



Evaluation of BBSRC's activities in crop science

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This document represents the views and conclusions of a panel of experts.

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Abbreviations

ATP	Advanced Training Partnership
BBSRC	Biotechnology and Biological Sciences Research Council
BSBEC	BBSRC Sustainable Bioenergy Centre
CGIAR	Consultative Group on International Agricultural Research Centres
CIRC	Crop Improvement Research Club
CSG	Core Strategic Grant
CSI	Crop Science Initiative
Defra	Department for Environment, Food and Rural Affairs
DfID	Department for International Development
DRINC	Diet and Health Research Industry Club
DTG	Doctoral Training Grant
DTP	Doctoral Training Partnership
ERA-NET	European Research Area Network
FACCE-JPI	Food Security, Agriculture and Climate Change Joint Programming Initiative
FLIP	Flexible Interchange Programme
GFS	Global Food Security
HAPI	Horticulture and Potato Initiative
IBERS	Institute of Biological, Environmental and Rural Sciences
IBTI	Integrated Biorefining Research and Technology Club
IPA	Industrial Partnership Award
IPI	Insect Pollinators Initiative
ISPG	Institute Strategic Programme Grant
JIC	John Innes Centre
LoLa	Longer and Larger Grant
RCUK	Research Councils UK
RAE	Research Assessment Exercise
REF	Research Excellence Framework
RTC	Research and Technology Club
SARID	Sustainable Agriculture Research for International Development
SCPRID	Sustainable Crop Production Research for International Development
SGCN	Small Grain Cereals Network
sLoLa	Strategic Longer and Larger Grant
SME	Small and Medium Enterprise
TGAC	The Genome Analysis Centre
TPS	Targeted Priority Studentship
TSB	Technology Strategy Board

Executive Summary

This document summarises the views of a specialist Review Panel convened to provide an independent evaluation of the effectiveness and impact of BBSRC's activities in crop science over the past decade, with particular reference to BBSRC's response to the Crop Science Review (published in 2004). The objectives of the evaluation were to:

- review BBSRC's activities in crop science and the Council's response to the Crop Science Review
- review the outcomes and impacts of BBSRC's investments in crop science research and training

Data for the evaluation were gathered from a number of sources including grant final reports, the Research Outcomes System, researcher surveys, the BBSRC grants database and other BBSRC records. The review of outcomes and impacts from past investments focused on the Crop Science Initiative, Targeted Priority Studentships in crop science, and responsive mode funding.

Key conclusions of the Review Panel

1. BBSRC's support for crop science was impressive

BBSRC provided extensive support for crop science over the evaluation period and increased the overall level of investment. The Council developed effective strategies for crop science and supported research and training through a variety of innovative mechanisms. It adapted existing funding instruments and developed new approaches as required, working with the research community, industry and other stakeholders. It also provided national leadership and contributed to the strong international profile of UK crop science, making notable contributions to the emerging food security agenda. BBSRC investments maintained and developed important national capabilities in crop science, particularly through its strategically-funded institutes. Substantial progress was made to increase the coordination and cohesion among the Council's crop science activities.

2. BBSRC responded successfully to the Crop Science Review recommendations

BBSRC's response to the Crop Science Review was very effective and the vast majority of the Review's recommendations were addressed. It was commendable that the Council was not simply responsive to the Review; it adopted an active, forward-looking approach, adapting its strategies and developing new interventions to exploit emerging opportunities and address new or developing challenges. However, elements of some of the Review's recommendations were not addressed sufficiently: for example, training programmes and career development, and support for public good plant breeding. Overall, the Crop Science Review was very timely and beneficial for UK crop science.

Without the Review and BBSRC's positive response to it, the UK would most probably lack crucial expertise to address the current strategic priority of food security.

3. The standard of BBSRC-supported crop science research and training was high

The outputs, outcomes and achievements arising from BBSRC's investments in crop science were very good. The high quality of the research and training was demonstrated through a variety of outputs including new scientific discoveries, new tools and resources, publications, collaborations and partnerships, further funding, intellectual property, and subsequent employment destinations. There were examples of excellent and outstanding research within the portfolio. However, a small proportion of research projects did not meet the expected standard and, more generally, there was scope to improve the level of BBSRC-funded researchers' interactions with international academics, industry and other non-academic stakeholders. The standard of reporting also varied considerably and was often too narrowly focused on a limited subset of outcomes. The two targeted funding schemes examined as part of the evaluation (i.e. the Crop Science Initiative, Targeted Priority Studentships in crop science) were very successful and had met their original objectives.

4. The research and training investments had clear potential to deliver economic and societal impacts

The delivery of high-quality training to students, postdoctoral researchers and other research staff was a major impact of BBSRC's investments in crop science and it contributed to a healthy bioscience sector through the provision of skilled workers to academia, industry and other areas of the economy. In addition, the investments had evident potential to produce benefits in a number of priority areas for the UK and globally including food security, environmental challenges, mitigating climate change, and human health. Clear capability for the research to contribute to UK economic growth was also demonstrated. In many cases, researchers had already made substantial progress towards realising these economic and societal impacts. Overall, however, progress was slower than might be expected. The level of engagement between researchers and industry was variable and some projects did not have clear predefined routes to deliver impact from the research. BBSRC should do more to maximise the impact of its investments by continuing to work with the research community to embed a culture which recognises the importance of delivering wider benefits from publicly-funded research. BBSRC should also identify and address the barriers which limit the exploitation of its crop science research. It should consider how to foster closer links between academic crop scientists and other parts of the agricultural sector. It should also improve researchers' participation in science communication and public engagement activities.

5. There is scope to broaden the coverage of BBSRC's crop science portfolio

BBSRC's crop science portfolio covered a good range of crops. Support was provided for research in many different crops, although funding was primarily focused on a small number of crops which are strategically important for the UK (e.g. wheat, barley, brassica). Now that technological advances are enabling high-level research in

previously intractable crops, it is timely for BBSRC to balance its activities across a broader range of species. For example, the portfolio should include increased representation for nutritionally-important crops, high-value crops which are important for farmers' livelihoods, and areas where user needs are not being met by the commercial sector. BBSRC worked in partnership with the research community to develop an effective research strategy for wheat. It should now extend this approach to other species, giving careful consideration to the need for, and objectives of, any public sector investment on a crop-by-crop basis. BBSRC must also ensure that research at the interface of BBSRC's remit and that of other funders is supported.

6. BBSRC's investment in basic plant science is very important and assists future innovation in crop science

Over the evaluation period, BBSRC rebalanced its plant science portfolio and increased the emphasis on crop science. Overall, the growth of investment in crop science did not appear to be at the expense of other plant science; crop science benefited from the general increase in BBSRC's research budget. However, there was a small reduction in the percentage of funding for this area. The distinctions between crop science and other plant science are now less relevant than they were in the past. It is now more important to consider the plant science community as a whole and to avoid creating tensions and artificial barriers between specific groups of researchers. The concept of translating research findings from model species to crops has also developed considerably since the publication of the Crop Science Review; the simple linear approach of 'model to crop' no longer fully captures the interactions and knowledge exchange between different areas of plant science. It was clear that the crop science portfolio benefited from BBSRC's long-term investment in basic plant science and that support for this research must be maintained to ensure future innovation and impact. BBSRC's investment in institutes also made a substantial contribution to sustaining the UK's ability to undertake crop science research.

7. There is an urgent need to address succession planning within the UK crop science community

BBSRC's support for crop science helped to maintain the existing research community, but was not sufficient to renew it. Many of the UK's current crop science research leaders will retire over the next decade and without appropriate succession planning there is a risk that vital skills, expertise and research programmes will be lost. It is essential that BBSRC makes succession planning a major priority, working with universities, the strategically-funded institutes, the research community, levy bodies, agricultural charities, and industry to ensure the long-term sustainability of the community. There is a need for support across the whole career structure, but BBSRC's immediate priority should be to support early-career scientists, for example, through the provision of targeted crop science fellowships. There are also several aspects of crop science training and skills development which require further investment.

8. BBSRC's responsibilities for crop science are increasing because of changes to the research landscape

The UK funding landscape for crop science research altered substantially in the years following the publication of the Crop Science Review. In particular, Defra withdrew much of its support for strategic and applied crop research. BBSRC became the leading UK

funder of crop science and this placed further significance on the work of the Council. BBSRC responded successfully to the additional challenges and opportunities, especially considering the constraints on its own resources. Nevertheless, a clear funding gap remains for applied crop research and this is limiting the translation of BBSRC-supported science into practical application. BBSRC must continue to explore how to respond to its growing responsibilities for crop science, thinking carefully about how far its remit should extend, how to prioritise different areas and activities, and how best to enable private sector participation in, or partnership with, publicly-funded research. BBSRC cannot deliver a strong UK crop science base alone and it must work closely with other funders in the public, private and charitable sectors. The Council has already demonstrated its ability to work effectively with other organisations through the Global Food Security Programme and other joint funding initiatives. It has cooperated with the Technology Strategy Board, particularly in the development of the Sustainable Agriculture and Food Innovation Platform, and it has made a valuable contribution to the development of the Government's Agri-Tech strategy. However, there are also some weaknesses that BBSRC should address, such as limited coordination with Defra. More broadly, there is a need for Government to address the diminished financial resources of Defra to enable the UK to realise the full benefits of its basic crop research. There is also a great need to bring together other technologies along with crop science to improve crop productivity in the field.

