WHY FARMING MATTERS

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WHY SCIENCE MATTERS FOR FARMING

NFU

100 YEARS

1908-2008

Contents

The timeline included in this report shows the key advances and critical points in the history of farming, and illustrates the progress that has been made. The case studies are included to give a flavour of the range, sophistication and impact of the science being applied today.

WHY SCIENCE MATTERS FOR FARMING

Foreword by NFU President Peter Kendall

Science and technology have always been a central part of farming, for all sectors and for all types of production. Today, science matters for farming more than ever before.

We are in a unique place in the history of agriculture. World population is expected to exceed nine billion by 2050, and an increasing number of people are moving out of poverty.

At the same time the world can expect to experience significant impacts of climate change including further increases in oil, fertiliser and food prices. The demands, challenges and opportunities for British agriculture are great.

In the 21st century farmers and growers will need to produce more food efficiently and safely, meet market demands, optimise the use of inputs, minimise environmental impact and provide positive environmental goods and services – all at the same time.

Why Science Matters for Farming combines a celebration of scientific progress through the history of our industry with calls for a refocusing of Government priorities and research funding to reflect the particular challenges of the 21st century.

There are two key aspects of the current situation that have prompted the NFU to launch this campaign. Firstly, the balance of government policies for agriculture and research between environment and productivity, and secondly, the level and focus of funding for research.

In the 21st century, agricultural research and development (R&D) needs to be directed towards optimising efficiency and productivity, and at the same time recognising that farming impacts upon, and is affected by, the environment. The NFU believes it is time for a genuine policy shift in agricultural science funding away from a sole focus on the environment, and towards recognising that production efficiency is a justified and essential endpoint for scientific research.

The significant decline in funding for UK agricultural R&D in recent decades must be reversed as a matter of urgency. Funding priorities should include proper resources given to applied science and translation to practice on the ground, where there is currently a serious fracture in the pipeline. Only then can the UK's impressive skills and expertise in agricultural and land-based science achieve their full potential in terms of value for money and economic impact.

It is dangerous to allow the current trend of funding cuts to continue, and not to address the impact it is already having on the numbers of scientists in this sector. Research cannot simply be switched on again once it has fallen below critical capacity. Also, we cannot rely on knowledge, expertise and new technologies to come from overseas.

The UK has a duty to maintain world-class expertise and facilities in agricultural R&D and to make the most of its productive capacity as climate change prevails.

The message of this report is clear: Science matters to the security of world food supplies and the global environment more than ever. It is the bedrock on which so much of agriculture's progress has been based and is essential to help deliver the efficiency of production in agriculture and horticulture so critically needed.

This must now be reflected in Government policy priorities and public attitudes to the use of science and technology in farming.

Peter Kendall
NFU President

NFU 100 YEARS 1908-2008

The NFU champions British farming and provides professional representation and services to its farmer and grower members

What has science achieved?





BBSRC ©

Science and technology: Its place in the history of farming

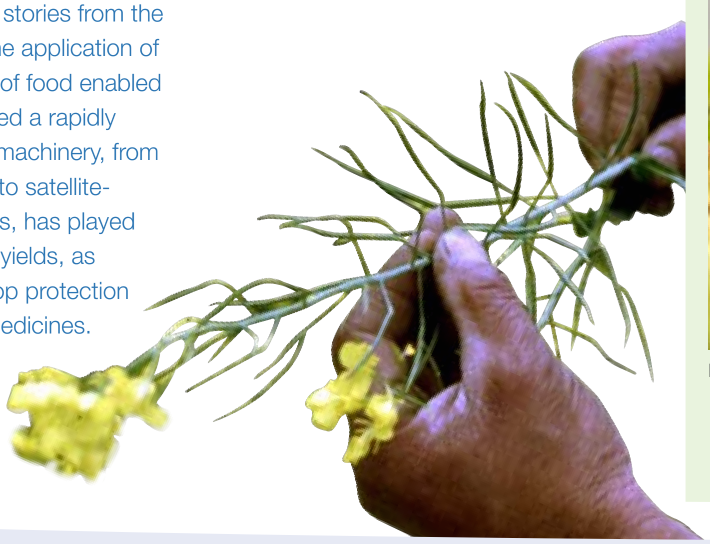
Summary

Human ingenuity and skill have always been hugely important to the development of farming. But it has been the appliance of science which has brought about the huge leaps forward we have seen in the past 200 years. Science has transformed farming from a small-scale, largely subsistence activity into an industry which, in the UK, produces over 60% of the food for a population of 60 million and is the core of a farming and food sector worth some £80 billion a year[1].

There are some incredible stories from the past century about how the application of science to the production of food enabled farmers and growers to feed a rapidly growing population. New machinery, from the double-furrow plough to satellite-guided combine harvesters, has played a critical role in increasing yields, as have artificial fertilisers, crop protection products and veterinary medicines.

Genetic improvement has been vital, with selective breeding of both plants and animals allowing significant improvements in productivity. Techniques for managing land, plants and animals, and the inputs used, have been developed and improved significantly. And this is true of all sectors and all production systems, conventional and organic alike.

If the challenges of the past have mostly been around productivity, to keep pace with population growth and provide food security, those of the present and future have a new dimension. Farmers and growers must continue to increase their productivity, not at the expense of the environment, as has sometimes happened in the past, but in harmony with it. And just as science has been vital in meeting the old challenges, so it will be even more important in the future. This is why science matters for farming.



CASE STUDY
Crop diseases

Phoma stem canker is a serious disease of brassica crops, which affects oilseed rape in the UK, and causes $900 million losses worldwide. As winters get warmer and wetter it significantly increases in severity and arrives earlier in spring.

A forecast model was developed as a tool to help guide the timing of fungicide application by farmers, and then extended to assess how global warming might affect future disease epidemics. Such modelling can be done for other plant diseases, helping to develop climate change adaptation policies for food security and wildlife. *(Rothamsted Research)*.

Phoma stem canker - Rothamsted Research ©

The Agricultural Revolution of the second half of the 18th century was a period of extraordinary innovation, and change in both the techniques and the structure of farming in Britain. But it was really in the 19th century, as Britain moved from being an agrarian society to an industrialised one, that scientific progress was translated into practice and productivity on the ground.

There were new machines designed for specific jobs, steam power, drainage, selective breeding to improve livestock, the use of protein-rich feed and attempts to reduce the impacts of disease on crops and animals. It was at this time that improvements in farming practice started to move from being the result of observations by practical farmers, to being based on the use of science to understand how plants and animals grow.

Some farmers applied this understanding to great effect, combined with significant innovation in management, reclamation, cultivation, cropping and stock improvement.

The Agricultural Societies played a vital role in popularising and spreading the new techniques, and success bred success as farmers saw for themselves the results that could be achieved through applying the new techniques.

CASE STUDY
Lameness in sheep

Lameness costs the UK sheep industry £31 million per year.

At present, little is known about the bacterium that causes footrot (a precursor of lameness).

Research is being carried out to identify which strains of the bacterium cause most disease and how the environment and the sheep influence their survival, leading to better advice on control *(University of Warwick, University of Bristol)*.

But the age of Victorian high farming, as it was known, was not to last. From the 1870s onwards a series of disastrous harvests in the UK, coupled with the arrival of huge quantities of, first, cheap grain from the USA mid-west and, subsequently, refrigerated meat from South America, plunged farming into a depression which was to last, with just a brief remission during and immediately after the First World War, for some 60 years.

What has science achieved?

