WGIN : Overview and update on RRes WGIN research

Kim Hammond-Kosack
Rothamsted Research

10th WGIN Stakeholders Meeting 27th November 2012
The Defra Crop Genetic Improvement Networks

Announced July 2002

Dr Donal Murphy-Bokern
Arable Crop Sciences & Pesticide Safety Unit
Science Directorate
Defra
Overall Objectives

To recreate the best of the past

• 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
Networks established

- Wheat (WGIN)
- Oilseed rape (OREGIN)
- Short rotation coppice (BEGIN)
- Pulse crops (PCGIN) 2005
- Miscanthus
- Oats
- Leafy Vegetables (VeGIN) 2009
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

Grain Producers and Utilisers

9 UK WHEAT BREEDING COMPANIES

MODEL SPECIES

EU

WGIN

BBSRC

OTHER CEREALS

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

Diagram:
- The network starts with "Commercialisation" at the top.
- "WGIN" is at the center, connected to "9 UK Wheat Breeding Companies" and "HGCA".
- "TSB BBSRC" and "Model Species" are connected to WGIN.
- "EU" is connected to WGIN.
- "INTERNATIONAL" and "Other Cereals" connect to WGIN.
- "IPA Responsive mode" connects to "BBR CICR STaR LOLAs".

Key Acronyms:
- BBSRC
- EU
- TSB
- IPA
- HGCA
- LINK
- ERA-PGs
- BBR
- CICR
- STaR
- LOLAs
Projects of 5 years duration

The WGIN 1 project (2003 – 2008) - £1.80 million
The WGIN 2 project (2008 – 2013) - £1.95 million

WGIN 2 project – funded partners
  John Innes Centre
  University of Nottingham
  Rothamsted Research
  + 2 pilot projects (1 yr / 2 yr)
Improving the environmental footprint of farming through crop genetics and targeted traits analysis
Defra’s current policy priorities addressed by WGIN

1. Support and develop British farming and encourage sustainable food production
Defra’s current policy priorities addressed by WGIN

2. Help to enhance the environment and biodiversity to improve quality of life

Increase in England of Nitrate Vulnerable Zones (NVZ) due to arable activities 2002 (blue) to 2009 (pink)
Defra’s current policy priorities addressed by WGIN

3. Support a strong and sustainable green economy, resilient to climate change
Tools and Resources

2. Near Isogenic lines (NILs) *

3. The Avalon x Cadenza Mapping popn

4. Paragon gamma and EMS popn

5. AE Watkins and Gediflux collections

6. New mapping popn for WUE (9) and 2 new popn 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)
Genetic mapping and marker development

- Establish a reference UK mapping population

Avalon x Cadenza -

203 double haploid lines

- Switch to ‘within the gene’ KASP\textsuperscript{ar} molecular markers

- Extended A x C population for fine mapping
Avalon x Cadenza – Near isogenic lines (NILs)
Large plot trial 2012/2013 – 3 reps

QTLs for different traits

Avalon Background
225  No of lines
1B ear emergence
1D ear emergence
2A height
2D height
2D yield
3B height
5A yield
6A height
6B height
6B height & 7D yield
1D ear emergence & 5A yield
7B yield
7D yield

Cadenza background
342  No of lines
1B ear emergence
1D ear emergence
2A height
2D height
3A height
3B height
3B yield
6A height
6B ear emergence & height

Simon Griffiths, JIC
The AE Watkins spring and winter wheat collection (JIC)

1930s collection from markets in 32 countries

Seed now available for > 1000 ‘purified’ lines

Represents germplasm never used in UK wheat breeding programmes

Simon Griffiths
Trait identification

1. Improved nitrogen use efficiency (NUE)

2. Grain quality (QTLs) linked to NUE

3. Improved water use efficiency (WUE)

Consecutive years of field trials

Malcolm Hawkesford, RRes

John Foulkes, U Nott
## Diversity NUE trial history

<table>
<thead>
<tr>
<th>Trial</th>
<th>Year</th>
<th>Varieties <em>(core of 9)</em></th>
<th>N-levels</th>
<th>kg N/ha</th>
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<td>2004</td>
<td>32</td>
<td>4</td>
<td>0,50,200,350</td>
<td>Blackhorse</td>
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<tr>
<td>2</td>
<td>2005</td>
<td>20</td>
<td>2</td>
<td>0,200</td>
<td>Fosters</td>
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<tr>
<td>3</td>
<td>2006</td>
<td>24</td>
<td>3</td>
<td>0,100,200</td>
<td>Meadow</td>
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<td>4</td>
<td>2007</td>
<td>24</td>
<td>4</td>
<td>0,100,200,350</td>
<td>Blackhorse</td>
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<tr>
<td>5</td>
<td>2008</td>
<td>24</td>
<td>4</td>
<td>0,100,200,350</td>
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<tr>
<td>6</td>
<td>2009</td>
<td>24 (include 6 x A x Cs)</td>
<td>4</td>
<td>0,100,200,350</td>
<td>Summerdells</td>
</tr>
<tr>
<td>7</td>
<td>2010</td>
<td>25 (include 6 x A x Cs)</td>
<td>4</td>
<td>0,100,200,350</td>
<td>Blackhorse</td>
</tr>
<tr>
<td>8</td>
<td>2011</td>
<td>25 (include 4 x A x Cs)</td>
<td>4</td>
<td>0,100,200,350</td>
<td>Meadow</td>
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<tr>
<td>9</td>
<td>2012</td>
<td>25 (include WUE/take-all)</td>
<td>4</td>
<td>0,100,200,350</td>
<td>Summerdells</td>
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<td>25 (include WUE/take-all)</td>
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</tr>
</tbody>
</table>
Rothamsted WGIN-N200 Combine Grain Yield (2004-12)

