Murphy-Bokern Konzepte

Royal Society
London

Dear Madam, Sir,

Thank you for your request for evidence for the Royal Society study on biological approaches to enhance food-crop production.

I am pleased to provide evidence. I am a general agricultural scientist working independently in the space between science and public policy development. My work seeks to deepen the dialogue between agricultural science and public policy development. I was involved in the development and management of the Defra agricultural research programme between 1999 and 2007 and I am familiar with the UK agricultural science base and the challenges facing it. Since leaving Defra in 2007, I have been engaged in studies of global agriculture relevant to the questions you pose.

I have had only a short time to prepare this evidence so my response is rather brief and I leave some of the scientific detail to others. I focus on research policy hoping to stimulate thinking.

I'll answer you questions directly.

1. Is there a need to increase global food-crop production to support present and future populations and their consumption patterns?

Yes. Despite the current trend towards a world-wide recession, the underlying fundamentals are clear. Due to a combination of growth in population and changes in diet, demands on primary agricultural production (crops and forages) will need to approximately double by 2050. A significantly different scenario involves either drastic cuts in the consumption of livestock products in the developed countries or continued dietary poverty in the developing world (or a combination of both). The first is unlikely, the second is unjust.

2. What do you consider to be the major scientific and other challenges to increasing food-crop production in developed and developing countries over the next 30 years?

Increasing yield under conditions of abiotic stress is a major target. This includes water stress, soil salinity and acidity. Raising yield in tropical climates is also crucial. This goes beyond just scientific advances – it depends on parallel economic advances and technical change affecting agricultural practice at all levels – from the peasant small holder to the corporate farm operators.

There is increasing evidence that yield potential has levelled off in our major crops. Record yields are not increasing as they did in the 20th century. This means we are reaching the limits of crop productivity using current crops and the canopy formation and photosynthetic system that they have. The yield increases achieved over the last century are essentially due to removal of constraints limiting crop growth, increasing canopy duration and increasing harvest index. The foundation of yield, the rate of photosynthesis per unit green area, has not increased systematically. The conservative nature of this parameter explains the levelling off in yield potential.

The BBSRC Crop Science Review published in 2004 consulted the international scientific community on, amongst other issues, the possible new research targets. That exercise was notable in that it revealed few if any mould breaking ideas or concepts for long-term research. I suggest that directors and leaders of research need to actively prospect across the world for new research targets that will lift the primary production potential of our major crops, in the context of a global effort. We need to collectively focus research efforts across national boundaries to at least realistically assess the possibility of a step change in photosynthetic efficiency. Recent studies

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reveal the decline in international investment in agricultural research, particularly by the USA. The trust of my argument is the need for a coordinated and targeted international response to the challenge of revitalising production oriented agricultural research. This amounts to a 'Marshall Plan' for agricultural science.

3. Can you identify recent or imminent scientific developments that will impact substantially on food-crop production over the next 30 years?

Specifically, no. Here I leave the identification of such developments to those closer to them. I think one of the features of fostering improvements to crop production is the importance of numerous small incremental changes across a broad front. A systems approach will ensure that the whole of these is more than the sum of the parts and it is these systems approaches that will deliver the step changes. Other consultees will provide evidence relating to specific targets. Crop genetic improvement is an obvious target and I expect other responses will cover it. I'd like to draw attention to the progress that has been made in simulation modelling of crop, field and farm level processes and the scope for delivering these to users are decision support systems. Very impressive progress was made between 1990 and 2000 in this area but delivery into practice has been hindered by fragmentation in public investment in delivery and an over-estimation of the ability of the private sector to invest in product development. The whole area of decision support aided by crop, region and season specific simulation modelling still offers great potential which can be realised by public investment in development infrastructure and data.

4. What biological approaches do you think have potential for food-crop improvement over the next 30 years and what benefits would they bring? These may include biotechnological, agroecological and other agronomic technologies. In your answer, please outline the current state of knowledge and the time you think it will take for the benefits from these approaches to be seen.

