ENDURE

European Network for Durable Exploitation of crop protection strategies

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Report on feasibility of redesigning arable crop rotations

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Dissemination Level	
PU Public	**X**
PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

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Summary

Reduction of pesticide use in arable crops not only requires improving crop protection practices or substituting non-chemical techniques (genetics, biological control) but also redesigning the cropping system and enlarging scales to multi-pest, crop rotations and landscape interactions. The ENDURE “RA2.6 Arable Crops System Case study” was therefore launched to:

- Acquire a wider knowledge on the current status of crop protection in key European cropping systems;
- Design and explore a wide range of innovative systems;
- Carry out a qualitative *ex ante* assessment, comparing these systems to the existing ones for multiple criteria;
- Identify those conditions that would help adopting such innovative solutions (in terms of technologies, market incentives or public policies).

This report updates deliverable DR2.8, gives a follow-up of the advancement of the working groups set up in 2008 and discusses the feasibility of designing and assessing truly innovative systems, i.e., systems combining changes in crop rotations, management practices and innovative technologies.

Report on the feasibility of redesigning arable crop rotations

Introduction

Significant reduction of pesticide use in arable crops not only requires improving crop protection practices (reduction of doses, decision-support systems to guide and optimise the decision process) or substituting non-chemical techniques to chemical practices (resistant varieties, biological and mechanical control) but also redesigning the cropping system itself and enlarging scales to multi-pest, crop rotations and landscape interactions. In order to make it possible to implement IPM strategies in Europe and provide decision-makers with a wide range of solutions, ENDURE aims to explore g a wide range of crop protection strategies, focusing on reduction of impact and/or reduction of dependence on pesticides.

The RA2.6 Arable Crops System Case study was therefore launched in order to:
- Acquire a wider knowledge on the current status of crop protection in key European cropping systems (i.e. not merely at crop level).
- Design and explore a wide range of innovative systems;
- Carry out a qualitative *ex ante* assessment, comparing these systems between them and with the existing ones for multiple criteria;
- Identify those conditions that would help adopting such innovative solutions (in terms of technologies, market incentives or public policies).

The first phase of this sub-activity (2008 workshops in Copenhagen and in Paris) discussed which cropping systems situations would better benefit from a systems approach in order to reduce dependence on pesticides and foster integration between sub-activities within ENDURE (crop specific case studies, innovative technologies, landscape ecology, assessment methodology, plant genetic resistance). This led to the selection of two typical arable cropping systems:
- Winter Crops Based Cropping Systems (France, Denmark, UK and Germany);
- Maize Based Cropping Systems (Italy, Hungary, France, Spain, and Northern Europe).

For each cropping system, a working group has been set up which includes a core group and representatives of other ENDURE sub-activities. The general approach undertaken by working groups is a desk study which will:
- characterize pest situations and crop management practices for Current Systems and Existing Advanced Systems in some European regions;
- analyze the coherence of current crop protection systems;
- design Innovative Systems (through a Scenario building approach) taking advantage of:
  - the potential of new combinations of existing practices (e.g., new crop rotation/integrated crop management)
  - new technologies and approaches (not yet validated): detection methods, habitat manipulation, semio-chemicals, new genotypes;
  - « non-technical » leverages, e.g., insurance schemes to reduce risk variability,
- analyze Innovative Systems and compare them to existing systems (in collaboration with RA2.4/RA3.1 sub-activities)
  - carry out an expert-based assessment of performances (using the *ex-ante* assessment tool designed by sub-activity RA2.4);
  - identify potential drawbacks in their adoption by stakeholders (through Focus groups);
  - identify conditions which would facilitate the adoption of innovative systems (Public policies, Market incentives, Extension) and discuss a research agenda (e.g., breeding targets);

In addition to these two working groups on winter crops and maize based rotations, a meta-analysis (RA2.6c) on rotational effects has been launched. Indeed, rotations are a key component of RA2.6 leverages (introduction of new crops into current rotations). RA2.6c is carrying out an investigation, using data available across the partners, into these effects by building on a preliminary analysis conducted at Rothamsted Research.

Follow-up report (M31)

The two arable crops working groups (WCCS and MBCS) have held several specific workshops and attended the DEXiPM workshop which discussed how the current, advanced and innovative systems could be assessed.

WCCS

Following the RA2.6a meeting in Copenhagen (December 2008, see appendix 1), the working group continued filling in information in three templates to supplement the formulation of Advanced Systems (AS) and Innovative Systems (IS1):
1) Listing major pests in WCCS,
2) Impacting factors to be considered for reducing pesticide use,
3) Effect of cultural practices on pests.

At the Rothamsted meeting (March 2009, see appendix 2), a Danish proposal on AS and IS1 was discussed with extension services from DAAS and the UK. Relevant links to the meta-analysis on rotational effects (RA2.6c), including major factors driving crop rotation composition, were also discussed.

Potential components for redesigning crop rotations were identified and their strength and weaknesses were discussed:

- Introduction of Spring-sown crops (control of grass weeds) or of triticale and rye (low demands for nutrients and pesticides);
- Variety mixtures (for disease control, better light interception and use of nutrients);
- Species mixtures (e.g., peas/barley in Denmark or UK, peas/winter wheat in France),
- Trap cropping (e.g., management of pollen beetles on conventional OSR);
- Landscape / habitat / margin management (greater landscape complexity increases natural enemy abundance)

RA2.6a participated in the RA2.4/RA3.1 meeting (mid-April) to discuss and learn about the DEXiPM assessment tool for assessing WCCS scenarios. This tool is planned for assessing the feasibility of AS and IS1 proposals.

Proposals for AS and IS from the four countries involved (UK, DK, FR and DE) will be discussed at the forthcoming workshop of mid-September. Next step will be the assessment of candidate systems and their comparison with current systems through the DEXiPM tool which was released by M30.

MBCS

During its Godollo meeting (January 2009, see appendix 3), the MBCS selected maize growing regions, agreed on implementing a SWOT analysis and designed templates for qualitative data

collection (expert interviews). Typical current and alternative systems were selected in each region and will serve as a basis for the description of the most common current systems, evaluate the advanced systems and designing innovative systems.
Key components for redesigning maize systems such as crop rotation and landscape management were discussed and will be further assessed.

