



# ICT framework for global wheat rust surveillance and monitoring

Jens G. Hansen<sup>1</sup>, Poul Lassen<sup>1</sup>, Mogens Hovmøller<sup>1</sup> & David Hodson<sup>2</sup>



AARHUS UNIVERSITY



# Outline

- ▶ What are the problems?
- ▶ Call for global action by Norman E. Borlaug
- ▶ Integrated Information Resources. ICT Framework for wheat rust data storage, data management and dissemination
- ▶ Major achievements and implications for Europe



# What are the problems ?

The Economist

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Wednesday September 19th 2012

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## Wheat rust and world farming

### Rust in the bread basket

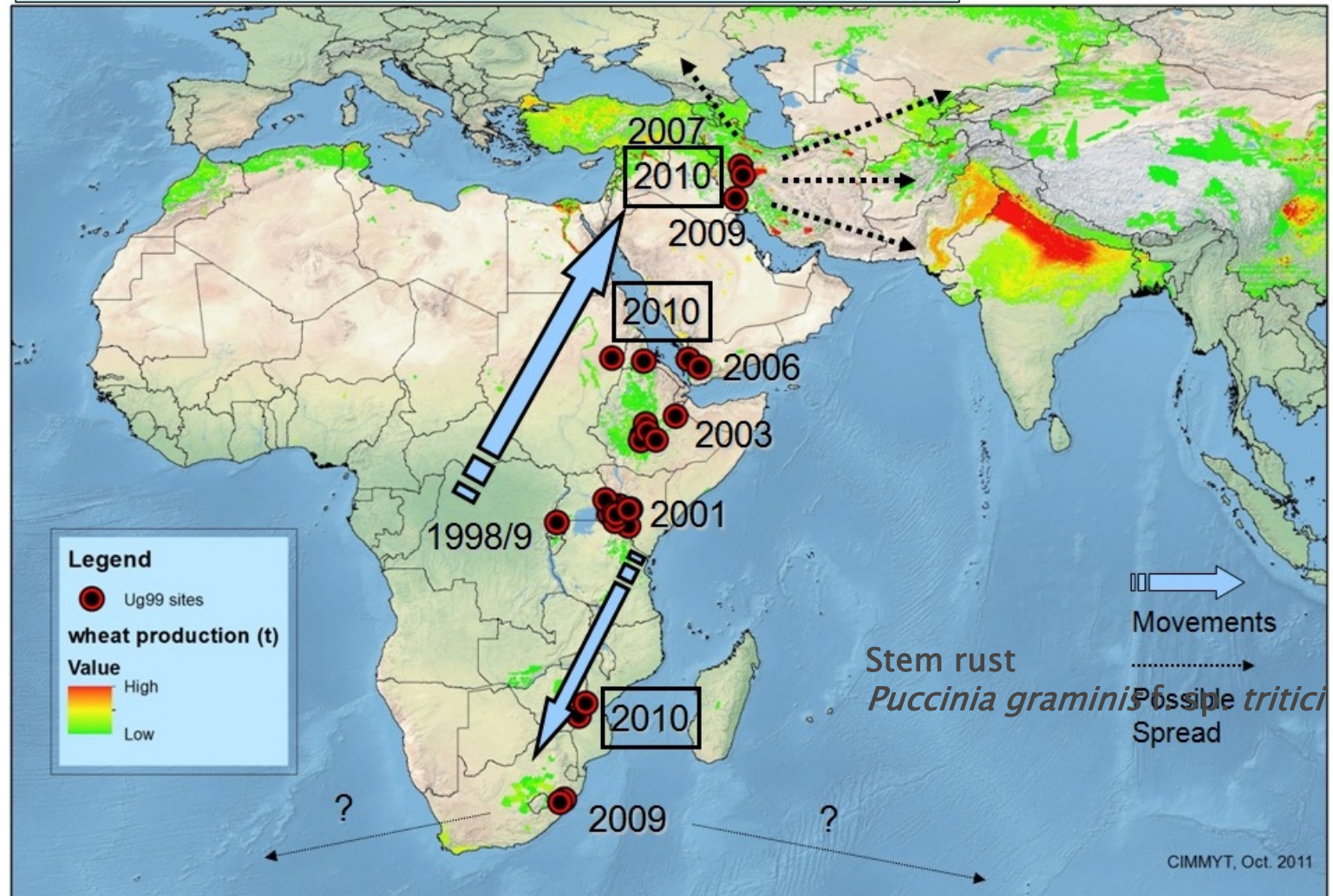
A crop-killing fungus is spreading wheat-growing areas

Jul 1st 2010 | from the print edition



IT IS sometimes called the "polio of agriculture". Wheat rust is not just back at scary forms. In some ways it is worse than in Nigeria. Wheat rust has spread silently camped at the gates of one of the world's largest wheat producers yet infected.

## THE SPREAD OF WHEAT STEM RUST UG99 LINEAGE





# What are the problems ?

EDITORIAL



Mogens Støvring  
Hovmøller and  
Annemarie Fejer  
Justesen are senior  
scientists and Stephanie  
Walter is a postdoctoral  
scientist in the Depart-  
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Management, Aarhus  
University, Slagelse,  
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mogens.hovmoller@  
agrsci.dk; stephanie.  
walter@agrsci.dk;  
annemariefejer.  
justesen@agrsci.dk

## Escal

LAST MONTH, Russia, at the  
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focused on t  
epidemics th  
must coordi  
research, pla  
In the 19  
rust that thro  
ative pathog  
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stem rust on  
large-scale e  
of yellow ru  
threat to the

Stripe rust, Sweden, 2011

[www.sciencemag.org](http://www.sciencemag.org) S





# Durable Rust Resistance in Wheat

## CHRONICLEONLINE

Feb. 27, 2011

### \$40M grant to fight wheat pathogen that threatens global food security

By Linda McCandless

The United Kingdom's Department for International Development (DFID) and the Bill & Melinda Gates Foundation announced today that they will invest \$40 million in a global project led by Cornell to combat deadly strains of Ug99, an evolving wheat pathogen that poses a dangerous threat to global food security, particularly in the poorest nations of the developing world.

