All-Party Parliamentary Group on Science & Technology in Agriculture

Notes of the sixth Annual General Meeting held on Monday 12 January 2015, Committee Room 11, Palace of Westminster

The science behind our daily loaf – UK wheat research in practice

Present:

Members
Mark Spencer MP
Earl of Selborne
Earl of Lindsay
Lord Cameron of Dillington

Guest Speakers
Martin Savage, Trade Policy Manager, National Association of British and Irish Millers
Phil Howell, Programme Lead, Cereal Pre-Breeding, NIAB
Paul Molyneux, Innovation Director, Hovis Ltd
Paul Temple, Mixed Farmer, East Yorkshire

Stakeholders
Keith Norman, Velcourt; Sir Gordon Conway, Imperial College; Anna Tiley, Bristol University; Gordon Polson, Federation of Bakers; Jan Chojecki, PBL; Steve Knight, USDA; Stan Phillips, Agriculture Counselor, US Embassy; Huw Jones, Rothamsted Research; John Scatchard, Wrights Flour Mills; Chris Warkup, KTN; Allan Wilkinson, HSBC; Simon Griffiths, John Innes Centre; Mimi Tanimoto, UK Plant Science Federation; Conan Fryer, Premier Foods; Penny Maplestone, BSPB; Richard Summers, RAGT; Mark Charlton, Allied Technical Centre; Graham Jellis, BCPC; Bob Beard, Warburtons; Oliver Savory, NFU; Sean Ryan, Defra; George Marriage, Marriages Flour Mills; Alex Waugh, nabim; Abigail Wood, nabim; Keith Newton, Whitworth Bros Ltd; Toby Cusworth, LFI; Richard Hall, ABIM; John Bingham, farmer; Adam Speed, CPA; Mabon Ellis, Sense About Science; Nus Ghani, Conservative PPC – Wealden; Daniel Pearsall, Group Co-ordinator

AGM

1. Election of Chair and Officers

All Members present agreed that the Group should continue to exist and operate as an approved All-Party Group within Parliament.

The nomination of Mark Spencer MP to serve as Chair of the Group was approved by all Members present.

Nominations for the Earl of Selborne, Lord Haskins, Huw Irranca-Davies MP and Roger Williams MP to continue as Vice-Chairs of the Group were approved with the agreement of all Members present.

The nomination of the Earl of Lindsay as an additional Vice-Chair of the Group was approved with the agreement of all members present.

2. Welcome & Introduction

Mark Spencer welcomed Members and stakeholders to the meeting, briefly introducing the topic for the meeting *'The science behind our daily loaf – UK wheat research in practice'* as a key opportunity to hear from a line-up of expert speakers from the research, farming and end-use processing sectors to showcase UK leadership in wheat research, production and processing, and to highlight the vital contribution of scientific and technological innovation in delivering our daily loaf of bread.

3. Guest speakers

[Please note that all speakers' slide presentations are available to download via the meetings section of the All-Party Group web-site at www.appg-agscience.org.uk]

Martin Savage, Trade Policy Manager, National Association of British and Irish Millers

Martin Savage (MS) provided an introduction to wheat, which in global terms is the largest crop by area (216m ha) and third largest by production (717m tonnes) behind maize and rice. Wheat is the UK's most significant crop, grown on 1.9m ha and the driver of the arable rotation, produced mainly for food and animal feed.

One of the earliest crops to be domesticated, in 9000 BC, MS explained that wheat originated in the 'fertile crescent' stretching across Turkey and Syria to Israel, first reaching the UK around 3000 BC.

The complexity of wheat, in terms of scientific research, lies in the fact that it took three separate crosses to produce the precursor of today's domesticated wheat, which includes five species - bread or common wheat, spelt wheat, durum wheat, einkorn and emmer. The hexaploid wheat genome is highly complex, comprising 42 chromosomes and more than 300,000 genes, underlining why the crop is so challenging to improve through breeding.

MS stressed that the value and importance of wheat lies in its superior bread-making characteristics when compared with other cereals.

On a global basis, wheat is grown in temperate regions of both northern and southern hemispheres. The largest producers are the EU, followed by China, India, Russia, the USA, Canada and Australia. UK wheat production can vary between 11m tonnes and 20m tonnes depending on harvest year, but is usually around the 13–15m tonne mark.

