

# **WGIN : Overview and update on RRes WGIN research**

**Kim Hammond-Kosack**  
**Rothamsted Research**



**8<sup>th</sup> WGIN Stakeholders Meeting 17<sup>th</sup> November 2010**

# The Defra Crop Genetic Improvement Networks

Announced July 2002

**Dr Donal Murphy-Bokern**

**Arable Crop Sciences & Pesticide  
Safety Unit**

**Science Directorate**

**Defra**



# Overall Objectives

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- **Each Crop Genetic Improvement Network =**  
**Virtual Plant Breeding Institute**
- **To use crop breeding for the sustainable development of the arable sector**
- **To connect public sector science to the private sector**

**To recreate the best of the past**

# Networks established

- **Wheat (WGIN)**
- **Oilseed rape (OREGIN)**
- **Short rotation coppice (BEGIN)**
- **Pulse crops**
- **Miscanthus**
- **Oats**

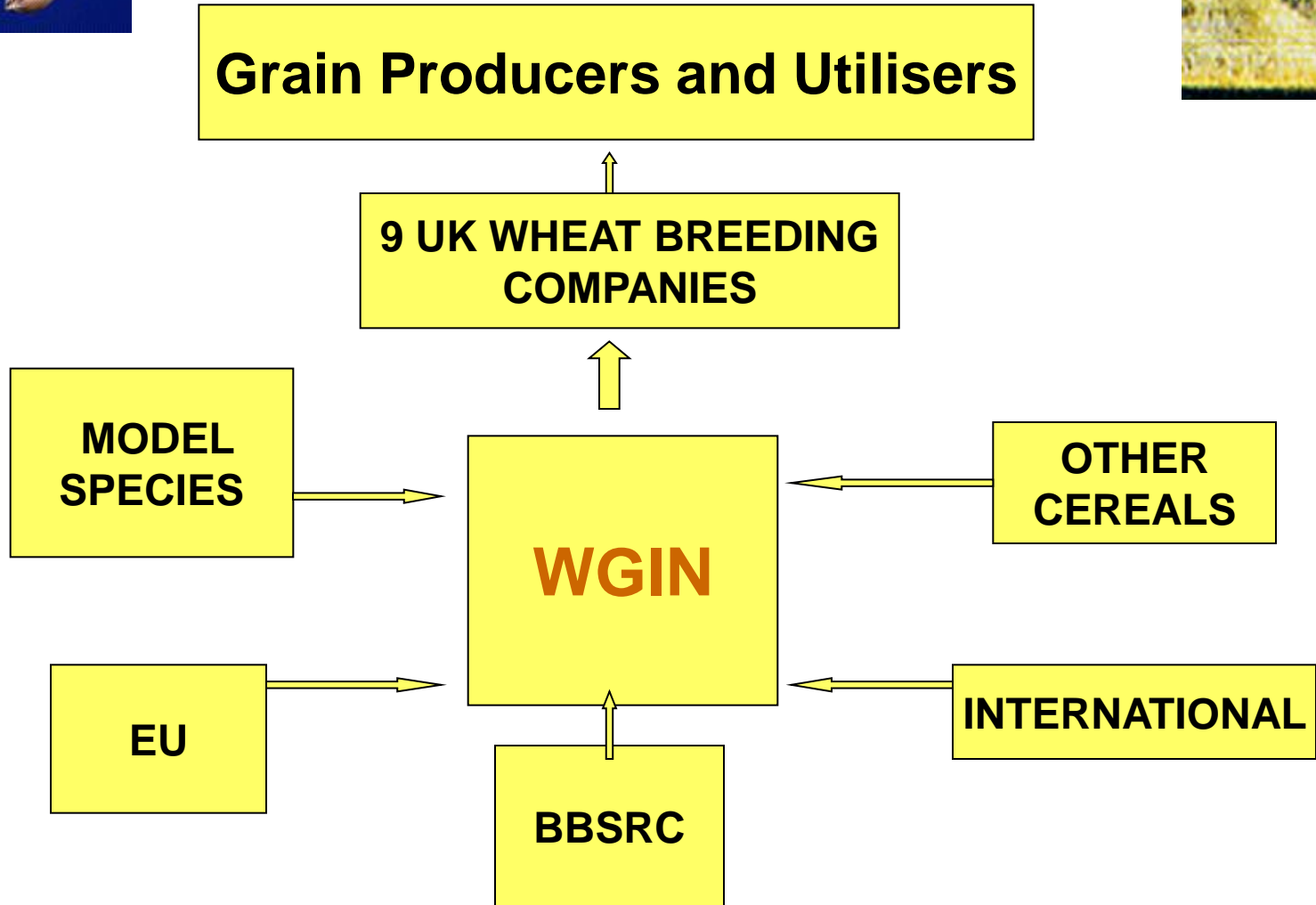


## The longer-term vision

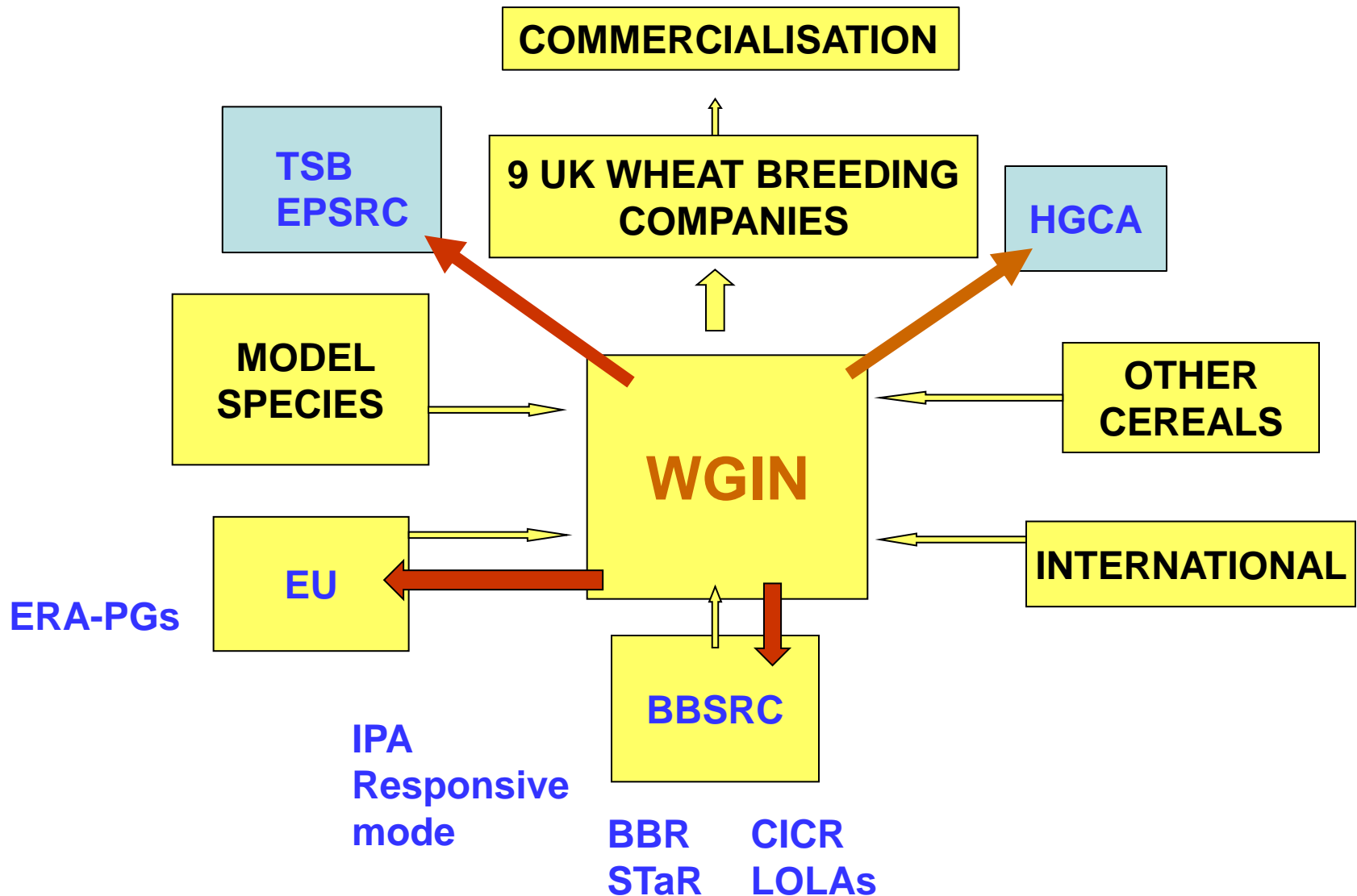
- A strong crop breeding sector deploying the best technologies science can offer
- A strong strategic and applied research base competing effectively for resources
- A strong base for international partnerships
- More resource efficient and productive crops



# The Defra WGIN



# The modest WGIN funds would attract additional funds to wheat research by other sponsors



## **The WGIN 2 project (2008 – 2013)**

**In April 2008 started discussions on future project resource development and trait targets**

- Defra**
- UK wheat breeding community**
- Other UK research groups**
- Other stakeholders**

