Overview of the WGIN4 Core Project
March 2018 – March 2023

Wheat
Genetic
Improvement
Network

Department
for Environment
Food & Rural Affairs

Kim Hammond-Kosack

Rothamsted Research

14th November 2019, 17th Stakeholder meeting, RRes, Herts

WGIN provides a research platform for the delivery of

- **tools**
- **resources**
- **bioinformatics (large scale DNA analyses)**

- **expertise for the identification of naturally occurring (useful) genetic variation in new traits**
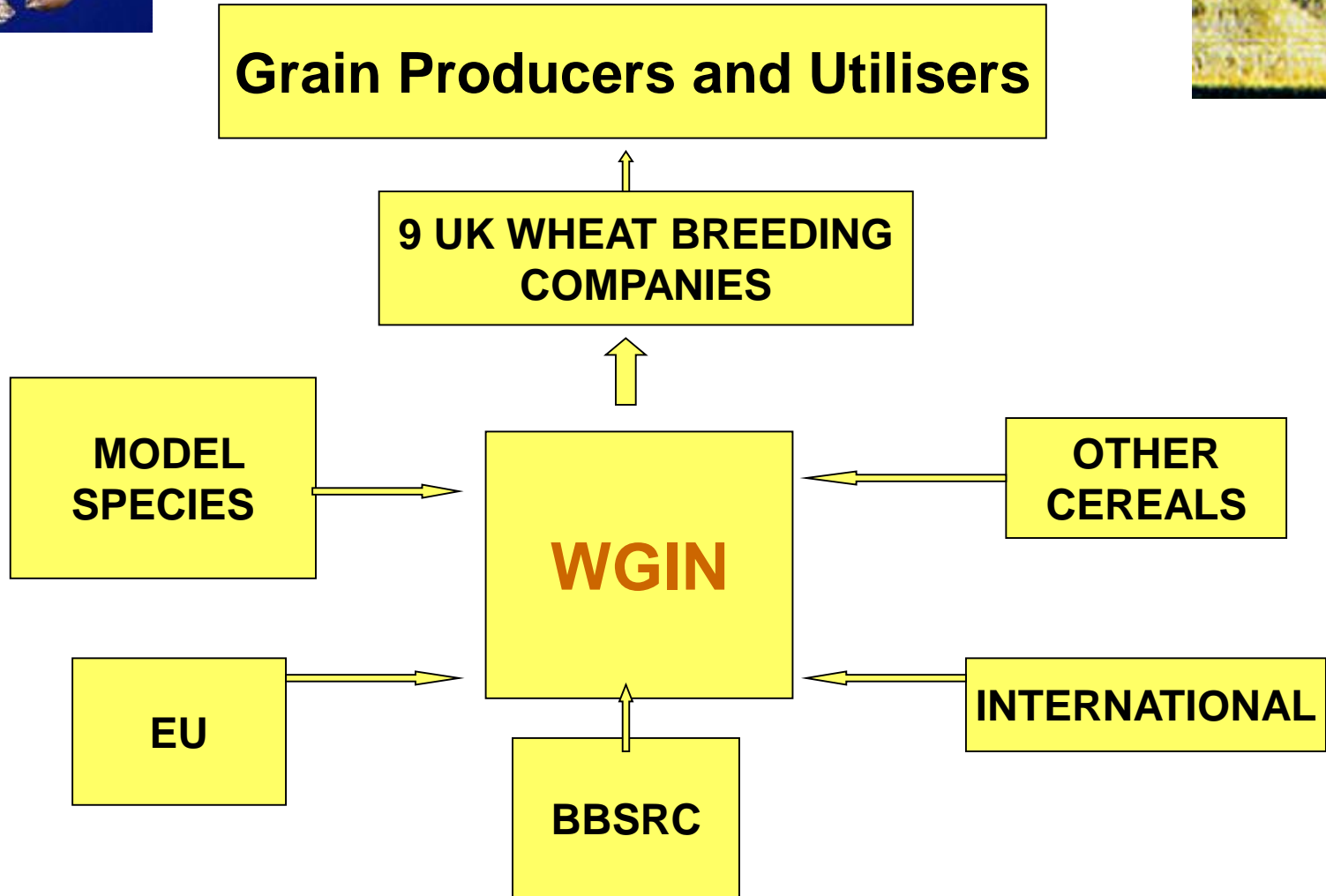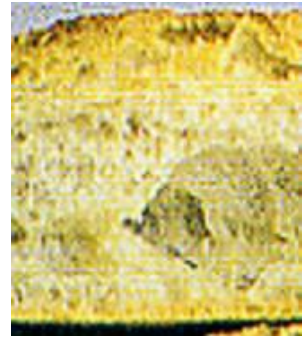
Yield and quality per se are excluded

