Project Report No. 462 December 2011 £7.49

EURO-wheat: A European collaboration on resistance characteristics of wheat cultivars, wheat pathogen virulence, disease management tools and fungicide efficacy

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EURO-wheat: A European collaboration on resistance characteristics of wheat cultivars, wheat pathogen virulence, disease management tools and fungicide efficacy

by
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CONTENTS

1. ABSTRACT

EURO-wheat is a part of a large European project entitled ENDURE (**E**uropean **N**etwork for the **Dur**able **E**xploitation of crop protection strategies) (www.endure-network.eu). It is an initiative to reshape European research and development on pesticide use in crops for the implementation of sustainable pest control strategies. It was selected for funding by the European Commission in response to call FP6, Food Quality and Safety. EURO-wheat is an internet-based platform accessible through the Virtual Laboratory of the main ENDURE website and was part-funded by the EU and part-funded by HGCA. The vision was to facilitate a platform containing the most important information about wheat disease management in an IPM context. Information can be accessed in different ways, e.g., through a specific PATHOSYSTEM, through a host CULTIVAR or through a FUNGICIDE, which may have effects across multiple diseases. Technical information is available on yellow rust races in several EU countries, searchable by year and country, Fusarium control measures, fungicide efficacy ratings in EU countries, cultivar disease ratings, decision support systems, disease thresholds, fungicide trade names, pathogen names including translations into non-English languages, fungicide resistance issues, cultural disease control methods and yield responses to fungicide use. The ENDURE and EURO-wheat web sites will continue to be populated beyond 2009. Currently the EURO-wheat website is not accessible to the general public although the intention is that all information will eventually be accessible via an open website.

2. EURO-WHEAT: A EUROPEAN COLLABORATION ON RESISTANCE CHARACTERISTICS OF WHEAT CULTIVARS, WHEAT PATHOGEN VIRULENCE, DISEASE MANAGEMENT TOOLS AND FUNGICIDE EFFICACY

2.1. Introduction to ENDURE and EURO-wheat

2.1.1. ENDURE (European Network for the DURable Exploitation of crop protection strategies)

EURO-wheat is a part of a large European project entitled ENDURE (**E**uropean **N**etwork for the **Dur**able **E**xploitation of crop protection strategies). It is an initiative to reshape European research and development on pesticide use in crops for the implementation of sustainable pest control strategies. It was selected for funding by the European Commission in response to call FP6, Food Quality and Safety. Its main focus was: “Safer and environmentally friendly production methods and technologies and healthier food stuffs”. This was to be largely achieved through reducing the use of plant protection products: The aim was to set up a European Network of Excellence NoE):

> *“The purpose is a durable restructuring of European research and development work on the use of plant protection products. The NoE should aim to reduce the use of these chemicals by including both fundamental research to deepen our understanding of the biology, ecology, behaviour and underlying genetics of the crop-pest system, and appropriate applied work (i.e. new and innovative technologies) to ensure that results are translated into practice. The network should include the expertise and knowledge available in the new Member States, and its restructuring should extend to projects already under way. It would be desirable to include in the network those working in or for INCO target countries whose agricultural products are exported to Europe. The NoE should “establish itself as a world leader for the development and implementation of durable pest control strategies, and should become recognised as the first point of reference in Europe not only for scientists but also for legislators and users. Industrial participation is recommended.”*

ENDURE Participants

		Country
• INRA (ENDURE Coordinator)		FR
• Association de Coordination Technique Agricole	ACTA	FR
• CIRAD		FR
• INRA Transfert	IT	FR
• International Biocontrol Manufacturers' Association	IBMA	INT
• Consiglio Nazionale delle Ricerche	CNR	IT
• Scuola Superiore di Studi Universitari e di Perfezionamento	SSSUP	IT
• Biologische Bundesanstalt für Land- und Forstwirtschaft	BBA	DE
• Rothamsted Research	RRES	UK
• Danish Institute of Agricultural Sciences	DIAS	DK
• Danish Agricultural Advisory Service	DAAS	DK
• Agroscope Swiss Federal Research Station	AGROS	CH
• Plant Breeding and Acclimatization Institute	IHAR	PL
• Szent István University	SZIE	HU
• Universitat de Lleida	UdL	ES
• Plant Research International (also representing PPO and LEI of Wageningen UR)	PRI	NL

2.1.2. EURO-wheat

EURO-wheat is an internet-based platform accessible through the Virtual Laboratory of the main ENDURE website. EURO-wheat was created by during the first 12 month of the project (www.eurowheat.org). The vision was to facilitate a platform containing the most important information about wheat disease management in an IPM context. Currently the EURO-wheat website is not accessible to the general public although the intention is that all information will eventually be accessible via an open website.

Initially the platform focused on areas where there was considerable data already available and where 3-4 key-personnel could be identified from existing ENDURE partners. In these first phases, the main focus was on the major wheat diseases 1) Septoria leaf blotch, 2) Yellow rust, and 3) Fusarium ear blight. The key personnel had to interact closely with the system development staff in Denmark to ensure access to, and compatibility with, formats of national data on, e.g., pathogen virulence, fungicide resistance, host resistance, and/or pesticide efficacy, as well as the technical formats of other Virtual Lab activities. This was to ensure sustainability throughout the ENDURE project and in the years thereafter.

In the second phase, the intention was to include additional traits or pathosystems from other partner countries. Partners outside ENDURE will be invited to add information to the platform (e.g., from Austria, Switzerland, Czech Republic), in order to reach a broader user group, and national organisations (extension etc) will be invited to give feed-back on the usefulness of the platform.

The EURO-wheat platform specifically focused on:

1. Updating information about pathogen virulence in different countries.
2. Extending existing features on the yellow rust pathosystem.
3. Results from European wheat disease nurseries were shared by including data from several European countries (results about wheat rusts for several years did exist but were not readily available for end-users).
4. Exchange information about disease management, including efficacy of fungicides and problems with fungicide resistance (the activity on fungicide resistance supported the wish expressed at the ENDURE annual 08 meeting).
5. Exchange information about disease resistance ranking of cultivars including yield responses to fungicides (different methods for ranking are used in different countries, methods of harmonizing data exchanged had to be designed).
6. Listing of relevant methods for field monitoring for diseases, available thresholds and Decision Support Systems dealing with diseases in wheat (the platform will provide links to available systems).
7. Exchange of specific information about Fusarium, ranking of cultivar susceptibility, summarising presence of Fusarium species.

The information in EURO-Wheat is to a large extent based on information collected in the first 12 months of the wheat case study, as well as previous European networks such as COST817 and the existing FP6 project BIOEXPLOIT (www.bioexploit.net). The target was to combine information on disease control in wheat, which is the biggest arable crop in Europe.

2.1.3. Interactions of EURO-wheat with other sub-activities in ENDURE

Contributions expected from other sub-activities in ENDURE

- Information generated by the wheat case study
- Once the ENDURE information centre have developed their platform information collected in the wheat case study and EURO-wheat will be related or linked to the information centre
- Harmonization or rationalization of all the different methods and rating scales for cultivars. Shared with the Virtual Lab "Methods and protocols"
- Interaction with virtual lab activity on Decision Support Systems
- Interaction with other EU –projects, e.g., BIOEXPLOIT. Utilisation of results from the latter is ensured by INRA, WAU and AU who are actively engaged in both projects
- Interaction with global activities on wheat rusts, facilitated by AU who have collaborative links to major CGIAR-institutions like CIMMYT and ICARDA, and the Borlaug Global Rust Initiative (http://www.globalrust.org/)

Contributions of EURO-wheat to other ENDURE sub-activities

- The wheat group will in future be able to offer support for validation of the model using regional trial data in order to verify if the model is usable
- System case study
- Fungicide resistance problems in wheat management have been identified and will be linked to the pesticide resistance group

Deliverables

No.	Deliverable	Lead Partner	Nature	Dissemination level
1	Design a web based Euro-wheat platform inspired by euroblight compatible with existing database structure in ENDURE	AU	P	RE
2	Deliver the first web-based prototype comprising at least two wheat pathosystems	AU	P	PU
3	Major part of the platform is publicly available for the end users (companies, extension, farmers etc.) supporting disease control strategies based on an IPM concept.	AU	P	PU

P = Prototype, PU = Public, RE = Restricted to a group specified by the consortium.

Contribution and responsibilities of each partner

Partners	Contribution and responsibilities
INRA	Deliver data from France on cultivar/host interaction and disease management.
ACTA	Support the data collection and evaluation of the value and user friendliness of the platform as an end-user.
JKI	Deliver data from Germany on cultivar/host interaction and disease management. Lead on Fusarium, Host workshop.
RRES	Deliver data from UK on cultivar/host interaction and disease management. Lead on fungicide resistance.
IHAR	Deliver data from Poland on cultivar/host interaction and disease management.
AU	Design webpage to cover the needs of a euro-wheat platform. Organise the collection of information needed for the platform. Organise a workshop together with JKI to discuss data formats, bottlenecks, knowledge gaps, reporting procedures etc., to ensure accessibility of national data relevant on a European scale. Ensure uploading of information. Lead on virulence data and fungicides.
DAAS	Support the data collection and evaluation of the value and user friendliness of the platform to an end-user.