MS explained that UK wheat production is mainly concentrated on the eastern side of the country from Kent in the south to Yorkshire in the north. Around 50% of UK wheat production goes for human and industrial uses, which includes flour as well as starch for the food industry and biofuels, while just under half (47%) is used for animal feed and 3% for seed. Surplus production, mainly quality types, is exported.

Since the early 1970s, total UK wheat production has increased threefold, and usage of home-grown wheat by UK flour millers has more than doubled over the same period, from 35% in 1971/72 to 72% in 2012/13. In very good harvest years, this proportion has reached as high as 85%.

Wheat end-use is determined by its quality in terms of hardness and protein content, ranging from the softer, lower protein wheats used for biscuits and cakes through to harder endosperm, high protein types suitable for breadmaking.

- MS explained the nabim system for classifying UK wheat, which used four categories (Groups 1, 2, 3 and 4) to rank varieties according to their functionality, eg suitability for breadmaking, biscuits or animal feed.

In conclusion, MS highlighted the major challenges facing wheat production in the future. These included meeting the needs of a growing world population and coping with changing weather patterns, as well as addressing competition from other crops (eg soya) and tackling the threat of new pests and diseases as the range of pesticide options declined.

MS considered that trade agreements and changing legislation also presented potential barriers to the development of wheat crop, as well as the challenge of science not keeping pace with these ever-changing demands.

Paul Molyneux, Innovation Director, Hovis Ltd

Providing a cereal processing perspective, Paul Molyneux (PM) highlighted four key areas in which scientific and technological innovation has made a significant contribution: product quality; process efficiency and control; nutrition and supply capability.

In terms of product quality and supply capability, improvements in the yield and quality of breadmaking wheat varieties have allowed UK millers and bakers to use a greater proportion of home-grown wheat, even allowing wholemeal bread to be produced from UK wheat.

But PM suggested that advancing scientific knowledge has also thrown up new challenges and difficulties, such as concerns over a range of food-borne mycotoxins leading to new legislation which was not the case or considered necessary 30 or 40 years ago.

In terms of process efficiency and control, PM described advances in the use of IT and technology – such as the use of NIR beams to measure and record flour protein, moisture content and starch damage automatically - allowing millers to achieve tight controls on flour quality and specification, as well as the increasing automation of the milling and baking process.

The sector has also delivered major improvements in nutrition – 40 years ago some 80% of the bread consumed was white, today that proportion is 40%.

Looking ahead to future developments, PM indicated that the industry has reached the limit of salt reduction – dough without salt gets too sticky and bread cannot be produced on an industrial scale.

PM considered that there are still potential improvements to be made in the consistency and reliability of home-grown breadmaking wheat quality to allow wholemeal bread to be made from UK wheat every harvest year – in 2012 it was virtually impossible to make wholemeal bread from home-grown wheat. He highlighted the contribution of the Crop Improvement Research Club in connecting plant scientists, breeders and the milling industry to address challenges such as this.

In terms of process efficiency and control, PM highlighted improvements in the efficiency of energy use – the next big on-cost after people and raw materials – as a major challenge for the milling and baking industry.

On nutrition, PM highlighted the need for clear and consistent messages in areas such as the contribution of carbohydrates (shortly to be reported on by the Scientific Advisory Committee on Nutrition). He criticised the role of celebrities such as Gwyneth Paltrow driving the debate over what people should eat – it was a challenge for the industry to get its

message across more effectively to ensure consumers receive sound and factual information about their diets.

Finally, PM considered that continued advances in the sustainability of UK wheat production will be required to enable flour millers to continue using home-grown wheat, particularly in areas such as climate resilience and carbon emissions (fuel and N fertiliser use) per tonne produced.

Dr Phil Howell, Programme Lead, Cereal Pre-Breeding, NIAB

Providing a research perspective, Phil Howell (PH) highlighted the complexity of the wheat crop, a hexaploid with 21 chromosome pairs falling into three distinct but related sets of seven – referred to as the A, B and D genomes - reflecting the crop's ancestral past. A draft but incomplete sequence of the wheat genome was published last year - the wheat genome is five times larger than the human genome, it is also technically difficult to work with due to the high proportion of repetitive DNA.