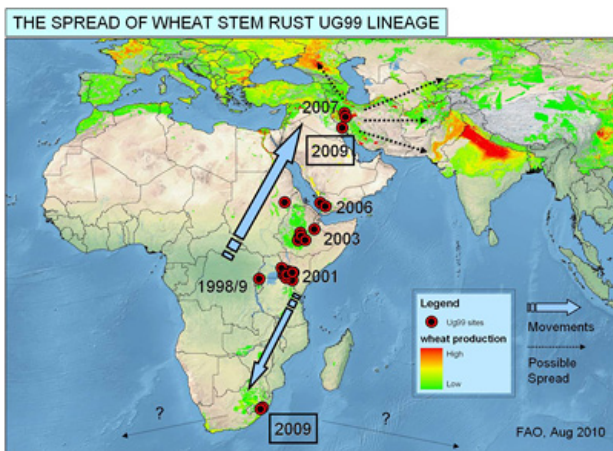


*Durable Rust Resistance in Wheat project*

Cornell plant breeder Ronnie Coffman, right; Bedada Girma, left, of the Ethiopian Institute of Agricultural Research; and Eshetu Sisay, manager of the Gonde Seed Farm, look for signs of infection in fields of stem and yellow rust-resistant wheat in Ethiopia.

The five-year grant to the Durable Rust Resistance in Wheat (DRRW) project at Cornell will support efforts to identify new stem rust-resistant genes in wheat, improve surveillance, and multiply and distribute rust-resistant wheat seed to farmers and their families.

"We cannot overstate the importance of this for addressing the causes of poverty, hunger and disease in the developing world," said Ronnie Coffman, Cornell professor of plant breeding and genetics and director of DRRW. "Against the backdrop of rising food prices, and wheat in particular, researchers worldwide will be able to play an increasingly vital role



[Click to enlarge](#)

## Durable Rust Resistance In Wheat Led by Cornell University

\$40,000,000

Phase II: 2011-2014





# RustTracker.org

A Global Wheat Rust Monitoring System

**CIMMYT**  
International Maize and Wheat Improvement Center



## CHRONICLE ONLINE

Sept. 4, 2012

### 'Rust-Tracker' to monitor deadly wind-borne wheat fungus

Top wheat experts reported a breakthrough in their ability to track strains of a deadly, rapidly mutating wheat pathogen called stem rust that threatens wheat fields from East Africa to South Asia.

Using data submitted by farmers and scientists, creators of Rust-Tracker, a global cereal rust monitoring system, say they can monitor 42 million hectares of wheat in 27 developing countries in the path of a wind-borne disease so virulent it could quickly turn a healthy field of wheat into a black mass of twisted stems and dried-up grains.



Ronnie Coffman, right, with project collaborator Germa Bedada.

At a symposium in Beijing organized by the Borlaug Global Rust Initiative (BGR) Sept. 1-4, scientists reported significant progress developing and introducing 20 new varieties of rust-resistant wheat. 3 for the new varieties is being deployed in eight nations for farmers to plant to prevent massive crop. But the experts warned that wheat fields in many countries remain largely unprotected from the dangerous pathogen.

"The research being presented at this meeting takes us significantly closer to our goal of protecting global wheat crop from rust diseases," said Ronnie Coffman, Cornell professor of plant breeding, principal investigator, director of the Durable Rust Resistance in Wheat Project and vice chair of BGR. "But the vast wheat-growing region that stretches across North Africa and Central Asia all the way to gateway to China -- the world's largest wheat-growing nation -- is still vulnerable."

Studies presented in Beijing reported on progress with isolating genes that confer resistance to the Ug99 fungus in a wild relative of wheat from Israel and Lebanon. An estimated 85 percent of wheat



Home Stem Rust Yellow Rust Leaf Rust Resistant Cultivars

#### Country Pages

Select Country

#### Rust Resources

- Survey Forms & Protocols
- Documents
- Rust Mapper
- Importance of Rusts
- Survey Mapper
- Stem Rust Pathotype Frequency Map

#### Contact

- Contact Details

#### Other Sites

- BGR (Globalrust.org)
- CIMMYT
- CIMMYT Wheat Atlas
- CIMMYT Wheat Doctor
- DWR, India
- FAO
- GRIS (Wheatpedigree.net)
- GRRC (Wheatrust.org)
- ICARDA

#### Latest Situation Updates

- Aug 17th, 2012: Latest version of Mehtaensis newsletter published by DWR, Flowerdale, Shimla. Comprehensive, updated information on rusts in India and South Asia
- Aug 15th, 2012: Short ("Belg") season surveys undertaken in the Bale zone of Ethiopia
- July 3, 2012: Eighth new Ug99 variant identified -- Race TTK-SF+ confirmed in South Africa and Zimbabwe

#### Translate

Translate to:  
English  
Translate  
Powered by Google Translate.

#### Rust in the news

Another Strain of Deadly Wheat Fungus - AllAfrica.com  
September 4, 2012  
Breakthrough against wheat pathogen - Financial Express Bangladesh August 31, 2012  
Researchers launch new 'Rust-Tracker' to monitor deadly wheat fungus in 27 ... - Science Codex August 31, 2012

#### Login

- Log in



RustTracker.org is developed by CIMMYT and other partners as part of the Borlaug Global Rust Initiative (BGR) to mitigate the threat of wheat rust diseases (stem rust, leaf rust and yellow rust). RustTracker.org is the primary web portal for global cereal rust surveillance and monitoring information.

RustTracker.org provides up to date information on the status of wheat rust diseases. Key features include:

- Field surveys: incidence and severity of disease
- Pathogen monitoring of important races e.g., "Ug99 race group"
- Resistant cultivar information
- Country-specific rust information (37 countries at present, but varying content for each country)
- A range of interactive, database driven, visualization tools

Initial development of RustTracker.org has focused on stem rust and the "Ug99 race group" in particular. Current content reflects these efforts, but in the near future expanded content for both yellow and leaf rust will be included.