The Defra WGIN
started in 2003

Grain Producers and Utilisers

9 UK WHEAT BREEDING COMPANIES

MODEL SPECIES

OTHER CEREALS

WGIN

EU

INTERNATIONAL

BBSRC

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

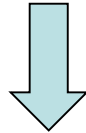## Mission statement - WGIN 2015 to 2023

Improving the resilience of the wheat crop through genetics and targeted traits analysis

Mission statement - WGIN 2003 to 2014

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

WGIN4 Core Research Project split

70 % **trait analyses**

30% **development of new genetic and genomic resources**

Four overarching challenges:

20% Enhanced Resource Efficiency **Nitrogen (NUE)**

25% Sustainability - Yield Stability **Spring drought, lodging* and stem anchorage***

30% Resilience **Resistance to slugs*, BYDV* vectored by aphids, Septoria, Yellow rust and the take-all root pathogen**

25% Quality **Yield, grain protein, grain specific weight*, NUE and nutrient partitioning as affected by N-input and disease***

* New for WGIN4

WGIN Diversity Trial
Resource Use Efficiency + Quality linked to NUE + Yield Stability + Resilience

16th Consecutive Diversity Trial 2018-2019

- **20 varieties, 3 levels of N (100, 200, 350 kg/ha)**

- **Two fungicide regimes – standard practice and reduced - some disease build up / earlier canopy senescence**

- **No insecticide regime**

- **2019 soil N samples collected, grain and straw samples taken at harvest for multiple analyses**

- **Weekly UAV flights (RGB + NIR) and ground based hyperspectral measurements**

Septoria leaf blotch

Yellow rust

Bird-cherry oat aphid (*Rhopalosiphum padi*)

English grain aphid (*Sitobion avenae*)

Aphids and BYDV assessments in Diversity trial 2019

Talk home message so far :
more N ⟹ more yellow rust ⟹ less aphids & beneficials

- **No BYDV field symptoms**

- **Aphid numbers differed between varieties**

- **Difference between N levels (contrary to literature)**

- Beneficials counted but no difference between N level or variety
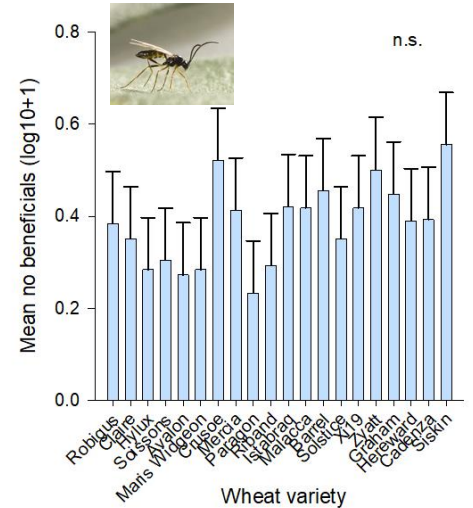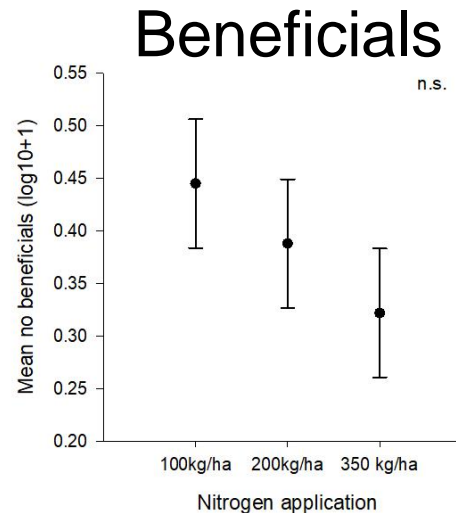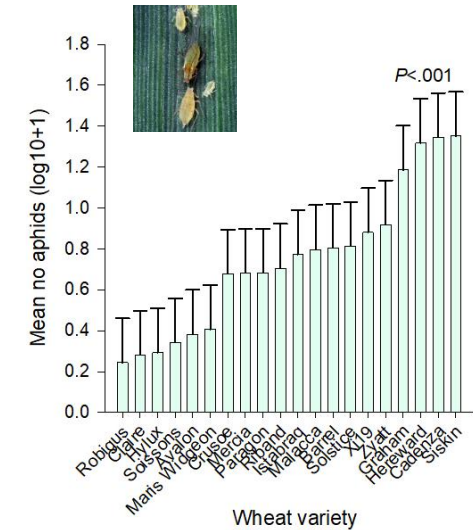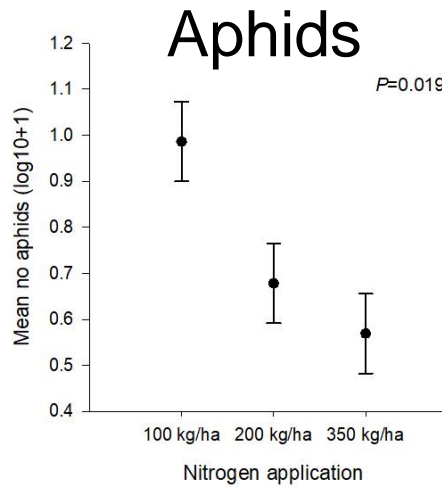
Aphids

