Conference reports

Is the understanding of physiology relevant to the future of plant breeding?

University of Reading, UK, 7 December 2010

Crop physiologists are particularly adept at telling breeders what they have done, rather than identifying what they need to do, and the development of wheat over the last 50 years is no exception.

A detailed understanding of why a variety is successful is often used to identify what an ideal crop type or ideotype might look like. Such an understanding can be particularly useful for breeders when selecting from tens of thousands of breeding lines in the field each year. Examples of desired traits, associated with higher yields, have included short stature, improved storage capacity, improved radiation use efficiency, and larger, longer-lived canopies. Commercial varieties with some or all of these traits became available through the 1980s and 1990's. Roger Sylvester-Bradley from ADAS, discussed how resultant increases in resource capture, use efficiencies, storage and partitioning, were instrumental in yield gains over recent decades. There is, however, significant debate as to how much further improvement in yield through these mechanisms is possible. Excessive emphasis on resource allocation to the grain can, for example, risk overlooking the importance of resource capture by, and functioning of, other organs.

Allocation of resources to the roots and stems: Sarah Clarke from ADAS described the development of a classic ideotype mechanical model for straw strength and root plate size. Absolute values for these varietal characters were given which could contribute to the selection of lines for reduced risk of lodging. Increased straw strength and the consequent higher carbon resource allocation to the plant structural components reduce the risk of plants falling over particularly under high fertility.

Less resources in the stems and leaves: John Foulkes provided background to the collaborative work at The University of Nottingham questioning what is the greatest potential ratio of dry matter to the grain, compared to total above ground biomass (the Harvest Index: HI). The most recent increases in HI have been through a reduced allocation of resources to stems and leaf sheaths in favour of the grain. Further improvements in grain number have involved investigations into the potential for increasing sink strength of the grain from introgressing the large ear CIMMYT type into UK breeding lines.

How much variation is feasible within the UK breeding programme? And what environmental variation is predicted in the future?

More resources to plant structural components: Tall, highly lignified and waxy plants decrease the incidence of disease, and exponentially increase the efficacy of fungicides. Mike Shaw from the University of Reading highlighted the trade-off between resource use for durable partial resistance through more resistant plant structural components, and grain yield.

The trade off

Height cannot be reduced without an effect on disease resistance; resources cannot be increased to the grain from the stem without implications for lodging. Further complexities exist in reduced height genotypes through the effects of Rht (reduced height) alleles. Mike Gooding from the University of Reading described the detailed interactions between crop height, nitrogen uptake and utilisation efficiencies, the effects on flowering, heat stress tolerance and establishment. He demonstrated through the experimentation with Near Isogenic Lines of these different Rht genes that the optimum ideotype varies with year, with farming system and most importantly with the character under evaluation.

We are at the infancy of understanding these interactions. Technology for targeted mutations (TILLING: Targeting Induced Local Lesions IN Genomes) uses a reverse genetics approach to identify loss of function mutants which are useful for example, for modifying grain filling period by delaying senescence. This valuable technique described by Cristobal Uauy from the JIC, however is limited to genes of which the function is known, that is, very few.

There is scope for TILLING to have a significant contribution to breeding in the future; the molecular technique of Marker Assisted Breeding is now a key strategy for high throughput selection for disease resistance. However, there remains significant, under-developed variation in the UK wheat germplasm. Bill Angus from Limagrain (UK) Ltd highlighted how much of the variation in the UK wheat

