



Rothamsted Research and the Value of Excellence:

A synthesis of the available evidence

Executive Summary

Report to Rothamsted Research

By *Séan Rickard Ltd.*

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INDEPENDENT ECONOMIC ANALYSIS

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About Rothamsted Research

We are the longest running agricultural research station in the world, providing cutting-edge science and innovation for over 170 years. Our mission is to deliver the knowledge and new practices to increase crop productivity and quality and to develop environmentally sustainable solutions for food and energy production.

Our strength lies in the integrated, multidisciplinary approach to research in plant, insect and soil science.

Rothamsted Research receives strategic funding from the BBSRC.



Foreword

by the Director & Chief Executive of Rothamsted Research
Professor Achim Dobermann

Assessing the impact of agricultural research is difficult because science is a complex and lengthy process, with pathways to impact that vary widely. It is common that research and development stages towards new technologies and know-how last 15 or even more years, followed by many more years for reaching peak adoption by farmers and other users of new technology. Adoption is often slow and diffuse, also because unlike in manufacturing many agricultural innovations need to be tailored to specific biophysical and even socioeconomic environments. Some of the many impact pathways may be known well, whereas others are not or are very difficult to quantify. Attribution presents another problem, i.e., it is often very difficult to quantify how much of the observed technological progress or other impact can be attributed to a specific innovation or an institution. Progress in productivity and efficiency is the result of many factors, including technology, knowledge and policy. Even more difficult is to assess the impact of agricultural technology on a wider range of ecosystem services and consumer benefits.

Nevertheless, in science we need to be willing to rigorously assess the relevance of our research. In his report, Sean Rickard has attempted to quantify the cumulative impact Rothamsted Research has had through key impact pathways that are most directly linked to its research. The economic approach used is in my view sound, providing a robust framework and a first overall estimate of the wider impact. Therein lies the main value of this study: it highlights the tremendous value of agricultural research. It has been demonstrated numerous times that rates of return on investment in agricultural R&D are high in both developed and developing countries, that spill over of innovations among countries is substantial, and that investments in R&D often have large, long-lasting cross-sectoral growth benefits¹⁻⁷.

Therefore, the results in their entirety are not surprising to me, although many assumptions had to be made and various potential impacts could not be included or assessed properly. We are aware that this can only be a starting point for improving the assessment of our impact in the future. This report will guide us in that, and it will also be of great value for developing our future science strategy. We will need to put better systems in place that will allow us to fill many of the data gaps and reduce uncertainties about key assumptions made. Hence, I invite everyone to contribute to a discussion on that or even come and work with us on it. We owe it to all our stakeholders to be held accountable for our research by being able to demonstrate impact in the real world. This report is meant to stimulate further discussion on how to achieve that.

¹ Alston, J.M., Andersen, M.A., James, J.S. & Pardey, P.G. *Persistence pays: U.S. agricultural productivity growth and the benefits from public R&D spending*. (Springer, New York, 2010).

² Alston, J.M., Andersen, M.A., James, J.S. & Pardey, P.G. The economic returns to U.S. Public agricultural research. *Am. J. Agric. Econ.* **93**, 1257-1277 (2011).

³ Bertini, C. & Glickman, D. *Advancing global food security: the power of science, trade, and business*. (The Chicago Council on Global Affairs, Chicago, 2013).

⁴ Fuglie, K.O., Wang, S.L. & Ball, V.E. *Productivity growth in agriculture: an international perspective*. (CABI, Wallingford, UK, 2012).

⁶ Renkow, M. & Byerlee, D. The impacts of CGIAR research: A review of recent evidence. *Food Policy* **35**, 391-402 (2010).

⁷ Stevenson, J.R., Villoria, N., Byerlee, D., Kelley, T. & Maredia, M. Green Revolution research saved an estimated 18 to 27 million hectares from being brought into agricultural production. *Proc. Natl. Acad. Sci.* **110**, 8363-8368 (2013).