RA2.6b also actively participated in the RA2.4/RA3.1 meeting (mid-April) to discuss and learn about the DEXiPM assessment tool for assessing MBCS scenarios. RA26b started using DEXiPM and designed a template (appendix 4) for describing innovative MBCS in order to feed directly DEXiPM (Padova meeting, June 2009).

Conclusions on the feasibility of redesigning arable crop rotations

RA2.6 working groups were asked to think of innovative systems without worrying too much on the bottlenecks they may cope with (economic viability, drawbacks in their adoption, technical difficulties, etc).

The availability of DEXiPM, a qualitative ex-ante multi-criteria assessment tool makes it possible to assess really innovative crop protection systems through two approaches:

- Under the current context (climate, market requirements, public policies, etc), compare performances of advanced and innovative systems with respect to current practices;
- For one specific innovative system, identify which context variables (leverages) could be used to make it possible its adoption (e.g., subsidies);

This double approach is made possible as DEXiPM only requires expert-based information for innovative systems. SCS working groups have been updated on the use of DEXiPM and consider it would be possible to design and assess really innovative solutions through this approach.

APPENDIX 1 MINUTES OF THE RA26A MEETING IN COPENHAGEN

Endure activity RA2.6: Redesigning crop protection systems – sub-activity on winter crops based cropping systems (WCCS)

Meeting: Second meeting on re-designing WCCS, first meeting was held in Paris in June 2008

Place: Axelborg, Copenhagen

Date: 2nd and 3rd December 2008

Time: Begins at 12:30 on the 2nd Dec. and is expected to end before 17:00 on the 3rd Dec.

Participants: Pinochet Xavier (CETIOM), Bo Melander (AU), Lise Nistrup Jørgensen (AU), Neal Evans (RRES), Elise Lô-Pelzer (INRA), Raymond Reau (INRA), Andrew Ferguson (RRES), Hans Pinnschmidt (AU), Ghita C. Nielsen (DAAS)

Agenda:

a) Presentation of organisations and expertises

b) An outline of the 3rd JPA

c) Crop rotations identified at the meeting in Paris, June 2008

d) Continuing listing the main pest problems on
- crop level
- crop rotation and impacting factors

e) Scenarios for pesticide reductions
- 0 pesticide scenario
- 0 pesticide scenario, then adding pesticides
- Others

f) Plan for future meetings

Main points discussed:

a) Presentation of organisations and expertises

- *Hans Pinnschmidt*, Aarhus University, (DK)
  Biology and control of crop diseases, variety resistance against diseases, representing ENDURE-activity RA4.2 resistance gene deployment
- *Pinochet Xavier*, CETIOM, (FR)
  Technical and applied research, support to basic research and extension service on winter oil seed rape (WOSR), sun flower, soybean and linseed. Management of pathogens, fungicide resistance, pest and diseases, special expertise on WOSR
- *Lise N. Jørgensen*, Aarhus University, (DK)
  Control of diseases in cereals, efficacy evaluation of fungicides as part of the registration procedure, policy issues. Optimizing and minimizing input of fungicides. Representing ENDURE-activity IA2.1 Eurowheat, strong linkage to the work of the WHEAT PEST MODEL (yield loss functions for all pests of relevance for winter wheat).
- *Ghita C. Nielsen,* DAAS, (DK)

National extension service. Expertise in pest and diseases in agricultural crops.

- *Neal Evans & Andrew Ferguson*, Rothamsted Research, (UK)
  Epidemiology, aerobiology, fungicide resistance, weed abundance, crop management, fungicide resistance, modeling and forecasting, special expertise in disease and pests in winter oi8l seed rape and cereals. Responsible for the Virtual lab in ENDURE
- *Elise Lô-Pelzer* (INRA), (FR)
  SIPPOM-modelling the effect of cropping systems and their spatial distribution on phoma stem canker severity and on the adaptation of *Leptosphaeria maculans* populations to winter oilseed rape resistant cultivars. Bridging the activities between RA2.4 and RA3's (multicriteria assessment and DEXIPM) and WCCS (RA2.6).
- *Raymond Reau*, INRA, (FR)
  Design of cropping systems especially winter cropping systems (North France), multicriteria assessments, model MASK (sustainable development), responsible for French network of innovative cropping systems, member of expert panel looking at the consequences of a 50% reduction in 10 years time.
- *Bo Melander*, AU, (DK)
  Expertise in physical, preventive and cultural weed control in agricultural and horticultural cropping systems. Weed ecology. Involved in ENDURE case studies on maize and vegetables crops. Sub-activity leader on the case study on Integrated Weed Management

b) An outline of the 3rd JPA

Bo Melander explained the 3rd JPA on WCCS and the text has been revised slightly according to responses of the participants. A revised version was uploaded on Friday the 5 Dec.

c) Crop rotations identified at the meeting in Paris, June 2008

Crops: It was decided to continue working on winter wheat, winter barley and winter oil seed rape.
Spring sown crops should be included when designing IS1/IS2

Crop rotations:

Crop rotations identified:

- W-W-W
- W-W-W-B-R
- W-W-B-R
- W-B-R
- W-R-W-R

W=winter wheat, B=winter barley, R=winter oil seed rape

Participants give feedback on the relevance of crop rotations.

d) Continuing listing the main pest problems on

- Crop level

The first listing focussed on the general pest problems considered to be of economic importance in the 3 major wintering crops: winter wheat, winter barley and winter oil seed rape.

HOMEWORK: the list should be checked by relevant expertises not being present at the meeting. JKI (Germany) was not present at the Axelborg meeting and should make the lists also. The lists below, **Appendix A**, reflect the outcome of the discussion but we suggest that the lists are revised to reflect the situation in each country: France, Germany, England and Denmark. The pests should be ranked starting with the most problematic problem first.
DEADLINE: 27 February 2009

- Crop rotation and impacting factors
  In the second listing, we listed the pest problems as those that may increase as a consequence of the interaction between the impacting factor and the specific rotation, see **Appendix B**. Appendix B is mainly supporting the information needed in **Appendix C.**
  NB. Soil type and climate cannot be manipulated but are something that may affect the outcome of the innovative systems we are proposing. These aspects need to be mentioned when formulating the new cropping systems

  HOMEWORK: finish the Appendix B country wise
  DEADLINE: 27 February 2009

- It was also decided to start listing the methods that can reduce pesticide use. The listing should be made pest wise as shown in **Appendix C**.

