HOUSES OF PARLIAMENT
PARLIAMENTARY OFFICE OF SCIENCE & TECHNOLOGY

Reducing Greenhouse-Gas Emissions from Crops
– closed POST breakfast event

Tuesday 20th January 2014, 0830-1000, Meeting Room M

This was the launch event for the 'Emissions from Crops' POSTnote. POST held this event for parliamentarians to discuss with academics and policy representatives the evidence for agricultural cropping's contribution to greenhouse-gas emissions and how to reduce emissions from growing and storing arable and horticultural crops.

The event was chaired by the Lord Cameron of Dillington, and attendees, including MPs, peers and parliamentary staff, heard briefly from seven speakers during general discussion of the issues:

- **Professor Dave Reay is Assistant Principal and Chair in Carbon Management & Education at the University of Edinburgh.**
- **Dr. Luke Spadavecchia is Agricultural Greenhouse-Gas Research & Development Platform Coordinator for Defra.**
- **Mr John Williams is a Senior Soil Scientist at ADAS UK Ltd and a member of the UK's Agricultural Greenhouse Gas Inventory Research Platform.**
- **Professor Simon Blackmore is Head of Engineering and a specialist in precision agriculture at Harper Adams University.**
- **Mr Laurence Smith is Senior Sustainability Researcher at the Organic Research Centre at Elm Farm and a member of the UK's Agricultural Greenhouse Gas Inventory Research Platform.**
- **Professor Malcolm Bennett is Professor of Plant Sciences in the Plant and Crop Sciences Division at the University of Nottingham.**
- **Professor Bill Sutherland holds the Miriam Rothschild Chair in Conservation Biology at the University of Cambridge and is president of the British Ecological Society.**

Breakfast Briefing Summary

- **Lord Cameron of Dillington (Chair)** opened the meeting. He reminded the group that over 80% of the UK's nitrous oxide emissions come from agriculture and that most of that is from soil. He also raised the issue of low soil carbon stocks in Sub-Saharan Africa and the consequent issues of soil erosion.
- **Professor Dave Reay** started the discussion by setting the issue of reducing emissions from crops in a global context. Population growth is a major global pressure and the challenge of feeding this growing population (projected to be 8 billion by 2025) has led to projections that we will need 50% more food by 2050. Prof. Reay quoted John Beddington's concept of 'The Perfect Storm': an intersection of food security, energy security, water security and climate change challenges.[1] He explained that crop production must be treated as a global issue and is subject to a number of pressures: increased demand due to population growth, land-use conflicts, and loss of productivity due to climate change. Heat tolerance of crops and changes in precipitation will be an issue in the tropics and sub-tropics, and this will affect us in the UK too – as we import 40% of our food. His key point was that we need to

[1] Beddington, J. (2009). Food, Energy, Water and the Climate: A Perfect Storm of Global Events? London. http://www.bis.gov.uk/assets/goscience/docs/p/perfect-storm-paper.pdf

look at mitigation of greenhouse gases across the supply chain. One example was that in Sub-Saharan Africa there are huge post-harvest losses due to water damage, pest damage and a vulnerable supply chain. A second example highlighted the huge potential for reducing food waste in the UK and globally. In later discussions, the potential for supporting the growing of local crop species and varieties was mentioned, such as millet and sorghum, which may be more robust to the effects of climate change.