JCB ©

However, the end of that period provides us with a baseline from which to compare what is considered to be the revolution of modern British agriculture that started in the late 1930s. When the political and economic drivers around this time enabled the industry to recover, science and technology could once again be applied to agriculture. But this time the science had a robust basis and could be used both directly, for example through improved varieties or animal vaccines, and also translated into commercial application by modification and demonstration on farms.

The wartime 'Dig for Victory' campaign and the peacetime drive for greater self-sufficiency in food that succeeded it were both built around an overt Government recognition of the importance of science to food production and a firm commitment to invest in it. That extended beyond the basic research into its application on farms.

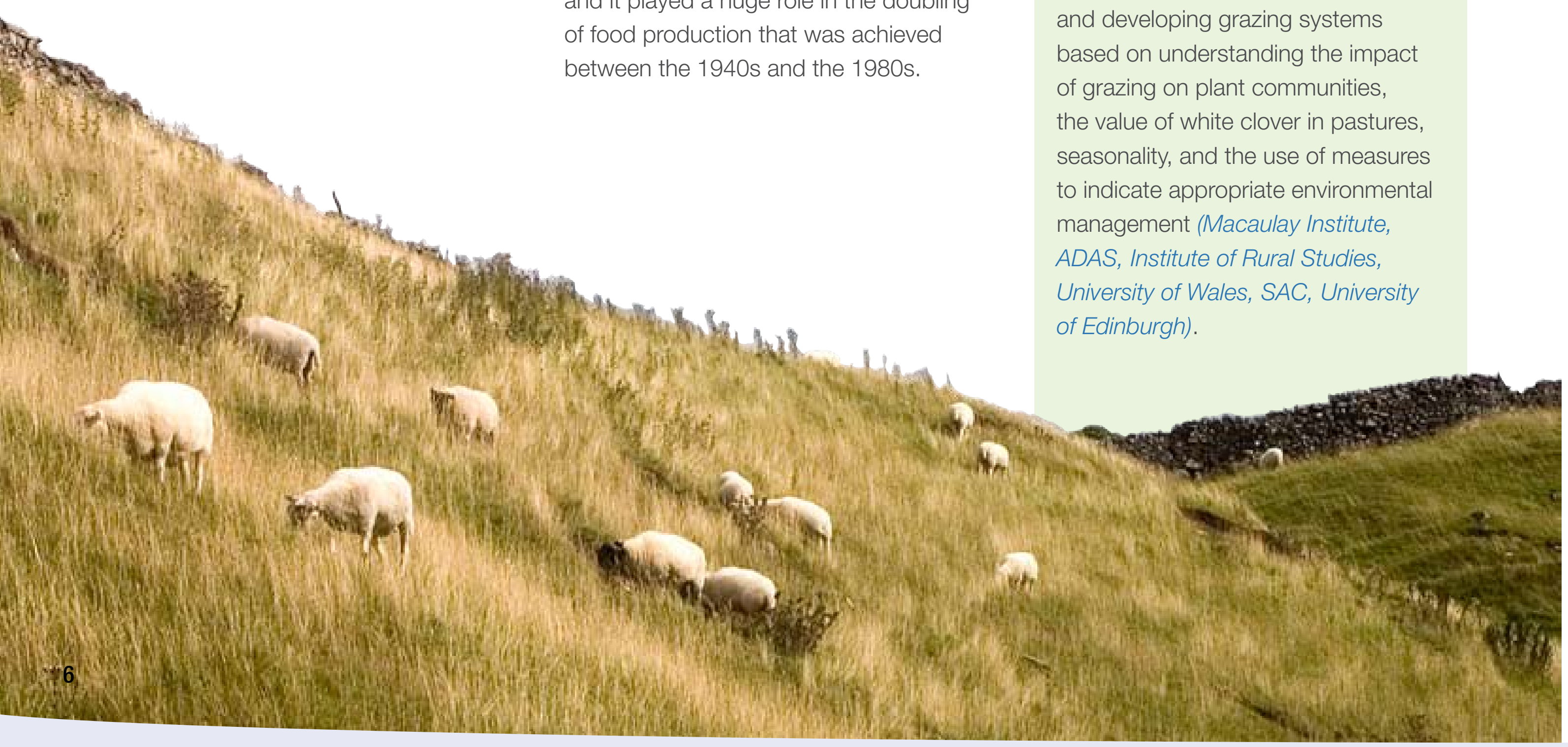
The National Agricultural Advisory Service (precursor to the Agricultural Development and Advisory Service ADAS), with its own 'experimental husbandry farms', and a network of farm advisers covering the entire country, was established in 1947 and funded by the Government. For the farmer or grower, the service was free, and it played a huge role in the doubling of food production that was achieved between the 1940s and the 1980s.

CASE STUDY
Biodiversity in upland areas

Upland livestock farmers must deliver environmental objectives for important plant biodiversity on their pastures but they must also be able to make a living and not compromise productivity.

Science-based management systems are already in use on farms across the UK, helping lamb and beef producers achieve both.

These include setting stocking rates and developing grazing systems based on understanding the impact of grazing on plant communities, the value of white clover in pastures, seasonality, and the use of measures to indicate appropriate environmental management *(Macaulay Institute, ADAS, Institute of Rural Studies, University of Wales, SAC, University of Edinburgh)*.



The advice and demonstration approach achieved momentum as new technologies were adopted by the most innovative and forward-thinking farmers, who achieved results of increased production and reduced costs, to the envy of their neighbours.

British agriculture and horticulture owes much of its historical success in terms of yield and quality of product to the successful and widespread application of science and technology.

The production of crops and livestock as we see it today is the result of many decades of the application of scientific research and innovation, and its commercial application on the ground. Indeed, the development of rotations, mechanised equipment, fertilisers, crop protection products and new varieties and breeds began to produce significant gains more than 100 years ago.

Yields, quality, reliability, labour productivity, variety, food safety, pest and disease control have all improved dramatically through technology and innovation based on science.

This enabled populations and economies to expand in all parts of the world. The farming industry adopted the technological developments and science-based solutions very quickly in the past, to great effect.

Mechanisation is particularly noteworthy as a technology that has revolutionised agriculture. The three-point linkage, patented by Harry Ferguson in 1928, is considered the most significant development in farm machinery design. The famous 'Little Grey Fergie' tractor was produced in 1946 and transformed the picture of farming in Britain and around the world in the 40s and 50s.

In more recent times, Fastrac tractors, rubber-belted tracks, robotic milking, Global Positioning Systems (GPS), controlled traffic systems and autosteer are just some of the new technologies and tractor designs that have changed the face of modern agriculture in a few decades.

The increase in the UK population during the past 300 years, and the move to urban living, has been made possible because of the farming industry's ability to provide a secure supply of a diverse diet of safe food.

That was obviously more difficult in war-time, but it was the way in which the industry rose to the challenge – using science to the best advantage – that had the greatest impact, both on the politicians and on farmers themselves. In the most striking way possible, it demonstrated the potential for farming to progress and to deliver what is demanded of it – and the potential of the scientific community to contribute to the process.

CASE STUDY
Mastitis in dairy cattle

Mastitis reduces dairy cow welfare and milk quality, costing the UK dairy industry around £200 million per year.

Research is being carried out to identify bacterial strains that can and cannot cause disease, along with bacterial proteins and chemical messages produced by the cow. Proteins will be candidates for vaccines and chemical messages will be targets for the production of therapeutics *(University of Oxford and IAH)*.

What has science achieved?

John Innes Foundation ©

CASE STUDY[2]

Reducing reliance on fertilisers

Fertiliser is an important agricultural input but its price has increased massively during the past year, and its manufacture and use has an adverse impact on the environment. The efficiency with which crops can benefit from the nutrients in fertiliser will affect their contribution to environmental pollution.