2.2. EURO-wheat

The EURO-wheat research platform (www.eurowheat.org) is a task in the Virtual Lab within the main ENDURE project. This report provides an overview of obtained results and achievements in this activity. Screen dumps of selected applications and information pages are given. This report concentrates on the technical side of the EURO-wheat research platform related to discussions in ENDURE on how to integrate and coordinate between facilities and information platforms.

2.2.1. Partner institutions and people

Nine different institutions are currently partners in the EURO-wheat network: INRA, ACTA, BBA, RRES, IHAR, AU, DAAS, NIAB and ARVALIS (Figure 1). All partners are members of the ENDURE Network of Excellence, except NIAB from the UK. Institutions from outside the ENDURE project are welcome to join the network. Seventeen people are members and have login access to the web site (Figure 2)

No.	Name	Country
1	Institut national de la recherche agronomique (INRA)	France
2	Association de coordination technique agricole (ACTA)	France
3	Julius Kuehn Institute - Federal Research Centre for Cultivated Plants (BBA)	Germany
4	Rothamsted Research (RRES)	United Kingdom
5	Plant Breeding and Acclimatization Institute (IHAR)	Poland
6	Aarhus University, Faculty of Agricultural Sciences (AU)	Denmark
7	Danish Agricultural Advisory Service (DAAS)	Denmark
8	National Institute of Agricultural Botany (NIAB)	United Kingdom
9	ARVALIS - Institut du végétal (ARVALIS)	France

Figure 1. Institutions involved in EURO-wheat

Name	Institution	Select
Cristian Lannau	Institut national de la recherche agronomique, France	
Claude Pope	Institut national de la recherche agronomique, France	
Kerstin Flat	Julius Kuehn Institute - Federal Research Centre for Cultivated Plants, Germany	
Marga Jahn	Julius Kuehn Institute - Federal Research Centre for Cultivated Plants, Germany	
Bernd Rodemann	Julius Kuehn Institute - Federal Research Centre for Cultivated Plants, Germany	
Bill Clark	Rothamsted Research, United Kingdom	
Neil Evans	Rothamsted Research, United Kingdom	
Jerzy Czembor	Plant Breeding and Acclimatization Institute, Poland	
Tomasz Goral	Plant Breeding and Acclimatization Institute, Poland	
Jens Grønbech Hansen	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Mogens S. Hovmøller	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Lise Nistrup Jørgensen	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Poul Lassen	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Ghita C. Nielsen	Danish Agricultural Advisory Service, Denmark	
Rosemary Bayles	National Institute of Agricultural Botany, United Kingdom	
Philippe du Cheyron	ARVALIS - Institut du végétal, France	
Claude Maumene	ARVALIS - Institut du végétal, France	

Figure 2. Main people and organisations involved in EURO-wheat

2.2.2. Major achievements of EURO-wheat

A first version of EURO-wheat was established during the first 12 months of the 2nd Joint Programme of Activity (JPA). The vision was to facilitate a platform containing the most important information about wheat disease management in an IPM context. The group held two workshops, one at Flakkebjerg, Denmark in spring 2008 and one in March 2009 in Berlin at the Julius Kuehn Institute.

- From an IT technical point of view the project has been successful. The EURO-wheat platform was established in 14 days based on a template of a web and database system developed by Aarhus University (Figure 4). Euroblight and EURO-wheat share the same database and several database and web applications. This is the major reason that it was possible to develop the EURO-wheat research platform quickly and with a very limited budget. Since 2008 several interactive applications and information pages have been implemented on EURO-wheat (Table 1).

- Remaining parts of EURO-wheat that have recently been developed are:
  i) applications to handle data on Fusarium species and severity/incidence across Europe.
  ii) information about wheat cultivars: disease resistance ranking and yield response to fungicides.

- We developed a method to integrate selected applications directly into the Virtual lab. In the first place this will be relevant for “Fungicide efficacy” and applications on “yellow rust pathotypes” in Europe.

- Crops, pests and diseases are identified using EPPO codes. The EURO-wheat database (Microsoft SQL) is capable of extracting data in XML format. Using the EPPO codes, exchange of data via XML, and use on RUN- applications in EURO-wheat will secure that data and information from EURO-wheat can be easily integrated with other ENDURE databases and platforms.

- We developed a feature that allows us to keep headings, label text strings etc. translated into several languages e.g. under applications for fungicide efficacy and yellow rust pathotypes.

- Other projects plan to use the platform for implementation and dissemination e.g. an online monitoring system on cereal diseases using Google maps for display of results. A platform for test and development of weather-based pest and disease models related to climate change research.

2.3. The EURO-wheat web site

Figure 3. EURO-wheat main page

Table 1. EURO-wheat top menu items and associated sub-menus. The headings refer to the same Top menu items as shown in Figure 4 above.

Project information	**Pathogens**	**Fungicides**	**Cultivars**	**Decision support**	**Public documents**	**Links**	**Data collection**
Institutions	Yellow Rust	Efficacy	Disease resistance ranking	Systems in Europe			Fungicide trade names
People	Fusarium	Resistance	Yield response to fungicide	Control thresholds			Country reports
Events	Disease names	Resistance examples in cereals		Cultural practice			Translate
My Profile		International trade names					
Upload a file							
Download a file							
My files							
Internal news							
Photos							

2.3.1. Screen dumps of selected applications and information pages

Screen dumps from menu Project information

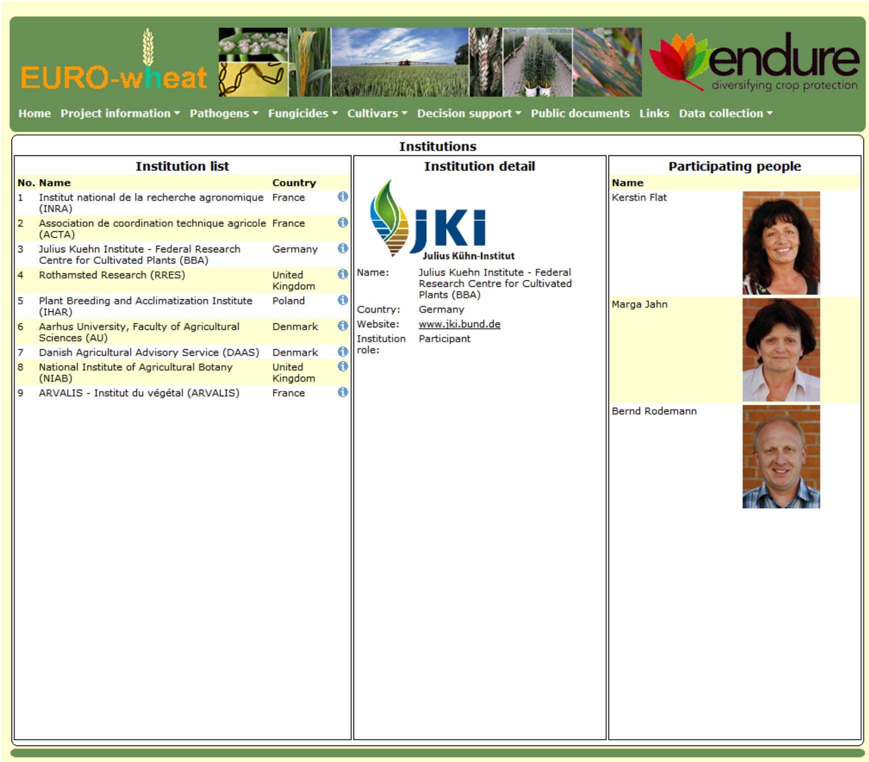


Figure 4. Submenu: Institutions. Click on the icon and Institution details change

Figure 5. Submenu: Photo gallery – Shows participants in project, institute locations, etc.