  HOMEWORK: please finish Appendix C for each country
  DEADLINE: 27 February 2009

e) Establishing current practice

We agreed that it would be important to establish what current practice is. Thus we have designed frames to obtain practitioners opinion on what is the current practice, not on the effects of current practice. By contrast, appendices B & C are designed to obtain expert opinion on the effect of different practice options.

HOMEWORK:
Background information related to the rotations should include information about the current treatment frequency index (TFI) in relation to yield, see attachment: *'TFI.ppt'*
Information about pest incidence and whether they exceed specific thresh holds, see attachments: *'EndureRA26aCurrentPesticideUsage'* and the guideline: *'ENDURERA26aPesticideUsageCurrentPractice'*
Finally a frame is designed to obtain practitioners' opinion on what is the current practice, not on the effects of current practice, see attachments: *'EndureRA26aRotationsTillageStrawCurrentPractice2'* and the guideline: *'ENDURERA26aRotationsTillageStrawCurrentPractice2'*
DEADLINE: 27 February 2009

e) Scenarios for pesticide reductions

The group discussed different options for defining new scenarios. A way of looking at it could be to make a proposal for different types of farms. Optimisation of current systems will limit creativity of innovative elements. Raymond Rau (FR) has experienced that it can be most productive to start with a low input scenario (close to organic).
We agreed that we should work on low input scenarios and evolve the AS and IS1 (described in the 3rd JPA) accordingly. This means that we should not try to target a certain percentage reduction in pesticide use but rather target a minimum.

f) Future plans and meetings

Decisions and checklist for the continuation of the systems case study:

- check the pests that we have suggested for each crop – only those of economic importance, **Appendix A**
- finish frame for filling in cultural practises and non-chemical methods pest-wise, **Appendix C.** Filling in **Appendix** B may serve as a background synthesis for making **Appendix C**
- Provide information on current yields (average for the whole country) and pesticide use (TFI) for the specific crops (average for the whole country), **see attachment *'TFI.ppt'***
- Provide information about thresholds, **se attachment *'EndureRA26aCurrentPesticideUsage'***
- Provide information about practitioners' opinion on current practice, **se attachment *'ENDURERA26aRotationsTillageStrawCurrentPractice2'***
- We decided to meet on **the 23 and 24th of March 2009** at Rothamsted (UK) to finalise designing AS and IS1 innovative systems before we meet with the other ENDURE-activities
- Everybody should have given thoughts to the two systems before the meeting in March 2009
- Frames (Appendixes A, B, C and attachments) and minutes of the Copenhagen meeting are send out after Christmas
- Frames (Appendixes A, B, C and attachments) returned to Bo Melander by the 27 February 2009

Bo Melander 8 January 2009

Form A. List of pests for WCCS

A1. Winter wheat – **weeds** (listing according to economic importance, contact the relevant experts in each member state)

Dicots	Monocots	Perennials
Tripleurospermum inodorum	*Apera spica-venti*	*Elymus repens*
Papaver rhoeas	*Lolium perenne*	*Cirsium arvensis*
Galium aparine	*Alopecurus myosuroides*	
Stellaria media	*Poa trivialis*	
Viola arvensis	*Poa annua*	
Capsella bursa-pastoris		

A2. Winter wheat – diseases (information available in wheat case study also for the German situation)

Air born	Soil born	Seed born	Debris spread
Septoria tritici (all 1)	Take all	Tilletia	*Septoria tritici* (all 1)
Brown rust (FR 2)	Tilletia	*Fusarium*	Tanspot
Yellow rust	Ergot	Ergot	Eyespot
Powdery mildew			Fusarium (FR 3)

‘FR 2’ means that brown rust would be ranked second in France and ‘FR 3’ third in France

A3. Winter wheat – pests

Mobile	Less mobile	Soil born
Aphids / virus vector	Orange wheat blossom midge	Slugs
Sitobion avenae,		
Rhopalosiphum dirhodum,		
Rhopalosiphum padi		
Cikade (virus vector)		

B1. Winter barley – weeds

Dicots	Monocots	Perennials
Tripleurospermum inodorum	*Apera spica-venti*	*Elymus repens*
Papaver rhoeas	*Lolium perenne*	*Cirsium arvensis*
Galium aparine	*Alopecurus myosuroides*	
Stellaria media	*Poa trivialis*	
Viola arvensis	*Poa annua*	
Capsella bursa-pastoris		

B2. Winter barley – diseases (most of the problems are also relevant for spring barley)

Air born	Soil born	Seed born	Debris spread

Brown rust Mildew Netblotch *Rhynchosporium* *Ramularia*	Take all	Ustilago Leaf stribe Netblotch *Fusarium* *Ramularia* *Rhynchosporium*	Netblotch *Rhynchosporium* *Ramularia*

B3. Winter barley – pests (also relevant for spring barley apart from slugs)

Mobile	**Less mobile**	**Soil born**
Aphids / virus vector *Sitobion avenae,* *Rhopalosiphum dirhodum,* *Rhopalosiphum padi*		Slugs

C1. Winter oil seed rape – weeds

Dicots	**Monocots**	**Perennials**
Sinapis arvensis *Rhaphanus raphanistrum* *Capsella bursa-partoris* *Tripleurospermum inodorum* *Papaver rhoeas* *Geranium spp.* *Calepina* *Galium aparine* *Orobanche ramosa*	*Lolium perenne* *Alopecurus myosuroides* Volunteers (barley/wheat) *Apera spica-venti*	*Elymus repens* *Cirsium arvensis*

C2. Winter oil seed rape – diseases (include fungicide as a growth regulator)

Air born	**Soil born**	**Seed born**	**Debris spread**
Altenaria *Phoma* *Botrytis* *Cylindrosporium* *Erysiphe crucuferarium*	*Sclerotinia* *Clubroot* *Verticillium*	*Phoma* *Altenaria*	*Phoma*

C3. W. oil seed rape – pests

Mobile	Less mobile	Soil born
Pollen beetle Rape stem weevil Cabbage stem flea beetle	Brassica pod midge	Slugs

Cabbage seed weevil
Myzus persicae (virus vector)
Pigeon

Form B.

