Technological Solutions
for Sustainable Agriculture

Anthea McIntyre MEP

Conservatives in the European Parliament

ECR European Conservatives and Reformists Group

Contents

Foreword by Meurig Raymond *3*

Introduction by Anthea McIntyre MEP *4*

Technological Solutions for Sustainable Agriculture in the EU *6*

Explanatory Statement *15*

Harper Adams Conference *17*

Commission Response *19*

European Parliament Hearing on Sustainable Plant Protection *21*

Creating an Agri-Tech Future at Harper Adams University by Dr David Llewellyn *28*

Acknowledgments *30*





Foreword

Meurig Raymond

Farmers and growers are the basis of an Agri-food industry that forms a hugely significant sector of the European economy. They also manage our countryside, and profitable, productive and resilient farm businesses are essential to deliver a productive farmed environment alongside sustainable food production. These businesses also face major challenges, with pressures on resources, rising costs, extreme weather, supply chain expectations, volatility, recession and regulation. These pressures bring with them a level of uncertainty that can be very difficult for farm businesses to manage. This position is not exclusive to Europe, but our farmers are part of a competitive and complex global system for food, feed and fibre. For European agriculture to be competitive on this global stage, the application and adoption of science, innovation and technology on farm and the use of robust evidence in the legislative process, are absolutely essential.

Farmers and growers are innovators and experimenters to the core, even if they do not always realise it. More sustainable, efficient, productive and competitive farming systems need access to the best knowledge and tools. It is not just innovative 'kit' that is needed but also optimum practices and management, tailored to the particular farming system. Farmers need the right skills and support to adopt new technologies and approaches, and the long-term security to apply them to their businesses.

The data revolution holds significant promise for agriculture. There are great opportunities to address the challenges I've outlined above using digital technologies, harnessing the vast amounts of data already collected during farm operations and across the landscape. We are seeing big changes in how farmers can access data and information to make decisions, and most now use precision tools to some degree. This trend will only keep moving upwards. However, the infrastructure must keep pace. My members are frustrated by poor connectivity, with broadband and mobile networks in rural areas representing a barrier to adoption of new technologies and a limiting factor in improved efficiency.

While funding for fundamental research remains important, there must also be sufficient money invested in applied research and knowledge exchange activities so that the science can have genuine impact on the ground. The key is to get the science translated into commercial practice by farmers, and there is arguably still underinvestment in this area. Knowledge "exchange", not just "transfer", between producers, advisors and scientists is critical. No amount of clever science and fancy widgets will boost productivity if knowledge exchange remains a bolt-on.

This report articulates very clearly the challenge and the scientific and technological solutions. It is vital that policy-making and regulation are firmly based on evidence, using sound science, taking into account the 'innovation principle', and avoiding emotion and political motivations. Legislation must be enabling and fit for purpose. In areas such as crop protection and biotechnology this is unfortunately not currently the case, and there is a real fear from both farming and science communities that this puts us at a disadvantage and hampers innovation.

Meurig Raymond
NFU President

Introduction

Anthea McIntyre MEP

Nothing is more important to mankind's future than agriculture and how we feed an ever-growing number of hungry mouths across the globe.

And nothing is more important to agriculture's future than the serious but sensitive application of new technology, chemical and genetic innovation and the harnessing of emerging digital, biological and physical science.

Consider these facts:

- The global population is estimated to reach 9.6 billion by 2050, meaning there will be around 2.4 billion more people than today.
- At least one third of food produced is wasted, and nearly half in some sectors.
- There is a pressing demand to produce more food which is safe, healthy and nutritious for EU and global citizens in order to deal with malnutrition, obesity, cardiovascular disease and other health problems.
- Availability of land for farming is under pressure as competition mounts from alternative land uses such as urbanisation, industry, tourism and recreation.

So if we are to feed millions more every year in a way that is ecologically and economically sustainable, we need to square the circle that puts farming efficiency at odds with the environment, public health and biodiversity.

The key to achieving that is technology. Not just more technology but more effective, more accessible and more affordable technology.

That is why, after I was re-elected to the the current European Parliament in 2014, I set out to make agri-tech a priority in my work on the Agriculture Committee.

After much preparatory work, the Parliament last year approved my report, titled *Technical Solutions for Sustainable Agriculture*. It covers a range of areas where effective harnessing of innovation will boost productivity while protecting the environment and biodiversity.

It considers applied research, precision farming, genetic diversity, precision breeding, plant protection, skills and better-regulation.

My central theme is that farmers are the major stewards of our environment. They need continued access to innovation, to new technology and to research in order to produce food in a sustainable way so that we can both feed the world and protect the environment for future generations.

The EU and the Member States, academia and industry, breeders, the agro-chemicals sector, farmers and food manufacturers must all work together to improve the translation of research into practice. From lab to farm to fork.

In researching the report I organised a high-level conference at Harper Adams University drawing together expertise from a whole range of relevant sectors – including science, academia, politics, farming, land-management and ecology.





The university's Vice Chancellor David Llewellyn subsequently contributed a paper on creating an agri-tech future - published here on page 28 - which showcases Harper Adams's groundbreaking work on precision farming and innovative engineering.

We also welcomed the expert advice of John Chinn, Chairman of the UK's Centre for Applied Crop Science, on the need for plant protection products and the impact on biodiversity - and his evidence is reproduced in full on page 21 of this report.

This input was crucial. And that is why when I came to consider how best to translate the report into a practical action and policy plan, I decided once again to call together my panel of expert witnesses, this time at the Royal Hotel, Ross-on-Wye.

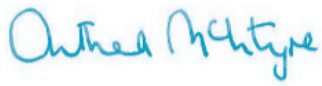
I could not have wished for a better response or for more ideas and focus to be generated in our two short but intense discussions - one covering the issues we should continue to push so long as we remain the EU, the second on what lessons we must learn and our priorities after Brexit.

Increased used of robots and drones, driverless tractors, more-accurate application of pesticides and better rural broadband were among the priorities highlighted. Deteriorating soil quality and reduced nutritional qualities in food were among the challenges flagged up.

This report brings together - in a comprehensive way, I hope - the quality and scope of the recommendations urged. I believe it provides some very practical and sensible pointers to ways in which our collective thoughts and advice can help shape policy and be translated into effective action.

The two pages of acknowledgments at the back tell you all you need to know about the range of our consultation and the collegiate approach we have taken to produce our conclusions.

These contributions were invaluable and I believe that our recommendations can play a major part in pushing the advance and harnessing of technology to the front of the agriculture and policy agendas.



Anthea McIntyre MEP
Conservative – West Midlands Region

Technological Solutions for Sustainable Agriculture Report as adopted by the European Parliament on 7th June 2016

European Parliament resolution of 7 June 2016 on technological solutions for sustainable agriculture in the EU (2015/2225(INI))

The European Parliament,

– having regard to the Treaty on the Functioning of the European Union (TFEU), in particular Articles 11, 114(3), 168(1) and 191 thereof,

– having regard to Council Decision 2013/743/EU of 3 December 2013 establishing the specific programme implementing Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020) and repealing Decisions 2006/971/EC, 2006/972/EC, 2006/973/EC, 2006/974/EC and 2006/975/EC1,

– having regard to Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020) and repealing Decision No 1982/2006/EC2,

– having regard to Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/20053,

– having regard to Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC4,

– having regard to Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides5,

– having regard to Regulation (EU) No 233/2014 of the European Parliament and of the Council of 11 March 2014 establishing a financing instrument for development cooperation for the period 2014-20201,

– having regard to Council Regulation (EC) No 870/2004 of 24 April 2004 establishing a Community programme on the conservation, characterisation, collection and utilisation of genetic resources in agriculture and repealing Regulation (EC) No 1467/942, and to the Commission report of 28 November 2013 entitled 'Agricultural Genetic Resources – from conservation to sustainable use' (COM(2013)0838),

– having regard to Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed3,

– having regard to the Memorandum of Understanding of 14 July 2014 between the European Commission and the European Investment Bank for cooperation in agriculture and rural development in 2014-2020,

– having regard to its resolution of 11 March 2014 on the future of Europe's horticulture sector – strategies for growth4,

– having regard to the 2014 study by Policy Department B: Structural and cohesion policies – Agriculture and rural development, entitled 'Precision agriculture: An opportunity for EU farmers – potential support with the CAP 2014-2020',

– having regard to the 2013 study by Science and Technology Options Assessment (STOA) entitled 'Technology options for feeding 10 billion people';

– having regard to the Commission communication of 29 February 2012 on the European Innovation Partnership 'Agricultural Productivity and Sustainability' (COM(2012)0079),





– having regard to the Commission communication of 13 February 2012 entitled ‘Innovating for Sustainable Growth: A Bioeconomy for Europe’ (COM(2012)0060),

– having regard to the Commission decision of 16 October 2015 on the setting up of the High Level Group of Scientific Advisors (C(2015)6946),

– having regard to the Commission communication of 19 May 2015 entitled ‘Better regulation for better results – An EU agenda’ (COM(2015)0215),