Screen dumps from menu Pathogens

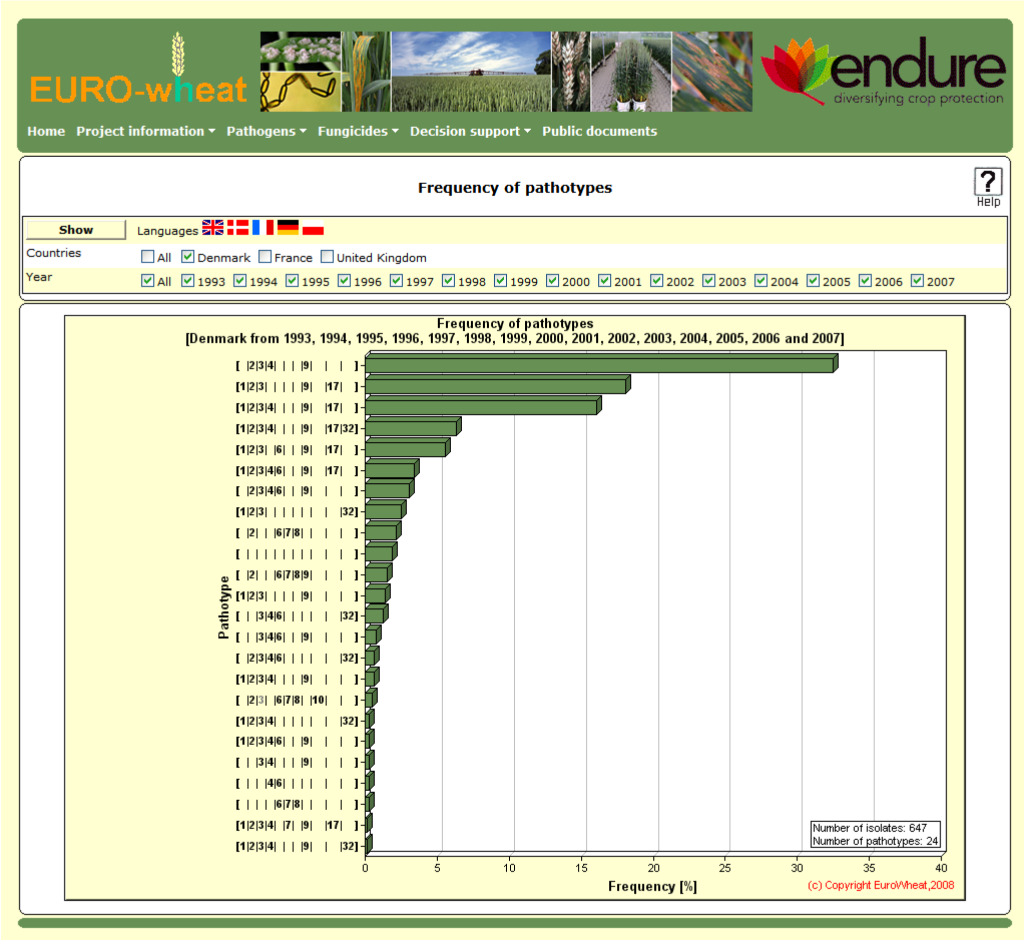


Figure 6. Submenu: Frequency of pathotypes of yellow rust in Denmark, France and UK, 1993-2008. The user can select different countries and years or combine more countries, years etc. Frequencies are re-calculated in real time

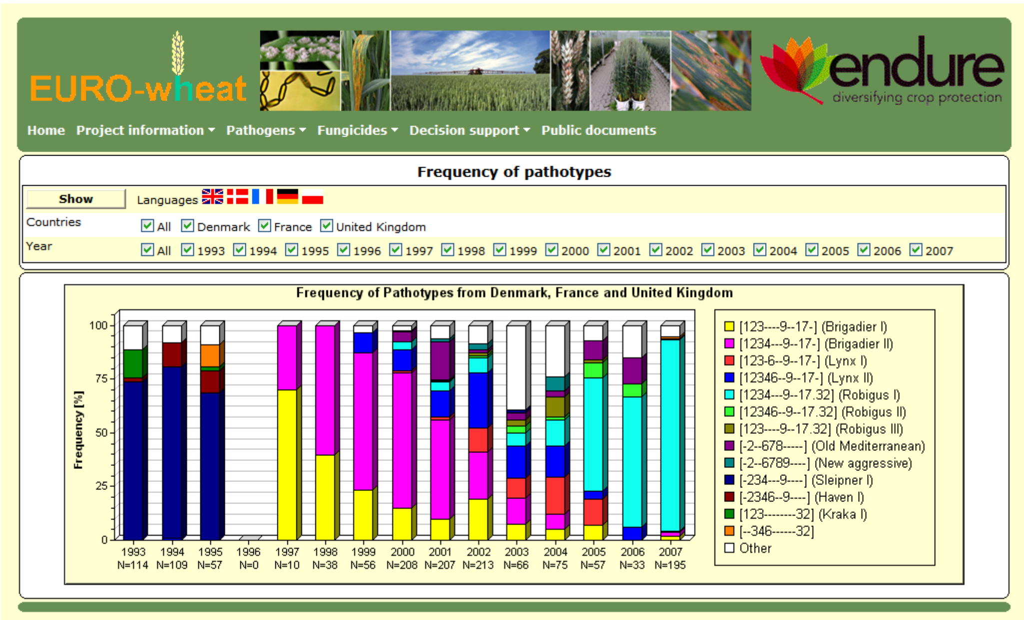


Figure 7. Submenu: Frequency of pathotypes over years and countries. The user can select different countries and years or combine more countries, years etc. Frequencies are re-calculated in real time.

EURO-wheat

endure
diversifying crop protection

Home Project information ▾ Pathogens ▾ Fungicides ▾ Decision support ▾ Public documents

Fusarium

Typical symptoms of infection by *Fusarium graminearum*. Copyright: Bill Clark, Rothamsted Research, UK.

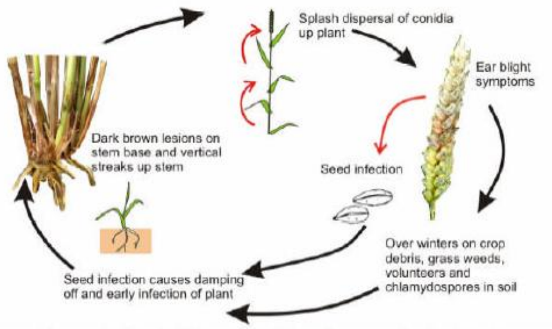


Figure 1. Typical life cycle of Fusarium species in wheat

General introduction

Fusarium is the name for a large family of fungi widely distributed in soil and associated with plants. There are several species of Fusarium that affect wheat, the main ones being *F. avenaceum*, *F.culmorum*, *F. graminearum*, *F. poae* and *F. langsethiae*. *Microdochium nivale* and *M.majus* also affect wheat and may cause head blight. Fusarium species can be separated by morphological differences or the use of PCR methods.

Mycotoxins

Fusarium head blight can reduce yields, but the fungi involved can also produce mycotoxins, dangerous to humans and livestock, and strict legal limits are in place for mycotoxins in grain destined for human consumption and animal feed.

Even though several species of Fusarium can affect wheat - not all of them produce mycotoxins. Microdochium species is one group giving head blight but not production of mycotoxins. The severity of attack depend mainly on weather conditions during flowering (warm and wet conditions are the worst) and a combination of agricultural factors.

Reducing the risks

There is a strong link between the risk from Fusarium and crop rotation and tillage methods. There is a particularly high risk in regions where maize is a widely grown crop in the rotation. Direct drilling and reduced tillage, which leave debris on the surface that can act as a source of inoculum, also increase the risk of Fusarium ear blight. In some countries growing wheat after wheat in combination with minimal tillage has also been found to increase the risk.

Ploughing can significantly reduce the risk but also use of resistant cultivars is another important factor. No cultivar can give 100% control of Fusarium ear blight, but cultivars with high levels of resistance are available. Several countries rank each year the relevant cultivars for susceptibility to Fusarium ear blight.

Several decision keys are made in different countries and can be used for evaluating the risk level for DON (deoxynivalenol, one of the mycotoxins produced by Fusarium) in a given field. The different risk assessments show that the right combination of agricultural practices can dramatically reduce the DON risk without the use of fungicides.

Updated April 2009, By Lise Nistrup Jørgensen

Figure 8. Submenu Fusarium species on grain. An interactive analysis tool will be developed similar to yellow rust above.