Canola, or oil seed rape, has been genetically modified to increase its nitrogen use efficiency, thereby reducing the amount of fertiliser it requires. Life-cycle assessment has been used to analyse the potential environmental impact of growing such a crop, as compared to a conventionally bred variety. The most significant benefits were predicted to be reductions in greenhouse gas emissions and diffuse water pollution.

Of course, the use of science and technology in food production can be controversial. In the past such innovations as artificial insemination, margarine and even pasteurisation have been criticised as dangerous, unnatural and unnecessary. Yet these are now taken for granted by the public and relied upon by farmers. Science has enabled detection and removal of harmful contaminants, making food safer and protecting the public from adulteration of food.

In recent times, with food plentiful and safe, applying science to food production has been met with suspicion by some and even thought of as inconsistent with quality, which itself is often linked to perceptions of 'natural'.

Widely reported food scares have also been a feature of public discourse. An extreme example is the application of genetic modification (GM) techniques to agriculture, which has caused particular anxiety and concern. In the UK and most of Europe, a highly charged and emotive debate continues to rage over the application of GM technology. Yet elsewhere in the world, it is being embraced, with some 114 million hectares of land planted with GM crops in the last harvest year, by 12 million farmers in 23 countries[3]. And it has been adopted more quickly and widely than any other crop technology in history.

One of the many ironies of this situation is that, whilst the use of GM technology in farming has been resisted in Europe, the adoption of the same technology in food processing, brewing and in the pharmaceutical industry has taken place without any significant public concern.

The applications in agriculture and horticulture of advanced breeding technologies such as GM and marker-assisted selection are developing all the time. They offer obvious potential for reducing oil-based inputs such as fertilisers and agro-chemicals, producing more nutritious food and feed or in breeding plants that are resistant to the consequences of climate change.

Given the huge challenge facing farmers around the world – to double or even treble production, from less land, using less water, in a progressively more difficult climate, without harming the environment – it is inconceivable that modern biotechnology will not have a key role to play in the future.

Another highly significant technological advance of recent decades is precision farming. In the space of about 15 years the take up of this technology has grown exponentially and has transformed crop production particularly in Australia and North America where it is combined with no-plough systems. While it requires data collection and analysis to be used to the full, it is still developing and has significant potential.

The use of GPS and extremely accurate autosteer tractors has helped deliver a step change in efficiency. It is just this precision and improvement in efficiency that is needed to conserve resources and optimise inputs at the same time as scaling up production. These technologies are another part of the toolbox of farm management techniques that symbolise why science matters for farming.

CASE STUDY[4]

Precision farming

AGCO Ltd ©

AGCO Ltd ©

The idea of precision, or site-specific, agriculture was developed in the early 1990s. In the space of only 15 years it has become a practical reality on millions of hectares around the world, and it is still developing.

The term describes the application of a set of mapping, remote sensing, data collection and robotic technologies that enable the farmer to manage crops precisely and accurately. For example a GPS (Global Positioning System) receiver on an auto-steer tractor with a 2cm accuracy allows drilling between the previous year's rows in a no-plough system. Cultivation, drilling and harvesting can be done in the dark more easily and are far less tiring. There is no overlap for fertilisers and crop protection products, so lower volumes are used. There are no 'misses' in herbicide application so weeds are controlled better.

Mapping of the variability within the whole field can enable management that is targeted and tailored precisely to the conditions, optimising inputs and yield. A lot of data over a number of years needs to be collected to make use of mapping factors such as soil type, nutrient levels, yield and moisture.

The potential for precision farming, as part of the technology toolbox, to make a significant difference to efficiency and productivity in the coming decades is huge.

WHY SCIENCE MATTERS FOR FARMING

What is the current state of agricultural science in the UK?

Rothamsted Research ©

Summary

The UK remains among the world leaders in pure and applied scientific research in agriculture and related subjects. However, in recent decades investment, of intellectual as well as financial capital, has fallen off, as successive Governments have taken the view that the level and efficiency of UK food production was no longer a prime national concern.

At the same time, the chronic economic difficulties of the farming sector have made it difficult to generate funds from within the industry to take the place of declining Government investment.

The result has been a serious and worsening decline in the UK's agricultural research and development capacity, evidenced in the closure of research facilities and a significant shortfall of investment in many others. We have also seen UK and global productivity gains levelling off, falling from a 4% annual increase up to the 1980s to around 1% now. These trends must be reversed.

Farming is a sector which delivers many 'public goods', whether they be in the security of food supply, the management of the countryside or the quality of the rural environment; public investment in farming's scientific base therefore has a clear logic to it.

This is especially true given the nature of the industry, made up as it is by tens of thousands of micro-businesses, which limits its ability to generate the funds necessary for pure and applied research. The risks, uncertainties and failures inherent in scientific research are not easily borne by commercial producers.

Government also has a direct interest in agricultural research science, in that the results will enable it to design and implement policy across a broad range of issues for which it has ultimate responsibility, ranging from food safety, through water quality to food security. Agricultural research gives a strong return on investment.

Against this background, a scenario has evolved in which Government broadly funds only what it considers 'public good' science. The industry itself, including through the Agriculture and Horticulture Development Board (AHDB) and LINK programmes, both adds value to public good research and carries the full burden of so-called 'near market' R&D.

The application of research results through agricultural extension services of one sort or another is also largely an industry responsibility, albeit sometimes part-funded from EU or Government programmes. Of course publicly-funded research should reflect Government priorities for farming. However, the wholly environmental focus of Government research policy is not sustainable and is no longer appropriate. Understanding impact on the environment is vital, but so is productivity and efficiency of production. Mitigation of environmental impact can no longer be the only goal of Government-funded agricultural and land-based research.

The end result of current funding policy is that total allocation in the UK for farming-related R&D has been falling sharply in real terms, evidenced by the 45% drop in MAFF funding between 1986 and 1998[5]. Applied science and the research and resources necessary to translate science into practice have been particularly badly hit.

The international picture is also worrying. There is a general trend of widespread cutbacks in publicly-funded R&D for the sector across the developed world, while China and India are ramping up investment. However, of the developed countries it is the US, Japan, France and Germany who conduct the majority of research in the sector (66% in 2000)[6].

It is inevitable that underinvestment will adversely affect productivity and it begs the question whether the UK's position relative to other countries is having a significant impact on the competitiveness of British agriculture. It is clear that this situation must be urgently addressed.

Concerns have been voiced for some time by both the science community and industry not only that the absolute level of investment in agricultural science has fallen to a dangerously low level, but that the pipeline which connects fundamental research to application on the ground is broken.

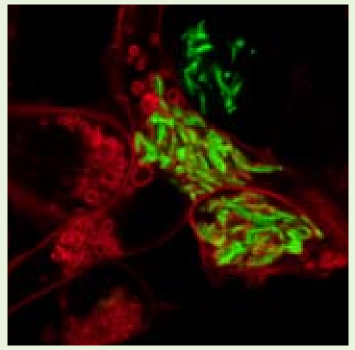
Certainly, there are some significant gaps that make it very difficult for the farming industry to take full advantage of the world class science the UK is capable of. For this potential to be realised, there must be adequate funding overall, and a significant increase in resources for translation and extension.

Land managers and farmers have always needed access to sound advice and information. In the 21st century they need this more than ever before, to be able to respond to the pressures of environmental, social and economic change. And so does the Government, if it is to achieve the behaviour change on the ground needed to deliver an ever growing range of policy objectives.