- **Dr Luke Spadavecchia** provided further policy context, highlighting Defra's role in reporting reductions in agricultural emissions to the United Nations Framework Convention on Climate Change. The UK is an Annex 1 signatory to the Kyoto Protocol, which means that the government has to report emissions from across whole economy on an annual basis, to strict guidelines. Nine to eleven percent of UK greenhouse gas emissions are from agriculture. These figures tie-in well with global estimates suggesting that agriculture contributes 10-12% of emissions. The emissions sources are divided into 6 sectors and agricultural emissions contribute to 3 of these sectors: i) fuel emissions (space heating, drying crops etc.) which contribute 1% or less of the UK's emissions; ii) agriculture's main contribution is from non-CO2 emissions and this amounts to around 9% of national emissions; and, iii) land use and forestry, the parts relevant to agriculture are 'cropland management and emissions' that occur because of conversion to cultivated land, which account for around 2% of UK emissions. There is also a net benefit of around 1% which is due to carbon sequestration in agricultural grasslands. He explained that greenhouse gas emissions from the agricultural sector as a whole in the UK have declined by 20% since 1990, largely as a result of a fall in livestock populations due to CAP reform, diseases and consumer preference (such as an increase in white meat consumption over red meat). With regard to mitigation, Dr Spadavecchia explained that Defra sees sustainable intensification as the best way for the UK to mitigate emissions from cropping. Mitigation of greenhouse gases from agriculture is a devolved area. Defra's current mitigation policy for England centres on an industry led, voluntary scheme aimed at reducing inefficiencies first and foremost. Over 90% of food output is from one third of farms, so there is room to improve the inefficient farms.
- **Mr John Williams** drilled down further into the technical aspects of reducing emissions from crops. While discussion of greenhouse gases usually focuses on carbon dioxide emissions, in agriculture it is nitrous oxide (N_2O) that is the primary contributor to global warming. Nitrous oxide emissions primarily arise from microbial activity following the application of man-made fertilisers, and Mr Williams outlined the importance of good nitrogen management on farms. He explained that nitrogen can be applied as synthetic fertiliser and as manures and slurries and the resultant nitrous oxide emissions were responsible for the majority of greenhouse gas emissions from agriculture. However, nitrogen is crucial for sustaining optimal crop production and Mr Williams explained that the most important aspect of nitrogen management on arable land was application of nitrogen to ensure optimal crop growth without applying too much (emissions efficiency). Any excess isn't used by the crop and is lost to the environment (as gaseous emissions and nitrogen pollution into waterways). He listed factors likely to affect crop growth such as soil structure, soil organic matter content, and ensuring adequate soil pH, potassium, phosphorous and sulphur. Sulphur deposition from air pollution has declined dramatically over the last 20 years as industrial emissions have reduced. So sulphur previously obtained 'for free' now has to be applied and there are increasing instances of sulphur deficiency in crops. Mr Williams moved onto discuss livestock farming – around 50% of the nitrogen added to soils in the UK comes from manures, slurries or grazing returns (manure deposited directly into fields). He explained that maximising their efficient use to attain optimal nitrogen addition would lead to productivity benefits as well as reduced pollution. Reducing nitrogen pollution (gaseous and into waterways) requires investment in farm infrastructure – such as increased storage capacity to enable the manures and slurries to be applied at optimal times (e.g. spring time

during plant growth) and also the use of improved spreading equipment to enable an even spread of manures and slurries to reduce losses to the environment. Mr Williams then outlined some innovative approaches to mitigation; chemical nitrification inhibitors have been shown to be very effective in reducing nitrous oxide emissions from soils (nitrification is a microbial process occurring in the soil which results in nitrous oxide emissions), but practicalities and economics have yet to be fully assessed. There is also potential for acidification of slurries to reduce ammonia emissions and enhance the crop available nitrogen supply from slurry application. Finally, Mr Williams explained that it was important to understand the most appropriate cultivation methods to ensure good soil structure over a range of soil type and moisture conditions. Visual soil assessment plays an important role in identifying the correct cultivation strategies and therefore the spade is an important tool in mitigating greenhouse-gas emissions.