9. BBSRC must maintain its strong support for UK crop science

BBSRC's support for crop science over the past decade was impressive. The health and morale of the UK crop science community improved substantially following the publication of the Crop Science Review and the Council's effective response to it. The research and training supported was of a high standard, produced very good outputs and achievements, and contributed to wider benefits to the public good. It is currently a very exciting time for crop science with new technologies, resources and knowledge creating opportunities for discovery and impact which were previously unfeasible. There is still much more to be done to realise these opportunities and it is essential that BBSRC continues to build on its long-standing and successful support for crop science research and training. BBSRC must maintain the current momentum with sustained investment to ensure that the UK takes advantage of the progress that has been made. With continued support, UK crop science will deliver innovative solutions to local and global problems and provide major contributions to the UK's economic growth.

1. Introduction

1.1 BBSRC

1. The Biotechnology and Biological Sciences Research Council (BBSRC) is one of seven Research Councils funded through the Department for Business, Innovation and Skills of the UK government. Its principal aim is to foster a world-class biological science community in the UK. The mission of BBSRC is to fund internationally competitive research, to provide training in the biosciences, to encourage opportunities for knowledge exchange and impact, and to engage the public and other stakeholders in dialogue on issues of scientific interest. BBSRC's Strategic Plan¹ describes the research priorities and enabling themes that drive the Council's investments.

1.2 The Crop Science Review

2. BBSRC conducts regular strategic reviews of important research topics within its remit to provide advice on future directions and priorities. During 2003 and 2004, an independent Panel conducted a review of BBSRC's support for research relevant to crop science. The aim was to take a medium- to long-term view of future crop science research in relation to strengths and weaknesses at the time, and recommend a strategy that would optimise the outputs from basic plant science research, including model systems, into crop science.
3. The Panel published its report, '*Review of BBSRC-funded research relevant to crop science*', in April 2004². The principal conclusions of the report were that BBSRC's (and the UK's wider) crop science portfolio lacked coordination, focus and strategic direction, and that the translation of basic plant science into improved crop varieties was not as effective as it needed to be. In particular, the Review, highlighted a lack of an effective delivery pipeline for taking the findings of underpinning research through to application by plant breeders. The Review made seventeen recommendations to BBSRC (see Appendix 3).

1.3 Evaluation objectives

4. BBSRC is committed to the effective evaluation of the research and training it funds. BBSRC's Evaluation Framework³ outlines the Council's approach to evaluation and the methodology used.
5. The Terms of Reference for the Review Panel are at Appendix 1. The aim of the evaluation was to review BBSRC's activities relevant to crop science since the publication of the Crop Science Review in 2004. A major objective was to assess whether, *as an organisation*, BBSRC responded successfully to the challenges identified in the Crop Science Review and whether BBSRC is well placed to address future challenges such as food security. In addition, the evaluation sought to identify achievements and impacts arising from BBSRC's investments in crop science.

¹ www.bbsrc.ac.uk/strategy

² www.bbsrc.ac.uk/web/FILES/Reviews/0404_crop_science.pdf

³ www.bbsrc.ac.uk/researchevaluation

1.4 Definition of crop science

6. Crop plants were defined as plants (including algae) and cultivated mushrooms grown to be harvested as food (cereals, vegetables, oils), livestock fodder, or for any other economic purpose. Such purposes include: use of trees for wood and paper production; extraction of non-food plant oils; use as materials (e.g. cotton); use for extraction of bio-pharmaceuticals; production of energy crops (such as for biofuels). The focus of this evaluation was food crops; non-food crops were not considered in detail. Throughout the text, the term brassica is used to refer to oilseed and vegetable brassica crops collectively.

1.5 Historical context

7. Over the past decade, BBSRC has made significant investments in crop science research and training through a variety of mechanisms (responsive mode, research initiatives, Research and Technology Clubs, Institute Strategic Programme Grants, studentships, fellowships). These investments and other associated activities were influenced by the Crop Science Review recommendations, but were also in response to many other drivers. In reviewing BBSRC's support for crop science, it was therefore important to consider the broader historical context and note the substantial changes in the research landscape over the evaluation period.
8. The Crop Science Review was published at the cusp of major technological upheaval in the biological sciences and it foresaw the tremendous impact that genomics would have on crop science research. However, the pace of technological advancement was much more rapid than originally envisaged and it is now possible to conduct research which was unfeasible at the time of the Review. The introduction of next generation sequencing and other high-throughput technologies revolutionised the research landscape, transforming researchers' ambitions and the scope of their research projects. Tools, resources and data which were previously only accessible to researchers working with model plant systems became potentially available for all crop species. Exciting scientific discoveries improved our knowledge of plant and microbial biology and, in parallel with technological progress, contributed to new and innovative approaches to crop improvement. Crop science must now be increasingly multidisciplinary in nature to take full advantage of these developments.
9. As a result of scientific and technological advances, the long-standing distinctions between crop science and other plant science blurred and became less relevant. Barriers to conducting research in crop species became less significant, providing scientists with greater choice about the most appropriate system to address their research interests. It is notable that crop plants are now being used as models to investigate fundamental biological questions. Again, this transition occurred more quickly than could have been anticipated at the time of the Crop Science Review.
10. There were significant changes to the UK crop science funding landscape over the evaluation period. In particular, the Department for Environment, Food and Rural Affairs (Defra) withdrew much of its support for strategic and applied crop research; this altered the BBSRC-Defra relationship, had a negative impact on the crop science research community and reduced the opportunities for translating high-quality basic research into practical application. Several universities reduced their support for crop science research and training. Most notably, the closures of Wye College and Warwick HRI, and the integration of only some of the latter's research capacity into the University of Warwick's School of Life Sciences, led to a damaging loss of facilities for crop science

and a longer-term erosion of skills and expertise. There were also changes in the associated industry sectors with, crucially, several multinational companies reducing their presence within the UK. The closure of academic and industry sites had a negative impact on institutions that continued to support crop science, particularly in the context of being able to access multidisciplinary expertise necessary to address key research questions.

11. The social and political context of crop science research also changed dramatically. A series of food price spikes contributed to greater awareness of the potential vulnerability of world food supplies and the challenge of producing enough safe and nutritious food in a sustainable way for a growing population. There was increased recognition of the essential role of crop science in delivering food security. The previously less fashionable area of improving crop yield became an important priority, as did the need to understand and mitigate the effects of climate change on crops and agricultural systems. The concept of sustainability developed and widened with, for example, further consideration of the interface between agriculture and environmental services. The Foresight report, '*The Future of Food and Farming*⁴', explored the increasing pressures on the global food system and had a major impact on global policy in this area.
12. Overall, therefore, the crop science research landscape altered substantially in the years following the publication of the Crop Science Review, creating new challenges and new opportunities for BBSRC. These changes placed increased emphasis and onus on the work of the Council, particularly in the context of its role as the leading funder of UK crop science and its responsibility for addressing the food security agenda. BBSRC's response to the Crop Science Review recommendations and the changing UK crop science research landscape are examined throughout the remainder of this report.

⁴ www.bis.gov.uk/assets/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf

2. BBSRC's activities in crop science

2.1 Summary

13. BBSRC's support for crop science over the evaluation period was impressive. The Council developed effective strategies for supporting crop science and invested in an exciting variety of relevant research and training⁵. It provided national leadership in crop science, working with the research community, industry, funding agencies and other stakeholders. It also contributed to the strong international profile of UK crop science, making notable contributions to the emerging food security agenda. BBSRC responded well to the Crop Science Review's recommendations and the evolving research landscape, and its activities had a positive impact on the health of UK crop science. However, some aspects were not addressed sufficiently and, in particular, there was not enough emphasis on succession planning within the crop science research community.

2.2 Strategy development

14. BBSRC's strategy development for crop science was generally very effective. The importance of crop science was recognised in both of BBSRC's Strategic Plans which covered the evaluation period. Strategy Advisory Panels were established to provide the Council with advice and included representation from academia, industry, government agencies and end-users. Strategic Partnerships were developed with key universities working in the area of crop science, contributing to a more joined up, synergistic and efficient approach to investment. BBSRC led the establishment of the UK's Global Food Security (GFS) programme⁶ and continues to lead the Research Council contributions to the developing research programme. It made a valuable contribution to the development of the Government's Agri-Tech strategy⁷. It also developed strategies for its investments in specific crop species; most notably, BBSRC worked with the research community to identify priorities for wheat research.
15. BBSRC developed its strategies relevant to crop science in response to the recommendations in the Crop Science Review. Moreover, it is commendable that the Council was not simply responsive to the Review; it adopted an active, forward-looking approach, constantly refreshing its strategy and seeking out emerging opportunities and identifying future challenges. Initially, BBSRC's priorities for crop science focused on translating discoveries from basic plant science into application in crops, but these subsequently broadened, particularly in the context of food security. BBSRC's strategic direction for crop science improved substantially after the publication of the Crop Science Review. The Council provided leadership, engaged with the research community, and worked to ensure greater coordination and cohesion within its crop science investments.

⁵ This chapter provides an overview of BBSRC's activities relevant to crop science since the publication of the 2004 Crop Science Review. It is not a comprehensive or detailed list of all BBSRC activities, but provides a summary of major or strategically-important activities, investments or developments. Further details on many activities can be found on the BBSRC website: www.bbsrc.ac.uk

⁶ GFS is a multi-agency programme bringing together the main UK public sector funders of research and training related to food. The programme aims to address the challenges of providing the world's growing population with a sustainable, secure supply of good quality food from less land with lower inputs. See: www.foodsecurity.ac.uk

⁷ www.gov.uk/government/publications/uk-agricultural-technologies-strategy

16. Gaps remain in BBSRC's strategies relevant to crop science and there is a need for the Council to continue to build on its achievements to date. BBSRC should now develop research strategies for other important UK crops in addition to wheat, noting that tools, resources and scientific knowledge are at very different stages of development for individual crops, and that the commercial environments differ extensively (e.g. the level of private sector investment). This is not solely the responsibility of BBSRC and the respective research communities must work together with the Council. There are opportunities to work more closely with other funders to understand and influence each other's strategies; UK crop science would have benefited from closer interactions between BBSRC and Defra over the evaluation period (particularly through the Genetic Improvement Networks). There are also challenges which may limit the effectiveness of BBSRC's crop science strategies including the clear tensions with the delivery of strategic research priorities through the responsive mode funding mechanism.

