All-Party Parliamentary Group on Science & Technology in Agriculture

Agro-Chemistry: new directions, new challenges?

Monday 31 October 2011, 4.30 – 6.00pm,
Committee Room 18, Palace of Westminster

Present:

Members
George Freeman MP (Chair)
Earl of Selborne
Mark Spencer MP
Sarah Newton MP
Lord Grantchester

Speakers
Dr David Lawrence, former Head of R&D, Syngenta
Professor John Pickett, Michael Elliott Distinguished Research Fellow, Rothamsted Research

Stakeholders
Neil Hipps, East Malling Research; Martin Savage, nabim; Dr David Sadler, Syngenta; Andy Mayer, BASF; Dr Andrea Graham, NFU; Julian Davies, Stockbridge Technology Centre; Ionwen Lewis, Women in Agriculture; Dr Bob Daniels, Scotts Miracle Gro; Dr Alan Baylis, Nuvistix Innovation; Dr David Hughes, Syngenta; Dr Ray Elliott, Syngenta; Ian Munnery, BSPB; Eric Paterson, Germains; Susanna Bolton, HGCA; Simon Leeds, A B Sugar; Ellen Friel, Royal Society of Chemistry; Colin Bedford, University College London; Kim Hammond Kosack, Rothamsted Research; Lorraine Martin, Royal Society of Chemistry; John Bingham, retired plant breeder; Dr Mindy Dulai, Royal Society of Chemistry; Adam Bowie, New Statesman; Angela Karp, Rothamsted Research; Colin West, MAGB; James Walton, IGD; Daniel Pearsall, Group Co-ordinator

1. Welcome & Introduction

George Freeman MP welcomed Members and stakeholders to a meeting in which the All-Party Group was pleased to joined forces with the Royal Society of Chemistry (RSC) in marking 2011 as the International Year of Chemistry and exploring how innovation in the chemical sciences was evolving and adapting to address the grand challenges of food security and climate change.

Dr Mindy Dulai introduced the RSC's work programme in agriculture, which had been identified as one of the top 10 challenges in the Society's 2009 roadmap for the chemical sciences.

Taking its cue from the Government's Foresight report, the focus of RSC activity in this area was to highlight the integral role of chemistry in delivering sustainable gains in agricultural productivity, not only through continued advances in established applications such as crop protection and nutrition, but also to demonstrate how chemical knowledge could be applied to deliver a holistic approach in other areas such as soil science, fertiliser technology and advanced plant genetics.

2. Guest Speakers:

Professor John Pickett, Michael Elliott Distinguished Research Fellow, Rothamsted Research

Dr David Lawrence, former Head of Research & Development, Syngenta

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

Aphid-resistant GM wheat

Faced with the urgent global need to feed a growing world population by sustainably increasing agricultural productivity – using fewer inputs and with reduced greenhouse gas emissions – Professor John Pickett (JP) highlighted the potential to exploit the knowledge base underpinning conventional agro-chemistry, but delivered as a component of the seed.

JP noted that many highly effective pesticide products were themselves derived from natural sources, such as the pyrethroid group of insecticides, in which the lead compound was derived from the daisy plant.

In-built genetic pest resistance in commercial crops had already been effectively delivered using GM techniques, for example in Bt cotton and maize, in which the naturally occurring soil bacterium *Bacillus thuringiensis*, already in widespread use as a biological pesticide, was expressed to make the crops toxic to certain insect pests.

Against this background, JP described the progress of research led by scientists at Rothamsted to develop wheat with in-built genetic resistance to aphids, an important pest of the crop and a major barrier to longer-term objectives to produce UK wheat crops capable of yielding 20 tonnes/ha by 2020.

But rather than producing plants which would be toxic to insect pests, the innovative approach taken by JP and colleagues was to target natural substances which, by non-toxic modes of action, would provide the next generation of pest control by influencing the behaviour of pest organisms.

JP explained that the aphid-resistant wheat being developed at Rothamsted was based on the introduction of a pheromone, or chemical signal, which is naturally produced by aphids when attacked to warn off other aphids. Expressing these chemical signals via crops had been successfully trialled on the model plant Arabidopsis and the concept had now been developed through GM transformation in the spring wheat variety Cadenza. The aphid alarm pheromone DNA had been introduced using biolistics – firing genetic material in the plant with a gene gun – followed by plant regeneration via tissue culture and selection for the desired trait using herbicide tolerance markers.

Laboratory-based tests of the GM wheat had confirmed that the plants emit the alarm pheromone in a very pure form, which not only repels aphids but also attracts their natural predators such as parasitoid wasps.

JP explained that the next stage in the research was to test the GM wheat under field conditions. Ministerial approval had recently been granted for field trials to begin at Rothamsted in 2012.

More sustainable Nitrogen fertiliser production and use

Dr David Lawrence (DL) expressed optimism that 9 billion people could be fed by 2050, but this would mean facing up to the realities of 'sustainable intensification' in relation to key impacts of agricultural activity such as water use, energy consumption and greenhouse gas emissions.