- **Professor Simon Blackmore** explained the exciting possibilities of precision farming, which employs advances in digital technology and engineering to make crop production processes more efficient – and less energy intensive. Small, smart machines are being developed at the National Centre for Precision Farming which can be deployed at any time of the year. Instead of working on improving the 'smartness' of the chemical, the researchers put the chemical into a smart machine to ensure "intelligently targeted inputs", from spraying herbicides at the leaf scale ("micro-droplet spraying") to targeting specific weed species with "weeding robots". They are also developing tractors using Defra funding. These tractors can carry instruments through orchards to measure the natural environmental conditions – such as thermal imaging for deriving irrigation status and use of multi-spectral images from crops to help understand the nutrient status. These approaches can move us towards a more flexible agricultural system; where smaller machines work in smaller fields, which will allow us to overcome the inertia we have in agricultural systems at the moment and will make them more efficient with a smaller environmental impact. Prof. Blackmore wishes to see agriculture overcome machine constraints whereby, for instance, at the moment we can't take out tractors and sprayers to spray weeds when the ground is too soft (wet); but with small weeding robots there is no concern about compaction of soil. In answer to a question about investment Prof. Blackmore explained that they were struggling to find anyone in the UK interested in making such robots. He predicted that it would be an SME start-up company that would get this going and he predicted that China would start making these soon. In the UK, there is some research on robotic strawberry harvesting is being funded through the government's Agri-Tech Strategy and there is some private investment in laser weeding and micro-droplet spraying. Prof. Blackmore explained that there is an issue with finance as the current agricultural machinery manufacturers feel that development of such machines is too disruptive to their business models.
- **Mr Laurence Smith** talked about agroecology – farming systems that focus on the long term protection of natural resources. Examples include use of crop rotations to build soil fertility and field margins to encourage natural predators. Agroecology encompasses practices such as organic farming, conservation agriculture and agroforestry. Lower greenhouse-gas emissions from agroecology systems are mainly due to lower inputs. In particular this is due to the use of clover to fix nitrogen in the soil that can help to avoid or reduce the need for application of synthetic fertiliser and associated manufacturing emissions. In such systems the livestock rely on forage grown on the farm and so reduce need for imported soya. Soya production is a major contributor to emissions from agriculture through land use change. Mixed farms ensure that manures and slurries can be added to arable and horticultural crops, which improve nutrient efficiency on the farm through the creation of synergies between livestock and cropping, and this also avoids stockpiling manures and slurries that can lead to nitrogen pollution. These practices can also build soil carbon levels and recent

evidence has shown higher levels of soil organic carbon on organic farms globally.[2] Studies of large-scale conversion to agroecological methods of farming have indicated that there would need to be more land converted to cultivation as yields under these systems are lower. However, Mr Smith explained that what many of these studies don't consider is the end-use of the product; for example, in high intensity livestock systems you could feed the grain that is fed to these animals to humans, which is more energy and emissions efficient. The Government of France has set out an action plan for the wider development and application agroecological methods. His last point was that agroecology can also offer tools for conventional farms to reduce inputs and improve soil carbon management and that some great results can come from integrating practices and tools from the range of farming practices, both conventional and agroecological.

- **Professor Malcolm Bennett** then explained the potential role of plants in reducing nitrogen applications, through selective breeding for roots which can improve the take-up of soil nutrients. Roots branch to catch nutrients. Researchers are breeding plants to improve root branching; however there is a cost to this with regard to the carbon requirements of plants. However, researchers are looking at varieties of maize in Sub-Saharan Africa which exhibit more root branching, and which double the yield under low nitrogen inputs, but do not have an associated carbon cost as the roots have half the number of cells which respire. The second area he talked about was how the plant modifies its environment. Plant roots pump up to 50% of all carbon captured from photosynthesis into the soil. They exude this carbon to lubricate the surrounding soil, which assists in pushing the roots through the soil. This carbon also feeds microbes which work to improve the soil structure. This has been shown to have a profound effect on denitrification (a process which releases nitrous oxide) and this research is flagged up in the POSTnote. Thirdly, he talked about soil management. Tillage (ploughing) and no- and minimum-tillage practices have dramatic effects on soil carbon and soil structure. Finally, Prof. Bennett predicted that producing genetically-modified cereals with the nitrogen fixing capabilities of legumes is very far in the future (and is possibly unattainable). He explained that fixing nitrogen incurs an energy cost to the plant. He concluded by stating his belief that managing nitrogen had the most potential for mitigation of emissions, followed by breeding for advantageous root architecture, then managing for root exudates and finally genetic modification to enable nitrogen-fixation into cereals.
- **Professor Bill Sutherland** called for people to work outside of disciplinary silos, for example considering how soil management interacts with water management and biodiversity etc. He concluded the session with a call for the better use, assessment and communication of evidence to support decision making by both farmers and policy-makers, as exemplified by the Conservation Evidence website. He highlighted the minimal environmental benefits conferred by Pillar 1 in the Common Agricultural Policy – as the available evidence was not considered. The use of apps was discussed, as increasing numbers of farmers are using them to assist in making farm decisions. Some concern was expressed about the information the apps referenced. This led to the mention of Defra's RB209 fertiliser manual and associated nutrient management tools such as PLANET and MANNER-*NPK* as a great resource for farmers and other land managers to help them plan their fertiliser applications to maximise crop yields and minimise losses to air (nitrous oxide and ammonia) and water (nitrate, ammonium and phosphorus).