Executive Summary

Abstract

Rothamsted Research is the oldest agricultural research institute in the world. It dates from 1843 and is credited with laying the foundations of modern scientific agriculture and establishing the principles of crop nutrition. Over its 172 years of existence, Rothamsted's researchers have made many significant contributions to agricultural science. In this report we seek to provide an estimate of the cumulative value of Rothamsted Research's total contribution to the UK economy, or more correctly to the living standards of its population. The approach adopted in this report is to use an established economic methodology to assess whether in the absence of Rothamsted's contribution to agricultural productivity total output by UK agriculture would be significantly lower than it is today. We provide an assessment of how much lower UK agriculture's productivity would be in the absence of Rothamsted Research's cumulative research output and consequently how much higher the prices of agricultural products would be. After allowing for the proportion of food products' prices accounted for by the prices of agricultural products we estimate that consumer food prices would be almost 5 per cent higher than they actually are. Taking into account how much UK households spent on food and drinks in 2014 within the home and outside,

we value the annual contribution of Rothamsted Research's erudition to feeding the nation in excess of £3 billion pounds a year.

Agricultural productivity and the role of science

- 1 In the post war period agricultural science has achieved a great deal. Since 1950, the world's population has almost tripled, from 2.5 billion to 7.4 billion. Over the same period, global production of cereals has outpaced population growth rising from 631 million tonnes in 1950 to over 2,550 million tonnes in 2014. This has had the effect that the amount of cereals available per person has grown from 249 kilograms in 1950 to 350 kilograms in 2014. This success story is largely the consequence of unprecedented increases in crop yields across the world rising from an average of 0.96 tonnes per hectare in 1950 to more than 3.5 tonnes in 2014. The fact that the Malthusian nightmare of a world unable to feed its population has not been realised is attributable to improvements in agricultural productivity and this has only been made possible by large and consistent investments in agricultural science research.
- 2 Rothamsted Research is the oldest agricultural research institute in the world. It dates from 1843 and is credited with laying the foundations of modern scientific agriculture and establishing the principles of crop nutrition. Over its 172 years of existence, Rothamsted's researchers have made many significant contributions to agricultural science including pioneering contributions in the fields of virology, nematology and soil science as well as the discovery and development of pyrethroid insecticides. The benefit of its many scientific contributions have impacted on the productivity and quality of the UK agricultural industry's output thereby greatly improving its cost efficiency and competitiveness. But to confine attention to the agricultural industry would be to grossly underestimate the true value of Rothamsted's research.
- 3 UK agriculture provides some three quarters of the UK's food and drink industry's raw materials. As a consequent, the more productive and competitive UK agriculture is as a supplier of raw materials the more it imparts not only a competitive advantage to food processors and manufacturers but also higher living standards to consumers via lower food prices, superior quality produce and greater choice. **The UK food chain culminates in £198 billion of expenditure by consumers. In the process it generates £107 billion of gross value added, involves some 410,000 enterprises and provides employment for some 4 million people; some 13 per cent of the UK's total employment.**
- 4 **Productivity, or more correctly the growth of productivity, is the ability to increase output from a given quantity of productive inputs and as such is an obvious index of social welfare and a key indicator of efficiency and competitiveness.** Rising productivity lowers the unit costs of production, it reduces waste and contributes to sustainability if it involves lower demands on natural resources per unit of output. Since the 1950s many studies have amassed convincing evidence demonstrating that individual nations and the world as a whole have benefited enormously from productivity growth in agriculture. But productivity growth depends on investment. Investment in farmer education, extension programmes and rural infrastructures all contribute to higher agricultural productivity but the studies are unanimous, it is investment in agricultural science that delivers the greatest contribution. The evidence shows that the benefits of agricultural research have generated value worth many times more than the investment costs.

Estimating the contribution of Rothamsted Research to the UK economy: the approach

