WGIN Stakeholder's Newsletter

October 2009

Cover Picture: Effect of take-all in field conditions

Next WGIN Stakeholder meeting – 25 November 2009, RRes, Harpenden

Contents:

Defra Wheat Genetic Improvement Network – Improving the environmental footprint of farming through crop genetics and targeted traits analysis

Background

The UK government is committed to more sustainable agriculture but this vision is facing an ever expanding range of environmental, energy and climate change challenges. Wheat is grown on a larger area and is more valuable than any other arable crop in the UK. Established in 2003, the Wheat Genetic Improvement Network (WGIN) arose directly from a realisation in the early 2000s that over the preceding two decades there had been a widening disconnection between commercial plant breeding activities and publicly funded plant and crop research. The overall aim of WGIN is to generate pre-breeding material carrying novel traits for the UK breeding companies and to deliver accessible technologies, thereby ensuring the means are available to produce new, improved varieties. An integrated scientific 'core' which combines underpinning work on molecular markers, genetic and genomic research, together with novel trait identification, are being pursued to achieve this goal. The programme is managed by a team including representatives of the key UK research groups and breeders. They ensure the programme and its outputs are communicated to the wider scientific and end user communities, via a web site, a stakeholder forum, focused meetings and peer reviewed publications. WGIN liaises with equivalent operations overseas to ensure the programme is internationally competitive.

The initial WGIN project ran for five years (2003-2008) and achieved considerable scientific success. In addition, the sustained networking activities and the availability of datasets generated by the project led to the establishment of many new wheat genetic improvement projects, including some funded jointly by the public sector and industry. Those funded by early 2008 were summarised in the May 2008 Stakeholders Newsletter and since then two additional projects have been agreed. There is no doubt that WGIN has a direct and significant impact on re-establishing the relationship between commercial plant breeding activities and public funded plant and crop research. However significant hurdles remain which currently prevent commercial implementation of much new research which should help to reduce the energy requirement and environmental impact of the UK wheat crop.

This project

The new WGIN Core Project started in 2008 to provide genetic and molecular resources for research in other defra projects and for a wide range of wheat research projects in the UK. The resources under development include wheat genetic stocks, mapping populations, molecular markers and marker technologies, trait identification and evaluation, genomics and bioinformatics. The initially funded partners are the John Innes Centre, Rothamsted Research and The University of Nottingham but support has been allocated for sub-contracted projects which will be awarded in open competition during 2009 (see website for details on the project – www.wgin.org.uk).

Objectives 2 - 4 Discovering and understanding the genes for a sustainable future in UK farming

Within the UK wheat breeding programmes there is an increasing use of molecular markers for selection in early generations. At the moment they are mostly used to select for or against relatively simple, major gene, traits segregating in wheat breeding programmes. In the longer term this trend will accelerate the targeted breeding of complex traits and the rate of genetic gain achieved for these traits. Key traits for a sustainable future for UK farming are those for the efficient use of inputs. Important questions are - How much grain yield per unit of nitrogen applied? How well does yield hold up in a dry year? How can pesticide inputs be reduced?

The responsibility for answering these questions relies upon research in publicly funded organisations such as WGIN. To do so, we identify genes of interest by a statistical analysis of large families of wheat derived from bi-parental crosses between known parents. This process is called quantitative trait locus (QTL) analysis. QTL analysis gives us a rough location of a trait locus on a wheat chromosome (Figure 1) - the last line of the 'address' for the genes of interest- Glasgow, London, and Birmingham, but without the 'postcode'! To get the 'post code' and 'house number' each gene has to be isolated from the others so that any effect on the trait of interest can be assigned directly to that specific gene without 'noise' from the others.

WGIN is developing specialised genetic materials for a number of genes identified as QTL within the WGIN programme and other publicly funded projects to identify the full gene 'address'. These stocks will then allow us to define the specific genetic and physiological basis of varietal improvement and so deliver better wheat varieties to UK farmers.

