IPM design and assessment

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IPM Innovation in Europe, Poznan, 15th January 2015
Outline

• Conceptual considerations

• Overview of methods to design and assess IPM-based cropping systems

• Identification of methodological challenges and future research pathways
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• Conceptual considerations

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Simplified representation of an agroecosystem

Crop

Microclimate

Soil

Pests/beneficials/other living organisms

Climate

Cropping system

Social, economic, environmental performances, (including risks)

Lescourret and Aubertot (2013)
PURE 2nd Annual meeting, Riva del Garda, Italy
Performances = f(cropping system, production situation)

Lescourret and Aubertot (2013)
PURE 2nd Annual meeting, Riva del Garda, Italy
The concept of production situation

Production situation: physical, chemical and biological components, except for the crop, of a given field (or agroecosystem) and its environment, as well as socio-economic drivers that affect farmer's decisions (adapted from Breman and de Wit, 1983; Aubertot and Robin, 2013).

Lescourret and Aubertot (2013)
PURE 2nd Annual meeting, Riva del Garda, Italy
The concept of cropping system

1. **Crop management or management practices**: logical and ordered combination of techniques on a plot to achieve an agricultural production (*Sebillotte 1974 – synthesis in Doré et al, 2006*)
The concept of cropping system

1. Crop management or management practices

2. From crop management to cropping systems: a sequence and/or a spatial combination of crops and the corresponding technical operations, involving not only the crops themselves, but also between-crop periods with bare soil or a plant cover (Boiffin et al, 2001)

*Can be extended to semi-natural habitats (field margin, woodlots in landscape…)*

Lescourret and Aubertot (2013)
PURE 2nd Annual meeting, Riva del Garda, Italy
The concept of cropping system

1. Crop management or management practices
2. From crop management to cropping systems
3. Cropping systems and decision processes are coupled

Lescourret and Aubertot (2013)
PURE 2nd Annual meeting, Riva del Garda, Italy
IPM: an old, polysemic, yet alive and kicking concept

Intelligent Pesticide Management

IPM is a sustainable approach to managing pests by combining biological, genetic, physical, cultural and chemical tools in a way that minimises economic, environmental and health risks.

Cf. Session "IPM guidelines" (Alaphilippe, 14.01.15); http://www.ipmnet.org/ipmdefinitions/
IPM: a nested concept…

- Rational Pesticide Use
- Integrated Pest Management
- Integrated Crop Management
- Integrated Farming
- Sustainable Agriculture

- Brent and Atkin (1987)
- Stern et al (1959)
- Heitefuss (1989)
- El Titi et al (1993)
The coupling of decision making and cropping systems to implement IPM strategies

Boiffin et al, 2001
Outline

- Conceptual considerations
- Overview of methods to design and assess IPM-based cropping systems
- Identification of methodological challenges and future pathways
Prototyping IPM solutions using expert knowledge and rule-based experiments (co-innovation in a given production situation)

Co-design

Virtual prototyping during workshops

Promising IPM-based cropping systems

Elementary IPM components

Innovative IPM-based cropping systems

Advises Training Demonstration

Elementary IPM components

Field experiment

Multi-criteria assessment

Benchmark of cropping system performances

Observations/measurements

Experiment set-up

Adapted from Lançon et al. (2008)

![DEXiPM structure diagram]

**Qualitative aggregation of more and more simple parameters ... until farming practices and context elements.**
An example of an IPM system experiment: the Bretegnière experiment of the RésoPest network (pesticide-free cropping systems, Cellier et al, Poster 56)
Competitive crop

Variety(ies) of barley resistant to diseases and lodging / variety(ies) of pea resistant to lodging and frost. Mechanical weeding in autumn, if possible, and spring.

Barley / pea intercrops

Ploughing

False seedbed

High sowing density, cultivar mixture. Tolerant to Phoma, including 10% of an earlier cultivar. Mechanical weeding in autumn and spring. Contans® if risk of sclerotinia.

False seedbed

Oilseed rape

Late sowing, high sowing density, cultivar mixture, tolerant to diseases. Mechanical weeding in autumn if possible, and spring.

Cover crop

Bread wheat

Ploughing

False seedbed

Soya (or sunflower)

Hardy crop (sunflower in case of high weed infestation)

2 strategies (soya): sowing with large space between rows or sowing in high density with close rows. Mechanical weeding, including hoeing. Contans® if risk of sclerotinia.

