DESIGNING FUTURE WHEAT

DFW

Wheat is a vital commercial crop and essential calorie source in the UK and globally. As the global population increases towards 10 billion people, with most increased consumption expected to occur in developing countries, the world will need to produce 60% more wheat by 2050 to meet global demand.

The BBSRC-funded Designing Future Wheat (DFW) programme is supporting eight UK research institutes and universities, including NIAB, to develop the germplasm and techniques required by plant breeders to sustainably face these future production challenges. DFW continues the work started under the BBSRC-funded Wheat Improvement Strategic Programme (WISP) (www.wheatisp.org).

focus on NIAB research

Increasing efficiency and sustainability

The DFW programme will develop improved germplasm for better yield, resistance to disease and a changing climate using high-throughput field technology and the genetic dissection of key traits. As part of this programme NIAB will be applying its extensive phenotyping expertise to maximise output from germplasm used within DFW, whether it be for drought tolerance or within hybrid wheat breeding programmes.

Adding value and resilience

DFW aims to enhance grain quality for human health, combat diet-related diseases and improve the resilience of wheat to biotic stresses. As part of this programme NIAB is developing germplasm with starch characteristics that improve the processing ability and digestibility of wheat.

Germplasm development for trait dissection

NIAB is characterising the novel genetic diversity captured from resynthesised wheat (SHW) and tetraploid wheats. This diversity is now in an elite wheat background and is available for exploration by the wheat research and breeding community. This is part of DFW's target to accelerate the discovery and deployment of genes and alleles of high value for breeding, particularly from other parts of the DFW programme and previous BBSRC-funded research.

IMPROVING NITROGEN USE EFFICIENCY

Using crop transformation science

There are increasing environmental and financial pressures on nitrogen use in agriculture in the UK and across the world, leading to possible restrictions in nitrogen use in the field. Research may allow farmers to reduce nitrogen use while maintaining or increasing yield.