**In March 2009 we completed the process**

**Total funding over 5 years - £1.95 million**



# **Mission statement - WGIN 2008 to 2013**

**Improving the environmental footprint of farming through crop genetics and targeted traits analysis**

# Wheat Genetic Improvement Network (WGIN) 2008-2013

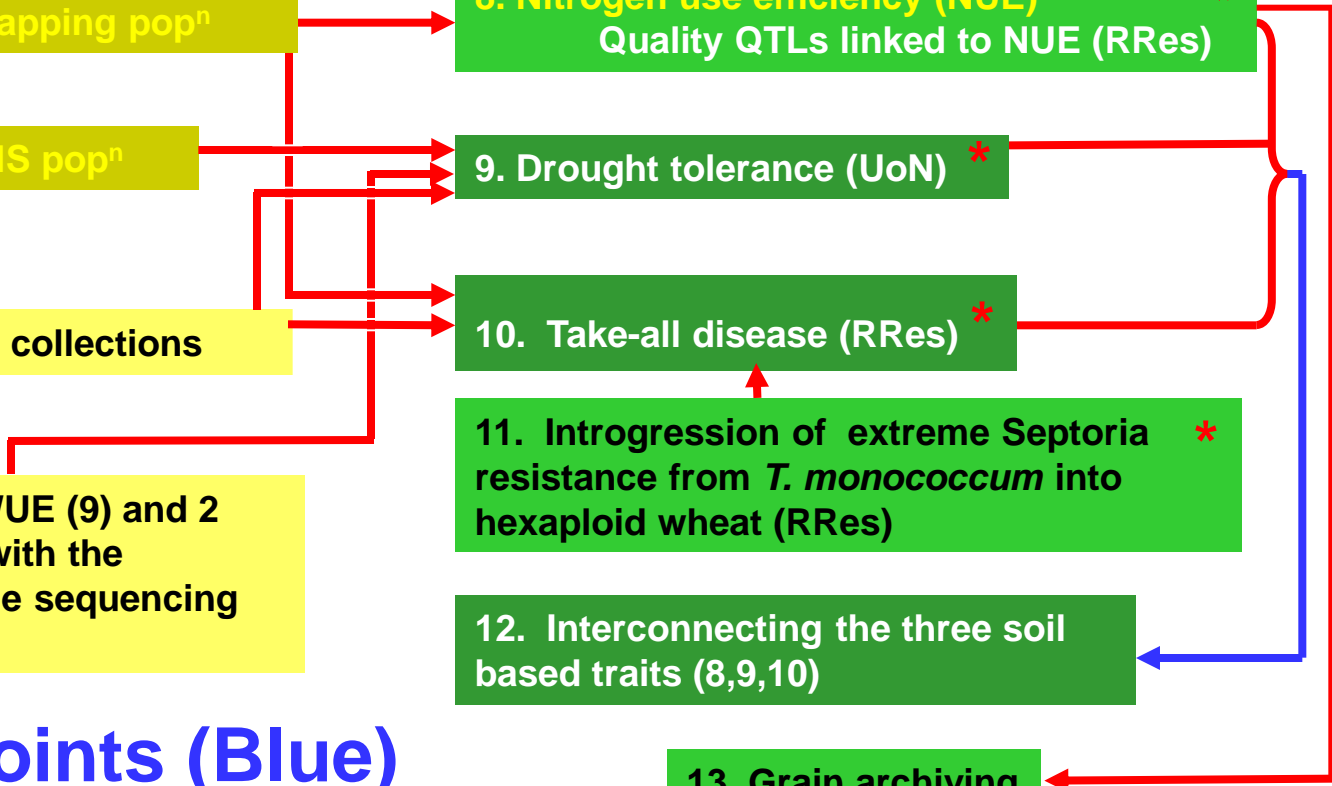
## Tools and Resources

- 2. Near Isogenic lines (NILs) \*
- 3. The Avalon x Cadenza Mapping pop<sup>n</sup>
- 4. Paragon gamma and EMS pop<sup>n</sup>
- 5. AE Watkins and Gediflux collections
- 6. New mapping pop<sup>n</sup> for WUE (9) and 2 new pop<sup>n</sup> to align WGIN 2 with the international wheat genome sequencing effort

## Targeted traits

- 7. Insect resistance (RRes) \*
- 8. Nitrogen use efficiency (NUE) \*  
Quality QTLs linked to NUE (RRes)
- 9. Drought tolerance (UoN) \*
- 10. Take-all disease (RRes) \*
- 11. Introgression of extreme Septoria resistance from *T. monococcum* into hexaploid wheat (RRes) \*
- 12. Interconnecting the three soil based traits (8,9,10)
- 13. Grain archiving

**Key control points (Blue)**  
**cross connections (Red)**



# Characterisation and provision of genetic resources

The **AE Watkins** spring and winter wheat collection  
(JIC)

**1930s collection from markets in 32 countries**

**Seed now available for 814 'purified' lines  
- with more lines to come**

**Represents germplasm never used in  
UK wheat breeding programmes**

**Simon Griffiths**

# Trait identification - RRes

1. Improved nitrogen use efficiency (NUE)
2. Grain quality (QTLs) linked to NUE

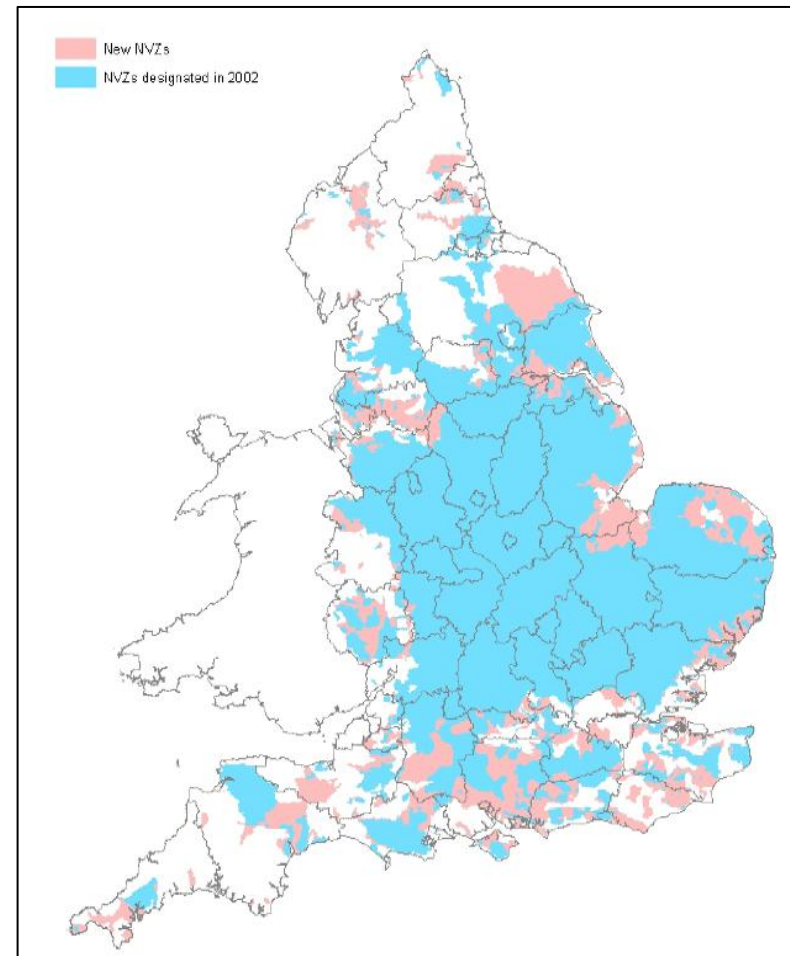
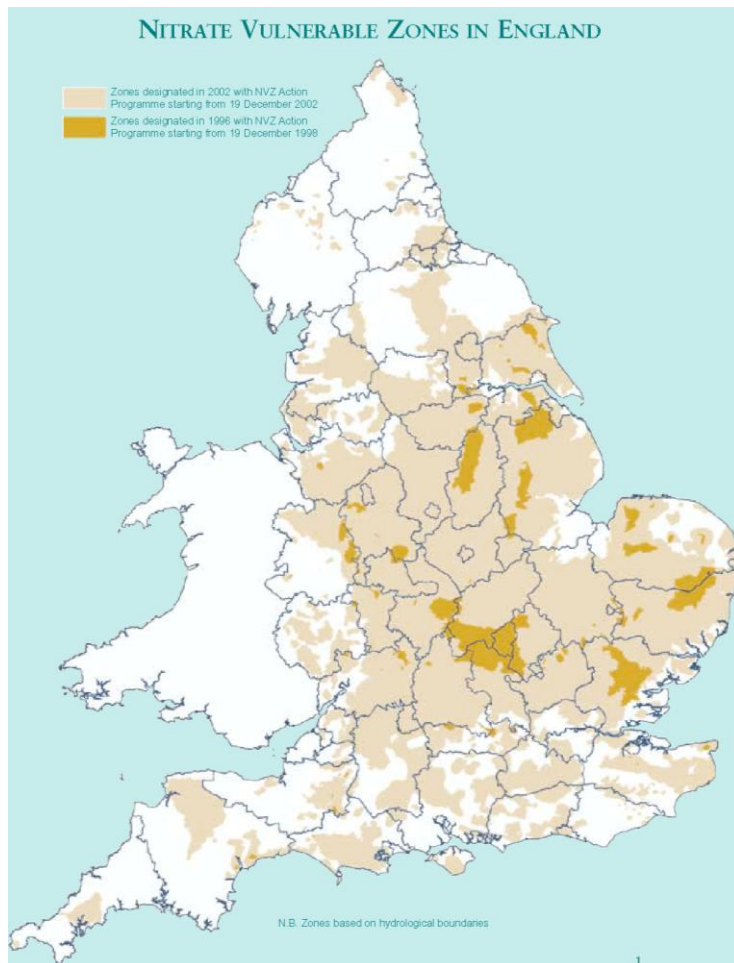
Consecutive years of field trials



