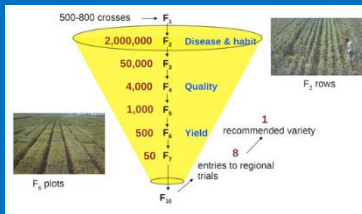
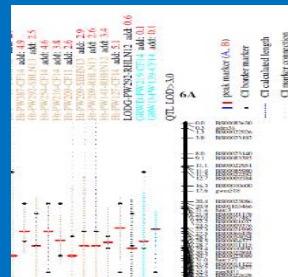
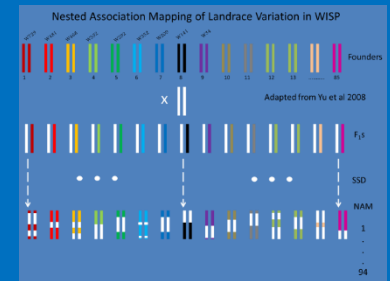


Designing Future Wheat

A coordinated UK wheat programme



The emergence of modern wheat has left a trail of untapped variation for UK agriculture

Modern varieties
Artificial selection



Wild relatives



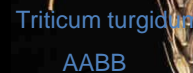
Triticum urartu
AA



Aegilops speltoides
BB

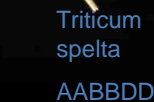


Triticum tauschii
DD

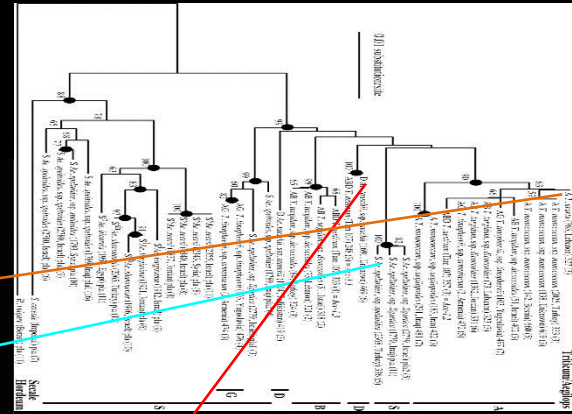


Triticum turgidum
AABB

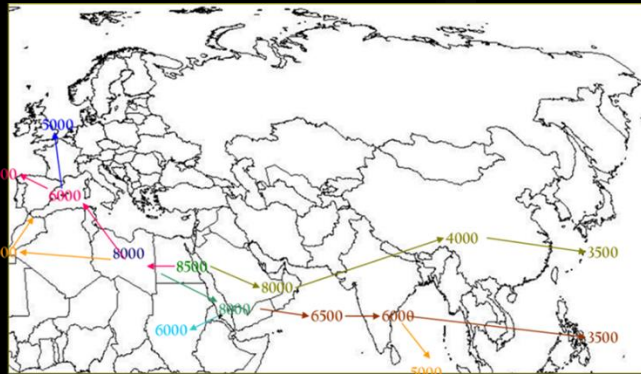
Landrace cultivars



Triticum spelta
AABBDD

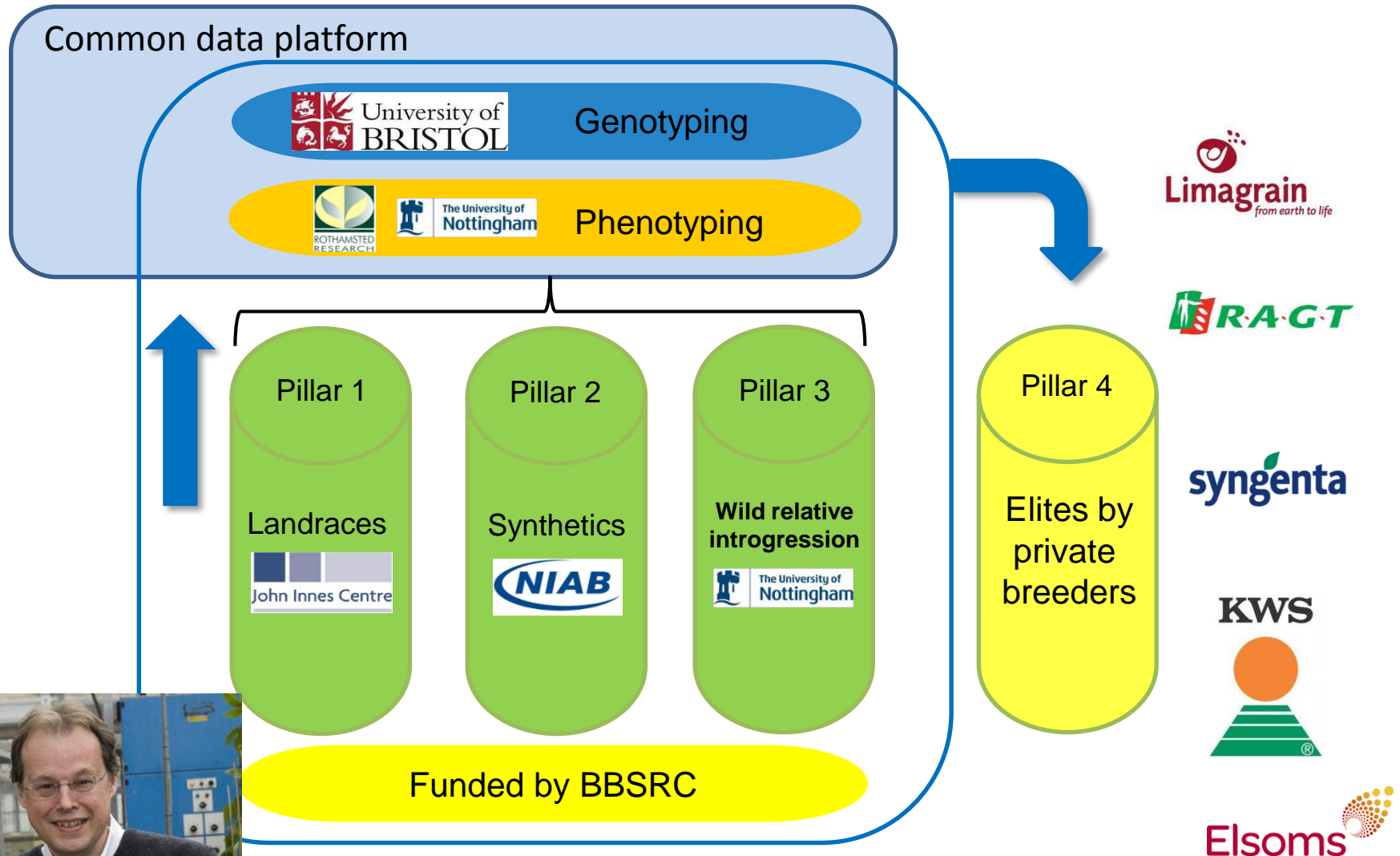


Natural selection



Domestication and the spread of agriculture

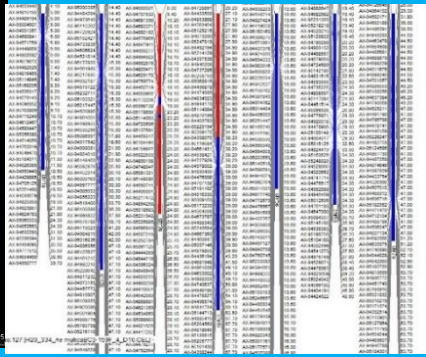