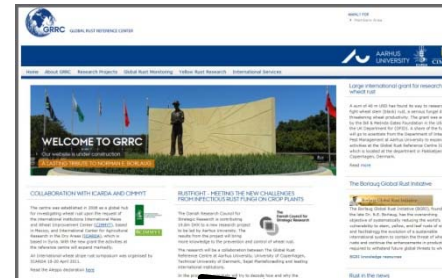
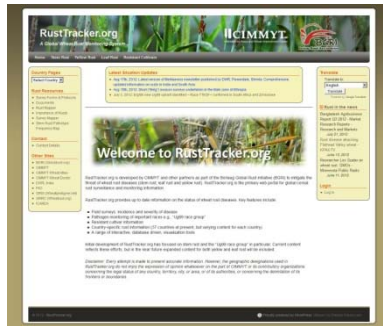
# Integrated Information Resources

Rust Tracker

Wheat Atlas

WheatRust.org

GlobalRust.org



**Wheat Rust Toolbox**

Survey  
Dbase

Barberry  
Dba

Trap  
Nursery  
Dbase

Pathotype  
Dbase

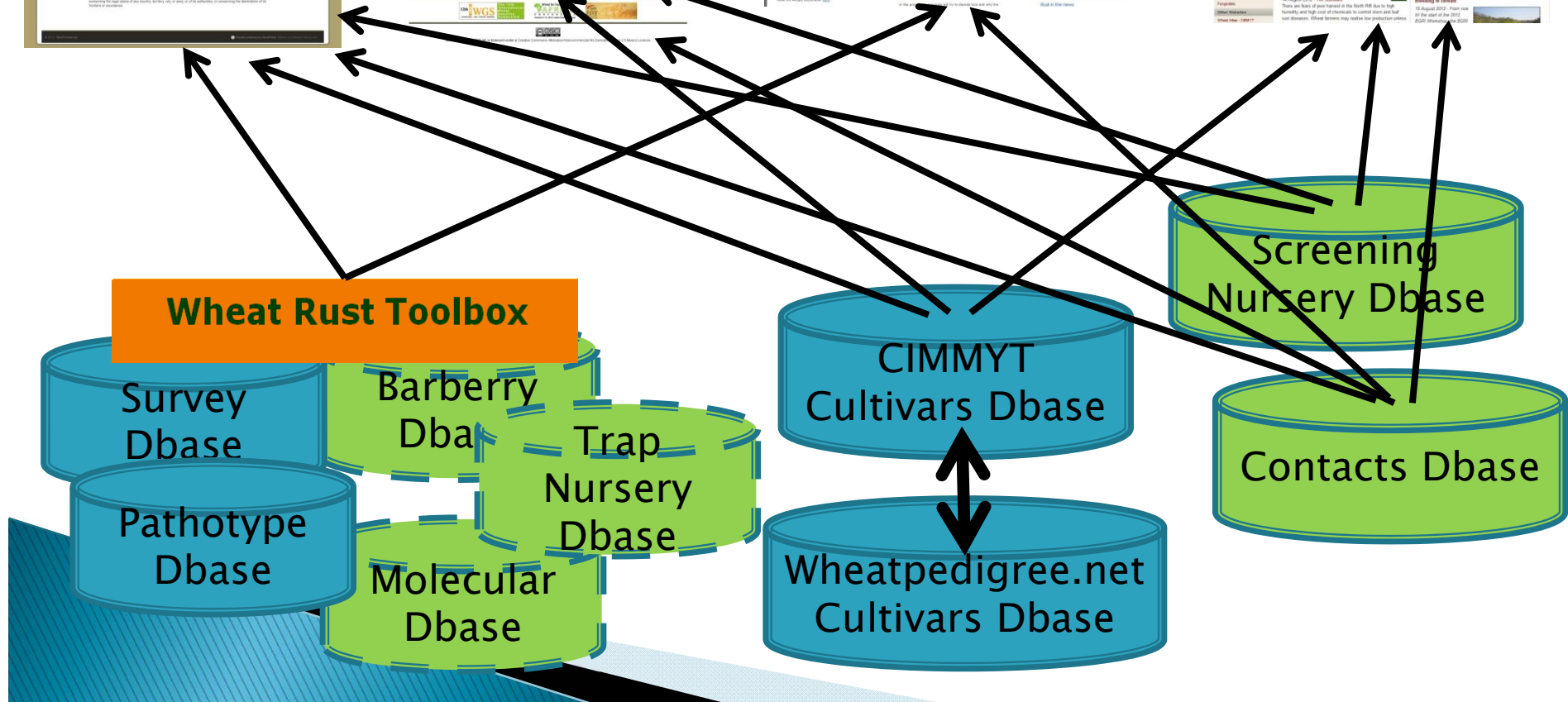
Molecular  
Dbase

CIMMYT  
Cultivars Dbase

Wheatpedigree.net  
Cultivars Dbase

Screening  
Nursery Dbase

Contacts Dbase





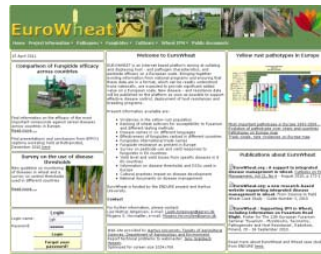
# Wheat Rust Toolbox framework



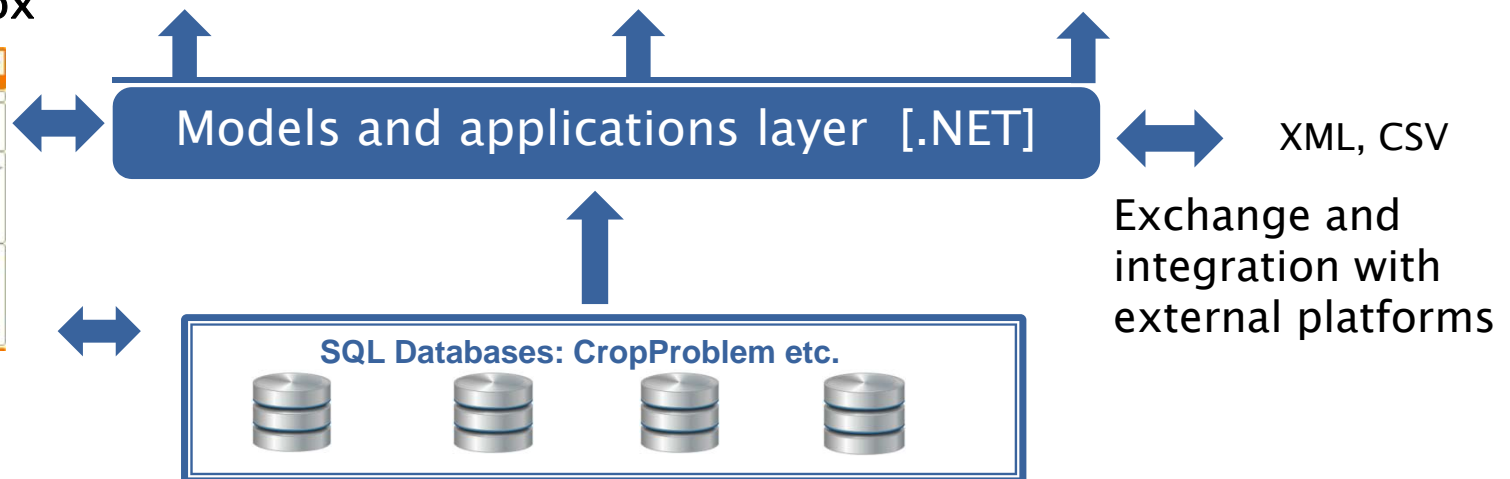
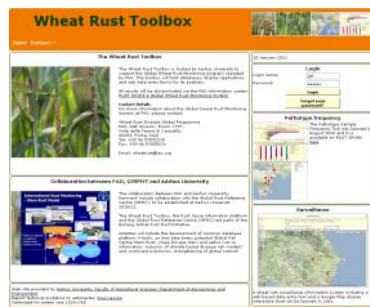
EuroWheat

GRRC

RustTracker



Wheat rust toolbox





# Wheat Rust Toolbox: Data management & web tools

NB: Generic - Applicable to all rusts

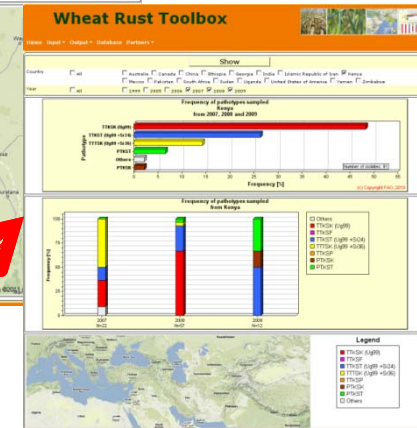
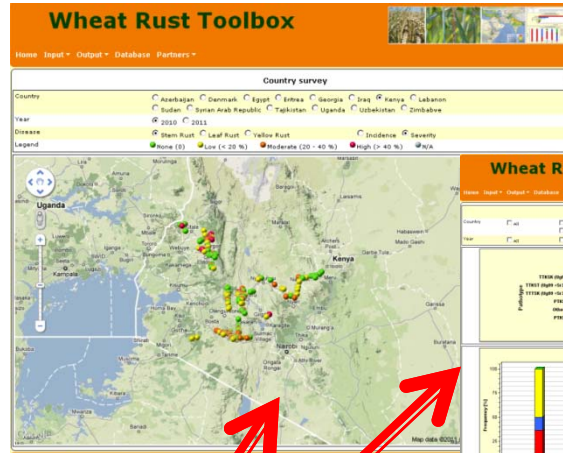
## On-line Data Entry



Smartphone survey tool

Quality control/publish

User Management

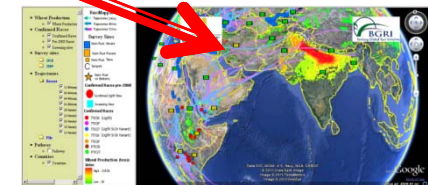


- Outputs:
- Survey Mapping