# Nitrate vulnerable zones in England

**1996 - darker colour**  
**2002 - new zones, fawn**

**2002 - blue**  
**2009 - new zones, pink**



# Workplan



**BBC Country File - 2009**

- **Diversity / N trials 2009-2013 (5 years)**
  - Core 15 genotypes
  - Exotics e.g. Watkins
  - Specific Avalon x Cadenza DH lines
  - Other germplasm as deemed appropriate, e.g. stay green
- **Avalon x Cadenza DH field trials 2009/10/11 (3 years) 204 lines**
  - high/low N (one low, 2 high N)
  - to supplement WGIN1 trials (one high, 2 low)
- **Avalon x Cadenza – Glasshouse trial 2012 30 lines**
- **Hereward x Malacca NILS**
  - fields trials 2012/13
  - 20 lines

**Malcolm Hawkesford**  
**Peter Barraclough**




| Variety          | Code | Nabim | Years | Yield | %N | Uptake | Utilisation |
|------------------|------|-------|-------|-------|----|--------|-------------|
| Avalon           | AV   | 1     | 5     |       |    |        |             |
| Flanders         | FL   | 1     | 1     |       |    |        |             |
| Hereward         | HE   | 1     | 5     |       |    |        |             |
| Hurley           | HU   | 1     | 5     |       |    |        |             |
| Malacca          | MA   | 1     | 5     |       |    |        |             |
| Mercia           | ME   | 1     | 4     |       |    |        |             |
| Maris Widgeon    | MW   | 1     | 5     |       |    |        |             |
| Shamrock         | SH   | 1     | 4     |       |    |        |             |
| Solstice         | SL   | 1     | 5     |       |    |        |             |
| Spark            | SP   | 1     | 1     |       |    |        |             |
| Xi 19            | XI   | 1     | 5     |       |    |        |             |
| Cadenza          | CA   | 2     | 5     |       |    |        |             |
| Cordiale         | CO   | 2     | 3     |       |    |        |             |
| Einstein         | EI   | 2     | 1     |       |    |        |             |
| Lynx             | LY   | 2     | 5     |       |    |        |             |
| Rialto           | RL   | 2     | 1     |       |    |        |             |
| Scorpion         | SC   | 2     | 1     |       |    |        |             |
| Soissons         | SS   | 2     | 5     |       |    |        |             |
| Beaver           | BE   | 3     | 4     |       |    |        |             |
| Claire           | CL   | 3     | 4     |       |    |        |             |
| Riband           | RI   | 3     | 5     |       |    |        |             |
| Robigus          | RO   | 3     | 4     |       |    |        |             |
| Istabraq         | IS   | 4     | 4     |       |    |        |             |
| Napier           | NA   | 4     | 3     |       |    |        |             |
| Savannah         | SA   | 4     | 4     |       |    |        |             |
| Paragon (spring) | PA   | 1     | 5     |       |    |        |             |
| Chablis (spring) | CH   | 2     | 1     |       |    |        |             |
| Arche            | AR   | F     | 1     |       |    |        |             |
| Batis            | BA   | G     | 5     |       |    |        |             |
| Caphorn          | CP   | F     | 1     |       |    |        |             |
| Cappelle Desprez | CD   | F     | 1     |       |    |        |             |
| Enorm            | EN   | G     | 1     |       |    |        |             |
| Isengrain        | IG   | F     | 1     |       |    |        |             |
| Monopol          | MO   | G     | 5     |       |    |        |             |
| Opus             | OP   | G     | 1     |       |    |        |             |
| PBis             | PB   | G     | 1     |       |    |        |             |
| Petrus           | PE   | G     | 1     |       |    |        |             |
| Sokrates         | SK   | G     | 5     |       |    |        |             |
| Zyta             | ZY   | P     | 1     |       |    |        |             |

Upper-Q  
Inter-Q  
Inter-Q  
Lower-Q

# Summary of variety performance (quartile rankings) based on 2004-07 WGIN datasets (200 kg-N/ha)


Europ. J. Agronomy 33 (2010) 1–11

Contents lists available at ScienceDirect



European Journal of Agronomy

journal homepage: [www.elsevier.com/locate/eja](http://www.elsevier.com/locate/eja)



## Nitrogen efficiency of wheat: Genotypic and environmental variation and prospects for improvement

Peter B. Barraclough<sup>a,\*</sup>, Jonathan R. Howarth<sup>a</sup>, Janina Jones<sup>a</sup>, Rafael Lopez-Bellido<sup>b</sup>, Saroj Parmar<sup>a</sup>, Caroline E. Shepherd<sup>a</sup>, Malcolm J. Hawkesford<sup>a</sup>





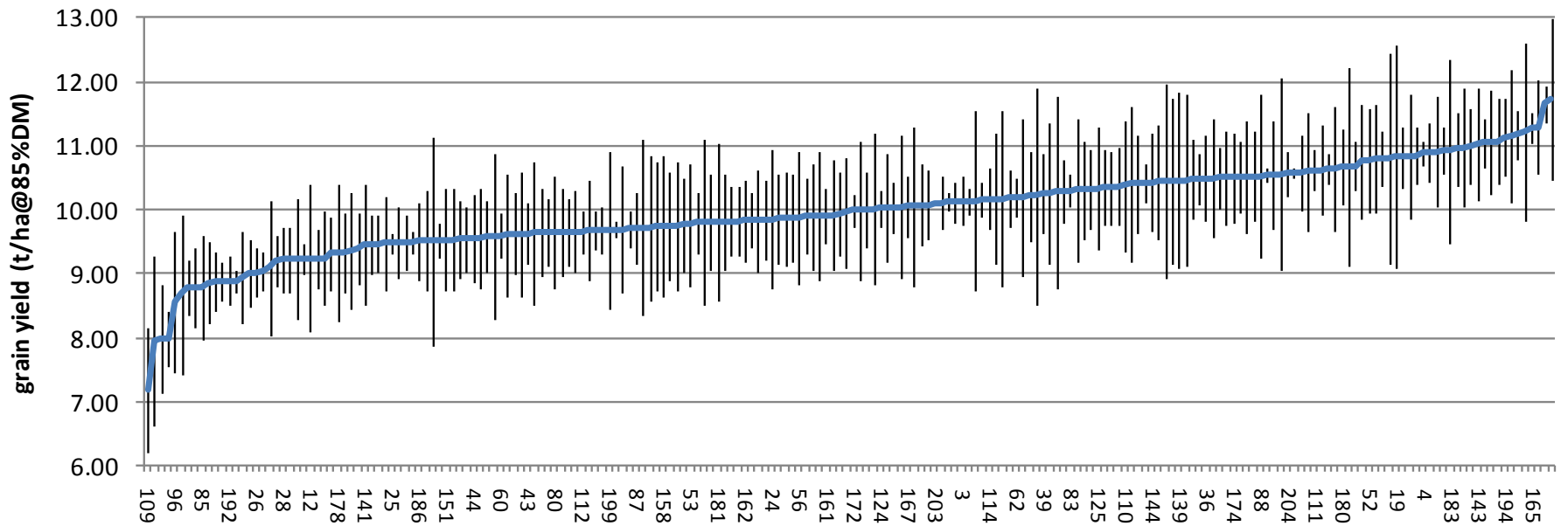
# A x C traits - Rothamsted

- **Core data (WGIN)**
  - Flowering time and height
  - Yield (grain and straw) and tgw
  - Nitrogen (grain and straw)
  - Computed NUtE, N uptake (final)
- **Supplementary studies (other funds)**
  - Leaf N and SPAD (anthesis and 21 dpa)
  - Leaf size (leaf 2)
  - Canopy longevity, reflectance, rate of senescence
  - Early N uptake
  - Gene expression
  - Root traits
  - Grain minerals