WISP (Wheat Improvement Strategic Programme): roles of partners 2011-17



8 Groups involved – coordinated by Graham Moore

Wild Relative Introgressions

Aegilops mutica
BC₃



Soil

60 pallets of soil per year = 105,000 litres

6 years = 630,000 litres

Pots

105,000 litres = 50,000 pots (2 litre)

6 years = 300,000



Crosses

4,000 to 5,000 per year

Programme total = 27,000



Crossing bags

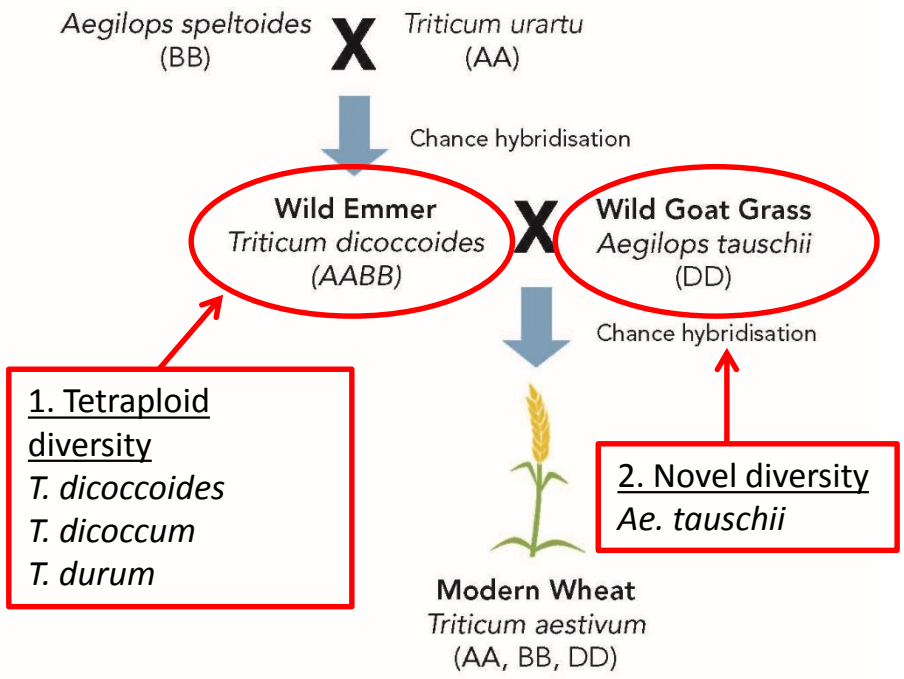
(for crosses and selfing)

Used 250,000 over the 6 years



Julie and Ian King

Synthetics



- 50 new synthetic wheats
- Selections of synthetic x Robigus and Paragon
- Paragon chromosome segment substitution lines.
- Tetraploid introgressions into bread wheat.

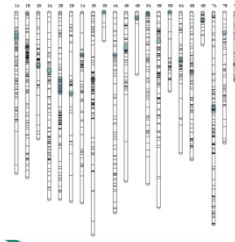
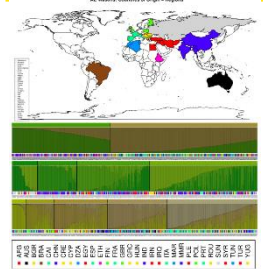