Beneficials

2. Reducing pest and disease pressure

Aphids

***Septoria* leaf blotch**

Yellow rust
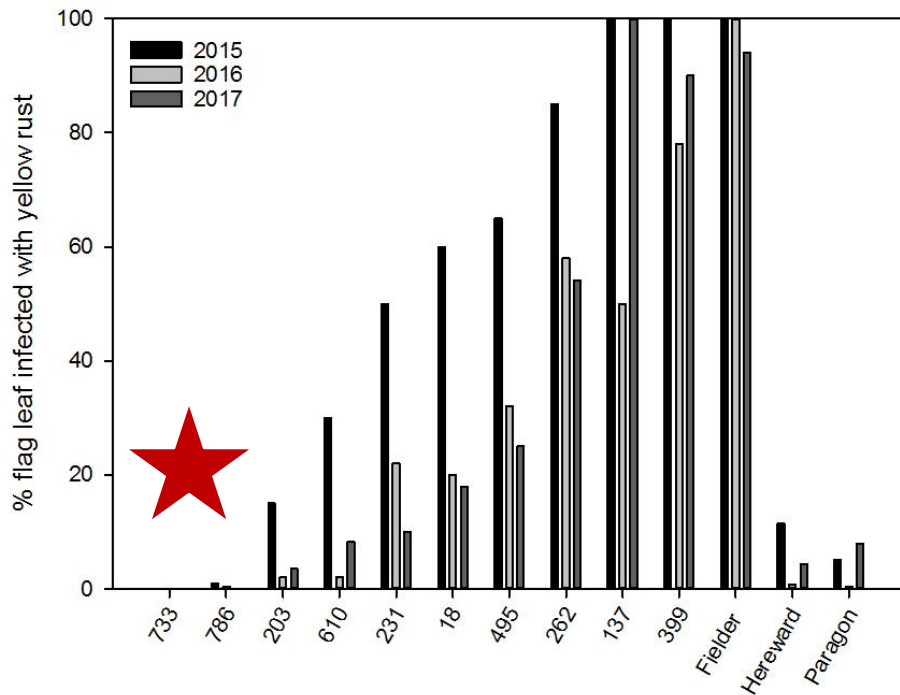
annually all crops at high risk