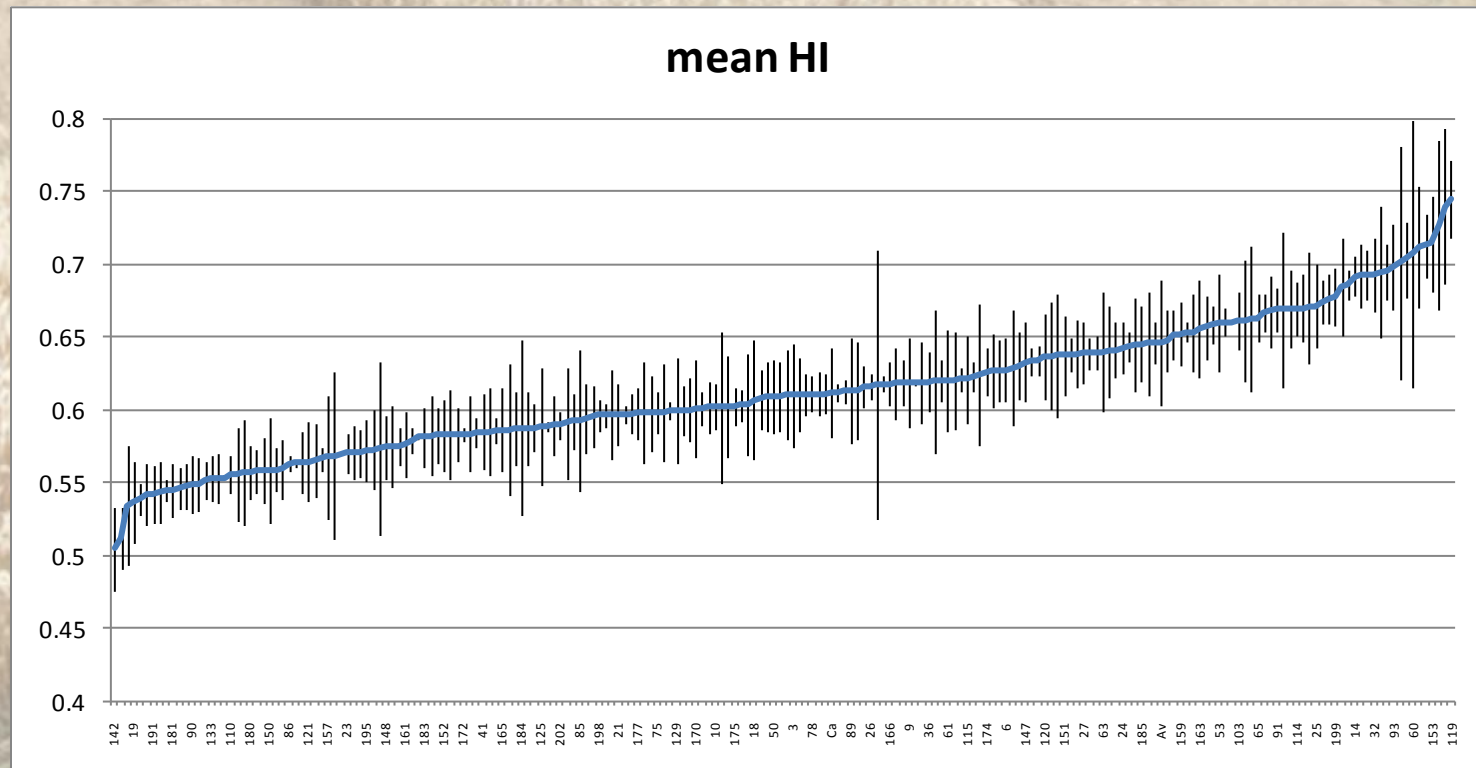
# A x C : Yields 2010

Rothamsted A x C 2010 200 kgN/ha



Individual A x C lines

# A x C: Harvest Index, 2010



Individual A x C lines

**Aim: QTL mapping  
for each sub-trait**

**Malcolm Hawkesford**



# Trait identification – RRes

## 2. Reducing pest and disease pressure

**Aphids**



***Septoria* leaf blotch**



**Take-all fungus**



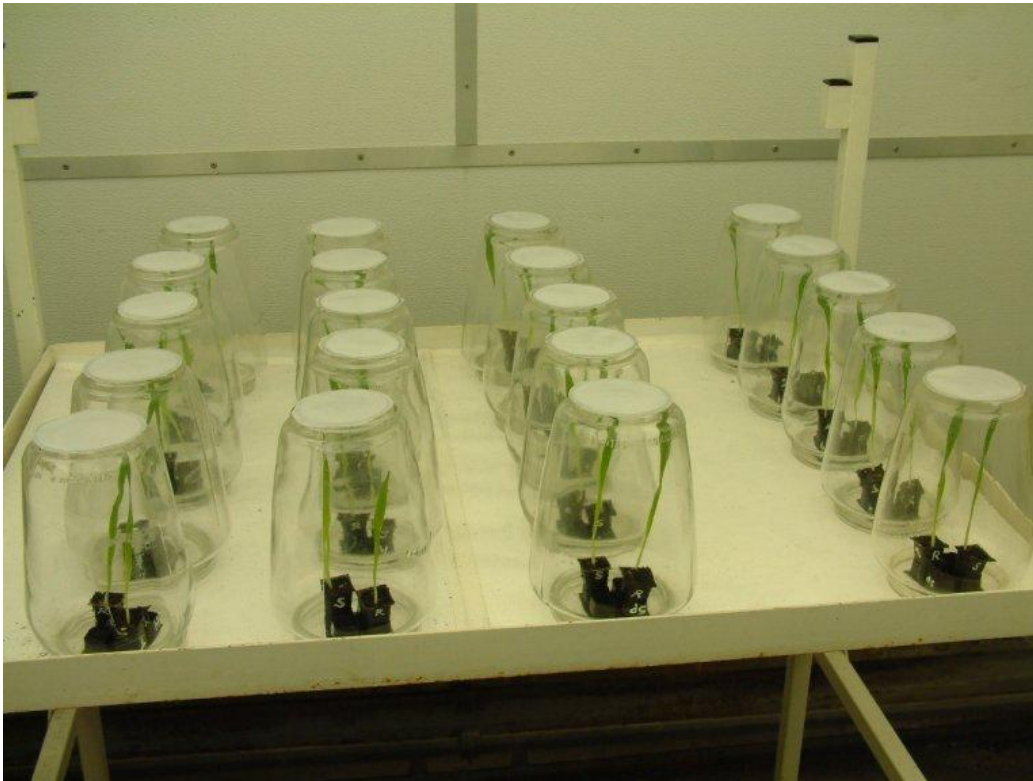
**Annually all crops at high risk**

**A major problem  
for 2<sup>nd</sup> / 3<sup>rd</sup> wheat  
crops**

**2<sup>nd</sup> wheat syndrome**

## Aphid 'choice' test by settlement

17 contrasting **S**park x **R**ialto lines (previously identified using two non-UK aphid species)

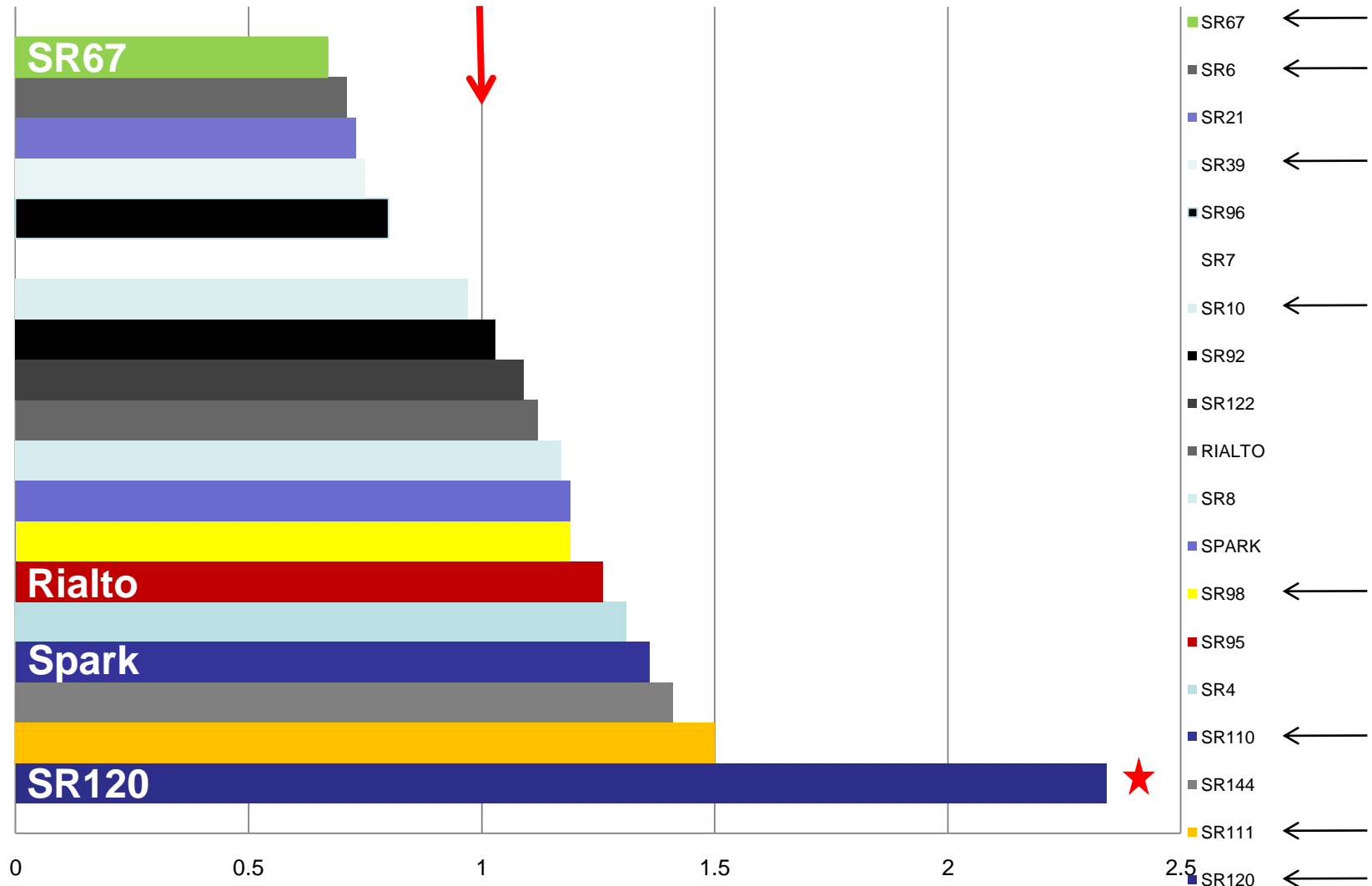


Per chamber  
one **S**R line  
vs  
**cv Solstice**

Add 10 alate aphids  
Score at 2,5 and **24h**

**Lesley Smart and Ruth Gordon-Weeks**

***Rhopalosiphum padi* choice tests with Spark x Rialto mapping lines. Nymphs produced at 24h as a proportion of nymphs produced on Solstice = 1**