Phil Howell

Alison Bentley

Landraces

1050 AE Watkins landrace cultivars



1272- QTL identified

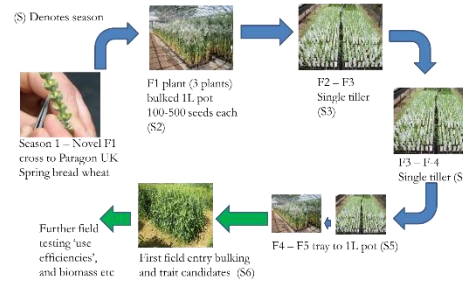
11- The Breeders Landrace Toolkit

Modern Bread Wheat

36-current UK winter wheat recommended list

Populations from 52 Watkins landrace cultivars trialled

WISP Development of 85 Mapping Populations



87 core landrace cultivars produce a segregating population of 7583

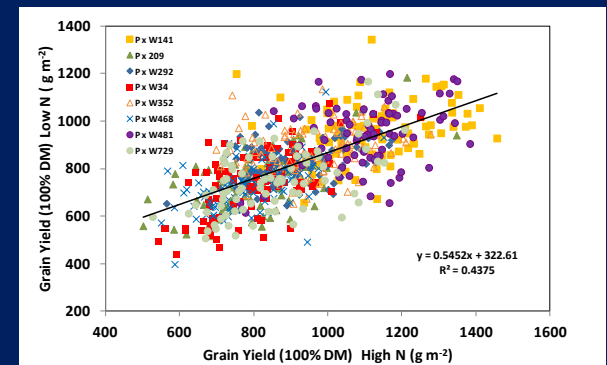
Discovering new genes for biomass and nitrogen use traits

Large scale field trials at Rothamsted and University of Nottingham assessing yield and biomass responses of WISP germlasm to different levels of Nitrogen fertilisation:



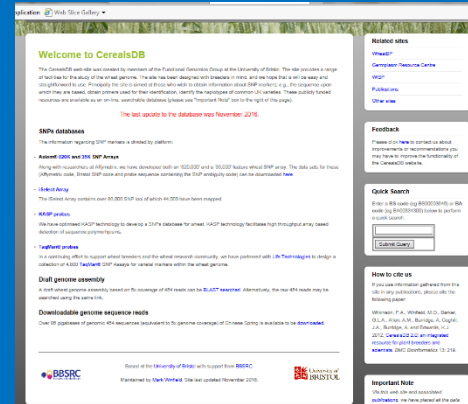
- 35 000 plots over the 6 years.
- Donor, mapping pops and P. Grain and straw saved from each plot.
- 70 000 samples, all archived.
- 0.8 million phenotypic data points
- The team walk 500km/yr phenotyping – 6 yrs, that's 3000km

Malcolm Hawkesford



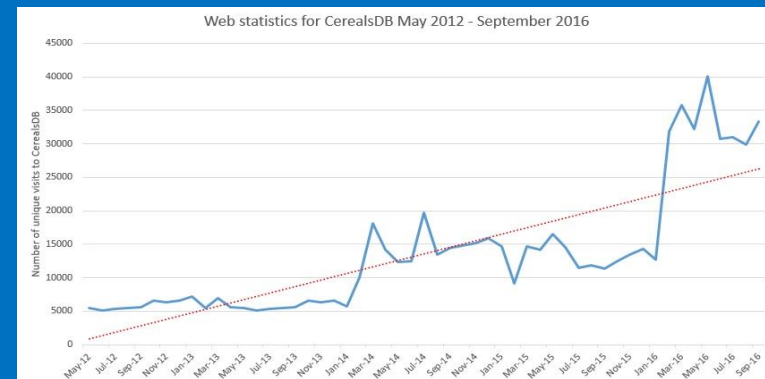
Genotyping

- 99,945 varietal wheat SNPs from resequencing 48 WISP lines
- High density genotyping arrays iSelect 81,587 and Axiom 820K array.
- Specialised Axiom arrays- 35K breeders and relatives arrays.
- Consensus genetics maps up to 56,000 SNPs.
- Over 5000 'One by one' KASP SNPs.
- Supporting WISP partners in MAS, mapping, and parental genotyping.
- High definition mapping of numerous, previously unknown, introgressions into bread wheat.



Keith Edwards

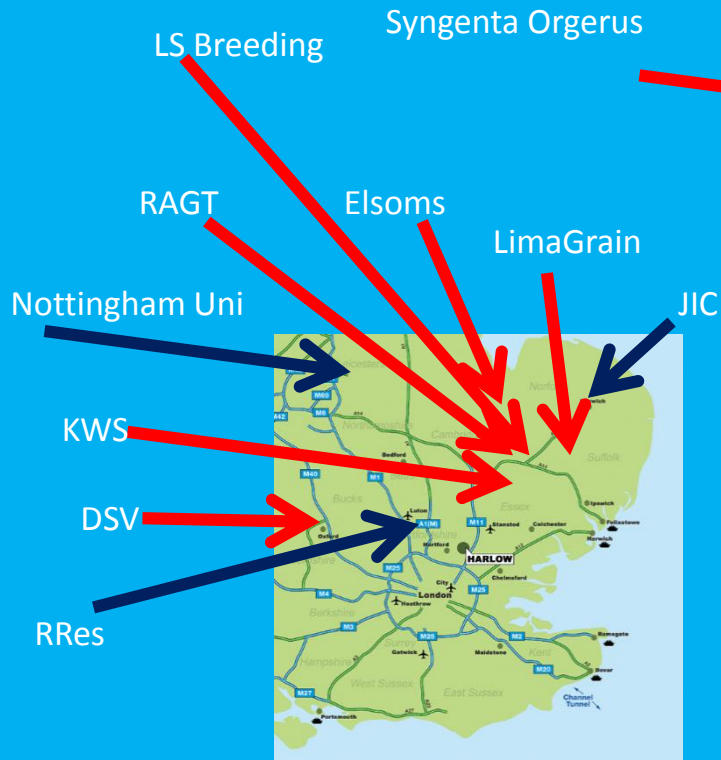
CerealsDB The data repository for WISP genotyping outputs



Frequently accessed by a large number of users worldwide

WISP Breeders Toolkit Trial Sites

2016/17



Toolkit dissemination events at RReS, NIAB, and JIC

Targeted alleles →

Complete NIL Series →

Background to Designing Future Wheat

The screenshot shows the BBSRC website with the following elements:

- Header:** BBSRC logo with the tagline "Building the bioeconomy" and "bioscience for the future". A search bar is located on the right.
- Navigation:** A horizontal menu with buttons for Home, Funding, Research (highlighted), Innovation, Skills, Public engagement, News, events and publications, and About us.
- Left Sidebar:** A vertical menu with "Research" at the top, followed by "Agriculture and food security" (highlighted), "Aquaculture", and "Our strategic interests in wheat research" (highlighted with a red arrow).
- Breadcrumbs:** Home > Research > Agriculture and food security > Our strategic interests in wheat research
- Main Content:**
 - ## Our strategic interests in wheat research
 - Recognising the importance of wheat, in 2013 BBSRC developed a 5-year wheat strategy under the chairmanship of Sir David Baulcombe. The strategy highlighted the importance of consolidating and building upon both BBSRC's and the UK's track record in wheat research, and noted that BBSRC has a major international leadership role to play.
 - In 2015 a BBSRC Council Wheat Sub-group was set up to discuss the strategic role BBSRC should play in UK wheat research. The Group was chaired by Professor Helen Sang and also included Sir David Baulcombe to provide continuity from the strategy development work. On the back of this work BBSRC Council endorsed a BBSRC Vision for wheat research and a series of recommendations to maintain the strategic wheat research in the UK.
- Right Sidebar:** A "Related links" section containing:
 - Advice for future wheat research published
 - Agriculture and Food Security Strategy Advisory Panel
- Footer:** "Share this page:" with icons for Facebook, Twitter, Email, Print, and a plus sign. Below it, a "cookie" notice.

<http://www.bbsrc.ac.uk/research/food-security/strategic-interests-in-wheat-research/>

A clear message for full scale integration

BBSRC Council said the large institute programmes should be:

- Built on the success of the WISP model.
- Part of a **single coherent coordinated package.**
- Cross-institute.
- Appropriately coordinated.
- Involving HEIs as appropriate.
- **Fully integrated.**



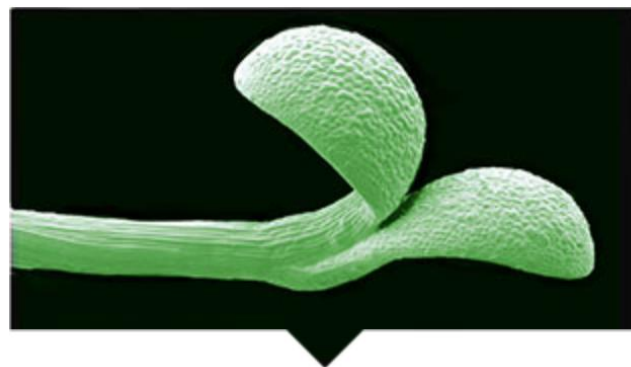
Challenge of scale

- WISP involved 8 research groups.
- Designing Future wheat involves around 30 groups.
- Graham Moore was asked to bring the programme together.
- GM also to act as coordinator/facilitator once DFW up and running.

20:20 Wheat ®



Ensuring food security is a major challenge for the future. Wheat provides a fifth of human food. However, wheat yields have declined. The average farm yield of wheat in the UK is currently 8.4 tonnes per hectare. The Institute is leading a programme of research and development to increase UK wheat yield potential to 20 tonnes of wheat per hectare within the next 20 years.

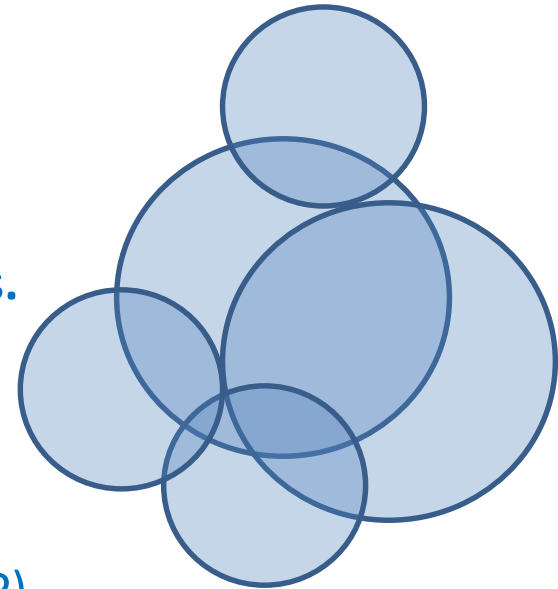


Growing Our Future

The Institute Strategic Programme on Growth and Development Underpinning Yield (GRO)

What space should Institute Strategic Programme (ISP) Activity fill in Wheat Research?

- Council/a council sub-group also agreed:
 - Trait dissection
 - Germplasm development
 - Supporting informatics were ISP activities.
- Other areas were better placed under:
 - Responsive Mode
 - BBSRC LINK
 - International grants (GCRF, Newton, IWYP)



Designing Future Wheat

ISP leader: Graham Moore; Deputy: M J Hawkesford

WP3: Germplasm

WP leader: Griffiths (JIC)

Topic 3.1
Germplasm
base

Topic 3.2
Deployment

WP1: Increased efficiency and sustainability

WP leader: Malcolm Hawkesford (RRes)

Topic 1.1
Optimizing
ideotypes

Topic 1.2
Enhancing
resource
use

WP2: Added value and resilience

WP leader: Cristobal Uauy (JIC)

Topic 2.1
Enhanced
Health
Benefits

Topic 2.2
Durable
resistance to
pathogens
and pests

WP4: Improved data access and analysis

WP lead: Robert Davey (EI)

Topic 4.1
Genomic
resources

Topic 4.2
Open data
framework

Designing Future Wheat

WP1: Increased efficiency and sustainability

WP2: Added value and resilience

WP Leaders

Malcolm Hawkesford (RRes)

Cristobal Uauy (JIC)