EURO-wheat

endure
diversifying crop protection

Home Project information ▾ Pathogens ▾ Fungicides ▾ Decision support ▾ Public documents

Disease names

Scientific name	🇬🇧	🇩🇪	🇫🇷	🇵🇱	🇩🇰	🇸🇪
Blumeria graminis f. sp. tritici	Powdery Mildew	Echter Mehltau	Oïdium	Maczniak prawdziwy	Hvedemeldug	Vetemjöldagg
Ceratobasidium cereale	Sharp Eyespot	Scharfer Augenfleck	Rhizoctone	Ostra plamistosc oczkowa	Skarp øjeplet	Skarp ögonfläck
Claviceps purpurea	Ergot	Mutterkorn	Ergot	Sporysz	Meldrøjer	Mjöldryga
Fusarium spp.	Fusarium Head Blight	Partielle Weißährigkeit, Taubährigkeit	Fusariose	Fuzarioza k?osów	Aksfusarium	Axfusarios
Gaeumannomyces graminis var. tritici	Take-all	Schwarzbeinigkeit	Piétin-échaudage	Zgorzel podstawy zdzbla	Goldfodsyge	Rotdödare
Hymenula cerealis	Cephalosporium Leaf Stripe	Cephalosporium-Streifenkrankheit	Cephalosporium	Naczyniowa pasiastosc lisci	Hvedegulstribe	Gulstrimsjuka
Monographella nivalis	Snow Mould	Schneeschimmel	Fusariose	Plesn sniegowa	Sneskimmel	Snömögel
Mycosphaerella graminicola	Septoria Leaf Blotch	Septoria-Blattdürre	Septoriose	Septorioza paskowana lisci	Hvedegråplet	Svartpricksjuka
Oculimacula spp.	Eyespot	Halmbruchkrankheit	Piétin-verse	Iamliwosc zdzbla	Knækkefodsyge	Stråknäckare
Phaeosphaeria nodorum	Leaf and Glume Blotch	Stagonospora-Blatt- und Spelzenbräune	Septoriose (septoriose des épis)	Septorioza plew	Hvedebrunplet	Brunfläcksjuka
Puccinia graminis f. sp. tritici	Stem Rust	Schwarzrost	Rouille noire	Rdza zdzblowa	Hvedesortrust	Svartrost
Puccinia striiformis	Yellow (Stripe) Rust	Gelbrost	Rouille jaune	Rdza zólta	Gulrust	Gulrost
Puccinia triticina	Leaf Rust	Braunrost	Rouille brune	Rdza brunatna	Brunrust	Brunrost
Pyrenophora tritici-repentis	Tan Spot	Pyrenophora-Blattdürre	Helminthosporiose	Brunatna plamistosc lisci	hvedebladplet	Vetets bladfläcksjuka
Tilletia controversa	Dwarf Bunt	Zwergsteinbrand	Carie naine	sniec karlowa	Dværgbrand	Dvärgstinksot
Tilletia tritici	Stinking Smut	Steinbrand	Carie commune	sniec cuchnaca	Stinkbrand	Stinksot
Typhula incarnata	Snow Rot	Typhula-Fäule		Palecznica zbóz	Trådkølle	Trådklubba

HGCA photos

Figure 9. Submenu: Disease names in different languages

Screen dumps from Top menu Fungicide

Trade names for different fungicides in different countries													
					product rate								
Active ingredient	**g/l**	**Active ingredient**	**g/l**	**Active ingredient**	**g/l**	**kg/l**	**Germany**	**France**	**Denmark**	**UK**	**Sweden**	**Holland**	**Poland**
Azoxystrobin	250					1	Amistar / PRIORI	Amistar	Amistar	Amistar	Amistar	Amistar	Amistar
Azoxystrobin	80	Chlorthalonil	400			2,5	Amistar Opti			Amistar Opti		Olympus	Olympus
Azoxystrobin	200	cyproconazole	80			1	Priori Xtra	Amistar Xtra/Priori Xtra		Priori Extra			
Azoxystrobin		Chlorthalonil		cyproconazole								Priori Protector	
Azoxystrobin	100	fenpropimorph	280			2		Amistar Pro		Amistar pro			
bromuconazole	200					1,25				Jazz/Tote			Granit
Chlorthalonil	750					1,4	Pugil 75 WG						
Chlorthalonil	500					2	Bravo 500/	Chlorthalonil		Joules/Bravo 500/Sonar	Bravo/Daconil 500	Daconil	Bravo 500/Gwarant
Chlorthalonil		Cyproconazol		Propiconazole			Cherikee			Cherokee			
Cyflufenamid	50					0,25	Vegas	alto /caddy		Cyflamid			Eminent Star
cyproconazole	100					1		Mohawk					
Cyproconazol	240					0,4	Alto 240	Alto/Caddy/Mohawk		Centaur		Caddy	
Cyproconazol	53	Cyprodinil	400			1,5	Radius WG	Iridia		Radius			
Cyproconazol	40	chlorothalonil	375			2		Citadelle		Alto Elite/Bravo Xtra			
Cyprodinil	750					1	Unix / PRIMA		Unix	Unix/Kayak	Unix/Chip		Unix
difenoconazole	250	propiconazole	250			0,5	Taspa						
difenoconazole	250					0,3				Plover			
Dimoxystrobin	133	Epoxiconazol	50			1,5	Swing Gold			Swing Gold	Swing Gold		Swing Top
Epoxiconazol	62,5	metrafenon	75	Fenpropimorph	200	2	Capalo			Capalo			Capalo
Epoxiconazol	100	Boscalid				1,5	Champion	Bell/Arolle	Bell	Tracker/Venture		Venture	
Epoxiconazol	43	Fenpropimorph	214	Pyraclostrobin	114	1,5	Diamant	Diamant		Diamant			
Epoxiconazol	125	kresoxim-methyl	125			1	JUWEL	Ogam	Opus Xtra	Allegro /Landmark			Allegro
Epoxiconazol	50	pyraclostrobin	133	kresoxim-methyl	67	1,5	OPTIMO	Opponent/Optimo		Opponent			
Epoxiconazol	125					1	Opus	Opus/Picarius	Opus/Rubric/Maredo	Opus	Opus		Opus/Soprano/Rubric
Epoxiconazol	84	Fenpropimorph	250			1,5	Opus Top	Opus Team	Opus Team	Opus Team/Eclipse	Opus Team	Opus team	Tango Star
Epoxiconazol	41,6	metconazol	30			3	OSIRIS*			Brutus			
Epoxiconazol	83	metrafenon	100			1,5				Ceando			Ceando
Fenpropidin	750					0,75-1	Zenit M	Gardian	Tern	Patrol/Tern	Tern	Mildin	
Fenpropimorph	750					1	Corbel	Corbel BASF		Corbel	Forbel	Corbel	Corbel
Fluoxastrobin	100	Prothioconazol	100			1,5	Fandango	Fandango S		Fandango/Maestro		Fandango	Fandango
Fluquinconazol	100					1,25	Flamenco			Flamenco			

Figure 10. Submenu: International trade names. Commercial product names of all active ingredients used, concentration and dose.

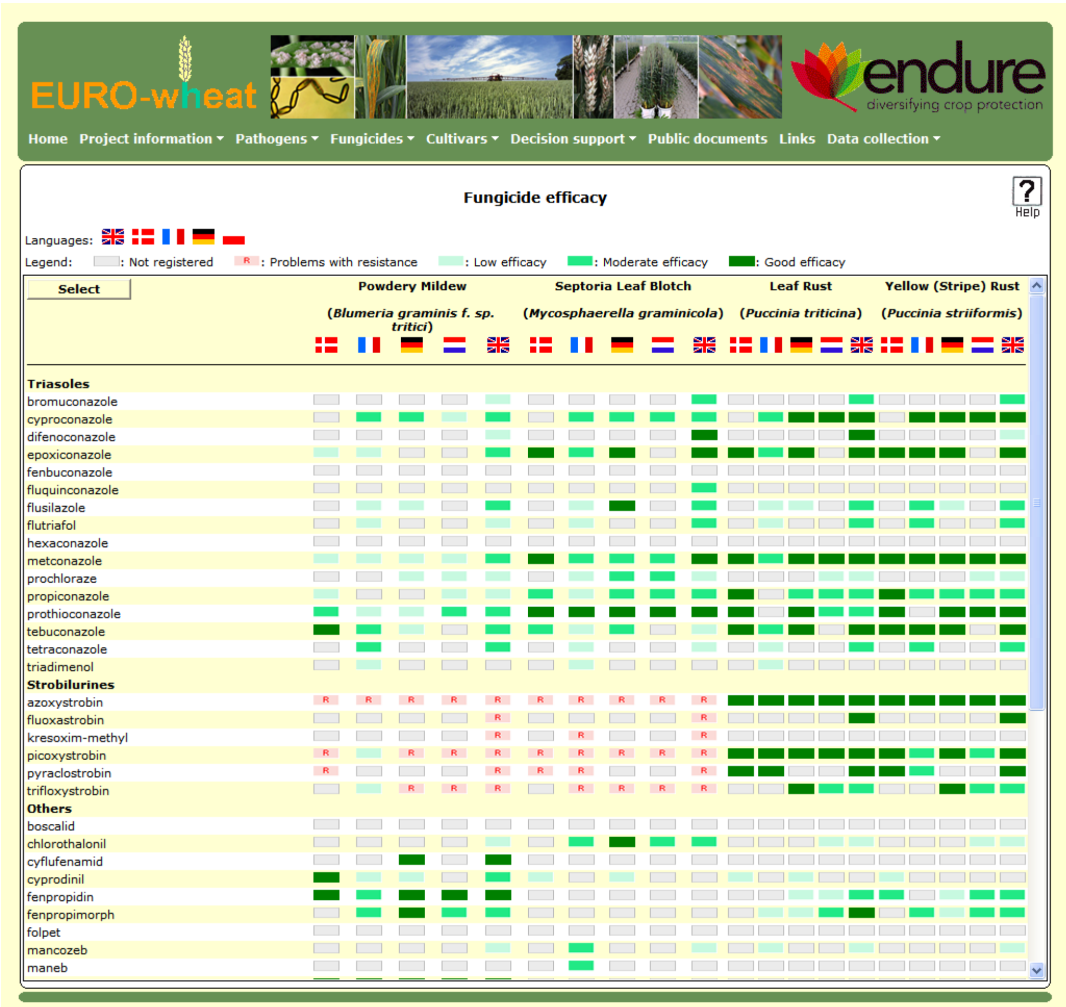


Figure 11. Submenu: Fungicide efficacy. The table can be designed on three factors: Countries, diseases and chemical compounds