2.3 Funding mechanisms and research investments

17. BBSRC supported a variety of research investments through diverse funding mechanisms, adapting its existing funding instruments and developing new approaches as required. Research Committee restructuring was a positive development which brought together crop science and other plant science under a single Committee. The introduction of Longer and Larger Grants (LoLas) and Strategic LoLas enabled crop scientists to obtain funding for research projects which required longer timescales and more extensive resources, which is particularly relevant in the context of crops' long generation times. There was strong investment for crop science within responsive mode⁸ and several initiatives provided targeted support: the Crop Science Initiative; Insect Pollinators Initiative (IPI); Horticulture and Potato Initiative (HAPI); Research and Technology Clubs (RTCs); the BBSRC Sustainable Bioenergy Centre (BSBEC); and a systems biology centre (the Centre for Plant Integrative Biology). BBSRC invested in several new or improved facilities which were directly or indirectly beneficial to the crop science community: The Genome Analysis Centre (TGAC); National Plant Phenomics Centre; North Wyke Farm Platform; and ELIXIR. There was also substantial investment in the development of tools and resources, especially genome sequencing⁹, and active participation in relevant RCUK cross-Council Research Programmes.
18. The innovative nature of BBSRC's research investments in crop science over the evaluation period was praiseworthy. The Council responded effectively to the recommendations in the Crop Science Review and continued to demonstrate flexibility in its thinking, designing appropriate investments to meet the needs of different sectors and crop species (e.g. horticulture vs. wheat). Nevertheless, there were some areas

⁸ BBSRC supports research through two major funding routes:

- **responsive mode:** grants awarded in response to unsolicited research proposals from any area relevant to BBSRC's missions
- **managed mode:** grants awarded through specific research initiatives or schemes in strategically significant areas; these are directed, time-limited funding programmes normally addressing an emerging scientific opportunity where there is a need to enhance a particular area of science within the established BBSRC research base.

⁹ BBSRC investment contributed to the sequencing and annotation of many crop and crop pathogen genomes over the evaluation period, often in partnership with other international funders. For example: *Acyrtosiphon pisum* (pea aphid); *Agaricus bisporus* (button mushroom); *Blumeria graminis* (powdery mildew); *Brachypodium distachyon* (purple false brome); *Brassica rapa* (Chinese cabbage); *Fragaria vesca* (strawberry); *Hevea brasiliensis* (rubber tree) – draft sequence; *Hordeum vulgare* (barley) – draft sequence; *Hyalopezonospora arabidopsis* (downy mildew); *Medicago trunculata* (legume); *Mycosphaerella graminicola* (septoria wheat blotch); *Oryza sativa* (rice); *Phytophthora infestans* (late blight); *Pythium ultimum* (plant pathogen); *Solanum lycopersicum* (tomato); *Solanum tuberosum* (potato); *Triticum aestivum* (wheat).

which could be improved. For example, while there was some evidence of coordination between different investments (e.g. the Wheat Improvement Strategic Programme which brought together sLoLa and institute funding), it was not clear how extensive this might be throughout the portfolio. In addition, although the introduction of Pathways to Impact (PtI)¹⁰ statements as part of the application process was useful, there is still considerable variation in the quality of the statements submitted. Furthermore, the research community remains concerned about how Research Committees balance the assessment criteria of scientific excellence and strategic relevance.

2.4 Collaborative research with industry

19. BBSRC's investments in crop science research and training underpin innovation in the UK agricultural sector. It is therefore very commendable that the Council engaged successfully with industry and that it encouraged and enabled the research community to establish links with industry partners. BBSRC introduced several Research and Technology Clubs (RTCs) to provide fora for academia and consortia of companies to work together to address common research objectives: the Crop Improvement Research Club (CIRC); the Integrated Biorefining Research and Technology Club (IBTI); and the Diet and Health Research Industry Club (DRINC). The Industrial Partnership Award (IPA) and 'stand-alone' LINK schemes also provided notable support for high quality collaborative research within responsive mode¹¹. BBSRC invested in several schemes to provide assistance with knowledge exchange, commercialisation and development, and these were used by the crop science community (e.g. Follow-on Fund, Knowledge Transfer Partnerships, Industry Interchange Programme). The Council also worked successfully with the Technology Strategy Board (TSB) to stimulate business-science collaborations and, in particular, assisted with the development of TSB's Sustainable Agriculture and Food Innovation Platform¹². The Industrial CASE scheme also provided valuable support for collaborative doctoral training with industry and other non-academic stakeholders¹³.
20. BBSRC's support for collaborative research with industry was generally very good. The Council demonstrated a creative and flexible approach, and the variety of funding mechanisms enabled individual companies to engage with academia in ways which most suited their needs. However, there were some concerns. For some of the evaluation period, BBSRC provided co-funding for Defra's themed LINK programmes which were valued by the research community as a mechanism for developing and translating ideas arising from BBSRC research into application; their subsequent closure was deeply regrettable and left a funding gap not met by alternative support from TSB or BBSRC's 'stand-alone' LINK scheme. Other potential issues included whether the IPA and 'stand-alone' LINK schemes are the best mechanism for engaging

¹⁰ In 2010, BBSRC introduced PtI statements as part of grant applications. All applicants for BBSRC research grant funding are required to submit a PtI statement which provides details of the activities which will help to contribute to potential economic and societal impact. As part of the application process, Committee members assess the PtI statements as Excellent, Satisfactory or Unsatisfactory. The PtI statements replaced Impact Plans, which were themselves introduced in 2010

¹¹ The IPA and 'stand-alone' LINK schemes were recently evaluated by an expert Review Panel. See: www.bbsrc.ac.uk/organisation/policies/reviews/funded-science/1209-ipa-sa-link-evaluation.aspx

¹² The Sustainable Agriculture and Food Innovation Platform was launched in 2009. It is £90M, five-year programme which aims to stimulate the development and adoption of new technologies to help improve the productivity of the UK food and farming industries, while decreasing their impact on the environment. It is a partnership between TSB, Defra and BBSRC.

¹³ The Industrial CASE scheme was recently evaluated by an expert Review Panel. See: www.bbsrc.ac.uk/organisation/policies/reviews/funded-science/1306-industrial-case-evaluation.aspx

with the variety of companies within the agricultural sector, as small and medium enterprises (SMEs) and companies with low-profitability may not be able to meet the minimum contribution requirements. Conversely, BBSRC's collaborative research schemes often provide a very good deal for larger companies (e.g. because of the high proportion of public to private sector investment) and there is a risk that this may reduce their incentive to invest in academia to the extent observed in other countries. There are also opportunities for greater industry involvement in crop science through collaboration with the relevant levy bodies which have not been fully realised.

2.5 BBSRC strategically-funded institutes

21. BBSRC makes strategic investments in four research institutes which are central to delivering its vision and strategic priorities in crop science: Rothamsted Research (RRes); the John Innes Centre (JIC); the Institute of Biological, Environmental and Rural Sciences (IBERS)¹⁴; and The Genome Analysis Centre (TGAC). At the time of the Crop Science Review, the institutes were primarily supported through a single Core Strategic Grant (CSG). This mechanism of support was subsequently changed to investment in a series of Institute Strategic Programmes funded by Institute Strategic Programme Grants (ISPGs)¹⁵. In addition, other funding streams were introduced to support national capabilities, knowledge exchange and commercialisation, and the ability to respond to emerging opportunities. The new funding model is welcome, providing greater transparency and accountability, and enabling the specific crop science programme objectives of the institutes to be identified.
22. As the quality of research conducted by individual institutes was reviewed in the 2011 Institute Assessment Exercise¹⁶ this was not covered in detail for this evaluation. It was clear that the institutes were very important components of BBSRC's support for crop science; they supported very high-quality research, were internationally respected, provided vital facilities and national capability, and enabled investment in longer-term programmes of strategic research. There were substantial changes to the remits of the institutes before and since the publication of the Crop Science Review. In general, their missions initially became narrower with increased emphasis on delivering world-leading fundamental science; in some instances this had a negative effect on the institutions' capacity to deliver against the recommendations of the Crop Science Review and increased the gap between fundamental and applied science in this area. In recent years greater priority was once again given to conducting strategically-relevant research. It is recognised that changes to institute governance will alter BBSRC's relationship with the institutes. Nevertheless, BBSRC should ensure that its investments in the institutes are focused on delivering the Council's strategic objectives and deliver outcomes which are distinctive from those in the university sector. In this context, it is important that BBSRC provides institutes with clear and stable expectations.

¹⁴ IBERS was formed in 2008 bringing together the Institutes of Rural Sciences and Biological Sciences at Aberystwyth University, and the Institute of Grassland and Environmental Research (IGER). IGER received strategic funding from BBSRC.

¹⁵ Institute Strategic Programmes are programmes of research with direct objectives funded by BBSRC through ISPGs and uplift objectives funded from other sources.