Interactions between impacting factors and crop rotation. The pest problems are described as those that may increase as a consequence of the interaction between the impacting factor and the specific rotation

D1. Crop rotation: W. wheat – W. barley – W. oil seed rape

Impacting factor	Level	Weeds	Diseases	Pests
Primary tillage	Ploughing plus stubble cultivation	*Papaver rhoeas* *Tripleurospermum Inodorum* *Capsella bursa-pastoris* *Viola arvensis*	Disease situation remains the same irrespective of the tillage method apart from *Phoma*	Pest problems are likely to become worse in oil seed rape because parasitoides are damaged by ploughing
	Ploughing without stubble cultivation	*Elymus repens* *Cirsium arvensis* Volunteers		Slugs
	Non-inversion cultivation	*Alopecurus myosuroides* *Apera spica-venti* *Elymus repens* *Cirsium arvensis* *Capsella bursa-pastoris* *Bromus* spp. *Poa annua* *Lolium perenne* *Galium aparine*	*Phoma*	BYDV Midges
	No cultivation	*Alopecurus myosuroides* *Apera spica-venti* *Elymus repens* *Cirsium arvensis* *Capsella bursa-pastoris* *Bromus spp.* *Poa annua* *Lolium perenne* *Galium aparine*	*Phoma*	BYDV Midges
Debris	Removed Left	-	- *Phoma*	- Slugs
Nitrogen (100 kg ha^{-1})	High		Other diseases in general (mildew,	Aphids in cereals at very high N-

	Low than 100 kg ha^{-1}		*Rynchosporium*) Take all, mildew	level (> 250 kg ha^{-1})
Application	Once Split		Mildew	
Sowing time	Early	Promote annual weeds in cereals but a competitive rape crop will decrease the problem. *Orobanche* increases in rape	Rape: *Cylindrosporium* Cereal: *Septoria*, rust diseases, take all, eye spot	Aphids: BYDV Cabbage stem flea beetle
	Delayed		Mildew	Slugs Pigeon
Row spacing Decrease	Increased density		Mildew, Netblotch, *Rynchosporium* *Cylindrium sporium,* *Sclerotinia*	?
	Decreased density	General but moderate increase of weed problems	*Septoria tritici*	Slugs
Row spacing Increase	Increased density		*Cylindrium sporium,* Sclerotinia	
	Decreased density	General increase of the weed problem – could become severe		Slugs (rape) Pigeon (rape)
Irrigation		Promote weed growth in general	*Sclerotinia*	
Landscape Nabouring crops Hedges Field size Size of rotation unit Woodland Field boundaries				

D2/D3. Crop rotation: W. wheat – W. wheat – W. barley – W. oil seed rape / W. wheat – W. wheat – W. wheat – W. barley – W. oil seed rape

Impacting factors	Level	Weeds	Diseases	Pests
Primary tillage	Inverting Tine cultivation Direct drilling			
Nitrogen	High Reduced			
Sowing time	Normal Delayed			
Climate				
Landscape Etc.				

D4. Crop rotation: W. wheat monoculture

Impacting factors	Level	Weeds	Diseases	Pests
Primary tillage	Inverting Tine cultivation Direct drilling			
Nitrogen	High Reduced			
Sowing time	Normal Delayed			
Climate				
Landscape Etc.				

D5. Crop rotation: W. wheat – W. rape – W. wheat – W. rape

Impacting factors	Level	Weeds	Diseases	Pests
Primary tillage	Inverting Tine cultivation Direct drilling			

Nitrogen	High Reduced				
Sowing time	Normal Delayed				
Climate					
Landscape Etc.					

Form C.

Cultural practices impact on pest, disease and weeds

Pest in crop		
Factor	**Description**	**Source**
Resistance genes		
Previous crop Frequency in rotation		
Sowing date		
Tillage		
Debris		
Volunteers		
Nitrogen amounts		
Nitrogen strategy		
Crop density Row spacing		
Margins management		
Landscape		
Soil type		
Climate?		

Mildew in wheat		
Factor	**Description**	**Source**
Resistance genes	Varieties with good resistance genes are known, and help to keep down the disease level. Many specific genes are used and described but also none specific resistance genes are known to be of importance	xx
Sowing date	Early sowing is known to increase disease level in autumn, but this rarely have impact on disease levels in spring. Late sowing in the autumn has however been seen to increase disease level in spring, as the very young plants in spring generally are more susceptible later early sown plants	Data from DAAS Jørgensen et al 1997
Tillage	Ploughing has been found to increase the risk of mildew compared with minimal tillage. It is the increased miniralization following ploughing which stimulate to more severe attack. More N is bound in plant parts using minimal tillage.	Jørgensen & Olsen (2006)
Debris and volunteers	Debris do not directly influence disease levels as mildew is an obligate parasite, fields with volunteers are an important source of inoculum as it serves as a green bridge for the spread of the disease between seasons.	
Nitrogen amounts	High nitrogen amounts increase the susceptibility of the crop due to easier penetration in plants grown at high N levels but also due to more dense crop with higher levels of humidity which is stimulating growth	Olesen et al 2003
Nitrogen strategy	Spilt strategies of N are less encouraging to high disease levels compared to single applications of a single high level	Olesen et al 2003
Crop density	High crop density stimulates mildew development as the humidity in the crop increases in favour of disease development.	Jørgensen et al
Landscape	The attacks are known to be higher at around hedges and in low and humid parts (black soils) of the field.	Bjerre et al. 2006
Soil type	Sandy soils are known to stimulate the disease development, this might be related to the crop being more exposed to stress on these soils. Stress in the form of draught is also seen to increase the risk.	Data from DAAS
Climate		

