ROTHAMSTED RESEARCH

Strategic Plan 2005-2010

WORLD-CLASS SCIENCE FOR
SUSTAINABLE LAND-MANAGEMENT

ROTHAMSTED
RESEARCH

Contents

Rothamsted Research comprises laboratories at Rothamsted and Broom's Barn and is sponsored by the Biotechnology and Biological Sciences Research Council.

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A listing of this year's publications from Rothamsted Research can be found at: www.rothamsted.ac.uk

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Director's Statement

Rothamsted Research is the primary UK source of independent and innovative science to meet societal requirements for sustainable crop-based agriculture in an enhanced environment. In this time of rapid change, the Institute intends to maintain its vital national and international role as a source of research from which new crop products and land management practices emerge. Rothamsted Research will also continue to be the first port of call for policy-makers requiring the firm foundation of science-based evidence. With the perspective of the next 5 year period, through to 2010, this Strategic Plan enunciates our ambitions in response to the expectations of our diverse sponsors and stakeholders. I commend the Plan to you and, should you require further information about Rothamsted Research, I invite you to visit our website: www.rothamsted.ac.uk

Ian Crute
Institute Director

The Rothamsted Research Mission

To be recognised internationally as a primary source of first-class scientific research and new knowledge that addresses stakeholder requirements for innovative policies, products and practices to enhance the economic, environmental and societal value of agricultural land

Rothamsted Research will deliver this Mission through working to achieve the following six objectives:

- Enhanced crop quality and more sustainable systems of production
- Environment-enhancing management practices for crops and associated habitats
- Protection and remediation of soil quality
- New sustainable products from crops
- Conservation and utilisation of biodiversity
- Elevating societal confidence in science for agriculture

Rothamsted Research has access to new state-of–the art facilities alongside unrivalled time-series of data and sample archives derived from its world-renowned "classical" experimental sites which continue to prove invaluable for studies on the impacts of environmental change. At the start of the 21st century, the multi-disciplinary research environment provided at Rothamsted Research represents an internationally unique establishment equipped to address today's priorities.

Key attributes of sustainable systems

Rothamsted Research identifies ten key attributes that define sustainable systems of agricultural land management:

- Predictable output over many generations
- Non-polluting
- Profitable and socially acceptable
- Based on renewable inputs
- Conserve valued landscapes and biodiversity
- Exploit natural processes for regulating constraints on productivity
- Maximise resource-use efficiency
- Do not defer or transfer potential problems elsewhere
- Adverse changes in the system are readily reversible
- Responsive to changing requirements and constraints (e.g. climate, population growth)

Placing Rothamsted Research in context

Rothamsted Research draws strength from its multidisciplinary environment and research that integrates chemistry, mathematics, ecology and crop sciences (including: genetics, pathology, entomology and soil science) to contribute predictive understanding and scientifically-sound options for the sustainable management of agricultural land.

Two important but distinctive drivers determine the scientific direction taken by Rothamsted Research:

- opportunity for scientific innovation and significant advances in knowledge and understanding;
- demand for new scientific knowledge and associated technologies to inform and influence emerging national and international economic and socio-political priorities.

The first originates from government expectations (enunciated through OST and BBSRC) that the outcome from their investment in science will be research of world-leading quality measured primarily by the impact that it has on the global scientific community. In contrast, the second is characterised by contributions to economic well-being, quality of life and implementation of policy objectives in both the public and commercial sectors.

Agriculture provides one of the most spectacular illustrations of the benefits that science can have on the well-being of mankind. Just a few generations ago almost nowhere in the world was free from deprivation resulting from an unpredictable food supply. The application of science has provided the industrialised world with a predictable supply of sufficient, good quality, affordable food. Over its 160 year history, Rothamsted has been centre-stage in this endeavour.

At the start of the 21st century, the context for land management in Europe is set by the inevitable expansion of the European Union, the globalisation of world trade, the expectations of an increasingly prosperous population, the strengthening "green agenda" and the increasing economic value accorded to land for purposes other than food production. In the developing world, over 840 million people are undernourished and the earth's population is set to rise from six billion to nine billion by 2050. In the next 50 years, the world must produce at least 75% more food each year than it does at present. We must reconcile the changes that affect land management in Europe with the requirements of the world's disadvantaged populations for land and food. Science that provides an understanding and delivery of more sustainable production systems unifies what at first sight might seem disparate requirements of primary producers in the industrialised and developing world.

Each year approximately nine million hectares of land are lost to agricultural production and over half of this is due to urbanisation. The value placed on land for purposes other than food production means that there is no sound argument for cultivating more land than is absolutely necessary. This is regardless of whether the sought-after use for land is to conserve the functional or aesthetic value of natural habitat or to create man-made amenities. With a view to future generations and to avoid the requirement for more land to be devoted to production there is an urgent need for science-based management and for new technologies that will replace the non-renewable inputs that drive current levels of output.