  - Pathotypes, +...

Data Export / Exchange

## Wheat Rust Toolbox

Crop Problem Dbase  
(survey, pathotypes, [Trap nursery, Molecular] )



External Applications  
e.g., RustMapper

# Data entry: Web page or Smart Phone

## WHEAT RUST TOOLBOX



Home Wheat Rust survey Barberry survey Rust management Isolates Database Partners Welcome jgh ! [ Log Out ]

### RUST SURVEY

Country: Ethiopia

Surveyor name:

Institution:

Location name:

Latitude: 8 decimal degrees  N  S 8° 0' 0" N

Longitude: 40 decimal degrees  E  W 40° 0' 0" E

Elevation: 0 meters

Survey site:  N/A  Farmer field  Weed  Road side  Trial

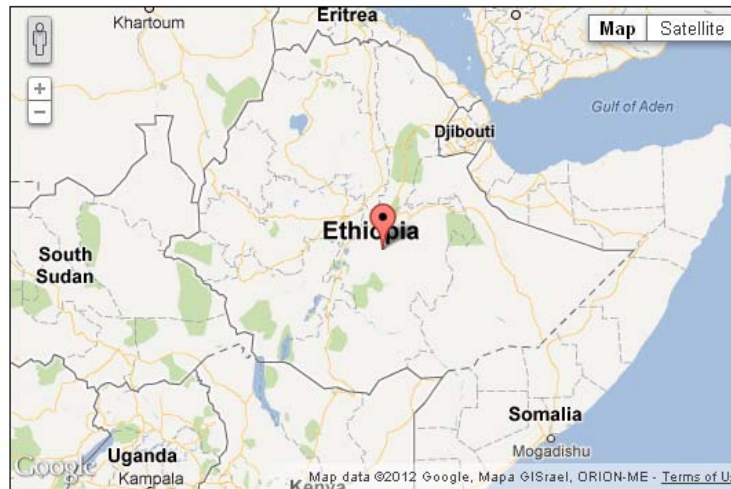
Field area size: 0 ha

Crop:  N/A  Bread wheat  Durum wheat  Barley  Triticale  Oats  Other

Cultivar name:

Date of survey: 20-09-2012

Growth stage:  N/A  Tillering  Boot  Flowering  Milk  Dough  Maturity



Diseases

Stem Rust Incidence at field level:  N/A  None (0)  Low (less than 20 %)  Moderate (20 - 40 %)  High (more than 40 %)

