report → DSS → Treatment options

1) Multiple treatments -> multiple field reports

**DSS - ‘decision engine’:**
1. Needs for weed control (WPT / TE)
2. Legal restrictions
3. Herbicides and dose rates
4. Optimized tank-mixtures
5. Non-chemical control
6. Max. Economic Net Return (ENR), or, min. cost, TFI, etc.
Integrated ‘best parts’
- Weed Potential Threat (WPT)

• Decision algorithms
  - ‘fuzzy logic’:
    – WPT in actual crop
    – WPT in crop rotation
    – actual WPT = maximum

• In maize:
  – WPT in actual crop exceeds WPT in crop rotations
  -> WPT in crop rotation can be ignored
     (simpler design)
Integrated ‘best parts’
- Target Efficacy (TE)

- Decision algorithms
  - designed by experts to avoid:
    - yield loss
    - propagation of weeds
    - … and more …
Integrated ‘best parts’
- herbicide dose-response functions
Integrated best parts
- optimization of herbicide tank-mixtures

- Linear optimization
- Meet needs for control (TE / WPT)
- Minimize e.g. cost, TFI
- Include 2-4 way herbicide mixtures
- Add adjuvants as required
Integrated best parts
- Economic Net Return (ENR)

ENR = value of reduced yield loss − cost of treatment
New features

• **Anti herbicide resistance strategies**
  – Control of resistant biotypes:
    • resistant biotype = new weed species
    • automatic selection of alternatives
  – Prevention/delay of resistance:
    • now in design phase

• **Mechanical weed control**
Customization

• Crop = maize

• Needs for control:
  – WPT: ‘very safe’ ‘reliable’
  – TE: ‘reliable’ ‘risky’

• Control:
  – herbicides
  – mechanical (to prove concept)

• Country partners decide:

<table>
<thead>
<tr>
<th>Country</th>
<th>Herbicides</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Italy</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Germany</td>
<td>29</td>
<td>58</td>
</tr>
</tbody>
</table>
IT system architecture

• Code: ASP.net / JAVA (2001)

• Microsoft SQL databases:
  – estimates of parameters
  – user-interfaces
  – … everything!

• New IT system architecture:
  – now in design phase
  – better, faster, new features
### Benchmarks of DSS with IPM - Directive 2009/128/EC

<table>
<thead>
<tr>
<th>No</th>
<th>Principle</th>
<th>DSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crop rotation, fertilization, soil cultivation, etc.</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Monitoring</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Thresholds</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Non-chemical control</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Targeted use of herbicides</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Use of herbicides on necessary levels</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Anti-resistance strategies</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Evaluation</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Field tests of DSS - experimental protocol

- 3 countries x 2 years x 2 sites = 12 trials

- Treatments:
  - Untreated
  - Standard = local ‘best practice’
  - DSS WPT ‘very safe’
  - DSS WPT ‘reliable’
  - DSS TE ‘reliable’
  - DSS TE ‘risky’

- Measurements:
  - Efficacy, yield, residual weeds
  - Cost/TFI
Results from field tests of DSS in Slovenia (examples from 2014)

by

Robert Leskovšek
Igor Zidarič
Gregor Urek
2014, efficacy

Total efficacy (%) 8 WAT

- TE reliable by COST
- TE risky by COST
- WPT very safe by COST
- WPT reliable by COST
- TE reliable
- TE risky
- WPT very safe
- WPT reliable
- Local practice

Herbicide efficacy (%)

Total efficacy (%) 7 WAT

- TE reliable by COST
- TE risky by COST
- WPT very safe by COST
- WPT reliable by COST
- TE reliable
- TE risky
- WPT very safe
- WPT reliable
- Local practice

Herbicide efficacy (%)
2014, residual weeds
2014, yield

Maize yield 2014

Dry grain yield (14 %)