There is a burgeoning of fundamental knowledge about how biological systems work. This is being catalysed by access to whole genome DNA sequences and a new synergy between the biological, physical and mathematical sciences. There is real

cause for optimism that new products and practices will emerge from this knowledge-based revolution in the biosciences. This provides the backdrop for the BBSRC's recently published Strategic Plan and Ten-Year Vision[1] [2]. The BBSRC strategy is focused on the concepts of integrative and predictive biology and is closely aligned with the way Rothamsted Research conceives and conducts its scientific programmes.

The Department for Environment, Food and Rural Affairs (Defra) has recently launched its five year strategy[3] following a statement on the Department's needs from science over the next decade[4]. Sustainable development is at the core of the Defra strategy that, in the context of the Institute's mission, seeks progress towards:

- reducing waste, carbon emissions and diffuse pollution from managed land;
- increasing the use of crops as sources of energy and petrochemical substitutes;
- conserving soils, biodiversity and valued landscapes.

The Institute can expect to be a major contributor to Defra's requirement for science innovation in support of its policy objectives and recently identified research priorities[5].

Rothamsted Research will strive over the next five years to make significant contributions to the introduction of new sustainable practices based on high quality ecological and environmental sciences together with new sustainable products based on high quality biomolecular sciences. Our objective will be to contribute significantly to the implementation of "Best Practice". Specifically, Rothamsted Research will deliver science in support of three high-priority requirements:

- a predictive understanding of managed ecosystems;
- sustainable crops and crop products;
- high-efficiency, low-input crop management systems.

These headline areas include specific research topics that are detailed in Boxes 1 – 3 below.

Box 1
Requirements for predictive understanding of managed ecosystems

- Integrated models of the carbon, nitrogen and sulphur cycles
- Integration of carbon cycle and climate change models
- Robust indicators of soil functional biodiversity and quality
- Systems for soil bioremediation
- Defined functional components of agroecosystems
- Understanding of evolutionary change and gene-flow in agroecosystems
- Sampling and analysing spatial variation
- Models of interaction between plants, pest, pathogens and their natural enemies
- Understanding ecological impacts of climate change

Box 2
Requirements for sustainable crops and crop products

- Resource use efficiency and reduced input requirements
- Resilience to stressful environments (physical and biological)
- Partitioning to usable biomass (quantity and quality)
- Renewable raw materials, petrochemical substitutes and bioenergy
- Nutritional enhancement and therapeutics
- Improved carbon fixation efficiency
- Optimised crop development and architecture

Box 3
Requirements for high-efficiency, low input crop management practices

- Exploiting natural defence mechanisms
- New targets for selective chemical intervention
- Management of resistance to agrochemicals
- Temporal and spatial precision management
- Optimising biological control
- Molecular diagnostics of plant health
- Minimisation of diffuse pollution

Recent scientific achievments and practical impact

The period since 2000 (when the previous Strategic Plan was published) has seen significant achievements in terms of both scientific progress and practical impact of relevance to end-user communities. A selected summary is provided to illustrate the contribution that the Institute has made to areas of continuing strategic importance.

Examples of scientific achievements (2000-2005)