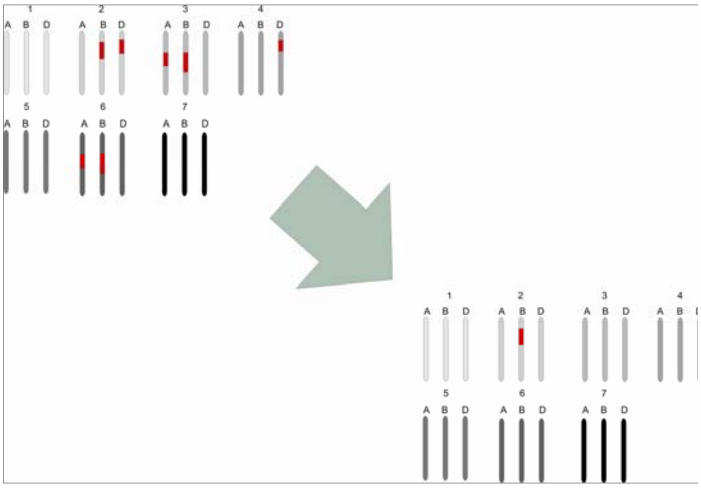


Figure 1: Wheat has twenty one pairs of chromosomes. On the top left, the diagram shows (in red) genes (Quantitative Trait Loci) controlling crop height identified using genetic analysis. Genetic material (Near Isogenic Lines- NILs) in which only one of those QTL differs is shown on the bottom right.

Objective 7 Insect resistance in wheat: Cereal aphids

Exploring if the differential response of hexaploid wheats to two different cereal aphid species has a genetic basis

The major pests of UK wheat, the grain aphid, *Sitobion avenae* (Picture 1), and the bird-cherry oat aphid, *Rhopalosiphum padi* (Picture 2), are carriers for Barley Yellow Dwarf Virus (BYDV). Both intercept nitrogen assimilates necessary for developing grain. This results in significant yield losses and affects the quality of bread making wheat. These aphids can be controlled by seed treatment and application of pyrethroid insecticides, but impetus for finding alternative control methods to insecticides has come, particularly from the public perception of health and environmental issues associated with insecticide use. The development of insect resistant wheat varieties is a grower-friendly insect pest management solution and would make a substantial contribution towards reducing insecticide use.

Picture 1 (top): *Rhopalosiphum padi;*
Picture 2 (bottom): *Sitobion avenae*

Breeding of resistant varieties has been particularly important in the management of other species of aphids attacking wheat worldwide e.g. the greenbug, *Schizaphis graminum*, and the Russian wheat aphid, *Diuraphis noxia*. However, despite considerable research effort, to date there are currently no commercial wheat varieties resistant to UK resident aphid species. The unique resources available through the WGIN project provide a great opportunity for targeted research on suitable traits for resistance to UK cereal aphid species.

Assessing the differential susceptibility to two cereal aphid species of targeted lines from the Spark x Rialto mapping population

In previous studies, some lines from the mapping population, produced from the crossing of UK varieties Spark and Rialto, had shown strong resistance or susceptibility to *D. noxia* and *S. graminum*, but only one of these lines showed a consistent effect against both aphid species. Seventeen of these extreme lines, plus the parents, have now been tested against *R. padi* and *S. avenae* in laboratory bioassays. Since the responses of *R. padi* and *S. avenae* to these particular lines were found to be more subtle than for the other two aphid species, a choice test rather than the more stringent no-choice test method was used. Replicated groups of 10 alate aphids were given the choice between two seedlings, at the first leaf growth stage, one of a standard variety, Solstice and the other of the test variety. The number of alates settled on each seedling was recorded at 2, 5 and 24h and the number of nymphs produced on each seedling was recorded at 24h. These data were then compared in a paired Students t test and the number of nymphs produced was expressed as a proportion of the nymphs produced on Solstice in the same assay, thus providing a "preference index" for both aphid species (Figures 2 & 3). Those lines that were much more or much less preferred than Solstice were retested to confirm the results. As for *D. noxia* and *S. graminum*, the most and least preferred lines were not the same for *R. padi* and *S. avenae*. However, there were a few lines where the responses coincided and one in particular that was very susceptible to 3 of the 4 aphid species. These data are now being checked to determine whether there is any genetic basis to the effects and the lines of extreme preference for *R. padi* and *S. avenae* will be tested further in aphid development assays to confirm the results. In addition, the possible role played by a family of plant defence secondary metabolites, the benzoxazinones e.g. DIMBOA, in the contrasting preference index of the two aphid species for these lines will now be explored.