Industrial hemp

False seedbed

Ploughing

Cover crop

Barley

Crop less sensitive to pests than winter barley. Cultivar tolerant to diseases. Mechanical weeding.

In case of high weed infestation, no cover crop and soil tillage to control them.

Early sowing, large space between row. Resistant variety. Mechanical weeding in autumn, if possible, and spring, including hoeing.

Early autumn-sown crop

Early spring-sown crop

Late autumn-sown crop

Late spring-sown crop

Harrowing of wheat sown in two twin-lines with an interrow of 25 cm

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Comparison between «analytical» and «system» field experiments

<table>
<thead>
<tr>
<th></th>
<th>Analytical experiments</th>
<th>System experiments</th>
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<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To test an hypothesis on the effects of one cropping practice, or at most of a couple of cropping practices in interaction, <em>ceteris paribus</em></td>
<td>To test whether given systems can reach multicriteria objectives and/or compare their respective performances</td>
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<tr>
<td><strong>N° of monitored variables</strong></td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Spatial scale</strong></td>
<td>1-ca 1000 m²</td>
<td>500-ca 5000 m²</td>
</tr>
<tr>
<td><strong>Temporal scale</strong></td>
<td>Cropping season, usually repeated 2 or 3 years</td>
<td>Several rotations, usually a minimum of 10 years (arable and perennial crops)</td>
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</table>
| **Advantages**          | - Experimental designs are usually statistically powerful enough with regards to the objectives  
                           - Enables to isolate the effects of a given practice  
                           - Easily comprehensible experimental network | - Enables to provide references for entire cropping systems on a long term basis  
                           - Enables to consider cumulative effects  
                           - Can embed analytical experiments |
IPM design using models

- DSS for one decision (usually pesticide application)
General conceptual framework of DSS for Rational Pesticide Use

- Information on cropping practices, soil & climate
- Economic drivers
- Is it relevant to spray?
- Injury observations
- Damage function (injury-damage relationship)
- Simulation model
IPM design using models

- DSS for one decision (usually pesticide application)
- Simulation models to compare crop management options
IPM design using models

\[
\frac{di}{dt} = k_1 p(n_i) + k_2 i(n_i)
\]

Disease incidence (%)

Take-all on wheat

Colbach et al. (1996)
IPM design using models

- DSS for one decision (usually pesticide application)
- Simulations to compare crop management options
- Optimisation of IPM-based cropping systems
IPM design using models. Optimisation 1/2

Ould Sidi and Lescourret (2011)
IPM design using models. Optimisation 2/2

How to enhance the durability of cultivar resistance against phoma stem canker (*Leptosphaeria maculans*/ *L Biglobosa*) on oilseed rape using ploughing?

Graph-based Markov Decision Process

![Graph-based Markov Decision Process diagram]

Cumulated gross margin (€)

Tixier et al. (2013)
Outline

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Methodological challenges

• Need for innovations in elementary components of IPM (several specific sessions and many posters)

• Need for more extensive data to describe interactions between cropping systems and productions situations leading to ecosystem services of agroecosystems

• Need for renewed modelling approaches to handle higher levels of complexity

• Better match between academic research and practical needs for end-users
Perspectives

2 statements from JE Jensens (VFL) and W Rossing (WU), Co-innovation session (14.01.15):

« PURE IPM-entry point did not work for farmers who think systemically »

• Make changes in our conceptual models (e.g. Lamanda et al, 2012)

« Linear approach is inappropriate for complex innovation »

• Need for co-innovation processes taking advantage of multiple expert knowledge to design IPM-based cropping systems aiming to reach a set of objectives in a given production situation (cf. Stephy guide, MS Petit, Market place)
Perspectives

• Stronger articulation between reductionist and holistic approaches
  - Objectives of reductionist (analytical) and holistic research (synthetical) research programs should be harmonised at the earliest stages; expert knowledge and dataset should better be combined

• Better integration of biophysical, socio-economic sciences, Information and Communication Technology
  - Co-innovation processes, participatory sciences, participatory modelling

http://ephytia.inra.fr
Perspectives

- Implementation of IPM-based cropping systems implies to address higher levels of complexity
  - New methods needed to characterise agroecosystems (e.g. metabarcoding, qualitative scouting)
  - Renewal of modelling approaches (cf. sessions « Tools for IPM design and assessment », « Integrated management of pest evolution »)

Qualitative expert knowledge-based modelling without mathematics (Robin and Aubertot, Poster 57)