PH highlighted recent progress in genome sequencing, beginning in 2000 with Arabidopsis, and followed by rice in 2006, noting that wheat scientists could also learn from the rice genome because many of the genes of both grass species are not only similar but also found in a similar order along the chromosome.

PH described the wheat crop's rich ancestral history, beginning around 100,000 years ago with a first chance cross between two different grass species which stabilised to produce wild emmer wheat - combining the A and B sets of chromosomes. This was followed 10,000 years ago when wild emmer was pollinated by wild goat grass, bringing the third set of D chromosomes and creating the wheat species *Triticum aestivum*, from which all modern wheat varieties are derived.

PH described the research work taking place at NIAB to re-synthesise the second cross, pollinating female (anthers removed) durum wheat lines with wild goat grass, rescuing the resulting embryos and growing them on in a culture medium to produce seedlings, which are then treated to double their chromosome number and stabilise the developing plants. The result is a stable synthetic hexaploid wheat which can then be crossed with modern wheat varieties to introduce new sources of potentially valuable genetic variation and diversity.

PH noted that the timescales and success rates of re-synthesis are challenging – 2-3 years to make synthetic wheat, 3-5 years to produce pre-breeding lines of UK-type material, then 7-10 years for the very best material to pass through commercial breeding programmes to reach the market as finished varieties.

PH highlighted the 'superwheat' coverage of NIAB's synthetic wheat project by Tom Heap on BBC Countryfile, prompting further widespread media coverage of the research and its potential to significantly improve the performance, quality and resilience of the wheat crop.

In seeking to improve the genetic make-up of the wheat crop, PH stressed the importance of assembling as many different sources of genetic diversity as possible, whether from existing variety collections, mutants, land races, related species (eg wild and cultivated emmer), as well as other sources of re-synthesised varieties (eg from CIMMYT).

PH also noted the valuable collaborative research taking place thanks to UK Government investment in the Wheat Institute Strategic Programme (WISP) in which NIAB's synthetic wheat programme is contributing to the related work of scientists at the John Innes Centre, Nottingham University, Bristol University and Rothamsted Research – working closely with

commercial wheat breeders to improve the yield, performance and resilience of the wheat crop.

Looking ahead, PH considered future innovations in the wheat crop:

- the introduction of F1 hybrid varieties, offering increased yields and stability;

- changes in breeding strategy, with increased use of genomic selection speeding up the rate of genetic improvement, and more focus on pre-breeding activity to exploit the diversity of material in public collections;

- more field trials of GM and genome-edited wheat, eg following successful Rothamsted field trials of aphid-resistant GM wheat, NIAB and JIC also working on take-all resistant GM wheat by transferring multiple genes from oats, while in 2014 a Chinese research group used genome-editing techniques to confer durable mildew resistance in wheat. PH noted that the regulatory status of genome-editing techniques within the EU remains undecided, although the US has already determined that they should not be regulated as GM techniques;

- increased focus on the importance of root research, using new x-ray scanning techniques and DNA assays to understand better the science of roots, root hairs and their influence on the growing plant and its environmental interactions;

- increased use of remote and high-throughput phenotyping – using sensors and imaging to measure and record subtle changes in the growing plant, whether under artificial laboratory conditions or in the field using hand-held or UAV-mounted devices (drones).

Paul Temple, Mixed Farmer, East Yorkshire

Providing a farmer's perspective, Paul Temple (PT) described his own farm business, a third generation family partnership farming 410 ha, including a six-course arable rotation – wheat, barley for seed, oilseed rape, vining peas, potatoes and forage maize – alongside a livestock enterprise comprising 400 head of suckler beef cattle.

PT viewed wheat not in isolation but as part of a mixed farming operation, both as a component of the arable rotation and with the soil fertility benefiting from the livestock manures from the beef operation and neighbouring pig and duck units.

PT emphasised that the countryside, beautiful as it is, is a man-made environment – every tree and hedge placed there strategically. He described it as a 'minor miracle' that wheat production on the thin Wold soil on his farm has increased from 4t/ha to 10t/ha over the past 40 years, thanks to the contribution of science and technology, adding that innovation in livestock genetics is also driving improvements in his beef operation.

Alongside high yields, production efficiency and sustainability, PT emphasised the importance of growing quality wheat destined for an end-market, also noting that the process of ensuring food safety starts on the farm.