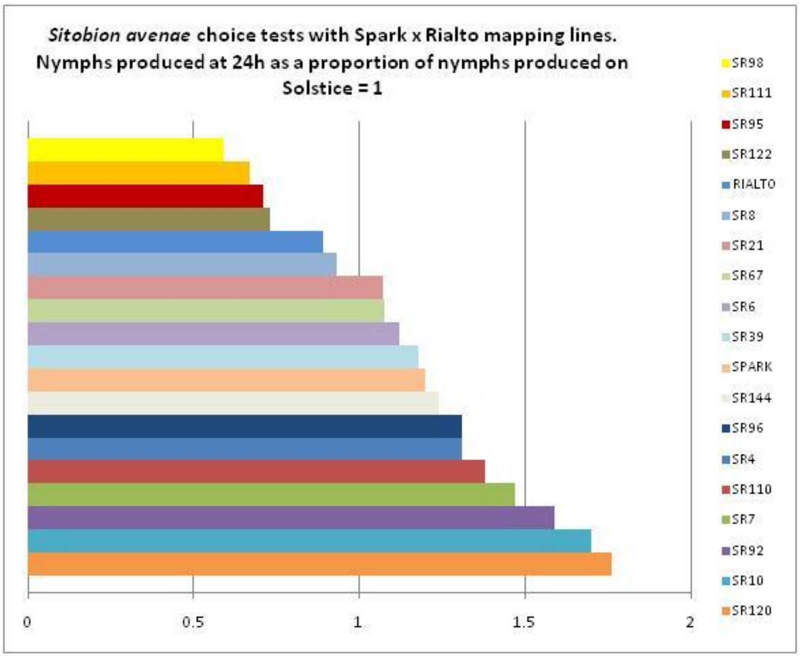


Figure 2: Preference of *Sitobion avenae* for nymph production on lines from the Spark x Rialto mapping population compared to Solstice

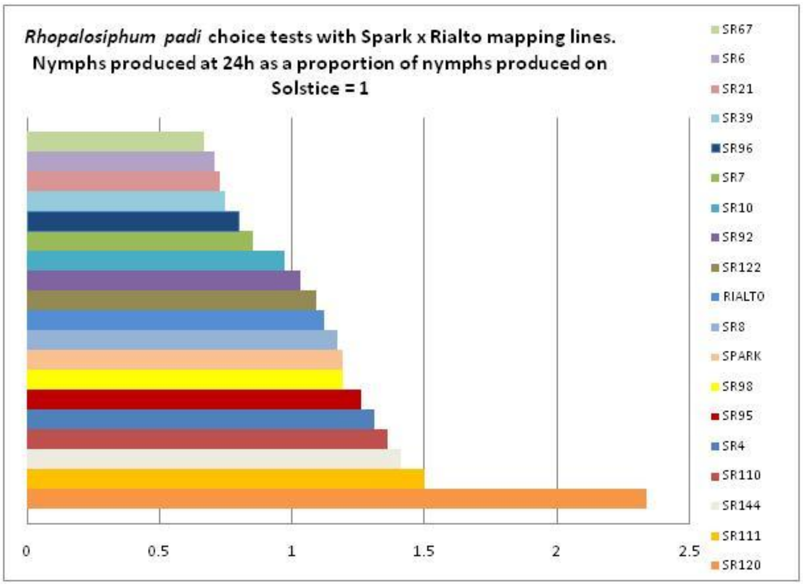


Figure 3: Preference of *Rhopalosiphum padi* for nymph production on lines from the Spark x Rialto mapping population compared to Solstice

Objective 8 Improvements of nitrogen use efficiency and quality QTLs linked to NUE: dissecting NUE and quality traits and QTLs

Best cereal yields and quality are currently usually dependent on large inputs of fertiliser nitrogen. Fertiliser production is expensive, requires energy from fossil fuels and excessive application has negative environmental consequences. Developing wheat lines which give high yields/quality with reduced N inputs will be beneficial to the environment and to the industry.