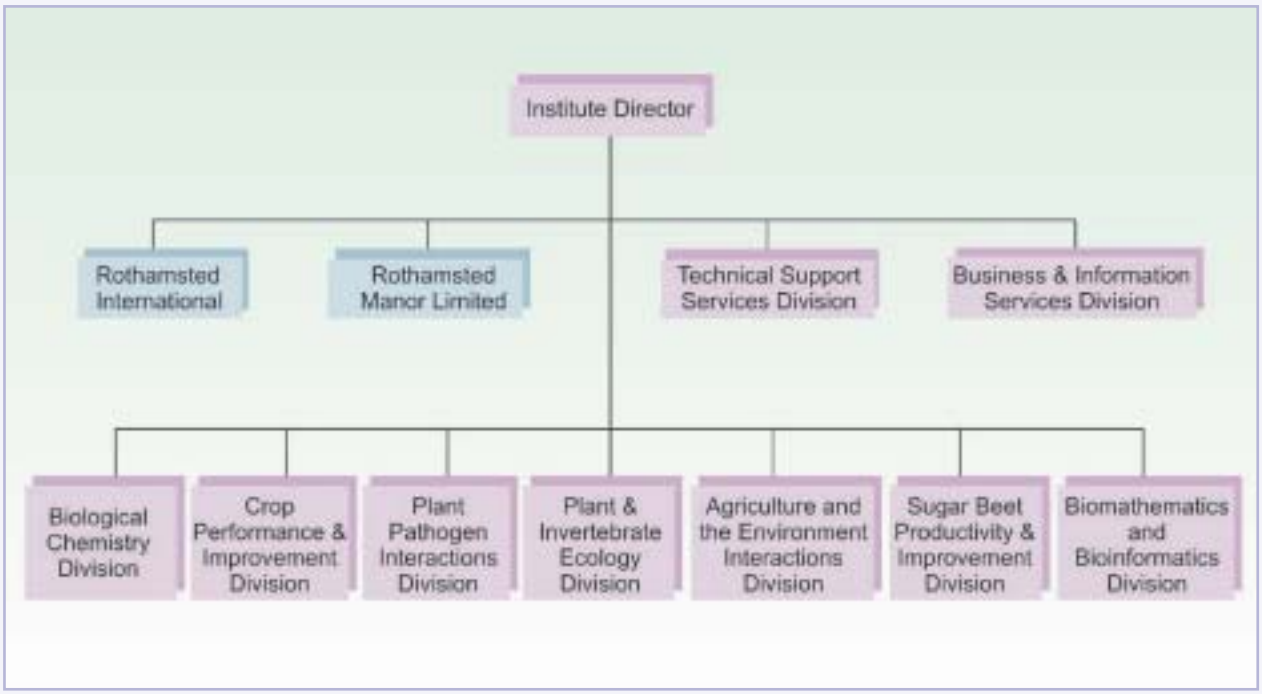
- The Rothamsted Carbon Model (RothC) has been linked with the Hadley Centre's climate model to provide a realistic simulation that demonstrates how climate change will lead to the release of additional CO_2 from global stocks of soil carbon and hence a positive feedback that could further reinforce climate change.
- Insects recognise and avoid non-host plants by detecting specific repellent compounds (or ratios of compounds) rather than failing to detect a positive cue. This hypothesis has now been extended to carnivorous or haematophagous insects which not only avoid non-host animals, but also avoid some individuals within the host species by the recognition of specific chemical cues.
- A general, computationally efficient, approach to the analysis of correlated data, such as that commonly arising from biological experiments, has been developed. The ability to identify errors due to correlated effects (e.g. genetic relationships, plot structure, climate) and deal with them differently from random error (noise) is crucial to both the correct interpretation of data and the development of accurate predictive models.
- Harmonic and vertical-looking radar technology has been exploited to provide new insights into insect movement. This has quantified the foraging behaviour of bees in agricultural landscapes (with implications for pollination and gene flow) as well as revealing hitherto unknown patterns of high altitude insect migration.
- Molecular assays have been devised to determine the amounts of DNA from two major cereal pathogens (septoria and stagonospora blotch diseases) present in wheat samples over a 160 year period from the Broadbalk archive. The incidence of both pathogens was shown to change over time, correlated with changes in atmospheric pollution. This has demonstrated the feasibility of studying long-term trends in pathogen populations using historical archive samples.
- By exploiting genes cloned from an alga and a fungus, substantial quantities of two very long-chain polyunsaturated fatty acids have been produced in plants. Production of omega-6 and omega-3 fatty acids in plants has demonstrated the feasibility of engineering a multi-step pathway to provide these essential nutrients that are at present only available to the human diet through animal sources such as fish.

Examples of outputs with practical significance (2000-2005)

- A new test for sulphur deficiency in crops has been developed using the ratio of malate:sulphate; this is now available on a commercial basis.
- Research on zinc ecotoxicology has demonstrated that bioavailability is the most important factor in terrestrial risk assessment. Consequently, the EU has concluded that risk is lower than previously perceived. This will save EU industry the considerable costs and employment losses that unnecessarily stringent measures would have caused.
- The impact on farmland biodiversity of weed management practices associated with the utilisation of herbicide-tolerant crops has been rigorously assessed at a farm scale. This work informed bodies advising the UK Government and the European Commission on the commercial production of crop varieties produced by genetic modification (GM).
- It has been shown that piperonyl butoxide can be used to overcome detoxification-based resistance to a number of commercial insecticides. New patents have been filed and commercial development is under way.
- The African witchweed, *Striga hermonthica*, is now being controlled on many resource-poor farmsteads in East Africa by a novel practice of intercropping the cereal crop with species of *Desmodium* which is a legume used to provide forage for cattle.
- New, high throughput diagnostic techniques have been devised to detect the mutations responsible for the development of resistance to pyrethroid insecticides and strobilurin fungicides in aphids and fungal pathogens of cereals, respectively. These techniques have been used to locate the occurrence of resistance and evaluate the success of strategies for practical management of the problem.

Organisation structure

Rothamsted Research conducts its science in seven thematic research divisions, comprising a variable number of research programmes headed by a scientist of international authority. Divisions are all multidisciplinary and programmes are created and disbanded in the context of ongoing internal review in response to new scientific opportunities or changes in sponsor priority. The non-scientific operations of the Institute are delivered by two additional, service divisions.



Organisational chart for Rothamsted Research. Rothamsted International (RI) and Rothamsted Manor Limited (RML) are wholly owned subsidiaries of Lawes Agricultural Trust Holdings. RI is a registered charity working for sustainable agricultural development in under-developed countries around the World. RML manages the Rothamsted Conference Centre and Rothamsted Manor.

Scientific missions and five year plan

Each of the seven research Divisions in Rothamsted Research has responsibility for delivery into a distinct thematic component of the overall Institute strategy. The missions of these seven Divisions along with some of their scientific targets for the forthcoming five year period are summarised here.

Plant-Pathogen Interactions Division

Mission

To develop effective, durable, economic and environmentally sound strategies for the control of crop diseases through an improved understanding of the interactions between plants, pathogenic agents and the environment.