Optimizing ideotypes

- Resilience to heat
- Canopy and height
- Grain number and size

Resource use efficiency

- Soil/root interactions
- NUE
- Innovative technology-phenotyping

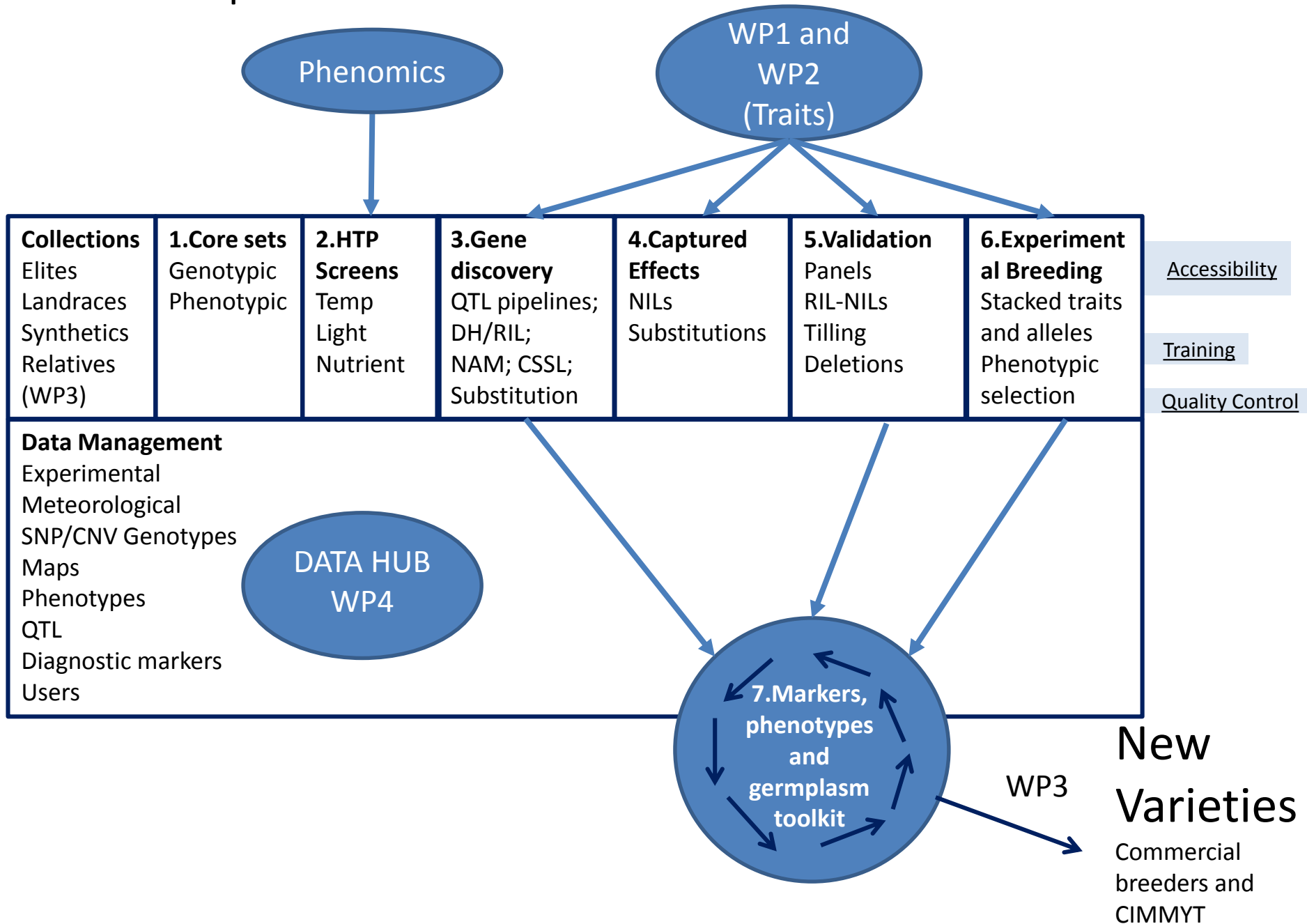
Safe, reliable and healthy grain

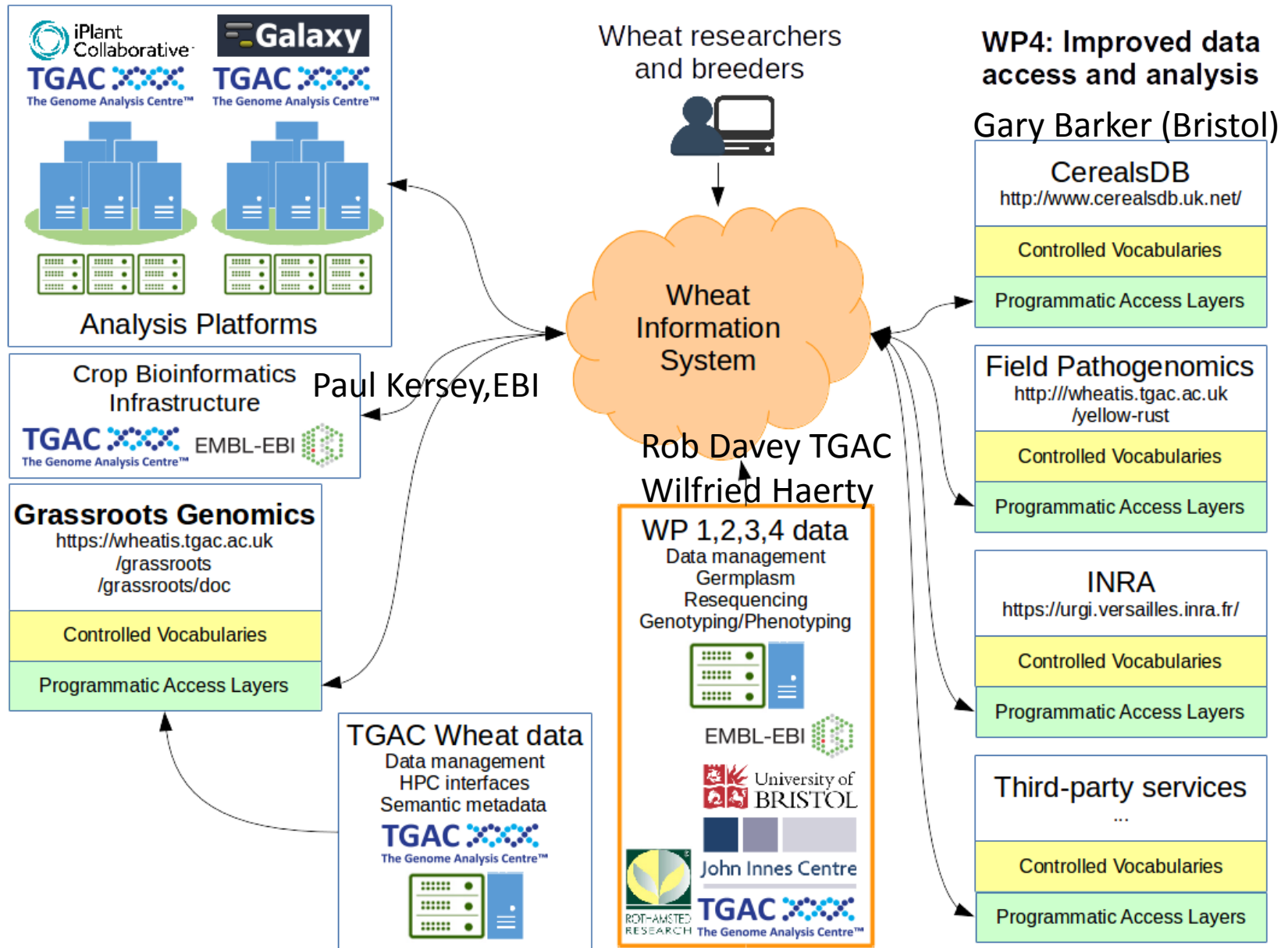
- Composition and health-starch-Fibre-Zinc and Iron

Durable resistance to pathogens and pests

- Durable resistance
- Pathogen biology (rusts, Septoria, Fusarium, take-all, mildew, eyespot; aphids)

WP3 Germplasm