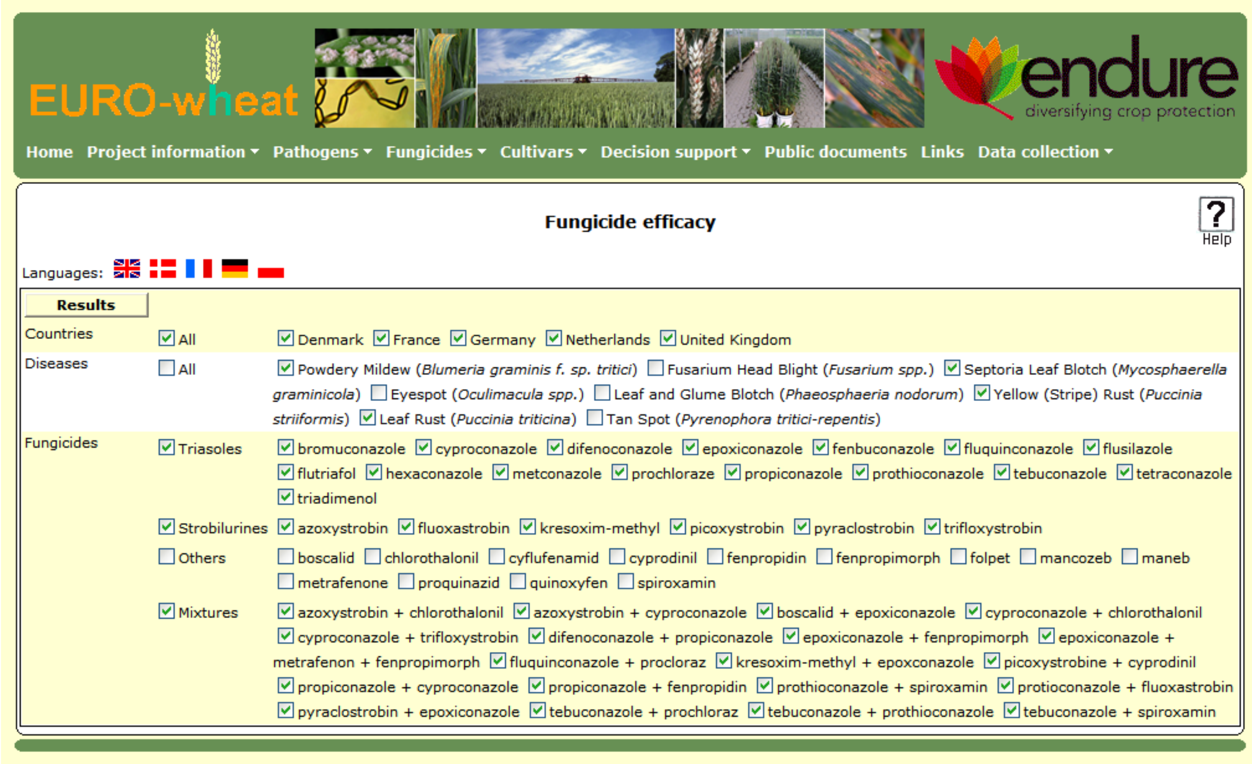
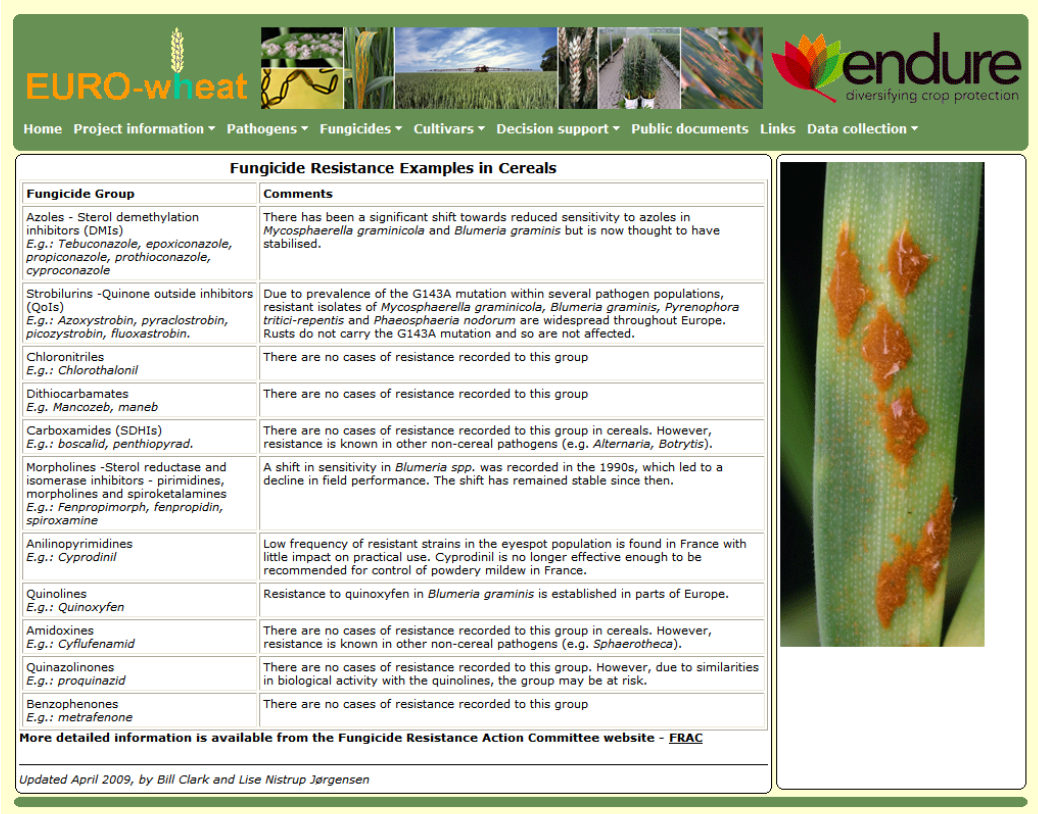


Figure 12. Submenu: Fungicide efficacy. The user can select countries, diseases and chemical compounds to be included in the table.

Figure 13. Submenu: Fungicide resistance information – general. Useful sources of information on fungicide resistance in the EU