¹⁶ www.bbsrc.ac.uk/web/FILES/Reviews/1210-report-of-iae-2011.pdf

2.6 International activities

23. The UK has an historic international reputation in crop science and BBSRC contributed to maintaining and strengthening this over the evaluation period. BBSRC supported a number of dedicated schemes which were used by UK crop scientists to establish partnership links with international researchers and it provided funding which enabled the UK crop science community to participate in international programmes and consortia. The Council worked with international partners to reduce barriers to collaboration, explore emerging science opportunities and address mutual interests and global challenges. In partnership with other funders, BBSRC developed application processes that reduce the 'double jeopardy' which can occur if individual components of a joint application must undergo peer review by separate funding agencies. BBSRC also worked with government departments and other organisations to overcome restrictions which prevent the Council from funding research outside the UK. Moreover, BBSRC's international activities were not limited to the European Union and the USA, but included interactions from the BRIC countries Brazil, India and China, nations with emerging economies (e.g. Taiwan, Vietnam), and developing countries in Africa, Asia and South America.
24. The portfolio of BBSRC's international activities included a large number of highlights, including the International Partnering Awards, the Food Security, Agriculture and Climate Change Joint Programming Initiative (FACCE-JPI), the European Research Area Networks (ERA-NETs), and the Ideas Labs with the National Science Foundation (NSF). BBSRC crop science has considerable potential to reduce hardship and promote prosperity in the developing world, and contribute to the realisation of the Millennium Development Goals¹⁷. The Sustainable Agriculture Research for International Development (SARID) and Sustainable Crop Production Research for International Development (SCPRID) were excellent examples of the UK using its crop science expertise to support research and training which benefits developing nations; BBSRC worked effectively with the UK's Department for International Development (DfID) and other organisations to deliver these initiatives. BBSRC is now notably more engaged in international activities than it was at the time of the Crop Science Review. However, there is scope for further interactions with international partners, particularly in the context of addressing food security challenges. For example, BBSRC should also consider how it might engage more closely with the Consultative Group on International Agricultural Research (CGIAR) Centres, large scale initiatives in the charity sector (e.g. Bill & Melinda Gates Foundation, Rockefeller Foundation) and other international government agencies and programmes (e.g. United States Agency for International Development, national programmes in developing countries).

2.7 Training, skills and career development

25. Research training and skills development are vital to maintain a healthy agricultural sector and they contribute to the UK's skilled workforce in academia and industry. Over the evaluation period, BBSRC invested in a welcome variety of activities covering different stages of career development. There was good support for doctoral training relevant to crop science through the Quota Doctoral Training Grant (DTG) competition, Doctoral Training Partnerships (DTPs), the Industrial CASE scheme and Targeted Priority Studentships (TPS). Beneficial changes to this support were introduced: the transition from three-year to four-year studentships; an increase in the Research

¹⁷ The Millennium Development Goals are eight international development goals that were officially established by the United Nations in 2000. For details see: www.un.org/millenniumgoals

Training Support Grant for each studentship; increased alignment of the studentship portfolio with BBSRC's strategic research priorities; and changes to the Industrial CASE scheme to encourage greater participation from SMEs and underrepresented sectors. There was reasonable engagement from the agricultural sector within BBSRC's programmes of collaborative training with industry. The changes to industry contribution requirements for Industrial CASE studentships also made collaborative training more accessible to small companies in the agriculture and horticulture sectors. Other BBSRC investments supporting crop science training and career development included: 'stand-alone' taught Masters programmes¹⁸; Advanced Training Partnerships¹⁹ (ATPs); the New Investigator scheme; David Phillips Fellowships; Institute Career Path Fellowships; the Flexible Interchange Programme (FLIP); and Research Experience Placements. The Council also worked with the Bioscience Federation (now the Society of Biology) to consult the UK research community and identify shortages in strategically-important and vulnerable niche areas of research expertise; institutions were subsequently asked to consider how they may address these skills shortages as part of DTP awards.

26. BBSRC's support for crop science training and skills development was generally positive with examples of innovative approaches. However, insufficient progress was made on addressing succession planning within the crop science community. It is essential that BBSRC ensures the long-term health of the community with new generations of scientists being able to develop their careers. This issue is now very pressing as many of the UK's leading crop scientists approach retirement and BBSRC must act quickly to prevent crucial skills and expertise from being lost. Support for early-career scientists is an essential element of succession planning and, as a priority, BBSRC should consider providing targeted fellowship support for crop science. Moreover, career development issues cannot be resolved by BBSRC alone and the Council must work with universities, its strategically-funded institutes, the research community, levy bodies, agricultural charities, and industry to identify and deliver effective solutions.
27. Crop science is often long-term, expensive, requiring specialised facilities, and applied in nature. As such, several factors have had a negative impact on the career development opportunities for crop scientists including: the Research Assessment Exercise (RAE) / Research Excellence Framework (REF), cost-cutting within institutions, and difficulties with attracting funding in areas where undergraduate degree courses are not popular. The presence of high-profile research leaders within the small UK crop science community may also have unintentionally limited opportunities for early-career researchers to develop their careers; for example, other scientists were more likely to collaborate with established researchers who they perceived to be leading particular research topics. BBSRC's investments in crop science training benefited academic and industry research communities and, in this context, BBSRC should ensure that all its training activities facilitate access to the sectors where the trained individuals may subsequently work. Progress is also needed in the provision of training in a number of fields such as plant breeding, soil science and weed science, as these remain relatively weak within the UK.

¹⁸ In 2011, BBSRC announced that it was withdrawing support for such Masters programmes in order to prioritise investment in PhD training. This brought BBSRC into line with other Research Councils.

¹⁹ Advanced Training Partnerships are sustainable formal collaborations between users and providers of high-level skills in the agri-food sector, bringing together companies with research and training organisations. They provide postgraduate level professional development in the area of agriculture and food production for a large number of industry specialists across the UK. See: www.bbsrc.ac.uk/business/training/advanced-training-partnerships.aspx

2.8 Community building activities

28. BBSRC supported several activities to foster stronger crop science communities, bringing together individuals and encouraging collaboration among researchers who would otherwise be competing. These worked well and had a very positive impact on the research community. Notable progress was made within the cereal and brassica communities where highlights included the Small Grain Cereals Network (SCGN), the Monogram Network²⁰ and the UK-Brassica Research Community²¹. GARNet²² was also very valuable for the UK Arabidopsis community. BBSRC should continue to fund community networks, building on these successes, and there is scope to improve community support for specific crop species (e.g. Solanaceae), develop communities which are species-independent (e.g. based around the use of particular technologies), and encourage greater integration between crop and other plant science (e.g. by working with organisations such as the UK Plant Science Federation). There is also a need to expand networks to include individuals from outside biological disciplines (including physical sciences, social sciences, agricultural systems). BBSRC must work with other Research Councils and funders to ensure that investments which support community activities are as effective as possible. The lack of coordination between BBSRC's community building activities and those of Defra's Genetic Improvement Networks was very disappointing; although the community tried to coordinate activities there was minimal cooperation between the funders.

2.9 BBSRC's response to the Crop Science Review

29. BBSRC's response to the Crop Science Review was impressive and the Council successfully addressed the majority of the Review's recommendations. The crop science landscape changed considerably after the publication of the Crop Science Review (see Chapter 1) and, as expected, the relevance of some specific recommendations diminished over time. BBSRC responded appropriately, adapting its strategies and developing new interventions to exploit emerging opportunities and address future challenges in the spirit of the Crop Science Review recommendations. It is difficult to disaggregate precisely which BBSRC activities were direct results of the Review and which may have been in response to other drivers. Nevertheless, the Council should be commended for its achievements, which reflect the efforts of BBSRC staff and the research community working together.
30. Elements of some of the Crop Science Review recommendations were not addressed sufficiently by BBSRC. There were gaps in the response to the recommendation regarding training programmes and career development (see section 2.7); in particular, while BBSRC's support was vital to sustaining the existing crop science community it was not sufficient to ensure its renewal. The Review's recommendation that BBSRC take the lead to establish a national plant breeding initiative was also not addressed in the way originally intended. Good support for wheat pre-breeding was provided through a LoLa grant, but there remains a significant gap in support for public good plant breeding and associated training. This is particularly the case in crops other than wheat and in areas related to crop production and management.
31. When the Crop Science Review was published in 2004, it provided a striking and timely reminder of the importance of crop science and the risks of failing to invest in

²⁰ www.monogram.ac.uk

²¹ www.brassica.info/ukbrc

²² www.garnetcommunity.org.uk

associated research and training. Moreover, it demonstrated that the work of UK crop scientists was valued and provided a vital morale boost to this research community. Ultimately, the Crop Science Review was very beneficial to the UK crop science and BBSRC should be commended for undertaking it. Without the Review and BBSRC's effective response to it, the health of the crop science community would now be more precarious and the UK would most probably lack crucial expertise to address the current strategic priority of food security.

3. Balance and coverage of the crop science portfolio

3.1 Summary

32. The coverage of BBSRC’s crop science portfolio was good and the balance appropriate, with increased investment in this area following the publication of the Crop Science Review. Support was provided for research in many different crops but funding was mainly concentrated in a relatively small number of species. The balance between crop science and other plant science shifted towards crop science, addressing a key recommendation of the Review.

3.2 BBSRC funding for crop science

33. BBSRC’s investment in crop science increased over the evaluation period, both as an absolute value and as a proportion of all BBSRC research grant funding (Table 1). Crop science was prioritised and benefited from a general increase in BBSRC’s research budget. It was also encouraging that crop science was largely protected from decreases in funding following the 2010 cross-Government Spending Review (where BBSRC received a flat-cash settlement). BBSRC effectively addressed the Crop Science Review’s recommendation to place greater emphasis on crop science. Many of the key crop targets and technological priorities identified within the Review remain relevant and there is a need for continued investment.

Table 1. Annual BBSRC spend for crop science

Research topic ²	Annual spend (£M) ¹					
	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Crop science	36.4	40.5	45.5	50.5	49.8	49.3
All plant science ³	60.9	67.1	71.3	75.3	73.3	69.0
All research grant funding	248.2	270.9	293.7	290.7	275.7	261.5
Crop science as a proportion of all research grant funding	15%	15%	15%	17%	18%	19%

¹ Data include responsive mode, initiatives, RTCs, CSGs / ISPGs, and fellowships. Capital & buildings, studentships and BBSRC payments to other funders are excluded.