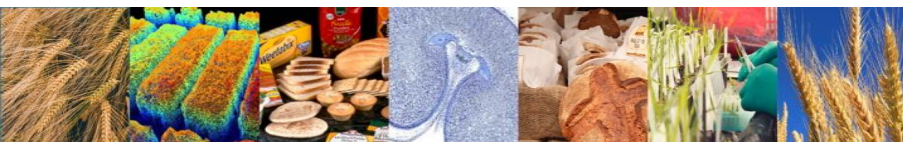
Multi-institute consortium

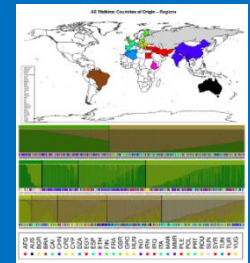


Earlham Institute



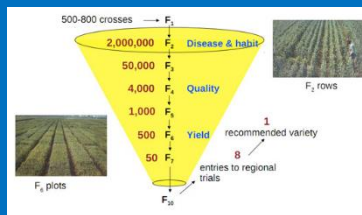
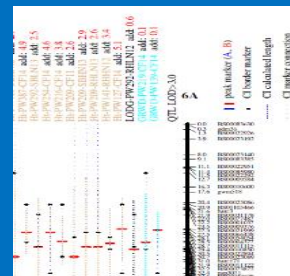
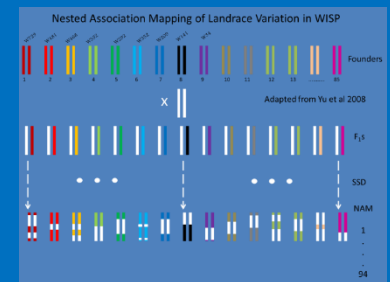
EMBL





Designing Future Wheat

A coordinated UK wheat programme





Designing Future Wheat

A Coordinated UK Wheat Programme

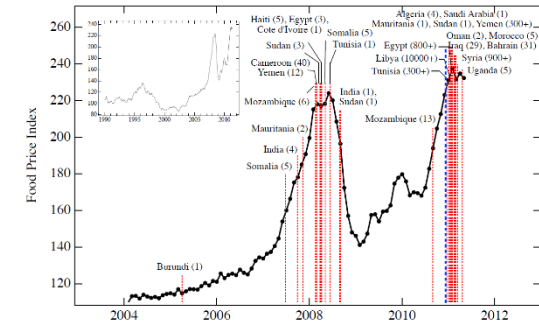
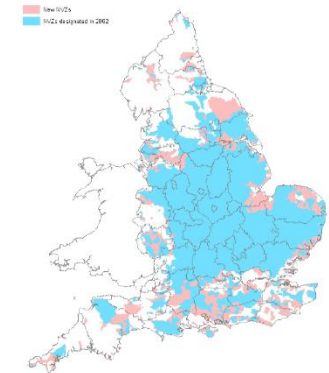
Malcolm J Hawkesford





Why Wheat? Why the level of Expenditure?