47 varieties + some A x C lines

Year

Grain yield (t/ha@85%DM)

200kg N

Yield stability - very poor

very good
2. Reducing pest and disease pressure

- **Aphids**
- **Septoria leaf blotch**
- **Take-all fungus**

Annually all crops at high risk for 2nd / 3rd wheat crops

A major problem for 2nd wheat syndrome
Septoria resistance

Hexaploid wheat

Triticum monococcum - diploid wheat AA

Field assessment over 5 years

Fine mapped locus to Chr7A

Introgression breeding

Pairing locus mutant $ph1$

cvs Chinese Spring, Paragon

Take-all resistance in $T. monococcum$

Field and pot test

Triticum monococcum accessions

Hereward A B C D E F G H I J K

Root with Take-all (%)

SED=3.718

Triticum monococcum accessions

Three mapping populations produced and F$_6$ populations to be screened in 2013
WGIN 2 Interconnecting the three soil based traits

Aim: To identify the lines with good tolerance to multiple stresses (years 4 – 5)

What are the similarities / differences between the three traits?
Accessing the WGIN germplasm

Two routes:
RRRes – by E. mailing directly to WGIN
JIC - Genetic Resources Unit

Accession numbers over 40,000 for RRRes WGIN accessions

Genetic Resources Unit
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 100%RH with some 600m² 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: +44 1603 450630 EMAIL: JIC.geneticresources@bbesc.ac.uk

Mike Ambrose
Central storage of grain from the field trials

8 years of field trials

The stored samples - 500 g / 1 kg grain at -20 C

~ 7,000 samples with associated metadata

Key biological resources for new projects and / or pilot studies
The Networking objectives

8 of the 20 activities
The Defra WGIN: Dissemination, Liaison and Communication

Annual “Stakeholders’ Forum” (Nov)
Focussed Workshop – 2009, 2013 ‘A x C mapping popn’
2010 – DArT marker analysis

Workshops with overseas partner organisations:
CIMMYT, INRA, 2010 – Serbia / Eastern Europe
2011- Brazil, 2013?

Web Site (www.WGIN.org.UK)
Six Monthly Electronic Newsletter
Scientific publications
Annual displays at ‘Cereals’
E. mail:wgin.defra@bbsrc.ac.uk
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

REAL 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.
Economic impact of WGIN

Special focus Newsletter May 2008
- £4.3 M new grants + £2.95 M existing grants

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

2nd WGIN project impact audit done in late 2011
- 20 new projects described in Nov 2011 Newsletter
  - £15 M new grants

14 projects partially industry funded

BBSRC, HGCA, Defra, Technology Strategy Board, Scottish Government, EU Lawes Trust, Rothamsted International, John Oldacre Foundation

+ many PhD student projects

The cost of WGIN 2 is £1.95 M over 5 years
WGIN in the wider context

**DRIVERS**
- Defra policy
- Breeders’ requirements
- Ability to deliver
- Academic insight

**SOURCES**
- Natural
- Induced
- Transgenic

WGIN breeding tools

**GENETIC VARIATION IN TRAITS**

**SELECTION**

**PLANT BREEDING**

**IMPROVED VARIETIES**

**CONSUMER BENEFITS**
- Healthy
- Safe
- Affordable

**ENVIRONMENTAL/POLICY BENEFITS**
- Improved N economy
- Reduced agrochemical/fungicide use
- Biofuels
- Climate change
- Improved water quality

**ECONOMIC BENEFITS**
- Food security
- Reduced imports
- Improved processing quality

**IMPROVED VARIETIES**
Defra
Donal Murphy-Bokern, Bruno Viegas, Kath Bainbridge, Farhana Amin and David Cooper

WGIN (present)
RRes - Peter Shewry
Kim Hammond-Kosack
Malcolm Hawkesford
Vanessa McMillan
Kostya Kanyuka
Suzanne Thrussell

JIC – Simon Griffiths
Susan Freeman
Cathy Mumford

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

JIC - Simon Orford
Michelle Leverington

The farm / trials staff at all the sites used

The Plant Breeders
The Management team

www.WGIN.org.UK
The relationship between WGIN and the major funding initiatives supporting UK wheat research (2000-2017)

Funders:
- defra
- BBSRC
- HGCA
- TSB
- others

- only wheat
- wheat + other crop species

Increasing funding for UK wheat research

- SGC workshops
- defra WGIN 1
- defra WGIN 2
- defra – LINK
- MONOGRAM network
- CIRC 1
- CIRC 2
- Wheat seq LoLa
- Pre-breeding WISP
- Wheat seq

HGCA

TSB + XXX

The WGIN disclaimer

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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
Three Defra’s current policy priorities addressed by WGIN

1. Support and develop British farming and encourage sustainable food production

   Help to enhance the competitiveness and resilience of the whole food chain, including farms and the fish industry, to help ensure a secure, environmentally sustainable and healthy supply of food with improved standards of animal welfare
Three Defra’s current policy priorities addressed by WGIN

2. Help to enhance the environment and biodiversity to improve quality of life

Enhance and protect the natural environment, including biodiversity and the marine environment, by reducing pollution, mitigating greenhouse gas emissions, and preventing habitat loss and degradation.

Increase in England of Nitrate Vulnerable Zones (NVZ) due to arable activities 2002 (blue) to 2009 (pink)
Three Defra’s current policy priorities addressed by WGIN

3. Support a strong and sustainable green economy, resilient to climate change

Help to create the conditions in which businesses can innovate, invest and grow; encourage businesses, people and communities to manage and use natural resources sustainably and to reduce waste; work to ensure that the UK economy is resilient to climate change; and enhance rural communities
Great Harpenden I - Full A x C mapping population

2010 - 2011