– having regard to its resolution of 17 December 2015 on patents and plant breeders’ rights5;

– having regard to Rule 52 of its Rules of Procedure,

– having regard to the report of the Committee on Agriculture and Rural Development (A8-0174/2016),

A. whereas our societies are facing multiple challenges involving agriculture and must play their part, and whereas the global population is estimated to reach 9.6 billion by 2050, meaning there will be around 2.4 billion more people than today;

B. Whereas on average at least one third of food produced is wasted, and nearly half in some sectors, and whereas one of the most effective ways of meeting this anticipated demand, while not depleting scarce resources, is by harnessing technological solutions to increase production, improve the means of distribution and tackle food waste;

C. whereas there is a pressing demand to produce more food which is safe, healthy and nutritious for EU and global citizens in order to deal with malnutrition, obesity, cardio-vascular disease, etc.; and whereas the EU’s high food quality standards enjoy worldwide recognition;

D. whereas there are many alternatives for land use which compete with farming, including urbanisation, industry, tourism and recreation;

E. whereas agricultural raw materials offer prospects for growth in green chemistry;

F. whereas making farming more sustainable is becoming an ever more important objective for operators, given the need to control costs in order to safeguard incomes, on the one hand, and to respond to the depletion and degradation of natural resources (soil, water, air and biodiversity) on the other; whereas agriculture accounts for 70 % of the world’s fresh water use, and whereas water availability is already a major limitation on agricultural production in some regions of the EU and globally; whereas the use of drinking water in agriculture can be significantly reduced by the effective use of modern irrigation techniques and by growing crops suited to the local climate;

G. whereas nitrogen fertilisers drive high yields, but their manufacture accounts for about 50 % of the fossil fuel energy consumed by agricultural production systems;

H. whereas global energy demand is predicted to rise by 40 % by 2030, and whereas serious thought must now be given to meeting this demand through increased energy efficiency and a secure energy mix that includes renewables; whereas research has shown that shorter agro-food chains can lead to reduced energy inputs with cost and environmental benefits;

I. whereas up to 40 % of global crop yields are lost to plant pests and diseases each year, and whereas this percentage is expected to increase significantly in the years ahead; whereas steps must be taken to prevent this figure from increasing further, including through systemic approaches and adaption of existing production models, and whereas climate change is contributing to this loss and leading to the emergence of ecologically novel plant pests and diseases;

J. whereas global warming is generating extreme weather events that result in droughts or floods that cause substantial damage to the population groups affected and pose severe risks to their food security; and whereas climate resilience in biologically and structurally diverse agro-ecosystems can help to reduce this risk;

K. whereas the EU’s genetic crop potential is not being consistently realised on Europe’s farms, where yields have plateaued in recent years;

L. whereas the diversity and quality of plant genetic resources play a crucial role in agricultural resilience and productivity,

thus being a determining factor for long-term farming and food security;

M. whereas closing the 'yield gap' poses a particular problem for the sustainable agriculture research agenda;

N. whereas precision farming involves the use of automation and other technologies to improve the precision and efficiency of key agricultural management practices, by using system-based approaches to collect and analyse data and optimise interactions between the weather, soil, water and crops, and whereas precision farming is ultimately designed to lower pesticide, fertiliser and water use while improving soil fertility and optimising yields;

O. whereas soil science shows us that healthy, living soils nurture and protect crops via beneficial species that defend against pathogens and pests and also provide plant crops with nutrients and water in exchange for sugars in plant root exudates; whereas agricultural practices may impact negatively on the biological, chemical and physical quality of soils, with consequences including soil erosion, degradation of soil structures and loss of fertility;

P. whereas the benefits of innovative technologies should not be limited to one type of agricultural practice and need to be applicable to all farming types, whether conventional or organic, livestock or arable, or small or large-scale;

Q. whereas the number of pesticide active substances was reduced by 70 % between 1993 and 2009, while the presence of pest outbreaks has increased in the European Union; whereas the approvals process, including the criteria for defining active substances and for new substances constituting an alternative to plant protection products, is becoming increasingly challenging for EU agriculture and its citizens; whereas there is a need to urgently address the lack of active substances for minor uses;

R. whereas insufficient crop protection solutions for specialty crops endangers the quality, diversity and sustainable production of food crops in the EU, which has a direct impact that has been estimated to amount to more than EUR 1 billion, including production loss and additional costs for farmers;

S. whereas short-term cycles in policy and research funding priorities can be detrimental to skills, infrastructure and innovation in agriculture, and whereas priority should be given to the efficient transfer of research findings from science to farmers, and to research programmes focused on improving the sustainability of agriculture, reducing production costs and increasing competitiveness;

Precision Farming (PF)

1. Notes that the agriculture sector has always relied on new farm business models and practices that include new techniques and production methods to increase outputs and adapt to new and changing circumstances; emphasises that ecosystem services, such as nutrient cycling, are of central importance to agriculture, and that some functions, such as carbon sequestration, go beyond food production;

2. Is convinced that innovation has the potential to contribute to achieving sustainable agriculture in the EU, and considers PF technologies to be particularly important for maintaining progress, but recognises the limits to its widespread adoption, including the reliability, manageability and limited knowledge of this technology and its adaptability to all farm types and sizes;

3. Takes the view that the principles underpinning PF can generate significant benefits for the environment, increase farmers' incomes, rationalise the use of agricultural machinery and significantly increase resource efficiency, including use of water for irrigation; therefore encourages the Commission to promote policies to stimulate the development and uptake of precision farming technologies for all farm types, irrespective of their size and production, whether crop and/or animal farming;

4. Highlights the particular need for the innovation process in PF to solve the problem of 'high cost' in the development and use of some PF technologies, and for farmers and the whole supply chain to be actively involved in the development of these technologies in order to ensure clear benefits at farm level and to help farms become more resilient;

5. Is convinced that economic development and sustainable production are not mutually exclusive and are achievable through innovation; stresses the need to support innovation in technology and governance by providing regulatory coherence, clarity and room for entrepreneurship, and urges the Commission to ensure that innovation is explicitly taken into account in forthcoming reviews and reforms of relevant legislation; highlights the fact that European agriculture is able to produce high-quality and high-added-value products together with profitable, knowledge-based solutions in order to feed a growing and more demanding world population;





6. Calls on industry, the Commission and the Member States to work in partnership to improve the performance and adaptability of robotic and other PF techniques in order for research funding to be used effectively in the interests of agriculture and horticulture;

7. Further calls on industry to exploit opportunities arising from innovation to develop PF capabilities which are accessible to all, thus empowering people with disabilities, promoting gender equality and broadening the skills base and employment opportunities in rural communities;

8. Welcomes the inclusion of PF robotics in the newly published Horizon 2020 work programme for 2016-2017, but regrets that proposals under this call do not require a multi-actor approach, which may mean that farmers are excluded from innovative developments; emphasises that PF can reduce resource use by at least 15 %; encourages the uptake of precision agriculture that provides new whole-farm management approaches, such as GPS/GNSS-technology-driven machinery and remotely piloted aircraft systems (RPASs);

Big data and informatics

9. Points out that the farming industry, like all other sectors of the economy, is undergoing a process of change; emphasises that modern farming was made possible only by the acceptance of scientific and technological progress, and that digital advances likewise offer the possibility of further development in the farming sector;

10. Emphasises that the collation and analysis of large integrated data sets has the potential to drive innovation in agriculture and is particularly useful in addressing and developing an efficient and sustainable food-chain that will benefit farmers, the economy, consumers and the environment; calls on the Commission and the Member States to remove the barriers to integrating complex and fragmented ICT systems, stimulating investment and covering training costs, and to make the necessary facilities more accessible to agriculture;

11. Welcomes the progress made by the European Space Agency (ESA) in developing PF; takes the view that the ESA's Sentinel 2B satellite, which is to be placed in orbit in late 2016, may give a clearer picture of the amount of land taken up by crops and forests, with the result that agricultural policies can be implemented more effectively, use of resources rationalised and harvesting periods optimised; calls on the Commission and the Member States to support the use of satellite-based systems;

Soil, water and nutrient management

12. Recognises soil degradation to be a major constraint in agricultural production, and calls for greater ambitions and efforts to improve soil and water management practices, particularly in light of climate change; welcomes the development of controlled traffic farming (CTF) technologies, which reduce soil damage caused by overworking of the land, and also welcomes recent efforts to integrate high-resolution remote sensing technologies into organic farming; encourages the Commission to quantify the environmental and production benefits of these new technologies and to ensure awareness, knowledge and technology transfer;

13. Calls for farmers to be included in the design, testing and dissemination of soil nutrient mapping technologies in order to help improve their effectiveness;

14. Regrets that the efficiency of nutrient use in the EU is very low, and stresses that action is needed to improve the efficiency of nitrogen (N), phosphorous (P) and potassium (K) use, in order to reduce their impact on the environment and improve food and energy production; calls for targeted research (and its applied use) to improve nutrient efficiency monitoring and the further optimisation of variable rate technologies;