Severity on infected plants:  N/A  None (0)  Low (less than 20 %)  Moderate (20 - 40 %)  High (more than 40 %)

Infection type:  R  M  S

Leaf Rust Incidence at field level:  N/A  None (0)  Low (less than 20 %)  Moderate (20 - 40 %)  High (more than 40 %)

Severity on infected plants:  N/A  None (0)  Low (less than 20 %)  Moderate (20 - 40 %)  High (more than 40 %)

Infection type:  R  M  S

Yellow Rust Incidence at field level:  N/A  None (0)  Low (less than 20 %)  Moderate (20 - 40 %)  High (more than 40 %)

Severity on infected plants:  N/A  None (0)  Low (less than 20 %)  Moderate (20 - 40 %)  High (more than 40 %)

Infection type:  R  M  S

Sample  Stem rust sample collected

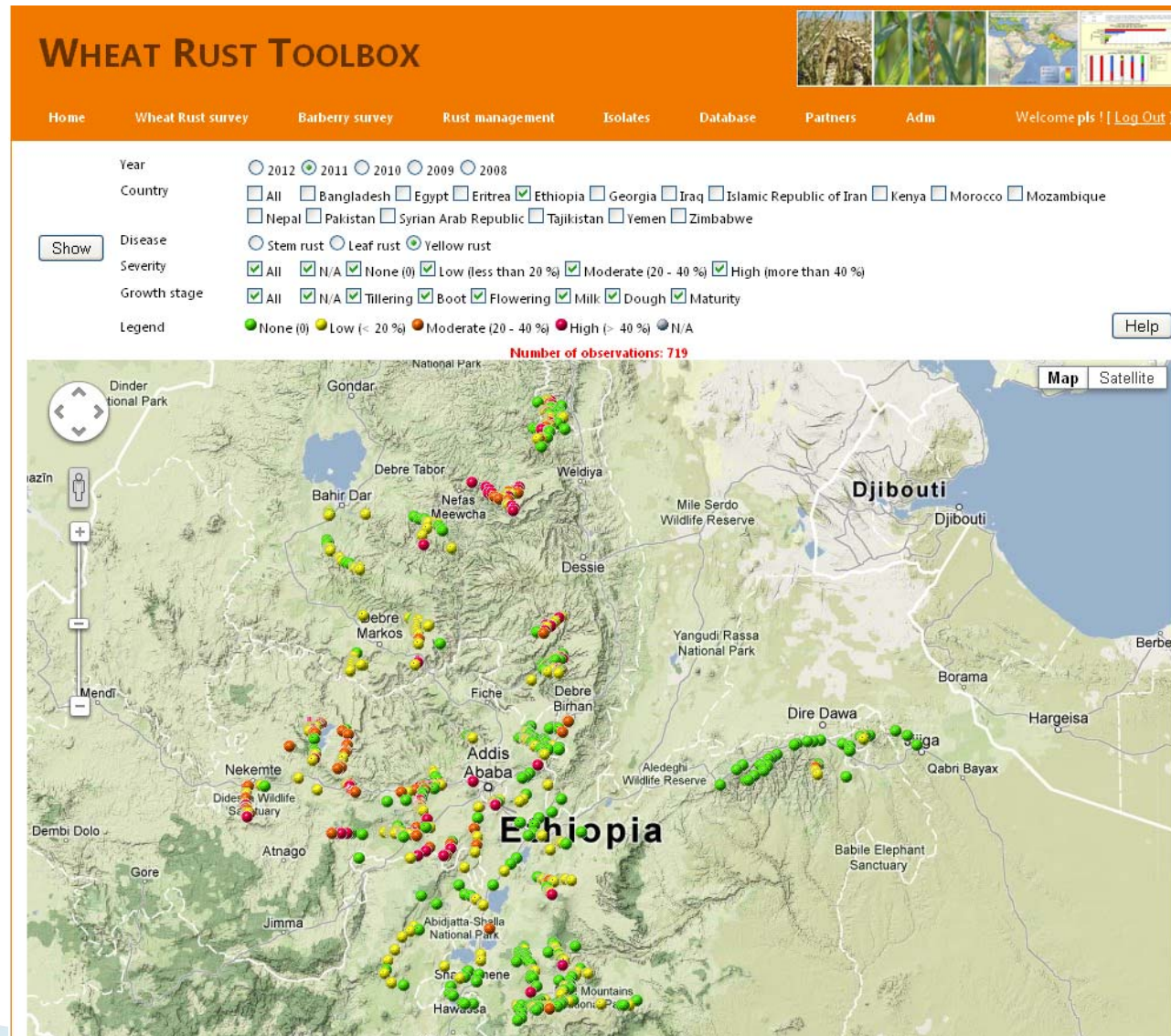
Comment:

Save





# Survey mapper tool



# “My Rust” – Analyse and download own data

Home Rust survey Rust management Input Output Database Partners Welcome jgh ! [ Log\_Out ]

COUNTRY: Ethiopia

**SUMMARY**

|   | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|------|------|------|------|------|-------|
| Number of observations                  | 578  | 877  | 1084 | 719  | 162  | 3420  |
| Number of observations with Stem Rust   | 184  | 309  | 292  | 158  | 90   | 1033  |
| Number of observations with Leaf Rust   | 125  | 391  | 278  | 144  | 59   | 997   |
| Number of observations with Yellow Rust | 177  | 416  | 590  | 414  | 52   | 1649  |
| Number of observations with no rust     | 1    | 0    | 221  | 207  | 30   | 459   |

**RUST SEVERITY** Numbers Frequency

**YEAR** 2012 2011 2010 2009 2008

**DISEASE** Stem rust Leaf rust Yellow rust

**LEGEND** None (0) Low (< 20%) Moderate (20 - 40%) High (> 40%)

Number of observations with location coordinates: 162

Map data ©2012 Google, ORION-ME - Terms of Use

**WHEAT RUST TOOLBOX**

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**RUST ANALYSING TOOL**

Country: Ethiopia

Year:  2012  2011  2010  2009  2008

First selection: Growth stage Second selection: Stem Rust severity Observations Frequency

