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

Broom’s Barn Research Centre, Higham, Bury St Edmunds, Suffolk IP28 6NP

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CONTENTS

1. ABSTRACT .............................................................................................................................................. 4

2. EURO-WHEAT: A EUROPEAN COLLABORATION ON RESISTANCE
   CHARACTERISTICS OF WHEAT CULTIVARS, WHEAT PATHOGEN VIRULENCE,
   DISEASE MANAGEMENT TOOLS AND FUNGICIDE EFFICACY ................................. 5

   2.1. Introduction to ENDURE and EURO-wheat .............................................................................. 5

      2.1.1. ENDURE (European Network for the DURable Exploitation of crop protection
             strategies) ......................................................................................................................... 5

      2.1.2. EURO-wheat .................................................................................................................. 6

      2.1.3. Interactions of EURO-wheat with other sub-activities in ENDURE ............................. 8

   2.2. EURO-wheat .................................................................................................................................. 9

      2.2.1. Partner institutions and people ....................................................................................... 9

      2.2.2. Major achievements of EURO-wheat ........................................................................... 11

   2.3. The EURO-wheat web site ......................................................................................................... 12

      2.3.1. Screen dumps of selected applications and information pages ................................. 13

   2.4. Discussion ..................................................................................................................................... 20
1. **ABSTRACT**

EURO-wheat is a part of a large European project entitled ENDURE (European Network for the **Durable** Exploitation 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 (European Network for the DURable Exploitation 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

- 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 PRI NL

(Also representing PPO and LEI of Wageningen UR)

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 feedback 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

<table>
<thead>
<tr>
<th>No.</th>
<th>Deliverable</th>
<th>Lead Partner</th>
<th>Nature</th>
<th>Dissemination level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design a web based Euro-wheat platform inspired by euroblight compatible with existing database structure in ENDURE</td>
<td>AU</td>
<td>P</td>
<td>RE</td>
</tr>
<tr>
<td>2</td>
<td>Deliver the first web-based prototype comprising at least two wheat pathosystems</td>
<td>AU</td>
<td>P</td>
<td>PU</td>
</tr>
<tr>
<td>3</td>
<td>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.</td>
<td>AU</td>
<td>P</td>
<td>PU</td>
</tr>
</tbody>
</table>

P = Prototype, PU = Public, RE = Restricted to a group specified by the consortium.
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).
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cristian Lannau</td>
<td>Institut national de la recherche agronomique, France</td>
<td>France</td>
</tr>
<tr>
<td>2</td>
<td>Claude Pope</td>
<td>Institut national de la recherche agronomique, France</td>
<td>France</td>
</tr>
<tr>
<td>3</td>
<td>Kerstin Flit</td>
<td>Julius Kuehn Institute - Federal Research Centre for Cultivated Plants</td>
<td>Germany</td>
</tr>
<tr>
<td>4</td>
<td>Margit Jahn</td>
<td>Julius Kuehn Institute - Federal Research Centre for Cultivated Plants</td>
<td>Germany</td>
</tr>
<tr>
<td>5</td>
<td>Bernd Rodemann</td>
<td>Julius Kuehn Institute - Federal Research Centre for Cultivated Plants</td>
<td>Germany</td>
</tr>
<tr>
<td>6</td>
<td>Bill Clark</td>
<td>Rothamsted Research, United Kingdom</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>7</td>
<td>Neil Evans</td>
<td>Rothamsted Research, United Kingdom</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>8</td>
<td>Jerzy Czembor</td>
<td>Plant Breeding and Acclimatization Institute, Poland</td>
<td>Poland</td>
</tr>
<tr>
<td>9</td>
<td>Tomasz Goral</td>
<td>Plant Breeding and Acclimatization Institute, Poland</td>
<td>Poland</td>
</tr>
<tr>
<td>10</td>
<td>Jens Granboch Hansen</td>
<td>Aarhus University, Faculty of Agricultural Sciences, Denmark</td>
<td>Denmark</td>
</tr>
<tr>
<td>11</td>
<td>Mogens S. Hovmoller</td>
<td>Aarhus University, Faculty of Agricultural Sciences, Denmark</td>
<td>Denmark</td>
</tr>
<tr>
<td>12</td>
<td>Lise Nistrup Jørgensen</td>
<td>Aarhus University, Faculty of Agricultural Sciences, Denmark</td>
<td>Denmark</td>
</tr>
<tr>
<td>13</td>
<td>Poul Lassen</td>
<td>Aarhus University, Faculty of Agricultural Sciences, Denmark</td>
<td>Denmark</td>
</tr>
<tr>
<td>14</td>
<td>Ghita C. Nielsen</td>
<td>Danish Agricultural Advisory Service, Denmark</td>
<td>Denmark</td>
</tr>
<tr>
<td>15</td>
<td>Rosemary Bayles</td>
<td>National Institute of Agricultural Botany, United Kingdom</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>16</td>
<td>Philippe du Cheyron</td>
<td>ARVALIS - Institut du végétal, France</td>
<td>France</td>
</tr>
<tr>
<td>17</td>
<td>Claude Meunier</td>
<td>ARVALIS - Institut du végétal, France</td>
<td>France</td>
</tr>
</tbody>
</table>