15. Agrees that the development of new technologies and innovative agricultural practices could contribute significantly to reduced use of plant protection products, fertiliser and water, and also combat soil erosion;

Genetic diversity

16. Is of the view that the loss of genetic diversity over the past century threatens food/feed security and undermines EU policies on sustainable agriculture, biodiversity protection and climate change mitigation strategies; believes that monoculture and a lack of crop rotation is a major factor in this loss; considers all plant varieties and animal species, including landraces, their wild and semi-wild relatives, and old and pioneer varieties to be essential for maintaining genetic diversity, breeding programmes and the production of sufficient, nutritious and healthy food;

17. Takes the view that EU regulation should enable farmers and breeders to make the best use of such genetic resources to safeguard biodiversity and innovation in developing new varieties; stresses that EU regulations should always aim not to undermine such innovative processes by putting an unnecessary administrative burden on breeders and farmers;

18. Stresses the need for greater dialogue between genetic banks, private and public plant research, breeders, end users and all other actors involved in the conservation and use of genetic resources, in order to build resilience and meet the challenges of sustainable farming throughout Europe;

19. Highlights the previous support from DG Agriculture and Rural Development (AGRI) and DG Research and Innovation (RTD) for genetic resource conservation activities, for example the European Native Seed Conservation Network (ENSCONET), but calls for successor programmes to continue the support for crop and livestock genetic conservation activities, especially the in-field use of genetic resources through on-farm measures;

20. Stresses the importance of opening up the conservation of genetic resources to a greater diversity of plant and animal species and for the research funding in this area to result in technological improvements for agriculture and horticulture;

21. Calls on the Commission to put forward proposals for the European strategy for the safeguarding of genetic diversity in agriculture provided for in Measure 10 of the EU Biodiversity Strategy for 2020;

22. Recognises the need to use germplasm collections responsibly in order to identify and characterise traits for resource use efficiency, pest and disease resistance and other attributes conferring improved quality and resilience; considers that this requires greater emphasis to be placed on phenotyping, which is a particular bottleneck for many crops;

23. Notes that the most effective way to maintain genetic diversity in agriculture is by using it in vivo; notes that of the three DUS criteria (distinctiveness, uniformity and stability) applied to official EU seed catalogues, uniformity and stability are not natural characteristics in genetically diverse plants; notes that adaptation to climate change is dependent upon high genetic variation; notes the increasingly concentrated seed markets and decreased variation per variety; encourages the role played by farm seed systems and exchanges in empowering farmers, and recognises participative breeding as a long tradition of innovation in rural communities;

24. Recognises the need to maintain and use genetic resources for long-term food security and to broaden the genetic base of modern plant and animal breeding programmes; recognises that organic farms face a shortage of new varieties that are resistant to pests and diseases and which could be cultivated without the use of plant protection products; supports the concept of access and benefit sharing, but urges implementation of the Nagoya Protocol, under Regulation (EU) No 511/2014, and Implementing Regulation (EU) 2015/1866, so that breeders are not deterred by the complexity and cost arising from using wild material to introduce new traits such as pest and disease resistance, nutritional quality and environmental resilience; notes that this should be done without disempowering rural communities that have stewarded species and bred varieties throughout the years;

25. Considers it essential to maintain and develop the performance of local breeds, given their ability to adapt to the characteristics of their native environment, and for farmers' rights to breed plants autonomously and to store and exchange seeds of different species and varieties to be respected, in order to ensure the genetic diversity of European agriculture;

26. Recognises the need to support suitable crop rotations that remain profitable for farmers; also highlights the need to maintain a range of suitable crop protection tools for a broad range of crops, in addition to genetic resources; stresses that, without such tools, the diversity of crops that can be produced profitably will be severely impacted;

Precision breeding

27. Supports the need for continuous progress in innovative breeding through the application of safe and proven techniques aimed at increasing not only the range of pest- and disease-resistant traits in crops, but also the range of food raw materials with nutritional and health-beneficial characteristics on the market;

28. Considers it important to ensure sustained support for development and use of future technological tools which may allow breeding to successfully address the societal challenges ahead;

29. Considers it timely for the Commission to publish the final report of the 'New Techniques' working group and to use its





scientific findings as a basis for, inter alia, clarifying the legal status of the breeding techniques currently under scrutiny and to use sound legal analysis in its deliberations;

30. Encourages open and transparent dialogue among all stakeholders and the public on the responsible development of high-precision, innovative solutions for breeding programmes, including on its risks and benefits; notes that this will require efforts to raise awareness and understanding of new techniques among farmers and the general public; calls on the Commission to ensure that consumers and farmers are sufficiently educated in new and emerging breeding techniques so as to ensure that an open and informed public debate can take place;

31. Expresses concern at the recent decision of the Enlarged Board of Appeal of the European Patent Office (EPO) of 25 March 2015 in Cases G2/12 and G2/13;

Plant protection products (PPPs)

32. Stresses the urgent need to review the implementation of the regulatory framework for PPPs and to develop a coherent, efficient, predictable, risk-based and scientifically robust assessment and approvals system; considers it important to reduce farmers dependence on pesticides as much as possible, noting that production of food and feed operates in a competitive, international environment; considers it important to develop PPPs which are cost-effective, safe to use and environment friendly;

33. Welcomes the 2016 Commission Work Programme REFIT initiatives which commit the EU to carrying out an evaluation of Regulation (EC) No 1107/2009 and Regulation (EC) No 396/2005; stresses that the REFIT process must not lead to the lowering of food safety and environmental protection standards;

34. Calls on the Commission to include in its report to Parliament and the Council options for amending and improving the current legislation, and in particular on the functioning of mutual recognition of authorisations and the zonal evaluations process;

35. Underlines the concern that the zonal authorisations system is not functioning, owing to the continued use of outdated national authorisation methodologies, and calls on the Commission to harmonise the approval system to ensure mutual recognition of products across the Member States in the zones identified in Regulation (EC) No 1107/2009;

36. Welcomes the latest Integrated Pest Management – European Research Area Network (IPM-ERANET) and the new coordination platform for 'minor uses', but considers that the platform could be better exploited to cover research and innovation with a view to addressing the lack of crop protection solutions for minor use and speciality crops;

37. Highlights the importance of transparently assessing the impacts of active substances with a view to ensuring sustainable agriculture in line with EU law, and of comprehensively evaluating the risk and hazards associated with the use of products, and recalls that the precautionary principle should be used when the degree of uncertainty is too high to ensure public health or good agricultural and environmental conditions;

38. Calls on DG Health and Food Safety (SANTE) to establish clear criteria for defining low-risk active substances for the development and use of low-risk pesticides, while considering evolving scientific knowledge and ensuring that the objectives of health and environmental protection are met, and to ensure that safety data are present for the criteria applied for all potential low-risk substances;

39. Takes the view that low-risk substances, including non-chemical alternatives to PPPs such as biological controls, should be given priority for evaluation by the rapporteur Member States and the European Food Safety Authority (EFSA) in order to help meet the aims of Directive 2009/128/EC regarding integrated pest management and the sustainable use of pesticides, especially for product use on minor and speciality crops;

40. Stresses that farmers need to have a bigger toolbox at hand to protect their crops and to decide which measure will best protect their crops; therefore encourages wider use of various alternatives to traditional pesticides, including biopesticides, as a component of integrated pest management, and calls for more efforts to be made to develop more cost-effective alternatives by supporting field research into and more demonstration of non-chemical alternatives and low-risk measures and pesticides which are more environment friendly;

41. Notes that biological controls are methods of protecting crops based on the use of living organisms or natural substances and could reduce the use of traditional pesticides and contribute to better plant resilience;

42. Calls on the Commission to come forward with an action plan and to set up an expert group in order to work towards a more sustainable pest management system; highlights the potential of a pest management system that improves the interaction between plant breeding efforts, natural combat systems and pesticide use;

43. Regrets the slow progress of the Member States and the Commission in respectively implementing and evaluating implementation of IPM and Directive 2009/128/EC;

Skill development and knowledge transfer

44. Recognises that the development of agri-related technologies requires a multitude of specialist skill sets and knowledge that are transdisciplinary in approach – these include, but are not limited to, general plant, animal and environmental science, physiology and engineering;

45. Regrets the increasing skill shortages in many of these professions, and calls on the Member States to work in partnership with industry, research institutions and other relevant stakeholders in the design of their next rural development programmes, including European Innovation Partnerships (EIPs), with a view to identifying opportunities to support skill development and knowledge transfer in these areas, including by means of training and apprenticeships for young farmers and new entrants;

46. Calls on the agricultural technologies sector to improve coordination and integration of on-farm demonstrations and use of demonstration and monitor farms with a view to sharing best practice at regional, national and European level, using currently available or new programmes, initiatives or resources;

47. Recognises the potential that precision farming and digital technology integration can have in making agriculture more attractive for young farmers and creating new opportunities for growth and employment in rural areas; believes that investing in the development of these technologies may foster generational change in farming;