**Rust Growth stage and Stem Rust severity from Ethiopia**

| Growth stage      | None (0) | Low (< 20%) | Moderate (20 - 40%) | High (> 40%) |
|-------------------|----------|-------------|---------------------|--------------|
| Tilling (N=94)    | 100      | 0           | 0                   | 0            |
| Boot (N=145)      | 100      | 0           | 0                   | 0            |
| Flowering (N=397) | 85       | 10          | 5                   | 0            |
| Milk (N=688)      | 65       | 25          | 10                  | 0            |
| Dough (N=998)     | 45       | 40          | 15                  | 0            |
| Maturity (N=226)  | 65       | 15          | 10                  | 10           |

Web site provided by Aarhus University, Faculty of Science and Technology, Department of Agroecology.  
Report technical problems to webmaster: Poul Lassen. Optimized for screen size 1024x768



# Hotspot analysis and risk mapping

Home Rust survey Rust management Input Output Database Partners Welcome jgh | [Log\_Out]

COUNTRY: Ethiopia

**SUMMARY**

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**RUST SEVERITY**

Numbers Frequency

Rust severity

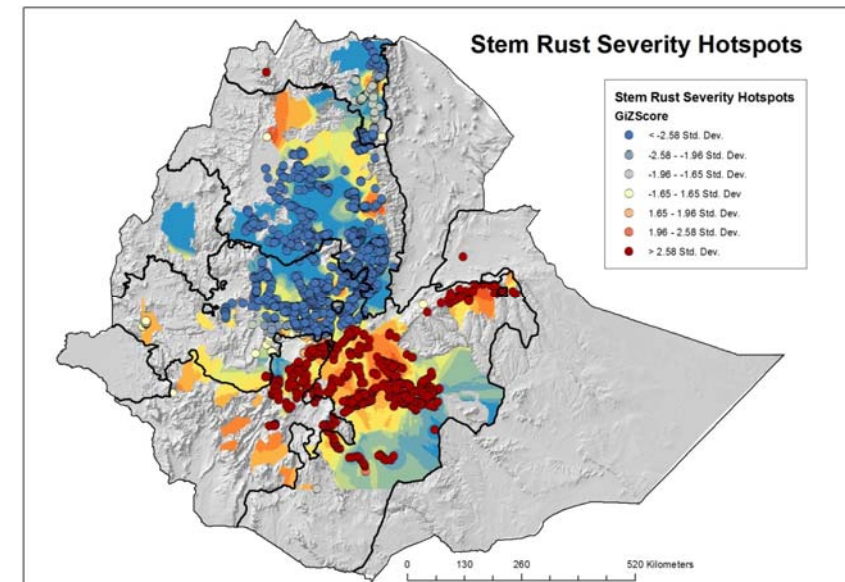
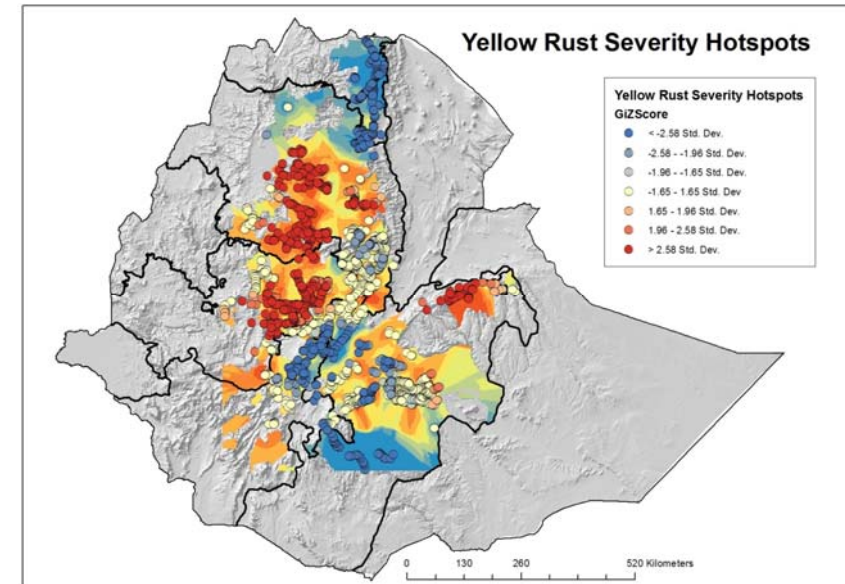
- Stem Rust Low (less than 20 %)
- Stem Rust Moderate (20 - 40 %)
- Stem Rust High (more than 40 %)
- Leaf Rust Low (less than 20 %)
- Leaf Rust Moderate (20 - 40 %)
- Leaf Rust High (more than 40 %)
- Yellow Rust Low (less than 20 %)
- Yellow Rust Moderate (20 - 40 %)
- Yellow Rust High (more than 40 %)

YEAR: 2012 2011 2010 2009 2008

DISEASE: Stem rust Leaf rust Yellow rust

LEGEND: None (0) Low (< 20 %) Moderate (20 - 40 %) High (> 40 %)

Number of observations with location coordinates: 162





Headed by  
Prof. Mogens S. Hovmøller



## GRRRC GLOBAL RUST REFERENCE CENTER



- Maintenance of global rust isolate collection
- Training & education of students, visitors and scientists
- Isolate characterization
  - Virulence phenotyping
  - Genotyping
  - Epidemic potential
- Rust tracking – early warning
- Development of the 'Wheat Rust Toolbox' & databases