Maize yield 2014

Dry grain yield (14 %)
2014, TFI

Treatment frequency index 2014

- TE reliable by COST
- TE risky by COST
- WPT very safe by COST
- WPT reliable by COST
- TE reliable
- TE risky
- WPT very safe
- WPT reliable
- Local practice

Site 9
Results from field tests of DSS in Italy (examples from 2013)

by

Roberta Masin, University of Padova, Italy
Maurizio Sattin (IBAF-CNR), Italy
Emanuele Germinianì, Università di Bologna, Italy
2013, site A

**Efficacy (%)**

- ET risky
- ET reliable
- WPT reliable
- WPT very safe
- Farmer's practice

**Grain yield (hKg/ha)**

- Untreated
- ET risky
- ET reliable
- WPT reliable
- WPT very safe
- Farmer's practice

**Weed Biomass (g/m²)**

- Untreated
- ET risky
- ET reliable
- WPT reliable
- WPT very safe
- Farmer's practice

(letters indicate significant differences (at P<0.05 Tukey's HSD test)
Cost, avg. 4 trials

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cost (Euro/ha)</th>
<th>Cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>80</td>
<td>100%</td>
</tr>
<tr>
<td>WPT reliable</td>
<td>66</td>
<td>82%</td>
</tr>
<tr>
<td>WPT very safe</td>
<td>96</td>
<td>120%</td>
</tr>
<tr>
<td>TE risky</td>
<td>77</td>
<td>96%</td>
</tr>
<tr>
<td>TE reliable</td>
<td>82</td>
<td>103%</td>
</tr>
</tbody>
</table>
Results from field tests of DSS in Germany (averages of 2013-2014)

by

Arnd Verschwele
Julius- Kühn-Institut, Braunschweig
Efficacy, avg. 3 trials
Yield, avg. 3 trials

Maize yield

Standard
TE reliable
TE risky
WPT reliable
WPT very safe

maize total biomass (t/ha)
<table>
<thead>
<tr>
<th>Nr.</th>
<th>Treatments</th>
<th>TFI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Site A</td>
</tr>
<tr>
<td>1</td>
<td>Untreated</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>TE reliable</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>TE risky</td>
<td>1.30</td>
</tr>
<tr>
<td>4</td>
<td>WPT reliable</td>
<td>1.55</td>
</tr>
<tr>
<td>5</td>
<td>WPT very safe</td>
<td>1.64</td>
</tr>
<tr>
<td>6</td>
<td>Standard</td>
<td>1.00</td>
</tr>
</tbody>
</table>

TFI, avg. 3 trials
Common conclusions

- A generic, online DSS for IWM has been designed and constructed
- Compliance with 7/8 general principles on IPM
- Customization for maize in Slovenia, Italy and Germany
- Recommendations are traceable
- Need for:
  - check/correction of ‘strange behavior’ by some prototypes
  - inclusion of more herbicides, weeds and data
Conclusions from Slovenia

3/4 trials and 2/4 DSS prototypes show that:

- efficacy, yield and residual weeds were on level with local standards
- TFI was reduced by 20-40%
Conclusions from Italy

4/4 trials and 2/4 DSS prototypes show that:

• efficacy, yield and residual weed infestation were on level with local standards
• cost was +/- 10-20%
Conclusions from Germany

3/4 trials and 4/4 DSS prototypes show that:

• efficacy and yield were on level with local standards
• TFI varied from +60% to -70% (varying standards)
Bottlenecks

- Limited access to data on herbicide efficacy (joint problem for DSS and IPM)

- Limited interest for field inspections (ENDURE)
Perspectives

• Results from PURE indicate that the DSS has potential for upscaling:
  – more crops
  – more countries

• … just give us more data, more money and more time … 😊
Online demonstration

- Today, Market square, room GAMMA
- 15 min. introductions:
  - 16:30, 17:00, 17:30, 18:00 hours
- THANK YOU FOR YOUR ATTENTION 😊