



# CIRC • CROP IMPROVEMENT RESEARCH CLUB

## SUMMER 2016 - IMPACT SUMMARY

*A £7M joint investment by public research funders  
and industry to improve productivity and quality in  
wheat, barley and oilseed rape*

[www.bbsrc.ac.uk/circ](http://www.bbsrc.ac.uk/circ)

# Crop Improvement Research Club (CIRC)

## Working together to deliver better crops for the UK

Food security is an increasingly important global issue. A growing world population, combined with climate change and the spread of crop pests, diseases and weeds threatens agricultural production and an urgent response is required.

CIRC supports excellent quality research focused on improving barley, oilseed rape and wheat for food uses.

Fourteen companies are members of CIRC and are representative of the breadth of innovation in the crop production and processing industry in the UK.

In return for a financial contribution to CIRC, the member companies gain early access to an exciting research portfolio of fifteen projects. The projects bring together a community of 60 investigators to form multidisciplinary teams focused on challenges identified by industry.

## Delivering Industrial Impact

CIRC has established a new capability for the sector to address significant research challenges associated with food security. The projects have

already generated useful outputs which are being used in industry:

- 380,000 DNA markers and a 'breeders chip' for better wheat from elite varieties, landraces and wild relatives
- Standardised lab test for grain skinning in barley
- High throughput assessment of root growth and architecture for screening new crop varieties
- Novel EMI methods to measure root performance and soil moisture in the field
- New genes and markers to combat Turnip Yellows Virus in oilseed rape
- Improved knowledge of how different crop varieties use photosynthesis
- Insight into new gene combinations to reduce pod-shatter in oilseed rape

***"The club enabled industry and academic partners to tackle collaboratively specific issues affecting crop breeding and processing"***

**Dr Peter Werner, R&D Breeder,  
KWS UK Ltd**

# Research to improve wheat, barley and oilseed rape

CIRC supports 15 research projects with £7M of funding from BBSRC, the Scottish Government and 14 member companies.

## Higher Yields

**Flexible Genotyping platform for wheat** *Bristol University & John Innes Centre*

**Manipulation of photosynthesis to improve yield** *Rothamsted Research & Essex University*

**Changing gene function to control pod shatter in Oilseed rape** *John Innes Centre*

**Exploring genes controlling fertility in wheat and barley** *Nottingham University*

## Better Quality

**Controlling grain skinning in barley** *SRUC & James Hutton Institute*

**Processability of malting barley** *James Hutton Institute*

**Role of lipids in bread dough quality** *Rothamsted Research & IFR*

**Glucosidase inhibitors for malting barley** *John Innes Institute*

**Production of wheat lacking B-type starch granules** *NIAB & John Innes Institute*

## Healthier Crops

**Sources of genetic resistance to Turnip Yellow Virus for oilseed rape** *Warwick University*

**Increasing pest resistance by an enhanced UV-B response** *Glasgow University*

**Fungal effectors as activators of novel resistances in cereals** *James Hutton Institute*

## Improved Roots

**Rhizosphere exudation and oilseed rape yield** *Warwick University*

**Phenotyping root function in wheat** *Rothamsted Research & Lancaster University*

**High throughput root phenotyping screens** *Nottingham University & James Hutton Institute*

# Abundant DNA markers from genome science

Developing new strategies to manipulate yield and resistance by marker-assisted selection (MAS) underpins our strategy to generate improved wheat varieties. This project identified 380,000 wheat DNA markers that allow us to:

- distinguish and dissect closely related elite lines to find new combinations
- follow and transfer small groups of genes from wild species for disease resistance
- backcross important traits such as OBM quickly into new lines
- 7000 markers have been validated and made available online via CerealsDB

DNA chips for rapid low cost analysis enable crop breeders to:

- screen hundreds of important genes in advanced elite crop populations
- screen thousands of genes in exotic germplasm to find new sources of resistance to crop pests and diseases
- screen ten times more genotypes at a tenth of a cost, meaning that farmers can have new varieties more quickly



*DNA chip with markers, image courtesy of Professor Keith Edwards, University of Bristol*

## **CIRC project: “Development and validation of a flexible genotyping platform for wheat”, 2011-2013**

Project team:

- Professor Keith Edwards, University of Bristol
- Dr Simon Griffith and Dr Cristobal Uauy, John Innes Centre
- PhD student Harriet Benbow