Five year targets

- Make widely available novel germplasm with characterised resistance to diseases of wheat and oilseed rape
- Exploit genomics to identify novel targets in fungi and nematodes for chemical and genetic intervention
- Develop and promote models that quantify the risks of fungal disease or nematode attack to guide optimised management strategies
- Develop generic tools for risk assessment and management of fungicide resistance
- Improve ways of determining diversity in the rhizosphere microbial community including its role in nutrient cycling and the suppression of disease

Crop Performance and Improvement Division

Mission

To improve crop productivity and quality by understanding and manipulating nutrient acquisition, primary and secondary metabolism, growth and development.

Five year targets

- Make available novel germplasm of wheat with improved processing qualities
- Establish high through-put wheat transformation to enable functional genomics
- Determine the role of epigenetics in genotype x environment interactions during embryogenesis
- Advance the utility of metabolomic technologies for fundamental and applied studies of plant biochemistry and development
- Demonstrate the feasibility of a genetics-based approach to improved utilisation of nitrogen by wheat and oilseed rape to allow a decrease in fertiliser applications without detrimental effects on yield and processing quality
- Produce predictable and economically viable quantities of "fish-oils" in plant seeds
- Demonstrate the feasibility of increasing carbon capture efficiency in plants
- Develop lines of wheat with enhanced nutritional quality for the human diet

Scientific missions and five year plan

Plant and Invertebrate Ecology Division

Mission

To integrate research on the ecology, behaviour and genetics of organisms inhabiting agricultural ecosystems in order to conserve and exploit biodiversity, monitor and predict the impacts of environmental change and optimise the performance of both chemical and non-chemical components of crop protection strategies.

Five year targets

- Develop models that predict, the functioning and resilience of ecosystems under different land management systems
- Improve the predictability of habitat manipulation and semiochemical use to enhance the control of crop pests by natural enemies
- Provide an improved understanding of the genetic aspects of biodiversity relevant to integrated pest management.
- Use long-term data sets to predict changes in insect abundance and community composition under different climate change scenarios
- Integrate genetic and ecological studies to support the development of bioenergy crops and assess their impact on agricultural environments

Biological Chemistry Division

Mission

To devise novel strategies for the management of insect pest and vector populations through the exploitation of naturally occurring semiochemicals that mediate behaviour and an understanding of insecticide resistance mechanisms.

Five year targets

- Understand and interfere with host location by crop pests and vectors of animal disease
- Characterise and exploit the molecular basis for plant defence against insects induced by *cis*-jasmone
- Understand the molecular basis for the detection of specific volatile molecules by insect olfactory systems
- Use mutations conferring insecticide resistance to understand the functioning of insect nervous system proteins and their interactions with xenobiotics
- Develop potential new industrial crops for the production of low molecular weight lipophilic compounds, including pheromones

Agriculture and Environment Division

Mission

To optimise crop yield and quality while protecting soils, water and the food chain in the global environment by improved understanding, mathematical interpretation and modelling of biogeochemical cycles of nutrients and pollutants.

Five year targets

- Improved understanding of the survival strategy of the soil microbial biomass and the processes that control the rate at which it mineralizes soil organic matter
- Identify interactions between soil structure, microbial ecology and plant growth to develop improved soil management strategies
- Improved understanding of trace element nutrition in plants spanning deficiency to toxicity including its impact on the food chain and human health
- Combine existing models of the carbon, nitrogen and sulphur cycles to produce an integrated C/N/S model for managed land
- Refine the linked Roth-C/Hadley Centre model to predict more precisely the interactions and feedbacks between land, ocean and atmosphere in a variety of climate change scenarios

Sugar Beet Research Division (Broom's Barn)

Mission

To enhance productivity and profitability of the sugar beet crop while minimising environmental impact through genetic improvement, mitigation of biotic and abiotic stresses and optimisation of production systems in the context of whole farm rotations.

Five year targets:

- Make available improved transformation and other biotechnologies for sugar beet
- Improve understanding of the processes of flowering in sugar beet to enable the development of varieties with resistance to premature bolting
- Identify, characterise and provide to breeders sources of durable resistance to virus yellows and rhizomania diseases
- Identify sources of drought resistance in sugar beet and new approaches to enable efficient selection for this trait in breeding programmes
- Develop management practices in the context of whole farm rotations that maximise in-crop and landscape biodiversity alongside high crop productivity

Biomathematics and Bioinformatics Division

Mission

To develop and apply mathematical, statistical and computational models of biological systems and to create novel methods for the integration, analysis and interpretation of highly variable and complex datasets.

Five year targets:

- Develop statistical approaches for dealing with correlated multi-environmental data or meta-data for a range of applications including plant breeding and genomics
- Develop a robust geostatistical approach to sampling and mapping soil properties that can address their extreme variability
- Use fluid dynamics methods to understand physical influences on insect flight and responses to environmental signals
- Develop models of crop architecture and performance integrated with climate models to predict effects of climate change
- Develop a generic approach to modelling crop disease epidemics for application in improved disease forecasting and predicting the impact of different disease management options
- Develop capability in bioinformatics and a general framework for data integration
- Create predictive models (at a variety of scales) of plant systems including physiology, development, pathogen and pest interactions

Scientific collaboration and communication

Rothamsted Research is well-placed to deliver integrated multi-disciplinary research projects as it can draw on a wide range of scientific skills, experience and facilities. Nevertheless, the conduct of scientific enquiry and the implementation of research outcomes increasingly require the creation of lasting collaborations and alliances that bring together different groups for mutual benefit.