**Figure 1.** Institutions involved in EURO-wheat

**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

![EURO-wheat web site screenshot](image)

**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.

<table>
<thead>
<tr>
<th>Project information</th>
<th>Pathogens</th>
<th>Fungicides</th>
<th>Cultivars</th>
<th>Decision support</th>
<th>Public documents</th>
<th>Links</th>
<th>Data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions</td>
<td>Yellow Rust</td>
<td>Efficacy</td>
<td>Disease resistance ranking</td>
<td>Systems in Europe</td>
<td></td>
<td></td>
<td>Fungicide trade names</td>
</tr>
<tr>
<td>People</td>
<td>Fusarium</td>
<td>Resistance</td>
<td>Yield response to fungicide</td>
<td>Control thresholds</td>
<td></td>
<td></td>
<td>Country reports</td>
</tr>
<tr>
<td>Events</td>
<td>Disease names</td>
<td>Resistance examples in cereals</td>
<td>Cultural practice</td>
<td></td>
<td></td>
<td></td>
<td>Translate</td>
</tr>
<tr>
<td>My Profile</td>
<td>International trade names</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Figure 9. Submenu: Disease names in different languages
Screen dumps from Top menu Fungicide

Table 1. Trade names for different fungicides in different countries.

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Active Ingredient</th>
<th>Active Ingredient</th>
<th>Active Ingredient</th>
<th>Active Ingredient</th>
<th>Fungicide</th>
<th>Fungicide</th>
<th>Fungicide</th>
<th>Fungicide</th>
<th>Fungicide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

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
Figure 14. Submenu: Fungicide Resistance Examples in Cereals

Screen dumps from Top menu Decision support

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

<table>
<thead>
<tr>
<th>Country</th>
<th>Control Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>&gt;50% infected wheat plants in harvestable stage at GS 30-32. The attack must have spread to the next to the outermost leaf sheath.</td>
</tr>
<tr>
<td>EU</td>
<td>10% max. tillers with penetrating lesions at GS 30-32.</td>
</tr>
<tr>
<td>EU</td>
<td>20% max. tillers with penetrating lesions at GS 30-32.</td>
</tr>
</tbody>
</table>

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

Cultural practices

<table>
<thead>
<tr>
<th>Cultural Practice</th>
<th>Impact on Disease Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>Enhanced soil fertility, leading to better crop growth and disease resistance.</td>
</tr>
<tr>
<td>Tillage</td>
<td>Reduced disease incidence due to the disruption of soil structure.</td>
</tr>
</tbody>
</table>

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