***“CIRC helps AHDB to meet its strategic R&D aims, complements its own research programme, and provides leverage for AHDB resources”***

**Dr Dhan Bhandari, Research & KT Manager Food & Feed Quality, AHDB Cereals & Oilseeds**

# Seeing underground for better roots

Improved root systems can contribute towards improved yield and more sustainable agricultural production. This project developed practical, low cost methods to screen plant root systems:

- High throughput screen to image root growth and architecture to select for seedling performance
- Field screening and sampling systems to record roots in action
- Lab screens applicable to oilseed rape, barley and wheat at less than £1 per plant
- Field method to image and count roots at high-resolution (e.g. 5cm) intervals in the soil profile
- Field trials of oilseed rape over three seasons identified correlations of root and seed parameters with crop establishment and yield
- Genetic loci affecting root growth and architecture were identified to accelerate the breeding of new varieties
- Mathematical models will help breeders to identify traits and genotypes are associated with improved root systems



*Dr Eric Ober, NIAB, demonstrating rhizotrons to look at root growth of different crops, image courtesy of Professor Simon Bright, CIRC coordinator*

## **CIRC project: “Delivering low-cost, high-throughput root phenotyping screens for arable crops”, 2012-2015**

Project team:

- Professor Martin Broadley, University of Nottingham
- Professor Philip J. White, James Hutton Institute
- Cathy Thomas, PhD student

## **CIRC project: “Phenotyping root function in wheat”, 2012-2015**

Project team:

- Prof Richard Whalley, Rothamsted Research

# New resistance genes to TuYV in OSR cultivars and wild plant reservoirs of the virus

Turnip yellow virus infects most oilseed rape crops in the UK, reducing the seed yield by up to 30%. Growers have used insecticides in attempts to control the virus however these are not always effective and the use of the most effective has been banned on oilseed rape:

- A new source of resistance to TuYV has been characterised
- Strong resistances from *B. rapa* and a *B. oleracea* wild relative have also been characterised and combined in resynthesized *B. napus*.
- Negotiations with breeders to exploit the resistances are underway
- Weeds such as Shepherds purse, groundsel and chickweed have been shown to be reservoirs for field infection as they are hosts of TuYV capable of infecting oilseed rape
- 179 full TuYV genomes from 6 European countries have been sequenced to enhance our understanding of the genetic diversity of the virus



*Keith Norman, Technical Director of Velcourt, and Dr John Walsh, University of Warwick, looking at new virus resistant oilseed rape lines at Cereals 2015. Image courtesy of Professor Simon Bright, CIRC coordinator*

## **CIRC project: “Exploring sources of resistance to Turnip Yellow Virus for deployment in oilseed rape”, 2012-2016**

Project team:

- Dr John Walsh, University of Warwick
- Max Newbert, PhD student

# Reproducible tests to assess barley grain skinning

The quality of malting barley is important for maintaining food safety, product quality and the competitiveness of the UK cereals industry.

The loss of the outer layer of the barley grain during or post-harvest is called grain skinning, and has negative impacts during malting.

Improving our understanding of how a plant's genetic make-up influences grain skinning will improve our ability to breed new barley varieties without this undesirable condition:

- Screening tests developed to rank existing varieties and to provide early screens for breeders
- 200 commercial lines assessed and low-risk varieties were identified
- Produced a list of environmental and crop handling risk factors for grain skinning
- Identified genetic loci linked to skinning to allow breeders to improve varieties
- Phenotypic data collected during the project will be made publicly available



*A sample of skinned barley, image courtesy of Dr Steve Hoad and Dr Maree Brennan, JHI*

## **CIRC project: “Causes and control of grain skinning in malting barley”, 2012-2016**

Project team:

- Professor Steve Hoad, SRUC
- Maree Brennan, PhD student
- Professor Bill Thomas, James Hutton Institute

***“Through the CIRC, SWRI established wider links with academic groups. Some of the existing links with academic groups were energised through CIRC activities. Subsequently, SWRI is doing more work with several academic partners”***

**Dr James Brosnan, Research Manager, SWRI**



# Controlling pod shatter in oilseed rape

The successful domestication of crops depends upon the plant's ability to hold its seeds until harvest. The problem of controlling seed dispersal was solved thousands of years ago for cereal crops but is still an issue for oilseed rape.

The average annual loss for farmers due to premature fruit opening, known as pod shatter, is more than 10%, and can exceed 70% in poor harvesting conditions.