One outcome of a recent review by the BBSRC of crop science has been a firm steer towards greater collaboration among BBSRC-sponsored institutes. Consequently, Rothamsted Research will be seeking over the period of this Plan to establish close working arrangements with the John Innes Centre (JIC) and the Institute of Grassland and Environmental Research (IGER) in crop genomics and genetic improvement. BBSRC also endorsed the plan to establish a cross-institute programme involving IGER and Rothamsted Research for research on sustainable soil function. This provides an exemplar of how a collective approach to the planning and delivery of institute research in strategically important areas can deliver scientific synergy.

Particular emphasis is placed in Rothamsted Research on international collaboration through active participation in European Framework Programmes, as well as taking full advantage of international fellowship and partnering funds. Department for International Development (DfID) funding provides a mechanism for supporting collaboration with the developing world and Rothamsted International plays a significant role in facilitating and furthering valuable links with overseas institutes and development organisations.

Papers published in the peer reviewed scientific literature, including specialist and niche journals, represent the primary measurable output from the work conducted by Rothamsted Research. The scale, scope and impact of published work emanating from any research establishment provide a measure of its profile within the national and international research community. Rothamsted Research seeks to ensure that research of generic scientific significance is published in high-impact, globally distributed journals at the same time as targeting work of more specialist interest to the leading journals serving more focussed communities of researchers and end-users. In addition to publication in the scientific literature, Rothamsted Research also accepts the responsibility for regular communication with a diversity of end-user communities through publications in a range of "popular" journals and other routes such as advisory leaflets and newsletters. In addition, the increasing prominence of participatory research through arrangements such as LINK provides a ready route to the vital process of knowledge transfer.

Rothamsted Research recognises that the internet plays an increasingly important role in the delivery of research results to the scientific community as well as to the public, our end users and other stakeholders. Significant material about Rothamsted Research, its history, management and science is available on the Institute web site www.rothamsted.ac.uk and through subsidiary web sites delivering specialist resources including interactive decision support systems. The Institute will maintain and expand its existing commitment to delivering information through the internet by direct submissions of data to recognised scientific data centres and by further development of databases with the latest internet access methods.

Knowledge transfer (KT) and practical impact

Knowledge generated by Rothamsted Research contributes to the management of agricultural land and the environment and our innovations lead to new policies, practices and products. The importance that Rothamsted Research attaches to KT is implicit in our mission statement and the institute is proud of its strong record of transferring science into practice through:

- the protection, licensing and sale of intellectual property;
- establishment of partnerships and networks of end-users;
- the Rothamsted Research Association (www.rothra.org/);
- the work of Rothamsted International;
- influencing policy makers and regulators;
- spin-outs and joint venture companies;
- the world-wide web;
- direct interaction with our user communities.

The Institute is a major international player in the publicly-funded community of researchers in mathematical, physical and biological sciences. This enables effective knowledge transfer to four primary groups of national and international end-users:

- policy makers and regulators in governmental and non-governmental organisations, focusing primarily on the environment, food, consumers, health and overseas development;
- advisory bodies, consultants and KT specialists in Europe and developing countries;
- farmers, land managers and their technical advisers;
- agricultural supply businesses, multinational corporations, crop processors, and retailers.

Our strategy for KT aims to build strong relationships with all groups of end-users. A potential conflict exists between policy demands for delivery of publicly accessible information that is independent of commercial influence, and the simultaneous demand for science that is relevant to industry with good prospects of making a contribution to wealth creation. This potential conflict is recognised and managed by Rothamsted Research through prioritising its objectives for KT as the following:

- to deliver science to an enabled user community of UK, European and developing country practitioners and farmers and thus contribute to wealth creation;
- to deliver science to policy makers and extension organisations, to the benefit of practitioners, farmers and society;
- to choose, on a technology by technology basis, the most suitable commercial arrangement and partners most likely to develop that technology into products and services;
- to maximise income to Rothamsted Research.

In all circumstances the mode of acquisition and interpretation of information operates independently, and interpreted data are placed in the public domain for scrutiny (usually following peer-review). Where necessary, delay to publication is allowed to secure patent protection.

The goal of our strategy is to ensure the maximum and most timely transfer of knowledge generated in Rothamsted Research to all appropriate users for conversion into innovative policies, practices and products. The strategy is being achieved by:

- ensuring that research is conceived and conducted with users in mind;
- fostering an expanded user community for maximum impact;
- cooperating with and consulting user communities throughout project development and delivery;
- influencing government and policy making bodies by maximising exposure of Rothamsted Research staff;
- identifying and exploiting all appropriate opportunities for the commercialisation of research from the Institute.

Public relations and communication: science and society

Rothamsted Research does not take for granted that the priorities it has set will necessarily be shared by society at large. By a variety of routes, Rothamsted Research receives the majority of its funding from the public purse; its scientists need public approbation and must work to attain it. There is an obligation to enunciate with clarity the rationale for the research it conducts, the anticipated benefits it expects will accrue to society and the way in which the scientific process is conducted.