Picture 3: BBC filming the diversity trial in August 2009

2009 harvest	2010 harvest
Avalon	Avalon
Cadenza	Cadenza
Claire	Chablis (NEW 09/10)
Cordiale	Claire
Hereward	Cordiale
Hurley	Gallant (NEW 09/10)
Istabraq	Hereward
Malacca	Istabraq
Marksman(NEW 08/09)	Malacca
Maris Widgeon	Marksman
Mercia	Maris Widgeon
Monopol	Mercia
Paragon	Oakley (NEW 09/10)
Riband	Paragon
Robigus	Riband
Soissons	Robigus
Solstice	Soissons
Xi19	Solstice
AxC line 100	Xi19
AxC line 116	AxC line 100
AxC line 99	AxC line 116
AxC line 155	AxC line 181
AxC line 127	AxC line 112
AxC line 82	AxC line 127
	AxC line 82

Table 1: Varieties in Rothamsted WGIN Diversity Trial for 2009 and 2010 harvest

Planned studies on NUE will build on initial observations of varietal and year to year variation observed during the first phase of WGIN (2004-08). Germplasm under investigation includes both commercial elite varieties and the Avalon x Cadenza mapping population. The mapping population allows both genetic mapping of traits and correlations between traits to be established. The analysis will be conducted at both low (100 kg/ha) and standard (200 kg/ha) N inputs, with a total of 6 trials spread over 5 years. A variety/4 nitrogen level trial is also being conducted annually (Picture 3), including a core set of lines, selected Avalon x Cadenza lines and a capacity for the selection of specific new varieties on an annual basis. For example in 2009/10, the high yielding/high quality variety, Gallant, and the highest yielding Nabim Group 4 variety, Oakley, will be included for the first time. In this trial trait characteristics and their dependency on nitrogen inputs are examined in more detail (see Table 1 for the full lists of lines included in the 2009 and 2010 harvests). Traits of interest will include nitrogen uptake, canopy development and longevity as well as grain quality.

Objective 10 Take-all disease

The name take-all was used in Australia in the 1870s, but was recognised as early as 1852 as a devastating disease of wheat. It is a damaging root disease and if severe symptoms occur around anthesis, then the crop often shows as stunted, prematurely ripening plants (Picture 4).Take-all is a patchy disease and being able to predict when a severe outbreak will occur has always been difficult. However, there are known factors which can encourage the disease, for example, cereals volunteers and grass weeds can act as carriers of the take-all fungus through the break-crop year. Also if the top soil is low in either phosphate or potash this will encourage the fungus to develop both in the soil and on the plant.

Within the WGIN1 project a series of experiments, started in the autumn of 2003, were designed to study the nitrogen use efficiency (NUE) of different NW European commercial winter wheat cultivars. Most of the cultivars chosen had good bread making qualities, and included both current and former elites. These experiments, all grown as first wheats, tested 22 cultivars at three or four nitrogen rates (0-

350Kg/ha), in randomised block designs of three replicates. Earlier trials done at Rothamsted in the 1980s had suggested that cultivars may differ in their ability to build up the take-all fungus at the start of an epidemic. These large experiments, of five years duration in WGIN1, provided an opportunity to further test this hypothesis. The take-all infectivity of the soil (i.e. inoculum) was measured by a soil core bioassay, using wheat seedlings as bait. This method is described in a recent HGCA report (Gutteridge, Treskic and Hammond-Kosack, K E. (2008) No 445 Dec). This research at Rothamsted has shown that the amount of inoculum in the soil after harvest was positively, and linearly, related to the severity of disease in the following wheat crop.

Picture 4: Square take-all patches at Rothamsted Research in June 2009

Results from the WGIN1 trials showed that cultivars could apparently build up take-all inoculum in the soil differentially during the growth of the first crop. Previous epidemiology studies on take-all showed that inoculum did not start to build up until May, but then continued to increase through to harvest if conditions were favourable. The years 2006-8 showed very different weather patterns which affected the inoculum build up. Weather conditions in 2006 were very dry during June and July with only a total of 50.6mm of rain, compared to 159.2mm and 125.6mm in 2007 and 2008, respectively. Also, air temperatures for the same period were higher, 21.6, 19.0, 18.8 for 2006, 2007 and 2008, respectively for June and 26.1, 20.0, 20.1 for 2006, 2007 and 2008 respectively for July. High temperatures and low rainfall in 2006 were not conducive for inoculum build up, in contrast, lower temperatures and high rainfall in 2007 was ideal. The amount of inoculum in the soil after harvest for four varieties between 2006 - 08 for the 200kg/N plots are shown in figure 4. The ranking of the varieties between years were consistent, with Hereward and Avalon building up most inoculum, Cadenza least and an intermediate level with Riband.