² Grants and projects are included in the research topic if a significant element of the research is considered relevant to the topic in question, even if it is not the main driver for the research. It is not possible to estimate the proportion of each grant or project that is of direct relevance to a given topic.

³ Plant science includes crop science and other plant science. It is not possible to determine accurately the level of funding for other plant science by subtracting the crop science figure from that of plant science. This is because individual grants may contain significant elements of both crop science and other plant science.

3.3 Crop science funding by species

34. The crop science portfolio included a good variety of crop species, with wheat (36%), barley (16%), brassicas (12%), rice (10%), potato (7%) and tomato (7%) the most represented²³. As expected, funding for individual species changed over the evaluation period with investment in some crops increasing (e.g. barley, lettuce, rice, wheat) while others decreased (e.g. legumes). The changes to the level of investment were driven by the Council's priorities for crop science and by the availability of new tools and resources for particular crops.
35. Overall, BBSRC funding was concentrated in a relatively small number of species, particularly cereals, and there are now opportunities to broaden the variety of crops which receive substantial support. Given the risk that a concentration of funding in a limited number of crops could become self-perpetuating or limit the effectiveness of publicly-funded training in crop science, BBSRC should be prepared to fund pump-priming activities for underrepresented crops. In this context, BBSRC's support for the development of new tools and resources is welcome. BBSRC should also consider the available private sector research funding for individual crops when reviewing the balance of its portfolio; BBSRC's investment has often concentrated in crops where the private sector was also making substantial investments. This is a complex issue, where it is important to recognise that industry and public good drivers for research may differ. BBSRC should work with industry partners to ensure all relevant interests are addressed.

3.4 Balance between crop science and other plant science

36. The Crop Science Review recommended that BBSRC should seek to re-balance its plant science portfolio to place greater emphasis on crop science. This recommendation was addressed effectively with the balance between crop science and other plant science shifting towards crop science over the evaluation period. Overall, the increased investment in crop science did not appear to be at the expense of other plant science; the increase in BBSRC's research budget over the period enabled additional support to be provided for crop science. However, there was a small reduction in the level of funding for other plant science.
37. The distinctions between crop science and other plant science were helpful at the time of the Crop Science Review as they highlighted the need to promote the transfer of knowledge from basic plant science into crops. However, these distinctions have subsequently become less relevant. It is now more important to consider the plant science community as a whole and avoid creating tensions and artificial barriers between specific groups of researchers. The UK's plant science community is internationally leading²⁴ in part because of its ability to work together effectively. Moreover, the future innovation in crop science is assisted by BBSRC's investment in basic plant science.

²³ Data are based on 362 research grants and institute projects which had BBSRC investment in the 2009/10 financial year. Other crops represented included: apple, bean, clover, cocoa, coconut, grape, lettuce, maize, millet, oat, orange, palm, peas, plantain, sorghum, soy, strawberry and sugar beet.

²⁴ An indication of the UK's performance in plant science is provided by a 2010 bibliometric analysis of G7 nations' research performance (Thomson Reuters). The UK was ranked first in citation impact (ratio of citations to publications) in the categories of 'Agricultural sciences', 'Plant / animal sciences' and 'Ecology / environment'. For details see: www.timeshighereducation.co.uk/story.asp?storycode=411986

4. Outcomes and achievements of BBSRC's investments in crop science

4.1 Summary

38. BBSRC's key investments in crop science over the evaluation period included the Crop Science Initiative (CSI), Targeted Priority Studentships (TPS) in crop science and responsive mode grants. All these funding mechanisms were effective, supporting high-quality research and training, and delivering an appropriate balance of basic, strategic and applied research across a good variety of crops. The research had strong potential to produce benefits to the public good and many projects had made good progress towards delivering agriculturally-relevant impacts; for others, however, the route for delivering wider impact was not clear. A review of longer-term research programmes also highlighted the excellent outcomes of BBSRC's investment in crop science over the past decade.

4.2 Crop Science Initiative

4.2.1 Background

39. The 2004 Crop Science Review recommended that BBSRC provide an additional £12M funding for a new research initiative aimed at delivering the specific crop science objectives identified in the report. In response, BBSRC launched the Crop Science Initiative (CSI) in September 2005. The aims of the initiative were to:

- apply the principles of sustainable development to future crop production
- promote the transfer of understanding of basic plant science to crop research
- enhance capabilities for the longer-term, including capacity building within the UK crop science community

BBSRC invested a total of £13.2M in the CSI, funding eighteen projects with start dates between November 2006 and April 2007. The initiative supported two main types of project: those which addressed specific biological questions and those which developed new tools, resources or experimental approaches.

4.2.2 Research quality

40. The standard of research conducted within the initiative was generally high and the majority of projects met their original objectives. There was some variation between the performance of individual CSI projects; while most were good or very good and a few were excellent, a small number did not meet the expected standard. The publication outputs arising from the CSI projects were good and compared well with other BBSRC-funded research. Eighty three original research articles had been published to date with an average (median) of 3.5 per completed project. Papers were published in good quality journals which were appropriate for the target audience of the research. There were examples of papers in high-impact multidisciplinary journals and prestigious journals in specific scientific fields, and there was a substantial level of international co-authorship.

41. The other outputs and achievements arising from the project also demonstrated the high quality of CSI research. The initiative contributed to the development of an impressive variety of tools and resources which were subsequently used by the wider research community. A substantial proportion of researchers obtained further funding to continue or develop their crop science research programmes and the sources of further funding²⁵ often indicated that they were developing plans to translate their findings into practical application. A high proportion of CSI projects (81%) contributed to a collaboration or partnership with international academics and these were mainly with researchers in other European Union countries, the USA, Australia, and China. In addition, a high proportion of projects (88%) contributed to interactions with industry; in total, collaborations and partnerships were reported with 19 companies²⁶ which included a mix of UK and overseas organisations, from SMEs to multinationals. The breadth and depth of interactions with industry and other non-academics varied considerably between individual projects, however, and while some were very deep, others appeared relatively shallow. Several projects (25%) resulted in applications to protect intellectual property. It should be noted that this was not a major objective of the initiative and many projects aimed to deliver freely accessible resources or knowledge.

4.2.3 Research impacts

42. CSI projects had strong potential to contribute to the public good and deliver economic and societal impacts. The research is likely to produce benefits in a number of priority areas for the UK: primarily food security and sustainable agriculture, but also the environment, mitigating climate change, human health and animal welfare. It is currently too early to assess the full impacts of the initiative as it can take many years for crop science research to be translated into practical application. Researchers were working to deliver wider benefits from their CSI research although, to date, the majority of projects had demonstrated potential rather than realised impacts. It was encouraging that several researchers had contributed to policy developments and that science communication and public engagement activities were reported for all CSI projects. However, the extent of individual researchers' participation in science communication and public engagement activities varied considerably and the associated reporting was often limited. More broadly, some projects did not have a clear predefined route for delivering benefits from the research, which was a significant weakness.

43. Research training and skills development are major impacts of BBSRC's investment in bioscience. They are vital to maintaining a healthy bioscience sector through the provision of skilled workers to academia, industry and other areas of the economy. A major impact of the CSI was the provision of high-quality crop science training to the staff employed on the grants and this was very beneficial to the UK crop science community. The available data indicated that the majority of research staff (e.g. postdoctoral researchers) remained in academia as their first destination after the project ended. It was slightly disappointing that there were no reports of staff moving into industry given the capacity building objective of the initiative, but this may reflect a shortage of researchers with crop science skills within academia at the time. In addition,

²⁵ Further funding was received from agricultural trusts, BBSRC, CGIAR, Defra, DfID, European Union, industry, levy bodies, NIAB, TSB, and trade groups.

²⁶ Collaborations and partnerships were reported with ADAS, Berry Gardens, BioPotatoes, Campden BRI, Ceres, Chromatin Inc, Driscolls Genetics, Elsoms, EnviroTech Construct, Igagro Ricerca, KWS, Limagrain, Monsanto, Muntons, Nickersonsm, Pukekohe Growers Suppliers, RAGT Seeds, Roche Diagnostics, Syngenta. Interactions were also reported with other non-academic stakeholders including British Wheat Breeders, HGCA, Horticulture Development Company, Scotch Whisky Research Institute, and the Yorkshire Agricultural Society

more could have been done by BBSRC to use the initiative to benefit doctoral training (e.g. through closer interactions with the Targeted Priority Studentships in crop science).

4.2.4 Balance and coverage of the portfolio

44. The balance and coverage of the CSI portfolio was good with support for a variety of species including barley, brassica, potato, strawberry ryegrass, tomato, wheat, and willow. The most represented crops were wheat (50% of projects), barley (22%) and brassica (22%)²⁷. There were some gaps and areas which would have benefited from increased funding (e.g. grasses, horticultural crops, legumes and oilseed rape), but this was to be expected considering the overall level of investment. The initiative provided strong support for strategic and applied research²⁸, which was welcome and ensured that the initiative was distinctive in comparison with responsive mode, where the crop science portfolio includes a much higher proportion of basic research. The majority of researchers (85%) had previously received support to conduct crop science research and nearly half had worked in the field of crop science for more than twenty years at the time of their application. As such, the initiative was very important in maintaining the existing crop science community but was not sufficient to renew it.

