Design and assessment of innovative cropping systems for winter crop-based crop successions, with limited use of pesticides

approach and point of view from three north-European countries in the EU project ENDURE

FOOD QUALITY AND SAFETY

SIXTH FRAMEWORK PROGRAMME

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endure
diversifying crop protection

Context

- **Arable crop protection: relied greatly on pesticides**
- **Pesticides are efficient but:**
  - Potential impacts on the environment (e.g. water quality) (e.g. Connel, 2005)
  - Potential impacts on human health (e.g. Tron *et al*., 2001)
  - Loss of efficiency due to adaptation of pest populations (e.g. McCartney *et al.*, 2007)
- **Current European political agenda: reducing impacts of agricultural practices**
  - ➔ Integrated crop management (ICM) systems with a more limited use of pesticides

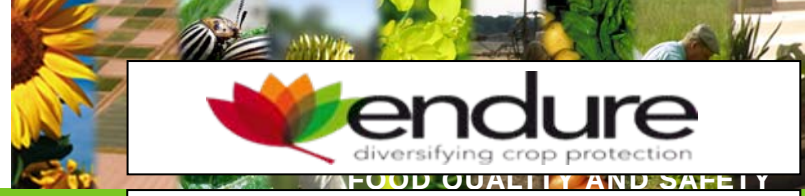
Context

- **ENDURE European project (FP6, www.endure-network.eu)**

  "European Network for the Durable Exploitation of Crop Protection Strategies" (2007-2010)

- **ENDURE RA2.6a: winter crop system case study**
  - Main objectives:
    - Describing widespread current systems
    - Design and assessment of theoretical innovative cropping systems with reduced pesticide inputs
  - Working group with researchers and advisors from three north-European countries: France, Denmark and United Kingdom
  - A multidisciplinary approach (weed science, pathology, agronomy landscape ecology)

Methodology



Context

Diagnosis: objectives, constraints

GUIDE LINES

Cropping system design

Prototypes Adaptation

PROTOTYPE

Context

Multi-criteria assessment

INNOVATIVE CROPPING SYSTEMS

Test in fields

Current cropping systems in each country

➔limit pesticide use

Theoretical innovative cropping systems

- According to expert opinion
- Exploring a wide range of protection strategies and different time and space scales

Assessment of cropping systems

- Predicted consequences for pesticide use (TFI)
- Overall sustainability (DEXiPM, Poster 281, session 3.2.3)

From Vereijken, 1997; Lançon et al. 2006

Description of current cropping systems

- **Local contexts accounted for**

  France: Poitou-Charentes region

  Denmark: most Danish regions, characterized by production of winter cereals for feedstuff

  UK: predominant arable area of England.

- **Description of current cropping systems**

Source: GNIS, INRA, Bayer

Typical crop sequences

- France: winter oilseed rape (WOSR)-winter wheat-winter barley
- Denmark: winter barley-WOSR-winter wheat-winter wheat
- UK: winter wheat-winter wheat-WOSR

Crop management practices: intensive agriculture

- e.g. high sowing density, intensive use of mineral fertilizers

Crop protection strategies mainly based on pesticides and on genetic or cultural control (e.g. resistant cultivars, cultivations)

Innovative cropping system design

Example of theoretical innovative cropping systems proposed

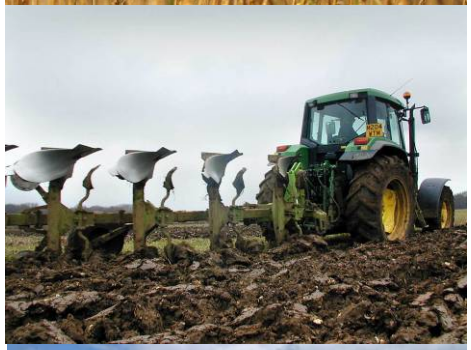
Crop sequence

- Diversification of crops and sowing periods
- Crops with high competitiveness against weeds, catch crops, or a fallow period for grass weed management

Source: INRA

  - France (ADAR, Reau and Landé, 2006): WOSR-winter wheat-spring barley-alfalfa-alfalfa-winter wheat-(mustard)-sunflower-triticale
  - Denmark: winter barley-WOSR-winter wheat-winter wheat-(catch crop)-spring barley-(undersown ley)-spring barley
  - UK: winter wheat-spring beans-optional winter wheat-fallow/spring barley/spring wheat-WOSR