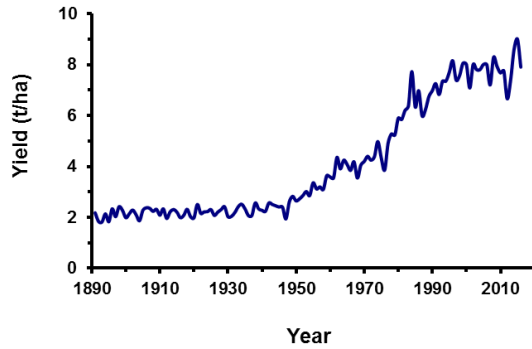
- Wheat is the **most important UK crop**, accounting for 40% of total crop acreage
- Wheat underpins the economically important and successful **UK food and drink industry**
- Wheat is one of the few UK crops with a truly **global reach** and impact
- Grown in **NVZs** (nitrate vulnerable zones)
- The world will require as much wheat in the next 50 years as has been produced in the last 10,000 years
 - Over 1.6 billion wheat consumers are at risk of starvation (300 million risk of dying), many in countries surrounding Europe
 - Health issues - overconsumption and starvation co-exist in same countries



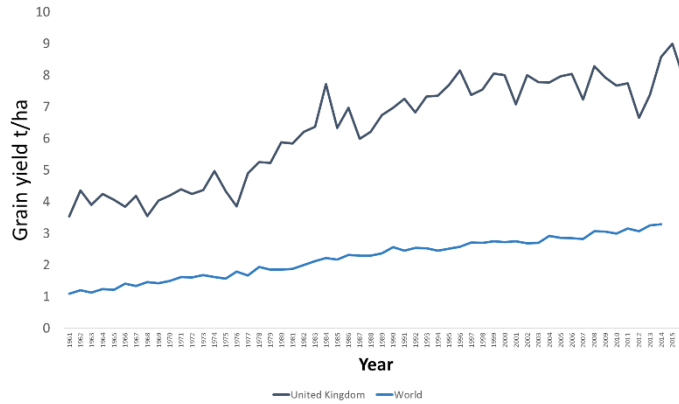


Status of wheat production

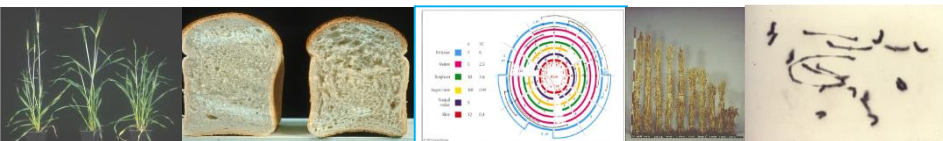
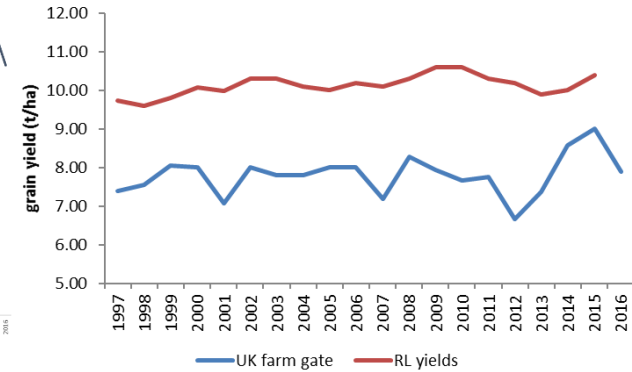
UK wheat yields (1890-2016)



UK and world yields (1961-2016)



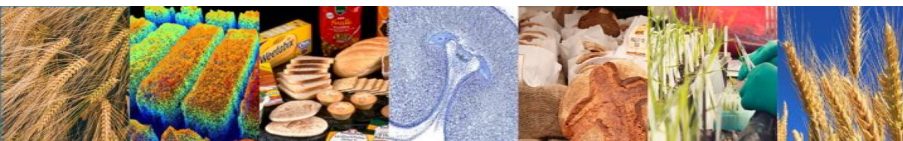
UK yield gap (1997-2016)





DFW Research Drivers

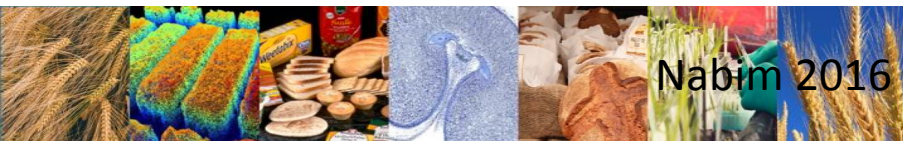
- Production for food security
 - 20% calories; 70% ↑ by 2050
- Anticipating future climates
 - Extreme events
- Sustainability
 - 33% NUE
- Health and nutrition
 - Fe and Zn (40 & 30% deficient); fibre
- Resilience
 - rusts, *Zymoseptoria*, *Fusarium*, take-all, aphids (10-25% yield gap)