Research and funding priorities

48. Recognises the long-term challenges associated with sustainable agriculture and horticulture, and calls on the Commission and the Member States to develop a long-term investment plan, assigning priority to a sectoral approach, with continuity of funding, for basic and applied research, and asks the Commission and the Member States to improve training for specialists in sustainable agriculture, and to ensure that expert consultation is available;

49. Considers that the plan should include cost-effective solutions and be applicable to small-scale producers, rural areas and outermost and mountainous regions; emphasises that farmers are the major stewards of the environment in Europe and need continued access to innovation and research, enabling them to produce food, feed and other products in a sustainable and more cost-effective way, while protecting the environment for future generations and enhancing biodiversity and ecosystem services;

50. Welcomes the progress made in applied research in recent years, but calls for greater efforts to guarantee knowledge transfer to end users and to involve farmers and other users of agricultural technologies and products, including small farms;

51. Calls for the European Innovation Partnership for competitive and sustainable agriculture, contained in the second pillar of the CAP, to be stepped up in order to create partnerships of innovative actors, including all farmers, and in particular small-scale farmers, further away from European decision-making centres;

52. Notes that, in Member States where public-private partnerships are used intelligently, there has been a greater shift towards applied research and a higher involvement of end users;

53. Considers it essential for the Commission and the Member States to develop projects which focus on the development of more resource-efficient agricultural practices and crop varieties, including locally specialised varieties, aimed at the conservation and improvement of soil fertility and nutrient exchange, especially given the increasing scarcity of water availability and certain key components of fertilisers such as phosphate; calls on the Commission to prioritise investment in the circular economy and climate-smart farming practices, with adequate funding incentives for research and uptake by farmers; underlines that the merits of aquaponics, closed loop nutrient cycling, agro-ecology, including agroforestry, conservation agriculture and sustainable forest management, sapropel, short feed chains, pasture-based grazing and low-input production should be duly evaluated, divulged and incentivised;





54. Also considers it essential for the Commission and the Member States to develop innovative projects for producing non-food products (bio-economy, renewable energy, etc.) and services with a view to developing a more resource-efficient agriculture industry (better use of water, energy, food for crops and animals, etc.), and one which is more autonomous;

55. Notes that, throughout much of the EU, independent or publically-funded centres for education, training and innovation in agriculture have declined or do not adequately cater for transdisciplinary approaches in emerging fields such as agricultural engineering; recognises that in some Member States farmers' qualifications are still limited, which makes access to, and the application of, new technologies more difficult, and therefore calls on the Commission to draw up a European plan for investment in technical or higher-level agricultural training and education;

56. Welcomes the recently launched European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), which aims to link research and practical farming, and calls on the Commission to play an active role in boosting coordination at national and cross-border level to promote an explicit innovation agenda linked to Horizon 2020 and to guarantee adequate knowledge transfer to end users;

57. Encourages the Commission and the Member States to do more to raise public awareness of the value of farming in the EU, and to develop trans-European centres for agricultural innovation that would demonstrate and enable appropriate access to innovative new technologies, sustainable agriculture, food security and sovereignty;

58. Stresses that the activities of these centres should enable access to new technologies not only for sustainable agriculture but also for sustainable rural development by working within communities, with rural SMEs, cooperatives and producer organisations; underlines that they should be transparent and open to the general public and farmers, and should have a trans-sector approach, fostering dialogue among sectors that may be impacted by innovation in different ways;

59. Urges the Commission to ensure that, alongside technological and scientific innovations, traditional techniques and farms can continue to flourish, given that these are an immense asset, being a source of cultural, rural, historical and tourism diversity, and provide a livelihood for numerous European small-scale farmers in a whole variety of regions;

60. Calls on the Member States to make better use of the financial instruments created under the joint Memorandum of Understanding between the Commission and the European Investment Bank in respect of agriculture and rural development for the period 2014-2020;

61. Emphasises the added value associated with these instruments, especially in terms of leverage effects and loan guarantees aimed at boosting the implementation of the sustainable agriculture and forestry research agenda, including Societal Challenge 2 of Horizon 2020; cites, in particular, their usefulness for reducing the investment needs and risks for farmers wishing to adopt expensive PF technology and methods;

Keeping Europe at the centre of scientific development and innovation

62. Notes that rural areas, including outermost and mountainous regions, are more exposed to actual and potential climate change, which makes them less attractive and more susceptible to aging populations and depopulation; recognises that agriculture must be allowed to adapt to meet changing circumstances using all available technological solutions to ensure that farmland is used more sustainably;

63. Notes that modern technologies in agriculture and a broader land use sector can help these sectors contribute fairly to global climate change mitigation efforts; in this context, highlights the need to broaden the definition of 'productive agriculture' and to fully support and respect those farming lands which provide public goods in climate mitigation and carbon sequestration, including agro-ecological farming;

64. Regards it as essential to preserve farmland in areas such as mountainous and peripheral areas in the Union, and backs all action to ensure that the mainly small-scale holdings there also have access to high technology tailored to their needs;

65. Considers it essential that reasonable EU regulation, oriented towards consumer safety and health and environmental protection, based on independent, peer-reviewed science, enables EU farm produce to be competitive and attractive on the internal and world markets, and calls for that principle to continue to hold good;

66. Notes in particular the high cost, long timescales and commercial and legal uncertainty of bringing new technologies

and sustainable products to market under current EU regulations; notes that these facts are even more evident in the outer-most regions, remote rural areas, less favoured areas and mountainous areas;

67. Urges the Commission to utilise and enhance all the characteristics of the outer-most regions by carrying out pilot projects in the field of technological and scientific innovation aimed at reducing their natural disadvantages and, given their small scale, the difficulty of gaining access to and applying the latest scientific and technological developments;

68. Calls on the Commission to improve its regulatory framework in line with the principles of Better Regulation so as to ensure timely, efficient and effective decision-making procedures, which could contribute to technological development in the EU;

69. Calls on the Commission to use its new Scientific Advice Mechanism (SAM) to refine a regulatory framework which places greater emphasis on risk-based and independent scientific evidence when assessing risks, hazards and benefits in the adoption or non-adoption of new technologies, products and practices;

70. Notes broad support for the adoption of the innovation principle, which would require EU legislative proposals to be fully assessed in terms of their impact on innovation;

71. Calls on the Commission to take more wide-ranging action in the field of scientific cooperation at international level, with a view, inter alia, to intensifying the exchange of information and identifying development opportunities;

72. Instructs its President to forward this resolution to the Council and the Commission.





Explanatory Statement

To accompany the draft report to the Agriculture Committee, this Explanatory Statement set out the basis and the justification for the proposals in the report.

As the global population rises, satisfying the demand for healthy food and optimal nutrition is one of the biggest challenges facing the world. Food demand is expected to increase by 70% by 2050. Shrinking land availability, environmental loss and degradation, shortages of water, increased energy demand, and the emergence of new pests and diseases are placing considerable pressure on our natural environment. The result is that farmers are finding it increasingly challenging to produce food in a sustainable way.

Technological innovation is a vital part of the solution. Agricultural technologies, in particular, have the potential to make farming more productive and more sustainable. Farmers recognise and appreciate this. In fact, many see technology - genetic, mechanical and increasingly digital- as the only realistic way of meeting the present challenges.

The EU should become a world leader in agricultural technology, innovation and sustainability. This report is about ensuring that Europe has a vibrant agricultural sector developing a wide range of innovations and technologies across all farming types whether conventional, organic or otherwise. We must ensure that the benefits of technological innovation are available to all our farmers. Finding solutions that work on a small scale in rural communities is equally important to addressing the challenges facing many of our large-scale farmers.

The need to improve productivity, competitiveness and environmental performance is not just about economics. With about 805 million people in the world suffering from chronic malnourishment and almost all of these living in developing countries, Europe surely has a moral obligation to optimise agricultural output and to increase production whilst doing this in the most sustainable way.

Whilst global concern over food and environmental security has brought a new focus to public sector R&D in recent years, European agriculture continues to trail behind many of its international competitors. Only sustained and prioritised investment in the research base will reverse this trend.

The starting point has to be targeted investment in applied and translational research. Not enough research is commercialised, so farmers are unable to take advantage of the opportunities that new technology and innovation provides. Similarly, where agricultural technologies are being developed, not all of these technologies are meeting farmers' needs, either because the technology has yet to be optimised or adapted to local farming conditions, or because it is capital intensive and lies out of reach for the small farmer.

Whilst farmers and scientists play different roles in the innovation process, improved outcomes can only be achieved with both parties working more closely together. Farmers are the end users of production and management technologies and the actors in the supply chain developing these technologies must tap into their practical experiences. Similarly, where farmers encounter a particular challenge in the field, they should be able to directly access scientists and make use of basic research to help find solutions.