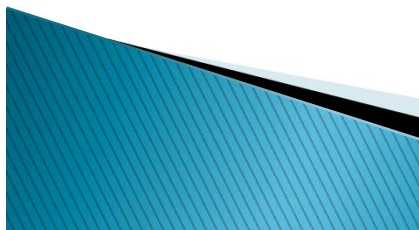


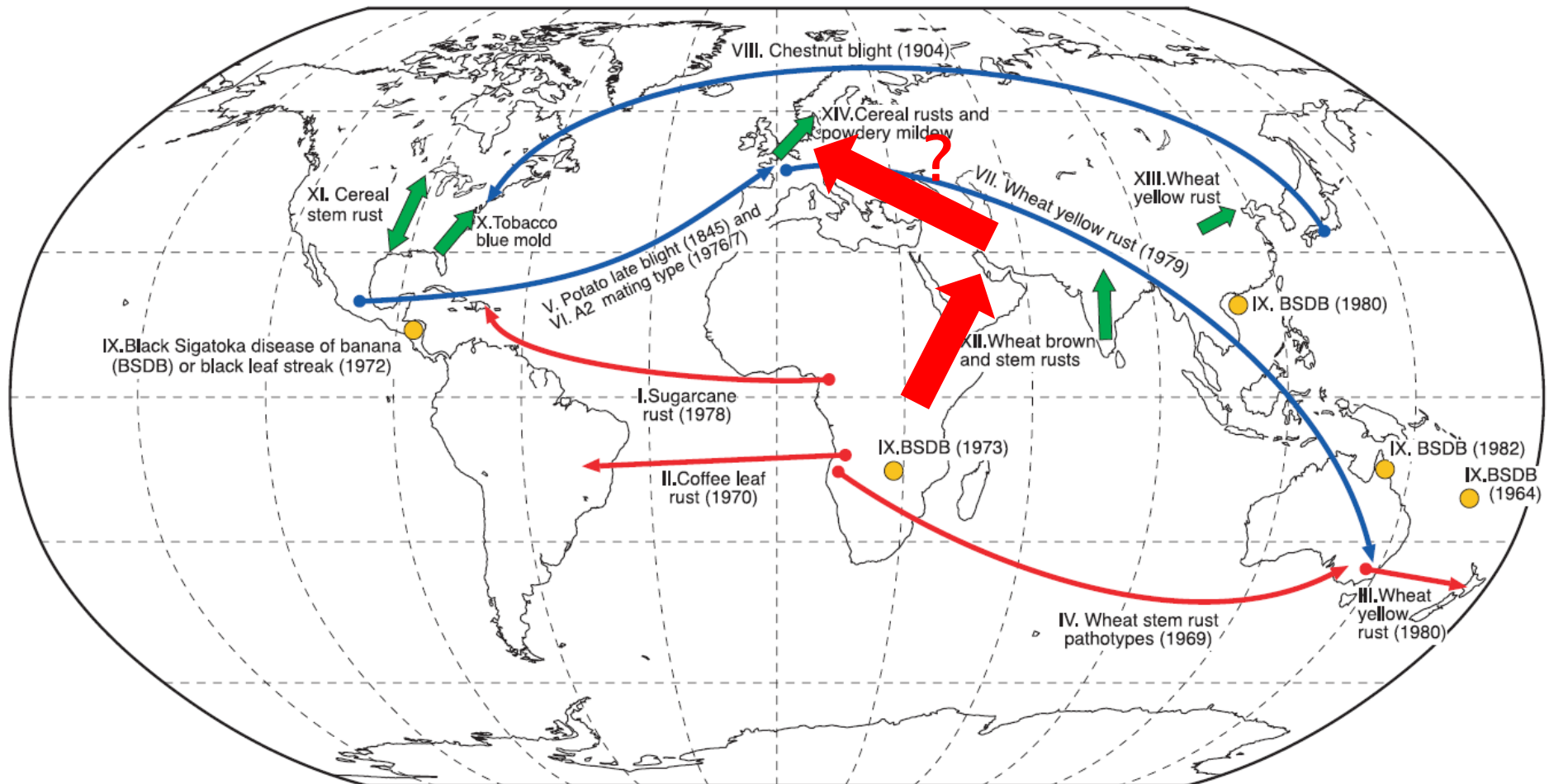
# Surveillance Summary:

Bars:

- Stem rust
- Leaf rust
- Stripe rust

Frequency of Fields attacked > 0 % severity





**Fig. 1.** Selected dispersal events of fungal pathogens. Red and blue arrows indicate invasions of new territories (first year recorded in brackets). Red arrows indicate dispersal that probably occurred by direct movement of airborne spores [I (12), II (11), III (23), and IV (52)]. Blue arrows indicate pathogens that were probably transported to the new territory in infected plant material or by people and spread thereafter as airborne spores [V (9),

VI (21), VII (22), and VIII (10)]. Orange circles indicate the worldwide spread of black Sigatoka disease of banana; the first outbreak recorded on each continent is marked [IX (19)]. Green arrows indicate periodic migrations of airborne spores in extinction-recolonization cycles [X (32), XI (33), XII (34), XIII (35–38), and XIV (41)]. [Background world map © C. Lukinbeal, Southern Connecticut State University, New Haven, Connecticut]