4.2.5 The initiative funding mechanism

45. There were additional benefits from funding crop science through the CSI compared with a similar investment in responsive mode. The initiative provided support for projects of up to five years' duration, thereby enabling researchers to address longer-term objectives and to cope with the lengthy life-cycles of crop species. Workshops and a dissemination event were held and were valuable to researchers, their research staff and other stakeholders; it also helped foster collaborations between researchers at different institutions. A major benefit was that the CSI raised the profile of the UK crop science community, nationally and internationally. It increased the confidence of the community and provided a clear indication that crop science research was valued by BBSRC.
46. Overall, the CSI was successful in meeting its original objectives. It contributed to sustainable crop production, enabled knowledge from basic plant science to be exploited in crops, and strengthened the capabilities of the UK crop science community. The initiative's objectives still remain relevant today; there is a clear on-going need to address the food security agenda, and to maintain and build capacity within the UK crop science community. There is also a need to ensure that BBSRC's investments in plant science deliver wider agricultural benefit. It is important to note, however, that the concept of translating research findings from model species into crops evolved considerably over the evaluation period. The simple linear approach of 'model to crop' envisaged by the initiative and the Crop Science Review no longer fully captures the interactions and knowledge exchange between different areas of plant science and

²⁷ Individual projects may be relevant to more than one crop

²⁸ Researchers can receive support for basic, strategic and applied research through BBSRC's funding mechanisms:

- **basic:** research conducted for the advancement of knowledge
- **strategic:** research conducted with the expectation that it will form a broad base of knowledge likely to underpin the solution of recognised or anticipated future problems
- **applied:** research that is directed primarily at addressing a specific, practical problem or objective

other disciplines relevant to crop production and management. Moreover, in many cases, it can be an inappropriate approach.

4.3 Targeted Priority Studentships in crop science

4.3.1 Background

47. The 2004 Crop Science Review recommended that BBSRC should review its training programmes and career development for crop scientists by considering the introduction of targeted schemes for training and recruitment at senior, postdoctoral and postgraduate levels. The Review highlighted a need to address the serious shortage of suitably trained personnel and limited career development in crop science. For doctoral training in particular, the Review identified a need to produce a new breed of crop scientists who were well trained in molecular plant biology as well as genetics and plant breeding, so that they could bridge the gap between crop science and other plant science. A Targeted Priority Studentship (TPS) competition was subsequently established to support studentships in the area of crop science. Funding was provided for eighteen four-year studentships over two calls. The first call supported studentships commencing in October 2006, with the second cohort commencing in October 2007.

4.3.2 Training quality

48. It was difficult to assess the quality of training supported through the TPS studentships from the data available, which were primarily from academic supervisors' self-assessments. However, students were based in very good institutions and had good supervisors with well-resourced labs. The outcomes and achievements arising from the studentships also indicated that the quality of training was high. The majority of students (87%) submitted their thesis within four years and all were awarded a PhD.
49. The level of publication output was similar to that observed for previous evaluations of BBSRC's training portfolio; to date, 41% of students had authored or co-authored an original research article, with the figure rising to 82% when papers in preparation were included. Nineteen original research articles had been published so far, and these were in good quality journals and included examples in prestigious, high-impact publications. A notable proportion of students (67%) had interactions with industry or other non-academic users during the studentship, which were often beneficial to the student's training and research project. However, the depth of the interactions was very varied; while a few studentships had close, formal interactions with industry, for most the interactions with non-academic stakeholders were informal. The high quality of the training was reflected in other notable achievements including novel and exciting scientific discoveries, the development of new methodologies and technologies, conference presentations, prizes and awards, science communication activities and further funding for the supervisor.

4.3.3 Training impact

50. Most students (73%) took up research-related positions after obtaining their PhD, either in academia (47%) or industry (27%), and the majority (87%) remained in the UK. Importantly, a higher proportion of TPS students obtained a research-related position in industry as their first destination compared with BBSRC's wider studentship portfolio. It

was also encouraging that half of the students (53%) pursued a career in crop science as their first destination. The remainder pursued careers in other plant science (7%), other science areas (20%) or outside science (20%).

4.3.4 The TPS funding mechanism

51. The TPS studentships enabled students to develop a good mix of traditional crop science and modern molecular skills. Although the TPS studentships were not especially distinctive compared with other BBSRC-funded studentships, there were several aspects which provided additional training opportunities. There was significant exposure to the broader crop science community and, in particular, attendance at the CSI workshops enabled TPS students to network with other crop scientists, interact with students based at other institutions, and develop a cohort identity. In addition, the provision of four-year studentships was very beneficial; at the time, studentships were predominantly of three years' duration, and the extra year enabled students to conduct a challenging student research project using crops and participate in a wider variety of activities. The TPS studentships also made an important contribution towards building capacity in the UK crop science community. Overall, the TPS funding mechanism was very effective, although from the evidence available it was difficult to determine whether they were more effective than other BBSRC-studentship support.

4.4 Responsive mode

4.4.1 Background

52. Responsive mode is the funding mechanism by which BBSRC awards grants in response to unsolicited research proposals from eligible applicants in any area relevant to the Council's mission. It has a very important role in supporting the UK's world-class bioscience community and accounts for approximately 50% of BBSRC investment in research grants. In the 2010/11 financial year, BBSRC spend through responsive mode was £138.1M, which included £13.2M (9.6%) classified as crop science.

4.4.2 Research quality

53. The overall standard of crop science research supported within responsive mode was very high with many examples of excellent and outstanding research. The research projects were productive, contributing to exciting scientific discoveries and the development of new tools, technologies and community resources. The publication outputs arising from the research were commendable, although a small number of projects did not produce as many papers as expected. To date, 202 original research articles had been published with an average (median) of three per completed project. The papers were published in good quality journals, with a notable proportion in very prestigious, high-impact journals and a good level of international co-authorship.
54. A high proportion of researchers obtained further funding to continue or develop their research programmes; the sources of further funding²⁹ were varied and included

²⁹ Further funding was received from agricultural trusts, BBSRC, Bill & Melinda Gates Foundation, British Council, Chemical Regulations Directorate, Defra, DfID, EPSRC, European and Mediterranean Plant Protection Organisation, European Union, European Science Foundation, Fungicide Resistance Action Committee, industry, levy bodies, New Zealand government, Pesticides Safety Directorate, Slovenian Research Agency, TSB, trade groups, and the Worldwide Universities Network.

support for more applied research. A notable proportion of projects (78%) contributed to new or improved collaborations with international academics, primarily in other European Union countries or the USA. In addition, approximately half (56%) of projects contributed to the establishment or further development of a collaboration or partnership with industry and, in total, interactions were reported with 34 companies³⁰. The extent of the interactions was varied, but some were significant and made substantial contributions to the project's success, particularly those supported through the Industrial Partnership Award scheme. A small proportion of projects (16%) led to applications to secure intellectual property (IP) rights and one contributed to the development of a spin-out company; this is similar to the level observed in other evaluations of the responsive mode portfolio. Overall, the outputs and outcomes demonstrate the high quality of crop science research supported within responsive mode. However, there is scope to increase further the level of BBSRC-funded researchers' interactions with international academics, industry and other non-academic stakeholders.

4.4.3 Research impacts

55. Responsive mode research was delivering, or had potential to deliver, economic and societal impacts in a number of areas. As expected, these related primarily to food security, but also included benefits to the environment, mitigating climate change, and human health. A few researchers had already made good progress towards realising impact from the research, working with companies to exploit their project's findings or contributing to the development of government policy. However, in general, the projects were further from delivering impact than the CSI awards, which probably reflects the higher proportion of basic research within the responsive mode portfolio. Science communication and public engagement activities were reported for nearly all projects (92%), although the extent of individual researchers' participation was variable. Responsive mode funding also provided high quality training to the staff employed on the projects, and the training and skills development delivered benefited academia, industry and the wider economy. The available first destination data for research staff were encouraging; most remained in academia within the UK as their first destination, with a small proportion being employed in industry or other sectors. In addition, responsive mode contributed to the UK's strong international profile in crop science and enabled the UK to participate in international research programmes.

4.4.4 Balance and coverage of the portfolio

56. Responsive mode funding supported a welcome variety of research projects. There was a good mix of projects which addressed specific biological questions or developed new tools and resources. The projects were predominantly for basic or strategic research, and the portfolio included a number of very strategically-important investments for BBSRC and the UK. However, there was only very limited support for applied research. Wheat (16%), barley (9%), brassicas (9%), potato (9%), legumes (8%), rice (8%) and

³⁰ Collaborations and partnerships were reported with ADAS, Advanced Technologies Cambridge, BASF, Bayer Crop Science, Biogemma, Biolog, Cereal Partners Worldwide, CropDesign, Dow Agrosciences, DuPont, General Motors Powertrain, GlaxoSmithKline, Higgins Agriculture, Keygene, KWS UK, Leatherhead Food International, Life Technologies, Limagrain, Marks and Spencer, Mendel Biotechnology, Monsanto, PepsiCo, Plant Impact, Prospero Therapeutics, Roche Applied Sciences, Sainsbury's, Seminis Vegetable Seeds, Shamrock Seed Company, Syngenta, Tesco, Unilever, United Biscuits, Verdia, Vitacress Salads. Interactions were also reported with other non-academic stakeholders including British Potato Council, Defra Science Advisory Council, Food Safety Agency, GCIRC, HGCA, Perry Foundation, Potato Processors Association, Teagasc, and the UK Cereal Pathogen Survey.

tomato (8%) were the most represented crops³¹, and approximately half of the projects involved studies of crop pathogens, pests and weeds. Some research areas appeared to be underrepresented; however, without a detailed analysis of unfunded applications, it was not clear whether this was due to fewer applications or lower quality applications in these areas. Overall, the responsive mode portfolio was more balanced than the CSI's, both in terms of the number of crop species supported and the previous crop science experience profile of the funded researchers. The majority of researchers (74%) had previously received support to conduct crop science research at the time of their application.