The EU and the Member States, academia and industry including breeders, the agro-chemicals sector, farmers and food manufacturers, must all work together to improve the translation of research into practice, from lab to farm to fork. This will allow Europe to unlock a new phase in agricultural innovation.

Recent investments and new funding priorities at Member State and EU level offer encouraging signs. The Horizon 2020 Framework Programme is the EU's biggest EU Research and Innovation programme ever, with some 80 billion euros of funding available over 7 years.

New investment is also taking place in the Member States. In the UK for example, the British Government is investing in a new 'Agri-Tech' Strategy, which aims to make the UK a world leader in agricultural technology, innovation and sustainability. This strategy is now underway and includes a £70 million investment in an Agri-Tech Catalyst to help accelerate the

commercialisation of agricultural research, and a further £90 million to establish Centres for Agricultural Innovation to support advances in sustainable agriculture.

Key to making all this happen will be to secure the appropriate skills, and to attract the right talent and expertise into the industry. The research skills needed to support the sector are rapidly changing and there is now a real risk of higher skills shortages in agronomy and plant pathology as many of the experienced professionals in these niche areas are nearing retirement. Throughout much of Europe, centres for education, training and innovation have declined and need to be revitalised, particularly in the emerging field of agricultural engineering. In short, the EU and the Member States must strive to make the Europe's agriculture sector more attractive to new entrants, either in farming, research or technology development. Furthermore, the Member States need to work more closely with industry to change the negative perceptions of the sector, as a low-skill, low-technology industry, so that agriculture can attract the skills required.

Creating a regulatory environment which is more innovation-friendly and ensuring that EU regulations do not act as barriers to innovation is also very important. Without a supportive regulatory regime, European industry will relocate to more dynamic markets. All too often, EU legislation places restrictions on products and technologies without adequate evidence of risk. EU legislation must be evidence-based in order to encourage innovation.

Most farmers and landowners are small businesses and minimising the administrative burden on these SMEs is vital. Margins in the agricultural sector are small and extra costs threaten the survival of some small farming operations.

Finally, the long term challenges of sustainable agriculture should be met with a joined-up approach from the Commission and Member States to ensure support for technological innovation, a regulatory framework that is risk based, underpinned by scientific evidence, continuity of basic and applied research and the development of agri-related skills.





Harper Adams Conference

To ensure that the report reflected the perspectives and priorities of those involved in Agri-technology, the initial draft was presented to a conference at Harper Adams University on 15th November 2015, where farmers, growers, academics, industry and government representatives, scientists, breeders and producers were all invited to contribute ideas. Many of these were added to the initial draft and some later formed amendments:

ECHA and EFSA should be referenced in relation to the REFIT programme, particularly in relation to the paper “Guidance on the Assessment of Exposure for Operators, Workers, Residents and Bystanders in Risk Assessment for Plant Protection Products”.

The report should call for the functioning of the Mutual Recognition system to be improved and for Mutual Recognition to be obligatory unless there are unacceptable environmental effects or different GAPs, (Generally Accepted Practices). Also Zonal evaluations should use the same methodologies and interpretations on environmental effects.

Phenotyping should be included in the text. There is a need to utilise germplasm collections to identify and characterise traits for resource use efficiency, pest and disease resistance and other attributes conferring improved quality and resilience.

Resistance to pesticides and to antibiotics should be emphasised in the report. This relates to maintaining a diversity of PPPs, it is unwise to rely too heavily on one or two methods of control. There should be at least 4 modes of action available for each pest/disease etc. With regard to antibiotics for livestock, it is important to find ways of reducing reliance on the antibiotics that are also used for humans.

The inclusion of PF robotics in the newly published Horizon 2020 work programme (2016-2017) should be welcomed in the report. However, it should be regretted that the proposals under this call do not require multi-actor approaches and thus will not access innovative approaches developed by farmers.

Previous support from DG Agri and DG Research for genetic resource conservation activities should be recognised. The text should call for the launch of successor programmes to continue support for crop and livestock genetic conservation activities in order not to lose the significant EU wide dialogue and momentum gained.

Agriculture is most directly affected by climate and is exposed to both actual and potential climate change. It is important that agriculture is allowed to adapt to meet changing circumstances using all available technological solutions.

Precision livestock farming should be included in the PF section, ensuring that PF is seen as applying to all aspects of agriculture, not just crop/horticultural production.





Commission Response

Follow up to the European Parliament resolution on technological solutions for sustainable agriculture in the EU, adopted by the Commission on 4 October 2016

The resolution lists a number of challenges and opportunities for agriculture:

Precision farming

Precision farming technologies offer many opportunities. The Commission is encouraged to promote the uptake. In this context the Commission is urged to include innovation in any forthcoming review or reform.

Big data and informatics

The Commission and Member States are called upon to remove barriers to integrating fragmented ICT systems. The resolution welcomes the development of satellite-based systems.

Soil, water and nutrient management

The resolution welcomes controlled traffic farming technologies (tramlining) to reduce soil damage and asks for targeted research to improve nutrient efficiency.

Genetic diversity

Farmers and breeders should be enabled to make best use of genetic resources. The EU Regulation "should aim not to undermine such innovative processes". The resolution asks for continued support for crop and livestock genetic conservation activities, especially in the in-field use of genetic resources through on-farm measures. The Commission is asked to propose a European strategy for the safeguarding of genetic diversity in agriculture.

Precision breeding

The resolution supports the need for continuous progress in innovative breeding. The Commission is asked to clarify the legal status of the new breeding techniques. The report encourages open and transparent dialogue among all stakeholders and the public on the responsible development of high-precision, innovative solutions for breeding programmes, including on its risks and benefits. The Commission is asked to ensure an open and informed public debate on emerging breeding techniques.

Plant protection products (PPPs)

The need to review the implementation of the regulatory framework is stressed. The resolution welcomes the latest Integrated Pest Management research network. The Commission is asked to set up an expert group to work towards a more sustainable pest management system.

Skills development and knowledge transfer

The increasing skill shortages in many agriculture relevant fields are regretted.

Research and funding priorities

The resolution asks for more attention for basic and applied agricultural research. It welcomes the progress made in applied research in recent years but calls for greater efforts to guarantee knowledge transfer. It calls for the EIP to be stepped up in order to create partnerships of innovative actors.

Keeping Europe at the centre of scientific development and innovation

It is considered essential that emerging technologies continue to be developed in the EU and that they are not “stifled by unnecessary and burdensome regulation”. The resolution notes the support for the adoption of “the innovation principle” which would require EU legislative proposals to be fully assessed in terms of their impact on innovation.

Finally, the Commission is called upon to take more wide ranging action in the field of scientific cooperation at international level.

Response to requests and overview of action taken, or intended to be taken, by the Commission:

On many issues the Commission largely shares the concerns of the Parliament as expressed in the resolution. Precision farming and the use of big data in agriculture will create many opportunities. The Commission supports developments in this area via European Innovation Partnership (EIP) network activities (focus group precision farming, seminar data driven new business models in agriculture) and research activities (agriculture pilot Internet of Things). The Commission will continue its efforts in this area.

The Commission shares the wish to step up efforts on knowledge transfer and the use of new scientific knowledge. New elements have been introduced in Horizon 2020 to assure that research responds to the sector’s needs. New instruments like thematic networks and multi-actor projects assure the close involvement of the sector from the start of the research projects.





European Parliament Hearing on Sustainable Plant Protection

Jim Nicholson MEP, Anthea McIntyre MEP, John Chinn and Julie Girling MEP

As a result of pressure from our European Conservatives and Reformists Group, the Agriculture and Rural Development Committee of the European Parliament held a Public Hearing on 'Sustainable Plant Protection – Opportunities and Challenges for the Agricultural Sector'. This took place on 20th March 2017 in Brussels.

The ECR put forward the name of John Chinn, Chairman of the Centre for Applied Crop Science as a keynote speaker. John spoke particularly on the need for Plant Protection Products and the impact on biodiversity. This is the transcript of his presentation.

Good afternoon Ladies and Gentlemen.

My name is John Chinn and I am a partner in a family farm in the UK where we grow asparagus, blueberries, green beans, potatoes, wheat, oilseed rape, rhubarb and a small vineyard.

I am here this afternoon in my role as Chairman of the Centre for Applied Crop Science. The Centre seeks to understand problems associated with crop health and protection which are challenging agricultural production and then engage with Research Scientists to find solutions. Appropriate and innovative use of Plant Protection Products is central to our work.

The world population of 7.5 billion people is forecast to increase to 10 billion by 2050. The great challenge of the 21st century is to produce more agricultural goods from the same area whilst protecting biodiversity.

25% of the European landscape is used for the production of permanent and arable crops, providing a livelihood for 12 million farmers and workers and helping to feed the EU population of 510 million people. We must eat, therefore we must farm.

The UN Food & Agriculture Organisation states that 'without crop protection tools farmers could lose as much as 80% of their harvests to damaging insects, weeds and plant diseases'.