# **‘No choice development’ assays to determine Mean Relative Growth Rate (MRGR)**

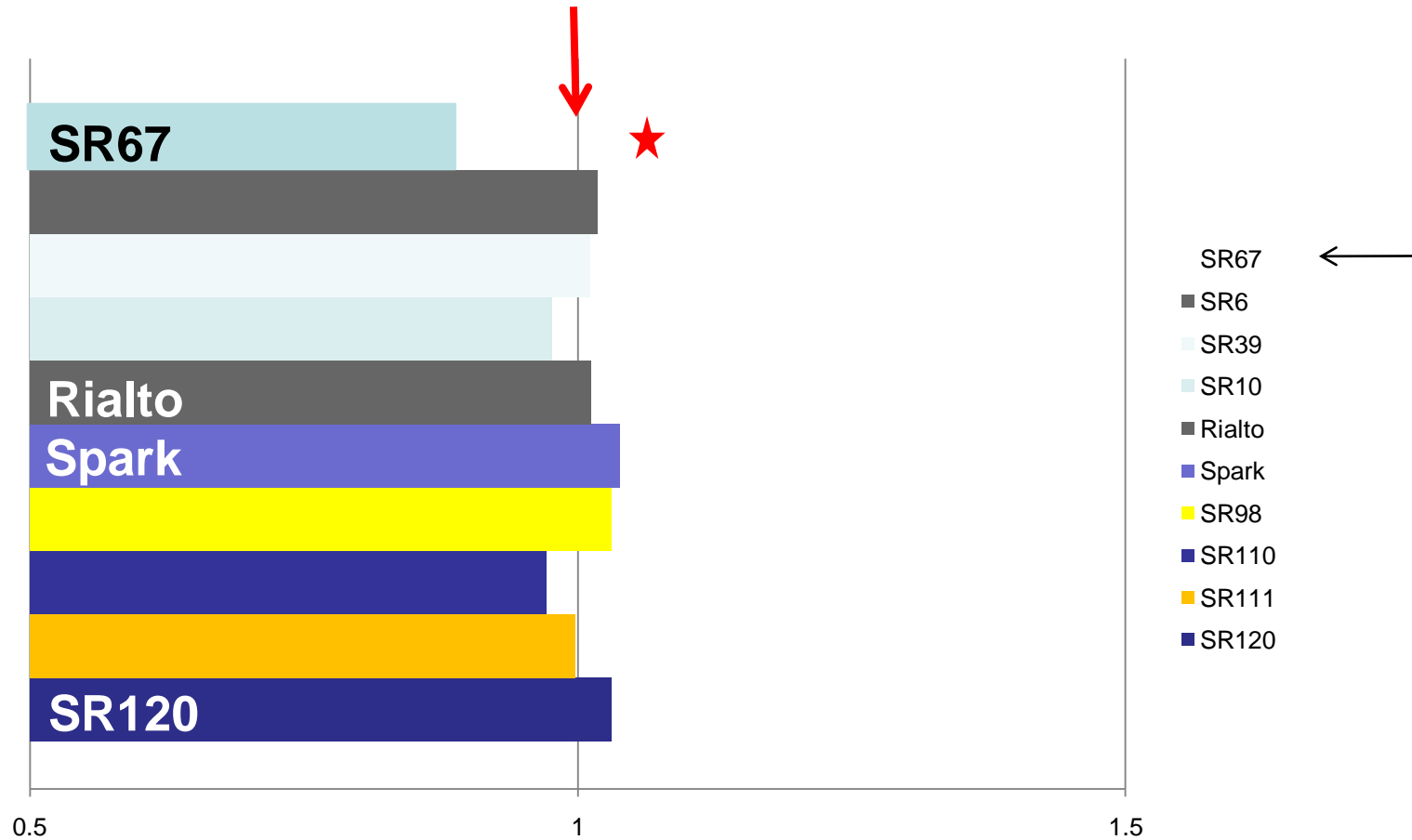


**5 pre-weighed neonatal nymphs** added to each **clip cage** (12 batches / line)

6 or 7 days later the **surviving nymphs - reweighed**

**Comparison with cv. Solstice, ANOVA analysis**

***Rhopalosiphum padi* aphid development assays with eight selected Spark x Rialto mapping lines.**  
**MTGR as a proportion of Solstice = 1**



**Line SR67 gave significantly less *R. padi* aphid development than Solstice  $P < 0.05$  but did not influence *Sitobion avenae* development**



# Take-all disease – soil-borne fungus

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In 1<sup>st</sup> wheats - no disease problem



A major problem  
for 2<sup>nd</sup> / 3<sup>rd</sup> wheat crops

**2<sup>nd</sup> wheat syndrome**



Typical take-all patch showing stunting  
and premature ripening of the crop

The risk of take-all is largely dependent on the amount of inoculum in  
the soil at the time of sowing

# An important WGIN 1 discovery

The genotype of the 1<sup>st</sup> wheat influence the amount of take-all inoculum build-up in the bulk soil



*Plant Pathology* (2010)

Doi: 10.1111/j.1365-3059.2010.02375.x

**Evidence that wheat cultivars differ in their ability to build up inoculum of the take-all fungus, *Gaeumannomyces graminis* var. *tritici*, under a first wheat crop**

V. E. McMillan, K. E. Hammond-Kosack and R. J. Gutteridge\*

*Department of Plant Pathology and Microbiology, Rothamsted Research, Harpenden, Hertfordshire AL5 2JQ, UK*