Investment in science generally in the UK has held up reasonably well in recent years. The UK committed 1.9% of GDP to research and development in 2007, compared with the EU target of 3%[7], and aims for 2.5% by 2014[8]. Government funding for science has doubled overall in the past 10 years, to £3.4 billion in 2007[9].

CASE STUDY

Bovine Tuberculosis (bTB)



Institute for Animal Health ©

TB disease in cattle is currently devastating the UK livestock industry. Last year 28,000 cattle were culled because of TB and during the first quarter of 2008 another 13,500 cattle have been lost.

Research plays a vital role in identifying the solutions to tackle the disease.

Genomic technologies are being used to assess how new strains of bovine TB can manipulate the bovine immune response *(VLA and IAH)*. Sciencific technologies enable the extraction of DNA from cattle with increased bTB resistance and genotype it to help identify new approaches to controlling the disease *(Roslin Institute and Queen's University Belfast)*.

However, the trend in funding for strategic and applied agricultural research has been moving in precisely the opposite direction. In real terms, Government science investment via MAFF (now Defra) fell by 45% between 1986 and 1998[5].

In 2007 Defra funding of the Biotechnology and Biological Sciences Research Council (BBSRC) institutes had dropped to £19 million from the real terms equivalent of £129 million in 1972, with further reductions expected. Overall, Defra's funding for sustainable agriculture will fall by a further 20% by 2010-11 on top of the 12% cut for 2006-07.

The institutes hit hardest by this – the Institute for Animal Health, the Institute for Grassland and Environmental Research and Rothamsted Research - are also those of most relevance and importance to the productivity and environmental performance of farming. There remains considerable expertise in the universities and institutes that still conduct research relevant for agriculture and horticulture. But our world-leader position is at risk of being eroded[10].

What is the current state of agricultural science in the UK?

Rothamsted Research ©

CASE STUDY[11]

Helping plants adapt to climate change

Plant cells can stop dividing under environmental stress preventing growth. Understanding this response and identifying genes that enable plants to tolerate stresses (such as drought, water logging and heat) associated with climate change could lead to improved crop varieties *(University of Cambridge, Rothamsted Research)*.

Drought is a particular problem for sugar beet growers, with yields expected to fall by a half in areas such as East Anglia. Scientists and international seed companies are working together to develop drought resistant varieties of sugar beet *(Broom's Barn)*.

Rothamsted Research ©

Funding cuts have led to numbers of scientists falling below a critical mass in some key areas, such as soil science, pest and disease resistance, bee pathology, animal nutrition and crop agronomy. This is happening just at the time when we need these scientists more than ever.

With less and less money available for agricultural research, it is essential that more value is achieved for each pound spent. It has been widely recognised that a more cohesive, 'joined-up' and collaborative approach is needed between all the funders and providers in the land-based science sector.

Defra itself was described as an 'intelligent customer for science' in the Office of Science and Innovation (OSI) review of science in the department[12]. The OSI review also stated that there is an obligation on Defra to build up and maintain external science expertise, and 'to ensure that its requirements for expertise and facilities can be met now and in the future'.

It is not a solution to simply call on industry to pick up the funding shortfall.

It is not only that there is significant public good associated with having a thriving farming and food industry in Britain. Or that there can be unease over too much reliance on private companies for R&D in the agri-food sectors. There are also more simple, logistical issues.

While new technologies have played an integral role in the history of modern agriculture, the ability of farmers to take risks and innovate can be limited, especially when margins are tight and incomes are low. They are governed by the growing cycle and by the many uncontrollable and unpredictable factors inherent in farming.

Experimentation is central to farming, and farmers can be considered as the ultimate applied engineers, biologists and ecologists. But in scientific research a high percentage of experiments will not work. Taking the risk that a new way of doing things may not deliver, or that a benefit may not be felt for several years, is very often impossible.

Knowledge transfer mechanisms are central to enabling benefit to be extracted from research. In the past demonstration farms, such as the Agricultural Development and Advisory Service (ADAS) experimental husbandry farms, have been critical and highly successful in putting science into practice. They are an ideal way for farmers to see what can be achieved, assess its relevance to themselves and apply it to their particular circumstances once the uncertainty has fallen to an acceptable level.

Agronomists, nutritionists and other farm advisers are a valuable way for science to reach practice, but they are an additional cost that smaller farmers especially may not be able to afford. Farmers still mourn the 'loss' of ADAS, privatised in 1997, identifying this as a barrier to their take up of new technologies and management practices. The ADAS experimental husbandry farms have now been sold, and many research stations carrying out field-scale applied agricultural research have been closed.

CASE STUDY

Smart use of water

Water availability is an important limiting factor in field vegetable production, particularly in southern Europe which is a major competitor for UK growers in the domestic market. Growing plants with a better water use efficiency could enable a more competitive UK sector in the future.

Warwick HRI ©

The potential to breed new cultivars that do not need as much water to grow has been improved by understanding the genetics responsible for both plants' reaction to drought and roots' ability to penetrate compacted soils *(Warwick HRI)*.

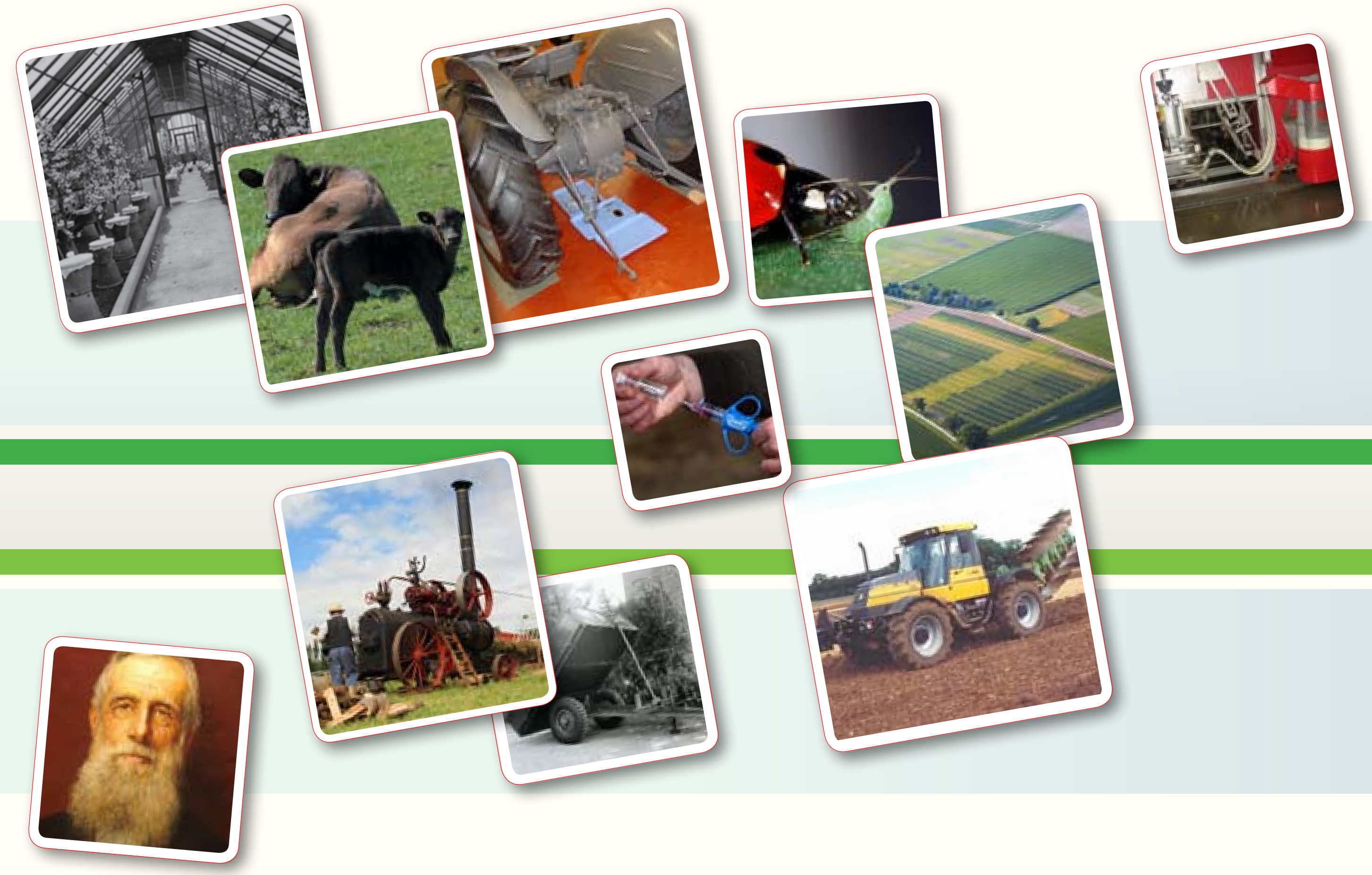
The new AHDB is committed to R&D as a critical part of its work but the money available from levies is stretched very thin. Much of it is spent on extension services, which are very valuable but can only reach a small proportion of producers as currently funded. The money farmers and growers pay through the levy can be boosted by collaboration and joint funding, such as through Defra LINK projects, and bringing in other industry funders. For example, the Home Grown Cereals Authority (HGCA) has increased co-funding so that almost £4 of research is carried out for every £1 of levy spent[13].