Septoroa in wheat		
Factor	**Description**	**Source**
Resistance genes	Varieties with good resistance genes are known, and help to keep down the disease level. Specific genes are known and described but also none specific resistance genes are known to be of importance	
Sowing date	Early sowing is known to increase disease level in autumn, which again can stimulated to higher disease levels in spring and summer. Late sowing is seen to decrease the disease level as epidemic generally gets delayed	Jørgensen et al 1997
Tillage	Ploughing has been found to increase the risk of septoria compared with minimal tillage. It is the increased miniralization following ploughing which stimulate to more severe attack. More N is bound in plant parts using minimal tillage.	Jørgensen & Olsen (2006)
Debris and volunteers	Debris may directly influence disease levels as ascospores are released from crop debris in the autumn. Volunteers are not important as source of inoculum as they will typically be destroyed before the attack becomes visual.	
Nitrogen amounts	High nitrogen amounts increase to some extend the susceptibility of the crop. The effect is not very difference in the interval between 120-200.	Olesen et al 2003
Nitrogen strategy	Spilt strategies has been seen to minimize the attack compared with single application .	Olesen et al 2003
Crop density	Low crop density stimulates septoria development as the splash effect easilier take place in an open crop stand.	Jørgensen et al 1997
Landscape	No specific information is known	
Soil type		
Climate	Dry weather reduces the risk as the disease need 48 hours of humidty to stimulate development.	

Eyespot in wheat		
Factor	**Description**	**Source**
Resistance genes	Varieties with moderate resistance genes are known, and help to keep down the disease level.	
Sowing date	Early sowing is known to increase disease risk. Late sowing is seen to decrease the disease level as epidemic generally gets delayed. When wheat is sown after wheat it is recommended to delay the sowing time to minimize the risk.	Schulz et al
Tillage	Tillage is not found to have a major impact on the disease. Ploughing can conserve the debris and then brirng increase the risk once it is brought back to the surface.	Jørgensen & Olsen (2006)
Debris and volunteers	Debris may directly influence disease levels as disease as both ascospores and condiespores are released from crop debris in the autumn.	
Nitrogen amounts	High nitrogen amounts increase to some extend the susceptibility of the crop.	
Nitrogen strategy	No information available	
Crop density	High crop density stimulates development as the humidity increases in a dense crop stand.	Jørgensen et al
Landscape	No specific information is known	
Soil type		
Climate	Dry weather reduces the risk as the disease particularly during elongation the crop as the crop escape the attack by fast growth.	

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Appendix 2 Minutes of the Rothamsted RA2.6a meeting

23-24/3/09, Rothamsted Research

Executive minutes

23 March 2009 Day 1

Chairperson: Andrew Ferguson

Recordkeeping: Neal Evans

Attendees: David Bohan (RRES), Neal Evans (RRES), Andrew Ferguson (RRES), Laurence Guichard (INRA), Lise Nistrup Jørgensen (AU), Bo Melander (AU), Ghita Cordsen Nielsen (DAAS), Keith Norman (Velcourt), Elise Lo Pelzer (INRA), Xavier Pinochet (ACTA), Raymond Reau (INRA), Bernd Rodemann (JKI).

Absent: Ian Denholm (RRES)

Meeting Introduction and aim

After a quick "round the table", Neal Evans (NE) gave an Introduction to the aims of the meeting, highlighted requirements form the 3rd JPA and outlined milestones and deliverables.

Preliminary analysis of the Farm Scale Evaluation data

David Bohan (DB) gave a presentation of some preliminary analyses that he had done with the UK FSE (non-GM) datasets (RA2.6c). This was an attempt to find a consistent way of comparing rotations that could be used across countries:

- 1000 crop sequences were examined;
- Looked at the seedbank effects;
- 60-70% of variance in seed banks could be predicted from three year rotational sequences;
- Climatic zone was surprisingly unimportant;
- Spring crops had bigger seed banks;
- Effects were determined more by crop type (e.g. winter or spring-sown, cereal, oilseed or legume etc) than by crop species.

The main conclusion from DB's analysis was that there was no "fixed" rotation for the UK and that crop sequence was incredibly varied.

DB's RA2.6c model can be used to test RA2.6a scenarios along with the ex-ante assessment tool DEXiPM – some of this work already done by Elise Lo Pelzer (ELP).

Preliminary analysis of data about cropping systems

UK

Neal Evans (NE) and Andrew Ferguson (AF) gave short presentations of initial results from the UK Grower/Advisor questionnaire and some data from interrogation of the UK PUS and CropMonitor surveys.

Generally these data backed up the results from DB that “rotations” in the UK were very varied and driven by many factors.

Although crop sequences were variable, the average gap between OSR crops was 2 – 3 years.

Minimum tillage was most common before WOSR and least common before barley (WOSR 49%, WW34%, WB 12%; 2006 data).

Pesticide use was greater for crops established after minimum tillage, especially herbicides and molluscicides.

There was evidence that the usage of insecticide sprays in oilseed rape was more than would be expected if treatment thresholds were used.

<u>DK</u>

Ghita C. Nielsen (GCN) stated the importance of pig farming in DK and that this was a driving force behind rotations, cereal production predominating (6 years of wheat was common).

Lise N. Jørgensen (LNJ) gave a quick resume of the tables of TFI for different countries.

Keith Norman (KN) suggested that the reason TFI was so high in the UK was that higher use of pesticide guaranteed the grower a good return and that the “bottom line” was the key factor in the majority of on-farm decisions.

LNJ agreed that higher UK fungicide use is easily justified as in the HGCA variety trials 2 tonnes ha^{-1} were commonly lost to disease.

<u>FR</u>

ELP suggested that the French situation was somewhat similar to the UK, WOSR being preceded by WW/cereals and WW being preceded by WW or WOSR (20% of the time in this latter case).

Xavier Pinochet (XP) Cropping with minimum tillage is increasing in France.

<u>D</u>

No information from Bernd Rodemann (BR) who has just joined the group.

General discussion at end of session

KN – OSR growers will lose the choice to use many crop protection products under 91/414. He and XP agreed that this would encourage monoculture (more cereals?)