- 5 We can separate Rothamsted Research's own or collaborative scientific contributions to agricultural productivity into three areas: plant science to increase potential yields; agronomy science to raise actual yields towards their potential; and crop protection science to minimise yield losses from pests and disease. Agricultural production is geo-climate sensitive, responding to local climate, soils and eco-systems thus productivity can only be maximised when scientific advances are aligned with the local geo-climate. Accordingly, Rothamsted Research can fairly claim that UK's agriculture's current level of productivity owes a considerable debt to its erudition and intellectual property. Of course Rothamsted Research is not the only organisation engaged in agricultural research in the UK but its long, proven record of many successful contributions justifies its ranking not only as a leader in the UK but also one of the world's leading centers of agricultural research.
- 6 In this report we seek to provide an estimate of the cumulative value of Rothamsted Research's total contribution to the UK economy, or more correctly to the living standards of its population. It is not however possible to provide a precise figure: in part because many scientific advances are the outcome of an incremental process where the work of more than one institution has contributed; and also data constraints have restricted the level of detail available necessarily limiting the analysis to aggregated data. In attempting to value Rothamsted Research's contribution we have eschewed the more traditional approaches that either focus on the institution itself to provide estimates of its employment or expenditure multipliers and/or attempt to estimate the Gross Value Added (GVA) for the agricultural industry of specific advances. While both are respected approaches – indeed the GVA methodology has recently been used by other research organisations in the UK – and both provide key information they greatly undervalue the total contribution of agricultural research.
- 7 The continued growth in the productivity and quality of agricultural production is not an end in itself; rather it is the basis for an efficient and competitive food chain which in turn delivers to consumers' food security at affordable prices, as well as safety, quality and choice in their food purchases. This is the real value of a science based agricultural industry and as such it dwarfs the value estimated at the level of the research institution or even the agricultural industry. **It is this value at the level of households that this report seeks to quantify.** As noted above by adopting this approach it is not possible to provide a precise value; rather it involves making estimates based in part on studies and in part on experience and judgement. By making the methodology clear and transparent the reader can form an opinion as to whether the estimated annual value of the cumulative impact of Rothamsted Research to the living standards of UK households is reasonable. Moreover, it provides a framework for future work as more detailed data becomes available.
- 8 **The approach adopted in this report is to use an established economic methodology to assess whether in the absence of Rothamsted's contribution to agricultural productivity total output by UK agriculture would be significantly lower than it is today.** Lower productivity implies not only reductions in crop yields but also higher production costs. Combined these two factors would raise selling prices across all sectors of agriculture. This follows, despite Rothamsted's focus on crops and grasses, because the reduction in cereals' yields would divert land from growing other arable/horticultural crops while raising livestock feed prices and thereby the prices of meat and dairy products. In addition, grazing livestock production costs would also be higher in the absence of Rothamsted's work on grasses and silage. Imports would not make-up the shortfall – certainly not without a corresponding rise in prices – because the loss of the spillovers from Rothamsted's research for other agricultural industries would also adversely influence levels of production in Europe and further afield.

Estimating the contribution of Rothamsted Research to the UK economy: the findings

9 In this report we provide an assessment of how much lower UK agriculture's productivity would be in the absence of Rothamsted Research's cumulative research output and consequently how much higher the prices of agricultural products would be. After allowing for the proportion of food products' prices accounted for by the prices of agricultural products we estimate that consumer food prices would be almost 5 per cent higher than they actually are. In 2014, UK households spend some £95 billion on food and soft drinks; that is, food and drinks purchased for consumption within the home. The effective of this would be an annual increase of more than £2 billion pounds in household's expenditure on food. In addition £55 billion was spent on food eaten outside the home e.g. in restaurants and a further £49 billion on alcoholic drinks. Although the agricultural content amounts to a smaller proportion of the total value when it comes to food eaten outside the home and in alcoholic drinks the rise in agricultural prices would, we estimate increase expenditure on these items by more than a billion pounds per year. Thus, **we value the annual contribution of Rothamsted Research's erudition to feeding the nation in excess of £3 billion pounds a year.**

10 The contribution to the cost of adequately feeding the population is the main benefit of Rothamsted Research but other benefits flow from an agricultural industry that is productive and competitive. The first is the many jobs in the food chain that depend on agriculture. In the UK there are 115,951 food service enterprises e.g., restaurants, employing some 1.64 million people and 1.18 million people employed in 53,112 retail food outlets. Employment in food processing, manufacture, wholesaling and distribution amounts to some 663,000 jobs spread across 28,309 enterprises. If the price of food was higher, the food industry would be smaller with implications for the number of enterprises as well as employment. Another potential cost to society of more expensive food – particularly fruit and vegetables – would be some loss of nutritional and health benefits as household's reduced consumption. And a less productive agricultural industry would be accompanied by a reduction in the area of countryside available for leisure and recreation as farmers sought to bring into production less productive land.

