

Genetic tools for better crop varieties are becoming available thanks to a collaboration between plant scientists and commercial breeders brought together in the Wheat Genetic Improvement Network (WGIN). Heather Briggs reports.

Designing future wheat – is it all in the genes?

Long-term research is teasing out which genes are responsible for traits such as yield consistency, crop resilience, enhanced resource efficiency and quality in wheat, to offer growers of the future access to elite varieties.

To do this wheat researchers have developed new genetic resources and new techniques to identify diversity in desirable traits by fine scale phenotyping and genetic dissection.

The aim is to provide wheat breeders with free access to databases of results so they can look up genes governing a particular trait and transfer the genes/alleles of interest to new UK varieties.

However, this is a long-term investment and breeders will need to take time in their own pre-breeding programmes to assess the value of new alleles, so the first of these varieties may take about 15 years before they are available.

Funded by Defra, WGIN has so far completed three phases. Initial studies investigated yield, quality and nitrogen use

Key traits selected for further exploration in WGIN-4

Resource use efficiency traits	Nitrogen use efficiency (NUE)
Yield stability traits:	Spring drought at GS31 Lodging
Resilience traits:	Stem anchorage Slug resistance Aphid resistance Barley yellow dwarf virus resistance Septoria resistance Yellow rust resistance Re-rooting following infection by the take-all fungus
Quality traits:	Grain protein Nitrogen use efficiency Nutrient partitioning as affected by N-input and disease

Source: WGIN

efficiency, together with year-to-year stability.

Efficiency

The WGIN researchers found UK wheat varieties selected solely under high fertiliser inputs differed greatly in the sub-traits controlling resource use efficiency, for example, uptake or utilisation, but none had the optimum sub-trait combination to make full use of the high fertiliser regime applied.

Following a survey of British wheat breeders in 2017, the fourth phase of WGIN has now begun.

Project coordinator Prof Kim Hammond-Kosack, of Rotham-



Part of WGIN's remit is to generate new wheat populations.

sted Research, says: "Newer research is tackling traits breeders have struggled to make progress with, such as lodging, slug resistance, take-all root disease, aphids, barley yellow dwarf virus [BYDV] and yield stability."

The impact, in terms of yield, grain quality and resource use efficiency, of yellow rust, septoria and powdery mildew will be evaluated. Brown rust and fusarium will be included if pressure is high.

As part of WGIN's remit is to generate new wheat populations, researchers will be making crosses between Recommended List (RL) varieties.

These seeds will be available

on request from the Genetic Resources Unit, says Dr Simon Griffiths, project leader in crop genetics at the John Innes Centre and a member of the WGIN team.

Dr Griffiths says: "The idea is to highlight genetic variation between RL groups and breeding programmes which have been used in recent years to produce the best UK varieties, rather than developing new ones."

Increasing climatic volatility has had an impact on wheat yields, particularly when drought conditions occur at the start of stem extension (GS31) when grain number is being determined, he says. ▶



WGIN has so far completed three phases which have investigated yield, quality and nitrogen use efficiency.

In the last seven years, drought in East Anglia has occurred five times during April, coinciding with this vulnerable period. As a result, the team has been looking for drought-tolerant characteristics and generated a new population from a cross between UK spring wheat Paragon and Garcia, bred for drought conditions in southern Europe.

Potential

Garcia had already been identified in previous WGIN projects as a variety with potential to be a donor of drought tolerance traits relevant to UK wheat.

"While we found many quantitative trait loci [QTLs] were shared by both varieties, such as those known to control flowering and height, there are at least two QTLs from Garcia

which increase yield," says Dr Griffiths.

Analysis of yield data showed lines carrying these loci performed better than Garcia under drought conditions in 2017 and, as a result, Garcia was nominated for inclusion in the BBSRC Breeders' Toolkit in February 2018.

Inclusion depends in part on results from a further three-year drought trial using this population alongside others identified for drought tolerance.

WGIN-4 research will also investigate new genetic resources which potentially harbour lodging-resistant lines. Analysis will look at above ground and root anchorage traits which could be selected in breeding programmes.

Dr Griffiths says: "There are

What is WGIN?

»WGIN is a research platform for the delivery of tools, resources, bioinformatic information, and expertise for the identification of useful, naturally-occurring genetic variation in new traits.

The WGIN-4 research work plan is a collaboration between scientists at

the John Innes Centre, Rothamsted Research, the National Institute of Agricultural Botany, and sub-contractor companies Affymetrix, Arbor Biosciences and Dovetail Genomics, plus the University of Bristol genomics facility and an overseas academic.

some tall UK varieties, such as Solstice and Panorama, which exhibit unexpectedly good standing power considering their height.

Traits

"This may be a result of anchorage traits so we will screen directly for this trait and

map new genes and alleles controlling plant anchorage to the soil."

Further strides are also expected to be taken to improve resistance to take-all root disease in wheat.

In WGIN-4, scientists will explore whether introgression confers re-rooting following take-all infection. In previous WGIN projects, moderate to strong resistance to take-all disease was identified within the diploid einkorn wheat *Triticum monococcum* (AmAm) and mapping populations were then taken forward to the F6 generation. These will now be fine phenotyped in-field.

"No wheat variety is perfect, but work pulling together different traits is helping move towards better varieties, so growers can obtain good yields in difficult seasons as well as when conditions are favourable," says Prof Hammond-Kosack.

WGIN's achievements to date

Germplasm development

- »UK reference resources to accelerate plant breeding
- »Taking ancient wheat landraces out of storage so their genes are now deployed in the BBSRC Breeders' Toolkit

Trait specifics

- »Long-term evaluation of commercial wheats for yield stability and responses to nitrogen fertiliser

- »Examination of trade-off between yield and quality

Resilience to aphids and BYDV

- »Identified ancestral wheat lines with resilience against aphids which are being introgressed into more modern wheat

Resilience to take-all and foliar disease

- »Identified genetic trait in

semi-modern wheat cultivars which minimises take-all inoculum build-up in the soil and improves resilience of second wheat crops

- »Identified root resistance to take-all disease in wheat landraces and ancestral wheat relatives (monococcum)
- »Focus on resistance to septoria leaf blotch disease and novel rooting trait from ancestral wheat relative