This study used the 1<sup>st</sup> wheat NUE diversity trial

**Richard Gutteridge**



## THE SOIL CORE POT BIOASSAY





# Soil core bioassay plants



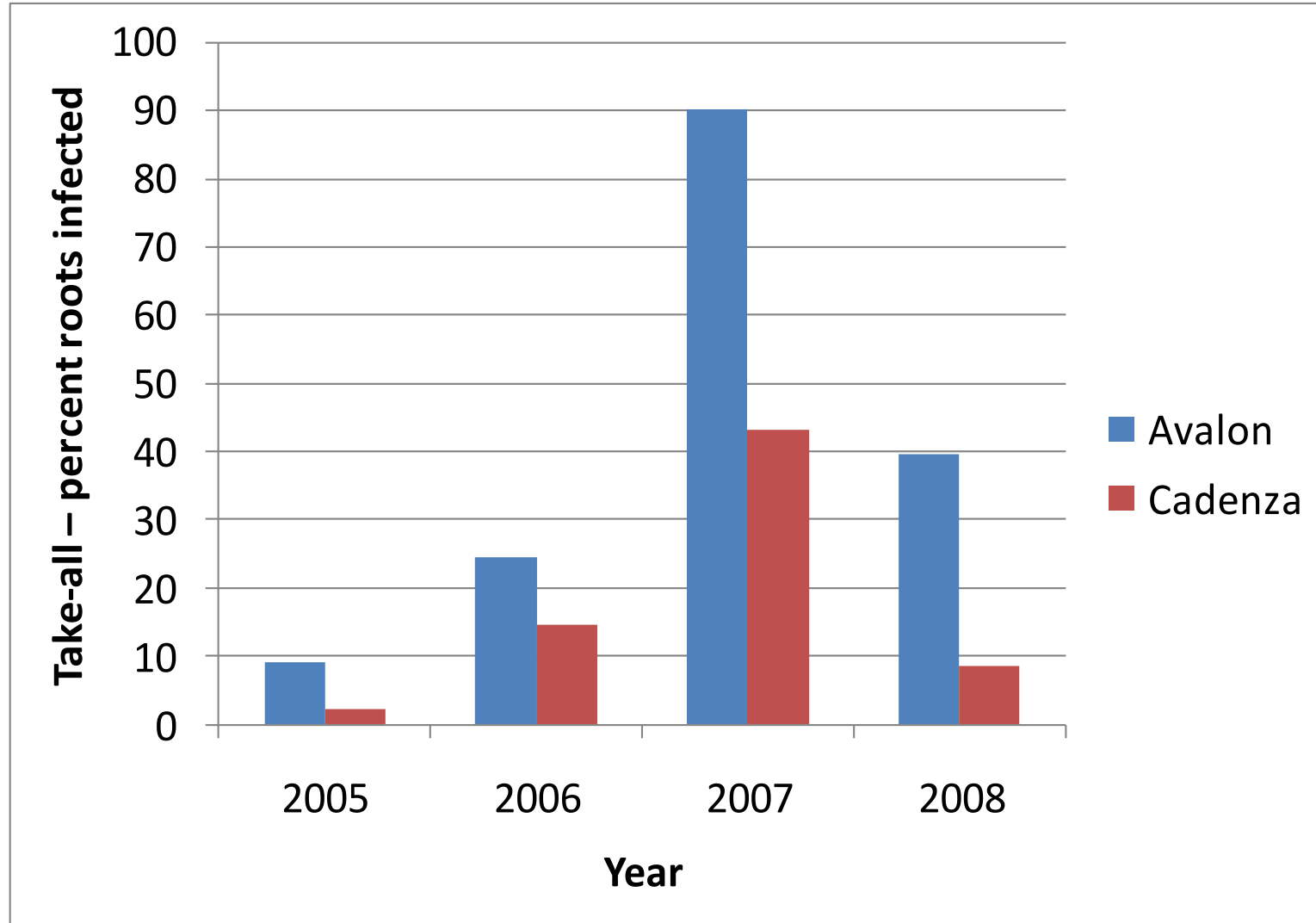
**Severe take-all infection**



**Slight take-all infection**

# % roots infected with take-all in a soil core bioassay Avalon and Cadenza 2005 - 2008 WGIN Diversity trials

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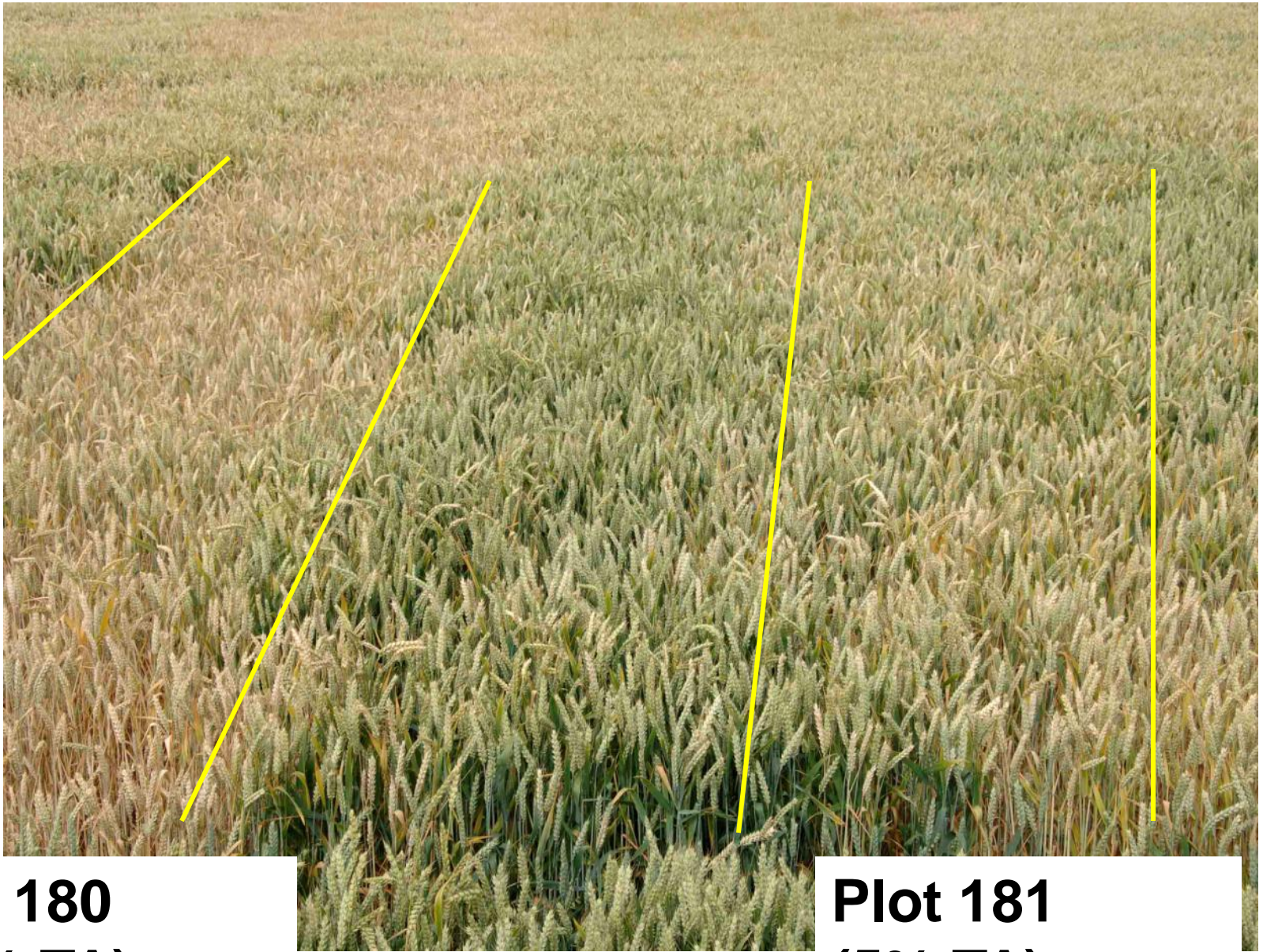