Successful wheat production begins with the soil, and PT noted a shift as farmers are now taking more of an interest in soil rather than just what is happening above ground, although a major challenge is lack of soil scientists in the UK supporting farmers and helping them to understand the importance of this vital medium.

PT noted that the technology around crop establishment is also advancing rapidly, with precision equipment available to vary seed rate and drilling depth according to field and soil conditions.

PT highlighted three key areas of science and technology for the wheat grower: genetics, nutrition and crop protection. He noted that the importance of genetics and wheat breeding is experiencing something of a renaissance after a period of marking time since the major yield and quality gains of varieties developed in the 1970s and 1980s. Crop nutrition is also becoming more sophisticated thanks to GPS mapping and precision farming advances, and is not restricted to the basic components of N, P and K but also considers other elements influencing soil fertility and productivity, including organic matter and rotations. Crop protection is also vital to the wheat grower to prevent yield loss due to weeds, disease and insect pests – and to keep crops standing to the point of harvest. Given access to these advances, PT considered that 15t/ha is an achievable yield on his farm.

But despite a strong research base, PT expressed concern that good initial science is not being translated onto farm and that EU farmers are being left behind their counterparts in places like the US due to the conflict in Europe of technology vs politics. This is reflected in the withdrawal of private sector R&D investment from Europe – yet UK farmers are facing challenges of resistant weeds and increasing disease pressures just as agrochemicals are being withdrawn and subjected to arbitrary bans.

In conclusion, PT highlighted science and technology as the key to driving sustainable improvements in wheat production, noting that current low commodity prices mask a long-term strategic requirement to increase global production. He stressed the importance of speaking up for science in agriculture, of championing the contribution of leading UK research institutes such as NIAB, Rothamsted and the John Innes Centre, of recognising the vital role of seed royalties in securing investment in future wheat breeding innovation, and ultimately of making the EU accountable for the scientific basis of its decisions on issues such as GM crops and pesticides.

4. Questions and discussion

The following key points arose during discussion:

Although he did not consider biofortification to be a sustainable solution to malnutrition in developing countries, Lord Cameron asked whether nutrition was sufficiently targeted in wheat R&D programmes, noting the suggestion from some nutritionists that a relentless focus on yield meant that today's wheat was digested twice as quickly as in the past, and was linked by some to a rise in diabetes. According to Paul Molyneux, this issue highlighted the lack of real science behind popular health and nutrition claims, since he could provide an assurance that the digestibility of wheat had not changed over time, nor had the glycaemic index, which was used to measure a carbohydrate-based food's contribution to blood glucose levels. However, he accepted the broader argument that nutrition outcomes should be a more central focus of wheat research and development programmes.

Retired wheat breeder John Bingham highlighted the need for more intensive research into sprouting resistance at harvest, and also noted that since protein content is inversely related to yield, GM techniques would be needed to modify the photosynthetic rate to deliver step change improvements in both yield and quality.

Mark Spencer asked about the prospects for perennial wheat, which PH confirmed was being investigated by a research team in Kansas.

Sir Gordon Conway noted that wheat yields in the UK, France and Germany were all following similar trends, but had become much more volatile in recent years. PT suggested that this could be due to more extremes of weather. PH added that loss of fungicide efficacy could be another factor likely to become even more significant with the prospective withdrawal of triazoles with no other active ingredients on the horizon.

Richard Summers (BSPB/RAGT) welcomed the progress in the UK towards a more co-ordinated and focused wheat improvement R&D pipeline, adding that there was a need to recognise plant breeders' ongoing contribution to boosting wheat yield potential, which had increased at 0.5% pa over the past 15 years although this was not translated from trials to national average yields.

Keith Norman (Velcourt) asked whether the UK was being left behind in wheat genetic research, noting that on a recent fact-finding visit to Israel he discovered that all their spring wheats are synthetic hexaploids and researchers are working on the development of octoploid wheat with a fourth genome added.

PH responded that NIAB's synthetic wheat programme was the first to work with high-input agriculture and that the contribution of re-synthesised spring wheat from CIMMYT had been repeatedly demonstrated in low-input agricultural systems.

Concluding the meeting, Mark Spencer MP thanked speakers and attendees for their contribution to a lively, informative and thought-provoking session.