However, there can be difficulties in putting together projects that can deliver both industry and Government objectives at the same time, since the latter do not include productivity and tend to be dominated by environmental outcomes.

This balance must be addressed and efficiency of production recognised as a legitimate goal for publicly-funded research.

The funds available for R&D from agriculture and horticulture industry levies are minimal when compared to the expenditure needed for the key research institutes and university departments. Contrast the AHDB spending of around £13.3 million per year for applied R&D with the BBSRC's current budget of £400 million per year for mostly fundamental and some strategic science[14].

WHY SCIENCE MATTERS



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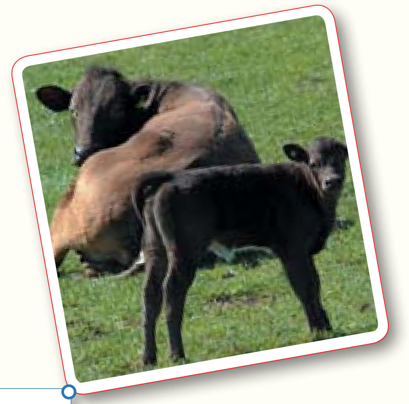
WHY SCIENCE MATTERS FOR FARMING TIMELINE

First agricultural revolution

Massive progress, based on practical application, trial and error by farmers



Start of period of increasing agricultural productivity

Selective breeding of livestock introduced

Limestone first applied to soil

John Deere makes steel plough

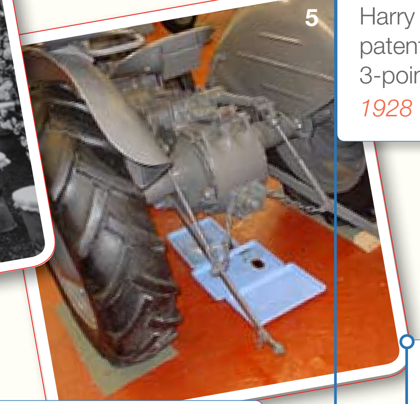
Royal Agricultural Society of England founded with motto "Practice with Science" 1838

Protein rich feed made using oilseed from British colonies

Pasteurisation invented 1862

Depression and stagnation in productivity

John Innes Horticulture Institution founded 1910



Welsh plant breeding station founded 1919

Harry Ferguson patents the 3-point linkage 1928

Agricultural Research Council set up 1931

Second agricultural revolution

application of agricultural science

Progress in 50 years…

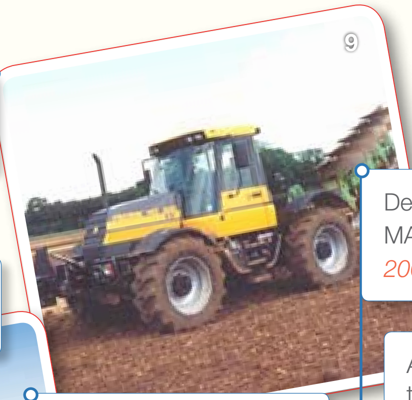
In 1936 4.5Mt combinable crops harvested → In 1986 26Mt combinable crops harvested

Britain 30% self sufficient in home-grown crops Late 1930s → Britain 80% self sufficient in home-grown crops Late 1980s

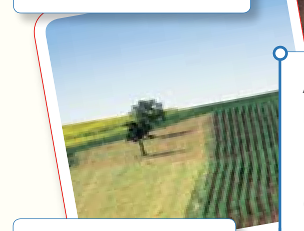
On average 10 piglets born per sow per year. Pigs consumed 4.95kg of feed for 1kg weight gain Late 1930s → On average 20 piglets born per sow per year. Pigs consumed 2.88kg feed for 1kg weight gain Late 1980s

- Wheat, barley and oats production increased 6-fold
- Poultry meat production increased 12-fold
- UK became net grain exporting country
- Cereal yields nearly treble
- Annual milk yield per cow increased by 65%
- Annual egg yield per bird increased by 79%
- Increasing mechanisation and use of fertilisers and pesticides
- New improved varieties of crops, selective breeding and hybrids in wheat and other grains
- Vaccines developed and routinely used
- Improved irrigation
- Artificial insemination refined and widely commercialised

JCB Fastrac tractor launched



Development of 'precision farming'



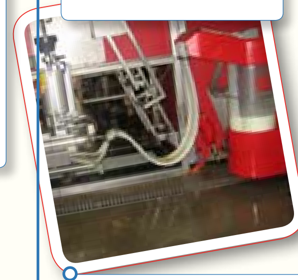
First yield mapping combine demonstrated in UK, providing farmers with data about their harvested crops

AFRC incorporated into new Biotechnology and Biological Sciences Research Council (BBSRC) 1994

Zeneca commercialise GM tomato in US 1994

Defra replaces MAFF 2001

Autosteer tractor systems in common use



Robotic milking used commercially around the world

New All Party Parliamentary Group on Science and Technology formed 2008

First draft of maize genome sequence (Washington University) 2008

92% of British pig units using artificial insemination for breeding 2008

1700	1710	1720	1730	1830	1840	1850	1860	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010

Increased use of fencing and crop rotations

Jethro Tull invented the seed drill

Increasing area of legumes grown

Land reclamation of fenlands, woodlands, upland pasture, lowland heath

Rothamsted Experiment Station (now Rothamsted Research) founded 1843

Pest control developed and used (chemical and biological)

Laws fertiliser patented

Herdbooks first used for constructive livestock breeding

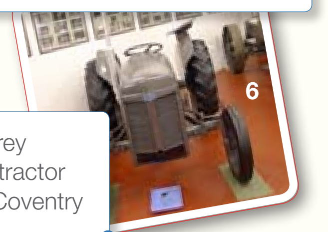
Steam power applied to farming, replacing animal power Late 1850s

1908-13 Haber-Bosch process of nitrogen fixation implemented commercially to produce synthetic fertilisers

Late 1940s to 1950s, first tipping trailer and backhoe introduced in UK by JCB

ADAS (Agricultural Development and Advisory Service) formed 1971, from National Agricultural Advisory Service (est.1947 as part of MAFF), the link between science and farming practice