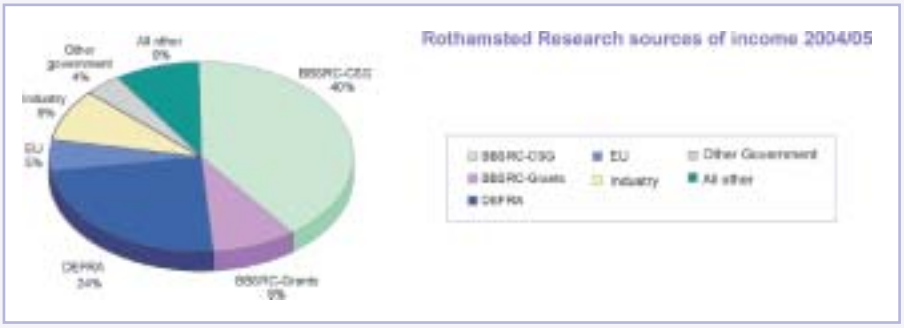
The public can be simultaneously fascinated and worried by revelations from scientific investigation; this provides at the same time both an opportunity and a threat in the interaction between an organisation such as Rothamsted Research and those whose support we need. As publicly expressed concerns about pesticide use and GM crops testify, it is not sufficient to assume that the public will either unquestioningly trust informed scientific opinion or subscribe without challenge to the rationale for particular research objectives. Consequently, Rothamsted Research is committed to taking all opportunities presented to engage positively with the public about its science. In the coming period, particular effort will be placed on two activities:

- to use outputs from research to heighten public awareness of the enormous national and international challenges that face society (including: climate change, food security and dwindling supplies of non-renewable resources);
- to explore ways of testing the extent of understanding and support among the public for the stated high-level research objectives of the Institute.

Finance

The Strategic Plan for the 12 month period ending 31 March 2005 (which was developed in 2000) indicated an expected annual income of £22.4m which was marginally exceeded. The proximity to target of projections made five years previously is noteworthy considering the period of change that Rothamsted Research has experienced. However, despite meeting income targets in the period preceding the current plan, levels of surplus have fallen short of that ideally required if the desired level of future capital investment is to be realised. Sources of income as percentages for 2004/05 (total £25.0m) are shown in the figure.

In line with government policy, BBSRC anticipates a move towards full economic cost operations from 2006/07 and this will require the generation of a larger annual surplus to enable long-term operational sustainability. Elevating income into Rothamsted Research is dependent on the interaction between the scale of funding available from sponsors (notably BBSRC, Defra, EU and industry) and the success of senior scientists in securing a greater share of the finite funding available than their competitors. Throughout the period of the plan there will need to be a concerted effort to contain expenditure although upward pressure on certain fixed costs is relentless. These include: energy prices, quality assurance, health and safety, environmental regulations, IT upgrades, data storage, and KT activities. Alongside the need to invest more in capital it is clear that Rothamsted Research will need to decrease its commitment to certain areas of science where income is in decline. At the same time, it will be necessary to make strides to increase revenue by continued recruitment of senior scientists in areas where income for research is both accessible but does not create internal competition with already successful and well-funded institute scientific activity. For these reasons, in the next five year period, Rothamsted Research anticipates a careful expansion of its role and remit accompanied by the development of particular strategic alliances with other organisations and even the prospect of mergers.



Capital development and asset management

In line with BBSRC policy for the establishment of a 10 year Estate Strategy, Rothamsted Research has developed a realistic but ambitious second phase redevelopment plan for the Rothamsted site following on from the works completed in 2004. This integrates the need to deal with significant levels of backlog maintenance on older buildings with upgrading facilities for our field based ecological and environmental sciences. The Institute proposes to remove all dispersed sub-standard facilities and, when funding allows, provide new facilities for agro-ecosystem science (including secure sample storage in line with quality assurance (QA) requirements), enable the consolidation of its dispersed non-science support functions, replace farm buildings and improve roads and security. Annual funding for routine maintenance of buildings and technical plant will be allocated to avoid the development of backlogs and plans will be developed for the routine replacement of essential scientific equipment, in addition to the regular competitive requirement to invest in new technologies. The continued close involvement of the Rothamsted Research Board in the capital expenditure and planning of the Institute follows from their successful role in the redevelopments completed in 2004.

Human Resources

Above all else, it is the commitment, expertise, vision and innovative capability of the staff of Rothamsted Research that are the key to the future of the organisation. The institute has been fortunate to recruit and retain a body of talented scientists and other committed professionals during the period of change that spans the years preceding development of this Plan. A key objective for the future will be to develop and maximise the potential of the existing staff while ensuring a healthy reinvigoration and renewal of skills and expertise. In this context, the Institute has a well-developed succession plan in place for senior staff and those with key strategic positions within the organisation. New challenges in the management of human resources are provided by recently implemented employment regulations on fixed-term contracts and retirement (the BBSRC "Decade of Retirement"). Rothamsted Research has established a working environment where scientists and other professionals can expect commitment and capability to be rewarded with continuity of employment and fair remuneration; in return, the organisation expects flexibility and strong professional performance. The institute has delivered on policy directives by placing most staff on indefinite contracts and is taking initiatives to remove gender bias. Since 2001, the organisation has moved from a position where 56% of scientific staff were employed on short-term contracts to a current position where the figure is less than 10%. All this is positive, but at any one time the institute expects to carry a significant number of staff whose posts are vulnerable due to flux in short-term funding. Changes in retirement arrangements will also impact on the organisation. Matching the research income profile with staffing levels and the skills base represents one of the most significant challenges facing institute management.