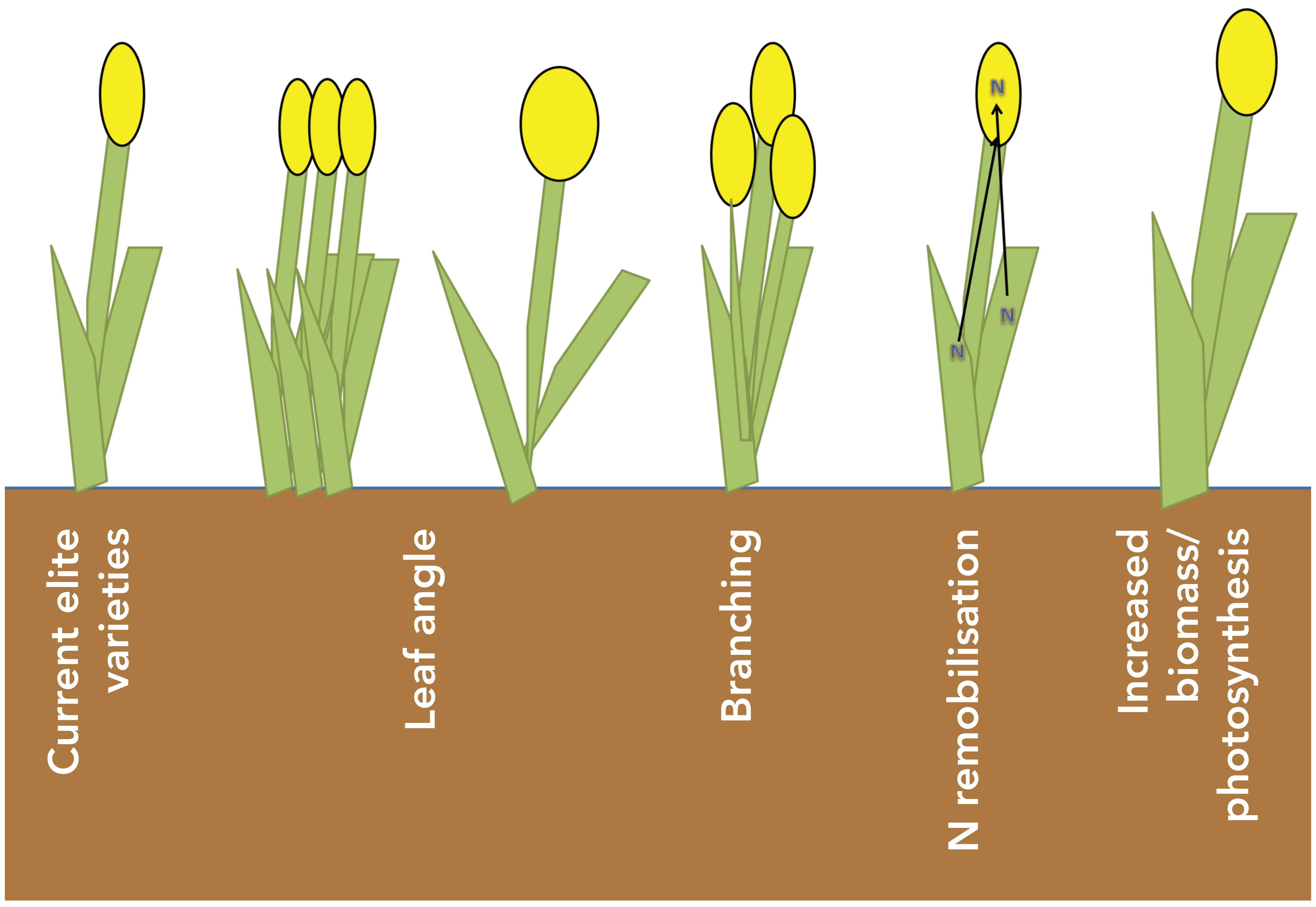
focus on NIAB research

As part of the CINTRIN project, NIAB and its partners are identifying key genes that determine how plants use nitrogen as part of their developmental processes. The research generates new knowledge and advice that can be used on farms in the UK and India.

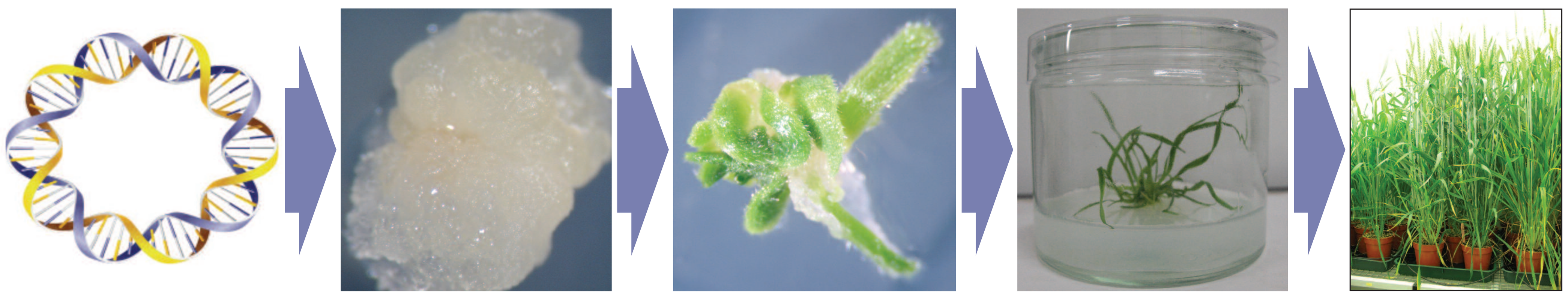
NIAB is looking at genes that control traits in wheat, such as leaf angle, branching, N-remobilisation, increased biomass and increasing the rate of photosynthesis, to improve nitrogen-use efficiency in the crop.

Working with the University of Cambridge and the Sainsbury Laboratory, NIAB has identified six key genes, from other cereals (rice, brachypodium and maize), to target these traits that could play a role in nitrogen-use efficiency. Using crop transformation techniques NIAB can produce wheat plants with these genes for evaluation within seven months. This research can then help breeders in the UK and India to produce better varieties with higher nitrogen-use efficiency.