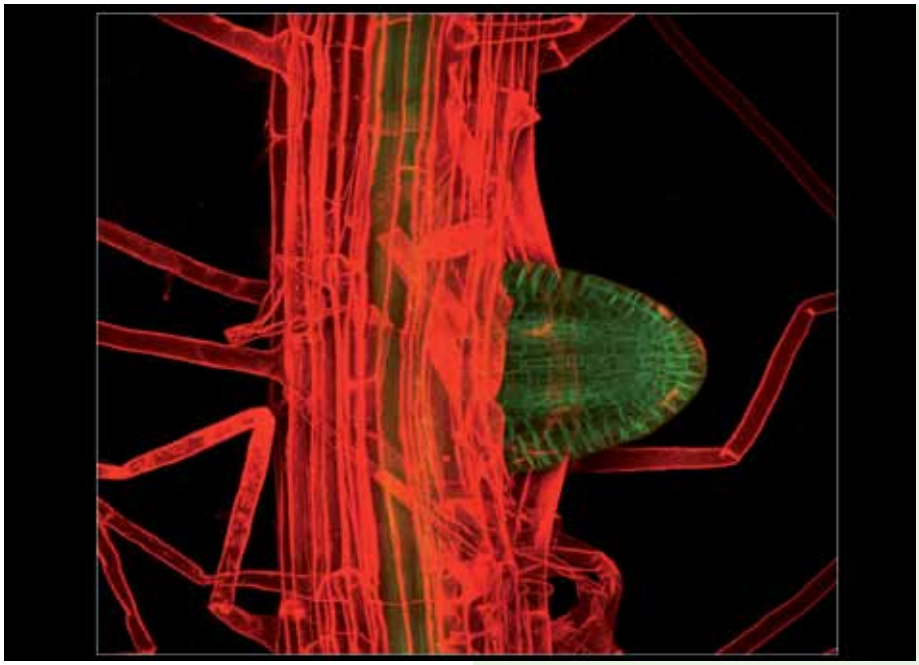
germplasm is under-exploited, and of unknown contribution to varietal performance in farmers field. He described how varieties need to fit into farmers' crop management. Cereals are being drilled earlier, but to date breeding developments have not exploited the lengthening of the early stages of crop establishment in terms of resource capture. These early drilled crops need to have later onset of reproductive development, to avoid frost damage, and a greater understanding of the genes controlling developmental responses to temperature, day length and vernalisation are essential. Further variation results from geographical location, farm management and climate: the genotype by environment interaction.

A detailed understanding of the existing variation needs to be justified in terms of genotypes for specific environments and the trade-offs which do, without doubt, exist. How much variation is feasible within the UK breeding programme? And what environmental variation is predicted in the future?

The difference in farm yields compared to Recommended List Trials is likely to be dominated by variations between arable fields; to include management, soil, system and climate. Is there a need to switch alliances to focus on the stability of production, compared to optimal yields under increasingly rare, optimal conditions?

The introduction of genetically modified crops may have a place in such a debate, but when breeding programmes have an enormous resource of under-exploited germplasm, of which the physiological basis is unknown, it could be argued that we should be focusing on the genes that are present in successful varieties, to improve the physiological basis of plant breeding.

-Hannah Jones



Water and nitrogen use efficiency and plants and crops

The Olde Barn Hotel, UK, 15–16 December 2010

One only has to open the paper or look at news websites to see that the issue of food security and climate change are becoming headlines. Shortages of water and the cost of fertilizer are clearly going to be problems in particular. The idea for this meeting was to bring together people from plant science, crop science and agriculture to present work and spark some cross-disciplinary ideas and emphasise the need to draw solutions from different areas. Not an easy task but Prof Bill Davies from The Environment Centre at Lancaster University struck the right note with the plenary describing how crop improvement efforts in terms of drought and water use efficiency are now exploring the chemical regulation of growth, development and functioning. Using the example of China which is facing acute water shortages in many regions he described how this approach is already helping to achieve higher water use efficiencies in many parts of the world.

The goal of this meeting was no doubt helped by the diverse backgrounds of the delegates, not just in terms of discipline but geography, coming from Spain, France, Morocco, Belgium, Sweden, Germany, Malaysia and UK. We are grateful to those who came long distances to contribute. We heard talks covering crops including UK cereals, African Bambara groundnut, biomass crops, potato, salad crops, oil seed rape and others. The level of systems analysed was also diverse from the molecular systems biology of individual plants, crop management to the impact of social changes in farming in China. On a scientific level this was therefore a fascinating opportunity to see how this topic affects food production and the environment and how each discipline has a part to play and some excellent discussion was initiated between and within groups in each session. The venue and catering was ideal for a conference of this size and the bar was definitely large enough! This type of inter-disiplinary meeting seems to represent a theme in AAB at the moment and I notice the upcoming 'systems approach to crop improvement meeting'. I hope these meetings continue to help to bring together plant and agricultural scientists towards common goals.

-Erik Murchie