DL explained that a fundamental requirement of high-yielding crop production was that plants need access to atmospheric nitrogen as a source of fixed nitrogen. This could be delivered in a number of ways – from the use of manure and biological fixation in plants such as clover and legumes through to chemical fixation through the Haber-Bosch process which had been used to manufacture fertiliser without significant change for around 100 years.

DL highlighted the range of challenges associated with all current nitrogen sources – eg yield penalty incurred by nitrogen-fixing plants, methane release from manure, and the high energy demands and leaching and soil run-off issues from chemical fertiliser.

But as concerns over energy costs and security continued to rise (fertiliser production consumes around 1% of global energy supplies and around 4% of natural gas supplies) alongside concerns over greenhouse gas emissions, DL highlighted a number of potential ways in which chemical approaches could help reduce the energy consumption and atmospheric N release associated with fertiliser manufacture and use, eg:

- Use of nano-catalysts in the fertiliser production process offered the potential to fix Nitrogen at 50^{o}C instead of 450^{o}C;
- New application regimes – on-demand applications in irrigation systems or use of alternative formulations which were now becoming more economic;
- Use of de-nitrification inhibitors – to restrict the conversion of soil Nitrogen by soil organisms to greenhouse gases;
- Root growth stimulators – use of chemicals to promote early root growth helping uptake of soil nutrients.

While plant scientists often talked up the potential to develop Nitrogen-fixing plants as a biological means of improving N use efficiency, DL argued that these chemistry-based approaches offered a more feasible route to address the Nitrogen balance but which received much less attention.

Soil science

DL also highlighted the need for increased investment in soil science to help understand the enormous variation in soil types, and the role of different soil types not only in controlling water and nutrient availability, nutrient leaching and emission of greenhouse gases, but also - as a biologically active rhizosphere – how soil and soil dwelling organisms interact with plants both positively (eg to promote growth) and negatively (eg in spreading disease).

DL highlighted how little was known about soil biodiversity, with only around 1% of soil dwelling organisms identified compared to around 80% for plants and animals.

Once again, new technology was opening up possibilities to improve the study of soil science, from genomic analysis of soil organisms to the use of advanced scanning, sensing and visualisation techniques to progress understanding of soil interactions.

Improved scientific understanding of such interactions would not only support the development of best practice in crop production – eg in relation to cultivations, fertiliser application and disease control – but at the macro-level would also build greater knowledge of how soil affects the landscape and aquatic ecosystems.

Smart sensing technologies

JP concluded the RSC presentations by highlighting the advances taking place in decision support systems to monitor and control the development of disease and pest pressures.

He referenced specific UK-based initiatives to help address crop production problems such as blight in potatoes, orange wheat blossom midge in wheat, and bruchid beetle in field beans.

While these systems relied on monitoring external factors such as weather, disease spores and insect numbers, JP highlighted the long-term potential to use the plants' own defence mechanisms to develop plants capable of detecting problems or challenges to crop productivity.

For example, when corn-borer moths attack maize plants to lay their eggs a signal is sent within the plant to release a pheromone which attracts beneficial parasitic wasps to help protect the plant.

JP predicted a future time when such mechanisms could be harnessed to develop highly sensitive 'sentinel plants' capable of detecting threats – eg pest and disease attack or lack of key nutrients and water – and signalling to a main crop of smart plants to switch on the solution to the problem by activating the response gene already bred into the plant through GM or other breeding method.

While this was a long-term prospect, JP highlighted work already underway with Embrapa in Brazil to identify the chemicals emitted by soybean plants when infected by rust diseases, a major global problem of the soybean crop. This research was intended to support even earlier means of detection and rapid response as a more effective approach to rust control.

3. Questions and discussion

The ensuing question and discussion session highlighted the following key points:

- The overall status of productive soils is not currently deteriorating and remains steady, although soil erosion and degradation does occur where forests have been converted to agricultural land;

- The thermodynamic barrier to conversion of natural gas in the fertiliser manufacture process means that realistically the technologies available would be capable of reducing energy consumption by 20-30%;

- While the Royal Society's 'Reaping the Benefits' report highlighted the need to invest £2bn more in agricultural research over the next 10 years, this was mainly targeted at biological objectives and there remained a fundamental gulf in research funding to address the grand challenges for chemistry in agriculture;

- Realising the objectives set out by the Royal Society and in the Government's more recent Foresight report would require new metrics for sustainable intensification in agriculture, relating productivity to resource use and environmental impact. Such metrics would be needed to set meaningful objectives and targets for the food supply chain and ultimately to make sustainable intensification profitable;

- Further discussion focused on the potential to reduce crop wastage through improved storage solutions, and the urgent need to promote the image of agriculture and particularly agricultural science among schoolchildren as an exciting and rewarding career path to the next generation.

Concluding the meeting, George Freeman thanked both speakers and the Royal Society of Chemistry for their contribution to an informative and thought-provoking session. As ever, this had highlighted the depth of expertise and ingenuity within the UK agri-food research base, and the enormous potential on offer, through scientific innovation, to improve the productive capacity and environmental sustainability of UK and global agriculture.