KN suggested that all of the following points were major drivers for rotational choice in the UK and should be considered by the group:

- Maximising farm gross margin
- Marketing strategy – cash flow needs
- Local market-driven opportunities
- Need to spread risk
- Scale of the farm, e.g. block-cropping on amalgamated businesses.
- Availability of labour – need to reduce peaks in labour needs
- On-farm storage capacity
- Combine harvester capacity / duration of harvesting window.
- Availability of specialist machinery.
- Soil type
- Presence of resistant weeds, especially blackgrass
- Residual fertiliser benefit
- Energy use
- Water use.

DEXiPM Presentation

ELP gave a presentation on progress with DEXiPM. The model assesses the overall suitability of a scenario/system including economic, social and environmental aspects.

The model only requires qualitative data. It can be adjusted to give different weightings to different criteria (e.g. economic, social, environmental, energy use etc) according to the needs of the user. It is aimed at farmers and policy makers. It is a very flexible system with lots of potential within RA26a, e.g. for assessing suggested AS and IS's.

Progress with Frames A, B and C:
Frames A (Description of pests and diseases in WCCS) and B (Interactions between impacting factors and crop rotation) to be retained for report/paper writing.

It was decided to collate returns for Appendix C templates (Cultural practices impact on pest, disease and weeds).
The following responsibilities were agreed:

LNJ - Cereal diseases
NE - OSR diseases
Bo Melander (BM) - Weeds
AF - OSR Pests
(AF/NE) A.N. Other - Cereal pests

Wrap up
AF thanked everyone for their input and suggested that all delegates have a serious thought about AS1 and IS1 scenarios for discussion the following morning.

24/3/09 – Day 2

Chairperson: Neal Evans

Recordkeeping: Andrew Ferguson

Attendees: Ian Denholm (RRES), Neal Evans (RRES), Andrew Ferguson (RRES), Laurence Guichard (INRA), Phil Humphrey (TAG), Lise Nistrup Jørgensen (AU), Bo Melander (AU), Ghita Cordsen Nielsen (DAAS), Elise Lo Pelzer (INRA), Xavier Pinochet (ACTA), Raymond Reau (INRA), Bernd Rodemann (JKI),

Introduction, aim of session and "view from ExCom"

After a quick "round the table" for Phil Humphrey's sake, NE thanked everyone for attending, highlighted the aims of the session and invited ID to speak.

Ian Denholm (ID) gave his view of what the ExComm expected from RA26a, re-iterating that there were no restrictions on our thought processes and that "blue sky thinking" was certainly an option. However, there must be "connectivity" between RA2.6 a, b and c. ID highlighted the "Foresight study" and indicated that the results were about to be released.

Presentation of AS, IS1 (and IS2) for Denmark

BM gave a presentation of the DK thoughts on AS and IS scenarios derived from a workshop held between scientists, famers and advisers.

AS for Denmark:

Design of AS-systems has some re-requisites (non-negotiable) for example rotations are governed by needs for cereals for pig production (as already mentioned by GCN).

Suggested components of AS:

- Inversion tillage
- Pesticide reduction related to current practices
- Perennial weeds controlled
- Wild oats hand weeded
- Certified seed used in 90% of areas
- Crop rotations considered:
  - Wb, WOSR, WW, WW+catch crop, SB
  - Wb, WOSR, WW, WW+catch crop, SB+catch crop/undersown ley, SB
- Looked at the individual crops to find ways to reduce pesticide input.

General discussion of potential components of IS stimulated by BM's presentation of DK ideas and presentation of ideas from France by LG, ELP and RR:

Phil Humphrey (PH): Spring-sown crops are useful for control of grass weeds (e.g. black grass in the UK)

Use of decision support systems (DSS's) is potentially important but, as KN mentioned, large growers in the UK are not very responsive to such systems. Scouting is too expensive and time-consuming. It is not seen as cost-effective. GCN: few growers use scouting in DK. ID there has been a failure to sell the idea of scouting to farmers.

BM: Row-cropping of OSR (50cm row spacing) allows weed control by inter-row cultivations.

Nutrient placement could be encouraged by economic drivers.

PH: Precision agriculture is needed (GPS) to optimise spray applications.

Variety mixtures: good for disease control, better light interception and use of nutrients. There are benefits to non-resistant crop cultivars of mixing them with resistant cultivars.

Variety mixtures are a stabilising factor: it is less likely that there will be a complete loss of a crop. There are problems in persuading growers to use varietal mixtures (UK, France and Denmark) because of concerns about their availability, their management and the marketability of the grain.

Species mixtures: In Denmark species mixtures are mostly used for fodder (silage) in organic systems (peas/barley or barley/oats). In the UK peas and barley are also sometimes grown for fodder. Fungicide needs are often less. In France winter peas are sometimes mixed with WW, increasing WW production (Laurence Guichard (LG) has papers on this), and WOSR may be undersown with clover (not very frost hardy), reducing herbicide use (XP).

Trap cropping: is already used in organic OSR in France and Switzerland and has potential for reducing pesticide use in the management of pollen beetles on conventional OSR (currently being tested at RRES; AF).

Landscape / habitat / margin management: AF there is increasingly good evidence that greater landscape complexity increases natural enemy abundance. PH: farmers in the UK have a positive view of habitat management encouraged in the UK by the Stewardship Schemes linked to EU support payments. ID: The driver for these schemes is public concern about bird populations and the ‘look’ of the countryside. The Rio summit in 1992 identified field margins as key habitats for biodiversity. PH believes the reduced need for insecticides on farms where he advises is directly linked to the adoption of margin management measures. It is not clear whether data exists to show whether farmers adopting Stewardship use less insecticide. ID: this is worth investigating.

Harvest techniques: BM mentioned the possibility of separating and collecting weed seeds during the harvesting operation. However, the technology is not ready for practise yet.

Spot mapping of weeds, then pre-emergence spot-spraying to reduce herbicide use.

Introduction of triticale and rye, which have relatively low demands for nutrients and pesticides.

Field size: oilseed rape pests invade crops from the edge and therefore large field size is likely to offer protection to the central part of the crop.