Progress will not be about picking between 'this or that', it is about supporting 'this and that' using a prioritisation process rooted in an understanding of the relevant crop and agricultural production systems. Crop genetic improvement is a key element using all breeding tools including those known a genetic modification. Another area of key important is ecological chemistry to control pests and weeds. Our cropping systems need to be designed with plans for protecting habitats – this will mean understanding the interactions between the cropping system and habitats at various scales, and making choices based on that understanding for various landscapes.

The timeframe for delivery is 10 to 20 years.

5. Which traits, across species or in specific food-crops, are appropriate targets for improvement? Comments could include information on why such traits are appropriate targets, the benefits they may bring, difficulties involved in targeting such traits and time required to see benefits from such improvement (for example, time needed to get improved varieties in farmers' fields).

Other responses will provide insight into traits based on much more detail knowledge. I want to draw attention to the potential of traits associated with crops' suitability for livestock feeding. Reconnecting crop and livestock production is a major strategic objective if we are to address a wide range of problems both in the developing and developed world. The targets include improving the amino acid profile of key feed crops and, in some cases, reducing the phosphorus and protein content of carbohydrate crops. We need to improve the protein quality of legume crops other than soy. We should also consider improving soy production in Europe to address the European N balance – a strategic target that does not seem to feature as a driver behind current European research investment.

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This is not just about harvested crops. Large areas of grassland are performing poorly and this has implications for land use. The potential to increase the availability of land for cropping by increasing the productivity of grassland is worth consideration.

6. Which current/future husbandry or farm management technologies for the enhancement of food-crop production are appropriate for development and dissemination and why? Comments could include information on the benefits they may bring, difficulties in scaling up their use in different parts of the world and time needed to get improved methods incorporated in farm practises.

The last twenty years has been characterised by a lack of direction and a degradation in the research and development machinery with respect to agricultural development. In particular, the sense of mission in the scientific community with respect to supporting technical change has been eroded. It is important that the scientific community restore a sense of purpose in supporting technical change in practice and uses its considerable autonomy to bring parity of esteem between those who deliver impact through the exploitation of science and those who use agricultural species as models for exploring fundamental scientific questions. In particular, we need to stop justifying fundamental research using agricultural species and the agricultural activity associated with those species. In other words, research models used in an agricultural development context need to support agriculture, not the other way round.

7. Do you anticipate/foresee any advances in engineering, materials science, chemistry or other non-biological science that will strongly influence future developments in food-crop production?

Broadly speaking, no. Apart from breakthroughs in photosynthesis or the development of totally new crop types – for example through perennation, I offer the perhaps pessimistic view that progress will be incremental. The step change will come from taking a systems approach and delivering research outputs safely to users and from a change in research and development policies and the establishment of new research and development systems. We need new structures for the delivery of research that reconsider the public good nature of the knowledge and technology outputs required. By ‘public good’ I mean that the outputs are in the public domain and their consumption is non-rival. This means the private sector will alone will under-invest. This year’s ‘food crisis’ shows clearly that the capacity to increase food production is a global public good. These new systems will be driven by the delivery of technical change, but it is important that research investments are planned strategically and not tram-lined onto specific technical outputs in a linear fashion.

8. What might be the possible consequences and impacts of biological approaches to enhance food-crop production on:
   a) crop yields and quality;
   b) world food prices;
   c) the environment;
   d) the livelihoods of farmers; and
   e) any other areas you think relevant.

(a). crop yields and quality

Biological approaches are often democratic because of the reliance on local resources and biological systems. They are essential if production is to expand in Africa without the environmental down-sides experienced in Europe.

(b) world food prices

Obviously increases in production reduce upward pressure on prices. In the short-term, prices will moderate considerably, but the long-term trend is upwards driven by economic growth. It has become clear that price volatility has increased and this is due to the interaction between nervous buyers and speculators. It is now clear that stocks must increase and that any temporary moderation or steep decline in prices should be buffered by stock-building.