Plant Protection Products combat plant pests which can be animals, plants or pathogens (such as fungi, bacteria or viruses) that have the potential to compete with human interests by inhibiting the cultivation of food and feed. Weeds may also be poisonous to humans and animals and pathogens such as Fusarium moulds, which are the cause of some of the most severe fungal diseases in European crops, produce toxic secondary metabolites called mycotoxins. These mycotoxins can cause chronic and sometimes fatal effects on animals and humans. The relatively stable molecular structure of mycotoxins allows them to survive the transition from field to fork. The use of Plant Protection Products to control injurious plant pests can bring a direct benefit to human and animal health.

Agricultural biodiversity includes farmed crops, livestock and all organisms that live within or pass through the agricultural environment, notably including pollinators and soil organisms. Soil is home to one of the richest, most complex biological communities on Earth. The soil organisms that inhabit the world beneath our feet are vital for maintaining balanced ecosystems, healthy soils, climate control and agricultural production. The main alternative to chemical weed control involves ploughing to bury weeds or some other form of tillage. Such disturbance of the soil damages the ecosystem and degrades the soil structure. It also introduces large quantities of atmospheric oxygen into the soil; this oxygen combines with organic matter in the soil to release the greenhouse gases, carbon dioxide and nitrous oxide at the same time reducing the organic matter content of the soil. The Centre for Applied Crop Science has state of the art facilities at Cranfield University for improving our understanding of soil ecosystems but for now we need to protect soil ecosystems by encouraging minimum tillage farming; such farming is dependent on Plant Protection Products, especially glyphosate.

The EU approval process for Plant Protection Products is one of the most stringent in the world. It currently takes over eleven years, requires an average of 200 scientific studies and costs in excess of 220 million euros to bring a product to the

EU market. This rigorous testing, combined with farmers' commitment to responsible use and stewardship, ensures that products are safe for human health and the environment. It does, however, result in challenging shortage of active ingredients for use on minor crops such as fruit and vegetables. A plant protection product is expected to meet the requirement of having 'no unacceptable effects on the environment' this includes consideration of 'its impact on biodiversity and the ecosystem'. EU processes are designed to manage and minimise potential negative impacts resulting from the application of pesticides. To help this process The Centre for Applied Crop Science is preparing to build a mesocosm near York in the UK. The mesocosm is an outdoor experimental system that examines the natural environment under controlled conditions. In this way mesocosm studies provide a link between field surveys and highly controlled laboratory experiments. The proposed mesocosm includes controlled watercourses and other features to record impact on field edges.

The EU process of plant protection registration assesses toxicity, hazard and risk. Toxicity is the degree to which a substance can damage a living organism, which is an intrinsic property of any compound. If the dose is large enough, any compound can be toxic to humans or the environment. It is notable that sodium chloride (table salt) has double the toxicity of glyphosate and copper sulphate (used as a fungicide in organic farming) has a toxicity nearly 200 times greater than glyphosate.

As a potato farmer, I am acutely aware of the threat to our industry from Potato Cyst Nematodes (abbreviated to PCN). 48% of potato growing land in the UK is infected with PCN which can reduce yields by up to 80%, costing the industry 32 million euros a year. PCN cysts can survive in the soil for 20 years making it a particularly challenging pathogen to control. The EU approval for the only remaining nematacides to control PCN is up for renewal by 2020. The nematicides are toxic chemicals but because they are applied direct into the soil and incorporated, there is negligible exposure. Risk equals hazard X exposure. The hazard is high but the exposure negligible so the risk from using these nematicides is low. Our research scientists are working on the development of brassicas such as Horseradish and Indian Mustard which can be grown as a biofumigants, releasing glucosynilates when incorporated into the soil, giving some control of PCN. The development work needs more time as we can currently only achieve 45 to 70% control.

A failure to distinguish between hazard and risk is an essential part of the confusion about perceived threats from or to our environment; in general hazard identification is easy and often speculative, risk evaluation is generally complex and demanding. Rational responses are not invariable, there is an extraordinary disregard for well documented risks while others, of marginal significance, distort public and private spending decisions. These factors, coupled with a perverse preference for natural toxicity over synthetic safety, lead to an indifferent performance in risk management in the community.

The collection of data about pesticides (on exposures, effects, distributions or persistence) will not answer the concerns of many about their use. Better data do not necessarily resolve issues especially when their interpretation by 'scientists' has become suspect, as Science itself is seen by some to be of problematic benefit to Mankind. As Max Weber noted in the 1930s, non-rational myths may force social and political changes. Since scepticism about received truths has long been a common attitude in opinion formers we must attempt to persuade them that the benefit to all of us greatly outweighs the hazards which some relate to pesticide use. Simply pointing out that infected or infested crops may contain dangerous toxins or levels of natural pesticides is an uncomfortable surprise to many.

Maintaining an appropriate population of weed species to support farmland wildlife is a challenge. It may be achieved by concentrating crop production on the central, most fertile parts of fields and providing conservation areas on field headlands and other less productive areas. Also through the development of much more selective herbicides and through more selective application using technologies such as video cameras, lasers and satellite navigation. These new technologies are developing rapidly but the agricultural industry needs the understanding of the environmental lobby; by working together we can achieve the twin goals of increased agricultural production and an enhanced environment. In England between 1978 and 1990, plant diversity on arable land was declining; but between 1998 and 2007, plant diversity in main plots increased by 36%. This was due to increases in the area of set-aside or fallow land, driven by agri-environment schemes.

If we are to produce more food at affordable prices, whilst maintaining our ecosystems and the services that they provide, we must collectively embrace innovation and construct our policies accordingly.

Thank you.





What can be done to build on the *Technological Solutions for Sustainable Agriculture* report?

In the year since the report on "Technological Solutions for Sustainable Agriculture in the EU" was adopted by the European Parliament, we have seen much interest and discussion on the subject of Agri-Tech. Broad support for the report across countries and parties in the European Parliament can provide a good basis for forwarding its recommendations as the UK prepares to leave the EU. In order to look at how we can build on the report before we leave the EU and how we can take the ideas forward post Brexit, a roundtable conference was held on 12th May at The Royal Hotel in Ross on Wye. This brought together a range of expertise in Agri-tech including scientists, academics, politicians, industry representatives, farmers and growers, land-managers and ecologists for an interesting and stimulating discussion.

A number of participants subsequently submitted contributions which have been grouped under the sub-headings of the original report:

Precision Farming (PF)

- Encourage Precision Farming (PF) practises which help buffer nature from industrial farming activities e.g. Use of heat sensing to detect and avoid ground nesting birds. Also encourage record keeping for monitoring change. (CC)

Soil, water and nutrient management

New technologies for characterising soil nutrient status (AK)

- Soils are a fundamental resource for most agriculture, and knowledge of soils is a necessary component of the sound management of agricultural systems. Soils and their management also affect most ecosystem services and understanding them is important for the whole of society. Therefore, an interactive database for existing and new soil information is an essential component of an innovative and sustainable agri-food system.

- Because of the importance of soils for agriculture and food production, soil science, soil surveys and soil analysis an old area of research. However, innovation in analytical tools now offers a new perspective on soil characteristics with great potential for intensified and sustainable agricultural systems. Dry spectroscopic analyses of soil and plant materials requires minimal infrastructure and maintenance, and is very economic and high throughput. Mid-infrared

(MIR) diffuse reflectance spectroscopy allows the simultaneous analysis of many soil characteristics compared to the traditional analysis of each characteristic individually, enabling the interaction of soil characteristics to be interpreted. Handheld X-ray fluorescence (XRF) spectroscopy provides total elemental content in seconds and X-ray diffraction (XRD) spectroscopy determines soil mineralogy. Finally, laser diffraction particle size analysis (LDPSA) measures soil texture and micro-aggregate stability in a fraction of the time compared with traditional tools. The whole set of analysis tools can be run with the same very small samples and with little sample preparation.

- These new tools can also help to better link soil characteristics with plant nutrient uptake. Even now, the relation between soil nutrient supply as measured in various soil tests and crop uptake is not well understood. Yet, the combined analysis of soil and crop samples using dry spectroscopy could directly relate plant nutrient status to soil characteristics, nutrient availability and fertiliser uptake. This will provide a predictive nutrient management framework for improved precision agriculture as well as for improving the nutritional quality of crop and animal products.

The soil microbiome (AK)

- The soil microbiome is very large and complex. It has the potential to improve nutrient provision to crops, to inhibit pathogens and promote plant growth, and to degrade chemical residues. There is also a downside: it can cause loss of nutrients from soil (e.g. by nitrous oxide emissions), it may contain pathogens and other organisms deleterious to plant growth, and it may degrade crop protection chemicals before they have any effect.

- Even in degraded soils where the numbers of microorganisms (bacteria, archaea, fungi, protists) are reduced, the diversity remains high. If conditions are returned to a more favourable state, then numbers recover. The very high diversity means that many species* perform the same function and so are inter-replaceable: this means that a change in species composition does not necessarily mean a loss of function. Therefore, the soil microbiome is often described as being functionally resilient.