The restored AE Watkins wheat collection

~1200 lines from 31 countries collected in the 1930s
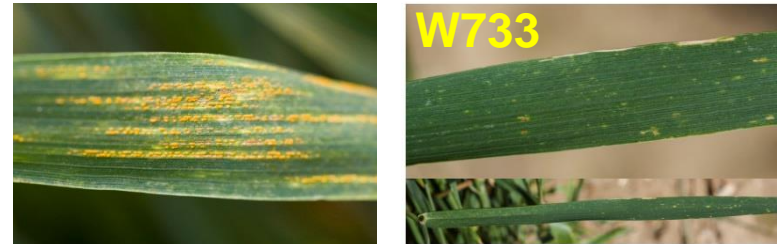## never previously used in modern breeding

Screened for multiple traits over multiple seasons

Yellow rust resistance – Watkins lines W733, W786

Adult plant *Yr* resistance in field trials since 2007

W733

Both lines are also fully resistant to Septoria

F$_1$ W733 x Fielder = **Fully resistant (Dominant trait)**
2019 F$_2$ field data - controlled by 1 or 2 genetic loci

F$_1$ W786 x Fielder = **Fully susceptible (Recessive trait)**
2019 F$_2$ field data - controlled by 1 genetic locus

Cereal aphid resistance in wheat

Growth room tests

T. monococcum

1 week

Number of nymphs produced

20 week

Number of nymphs produced

Bird cherry-oat aphid
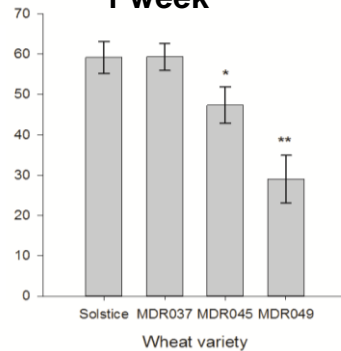
English grain aphid
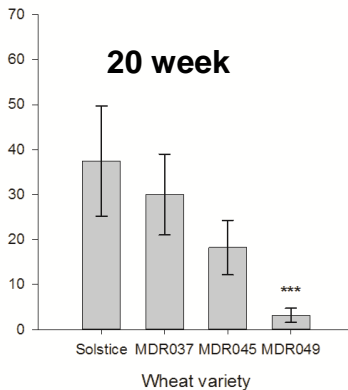
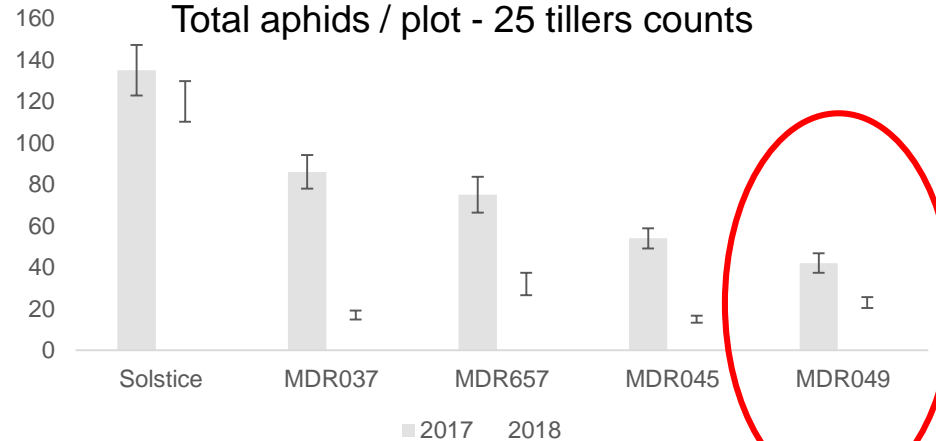## Field trials