4.4.5 The responsive mode funding mechanism

57. The responsive mode funding mechanism is an essential component of BBSRC's investment in crop science. It supports the highest quality research, driven by a very competitive application process. The investment in basic crop science research through responsive mode is very important, underpinning future research and developments which will ultimately deliver economic and societal benefits to the UK. It is also advantageous that crop science and other plant science responsive mode applications are mainly assessed by a single Research Committee. Nevertheless, there are some potential concerns with the mechanism. There are perceptions within the research community that Research Committees favour particular types or areas of research, that they are too conservative, and that it can be more difficult to receive support for strategic or applied research. Community behaviour can be driven by these perceptions, potentially biasing the variety of applications received and preventing the most creative applications from being submitted. BBSRC must ensure that Research Committees have the appropriate expertise for the assessment of all types of research proposals: basic, strategic or applied. BBSRC may also wish to consider whether responsive mode is the best mechanism for identifying the most exciting, cutting-edge ideas or encouraging intellectual leadership. There is anecdotal evidence that researchers use other sources of funding to support their most original and imaginative proposals (e.g. the Leverhulme Trust).

4.5 Researchers with longer-term BBSRC support for crop science

4.5.1 Background

58. The CSI, TPS and responsive mode elements of this evaluation examined the effectiveness and outcomes of specific BBSRC interventions, with a focus on the performance of individual awards. To complement these analyses, the Panel also examined the research programmes of nine researchers who had received longer-term support for crop science over the past decade; the sample included researchers based at BBSRC strategically-funded institutes and those at universities. Between 2001 and 2011, these researchers were awarded over £27M in BBSRC crop science funding, including £20M of responsive mode and research initiative funding and accounting for 9% of BBSRC's total investment in crop science through these funding mechanisms during this period.

³¹ Data are for 210 responsive mode projects classified as crop science with start dates between January 2004 and May 2011.

4.5.2 Research quality

59. The standard of the research programmes was very impressive with many examples of excellent and outstanding research. The researchers made strong contributions to their respective fields, producing important scientific discoveries and developing key resources for the wider community. The outputs of the research were very good and a large number of high-quality original research articles were published in an appropriate mix of high-impact and specialist journals. The researchers also established wide networks of academic and non-academic collaborators in the UK and internationally. These interactions enabled the researchers to realise their objectives more effectively and increase the reach of their research, sometimes into unexpected areas with novel applications. Moreover, their work influenced the directions of other academic and industry research. Overall, the outputs and achievements from the individual research programmes were more than the sum of their component parts.
60. The researchers' programmes were well-rounded with consistent themes and aims, and were primarily supported through the effective use of BBSRC's funding mechanisms (e.g. responsive mode, initiatives, RTCs, ISPGs); between 50% and 90% of researchers' funding was from BBSRC. The researchers were very successful in obtaining funding from other sources, a further indicator of the quality of their research, and it was likely that longer-term BBSRC support had enabled them to take advantage of these other funding opportunities. It was notable that the sample researchers had overcome substantial challenges to deliver their research objectives. They pursued their research interests persistently over a period when other areas of plant science were more fashionable and when it was more difficult to receive funding for crop science.

4.5.3 Research impacts

61. All the individual research programmes were producing benefits beyond the research base itself and there were very good examples of agriculturally-relevant impacts for the UK and internationally. Researchers used a variety of approaches to exploit their findings and it was encouraging that they were seeking out the most appropriate means to deliver impact. In some instances this involved developing a portfolio of IP and licensing; in others the research was made freely available. The latter was particularly relevant when the intended beneficiaries were in developing countries. Researchers were actively involved in knowledge exchange with industry, plant breeders and other non-academic stakeholders. Good progress had been made towards realising the benefits of the research in elite, commercially-grown crop varieties, although it is important to note that this is a lengthy process. The researchers were also making other valuable contributions to the public good including influencing government policy, training the next generation of scientists, and science communication and public engagement activities. A common theme among the sample researchers was their generous and substantive contribution to the wider crop science community, helping to establish and develop UK community networks, participating in international science programmes, and providing guidance and leadership.
62. Overall, this group of researchers had made better progress toward delivering agriculturally-relevant impacts than observed for the CSI or responsive mode grants. This is positive and reassuring, given the seniority of the researchers, the level of support, and the longer-term nature of the sample programmes. The outcomes and impact of the work validates the decisions to invest repeatedly in these high-calibre individuals. All the sample researchers are in the later stages of their careers, however,

emphasising the urgent need for BBSRC to identify and support the next generation of crop science research leaders in the UK.

4.6 Reporting

63. The outcomes and achievements of BBSRC's investment in crop science through the CSI, TPS, responsive mode and longer-term research programmes were captured through end-of-award reporting, the Research Outcomes System, and surveys conducted specifically for the evaluation. The standard of reporting varied considerably between individual awards and it was generally too narrow, with award holders focusing on a limited subset of outcomes, particularly the scientific outputs and the associated publications. Moreover, there was some over reporting and it was often difficult to identify the key publication(s) arising from the project. There was limited recognition of the broader context of the research within the reporting; for example, information on staff development was patchy, with some reports providing no information on staff first destinations. More specifically, there was no formal reporting on the outcomes and achievements of BBSRC's investments in doctoral training. These weaknesses were not unexpected given the context at the time of funding and similar observations were made in other evaluations of BBSRC research and training. However, it is now important to ensure award holders provide information on a wider variety of outputs and outcomes. In this context, it is important that BBSRC's reporting is structured in a way which encourages a more consistent approach to the provision of outputs and outcomes data, and that appropriate guidance to researchers is provided.
64. There is a need to improve reporting on the potential benefits of the research to agriculturally-relevant problems and the follow-on activities researchers will pursue to ensure the wider uptake of their work. It was disappointing that these were not clearly described in end-of-award reports, particularly as many projects produced scientific discoveries which could deliver important benefits. The projects sampled for this evaluation were funded before the introduction of Pathways to Impact (Pti) statements which describe the activities which will help to contribute to the potential economic and societal impact from the research. It will take time to embed a culture which routinely considers the wider impact of the research, and BBSRC should continue to work closely with the research community to achieve this. It is essential that BBSRC is able to capture and demonstrate the broader impact of its investment in crop science to develop a strong case to government for continued support. BBSRC should also consider the barriers which may limit the exploitation of research and work with community to address them. Finally, it is important that the outputs from publicly funded research are available to a wide audience. In this context, the Research Councils support for data sharing³², open access and Gateway to Research³³ are welcome.

³² www.bbsrc.ac.uk/datasharing

³³ Gateway to Research is a system providing key data from the seven UK Research Councils in one location. See: <http://gtr.rcuk.ac.uk/>

5. Conclusions and future considerations

5.1 Conclusions

65. BBSRC's support for crop science over the evaluation period was very effective. The Council successfully addressed the recommendations in the Crop Science Review and responded to the rapidly changing crop science research landscape in an agile and flexible manner. BBSRC developed effective strategies for supporting crop science, invested in a diverse set of funding mechanisms, and rebalanced the plant science portfolio placing greater emphasis on crop science. It fostered collaborations with industry and other non-academic stakeholders, strengthened the international profile of UK crop science research, provided good support for training, and helped to develop strong crop science communities. It worked in partnership with the research community, other funders, industry and other stakeholders to reinvigorate UK crop science research.
66. The outputs, outcomes and achievements arising from BBSRC's investments in crop science were very good. The quality of research and training supported was high and was demonstrated through a variety of outputs: new scientific discoveries, new tools and resources, publications, collaborations and partnerships, further funding, intellectual property, and staff destinations. There was high potential for the research to deliver wider benefits to the public good, particularly in the area of food security, but also the environment, mitigating climate change, and human health. Many researchers had made good progress towards realising agriculturally-relevant impacts from their research.
67. Some aspects of BBSRC's support for crop science research and training could have been delivered more effectively. For example, although the Council's investments maintained the existing crop science community, they did not renew it sufficiently and some expertise was lost. Moreover, some specific skills areas were not fully addressed by BBSRC's training programmes and there was insufficient emphasis on succession planning. There is still scope to increase the cohesion and coordination of the crop science research portfolio, particularly within responsive mode and to ensure that BBSRC's research investments are translated into practical application to deliver economic and societal impacts. In addition, some opportunities to work more closely with Defra to bridge the gap for public good plant breeding were missed.

5.2 Future considerations

5.2.1 BBSRC remit

68. BBSRC's responsibilities for crop science have grown in response to the changing crop science research landscape. The Council must continue to explore how to respond to these developments, seizing the opportunity to redefine its role in supporting crop science. In particular, BBSRC must consider how to address the increased demands placed on it and think carefully about how far its remit could and should extend. BBSRC should continue taking a strategic approach to its investments in crop science, using a mix of targeted and responsive support. The constraints to public sector resources in the current economic climate are likely to limit the scope for BBSRC to increase its level

of support and it will be important to prioritise different areas effectively. There are a number of broad issues which BBSRC should consider, including:

- Which areas of crop science are most important for the UK?
- To which areas can UK crop scientists make unique contributions?
- How can BBSRC best work with other funders to make the most efficient use of resources and avoid duplication?
- How can BBSRC best enable private sector participation in, or partnership with, publicly-funded research projects?
- How can BBSRC and the crop science community best understand the needs of user communities?
- What is the appropriate balance between the ‘technology-push’ and ‘market-pull’ drivers within the portfolio?
- In which underserved markets can publicly-funded crop science have the biggest impact?
- To what extent do BBSRC’s investments have differential effects on different communities?
- Which steps in the delivery pipeline should BBSRC be supporting?