- There have now been many studies documenting the species diversity of different soils under different treatments, crops, etc., but few that try to compare functional potential. Now, it is being addressed by metagenomic studies, where DNA from the soil microbiome is isolated in bulk and sequenced, then analysed using bioinformatics.

- If we can understand more about the soil microbiome, how it relates to the microbiomes of different crop plants (mostly recruited from soil), and how it responds to different treatments, then potentially we can manage it for our advantage and achieve more sustainable agriculture.

- Note *The term “species” is not usually used in microbial ecology, rather “operational taxonomic units” – OTU – but species is a convenient analogy.

Implications of soil microbial diversity for the application of new genetic technologies (AK)

- Because the soil microbiome is incredibly large and diverse, and is adapted to its environment, it is difficult to introduce new microbial inoculants unless they have a protected niche such as a specific symbiotic relationship with a host plant (such as rhizobia that form root nodules on legumes). Thus, GM bacteria designed to perform a function are unlikely to survive long. Their genes may survive: there are several natural mechanisms by which bacteria acquire DNA from





unrelated species. However, without a very strong positive selection, these hybrids are unlikely to survive or at least remain below the limits of detection.

- framework for improved precision agriculture as well as for improving the nutritional quality of crop and animal products.

Genetic diversity

- As a result of recommendations adopted by the European Parliament in the Technological Solutions report, there will be a hearing in the Agriculture and Rural Development Committee on the topic of "Genetic diversity, conservation and crop wild relatives". It will take place in December 2017 and will be a chance to voice concerns on the issue of genetic diversity and how EU regulation can affect this. (CH)

- Ornamental Plant Genetic Resources are an essential health and social wellbeing resource. The Royal Horticultural Society (RHS) estimates circa. 400,000 different types of cultivated plants grown in UK gardens. There is an increasing body of evidence that these ornamental plant genetic resources play a significant role in improving mental, physical and social health and well-being and provide many ecosystem services including pollution capture, noise reduction, mitigation against climate change, flash flooding and excess water surface run-off and help to support pollinators and biodiversity. Therefore, ornamental plant genetic resources have great potential to improve health and wellbeing and it is critical that we conserve and better understand how to use them so that we can maximise these environmental and health and wellbeing benefits. (AG)

Precision breeding

- As called for in the Technological Solutions report, the High Level Group of the Commission's Scientific Advice Mechanism (SAM) has published an independent Explanatory Note on 'New Techniques in Agricultural Biotechnology'. This publication provides a detailed scientific description of the full spectrum of agricultural breeding techniques used in plants, animals and microorganisms. Drawing on scientific reviews, expert opinions and reports, the document describes and compares the new techniques with conventional breeding techniques and with established techniques of genetic modification. (CH)

- The report "New techniques in agricultural biotechnology" written for the European Commission by the High Level Group of Scientific Advisors is a comprehensive document providing an unbiased comparison between conventional breeding techniques (CBT), established techniques of genetic modification (ETGM) and new breeding techniques (NBT), which include genome editing technologies, when applied to plants, animals and microbes. The report builds on the document "New Plant Breeding Techniques: state-of-the-art and prospects for commercial development" written for the European Commission by Lusser et al. in 2011. The evidence presented in the report is based on the scientific literature. The above mentioned techniques are compared in terms of precision, unintended effects, detectability of genetic/epigenetic changes, speed, cost etc. Overall, the report is very good although there are some inaccuracies (e.g. SDN2 and SDN3 are said to rely on homology-directed repair (HDR), while SDN2- and SDN3-induced DNA modifications can, actually, be achieved by exploiting the NHEJ DNA repair pathway as well). Also, the report should have emphasised that DNA modifications introduced by an SDN1, such as CRISPR ribonucleoprotein (RNP), do not require supplying exogenous DNA. This should have been clearly stated in Tables 2A and 3A. (AK)

Plant protection products (PPPs)

- We need to address the need to prevent use of outdated, inefficient application equipment (e.g. sprayers) and encourage and incentivise the adoption of PF. Encourage farmers to work as groups and share machinery, skill swop etc. Target funding towards groups. (CC)

Skills development and knowledge transfer

- Training and skills are required at at all levels (including tertiary/University, advisory services, apprenticeships) for agriculture, fundamental research (genetics, soil science, engineering), and translation to practice (PHH & TS)

- Great emphasis was placed on the need to bring young people into the agricultural industry. There is clear need to get the next generation interested in farming and they will need the innovative skills set to be able to take farming forward.

Research and funding priorities

- One particular aspect that is relevant both to UK and EU projects is in terms of any models/software that is developed. There is rarely the funding available afterwards to sustain software/web sites – unless a deal is struck with a commercial partner – and as systems change they are no longer viable. (RC)

- The EU should implement policies and provide appropriate support to facilitate new science and development, and the applications of new technology in agriculture, horticulture and environmental services. (PHH & TS)

- There is a great need for more applied research, particularly research that leads to better knowledge, skills and practices, to ensure that new technologies are used in the best possible manner. There should be a better balance of fundamental, applied and translational research and development to ensure efficient, fast translation of new discoveries into actual technologies and commercial products. (AM)

- SMEs/Universities must be able to take part in major innovation without incurring unnecessary costs which limit participation to multi-nationals or major research Institutes. They should also be able to benefit from the application of new technology without huge delay. (PHH & TS)

- There is still a long way to go in terms of getting universities and others to recognise the value of applied science. Until applied scientists are recognised as being as valuable as those doing more fundamental research it will be hard to encourage them to work in applied research – and indeed there are few career paths for applied scientists in horticulture/agriculture. This does not seem to be the same in engineering for example. (RC)

- At present the capacity in the UK to undertake serious and meaningful applied science both in terms of structural facilities and people is severely limited. Much of the Science community at all levels relies on working with groups in other EU Countries. It is extremely important to fully document all the existing networks and the level of input such that going forwards the networks can be kept live and hopefully allow continued joint working. (NB)

- The last time a review of the capabilities for applied R&D in Horticulture was undertaken was before any suggestion of Brexit. This was done by the HIP (Horticultural Innovation Partnership) and was an update on the previous report by Jamieson for the National Horticultural Forum. In the light of the changes we are about to enter into it would be prudent to commission a new review in the light of changes and to particularly look at the needs of Growers going forward in developing existing or new crops to reduce imports and reduce reliance on fossil fuels. (NB)

- The EU must continue with its promised reforms of CAP and evolution of rural policies; including employment, training, research and finance available to rural businesses. (PHH & TS)

Keeping Europe at the centre of scientific development and innovation

- The EU needs a robust, science-based advisory framework for policy making. In particular, the current regulatory mechanisms for genetically modified organisms (crops and animals) and crop protection chemicals are non-functional. Suitable mechanisms will be required in the UK, and it would be much better that these mirror international (EU and WTO) practices. (PHH & TS)

- While the UK is in the EU, we need to ensure that appropriate standards and robust regulations are in place across as many areas of the EU as possible. Good examples of this are Julie Girling MEP's work on animal welfare regulation





and Anthea McIntyre MEP's work on plant health and biosecurity regulation. (PHH &TS)

- We need a fast-responding, appropriate and science-based regulatory landscape, which is robust and certain. Above all, we must remove uncertainty from regulations and approvals. (PHH & TS)
- Consideration should be given as to whether insurance/liability 'regulation' may be more appropriate. (PHH & TS)
- The EU must ensure all policies are evaluated for effects on rural communities. (PHH & TS)
- More work is needed to simplify and update regulation in the area of Agri-tech. The UK has the capacity to be a world leader in this industry and a major exporter. Much Agri-technology has the potential to also benefit other industries and to be a relatively low risk proving ground for new technologies. For example, autonomous tractor technology can feed into the development of autonomous cars. Regulation has not kept pace with machinery evolution, for examples new application methods make existing rules on chemical application outdated. (FC)
- I think there is still some work to be done in terms of follow-on and disseminating information from EU projects. Particularly once the funding has ceased they disappear from view. (RC)
- We need to work pretty hard now to embed ourselves in networks with regard to science, technology and regulation so that we don't get left out post-BREXIT. I think we all need to identify these networks. The UK horticulture industry is reliant on overseas information and cooperation with regard to a good deal of its innovative activity. It would be good to strengthen science and technology links with the USA, Canada etc. if European opportunities are going to dwindle – although to develop all links would be best. It would be tremendous if the UK government would commit now to funding UK partners in EU projects post-BREXIT. (RC)