New traits that could improve nitrogen use efficiency



The crop transformation process, from DNA to plant within seven months



CINTRIN
a truly translational centre

The Cambridge India Network for Translational Research in Nitrogen, otherwise known as CINTRIN, is one of four UK-India Virtual Joint Centres in Agricultural Nitrogen funded by the Newton Fund in 2016. It brings together partners from the UK and India with a focus on production of the important cereals – wheat, sorghum and pearl millet – which are central to food security in India but where current yields are supported by fertiliser inputs (particularly nitrogen, as well as phosphate and potash).

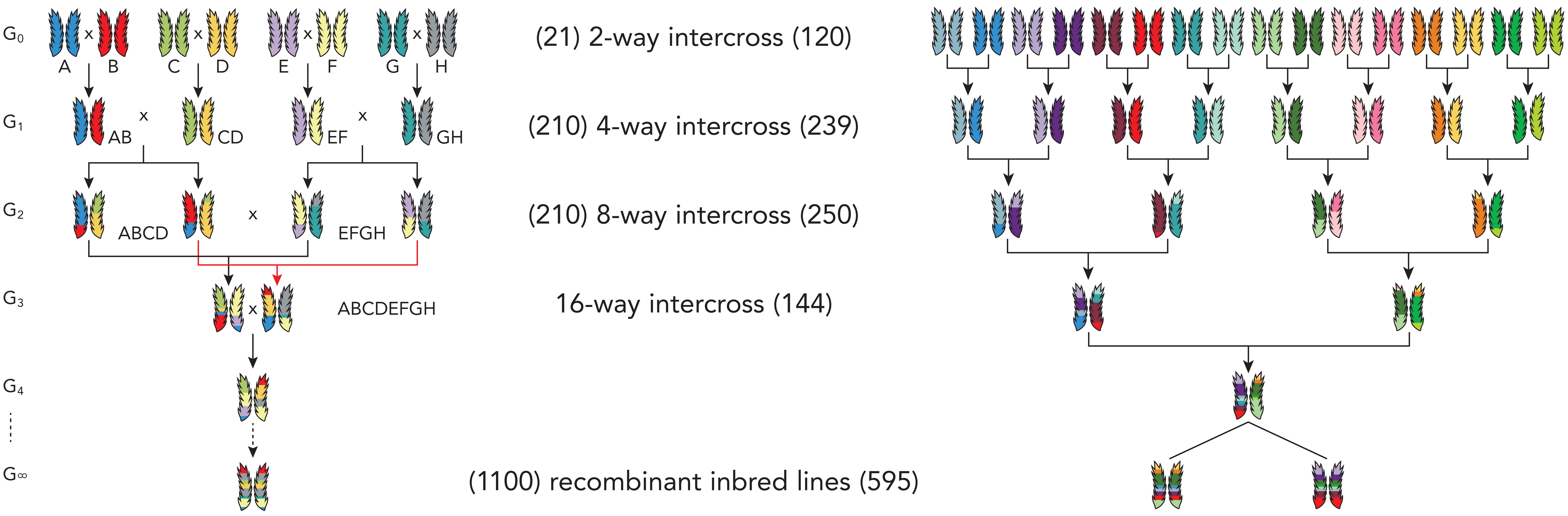
NIAB

Plant Science into Practice

100 YEARS OF PLANT SCIENCE 1919-2019

USING MAGIC TO IMPROVE WHEAT GRAIN YIELD

NIAB has created two Multi-founder Advanced Generation InterCross (MAGIC) wheat populations from 8 and 16 founder varieties, respectively. These populations capture and mix together a large proportion (80-90%) of the genetic and phenotypic diversity of UK wheat germplasm in a single cross.