T. monococcum (diploid wheat)

Field trials Rothamsted Research 2017 & 2018

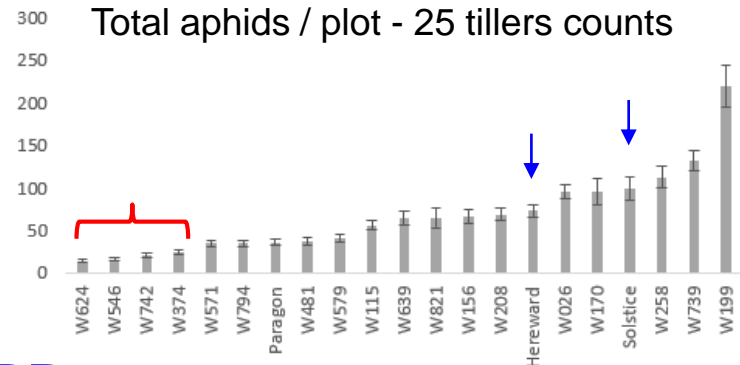Total aphids / plot - 25 tillers counts

■ 2017   2018

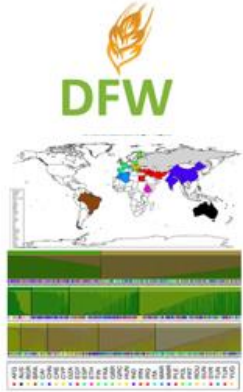### Watkins Landraces

Field trial Rothamsted 2018

Total aphids / plot - 25 tillers counts

Gia Aradottir, RRes

Development of new genetic and genomic resources

7 main activities

Paragon – a benchmark for genomics led wheat breeding in the UK

DFW

BBSRC wheat programme followed WGIN using Paragon as 'standard' genetic background
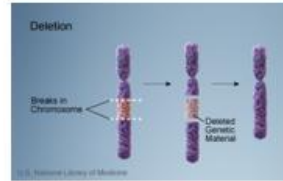
WGIN 5000 gamma induced deletions, now skim sequenced.

WGIN Paragon library- major genes and QTL from LINK projects can be directly compared (+/- QTL NILs).

10+ GENOME PROJECT

Paragon genome sequenced

7000 fixed (M7) Paragon EMS (chemical) mutants
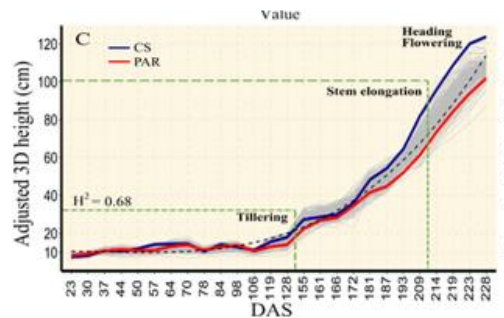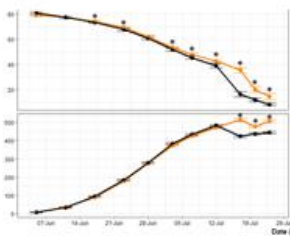
Paragon (UK reference) x Chinese Spring (world reference). A WGIN RIL population (n=384)

Simon Griffiths + GRU, JIC

WGIN1 Avalon x Cadenza Double Haploid mapping population (n = 202)

The world's most phenotyped mapping population

Avalon
- winter type
- high bread making quality
- lax habit
- large leaves
- good for weed suppression
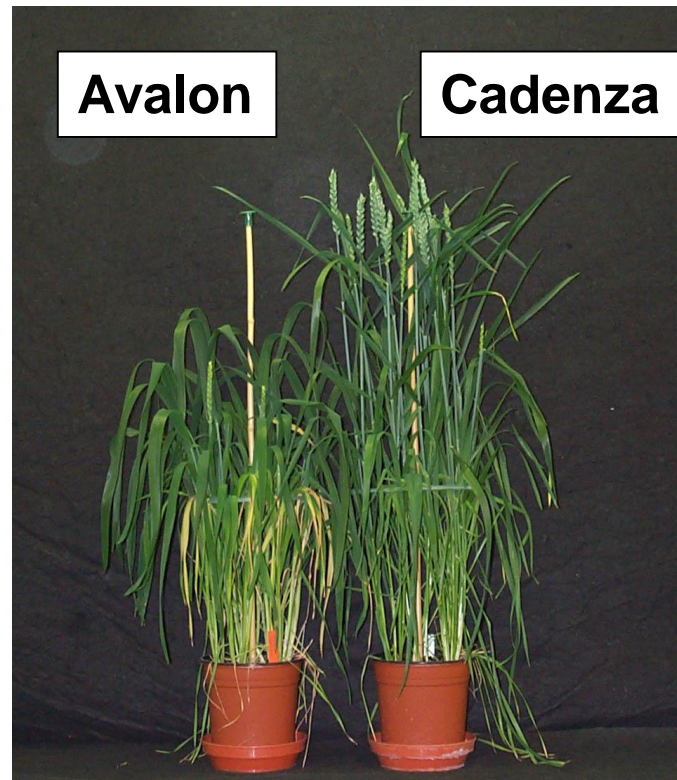
Avalon   Cadenza

Cadenza
- facultative spring type
- no bread making quality
- erect habit
- smaller leaves
- good resistance to Septoria disease

A chromosome segment substitution library (CSSL) for Avalon x Cadenza

WGIN3 & WGIN4

Undertaking **TILING the whole genome with chromosome segments** to make recombinant substitution lines.