# A novel observation in the Defra Wheat Genetic Improvement trials – square take-all patches



early July 2008



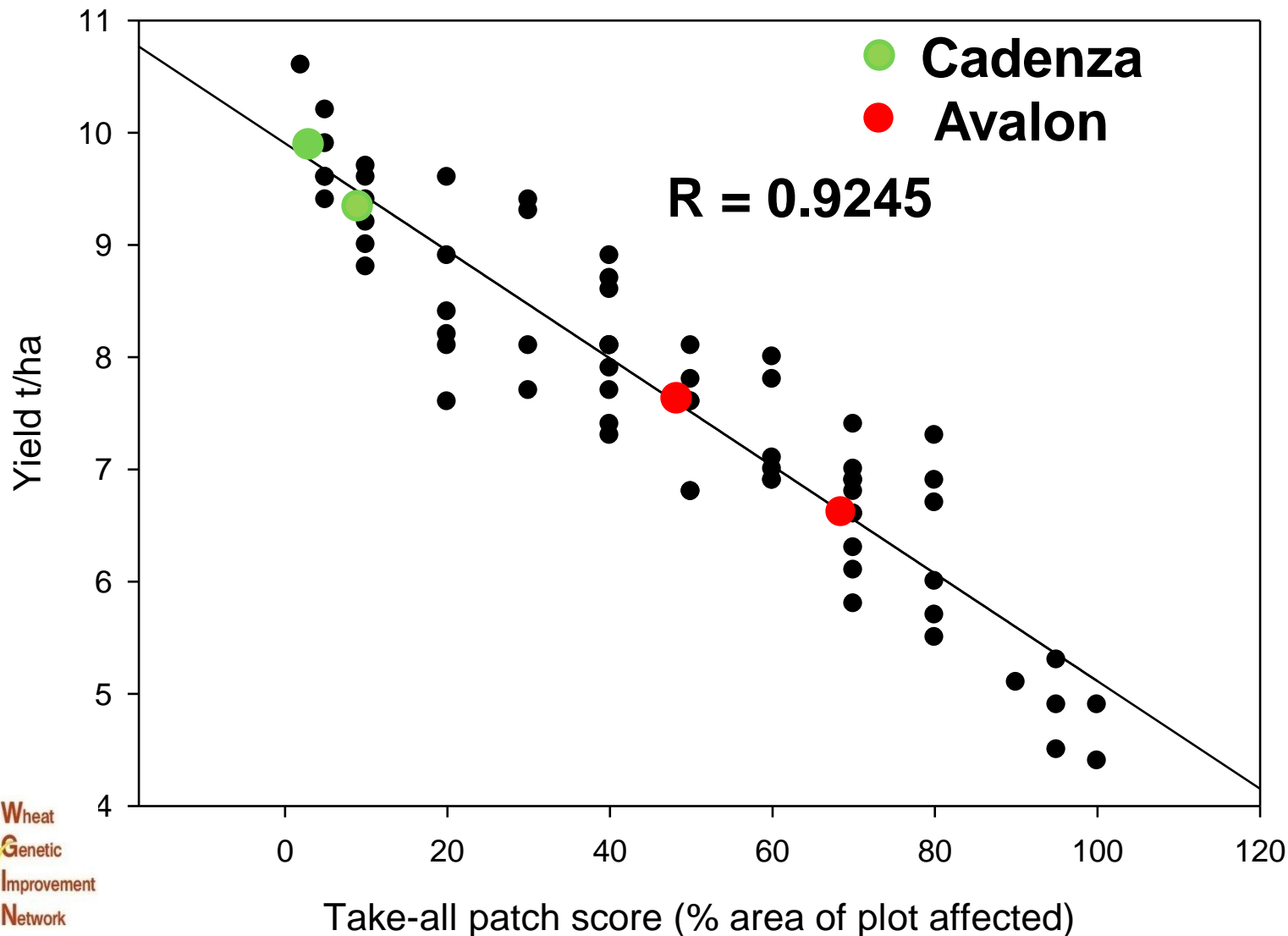


**Plot 180**  
**(95% TA)**  
**Yield 5.25 t/ha**

**Plot 181**  
**(5% TA)**  
**Yield 9.61 t/ha**

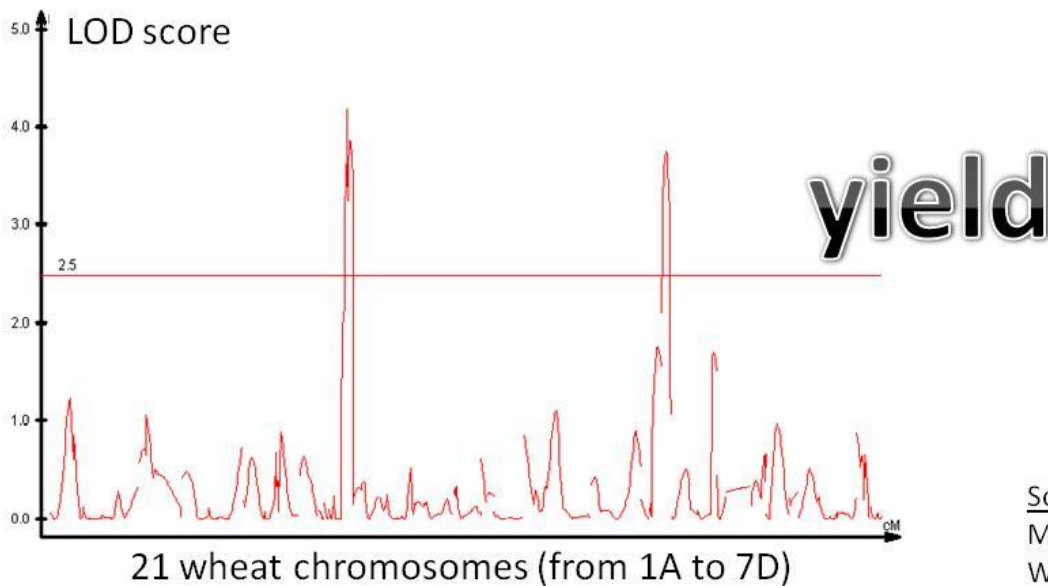
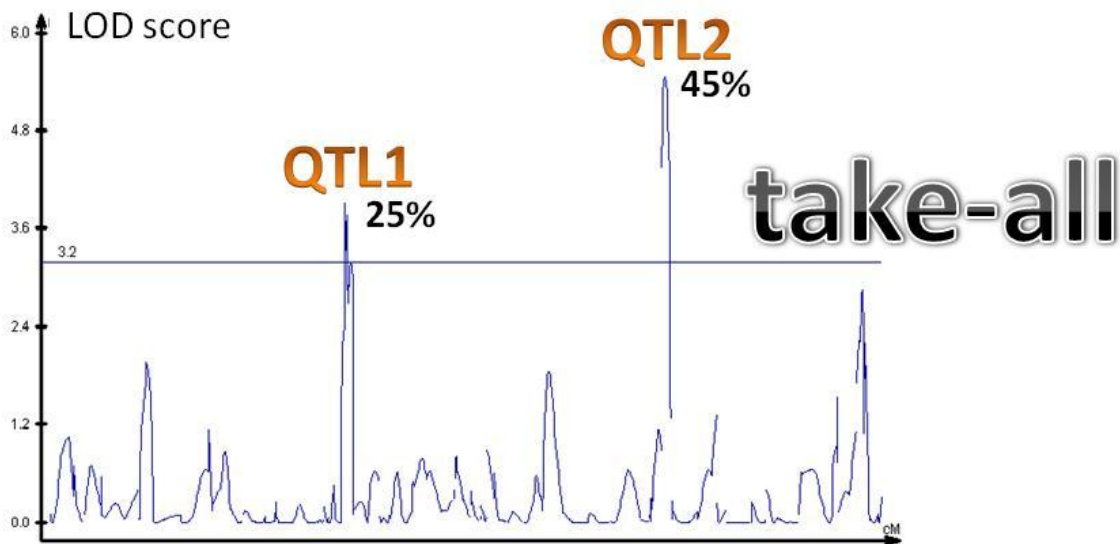
# Avalon x Cadenza 62 DH lines + 4 parental as seed multiplication plots in 2008, oversown with Oakley in 2009.

## Relationship between take-all patch score and yield.





# Mapping QTLs involved in take-all build-up in soil

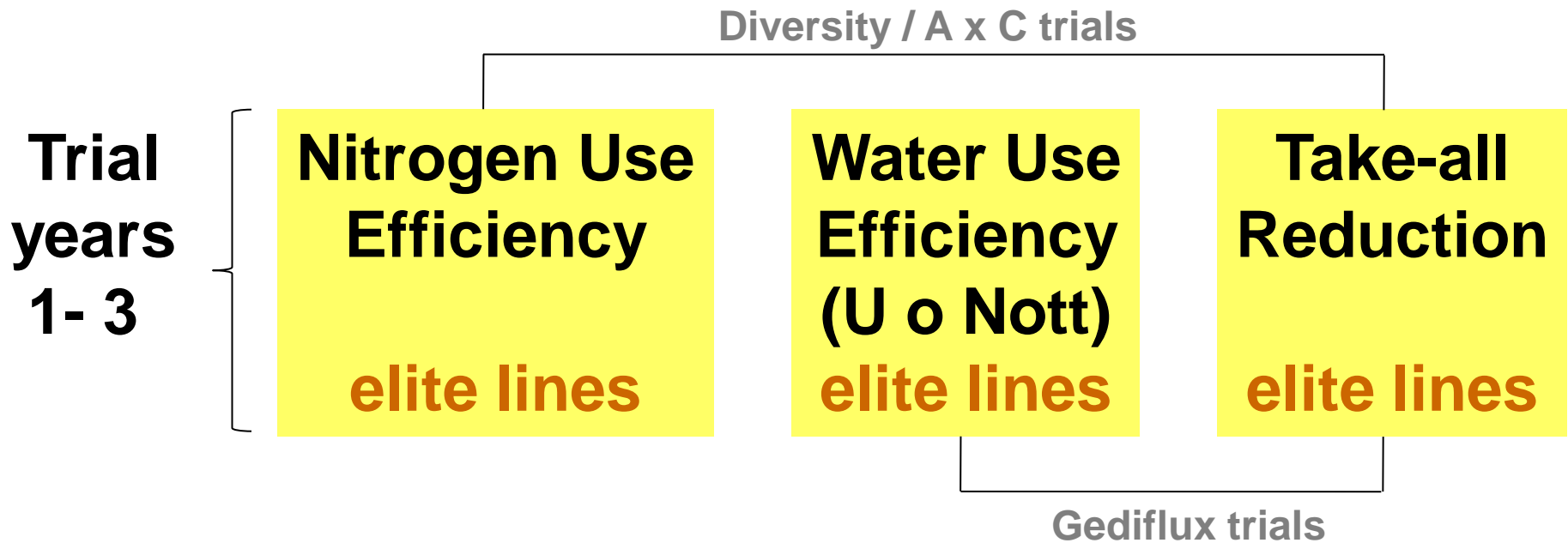


KTN  
TSB



Software used:  
MapQTL5  
Windows QTL Cartographer v2.5

# WGIN 2 Interconnecting the three soil based traits



**Aim:** To identify the lines with good tolerance to multiple stresses

**What are the similarities / differences between the three traits ?**

# Accessing the WGIN germplasm

Two routes:

RRes – by E. mailing directly to WGIN

JIC - Genetic Resources Unit



Collections /  
Databases

## Genetic Resources Unit

What's New

People

GRU  
Publications

Links

Return to  
Genetic  
Resources

The Centre is custodian of a number of key germplasm collections which serve academic, industrial and non-industrial groups both within the UK and internationally. They are the subject of research in their own right as well as being involved in a range of collaborative programmes. The collections housed within a purpose built facility maintained at 1.5 °C and 10%RH with some 600m<sup>3</sup> of storage capacity.

Material from the collections is available on request to research, academic and commercial communities subject to availability. A material transfer agreement is required before seed is released. Please email for details of the agreement.

For further information relating to the collections please contact: Mike Ambrose  
John Innes Centre, Norwich Research Park Colney Lane, Norwich, NR4 7UH.  
TEL: +01603 450630 EMAIL: JIC.geneticresources@bbsrc.ac.uk

**Accession numbers  
over 40,000 for  
RRes WGIN  
accessions**

**Mike Ambrose**

# **The Networking objectives**

**8 of the 20 activities**

# The Defra WGIN: Dissemination, Liaison and Communication

Annual “Stakeholders’ Forum” (Nov)

Focussed Workshop – 2009 ‘A x C mapping pop<sup>n</sup>’  
2010 – DArT marker analysis

Workshops with overseas partner organisations:  
CIMMYT, INRA, 2010 – Serbia / Eastern Europe

Web Site ([www.WGIN.org.UK](http://www.WGIN.org.UK) )

Six Monthly Electronic Newsletter

Scientific publications

Annual displays at ‘Cereals’

E. mail:wgin.defra@bbsrc.ac.uk



ABOUT

INFORMATION

RESOURCES

STAKEHOLDERS

HOME >

## Welcome to WGIN 2nd Phase (2009-2013)

*Defra Wheat Genetic Improvement Network - Improving the environmental footprint of farming through crop genetics and targeted traits analysis*

### Background

The UK government is committed to more sustainable agriculture but this vision is facing an ever expanding range of environmental, energy and climate change challenges. Wheat is grown on a larger area and is more valuable than any other arable crop in the UK. Established in 2003, the Wheat Genetic Improvement Network (WGIN) arose directly from a realisation in the early 2000s that over the preceding two decades there had been a widening disconnection between commercial plant breeding activities and publicly funded plant and crop research. The overall aim of WGIN is to generate pre-breeding material carrying novel traits for the UK breeding companies and to deliver accessible technologies, thereby ensuring the means are available to produce new, improved varieties. An integrated scientific 'core' which combines underpinning work on molecular markers, genetic and genomic research, together with novel trait identification, are being pursued to achieve this goal.



### site guide

The site is grouped into the following four sections:

**ABOUT** - for general information about WGIN, including news items and contacts.

**INFORMATION** - for more detailed information about WGIN, including reports and information tools.

**RESOURCES** - for experimental resources and research related tools

**STAKEHOLDERS** - for information on the Stakeholders Forum

Please use our interactive dropdown menus, the side menus, or the link tracker to navigate the site.

--see [site-map](#) for overview

### RECENT UPDATES

OLD Site - [The old site is still available here.](#)

**Disclaimer:** WGIN is a publicly funded project and the data and resources it generates are freely available to the research community, providing that the use of any WGIN data and resources are acknowledged.