1946 'Little grey Fergie' TE20 tractor produced in Coventry



1983 Agricultural Research Council (ARC) becomes Agricultural and Food Research Council (AFRC)

Mid 1980s controlled traffic farming systems start to be used in Australia

First rubber track tractor introduced by Caterpillar 1987

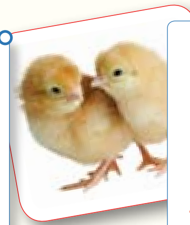
Barnes report on government agricultural R&D expenditure published 1988

ADAS privatised 1997

GM tomato purée on UK supermarket shelves 1996

1.66M hectares commercial GM crops grown (in US, Canada, Australia, Argentina) 1996

Whole of chicken genome is sequenced (Wageningen University) 2004



Barley genome sequenced (international consortium) 2012

Rice genome mapped (international consortium) 2005

Drought tolerant maize launch in US 2012

Population

Sources: Census & Office of National Statistics

1750	1801	1901	1931	1961	1981	1991	2000	2006	2011	2031	2081
5.6 million (E&W)	10.5 million (not NI)	38.2 million (UK)	46 million (UK)	52.8 million (UK)	56.4 million (UK)	57.4 million (UK)	58.9 million (UK)	60.6 million (UK)	62.8 million (UK)	71.1 million (UK)	85 million (UK)

FOR FARMING **TIMELINE**

1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030

open

WHY SCIENCE MATTERS FOR FARMING

What is the current state of agricultural science in the UK

Internationally, the private sector spends significant amounts on R&D, although this is largely highly competitive and commercially sensitive. The major agricultural multinational companies spend $7.3 billion per year on agriculture-related research, more than 20 times the budget of the public sector Consultative Group on International Agricultural Research (CGIAR)[15].

As an individual farmer, achieving a return on R&D investment is difficult. Private sector research tends to be focussed on technologies that can be protected and specifically marketed to ensure this return. The competitive nature of the findings means their availability is limited. For all of these reasons, the justification for public-funding of agricultural science cannot be in doubt.

Some of the UK's competitors for both supplying and importing the global market for agricultural goods are emerging as big players in science and technological innovation. Developing countries overtook developed countries in providing more publicly funded agricultural R&D for the first time during the 1990s. In 2000 China and India alone spent 39.1% of the funds used by developing countries on agricultural R&D[6]. China is now doubling its spending on agricultural biotechnology in the next five years from a current level of $400 million, and it already accounts for 20% of global investment in R&D in the biotech sector[16]. These figures demonstrate the stark contrast between the UK's continued trend of underinvestment and the recognition in certain rapidly developing countries that agricultural R&D is vital to improve their economic prospects.

While it may be tempting to those responsible for footing the bill for agricultural-related research to rely on international collaboration and spillover from other countries, this cannot be a healthy or responsible position for the UK.

CASE STUDY
Artificial insemination

Institute for Animal Health ©

Artificial insemination (AI) was the first major application of biotechnology to animals and it has revolutionised livestock production. It is now standard practice in all systems, including organic.

AI reduces disease risk; allows targeted genetic improvement; increases the number of offspring possible per sire especially in cattle as bull semen can be diluted significantly; allows trade and transport of semen around the world and therefore greater potential for genetic improvement of livestock.[17]

Much more recently, sexed semen technology has been developed, and offered commercially for the first time in 2000 by Cogent Breeding. Sexed semen enables cattle producers to target their breeding programmes, to achieve, for example, massively increased chances of producing female calves for replacements in dairy herds.

The UK has a history of world-leading science, with the infrastructure and expertise to deliver it and has been one of the countries the developing world has relied on for accessing agricultural technologies and research.

The British Government begins its 2004 'Science and innovation investment framework' report with a clear statement that in a highly competitive global economy technology, skills and innovation are what enable nations to thrive. This philosophy must be applied to agriculture and future investment must also reflect this.

Importantly, there is a particular need for science that is relevant to the UK, due to the unique nature of our climate, land use and other environmental factors. Even within the UK, there is significant variation between the various regions, meaning that research at a regional level is essential, but can be difficult to manage within the academic funding infrastructure.

Farming is not a production line made up of discrete processes or standard operating procedures. It operates within complex systems, and a farm must be viewed in a holistic way by both science and regulation if either is to have any positive impact. For example, understanding and predicting the way various elements flow through grassland systems, which make up 68% of UK agricultural land[18], and the impact they have, is essential to develop management approaches to optimise the output from that system. The scale, in terms of time and space, of the kind of strategic and applied research needed for agriculture is one of the key challenges in terms of securing and maintaining funding. The long-term, field-scale studies such as the Park Grass Experiment and Broadbalk at Rothamsted, are extremely valuable in giving a picture of a whole system and its interaction with environmental and agronomic factors. They must continue to be funded.

Science has an important link to regulation. It should be used as the basis of farming policy, and the legislation and its implementation that arises from that policy.

The theory of evidence-based policy is now a firm aspiration across Government and in the EU Commission. Research can improve the ability of regulations to achieve what they are designed to, without leading to unintended consequences and contradictions.

UK Government officials must also be able to use science and evidence in their negotiations in Brussels. There is concern that, rather than evidence-based regulation, the policies are decided and then the research is commissioned to back up this policy. It is understandable that the uncertainty inherent in research results can be problematic for policy makers, and that judgement will have to be used. However, communication and integration of such uncertainty must be a key part of the process and it must not be used as a reason to discount the science.

Government priorities for UK agriculture and horticulture will develop as the global situation changes, and priorities for science and innovation in farming must reflect this. Maximising efficiency at the same time as caring for the environment without compromising the ability to produce have to be sensible aspirations for 21st century farming.

If expertise and resources are allowed to fall to too low a level, it will not be possible to simply switch the research on again when we desperately need it.

What are the challenges we face now and in the future?




CASE STUDY
Improving yields

Organic and other low-input production systems can result in shortfalls in yield and quality. Finding ways to increase the productivity of such systems is an important goal.

As input prices rise and variations in weather increase, there could be a benefit in increasing the genetic diversity within a crop to buffer reduced inputs and variation in environmental conditions.

The concept of 'composite cross populations' is being tested, including commercial potential and using molecular markers to monitor genetic evolution of the crops in different regions, years and management systems *(John Innes Centre)*.

Summary

The 21st century presents farmers and growers with a wider range of more complex challenges than they have ever faced before.

The industry is now in the position of having to compete in a truly global marketplace; to increase productivity; to be more efficient at using inputs; to protect and enhance the environment; to meet exacting quality, welfare and safety standards; and to both mitigate and adapt to climate change.

Productivity of all goods and services must be optimised, as opposed to maximised. This is a tall order, and the need for science to help answer these multifarious and sometimes conflicting demands is greater even than it was during the second agricultural revolution in the 50 years between 1930 and 1980, when productivity was the over-riding concern.

The overarching priority for farming in the 21st century is to increase production output for each unit of input. We need to scale up production and be more efficient at the same time. 'Inputs' in this sense covers everything that is needed to produce agricultural and horticultural outputs, including energy in all its many forms, feed, fertiliser, water, plant protection products, labour and the land itself. This priority clearly recognises the fact that not only will all inputs become increasingly expensive but also that their use will always have an environmental footprint.

A strategic view of future demands on agriculture in the UK and around the world will have to acknowledge that protecting farmers' ability to produce is as important a goal as environmental conservation.

Science undoubtedly offers solutions that industry and society need. But the research required for technological advances cannot simply be switched on and expected to deliver whenever a crisis comes along.