TILING PATH

Individual 1 + Individual 2 + Individual 3 + Individual 4   Etc

Desired coverage for each of the 21 chromosomes

Individual A + Individual B + Individual C + Individual D   Etc

Avalon
Cadenza

~ 1200 lines characterised with markers
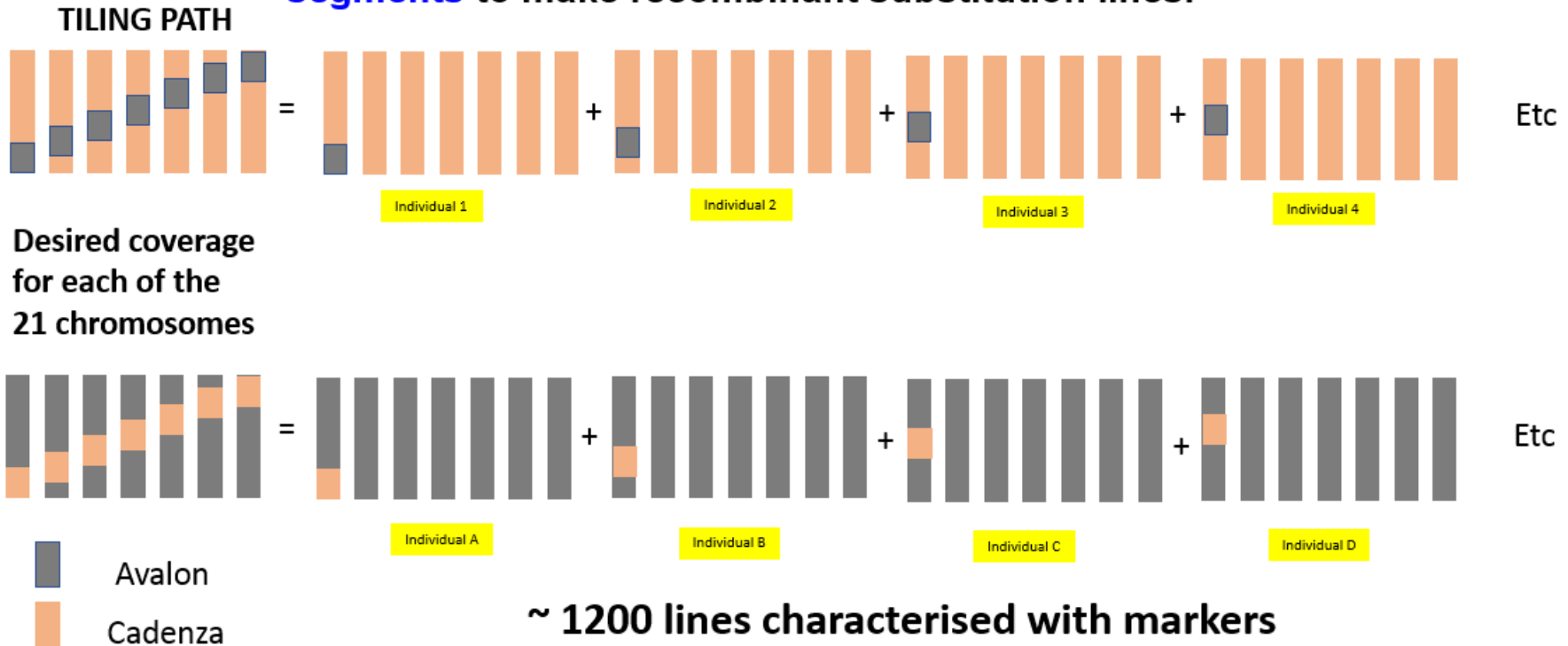
Help researchers to pinpoint the chromosome regions controlling each trait of interest