(c) The environment

An increase in crop production potential creates options – without a dramatic increase in production potential much of the world will not be able to look forward to the luxury that Europe has had – plentiful supplies of food and the choice of extensive land-use and farming systems for those who want them. Taking a global perspective, halting deforestation is a number one environmental target. Land-use change is responsible for 18% of global greenhouse gas emissions and dominated by deforestation. This deforestation has a number of interrelated complex social and economic drivers but the land cleared generally ends up in agriculture. Saving the Amazon and similar habitats in Africa and South-east Asia is one of the great projects of our time, and raising the efficiency of production is part of the solution.

9. What are the potential barriers to the application of biological approaches to enhance food-crop production? These barriers might include matters relating to regulation, national and international policies, adequacy of the skills base, research infrastructure and resource availability including germplasm conservation, and knowledge transfer and intellectual property issues. Please also comment on the appropriate relative contribution of private and public sectors, and on whether there is sufficient public sector breeding and training in plant breeding.

The public good nature of agricultural knowledge and technology has been under-estimated and the ability of the private sector to deliver knowledge and technology has been over-estimated. It is sometimes forgotten that the great step changes in agricultural science in the 20th century were the product of public investment and broadly speaking delivered into the public domain. This applies to pesticides as well as improved germplasm.

All over the developed world, particularly in Europe, national governments have withdrawn from strategic agricultural research, particularly in research institutes. What's left is an increasing proportion of fundamental research that uses agricultural species as models, and an array of private sector activities. This fundamental research is particularly footloose in Universities. We must assume that national governments, agencies such as Defra, will NOT return to their previous role as investors in agricultural research. An international approach is necessary.

Systems and interdisciplinary thinking is essential. Much of what passes as interdisciplinary research is in fact a loose alliance between separate disciplines – there is a lot of multi-disciplinary activity, but relatively little interdisciplinary thinking. This is particularly evident in England and can be traced in my view to the narrow base of the three year degree following a narrowly focused A level system. Degrees are broad and shallow or deep and specialised. There is a scarcity of people in research who appreciate the systems or strategic context of their research and who design research programmes around the needs of the system and the needs of the research user. Likewise in research management, there is a scarcity of people who can orientate research investment to meet the needs of the development of complex systems, particularly in the long-term.

It could be argued that the Bologne process may have adverse effects in the rest of Europe as Universities seem to be adopting almost by default the shortest option (three years) for primary degrees without considering the special characteristics of the English education system that they are following. Agricultural science is particularly vulnerable to this. It is worth considering the introduction of a longer general degree programme in England aimed at delivering high quality broad-based professional leaders.

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We need parity in esteem between those scientists who do deliver scientific new knowledge by conducting fundamental research that is used by other researchers and those who develop and support technical change. This means equal consideration of all sorts of scientific outputs and impacts. In most countries, including the UK, such a change in the reward system is in the gift of the scientific community.

My last point is the need to completely change the mindset of those who finance and those who deliver research. The current model is based on 'funding' the 'funded'. The mindset in the public research community around the idea that organisations 'fund' and researchers are 'funded' damages both. It results in a mutually harmful doner/donee relationship and mentality which does not foster a focus on returns. Embedding the consideration of the public financing of research as an investment would have benefits for both the researchers and the public bodies that support them. A 'funder' mentality leads to the assumption that cutting research financing is an easy option in addressing local short-term financial difficulties. A 'investor' will consider consequences in terms of lost returns of the loss of research before terminating financing. The consideration of the finance as an investment would focus financing organisations on delivering a return and designing research portfolios accordingly. Likewise on the research provider side, the realisation that the flow of finance is an investment would focus researchers' minds on the responsibility of delivering returns.

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Post-script
This consultation informed the Royal Society's report "Reaping the benefits"
http://royalsociety.org/Reapingthebenefits/

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