69. BBSRC should also consider the extent to which it should invest in public good plant breeding, noting that this is a complex issue where other government departments and the private sector also have interests and responsibilities. There is a strong case for the UK to support public good plant breeding in some form to ensure that the available crop varieties meet the needs of farmers and other users, and to deliver public good and economic benefits³⁴. The plant breeding pipeline may sometimes be too risky or offer too limited return on investment for commercial breeders. Public good plant breeding provides opportunities for higher-risk ideas arising from publicly-funded research to be translated into application, and for a wider range of crops and traits to be covered (some of which may be important to farmers’ incomes, but are a low priority for breeding companies). Public good plant breeding need not compete with activities in the private sector and there are clear opportunities for complementary activities and cooperation. In other countries, the plant breeding industry works in a very cooperative way with academia, providing substantial financial and ‘in-kind’ support; however, in the UK, the limited size of the plant breeding industry makes this more challenging. BBSRC should build on the mechanisms it has put in place to enable researchers to work with industry as these are beginning to show benefits within the plant breeding sector.

5.2.2 Interactions with other funders and organisations

70. BBSRC is now the UK’s leading funder of crop science research, but it cannot deliver a strong UK crop science base alone. It must cooperate and collaborate with other funders in the public, private and charitable sectors within and outside the UK. As a priority, BBSRC should work more closely with Defra, the Agriculture and Horticulture Development Board (AHDB), and other crop-based levy bodies. These organisations share a desire to maintain a strategic research capability in crops within the UK and can help translate BBSRC-funded research into practice. In addition, BBSRC must build on its partnerships with other relevant Research Councils. Interactions with other funders should be broad and not driven solely by the need to leverage additional funding, as some may be better placed to offer expertise or influence policy. BBSRC also needs to

³⁴ For an analysis of the impact of the privatisation of plant breeding within the UK see: *Privatization of Crop Breeding in the UK: Lessons for Other Countries*.
www.aes.ac.uk/cms/upload_area/member_documents/Richard_Gray_Galushko-Gray%20AES%20Warwick.pdf

develop closer partnerships with UK research organisations that provide key research and training capabilities relevant to crop science. The Councils' ability to deliver its strategic objectives can be affected by the decisions of these other organisations, and it is important that the UK's national capability in crop science is not damaged by their decisions.

5.2.3 Balance and coverage of the portfolio

71. BBSRC's crop science portfolio is heavily focused on a small number of crops (e.g. wheat, barley, brassica) and it is timely for BBSRC to balance its activities across a broader range of species that are important for UK food security. The Council's investments in crop science should reflect the vital contribution of crops to diet and health; the portfolio should include a mix of cereal, fruit and vegetable crops which are important for meeting calorific and nutritional dietary needs. BBSRC should also work with user communities to identify crops with high-value markets which are important for farmers' livelihoods, and determine where users' needs for new crop varieties are not being met by the commercial sector. Technological advances are enabling high-level research in previously intractable crops, creating new opportunities to expand the coverage of the portfolio. BBSRC worked in partnership with the research community to produce an effective research strategy for wheat and is developing a strategy for brassicas. It should now extend this approach to more species, giving careful consideration to the need for, and objectives of, any public sector investment on a crop-by-crop basis. Strategies for individual crops should recognise that improvements to crop yield and quality will not be delivered through plant breeding alone and that a broader set of approaches will be required to produce desirable phenotypes. Publicly-funded research must also contribute to the development of improved crop production and management systems (e.g. plant nutrition, soil health, crop protection, agroecology), and engage with industries that deliver associated technologies to the field.
72. Crop production in agricultural practice depends on many more sciences than biology. Chemistry, physics, mathematics, materials science and engineering are all vital for future innovation in the agricultural and food manufacturing sectors, and for the sustainable intensification of farming. There are elements of crop science and agriculture which are at the interface of BBSRC's remit and those of other funders (e.g. the interactions between genotype and environment, phenotyping in the field, land use, agricultural engineering). It is important that BBSRC works with other Research Councils and funders to ensure that research at these interfaces is supported. In this context, it is especially important for BBSRC to develop closer interactions with EPSRC and NERC. The BBSRC-led Global Food Security programme is an excellent example of cross-funder working, which has clear potential to address the research needs at the interfaces of different funders.
73. BBSRC's crop science portfolio benefited from the Council's long-term investment in basic plant science and, more generally, from other fundamental science (e.g. biochemistry, bioinformatics, microbiology, molecular biology, structural biology, systems biology, the development of new technologies). Although the traditional distinctions between crop science and other plant science are now less relevant than in the past, it is vital that BBSRC continues its support for basic plant science, both in crops and in model systems. The UK plant science community is very competitive internationally and BBSRC must provide the resources to ensure that it remains so in the future, working with other funders to support a balance of basic, strategic and applied research investments. Discoveries from fundamental plant science research will

form the foundation for future innovation in crops and, ultimately, deliver economic and societal benefits for the UK and elsewhere.

5.2.4 Succession planning and training

74. Many of the UK's current crop science research leaders will retire over the next decade and there is a risk that vital skills and expertise will be lost. It is therefore essential that succession planning within the crop science community becomes a major priority for BBSRC and that the Council works with the research community to identify how important programmes of research will continue. The challenges are likely to be greater within the university sector than for BBSRC's strategically-funded institutes; BBSRC will need to work closely with key research organisations, perhaps through its Strategic Partnership programme. Although there is a need to support crop science researchers across the whole career structure, BBSRC's immediate focus should be supporting early-career scientists. In this context, the provision of targeted fellowships in crop science would be very beneficial.
75. Training and skills development are vital to the long-term health of the UK crop science community and the associated industry sectors. There are several areas of training which appear to require additional support (e.g. agronomy, bioinformatics, entomology, physiology, plant breeding, quantitative genetics, soil science), many of which were identified in BBSRC's 2009 report on *Strategically-important and vulnerable capabilities in UK bioscience*³⁵. BBSRC now encourages institutions with DTP awards to use the funding to support doctoral training in these niche and vulnerable skills areas. This is welcome, but is unlikely to have a significant impact on addressing the skill shortages and more targeted action is required. BBSRC should ensure that its crop science training places greater emphasis on the development of interdisciplinary skill sets, as these will become increasingly important for the continued delivery of excellent research. The Council should also work with universities to expose undergraduates to crop science and encourage the best individuals to consider a career in this area. In addition, broader skills are required to develop and deploy new varieties of crops which can be grown in the field and deliver agricultural benefits. Supporting the development of these skills may be outside BBSRC's remit, but a lack of relevant training has implications for the effective translation of BBSRC research into practical application. Where appropriate, BBSRC should work with other organisations (e.g. levy bodies) who have shared interests in maintaining and developing the spectrum of skills and expertise which support crop science.

5.2.5 Maximising the impact from BBSRC research

76. The world-leading crop science research supported by BBSRC has strong potential to deliver wider economic and societal benefits in the UK and globally. To date, however, progress towards realising this potential has been too slow. BBSRC must do more to maximise the impact of its investments. It should continue to work with the research community to embed a culture which recognises the importance of delivering wider benefits from publicly-funded research. It should also develop a deeper understanding of the mechanisms for impact delivery, drawing on expertise from economists and social scientists, noting that existing approaches may not be the most efficient. BBSRC should identify and, where possible, address the barriers which limit the exploitation of its crop science research. In particular, it should consider how to address the funding gap for

³⁵ www.bbsrc.ac.uk/organisation/policies/reviews/consultations/0905-bioscience-research-skills.aspx

further development and commercialisation of research findings; within the agricultural sector, there is a clear need to 'de-risk' research before it is taken up by the private sector (e.g. plant breeders and the agricultural supply industries). BBSRC should also consider how to foster closer links between academic researchers and other parts of the agricultural sector. It was notable that research projects with links to industry had clearer routes for the delivery of impact.

77. For research to deliver benefits to agricultural systems, it is essential that the public has confidence in the science and technologies that underpin food production. In this context, BBSRC should improve researchers' participation in science communication and public engagement activities. It should also explore opportunities to work with ESRC to develop a better understanding of public attitudes to food and technology.

5.2.6 The changing landscape for crop science research

78. This evaluation highlights the intense pace of change in the UK crop science research landscape over the past decade. New opportunities and challenges arose continuously, including the development and rapid uptake of new technologies, the constantly evolving social and political context of the research, and changes to the funding landscape. In hindsight, these changes occurred more quickly than expected and it could have been useful to examine BBSRC's progress in addressing the recommendations of the Crop Science Review sooner. This rapid pace of change is unlikely to decline in future and BBSRC must continue to respond effectively. The Council will need to review and refine its crop science strategies regularly to take account of developments in the UK and globally.

5.3 Summary

79. Overall, BBSRC's support for crop science over the past decade was impressive. The health of the UK crop science community improved substantially following the publication of the Crop Science Review and the Council's effective response to it. The research and training supported was of a high standard, resulted in very good outputs, outcomes and achievements, and contributed to wider benefits to the public good. There is still more to be done to ensure that the UK maintains its strong international standing in crop science. Many of the Review's recommendations remain relevant and changes to the crop science landscape have created new challenges for BBSRC. Equally, there are exciting new opportunities to pursue.
80. It is currently a very exciting time for crop science. New technologies, resources and knowledge are creating opportunities for scientific discoveries in crops which were previously only possible using model plant systems. In 2004, the Crop Science Review foresaw the potential of genomics to create a step-change for crop science research. At the time, it was impossible to foresee how pervasive and transformative these technologies would become. Crop scientists are now poised to exploit genome information in much more sophisticated ways and there are possibilities to deliver far-reaching impacts. The future is uncertain and the challenges facing global agriculture unprecedented. There is a need to produce more food in a sustainable manner while protecting the environment and adapting to climate change. It is essential that BBSRC continues to build on its long-standing and successful support for crop science research and training. It must maintain the current momentum with sustained investment and show leadership to coordinate the efforts of other funders in this area. This will ensure that UK can take advantage of its strong position in crop science to deliver innovative

solutions to urgent issues such as food security, while also providing major contributions to the UK's economic growth.