As we have shown, recent decades have seen a serious under-investment in agricultural science, a complete shift in focus away from production and the running down of facilities and resources for translation and knowledge transfer. This legacy means that the vital process of reinvigorating agricultural science will be starting from a worryingly low baseline.

There remains huge potential in UK science to make a real difference to farmers' ability to face the challenges of the 21st century, as long as it is delivered in a cohesive, strategic and accessible way.

WHY SCIENCE MATTERS FOR FARMING

As we approach the second decade of the 21st century, productivity is once again being seen as a politically important objective for farming.

But in comparison with previous periods when farmers and growers were encouraged, enabled and incentivised to expand output, the context is different and our knowledge of the complex relationship between agriculture and the environment is deeper.

It is acknowledged that farming has an environmental footprint, but it is also an integral part of the environment in its own right. Farming in the 21st century must deliver increased market outputs of a variety of crops and animals for food, renewable energy and industrial materials, at the same time as increasing its output of non-market goods, such as clean water and air, wildlife habitat and an attractive, accessible landscape.

For farming to achieve all of this, in a context of a changing climate and diminishing resources, it will need innovation in management and new technologies more than ever before. The challenge is that we need it urgently. Food prices are rising to unprecedented levels and there is no indication that they will return to their former trend of decrease in the foreseeable future[19].

CASE STUDY
Milk production

www.ukagriculture.com

Incredible gains in efficiency of milk production by dairy cows have led to total UK milk supply being at the same level now as in the 1970s, but with 40% fewer cows. Average milk yield is now 7900 litres per year, compared to 900 litres in the late seventeenth century [20].

The advances in yield are largely due to genetic improvement and better nutrition. For a cow to produce milk she must have had a calf first but dairy herd fertility is declining, meaning many cows are not fulfilling their milk yield potential. It is estimated this costs the UK dairy industry £300 million per year.

The environmental benefit of maintaining yield with fewer cows is clear and science has shown that high-yielding cows do not suffer reduced fertility if their nutrition is carefully managed. Significant progress has been made in understanding links between nutrition, hormones, yield and genetics, resulting in practical science-based strategies used on commercial farms *(University of Nottingham, Roslin Institute, SAC)*.

The genetic basis of declining fertility can be addressed through selective breeding. A Fertility Index has been developed to enable farmers to genetically improve their herd by knowing the genetic merit of the bull *(DairyCo, University of Nottingham, University of Edinburgh, Roslin Institute, Scottish Agricultural College)*.

Using measures of genetic merit in dairy cattle in the UK in the past 20 years has been worth over £400 million in farm gate prices - a figure which is still rising.

WHY SCIENCE MATTERS FOR FARMING

What are the challenges we face now and in the future?

Ultimately, it is the consumer who receives the benefit of scientific progress in productivity and efficiency in the shape of lower prices and a more varied diet than would otherwise have been the case. That will be just as true in the future as it has been in the past, and even more of a priority.

There will be increasing and sometimes conflicting demands for food, feed, fuel and fibre, as well as the land on which they are grown, which is also needed for housing, infrastructure and ecosystem services.

There is also growing demand for food with higher and more specific quality attributes. This demonstrates the unique position farming is in, and why it matters so critically to this country.

The hugely varied range of 'products' that agriculture must deliver must all be assessed according to their value to society and also their cost of production, in order for this to be reflected in the price that a farmer can expect to receive for the goods. Such analysis must be based on evidence, gathered through scientific research, not the fashion or political mood at the time.

Biotechnology, in its broadest sense, has tremendous potential to improve both competitiveness and its environmental footprint in all sectors of food and agriculture. Applied to crops, millions of farmers are using this technology, the vast majority in developing countries.

There are obvious benefits, for both the environment and consumers, from breeding crops that will make better use of inputs such as nitrogen and water; or crops that are drought tolerant; or crops that can deliver nutritional benefits, such as higher starch, oil, protein or omega 3 levels.

On a global scale, the application of biotechnology will continue to play a significant role in the future of farming. The complete genomes of important organisms are being sequenced, which can not only lead to breeding better plants and animals but also new methods of producing industrial feedstocks and fuels from non-food crops.

Past and existing problems evolve and completely new ones emerge, which requires an ever-evolving range of tools to tackle them. We will need all the knowledge and innovation we have, and more, to meet the challenges set out in this report.

CASE STUDY

Improved sheep stocks

Genetic selection of sheep breeding stock has traditionally been done by eye, which is not particularly reliable.

Science-based tools are now allowing sheep breeding to move into the 21st century and are benefiting farmers, the meat industry, consumers and the sheep themselves.

Traits are identified and bred in for leaner and better composed carcasses, scrapie, nematode and other disease resistance. These tools are delivering real economic benefits over the years *(SAC, Roslin Institute, ADAS, Institute of Rural Studies, University of Wales, University of Bristol, Biomathematics and Statistics Scotland, IAH Neuropathogenesis Unit)*.

WHY SCIENCE MATTERS FOR FARMING

Genetic improvement of both plants and livestock has been central to the success of agriculture since Neolithic times and has led to a vast improvement in yield and quality. It is essential to keep developing genotypes with characteristics to cope better with disease, make a better end product and thrive in a changing environment.

The return on investment on this work can be great. It has been estimated that 60% of the increase in yields seen in the decades after the Second World War was attributable to improved varieties, with the rest due to agronomic progress[21].

Wheat has shown an average 1% per year yield gain potential over the past 30 years[22]. However, to achieve the full potential of the new varieties and breeds, and to close the 'yield gap' in the future, their management must be optimised.

More could be achieved with the varieties and breeds we have now. While yield potential is still growing, as shown through the trials resulting in HGCA Recommended Lists® of crops, these yields are not necessarily achieved on farm.

A number of factors may be involved, such as cost pressures and the loss of independent, expert agronomy advice. Now, greater emphasis on applied research and extension is essential if the potential demonstrated by the scientists is to be realised by practical farmers.

The funding currently available for this work through the levy board companies is simply not sufficient to fully meet the task in hand. It is essential that there is committed and long-term research, translated into practice, in subjects such as soil science, pest and disease resistance, animal nutrition, weed science, crop agronomy… the list goes on.

Optimisation of all aspects of management and input use must be a key goal for agricultural R&D.

The recent development of 'precision farming' is an ideal system for 21st century productive and sustainable agriculture. It aims to understand and meet the exact needs of the crop in terms of inputs such as nutrition, protection against pests and diseases, water, temperature and light. It enables there to be no overlaps and no gaps. This technology allows production systems to be tracked and tailored with precision. Every input can be used to optimum effect.

While it cannot achieve results for a farmer straight off the shelf, as new crop varieties can, because of the level of data collection and analysis required, precision farming is already being widely used at a commercial scale.

Warwick HRI ©

What are the challenges we face now and in the future?

More applications will certainly be developed with time to maximise productivity and minimise environmental impact.

Sensor technology linked to information and communication systems has many applications in agriculture and horticulture, with the potential to significantly improve farmer's decision making, such as when to irrigate or protect their crops.

Regulation is a fact of life for today's farmers and growers, and despite high-level efforts aimed at reducing and simplifying the regulatory burden, it will continue to be an important factor in 21st century agriculture. In some cases, such regulation affects the ability of farmers to manage the land, inputs and resources in the most efficient way.

A good example is the diminishing range of products available to protect crops against pests and diseases, which will be accelerated by EU legislation on pesticide authorisation. This jeopardises the management of resistance and increases the likelihood of pesticides finding their way into watercourses as more growers rely on fewer products.