Innovative cropping system design



Source: Rothamsted research, GNIS

Theoretical innovative cropping systems proposed:

➔ Examples of crop management choices (not exhaustive)

Cultivars: resistant (Fr, Dk, UK), cultivar mixtures (Dk)

Cereal seed rate: Decreased for mechanical weeding (Fr), Increased to improve competitiveness against weeds (Dk, UK)

Tillage:

- Stale seedbeds (Fr, Dk; already a standard technique in the UK),
- Minimised ploughing (Fr, UK; conservation of natural enemies), ploughing each year (Dk, weed management)

Landscape management: Non-crop habitats (natural enemies and pollinators), turnip rape sown at WOSR margins (trap pollen beetle) (UK, Fr)

Hi-tech practices: DSS, precision spray application (UK, Dk)

Biological control: against sclerotinia (Fr)

Innovative cropping system design: Discussion

- **Two approaches were chosen for the design of the innovative CS**

Efficiency-substitution (Hill & MacRae, 1995)

- Innovative cropping systems are devised by modifying the current CS
- Pesticide use reduction through the introduction of
  - low-tech practices (e.g. optimized/adjusted dosages, sowing densities and dates, cultivars, crop sequences, tillage etc.)
  - hi-tech practices (e.g. GPS-guided applications, pesticide targeting, decision support systems)

➔Mix of preventative and curative pest management (UK and Denmark)

Redesign (Hill & MacRae, 1995)

- Innovative CS are designed based on a CS with no pesticide
  - all possible low technology means to control pests (including crop sequence)
  - pesticides only added when alternative practices would possibly fail

➔Firmly emphasises preventative measures (France)

Innovative cropping system design: Discussion

- **Two approaches for the design of innovative CS: efficiency-substitution and redesign (Hill & MacRae, 1995)**

  Arise from the main priorities chosen by the authors and from the contexts

  - Maintain profitability and yield (UK)
  - Support pig production, already low TFI levels (Denmark)

  ➔Some options for pesticide reduction are limited, and a less radical redesign of the CS is preferred

  - High priority given to reducing TFI, and suitability of the local context chosen for a wider range of crops (France)

  ➔More complete redesign of the CS, including radical modification of the crop sequence

Cropping system assessment

- **Predicted consequences for pesticide use**

  Treatment Frequency Index (TFI) based on expert opinion

	France (ADAR)	UK	Denmark
Current cropping systems	**5.8**	**6.2**	**2.5**
Innovative cropping system	**0.4**	**2.7 - 3.4**	**1.6**

➔ **Big difference in current levels of TFI between countries**

Differences in pest prevalence, climate, national priorities and policy, extension services

➔ **Consequences in terms of the performance of innovative systems in comparison with current systems**

According to authors' hypotheses, TFI may potentially be reduced by 93 % and by 56 % with the French and UK innovative CS described

Despite low level of current TFI, it may potentially be reduced by 36 % in Dk

Cropping system assessment

Overall sustainability assessment

Environmental sustainability (resource use, environmental quality, biodiversity)

- Significantly improved with the French and English innovative CS described
- Slightly improved with the Danish innovative CS described (changes are shallower)

Economic sustainability (profitability, medium and long term viability)

- Reduced in each country:
  - new rotations may be associated with more risk and variability, even if the production cost can be reduced due to less chemical inputs.
  - smaller volumes for collecting firms when crop successions are diversified

Social sustainability (market access, farmer health, society)

- Either improved (re-design, France) or little changed (efficiency-substitution approach, England and Denmark)

Cropping system assessment: Discussion

Assessment of innovative cropping systems

TFI estimation

- Good indicator to assess the pesticide reduction
- But a low level of TFI does not mean a sustainable cropping system

The multicriteria assessment of the sustainability of cropping system is fundamental

- Differed according to approaches
  - Redesign: more environmentally sustainable
  - Efficiency-substitution: more economically sustainable in the current economical context

➔ The *ex ante* multicriteria assessment is a prerequisite to increase the efficiency of the innovation process (reducing the number of solutions to be tested in field experiments)