Sowing date: effects of sowing date on different pests and pathogens vary. Sowing date should be chosen according to local risk factors.

Presentation on methods of developing AS and IS’s, RR:

Two alternative approaches are possible: theoretical or practical. A theoretical system could be applicable to all countries whereas a practical system would be different for each country.

It was agreed that, in the first instance, each country would separately draft AS and IS1 using workshop discussions on the lines of that held by DK.

It was agreed that IS1 and IS2 development should not be constrained by the economics of the systems or by other potential difficulties in implementation but such problems must be recognised and stated.

Draft structure of Report for RA2.6a

LNJ proposed an outline structure for the report for this activity:

Introduction
State of the art
Links to DEXiPM
AS
IS1
IS2
Appendices

This will be further developed and circulated by BM.

Forward Workplan
Collation of Appendix C:
- Lise - Cereal diseases
- Neal - OSR diseases
- Bo - Weeds
- Andrew - OSR Pests
- (Andrew/Neal) A.N. Other - Cereal pests

Deadline for all for contributions to collators 1 May.

Raymond/Elise to send a complete French template to include input for DEXiPM

Deadline: 1st May

Outline for report (Bo/Neal), with headings/suggestions on authors. Draft report ready before next meeting in September

Deadline for Report structure to be circulated: Early June

Next meeting
15-16 September, Paris

Wrap up
NE thanked everyone for their input to the meeting, especially those from outside the group, Keith Norman, Phil Humphries, Dave Bohan and Ian Denholm. He thanked those who had travelled to Rothamsted and wished them safe journeys home. A short tour of Broadbalk and Park Grass, two of Rothamsted's long-running classical experiments, was conducted by Ian Denholm before departure.

Appendix 3 Minutes of the Godollo RA2.6b meeting

Workshop RA2.6b, Maize Based Cropping System (MBCS), Godollo, 19-20 January 2009
Executive minutes

Attendees: J. Kiss SZIE, M. Sattin CNR, P: Kudsk AU, Jean Baptiste Thibord Arvalis, C. Moonen and E. Marraccini SSSUP, R. Ban and I. Madarasz SZIE.
Apologies: X. Pons UdL

Program, discussion points see the Agenda.

It was agreed that contact with RA1.2 MCS (maize case study) should be established, data and conclusions of MCS will be important inputs for MBCS. J. Kiss reminded the participants that this link has been planned and relevant funds allocated. The need is extending what was done for maize (expert interviews) to those systems where maize is predominant and extending the analysis to the other crops included in the maize based rotations. For non-maize crops, it was agreed to focus on pests (pests includes arthropods, pathogens and weeds) relevant to maize in the arable system.

Information on maize based systems from selected Partners/regions:

France:
1.4 Mha grain maize and 1.4 Mha silage maize. Half of the grain production (south-west of France) is irrigated. Silage production is concentrated in North-West. 50,000 ha of seed production in south-west, about 25,000 ha of sweet corn in south west. The cropping system in South-West is based on continuous maize. The other grain production regions are Britain and Alsace. The silage maize is mainly in Britain. Seed production is a major economic activity.

First detections of *Diabrotica virgifera* (Western Corn Rootworm, WCR) were linked to airport locations but it has also been found along motorways. This may be linked to the sampling intensity-scheme too. In the “focus zones” (see relevant Commission Decisions 2003/766/EC and 2006/564/EC and Commission Recommendation 2006/565/EC) maize can be cultivated only once every three years.
In Alsace, when there is capture of WCR, farmers have to rotate maize to wheat or to another non-maize crop, but the yield for wheat is 6 or 7 t per hectare, while for maize is 10 t per hectare. Thus the consequence of rotation is income and profit losses but gain of more healthy rotation system, move towards IPM and save insecticide use to control WCR larvae. Thus, the issue is the short and long term benefits, advantages along IPM implementation.

Italy: 1.2 Mha (about 20% silage). Limited implementation of IPM in arable cropping systems so far. According to different areas, continuous maize (i.e. maize after maize in the cropping system, which is often called in other Member States as monoculture) involve about 20-50% of the cultivated area. Major problems: weeds, Diabrotica, European Corn Borer (ECB), soil born pests. A lot of information on the actual situation has already been collected in the maize case study. In some areas of the Po Valley maize is not only a crop “by itself” but is functional to the farming system (i.e. cheese/cow/pig production).

Hungary: About 1.2-1.3 Mha. 220 Kha of IPM production in maize in Hungary, in most areas with no irrigation. In Hungary sunflower is generally cultivated once every four year because of Sclerotia problem. Maize is often cultivated as continuous crop or in rotation with cereals, sunflower etc. depending on region. IPM/IF implementation was part of agri-environmental programs 2004-2009. For details on SZIE activities related to WCR management see arable system web site in ENDURE (deliverables of terminated EU-6 SSA Diabr-Act project, in which SZIE and J. Kiss was Task Leader of IPM for WCR).

For the northern region (The Netherlands, Denmark, Germany and Poland) P. Kudsk will be responsible for the collection of information.

Contribution of Spain to this activity is important because of the surfaces and the systems of maize (irrigated systems). For Spain, X. Pons (UdL, who could not attend the meeting) confirmed his contribution in the future.

Milestone M2.6b1: 1st workshop held to determine approach for SWOT analysis by M27

Points for common approach for SWOT analysis discussed and agreed as follows:

We need to look at the **bottlenecks** of existing maize based systems.

Check RA2.2 3rd JPA: inputs expected from MBCS needs to be discussed and **clarified**.

What is the present pest and cultivation situation? To be checked with the EU maize growers association.

We'll have to describe also the maize as energy-crop, as part of the system, but **not much effort** on it.

MCS looks at maize pest problems and its conclusions will be **further elaborated in MBCS**.

There is a **gap** between available technical solutions (for IPM) and the actual applications.

Key question: What are the driving forces for farmer's decision (i.e. economics, legal constraints, personal choice)?

Prevailing pests in each regions (info coming from Maize CS) are available.

Also identify basic constraints in MBCS (e.g. water availability in Hungary and Italy.

What is the benefit for the farmer?