Ten strategic operational objectives

In addition to the scientific objectives, Rothamsted Research has identified ten key strategic organisational and operational objectives that represent their primary focus for the next five year period (2005-2010) represented by this plan.

1. Balance scientific recruitment, career management and succession planning to achieve staffing levels and skills necessary to sustain a world-leading research establishment. This requires appropriate and fairly implemented policies on pay, retirement, diversity, training, limited-term contracts and procedures for redeployment or redundancy.
2. Sustain a high quality and well-equipped scientific environment. This embraces the need to implement changes associated with operating on a full economic cost basis as well as continued capital investment in buildings and equipment.
3. Ensure a high level of technical and administrative support to science Divisions. This involves continual improvement of administrative systems and increased efficiency.
4. Ensure institute scientific organisation and structures deliver multi-disciplinary, integrative bioscience closely aligned with the BBSRC strategic vision and the needs of other sponsors. This is connected to scientific succession planning and strategic capital and estate planning.
5. Catalyse and coordinate collaborative and integrated scientific planning and delivery across the UK and the EU. This includes the initiation and operation of Cross-institute Programmes (CIP) with other BBSRC institutes and engagement in EU-supported mechanisms to improve networking and minimise duplication of effort.
6. Strengthen linkages with and delivery to end-user communities. This includes enhanced strategic alliances with organisations involved in consultancy and near-market scientific activities as well as strengthening the scope of the Rothamsted Research Association.
7. Strengthen local academic linkages. This seeks additional benefits from formal links with academia as well as the close geographical proximity to colleges of the University of London.
8. Maintaining robust risk management practices. This includes a process of continual improvement in the operation of quality control and assurance within all science and non-science activities. A system of internal quality assurance (QA) audit for all projects has been established in line with the Code of Practice agreed jointly between BBSRC, the Natural Environment Research Council (NERC), Defra and the Food Standards Agency (FSA). During the period of this Plan, systems for QA will be kept under review and the requirement to progress to operation under ISO criteria will be appraised.
9. Maintaining awareness of all opportunities to obtain commercial benefit from scientific activities, facilities and other capabilities. This includes exploration of opportunities presented by the East of England Development Agency and exploiting BBSRC investment in Plant Bioscience Limited (PBL).
10. Maintaining the productive working relationship between Rothamsted Research, BBSRC and the Lawes Agricultural Trust Company Limited (LATCo). This embraces strategic estate planning issues as well as long-term considerations of operational sustainability.

Origins of Rothamsted

Rothamsted Research came into being on 1 January 2003 with the merger of two separate components of the former Institute of Arable Crops Research located at Long Ashton Research Station (near Bristol) and Rothamsted Experimental Station (in Harpenden). The latter included its Broom's Barn site (near Bury St Edmunds).

Rothamsted has been at the forefront of scientific developments in crop-based agriculture and interactions with the environment since its foundation in 1843; it is the longest established, active agricultural research organisation in the world. Rothamsted Research also benefits from 100 years of horticultural and agricultural research conducted at Long Ashton. Broom's Barn opened in 1960, under the auspices of Rothamsted Experimental Station, to provide a UK centre for research on sugar beet.

Rothamsted Research is a public sector research establishment (PSRE) receiving a grant-in-aid from its primary sponsor: the Biological Sciences and Biotechnology Research Council (BBSRC). Over a five year period, concluding during 2004, Rothamsted received very substantial capital investment from BBSRC. This investment catalysed the processes of restructuring that gave rise to Rothamsted Research.

The organisation now boasts state-of-the-art facilities for plant, insect and microbiological experimentation including access to modern imaging and analytical post-genomic technologies. An award-winning new laboratory, the Centenary Building, represents a spectacular centre-piece to the Rothamsted site which has also benefited from: provision of first-class catering and conferencing facilities, remodelling of some older laboratories and integration, in refurbished facilities, of internationally significant library collections.

Legal status and governance

Rothamsted Research Limited is a company limited by guarantee and an independent charity that is governed by a Board of (non-executive) Directors comprising fourteen members (including the Chairman) who act *ad hominum*. The Directors are nominated by: BBSRC (5), the Lawes Agricultural Trust Company Limited (LATCo) (6), the National Farmer's Union (NFU) (1) and the Scottish Executive Environment and Rural Affairs Department (SEERAD) (1). The Chair is jointly nominated by BBSRC and LATCo. Directors are unremunerated, normally serve for a term of three years and may be reappointed for up to two terms. Details of the current Board members are available at: www.rothamsted.ac.uk. The Chief Executive of Rothamsted Research is the Institute Director who is in attendance at Board meetings along with two Associate Directors and the Company Secretary.