Avalon and Cadenza have shown a consistent contrasting ability to build up the take-all fungus in the soil in a first wheat situation. Within the WGIN project, seed of the A x C double haploid population has been made available for the study of may traits (WGIN 2 main objective 3). One A x C experiment at Rothamsted in 2008, which consisted of 62 lines along with two plots of each parent grown as large well spaced plots for seed multiplication, was over sown with winter wheat cv. Oakley in 2009. In early July patches of take-all were evident over this site and the location of each of the 2008 plots was clearly visible (Figures 5 and 6). The percentage of area of each 2008 plot was score for take-all patches on July 7th 2009 and grain yields for each plot taken in August. There was distinct difference between the parent varieties. The percentage areas affected by take-all patches for the two Cadenza plots were 5% and 10% and yielded 9.9t/ha and 9.4t/ha, respectively. For Avalon the take-all scores were 50% and 70% with yields of 7.8t/ha and 6.6t/ha, respectively. Overall there

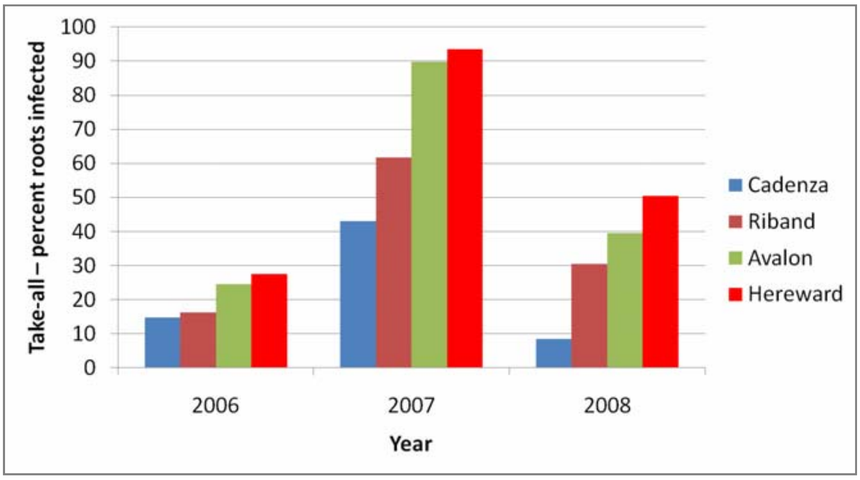
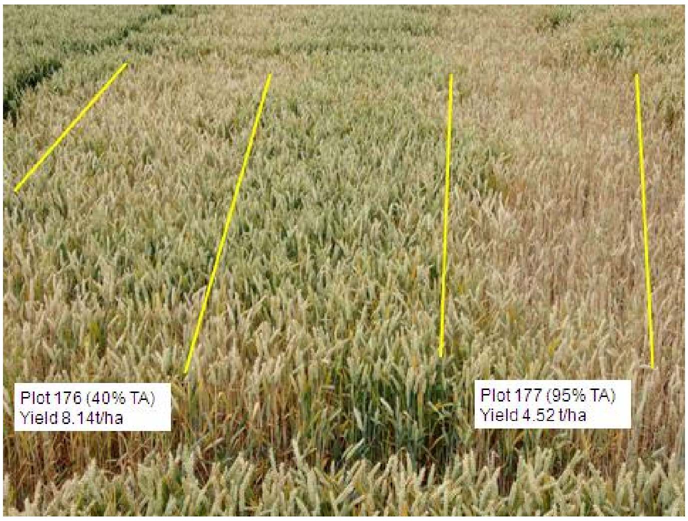


Figure 4: Take-all infectivity of soil in August after different winter wheat varieties



Figures 5 and 6: Yield difference in plot mildly and severely affected by take-all

was a significant correlation between the take-all patch score and yield (Figure 7).