Pests and diseases are not going to go away. They will continue to reduce yield and quality, and in some areas even make it almost impossible to grow certain crops. Such a compromised position is not a strategic or sensible one for farmers and growers to be forced into for all the reasons stated throughout this report.

It is essential that more methods of control, better plants and targeted management techniques are developed so that productivity can be maintained.

CASE STUDY

Aphids predict climate changes

Rothamsted Research ©

Aphids can cause huge damage to many crops, amounting to potential losses of 100s of millions of pounds per year. Scientists have been monitoring all aphid species for over 40 years across the UK. Analysis of the data from these traps has shown aphids appearing significantly earlier in the spring following milder winters.

One of the most damaging species in the UK is the peach-potato aphid. The research has shown that it flies two weeks earlier for every 1°C rise in mean temperature for January and February combined. Numbers of aphids flying are also higher in spring and early summer, which is just the time when crops are most vulnerable. This work, along with Europe-wide analysis, is valuable in enabling control measures to be timed, to prepare growers for the coming season and to understand longer term impacts of climate change.

WHY SCIENCE MATTERS FOR FARMING

Farmers and growers operate at the mercy of some powerful forces, including world markets, EU regulations, pests, diseases, politics and the weather. Resilience and adaptation are essential ingredients for withstanding these challenges and, like any industry, agriculture must be 'future-proofed' to ensure it can survive and prosper as circumstances change. Scientific research, effectively applied, is vital in achieving this resilience.

Efficient productive farming that can also deliver environmental goods must be the priority in all systems and all sectors, organic, conventional, crops and livestock. This will not happen on its own but there is huge potential for success if science, research and technology can be harnessed once again.

CASE STUDY

Bluetongue virus research

Institute for Animal Health ©

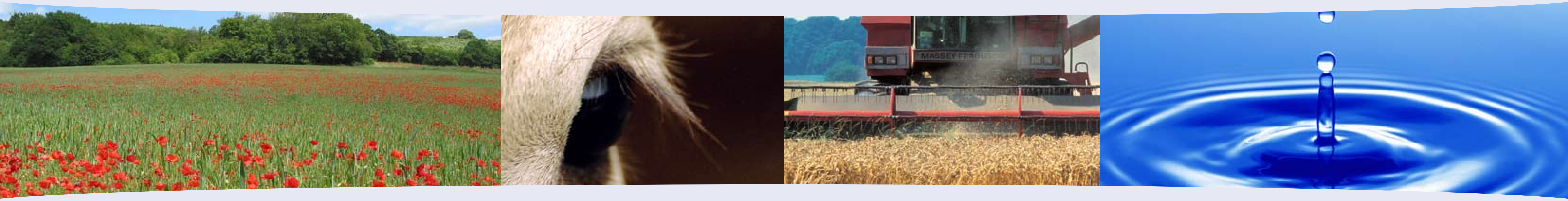
The link between scientific research carried out over many years and direct practical benefit to farmers is very well demonstrated by the bluetongue virus (BTV) work at the Institute for Animal Health (IAH). In 2007, the direct cost of bluetongue in northern Europe was over £95 million. When it hit the UK, world-leading expertise was in place in this country to diagnose the disease and advise Government and industry on ways to manage it through vaccination.

Between 1998 and 2005, IAH scientists monitored populations of the midge species that transmit bluetongue as they spread north into areas that had never before been affected. Modelling and satellite imagery predicted the distribution of the midge and thereby the disease itself. The warming of Europe's climate was shown to drive BTV transmission through the range of insects, with more species being able to transmit it, and in greater numbers. The scientist predictions were proved correct in 2006 when BTV entered Northern Europe, with devastating effect.

In collaboration with the meteorological office, IAH identified the winds that the midges travel on to predict when and where disease would hit the UK, as it did in August 2007. This work continues with new ways to trap the tiny midges and monitor the way they fly and bite are being used to predict the risk and develop control strategies. Another study will assess the benefits of vaccination in 2008 and how vaccination has been taken up by farmers.

Supporters

WHY SCIENCE MATTERS FOR FARMING



Professor Mervyn Humphreys, Head of IBERS Gorgerddan

"While science innovation and quality is of paramount importance, we also recognise that research delivery is vitally important. Investigative science must be linked to practical applications to meet the needs of sustainable environments, agri-industry and farming-based communities and hence provide distinctive science 'outcomes'."

Professor John Oldham, Head of Research and Development, Scottish Agricultural College

"SAC has a long track record of working with the farming industries and communities to do applied research and to translate research outcomes into practice. For the last two decades this has been seen as somewhat unfashionable; let us hope that, from now on, this will no longer be the case."

Doctor Tina Barsby, Director of National Institute of Agricultural Botany (NIAB)

"The significance and importance of UK farming has never been greater. The need for sustainable food production and adaptation to changing climatic conditions means that as a nation we need to recognize and support the application of science and technology to agriculture. We also need to inspire the next generation of agricultural scientists who can make a real difference to the global challenges we face."

Professor Ian Crute, Director of Rothamsted Research

"Our future well-being in a rapidly changing world presents us with a clear challenge. We must significantly elevate production without cultivating more land while simultaneously reducing greenhouse gas emissions and reliance on non-renewable inputs. To meet this challenge we must create a steady flow of innovative products and practices into agriculture and this in turn demands more investment in research and the re-building of a severely eroded skills base."

Professor Simon Bright, Warwick University Horticulture Research International

"UK horticulture is worth around £9 billion a year and is driven by trends, markets and scientific innovation. Warwick HRI, at the University of Warwick, provides fundamental understanding of plants and crop systems and the translation of this research into practical outcomes. Hot topics now, where interdisciplinary research is essential to drive future innovations, are biodiversity, ecosystems services, adaptation of crop production systems to climate change and the development of sustainable sources of energy, chemicals and raw materials for a low carbon world."

David Gregory, Marks and Spencer

"Looking to the future, there are real challenges emerging including the impact of climate change, the increasing cost of farming inputs and a potential scarcity of labour in the whole food supply chain. For British Agriculture to rise to these and other challenges, yet at the same time meeting British consumer needs for affordable high quality and healthy agricultural and horticultural products, there is a real need for supporting science and technology to be made available to farmers and growers in a practical and timely fashion."

Dick Taverne, Chair of Sense About Science

"How can we end hunger, feed another three billion people and cater for middle class lifestyles for many hundreds of millions more in Asia, as well as the effects of global warming, unless agriculture uses every available technology that science can develop? Agricultural science has made a huge contribution to our present prosperity, health and longevity. Nothing could be more disastrous than to heed the fashionable calls to turn our backs on science and 'Go back to nature'."

Iain Ferguson CBE, President of the Food and Drink Federation

"Science and technology has long played a major role in bringing safe, affordable and nutritious food to our nation. Never has the need for science been greater, as we find the environment for meeting all the needs of society across the globe, increasingly complex and at times conflicted. Progress in farming and the food chain will always attract huge governmental, NGO and public interest, but science that is empathetic with long term pressures and needs is more essential now, than it has ever been."

Steve Visscher, Interim Chief Executive, Biotechnology and Biological Sciences Research Council (BBSRC)

"It is more important than ever that the UK's world-class science base is supporting UK farming. Climate change, land use pressures, exotic animal disease, population growth and global uncertainty could all threaten future food security. UK scientists, many funded and supported by BBSRC, are working on a wide range of projects in plant, crop and animal science that will underpin the future prosperity of UK farming and the quality of life for the UK public."

More supporters' quotes can be found by visiting www.whyfarmingmatter.co.uk

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CASE STUDIES

For further reading and more details of case studies in this report please visit www.whyfarmingmatters.co.uk

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