## REVIEW: EPIDEMIOLOGY

### Aerial Dispersal of Pathogens on the Global and Continental Scales and Its Impact on Plant Disease

James K. M. Brown<sup>1</sup>\* and Mogens S. Hovmøller<sup>2</sup>\*



## Pathotype by year, Europe map

Show

Year

All

2000

2001

2002

2003

2004

2005

2006

2007

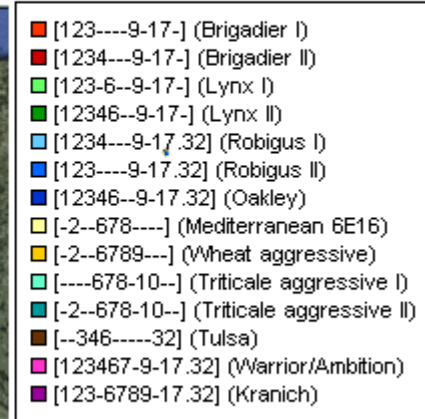
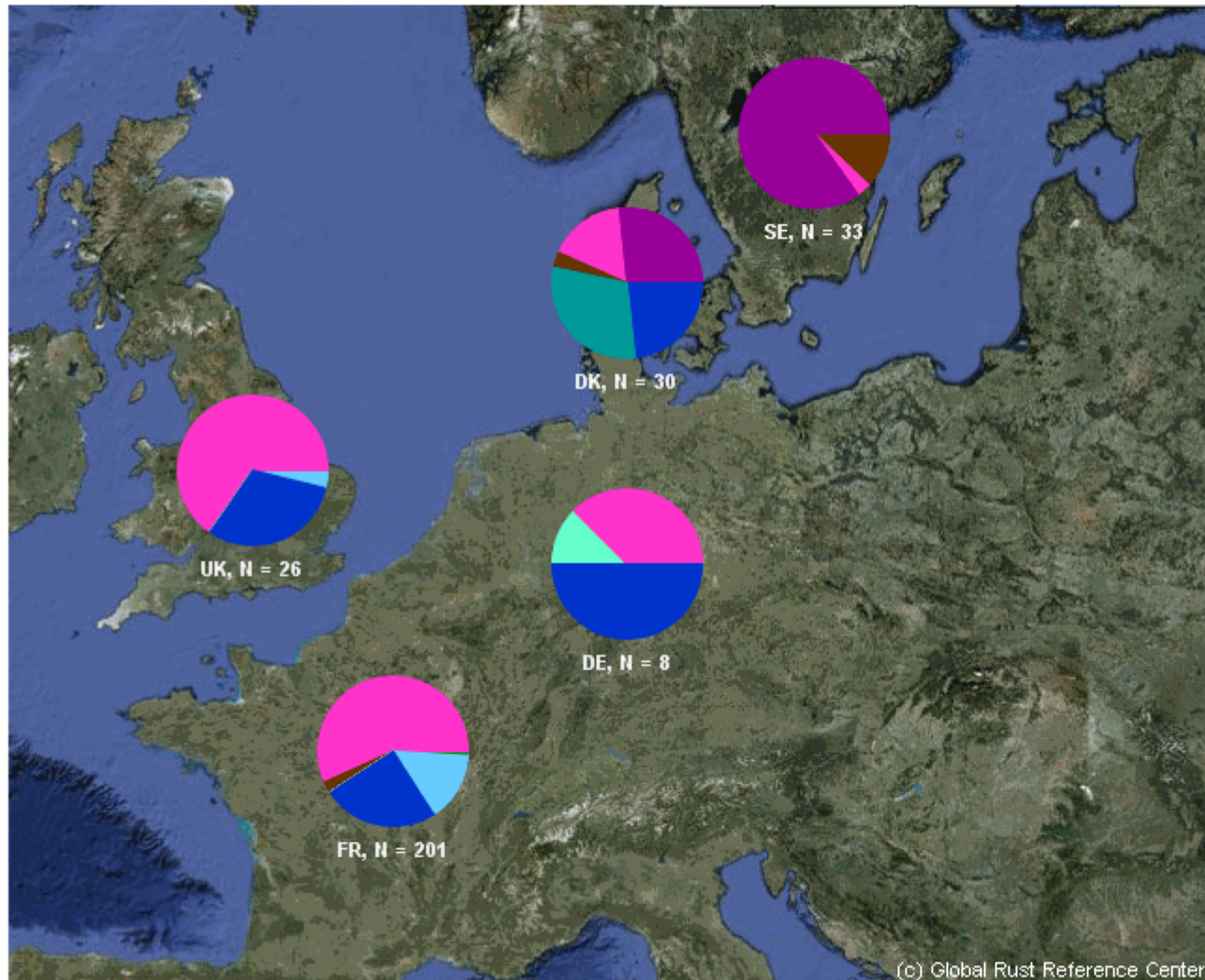
2008

2009

2010

2011

Help



(c) Global Rust Reference Center

Data provided by: Institut National de la Recherche Agronomique (France), Julius Kühn-Institut, Federal Research Centre for Cultivated Plants (Germany and Austria), National Institute of Agricultural Botany (United Kingdom) and Aarhus University (Denmark and Sweden)





# What's new?

## 2009-2010

- New aggressive race threatening triticale production appeared in Scandinavia and Germany
- Losses of 50-100% were typical for organic growers in DK





# What's new in Europe?

## 2009-2010

- New aggressive races is threatening triticale production appeared in Scandinavia and Germany
- Losses of 50-100% were typical for organic growers in DK

## 2011

- Two multi-virulent races showing massive telia-formation (greenhouse and field) appeared for the first time
- The 'Ambition/Warrior' race present in Spain, France, UK, Germany, Denmark and Sweden, - in high frequencies





# What's new?

## 2009-2010

- New aggressive races is threatening triticale production appeared in Scandinavia and Germany
- Losses of 50-100% were typical for organic growers in DK

## 2011

- Two multi-virulent races with abundant telia-formation (greenhouse and field) appeared for the first time
- The 'Ambition/Warrior' race present in Spain, France, UK, Germany, Denmark and Sweden

## 2012

- Unusual high number of varieties affected in field trials
- Widespread epidemics in Spain, France, UK, Denmark and Sweden – increasing demands for fungicide sprays





# Outstanding questions/ Warrior/Ambition race

## Geographical and evolutionary origin?

- Recombination involving *Pst* of NW-European origin?
- Mutation in a European strain
- Exotic incursion

## Or Preliminary results (September 2012):

1.

2.

3.



- Isolates of Ambition/Warrior race had unique SSR fingerprint
- Ambition/Warrior race had many characteristics in common with *Pst* populations in Asia
- Likely new exotic incursion into NW Europe



# Summary

- ❑ Integrated Information Resources – and ICT framework established
- ❑ Data collected in dedicated structured databases, use of standard methods, network of expert labs, quality control, “on-the-fly” dissemination on several information platforms.
- ❑ More robust conclusions, stimulate data contribution and collaboration between partners and users
- ❑ 27 Countries participate in surveillance – 20% of global wheat area
- ❑ 8 members of the Ug99 race group – we know what they are, where they are and where they (most likely) are heading!
- ❑ Introduction of SR rust resistant cultivars in risk areas on the track
- ❑ New exotic stripe rust from Asia to Europe/Africa to USA, Asia and Australia. The Global Rust Reference Center and its network of partners is prepared to analyse it in a global context



# Acknowledgments

- ▶ All contributing national partners
- ▶ PBI, University of Sydney
- ▶ ICARDA
- ▶ CIMMYT
- ▶ AAFC, Canada
- ▶ CDL, Minnesota, USA
- ▶ University of the Free State, South Africa
- ▶ GRRC, Aarhus University, Denmark
- ▶ BGRI / Cornell University

## **Donors:**

- ▶ Bill & Melinda Gates Foundation
- ▶ DFID
- ▶ USAID
- ▶ IFAD