This project developed genetic approaches to controlling pod shatter:

- New mutations in a key gene for shatter, *IND*, were identified in oilseed rape and combined to give a range of shattering performance
- 2016 trials on-going to assess comparative performance with current varieties
- plant materials available for research testing and the genes come with precise DNA SNP markers to facilitate rapid breeding deployment



*Pod shatter in oilseed rape, image courtesy of Andrew Davis, John Innes Centre*

## **CIRC Project: “Exploring knowledge of gene function to combat pod shatter in oilseed rape”, 2011-2016**

- Professor Lars Østergaard, John Innes Centre

*“Membership of CIRC enabled KWS to influence a portfolio of funded projects, some of which were more risky, however the risk was worth taking. CIRC addressed practical issues important to the R&D strategy of KWS”*

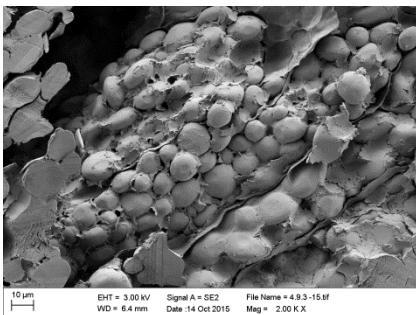
**Dr Peter Werner, R&D Breeder,  
KWS UK Ltd**



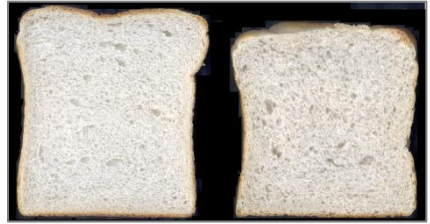
# Breeding wheat and barley for product quality

These projects have improved our understanding of wheat and barley grain quality for dough making and malting:

- A line of wheat lacking B-type granules was selected by stacking deletions of the homologous *Bgc-1* loci (responsible for B-granule content). A-granule content and grain weight are not affected
- Identified lipids associated with the stability of gas bubbles in wheat dough which can be manipulated to improve bread making quality
- New natural products were identified that can inhibit loss of starch and rootlet growth during malting of barley grains



*A scanning electron microscopy image of starch granules of wheat lacking B-type granules, image courtesy of Dr Kay Trafford, NIAB*



*Bread baked with or without emulsifier and hard fat, image courtesy Peter Skeggs, Rothamsted Research*

## **CIRC Project: “Production of wheat lacking B-type starch granules”, 2012-2016**

- Dr Kay Trafford, NIAB

## **CIRC Project: “The role of lipids in determining gas bubble retention in wheat dough”, 2013-2015**

- Professor Peter Shewry, Rothamsted Research

## **CIRC Project: “Glucosidase inhibitors: new approaches to malting efficiency”, 2011-2014**

- Professor Alison Smith, JIC

## Growing new crop research scientists

PhD students were supported by BBSRC through CIRC. The students were trained in leading research labs with regular contact from industry during their studies. Many visited or worked with company members and represent new talent for the sector.

- Harriet Benbow, University of Bristol, wheat genetics
- Cathy Thomas, University of Nottingham, roots and soil interactions in oilseed rape
- Max Newbert, University of Warwick, genetics and phytopathology in oilseed rape
- Byoung Min, Rothamsted Research, wheat grain quality
- Mike Rugen, John Innes Centre, starch degradation and barley grain quality
- Lucie Griffe, James Hutton Institute, functional genomics and phytopathology in barley
- Christopher Hale, University of Warwick, oilseed rape root exudates and their role in yield improvement
- Kathryn Grant, SRUC, varietal differences in grain skinning
- Kirsty McInnes, University of Glasgow



*CIRC PhD student Kirsty McInnes, University of Glasgow, at Cereals 2015, image courtesy of Simon Bright, CIRC coordinator*

***“CIRC is providing a good support network for younger researchers, and compliments AHDB’s internal PhD programme”***

**Dr Dhan Bhandari, Research & KT Manager Food & Feed Quality, AHDB Cereals & Oilseeds**

***“One of the most important impacts of CIRC is the creation of a pool of young scientists working on crops. Succession planning in crop science is of strategic importance to SWRI”***

**Dr James Brosnan, Research Manager, SWRI**

Managed by BBSRC, CIRC is a partnership between the Research Councils, Scottish Government and a consortium of companies with interests in crop production and processing.





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