EU aims at reducing pesticide use.

Following the definition of system, how many systems do we have? And then the no. of crops involved ii the system should be defined.

Maize Case Study has data of possible rotation. We have to think about why there are only 30% of other crops in the rotation. We have to think why IPM solutions are applied only at small scale. Then we will understand why farmers are doing these systems. In the second step we have to draft some kind of scenario, thus having a stabile system, how we will change? What are the factors we think that are not possible or feasible to change? It means that we can list all the other solutions.

We should describe cropping systems, we may not cover exactly the same regions. For each region we list the most important pests and assess where a systems approach would be relevant. At that point we may introduce socio-economic considerations to understand why solutions are used or not used. Once we know what the bottlenecks are, we can say that technical solutions are needed or that socio-economic assessment is needed. Why do farmers not apply any technical solution? Or the other way around: what is the main aim of the farmer in his activity? Maximal profit? Fulfilling and complying with legal requirements of nature conservation? Do we know exactly what are the main driving forces for farmers? This question should be somewhere considered. Our question is can we influence the driving forces and background of farmers and orient them to go more towards IPM?

Timeline and Tasks

Collection of info on actual situation and possible actions to reduce pesticide use, for other crops focus only on pests relevant to maize in the rotation system. Participants went through Kiss' and Moonen's templates on expert knowledge collection. Decided to use the template from Moonen and some modifications were agreed. Considering the variety involved in cropping systems we need to simplify and categorise them.

Template based on the factorial combination of **three variables**:

- grain or silage production
- rotation or no-rotation and
- irrigation or no-irrigation.

Actual systems involved in this study will be fitted to the 8 possible systems resulting from the factorial combination of the above three factors. It is important to make interviews with farmers and advisors doing IPM on maize, understand their difficulties and advantages, understanding the food supply chain they are involved.

Deadlines:
MCS xls questionnaire and file: Check the file with data inputs on maize compiled by P. Muron (action: Kiss-Sattin). It will be made available for MBCS partners

MBCS xls sheet and file:

- Comments to Camilla by 27 January, back revised version late February and distributed by late March (Kiss-Sattin).
- 7-8 final documents are expected from the MBCS (all Partners).
- Agreed on a MBCS Core-Group meeting on **11-12 June** in Padova (Italy).
- Data gathered in each country/area through expert interviews should be sent to all other partners of the MBCS one week before the meeting in June.
- Socio-economic aspects: C. Moonen and I. Madarasz (to be clarified by early April).
- Landscape elements related to MBCS: A. Veres, to be clarified by early April

General meeting of all MBCS participants plus representatives of other relevant sub-activities: 6-7 July 2009 in Pau, southern France: decided who to invite and invitation should be sent soon (action Kiss-Sattin).

Official deadline for preparing the regional material sent by other partners in October 2009.

Looking ahead we could have **two scenarios** to explore: looking at 2014 (available innovative technologies) and around 2020 with “not existent technologies”.
Research gaps to be identified at the end.

Additional:
J. Kiss and M. Sattin will attend MCS workshop (early April, Zurich)
J. Kiss and M. Sattin will attend RA2.4/3.1 workshop (late April, Paris)

Appendix 4 Template for MBCS description

Advanced system description

Region/Country:
Maize system:

General information / Context:

- **Site:**
- **Soil and climate:**
- **Regional context:**
- **Specificity of the farm where the system is proposed:**

CURRENT SYSTEM

At least, the crop sequence should be described, as well as main risks regarding pests and expected yield. The detail of crop management could be given if a comparison between systems with DEXiPM is required.

Crop sequence:
Crop protection strategy:
Main pest risk:
Expected yield given the context:

ADVANCED SYSTEM

Proposed crop sequence for AS prototype (where relevant):

Principles: *principles of the AS are proposed regarding the main pest risk identified in the current system*

Pest	Scale	Main crop protection strategies, main principles	Aim Impact on pests	Others impacts disadvantages & advantages
WEEDS	**Landscape**			
	Cropping system			
	Crop 1:			
	Crop 2:			
	Crop 3:			
	Crop 4:			
INSECTS PESTS	**Landscape**			
	Cropping system			
	Crop 1:			
	Crop 2:			
	Crop 3:			
	Crop 4:			
DISEASE	**Cropping system**			
	Crop 1:			
	Crop 2:			
	Crop 3:			
	Crop 4:			

LANDSCAPE MANAGEMENT PRACTICES

Landscape management	Period	Practice	Observations
Field margin			
Non-productive area			
Surrounding fields			

CROP MANAGEMENT PRACTICES

Crop management	Period	Practice and description	Observations (advantages & disadvantages)	Pesticide reduction
CROP SEQUENCE				
Pre-drilling tillage				
CROP 1:				
Drilling				
Mechanical weeding				
Mineral Fertilization				
Organic Fertilization				
Herbicide				

Fungicide				
Insecticide				
Growth regulator				
Other chemical product				
Biological control product (elicitor, pheromone…)				
Irrigation				
Harvest				
POST-HARVEST MANAGEMENT/ pre drilling tillage				
Intermediate crop				
CROP 2:				
Drilling				
Mechanical weeding				
Mineral Fertilization				
Organic Fertilization				
Herbicide				
Fungicide				
Insecticide				
Growth regulator				
Other chemical product				
Biological control product (elicitor, pheromone…)				
Irrigation				

Harvest				
POST-HARVEST MANAGEMENT/ pre drilling tillage				
CROP 3:				
Drilling				
Mechanical weeding				
Mineral Fertilization				
Organic Fertilization				
Herbicide				
Fungicide				
Insecticide				
Growth regulator				
Other chemical product				
Biological control product (elicitor, pheromone…)				
Irrigation				
Harvest				
POST-HARVEST MANAGEMENT/ pre drilling tillage				
CROP 4:				
Drilling				
Mechanical weeding				
Mineral				

Fertilization				
Organic Fertilization				
Herbicide				
Fungicide				
Insecticide				
Growth regulator				
Other chemical product				
Biological control product (elicitor, pheromone…)				
Irrigation				
Harvest				
POST-HARVEST MANAGEMENT/ pre drilling tillage				