Sponsored by: [Defra \(UK\)](#)  
Hosted by: [Rothamsted Research](#)  
Maintained by: [Elke Anzinger](#)  
Edited by: Kim Hammond-Kosack  
Designed by: Pierre Carion  
Last updated:



The University of  
Nottingham



John Innes Centre



ROTHAMSTED  
RESEARCH

Maintained by  
**Elke Anzinger**  
Project assistant

Accessible via the  
**MONOGRAM**  
website

# **Economic impact of WGIN**

**Special focus Newsletter May 2008**

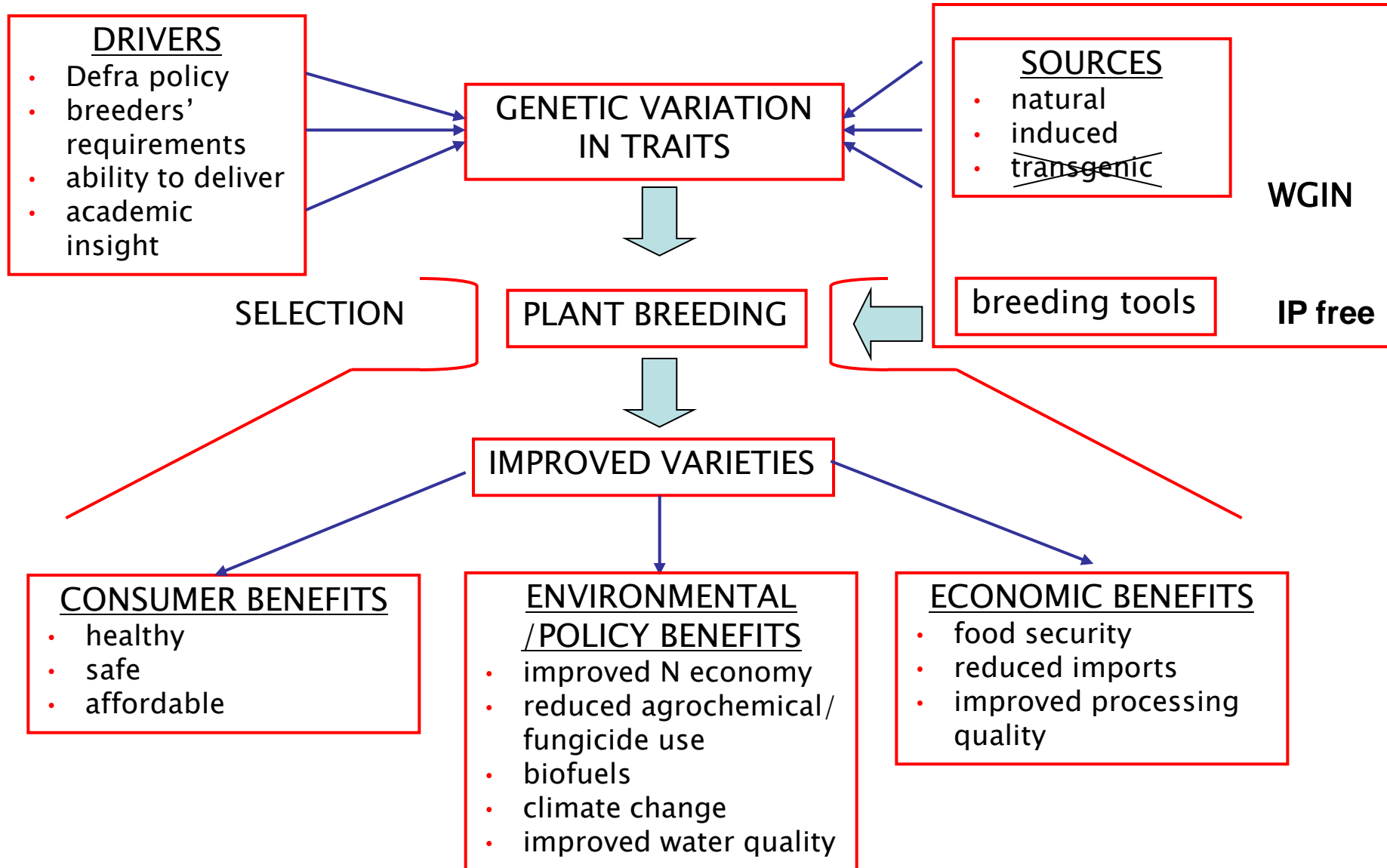
**- £7.3 M new grants**

**The cost of WGIN 1 was £1.8 M over 5 years**

**Another WGIN project impact audit just started**

**- 3 new projects described in Nov 2010 Newsletter - £942 K**

# WGIN in the wider context





# Defra

**Donal Murphy-Bokern, Bruno Viegas, Kath Bainbridge  
and Farhana Amin**

## **WGIN (present)**

**RRes - Peter Shewry  
Kim Hammond-Kosack  
Malcolm Hawkesford  
Richard Gutteridge  
Lesley Smart  
Ruth Gordon-Weeks  
Elke Anzinger**

**JIC – Simon Griffiths  
Simon Orford  
Michelle Leverington**

**UoN - John Foulkes  
Jayalath DeSilva**

## **WGIN (past)**

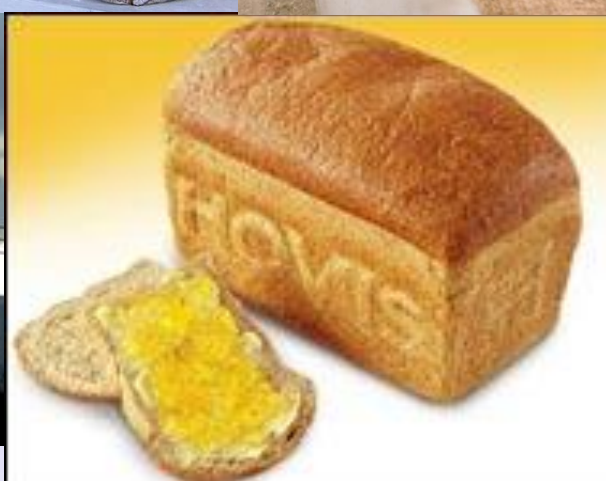
**RRes – Andy Phillips  
Katie Tearall  
Peter Barraclough  
Hai-Chun Jing  
Carlos Bayon  
Sam Irving**

**JIC - John Snape  
Robert Koebner  
Liz Sayers  
Christian Rogers  
Pauline Stephenson  
Leodie Alibert**

**The farm / trials staff at all the sites used**

**The Plant Breeders  
The Management team**

**[www.WGIN.org.UK](http://www.WGIN.org.UK)**



- Spring
- 1
- 2A
- 2B
- 3A
- 3B
- 4A
- 4B
- 4C
- 5A
- 5B
- 6A
- 6B
- Fall/winter
- 7
- 8
- 9
- Winter
- 10
- 11
- 12
- 13

**Ford**

**Wheat Straw Bio-Filled Polypropylene**  
Industry and World-First Usage in Quarter Trim Bins on 2010 Ford Flex

**AgriPlas™**





## The WGIN disclaimer

**WGIN is a publicly funded project and the **data and resources** it generates are freely available to the research community, providing that the **use** of any WGIN data and resources are **acknowledged**.**

**In grant applications as well as final publications**

**We developed in early 2010 : A generic statement on data and resource use by others**

**Please use this statement and inform us of all successful activities**

## **Additional funds**

**EPSRC – TSB ‘Improving Crop Protection for Food Security’ initiative**

**Low Take All inoculum Build-up project - LowTAB**

**Started in Oct 2010**

**5 years duration**

**RRes + 3 commercial wheat breeding companies**

**Application developed with the help of the Biosciences Knowledge Transfer Network (KTN)**

# The Defra WGIN 1 Core Project (2003-2008)

## Aims:

**To Underpin Wheat Improvement by Plant Breeders**

## Approaches:

- 1. Characterisation and provision of genetic resources**
- 2. Genetic mapping (A x C) and marker development**
- 3. Trait identification – Nitrogen use efficiency**
- 4. Identification and generation of novel variation in key traits : using non-GM approaches**
- 5. Central storage of grain from field trials**
- 6. Liaison and communication**

## Funded research partners:

**Rothamsted Research and John Innes Centre**

**some funds for one sub-contractor project**

# Characterisation and provision of genetic resources

March 2007 WGIN newsletter – special issue resources

Seed is available via the JIC Genetic Resource Unit

**Two large EMS populations for hexaploid spring wheat**

**Paragon and Cadenza**

**Gamma irradiated Paragon population**

**Ion beam irradiated Cadenza populations**

**Many resources for the diploid wheat**

***Triticum monococcum***

# **Central storage of grain from the field trials**

**5 years of field trials**

**The stored samples - 1 kg grain at - 20 C**

**Genotype diversity trial – for all years and all plots**

**Avalon x Cadenza - for some years, all plots**

**~ 4,500 samples with associated metadata**

**A key biological resources for new projects  
and / or pilot studies**

# Economic impact of WGIN

Special focus Newsletter May 2008

The cost of WGIN 1 was £1.8 M over 5 years

What was the return ?

## WGIN 1

1. Funded BBSRC projects using WGIN data and resources - £ 3.0M
2. Funded projects using WGIN data in the application - £ 4.3M  
(BBSRC, EU-FP6, HGCA, LINK, RIF, PhD projects)

Another WGIN project impact audit just started

- 4 new projects described in Nov 2010 Newsletter