---

[2] Andreas Gattinger et al., 'Enhanced Top Soil Carbon Stocks under Organic Farming', *Proceedings of the National Academy of Sciences* 109, no. 44 (30 October 2012): 18226–31, doi:10.1073/pnas.1209429109.

A number of points were raised in the discussion between parliamentarians and speakers:

- It was pointed out that the range of emerging technologies and innovative research presented painted an encouraging picture of how we might meet the challenge of reducing greenhouse gas emissions from crops. A question was then raised as to how we ensure that this research translates into both the creation of appropriate policy frameworks, and into changing farming practices on the ground. Consequently, the group identified a need for genuine knowledge transfer between scientists, policy-makers, and importantly, farmers, both in the UK and abroad to ensure both that the latest research is put into practice, and that researchers are addressing practitioners' most pressing questions.
- Agricultural extension was mentioned a number of times. The lack of agricultural extension in the UK and its positive role in other countries, such as the USA, in educating farmers about how to be more efficient and in communicating the latest research (agricultural extension is a general term meaning the application of scientific research and new knowledge to agricultural practices through farmer education). The privatisation of ADAS was talked about, along with concerns about the provision of extension services generally across Europe (ADAS was originally established in 1946 as the advisory and research arm of the Ministry of Agriculture, Fisheries and Food (MAFF), it was privatised in 1997). It was said that agricultural extension is embedded in Scotland but not in England and Wales.
- In discussion of the potential for GM technologies to assist in mitigating emissions Prof. Bennett explained that some traits, such as pesticide resistance, are controlled by just a few genes, whereas something like nitrogen fixation will require the transfer of hundreds of genes.
- A question was raised about applying minimum and no tillage (ploughing) as some very persistent weeds can flourish under such management practices, such as blackgrass. Prof. Bennett explained that there is currently a research project exploring breeding blackgrass resistant wheat varieties that can out-compete the weed. Prof. Blackmore then talked about the possibilities of micro-tillage. Lord Cameron mentioned that tillage in some parts of the world such as Sub-Saharan Africa can be devastating for soil as it can just blow-away, so micro-tillage would be of benefit there. Dr Spadavecchia then explained that the effects of no-tillage on soil organic carbon are a mixed picture and Prof. Sutherland mentioned a recent review of this practice which concluded that the practice just redistributes the carbon in the soil profile[3] and that once the soil is tilled again the emissions mitigation benefits are lost.
- Dietary change was raised and said to be the 'elephant in the room' with regard to emissions. A question was then asked about synthetic meat and Mr Smith thought it had some potential, but consumer acceptance would be an issue. The link between meat consumption and health messages was then raised. A question was then asked about energy efficiency with regard to grain-fed animals, and reducing the amount of grain fed to livestock was highlighted as an important method to reduce greenhouse gas emissions and land use change associated with imported soya. Mr Smith also told the group that if we can increase forage in the diet of pigs and chickens (studies have shown it can contribute up to 60% of the energy requirement within pig diets) then this could potentially improve the emissions efficiency of the meat.

---

[3] David S. Powlson et al., 'Limited Potential of No-till Agriculture for Climate Change Mitigation', *Nature Climate Change* 4, no. 8 (August 2014): 678–83, doi:10.1038/nclimate2292.