11 Turning to the future, a number of recent, high profile studies have pointed out that in the coming decades the global food system is facing a serious challenge in supplying the increasing demand for food. One of these studies commissioned by the Royal Society introduced the concept of sustainable intensification as a solution to the severe restraints imposed by the limited scope to increase the agricultural land area and the increasing scarcity of natural resources including freshwater. The concept involves intensifying production i.e. increasing the output from the current area of cultivated land but in a manner that reduces both the use, per unit of output, of non-renewable resources and damage to essential ecosystem services. The Royal Society concluded that in order to deliver sustainable intensification there is a clear need for publicly funded science. Moreover the authors argued that in achieving this outcome genetic improvements via plant science must be augmented by advances in agronomy. In addition to those recommendations, it is now accepted that delivery of sustainable intensification will also require the collective contribution of bioinformatics, big data acquisition technologies and big data analyses tools and systems approaches to agriculture. The delivery of practical solutions for farmers underpinned by this multidisciplinary research will require the relevant and appropriate policy and regulatory frameworks, nationally and internationally.

Rothamsted Research and future work: the need and value of long term investment in agricultural science

12 Rothamsted Research has a long and successful record of delivering excellent science with relevance to farmers. Its broad based research encompasses the whole plant system including not only biotechnology, but also agronomy and agroecology to guide agricultural practice. Rothamsted Research set out its research strategy for 2012-2017 in response to these challenges. The 2012-2017 science strategy involves developing innovative approaches to crop genetics, nutrients, water utilisation, plant protection, nutrition and soil productivity. Rothamsted Research's strategy, in collaboration with partner research facilities in the UK and beyond, is designed to deliver the scientific knowledge, innovation and agronomic practices that will increase crop yields, livestock production and quality while minimising the use of non-renewable resources within sustainable production systems. The strategy which relies on a mixture of mathematical modeling, laboratory experiments and field trials, is focused on four outcomes: to more than double potential wheat yields by 2020; to improve the nutritional value of wheat and oilseeds; to provide renewable and low carbon crop alternatives to fossil fuel-based energy; and to design practical, sustainable agricultural systems. Rothamsted Research now is working on developing its future strategy (2017-2022) and its longer term vision. Rothamsted Research will continue on its strengths but also expand and further develop a multidisciplinary approach to provide high quality science with a strong focus on delivering relevant solutions for agriculture in the context of sustainable intensification.

13 Academic studies demonstrate that the returns to investment in agricultural science continue to be enormous. Perhaps 25 years ago it was understandable that many governments and food industry participants believed that the first green revolution had worked its magic and provided the science and technology to affordably feed the world. Consequently since the early 1990s there has been a significant scaling back in public expenditure on agricultural R&D across developed nations. And public funding has declined more in the UK than elsewhere. Now we are less sanguine. Once again we are reliant on science to provide solutions to one of the greatest challenges facing the world. But achieving the necessary advances is compromised by current levels of public investment. The science underpinning food crop production – as in all areas of biology – is being revolutionised by several new technological developments including genome sequencing and genetic modification. These technologies offer the prospect of greatly speeding-up the breeding of desirable traits in plants and Rothamsted Research is in the vanguard of these technologies. **The future affordability of food, and indeed the quality of life, depend on successful scientific advances in these new areas of research.**

14 Although the focus of this report is an economic valuation of the benefits of Rothamsted's research to the production of a sufficient, affordable and high quality food supply for the UK's population, it is important to acknowledge – particularly as the food challenge is global – Rothamsted's involvement in overseas research projects and its worldwide reputation. Rothamsted Research is a world leader in plant and agricultural sciences and it works with more than 50 countries to promote and share excellence in agricultural and environmental sciences as well as addressing concerns relating to sustainability. It fosters international co-operation in research for the benefit of international development and provides training opportunities and other capacity building measures to strengthen national research. Rothamsted Research is an important training destination for post graduate and postdoctoral participants from overseas. As such Rothamsted Research has become a very important linkage in the development of lasting relationships and collaborations with scientists throughout the world; an impact that is difficult to quantify but is likely to be large.

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