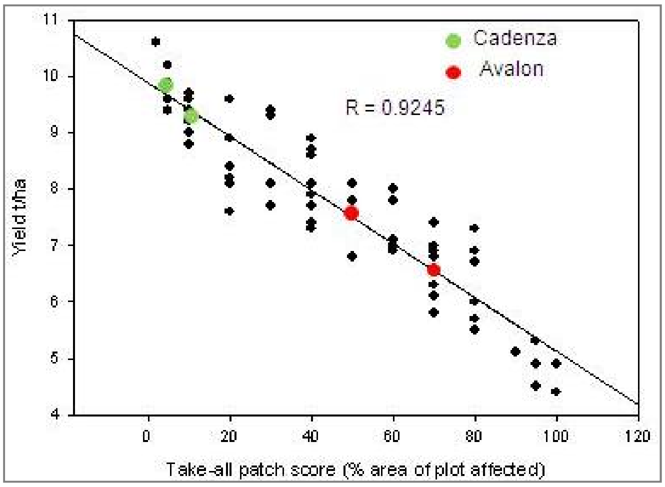


Figure 7: Avalon x Cadenza lines in 2008, oversown with wheat cv. Oakley in 2009. Relationship between take-all patch score and yield.

It is likely that the differences observed in 2009 was a result of the differential build up on soil inoculum in 2008. This year, soil cores have been taken from the full 203 DH line A x C experiment to further study this phenomenon.

Acknowledging use of WGIN resources and data:

WGIN is a publicly funded project and the data and resources it generates are freely available to the research community, providing that the use of any WGIN data and resources are acknowledged. Acknowledging the use of WGIN data is an important way of ensuring that WGIN can continue its work in this manner.

Publicatons:

Simon Griffiths, James Simmonds, Michelle Leverington, Yingkun Wang, Lesley Fish, Liz Sayers, Leodie Alibert, Simon Orford, Luzie Wingen, Laurence Herry, Sebastien Faure, David Laurie, Lorelei Bilham, John Snape. Meta-QTL analysis of the genetic control of ear emergence in elite European winter wheat germplasm. Theoretical and Applied Genetics 119 (2009), doi 10.1007/s00122-009-1046-x

Jing HC, Bayon C, Kanyuka K, Berry S, Wenzel P, Huttner E, Kilian A, Hamond-Kosack KE. (2009) DArT markers: diversity analyses, genomes comparison, mapping and integration with SSR markers in *Triticum monococcum*. BMC Genomics, 10: 458. doi:10.1186/1471-2164-10-458

Forthcoming events:

WGIN stakeholder meeting: 25 November 2009, Rothamsted Research, Harpenden – see next page for the full programme

Monogram Network Workshop: 2 – 4 March 2010, Norwich; web: http://www.monogram.ac.uk/announce.php)

Eucarpia Cereals Section Meeting: 6 – 8 April 2010, Cambridge; web: http://www.niab.com/news_and_events/article/63

Joint Healthgrain/Bioexploit Workshop: 6 – 8 April 2010, part of the Eucarpia meeting in Cambridge; web: www.bioexplloit.net

Wheat Genetic Improvement Network

WGIN Stakeholders Meeting
25 November 2009, RRes
Programme

10:00	Arrival and coffee
	Agriculture in a changing world
10:30	International Drivers - *Peter Shewry (RRes)*
10:40	Strategy of the HGCA Levy Board – *Susannah Bolton (HGCA)*
11:00	The wheat market – an international perspective - *Jack Watts (HGCA)*
11:20	Wheat breeding: challenges and research opportunities – Richard *Summers (RAGT)*
11:40	BBSRC Initiatives: The Crop Improvement Club – *Dan Godfrey (BBSRC)*
12:00	Sustainable Agriculture and Food Innovation Platform - *Alex Chaix (Technology Strategy Board)*
12:20	Carbon sinks in a changing environment – *Andy Whitmore (RRes)*
12:40	Agriculture in a changing climate – *Mikhail Semenov (RRes)*
13:00	Lunch
	The Wheat Genetic Improvement Network
14:00	WGIN 2009 – 2013: An Overview –*Kim Hammond Kosack (RRes)*
14:20	The Avalon x Cadenza DH population - *Simon Griffiths (JIC)*
14:40	Nitrogen mobilisation in wheat – *Malcolm Hawkesford (RRes)*
15:00	Discussion
15:20	Tea and finish

For further information on the WGIN project please see www.wgin.org.uk or contact us at wgin.defra@bbsrc.ac.uk.

The contributors to this newsletter were: At Rothamsted Research: Kim Hammond-Kosack, Malcolm Hawkesford, Peter Shewry, Lesley Smart, Richard Gutteridge and Elke Anzinger. At the John Innes Centre: Simon Griffith, Simon Orford and Michelle Leverington.

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