Fungicide Resistance Examples in Cereals

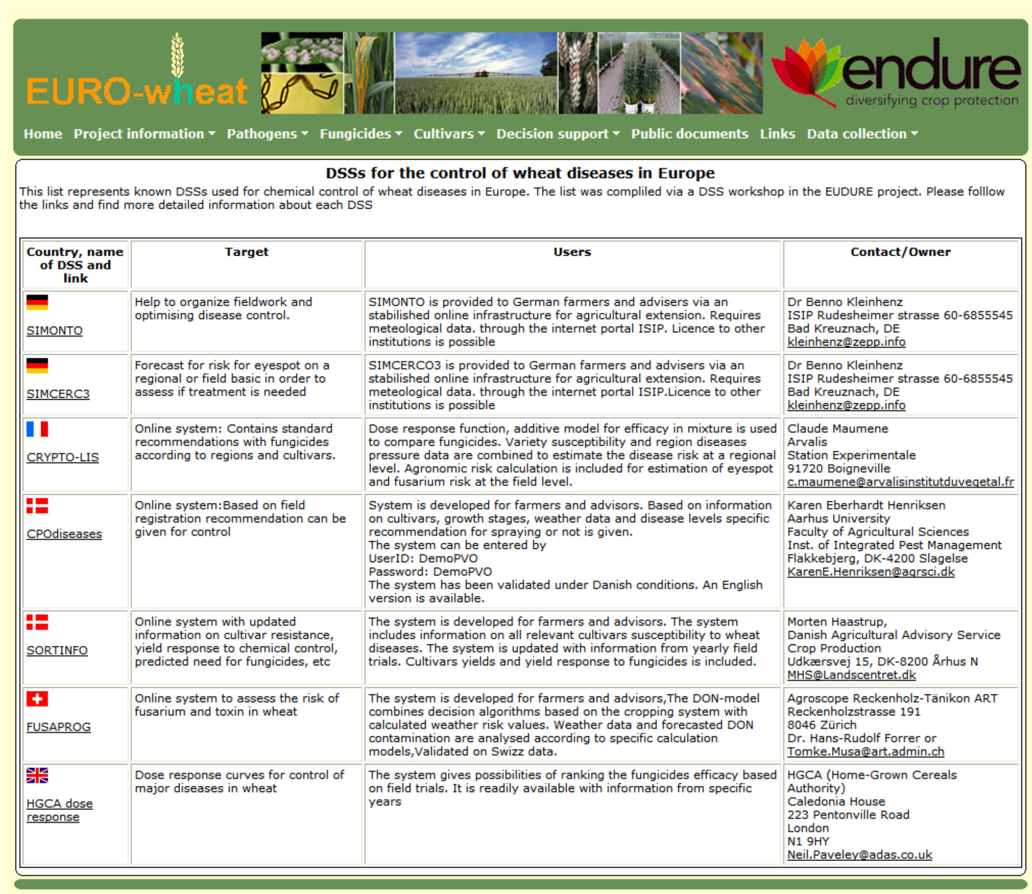
Fungicide Group	Comments
Azoles - Sterol demethylation inhibitors (DMIs) *E.g.: Tebuconazole, epoxiconazole, propiconazole, prothioconazole, cyproconazole*	There has been a significant shift towards reduced sensitivity to azoles in *Mycosphaerella graminicola* and *Blumeria graminis* but is now thought to have stabilised.
Strobilurins -Quinone outside inhibitors (QoIs) *E.g.: Azoxystrobin, pyraclostrobin, picozystrobin, fluoxastrobin.*	Due to prevalence of the G143A mutation within several pathogen populations, resistant isolates of *Mycosphaerella graminicola, Blumeria graminis, Pyrenophora tritici-repentis* and *Phaeosphaeria nodorum* are widespread throughout Europe. Rusts do not carry the G143A mutation and so are not affected.
Chloronitriles *E.g.: Chlorothalonil*	There are no cases of resistance recorded to this group
Dithiocarbamates *E.g. Mancozeb, maneb*	There are no cases of resistance recorded to this group
Carboxamides (SDHIs) *E.g.: boscalid, penthiopyrad.*	There are no cases of resistance recorded to this group in cereals. However, resistance is known in other non-cereal pathogens (e.g. *Alternaria, Botrytis*).
Morpholines -Sterol reductase and isomerase inhibitors - pirimidines, morpholines and spiroketalamines *E.g.: Fenpropimorph, fenpropidin, spiroxamine*	A shift in sensitivity in *Blumeria spp.* was recorded in the 1990s, which led to a decline in field performance. The shift has remained stable since then.
Anilinopyrimidines *E.g.: Cyprodinil*	Low frequency of resistant strains in the eyespot population is found in France with little impact on practical use. Cyprodinil is no longer effective enough to be recommended for control of powdery mildew in France.
Quinolines *E.g.: Quinoxyfen*	Resistance to quinoxyfen in *Blumeria graminis* is established in parts of Europe.
Amidoxines *E.g.: Cyflufenamid*	There are no cases of resistance recorded to this group in cereals. However, resistance is known in other non-cereal pathogens (e.g. *Sphaerotheca*).
Quinazolinones *E.g.: proquinazid*	There are no cases of resistance recorded to this group. However, due to similarities in biological activity with the quinolines, the group may be at risk.
Benzophenones *E.g.: metrafenone*	There are no cases of resistance recorded to this group

More detailed information is available from the Fungicide Resistance Action Committee website - FRAC

Updated April 2009, by Bill Clark and Lise Nistrup Jørgensen

Figure 14. Submenu: Fungicide Resistance Examples in Cereals

Screen dumps from Top menu Decision support

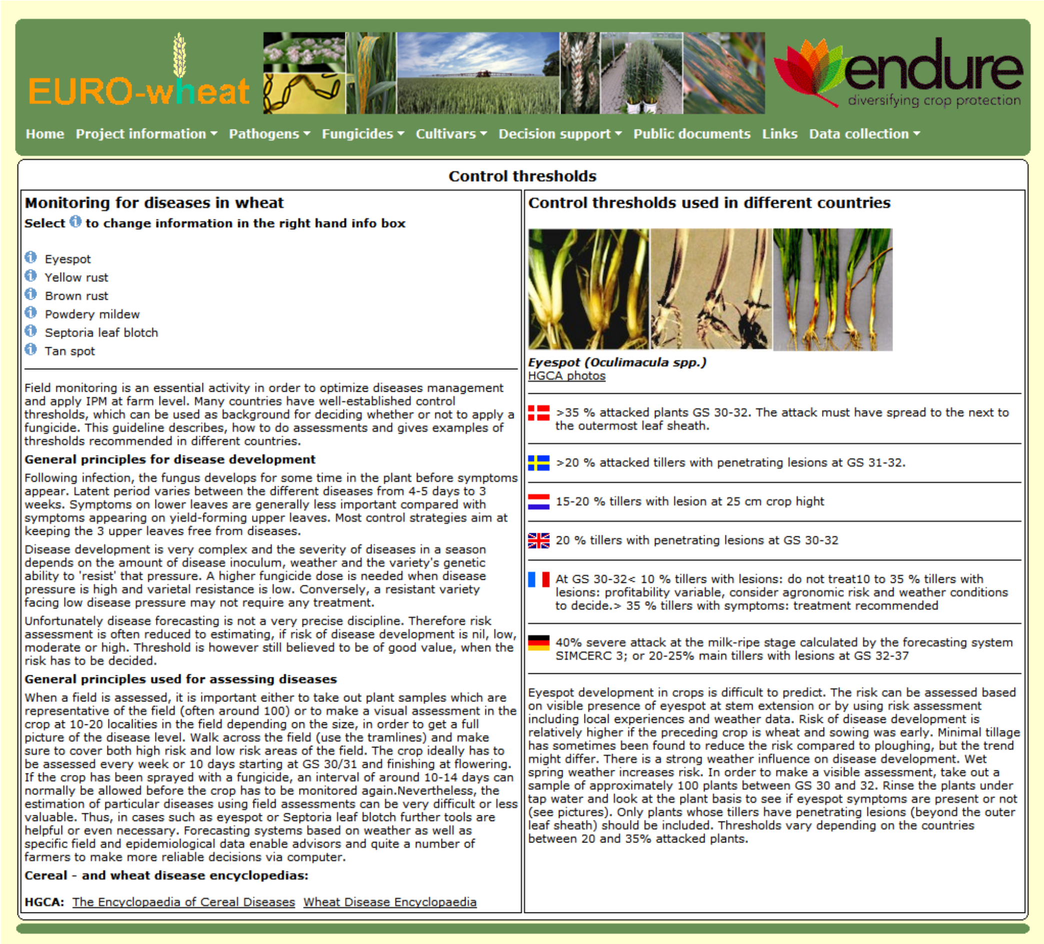


DSSs for the control of wheat diseases in Europe

This list represents known DSSs used for chemical control of wheat diseases in Europe. The list was complied via a DSS workshop in the EUDURE project. Please folllow the links and find more detailed information about each DSS

Country, name of DSS and link	Target	Users	Contact/Owner
SIMONTO	Help to organize fieldwork and optimising disease control.	SIMONTO is provided to German farmers and advisers via an stabilished online infrastructure for agricultural extension. Requires meteological data. through the internet portal ISIP. Licence to other institutions is possible	Dr Benno Kleinhenz ISIP Rudesheimer strasse 60-6855545 Bad Kreuznach, DE kleinhenz@zepp.info
SIMCERC3	Forecast for risk for eyespot on a regional or field basic in order to assess if treatment is needed	SIMCERCO3 is provided to German farmers and advisers via an stabilished online infrastructure for agricultural extension. Requires meteological data. through the internet portal ISIP.Licence to other institutions is possible	Dr Benno Kleinhenz ISIP Rudesheimer strasse 60-6855545 Bad Kreuznach, DE kleinhenz@zepp.info
CRYPTO-LIS	Online system: Contains standard recommendations with fungicides according to regions and cultivars.	Dose response function, additive model for efficacy in mixture is used to compare fungicides. Variety susceptibility and region diseases pressure data are combined to estimate the disease risk at a regional level. Agronomic risk calculation is included for estimation of eyespot and fusarium risk at the field level.	Claude Maumene Arvalis Station Experimentale 91720 Boigneville c.maumene@arvalisinstitutduvegetal.fr
CPOdiseases	Online system:Based on field registration recommendation can be given for control	System is developed for farmers and advisors. Based on information on cultivars, growth stages, weather data and disease levels specific recommendation for spraying or not is given. The system can be entered by UserID: DemoPVO Password: DemoPVO The system has been validated under Danish conditions. An English version is available.	Karen Eberhardt Henriksen Aarhus University Faculty of Agricultural Sciences Inst. of Integrated Pest Management Flakkebjerg, DK-4200 Slagelse KarenE.Henriksen@agrsci.dk
SORTINFO	Online system with updated information on cultivar resistance, yield response to chemical control, predicted need for fungicides, etc	The system is developed for farmers and advisors. The system includes information on all relevant cultivars susceptibility to wheat diseases. The system is updated with information from yearly field trials. Cultivars yields and yield response to fungicides is included.	Morten Haastrup, Danish Agricultural Advisory Service Crop Production Udkærsvej 15, DK-8200 Århus N MHS@Landscentret.dk
FUSAPROG	Online system to assess the risk of fusarium and toxin in wheat	The system is developed for farmers and advisors,The DON-model combines decision algorithms based on the cropping system with calculated weather risk values. Weather data and forecasted DON contamination are analysed according to specific calculation models,Validated on Swizz data.	Agroscope Reckenholz-Tänikon ART Reckenholzstrasse 191 8046 Zürich Dr. Hans-Rudolf Forrer or Tomke.Musa@art.admin.ch
HGCA dose response	Dose response curves for control of major diseases in wheat	The system gives possibilities of ranking the fungicides efficacy based on field trials. It is readily available with information from specific years	HGCA (Home-Grown Cereals Authority) Caledonia House 223 Pentonville Road London N1 9HY Neil.Paveley@adas.co.uk