Food security

- We should advocate a future agriculture which achieves full efficiency and resilience by engaging with the services Nature can provide e.g. meeting the needs of natural predators and wild pollinators and recognising their contribution to yield enhancement and reductions in pesticide use/lower input farming systems. (Beneficial insects are reduced by e.g. habitat loss, insecticides, herbicides, and monoculture) (CC)
- We should highlight the advantages of less focus by supermarkets on the cosmetic appearance of fruit and vegetables and more focus on the nutritional value and environmental cost (CC).
- There is a role for grazing livestock systems in food security. In response to marked increases in meat consumption over recent decades that are set to continue for the foreseeable future, it is commonly stated that meat production is 10 times less efficient than crops, wastes scarce water resources, contributes 14.5% of global greenhouse gas (GHG) emissions, is the most significant cause of habitat degradation on 30% of the Earth's surface, and eating red meat is unhealthy and unethical. An alternative view is that grazing (rather than housed intensively reared) livestock may have production efficiency much closer to equality with crops when considered from a nutrient delivery standpoint, is important in maintaining a range of ecosystem services, can protect or even regenerate land and that dietary advice should look for optimal levels of animal products rather than eradication, to utilise ruminant as converters of low value feed (grazing and by-products) into high value nutrition when consumed responsibly. While analysis of agricultural biomass flows suggests that, sustainable intensification notwithstanding, reduction on the demand side and in food waste will be necessary to curb emissions, rearing livestock on non-human edible forages and crop residues can provide meat and other livestock products as an excellent provider of essential nutrients (e.g. essential amino acids, vitamin B12, Fe, omega-3 fatty acids) for a sustainable and balanced diet. (AK)

Further information on the contributors can be found at the back of this report. The contributors above are: AG-Alistair Griffiths, AK-Angela Karp, CC-Caroline Corsie, CH-Caroline Healy, FC-Frankie Colwill, NB-Neil Bragg, PHH-Pat Heslop-Harrison, RC-Rosemary Collier, TS-Trude Schwarzacher

These are some of the priorities that we should focus on and ideas that we can continue to champion while the UK is in the EU.

The second half of the round-table conference was a discussion on what happens after the UK leaves the European Union and how Agri-tech fits into this new political landscape. We hope to produce a separate document to outline the issues discussed and to describe what steps should be taken to ensure innovation in agriculture is at the top of the agenda.

Creating an Agri-Tech Future at Harper Adams University *by Dr David Llewellyn, Vice-Chancellor*

Since the foundation of the National Centre for Precision Farming (NCPF) in early 2012, Harper Adams University, in Shropshire, has been at the forefront of the UK's development of agri-technologies based on the application of advanced engineering principles to new farming techniques. It has addressed this emerging field by the means of applied research, conducted with industry, and through a range of educational activities aimed at improving the skills base in the use of new technologies in farming practice.

Our early work in research sought to gain an understanding of what other nations were doing to explore the use of advanced agricultural engineering solutions, such as the application of robotics, sensor technologies and data management systems. A Royal Academy of Engineering Distinguished Visiting Fellowship for Professor Noboro Noguchi of Hokkaido University, a leading expert in large-scale autonomous agricultural vehicle systems, gave us some early insights into how our smaller-scale vehicle solutions could be developed. A further Visiting Fellowship from EMBRAPA in Brazil similarly exposed our engineers and scientists to different forms of precision agriculture and the need to rethink the UK's approach to system development.


1

Some of our early work involved investigations of the application of precision agriculture to soil health and water management. A long-term Controlled Traffic Farming (CTF) (Image 1) trial has been operating on the University farm since 2011. Using 'digital tramlines' to enable us to analyse the impact of machinery on soils has led us to reconsider how CTF techniques could be implemented in UK farm settings. Our research identified that machinery was likely to traverse up to 86% of an arable field and even up to 64% on grassland, causing damage from soil compaction in the process. Working with Vaderstaad (Sweden) and Michelin (France) we have looked at the application of farm equipment and low pressure tyre systems on soil health. CTF systems rely on machinery being able to follow a particular 'pathway' on a field and this meant that some elements of equipment needed to be re-engineered to be of use in a CTF environment. Our work with Big Bale, funded by Innovate UK, incorporated novel sensors, automation and Global Positioning System (GPS) tagging to supplement the company's novel Transtacker system. We worked with the Worshipful Company of Farmers to develop a report on the potential of no-till systems for arable farming in 2014. More recent work, for AHDB Dairy, conducted with Scotland's Rural College (SRUC) and CTF Europe, has investigated the system design and economics of CTF in grass silage production. Our research in the field of CTF has been replicated in Zambia and at the University of Illinois in the USA. A comparative study by the University and AHDB Cereals and Oilseeds, over a 4-year rotation, has shown that CTF can have a significant impact on increasing arable crop yields.

2

While the use of standard equipment with precision farming techniques can prove beneficial, there are likely to be further gains from more disruptive forms of technology. Our work has encompassed methods to not only improve soil health and crop yields, but also to help reduce the environmental impacts of chemical inputs. Novel approaches have included studies on laser weedkilling systems, the use of robots to harvest fresh produce such as strawberries and the implementation of second generation drones, capable of undertaking field tasks rather than simply capturing images. Most recently, our Hands free Hectare project (Image 2) has gained significant national and international interest. Working with Yorkshire's Precision Decisions Ltd, and with the support of Innovate UK, we are in the middle of a 'proof of concept' experiment to grow a hectare of barley using autonomous systems. Importantly, these systems, including a robotic tractor and associated farm machinery, a robotic combine harvester and drones for agronomy, have been repurposed from standard smaller scale farm equipment, creating a near 'off the shelf' approach to this project. While other farm robots have been created, in the UK and internationally, this is a world-first attempt to implement an autonomous arable system, which could demonstrate the potential for even more disruptive technologies in the years to come.

Systems of this nature are advancing rapidly in other areas of agriculture, and the University is involved in a significant development in precision livestock farming (PLF) (Image 3) via its work on dairy cow behaviour and welfare. New sensors





to collect information from cows, and their living environment, will soon go live in a 'Smart Dairy' being created at Harper Adams as part of the Government's investment in a Centre for Innovation in Engineering and Precision Farming under the UK Strategy for Agricultural Technologies. Our work, to date, has shown that, amongst other things, leg-mounted sensors originally designed to detect oestrus behaviour can also help detect the early stages of lameness in dairy cows. The new dairy facility, which will also employ robotic milking equipment, will enable us to work with a range of PLF technology companies to deliver integrated solutions that will help ensure the UK dairy industry is economically and environmentally sustainable whilst also promoting good cow welfare.

In a further development, our entomologists have been working on the creation of Precision Entomology (PE) techniques. Using RFID transmitters they are tracking vine weevils to understand their behaviour so that bio-controls, rather than pesticides, can be used to reduce the damage they cause to fresh produce crops. Other members of our entomology team are using microchips to track slugs (Image 4), on the surface and underground, so as to better target interventions to reduce their populations. There is considerable scope to 'connect' work of this nature with other engineering developments in crop and livestock precision farming. The unique multidisciplinary environment available at the University, with its focus on applied research, is providing a valuable resource for others involved in research and education in agri-technologies. We will shortly be adding to that resource with the appointment of two international scholars to Chairs in Agri-Technology Economics, creating a UK Centre in this new field that will enable us to better understand the business case behind the adoption of new technologies in UK farming.

In education, our work with BASIS, the independent standards setting and auditing organisation for the pesticide, fertiliser and allied agricultural industries, has led to courses to certify the use of agricultural drones, accredited by the University and for which it is an approved training provider. We have established a joint Masters programme in Advanced Mechatronics with China Agricultural University, which has gained China Scholarship Council support for 15 students each year to study in the UK. Summer school programmes in precision farming have been run for other universities in China, and the University's educational activities in this aspect of engineering have extended as far afield as students from France, Brazil, and the Dominican Republic. The NCPF's Drones Special Interest Group has over 100 members and has been engaged in, amongst other things, developing a self-regulation regime for the use of agricultural drones.

The UK Strategy for Agricultural Technologies Centre for Innovation in Engineering and Precision Farming (known as the Agri-EPI Centre) (Image 5) will also see a new agri-tech 'hub' open at the University this summer. Working with Cranfield University and SRUC, and with over 100 companies associated with the Centre, Harper Adams will be a location where industry and academia can collaborate to develop and implement new forms of agri-technologies. Uniquely, the Centre is creating 30 demonstration farms as part of its work, to act as a test bed for agri-technologies and to gather data on their use in farming systems across the UK. The Government's recent Growth Deal resulted in a commitment to invest £9m to assist the nearby development of an Innovation Park that will act as a location for agri-tech company growth and inward investment. This initiative will enable the creation of an agri-tech 'cluster' that will help deliver the UK Strategy but will also provide opportunities for international collaboration and trade in this emerging industry sector.

Our engagement in the field of agri-technologies has brought visitors from around the world to see our work and to learn what the UK can contribute to advanced engineering solutions to modern-day challenges in global agricultural systems. As the UK seeks to establish a new position on the world stage over the next few years, the potential for agri-technologies to play a major part in supporting our domestic food production, but also to contribute to wider issues of food security, is immense. Harper Adams University's role, thus far, has been to stimulate debate, identify concepts, harness industry support, explain the potential of farming innovations to the wider public and put ideas into practice. There is more to be done in this new field, and we stand ready to help the UK play a leading role in the agri-tech movement in food production in the years to come.

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