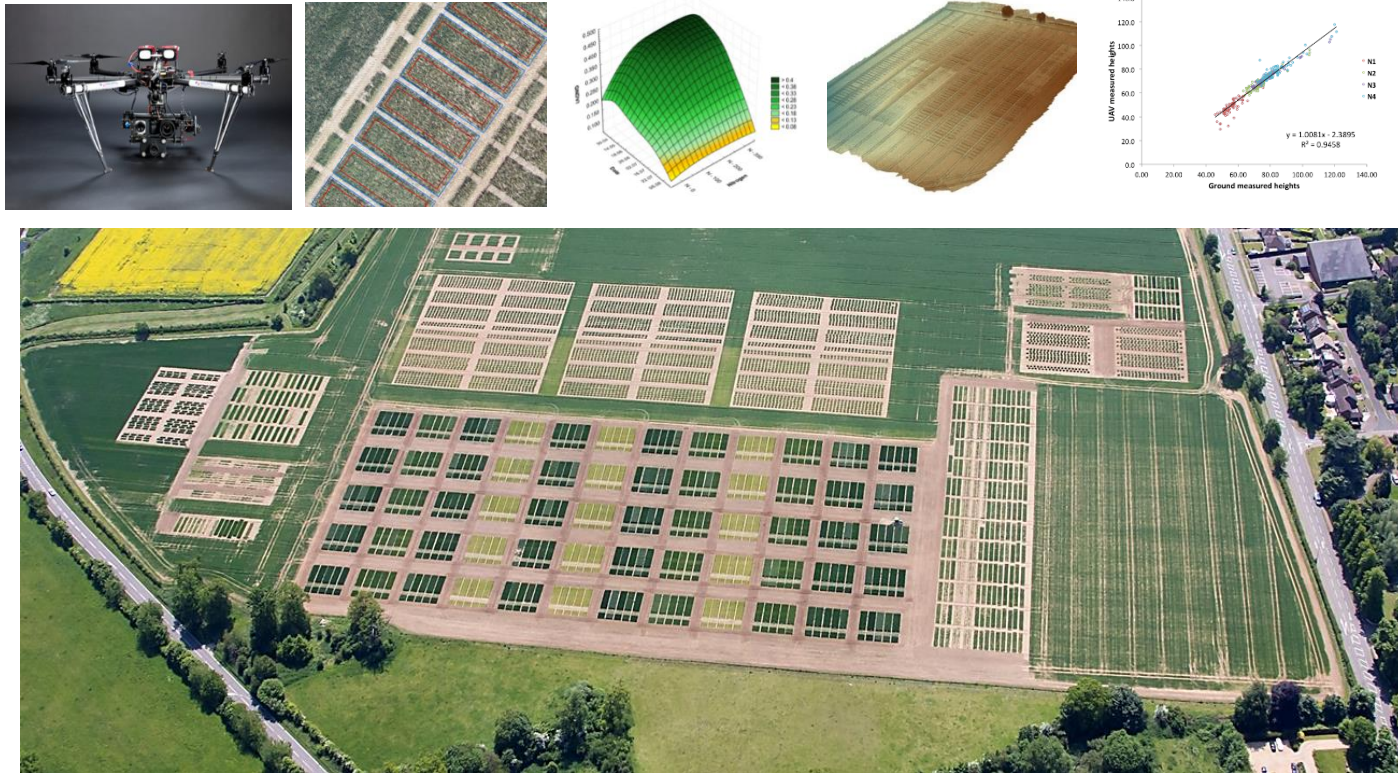
DFW key approaches

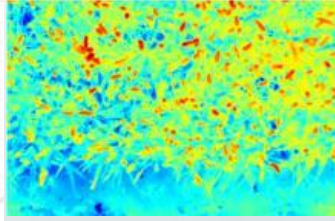
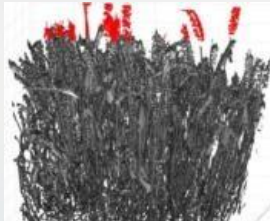
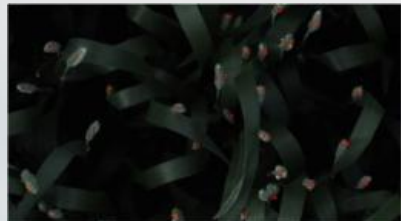
- Exploiting germplasm and genomics
- Dissecting key traits
- Utilizing new technologies in phenotyping
- New gene discovery
- Determining underpinning mechanisms
- Delivery of breeder toolkits
- Integration and analysis of data sets





HTP phenotyping/germplasm (variety) screening





Nabim 2016



DFW pathways to impact

- Showcase toolkit of 96 premium pre-breeding lines (and associated information) concept, refreshed each year, similar to the national list.
- Prebreeding germplasm will be freely available free of IP restriction.
- This further refines the successful toolkit concept developed in the BBSRC WISP programme, which was also free of IP restrictions.
- Ongoing Funded link projects include Defra WGIN (JIC/RRes), Syngenta (RRes).
- Wide reaching programme of training will be offered:
 - Over 70 post graduate students associated with the programme
 - Annual courses open to the wider community (for example wheat genetics).
 - Undergraduate summer students
 - School activities



Thank you

"In the next 50 years, we will need to harvest as much wheat as has been produced since the beginning of agriculture, some 10,000 years ago."

The [BBSRC](#) wheat breeding programme is divided into 4 pillars (Landraces, Synthetics, Alien Introgression, Elite Wheats) and 2 themes (Phenotyping and Genotyping). These are represented by the 6 circles below; each is clickable and takes you to the website of the respective area).

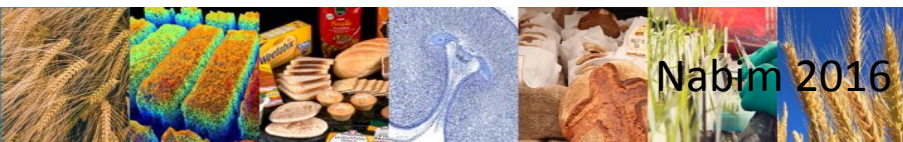




Background to Designing Future Wheat

Further 2013 BBSRC wheat review statements:

- BBSRC investment in wheat was uncoordinated, across a number of sites, despite a critical mass of wheat researchers.
- Wheat researchers in BBSRC funded institutes (RRes, JIC, EI) were part of 7 institute (ISPG) programmes, and one cross-institutional (WISP).
- In contrast some countries have individual centres with a similar level of total wheat funding; others have coordinated programmes.
- In 2011, the G20 Wheat Initiative was established by ministers to coordinate research.
- The age demographic of the wheat research community was an issue.



1050 AE Watkins landrace cultivars



1272- QTL identified

11- The Breeders Landrace Toolkit

Modern

36-current US winter wheat recommended list

Populations from 52 Watkins landrace cultivars trialled