Figure 15. Submenu: Control thresholds - Overview of DSSs for the control of wheat diseases in Europe



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Control thresholds

Monitoring for diseases in wheat

Select to change information in the right hand info box

- Eyespot
- Yellow rust
- Brown rust
- Powdery mildew
- Septoria leaf blotch
- Tan spot

Field monitoring is an essential activity in order to optimize diseases management and apply IPM at farm level. Many countries have well-established control thresholds, which can be used as background for deciding whether or not to apply a fungicide. This guideline describes, how to do assessments and gives examples of thresholds recommended in different countries.

General principles for disease development

Following infection, the fungus develops for some time in the plant before symptoms appear. Latent period varies between the different diseases from 4-5 days to 3 weeks. Symptoms on lower leaves are generally less important compared with symptoms appearing on yield-forming upper leaves. Most control strategies aim at keeping the 3 upper leaves free from diseases.

Disease development is very complex and the severity of diseases in a season depends on the amount of disease inoculum, weather and the variety's genetic ability to 'resist' that pressure. A higher fungicide dose is needed when disease pressure is high and varietal resistance is low. Conversely, a resistant variety facing low disease pressure may not require any treatment.

Unfortunately disease forecasting is not a very precise discipline. Therefore risk assessment is often reduced to estimating, if risk of disease development is nil, low, moderate or high. Threshold is however still believed to be of good value, when the risk has to be decided.

General principles used for assessing diseases

When a field is assessed, it is important either to take out plant samples which are representative of the field (often around 100) or to make a visual assessment in the crop at 10-20 localities in the field depending on the size, in order to get a full picture of the disease level. Walk across the field (use the tramlines) and make sure to cover both high risk and low risk areas of the field. The crop ideally has to be assessed every week or 10 days starting at GS 30/31 and finishing at flowering. If the crop has been sprayed with a fungicide, an interval of around 10-14 days can normally be allowed before the crop has to be monitored again.Nevertheless, the estimation of particular diseases using field assessments can be very difficult or less valuable. Thus, in cases such as eyespot or Septoria leaf blotch further tools are helpful or even necessary. Forecasting systems based on weather as well as specific field and epidemiological data enable advisors and quite a number of farmers to make more reliable decisions via computer.

Cereal - and wheat disease encyclopedias:

HGCA: The Encyclopaedia of Cereal Diseases Wheat Disease Encyclopaedia

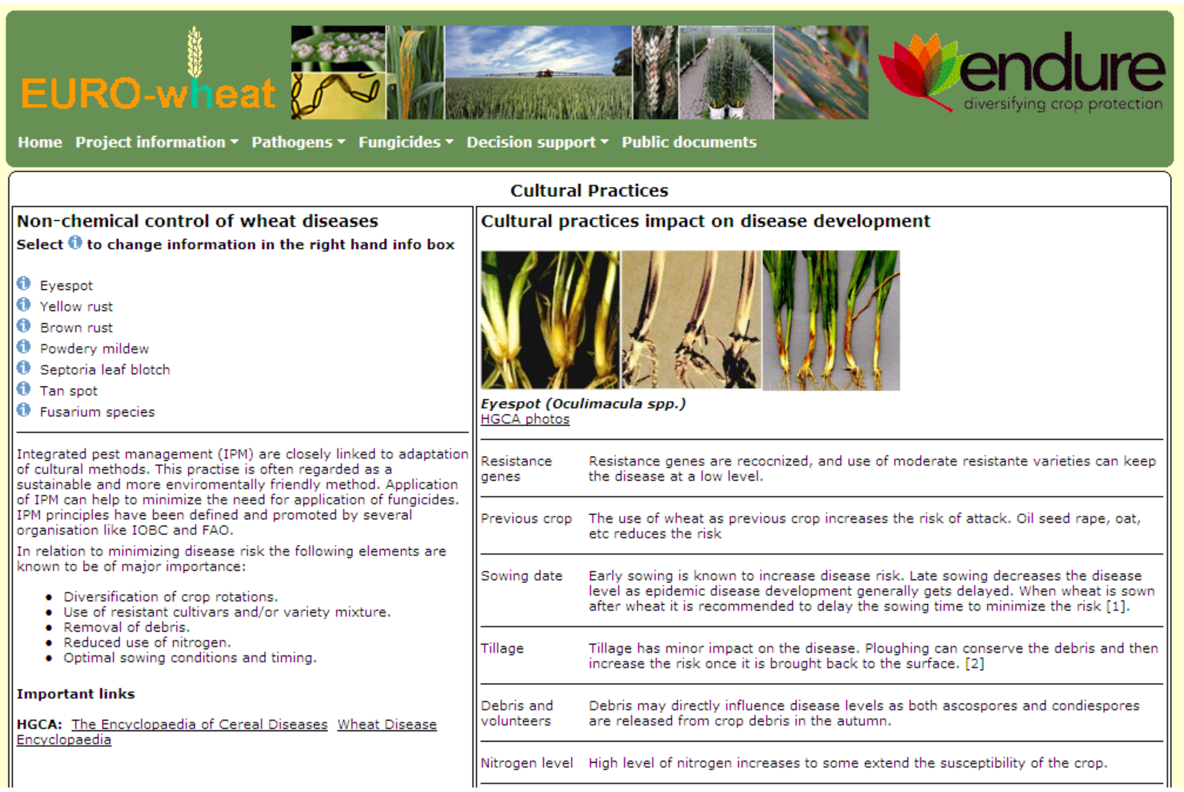
Control thresholds used in different countries

Eyespot (Oculimacula spp.)
HGCA photos

Denmark	>35 % attacked plants GS 30-32. The attack must have spread to the next to the outermost leaf sheath.
Sweden	>20 % attacked tillers with penetrating lesions at GS 31-32.
Netherlands	15-20 % tillers with lesion at 25 cm crop hight
UK	20 % tillers with penetrating lesions at GS 30-32
France	At GS 30-32< 10 % tillers with lesions: do not treat10 to 35 % tillers with lesions: profitability variable, consider agronomic risk and weather conditions to decide.> 35 % tillers with symptoms: treatment recommended
Germany	40% severe attack at the milk-ripe stage calculated by the forecasting system SIMCERC 3; or 20-25% main tillers with lesions at GS 32-37

Eyespot development in crops is difficult to predict. The risk can be assessed based on visible presence of eyespot at stem extension or by using risk assessment including local experiences and weather data. Risk of disease development is relatively higher if the preceding crop is wheat and sowing was early. Minimal tillage has sometimes been found to reduce the risk compared to ploughing, but the trend might differ. There is a strong weather influence on disease development. Wet spring weather increases risk. In order to make a visible assessment, take out a sample of approximately 100 plants between GS 30 and 32. Rinse the plants under tap water and look at the plant basis to see if eyespot symptoms are present or not (see pictures). Only plants whose tillers have penetrating lesions (beyond the outer leaf sheath) should be included. Thresholds vary depending on the countries between 20 and 35% attacked plants.

Figure 16. Submenu: Control thresholds. For different diseases as applied by different countries in EU.



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Cultural Practices

Non-chemical control of wheat diseases

Select to change information in the right hand info box

- Eyespot
- Yellow rust
- Brown rust
- Powdery mildew
- Septoria leaf blotch
- Tan spot
- Fusarium species

Integrated pest management (IPM) are closely linked to adaptation of cultural methods. This practise is often regarded as a sustainable and more enviromentally friendly method. Application of IPM can help to minimize the need for application of fungicides. IPM principles have been defined and promoted by several organisation like IOBC and FAO.

In relation to minimizing disease risk the following elements are known to be of major importance:

- Diversification of crop rotations.
- Use of resistant cultivars and/or variety mixture.
- Removal of debris.
- Reduced use of nitrogen.
- Optimal sowing conditions and timing.