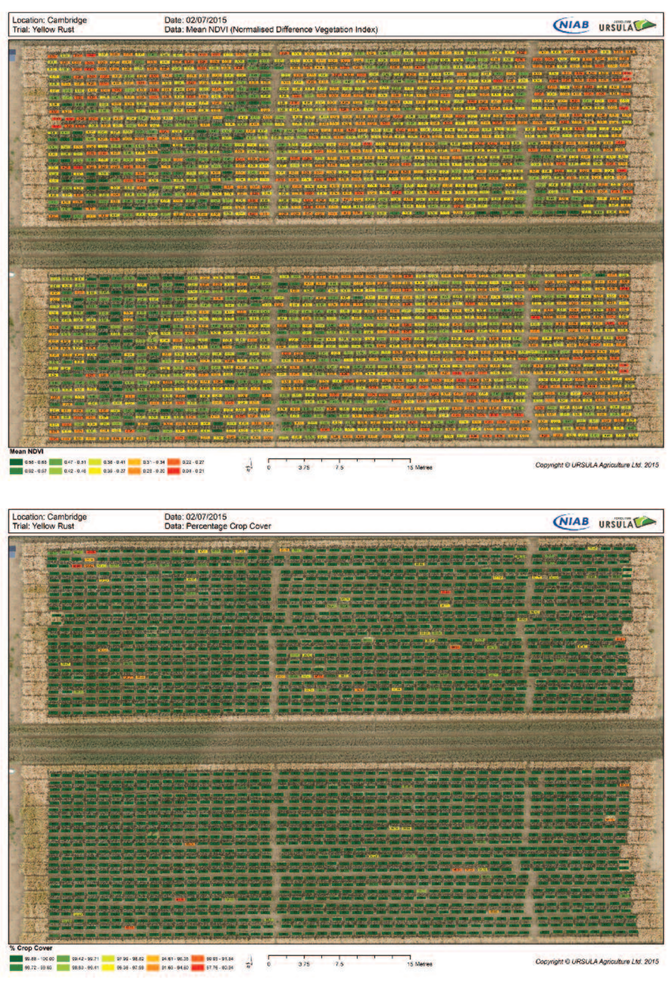


By mixing together all this genetic diversity over several generations, NIAB research shows:

- a high proportion (on average 33%) of trait extremes are found outside the range of all 8 founders, leading to novel genetic combinations for potential breeding use;
- different combinations of yield component traits contributing to high yield, e.g. high/low tiller number, small/large ears, low/high TGW. The next step is to investigate trade-offs and optimise components to maximise yield;
- rapid and precise detection of genetic regions underlying yield and yield component trait variation. This includes novel and accurate genetic markers for marker-assisted selection and an understanding of how genes interact to produce high yield, how these interactions underlie trade-offs, and how they may be manipulated to increase yield.

NIAB MAGIC projects include research on:

Disease resistance



Plant root structure

Photosynthesis

Yield components

Innovation in PLANT BREEDING

IMPROVING FABA (FIELD) BEANS THROUGH GENETICS AND BREEDING

The Pulse Crop Genetic Improvement Network (PCGIN) supports the development of pea and bean crops for UK agriculture and increases the potential for home-produced plant protein. New funding from Defra (2018-2023) continues to support this important research platform, providing a link between growers, industry and the research base to achieve added value for pulse crops.

PCGIN

www.pcgin.org

focus on NIAB research

NIAB's work within the PCGIN platform is on faba bean, improving crop reliability and productivity and supporting plant breeders and research. Research includes:

Traits for on-farm resilience:

- Downy mildew resistance – genetic mapping of resistance to *Peronospora viciae* f. sp *fabae* from landraces.
- Water stress tolerance – transcriptomics studies investigating differences in gene expression under water stress.
- Chocolate spot resistance – genetic mapping of partial resistance to *Botrytis fabae* from older varieties.
- Foot rot resistance – screening diversity collections to identify new potential sources of resistance against *Fusarium solani*, and other *Fusarium* spp.

Downy mildew

Water stress trial

Chocolate spot

Foot rot

Tools for plant breeders:

- Characterised material – inbred, genotyped lines for breeding.
- Molecular markers (KASP markers), screening genetic diversity, genetic maps, identifying robust markers linked to important traits (www.viciatoolbox.org).

Supporting research:

- Genetic studies using inbred lines.
- Material for PhD projects – development of mapping populations.
- Pathogen diversity assessments – screening of UK faba bean pathogen populations to investigate race structure and implications on managing disease.

Variety material of faba bean is closely related, confirming the need to introduce more diversity into the crop

Boxer	*Fuego*	*Fury*	*Lynx*	*Pyramid*	*Vertigo*	
1.00						Boxer
0.97	1.00					Fuego
0.85	0.85	1.00				Fury
0.84	0.80	0.72	1.00			Lynx
0.60	0.63	0.56	0.50	1.00		Pyramid
0.89	0.86	0.75	0.85	0.52	1.00	Vertigo

Genetic map