The Networking objectives

Maintaining and enhancing the public – private network

9 activities

The Defra WGIN: Dissemination, Liaison and Communication

Annual "Stakeholders' Forum" (Nov) 70-100 attendees

Focussed Workshop – 2009, 2013 'A x C mapping pop^{n}'

2010 – DArT marker analysis

Workshops with overseas partner organisations:

Seven funded by BBSRC (2018 – Kazakhstan, 2020 - Baltic)

Web Site (www.WGIN.org.UK), Electronic Newsletters
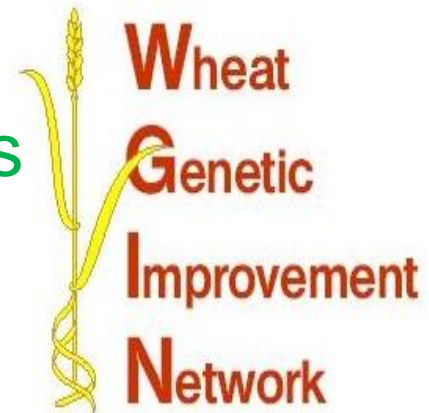
Scientific publications ~ 82 articles

Annual displays at 'Cereals'

*Talks at AHDB strategic and monitor farms

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

Twitter Handle - **@WheatGIN**

Wheat **G**enetic **I**mprovement **N**etwork

Read more about WGIN4 go to the April 2019 Newsletter

Wheat Genetic Improvement Network (WGIN4) 2018-2023

Department for Environment Food & Rural Affairs

Wheat Genetic Improvement Network

WP1 Management Meetings – The Network

Red text - new to WGIN 4

WP1 Enhancing the Network and Communication of Results

- AHDB strategic and monitor farms
- Website
- Annual Stakeholders forum
- International collaborations

- Electronic Newsletter
- Focussed UK/intl. workshops
- Public outreach
- Publications + data deposits

WP2 Tools and Resources

- Maintain and further develop, mapping pop^n, Paragon lib, Watkins/Gediflux, *T. monococcum* collections
- Observation plots on candidate cultivars
- Complete the A x C NIL TILING pop^n / CSSL
- Complete the *T. monococcum* introgression
- Sequence and assemble *T. monococcum* Chr 7A
- Trait related gene-specific marker development (KASP) from the *PROMOTOME* capture and *WAK* capture exps

WP3 Targeted Traits

Improving Crop Resilience (30%)
- BYDV resistance, slug resistance
- Take-all resistance and 3N re-rooting
- Septoria and yellow rust resistance

Yield Stability / Sustainability (25%)
- Spring drought tolerance
- Lodging resistance, stem anchorage

Enhanced Resource Use Efficiency (20%)
- Nitrogen use efficiency (NUE)

Quality Resilience (25%)
- Yield-to-grain protein, NUE
- Nutrient partitioning vis N-input and disease

Fine Phenotyping at Multiple Scales

WP4 Genetic and QTL Analyses
for each of the targeted traits (WP3)

Sub-Contractors – NGS Genome / Exome Analyses / Yellow Rust Races

[red text - new to WGIN4]   [black text - continuing from WGIN3]

Helen Riordan, Andy Cuthbertson, *Martin Cannell,
Giulia Cuccato and David Cooper (RAG)

WGIN3 / WGIN4

RRes - **Kim Hammond-Kosack**
Peter Shewry
Malcolm Hawkesford
Andrew Riche
***Vanessa McMillan**
Gail Canning
Kostya Kanyuka
***Gia Aradottir**
Michael Hammond-Kosack

JIC – **Simon Griffiths**
Clare Lister
GRU – WGIN seed stocks

Sub-contractors

Bristol Genomics – Jane Coghill's team **Affymetrix (35K wheat breeders array)**
Arbor BioSciences, Michigan, USA
Dovetail Genomics, San Diego, USA* **NIAB, Cambridge*** ***new WGIN 4**

The Management team

The Plant Breeders (9)
ADAS
AHDB
NIAB
Univ Bristol
Defra

***Recent leaves**

The farm / trials staff at all the sites used
Numerous summer students

Department
for Environment
Food & Rural Affairs