Important links

HGCA: The Encyclopaedia of Cereal Diseases Wheat Disease Encyclopaedia

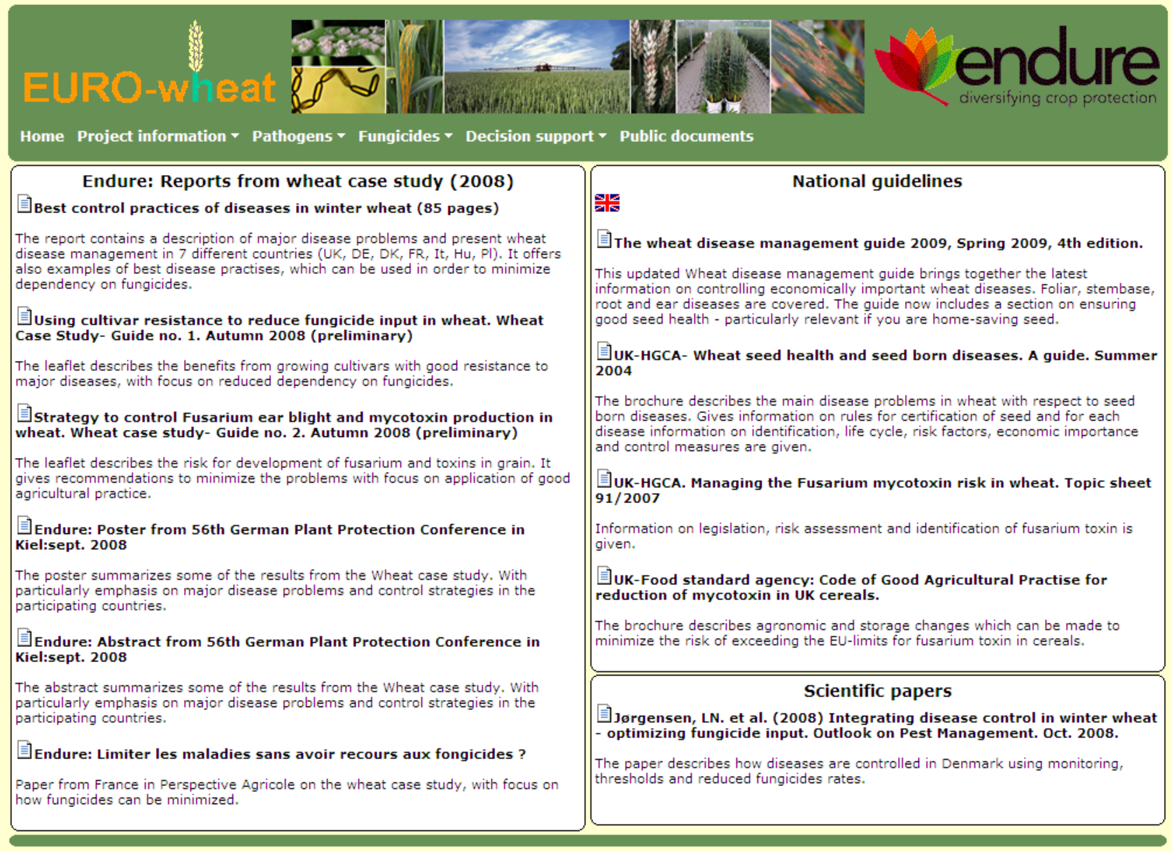
Cultural practices impact on disease development

Eyespot (Oculimacula spp.)
HGCA photos

Resistance genes	Resistance genes are recocnized, and use of moderate resistante varieties can keep the disease at a low level.
Previous crop	The use of wheat as previous crop increases the risk of attack. Oil seed rape, oat, etc reduces the risk
Sowing date	Early sowing is known to increase disease risk. Late sowing decreases the disease level as epidemic disease development generally gets delayed. When wheat is sown after wheat it is recommended to delay the sowing time to minimize the risk [1].
Tillage	Tillage has minor impact on the disease. Ploughing can conserve the debris and then increase the risk once it is brought back to the surface. [2]
Debris and volunteers	Debris may directly influence disease levels as both ascospores and condiespores are released from crop debris in the autumn.
Nitrogen level	High level of nitrogen increases to some extend the susceptibility of the crop.

Figure 17. Submenu: Cultural control methods. For a range of major diseases.

Screen dumps from Top menu Public documents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Endure: Reports from wheat case study (2008)

Best control practices of diseases in winter wheat (85 pages)

The report contains a description of major disease problems and present wheat disease management in 7 different countries (UK, DE, DK, FR, It, Hu, Pl). It offers also examples of best disease practises, which can be used in order to minimize dependency on fungicides.

Using cultivar resistance to reduce fungicide input in wheat. Wheat Case Study- Guide no. 1. Autumn 2008 (preliminary)

The leaflet describes the benefits from growing cultivars with good resistance to major diseases, with focus on reduced dependency on fungicides.

Strategy to control Fusarium ear blight and mycotoxin production in wheat. Wheat case study- Guide no. 2. Autumn 2008 (preliminary)

The leaflet describes the risk for development of fusarium and toxins in grain. It gives recommendations to minimize the problems with focus on application of good agricultural practice.

Endure: Poster from 56th German Plant Protection Conference in Kiel:sept. 2008

The poster summarizes some of the results from the Wheat case study. With particularly emphasis on major disease problems and control strategies in the participating countries.

Endure: Abstract from 56th German Plant Protection Conference in Kiel:sept. 2008

The abstract summarizes some of the results from the Wheat case study. With particularly emphasis on major disease problems and control strategies in the participating countries.

Endure: Limiter les maladies sans avoir recours aux fongicides ?

Paper from France in Perspective Agricole on the wheat case study, with focus on how fungicides can be minimized.

National guidelines

The wheat disease management guide 2009, Spring 2009, 4th edition.

This updated Wheat disease management guide brings together the latest information on controlling economically important wheat diseases. Foliar, stembase, root and ear diseases are covered. The guide now includes a section on ensuring good seed health - particularly relevant if you are home-saving seed.

UK-HGCA- Wheat seed health and seed born diseases. A guide. Summer 2004

The brochure describes the main disease problems in wheat with respect to seed born diseases. Gives information on rules for certification of seed and for each disease information on identification, life cycle, risk factors, economic importance and control measures are given.

UK-HGCA. Managing the Fusarium mycotoxin risk in wheat. Topic sheet 91/2007

Information on legislation, risk assessment and identification of fusarium toxin is given.

UK-Food standard agency: Code of Good Agricultural Practise for reduction of mycotoxin in UK cereals.

The brochure describes agronomic and storage changes which can be made to minimize the risk of exceeding the EU-limits for fusarium toxin in cereals.

Scientific papers

Jørgensen, LN. et al. (2008) Integrating disease control in winter wheat - optimizing fungicide input. Outlook on Pest Management. Oct. 2008.

The paper describes how diseases are controlled in Denmark using monitoring, thresholds and reduced fungicides rates.

Figure 18. This section contains useful documents relating to disease control in various EU countries.

2.4. Discussion

The EURO-wheat project has clearly demonstrated how value can be added to existing information that may be disparate throughout EU countries. The establishment of a Network of Excellence by the ENDURE project effectively created a set of contacts, both individuals and institutions, that could be used to both provide existing information or to create specific documents addressing particular issues. The coming together of these individuals highlighted the considerable variation that exists within the EU in the way information is presented, how data are gathered, how tests are carried out etc. Much of this information, however valuable within the country of origin, is of limited value to other EU countries without an understanding of the methodology and methods of interpretation used (excluding problems of language). The EURO-wheat project has tried to bring this type of information together and represent it in a common format that enables potential users to have access to a much wider range of information. Examples of the types of information collected for EURO-wheat include:

1. Cultivar resistance ratings.
   In the UK we are accustomed to disease resistance ratings on a 0-9 scale where 9 is highly resistant, so high figures are 'good'. Other EU countries use a range of other scales, some where a high figure denotes high susceptibility. Cross-country rankings have been produced so that disease resistance of common cultivars can be compared.

2. Fungicide performance
   In the UK fungicide performance is commonly represented on a 4-star rating scale (e.g. HGCA Wheat Disease Management Guide). Other countries use a 3-star rating or a 'good', 'moderate' and 'poor' rating. This makes comparison across countries difficult. EURO-wheat has amalgamated all ratings into a common scale so that cross-country comparisons are possible.

3. Yellow rust virulences
   EURO-wheat has gathered common datasets on pathogen virulences from EU countries allowing us to track the occurred.nce of new virulence factors in different EU countries. This has highlighted the role of the UK as most often new races arise in the UK and are only detected in France and Denmark in subsequent seasons. This also gives us useful information on the evolution of races over seasons.

4. Fungicide resistance information
   EURO-wheat has brought together wide-ranging sources of information on both the occurrence of resistance in wheat pathogens and measures taken to try and prevent or reduce the incidence and spread of resistance. It has made links between the various Fungicide Resistance Action Groups in the EU.

There are many other examples within EURO-wheat of where European collaboration can add value to datasets in this way. The web-site will continue to be populated beyond the life of the HGCA-funded component and we must investigate ways of making the information more widely available, either via the ENDURE web-site or perhaps via the HGCA web-site.