The BBSRC provides approximately half of the recurrent funding for the research programmes that are undertaken (see Section 10). This funding comprises an annual grant-in-aid (the so-called Core Strategic Grant – CSG) supplemented by competitively won project grants. BBSRC also provides the majority of investment in equipment and facilities and is the employer of staff at Rothamsted Research. BBSRC is a Non-departmental Public Body (NDPB) that reports its activities to the UK government through the Office of Science and Technology (OST) within the Department of Trade and Industry (DTI). The Institute Director reports to the Chief Executive of BBSRC in discharging responsibility for public funds as Sub-accounting Officer. LATCo owns the estates at Rothamsted and Broom's Barn, including many of the buildings used by Rothamsted Research. LATCo is a charitable trust that owes its existence to an endowment made by Sir John Bennett Lawes, the founder of Rothamsted. In compliance with its Deed of Foundation, LATCo supports agricultural science nationally and internationally, primarily through the provision of facilities and funding to Rothamsted Research and Rothamsted International. There are eight members of the LATCo Board of Directors (including the Chair) who are all nominated by the Royal Society. Details of the current Board members are available at: www.rothamsted.ac.uk. The Director and Company Secretary of Rothamsted Research are also the executive officers of LATCo.

Rothamsted International (RI) is a subsidiary charity of LATCo that provides the focus for most of Rothamsted's science in support of international sustainable development. RI operates an International Fellowship Scheme (RIFS) that has enabled over 100 scientists from developing and emerging countries to receive high-level training and career-enhancing experience at Rothamsted. RI has a small board of directors nominated by LATCo and the Chief Executive is currently the Company Secretary of Rothamsted Research. Details of the current Board members are available at: www.rothamsted.ac.uk.

Rothamsted Research is the primary vehicle through which the objectives of LATCo (including RI) and BBSRC are delivered. As such, the entirety of "Rothamsted" is best considered to be an enduring "partnership" between three parties with coincident interests: LATCo, BBSRC and Rothamsted Research (RRes). The (executive) Director of RRes and LATCo, as an employee of BBSRC, is charged with facilitating the long-term operational functionality and sustainability of the Rothamsted "partnership".

Stakeholders

Stakeholders in Rothamsted Research include: BBSRC and other UK research councils; UK government departments and agencies; the European Union; UK agricultural levy bodies; commercial concerns in the crop-product chain and land management sectors; agricultural supply-side businesses internationally; agencies active in global development; organisations and individuals with whom we enjoy scientific collaboration; all our employees and the public at large who indirectly fund the majority of our work.

Members of Rothamsted Research and LATCo Boards

Board of Directors – Rothamsted Research Limited

Professor E C Cocking DSc, FRS (*Emeritus Professor of Botany, University of Nottingham*) nominated by LATCo
P W Chamberlain (*Oxfordshire farmer*) nominated by NFU
R Ellis (*Chair, East of England Development Agency*) nominated by LATCo
Professor M W Elves DSc (*Former Director of Scientific and Educational Affairs, Glaxo Wellcome plc*) nominated by LATCo
Dr D A Evans (*Former Head of Research and Technology, Syngenta International AG*) nominated by BBSRC
I G T Ferguson (*Resigned February 2005*) (*Chief Executive Tate & Lyle plc*) nominated by LATCo
Professor S J Gurr (*Lecturer in Molecular Plant Pathology University of Oxford*) nominated by LATCo
Professor K Killham (*Professor of Soil Science, University of Aberdeen*) nominated by SEERAD
Professor B J Legg (*Former Director and Chief Executive, NIAB*) nominated by BBSRC
Professor D J Read FRS – Chairman (*Professor of Plant Sciences, University of Sheffield*) nominated by BBSRC & LATCo
Professor C V Robinson FRS (*Professor of Biological Chemistry, University of Cambridge*) nominated by BBSRC
Dr R G Turner (*Former Chief Executive, British Society of Plant Breeders*) nominated by LATCo

Company Secretary: S James
Ex-officio: Professor I R Crute, Professor B R Kerry, Professor P R Shewry

Board of Directors – Lawes Agricultural Trust Company

Members of the Board of LATCo are nominated by the Royal Society.

Professor Sir Richard Southwood DL, FRS (*Chairman until April 2005*)
Earl of Selborne, KBE, FRS
Lord Cameron of Dillington
Lord De Ramsey DL (*Chairman from April 2005*)
Lord Haskins
Professor Sir Tom Blundell FRS
Professor E C Cocking DSc, FRS
Professor G Conway FRS

Company Secretary: S James
Ex-officio: Professor I R Crute

1 BBSRC (2003) World Class Bioscience. Strategic Plan 2003-2008. 32pp.
2 BBSRC (2003) Bioscience for Society: a Ten-Year Vision. "Towards predictive biology".
3 HM Government (2004) "Delivering the Essentials of Life" Defra's Five Year Strategy. 91pp.
4 Department for Environment, Food and Rural Affairs (2004) Evidence and innovation: Defra's needs from the sciences over the next 10 years. 49pp.
5 Department for Environment, Food and Rural Affairs (2005) The first report of the Sustainable Farming and Food Research Priorities Group 43pp.

Rothamsted Research location map

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