The Development of Horticultural Science in England, 1910-1930

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I, Paul Smith, confirm the work presented in this thesis is my own. Where information has been derived from other sources, I confirm it has been indicated in the thesis.

Abstract

This thesis explores how horticultural science was shaped in England in the period 1910-1930. Horticultural science research in the early twentieth century exhibited marked diversity and horticulture included bees, chickens, pigeons,pigs, goats, rabbits and hares besides plants. Horticultural science was characterised by various tensions arising from efforts to demarcate it from agriculture and by internecine disputes between government organisations such as the Board of Agriculture, the Board of Education and the Development Commission for control of the innovative state system of horticultural research and education that developed after 1909. Both fundamental and applied science research played an important role in this development.

This thesis discusses the promotion of horticultural science in the nineteenth century by private institutions, societies and scientists and after 1890 by the government, in order to provide reference points for comparisons with early twentieth century horticultural science. Efforts made by the new Horticultural Department of the Board of Agriculture and by scientists and commercial growers raised the academic status of horticultural science and the professional status of its practitioners.

Horticulture is treated as a working world and the response of the commercial sector to research station science is analysed. In detailing the scientific investigations conducted by the state and the commercial sector, in discussing state consumer-oriented policies based on research station science and in examining responses of allotment holders and consumers of fruit and vegetables to these policies, this dissertation offers an original contribution to the history of the life sciences.

List of Tables and Figures

List of Photographs

List of Abbreviations

ARBGK – Archives Royal Botanic Gardens Kew

BAAS – British Association for the Advancement of Science

BAF – Board of Agriculture and Fisheries

BAS – Board of Agriculture for Scotland

BBA – British Beekeepers Association

BOE – Board of Education

BWSCS – Bath and West Southern Counties Society

CERS – Cheshunt Experimental and Research Station

DATI – Department of Agriculture and Technical Instruction

DC – Development Commission

DF – Development Fund

EMB – Empire Marketing Board

EMRS – East Malling Research Station

FVPRS – Fruit and Vegetable Preservation Research Station

JIHI – John Innes Horticultural Institution

LAA – Lancashire Archives

LARS – Long Ashton Research Station

LIA – Lincolnshire Archives

LS – Linnean Society of London

LTRS – Low Temperature Research Station

MAF – Ministry of Agriculture and Fisheries

MERL – Museum of English Rural Life

MSCAUL – Marks and Spencer Company Archive, University of Leeds

NA – National Archives (Kew)

NIAB EMRL – National Institute of Agricultural Botany East
East Malling Research Library

NIPH – National Institute of Poultry Husabandry

PA – Parliamentary Archives

PGCCC – Pennells Garden Centre Catalogue Collection

RAC – Royal Agricultural College

RASE – Royal Agricultural Society of England

RBGK – Royal Botanic Gardens Kew

RCHS – Royal Caledonian Horticultural Society

RHSI – Royal Horticultural Society of Ireland

RHSLL – Royal Horticultural Society Lindley Library

RS – Royal Society

SEAMC – Society for the Encouragement of Arts, Manufactures and Commerce

SHAC – Seale Hayne Agricultural College

THSL – The Horticultural Society of London

TKMOA – The Keep Mass Observation Archive

TMCC – Thompson and Morgan Catalogue Collection

TSAML – The Sainsbury Archive, Museum of London

UCSC – University College Special Collections

Table of Contents

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This thesis is dedicated to the memory of my father and my mother for their love and for encouraging my interest in gardening and natural history.

Chapter 1

Introduction

This thesis examines the development of horticultural science in England in the period 1910 to 1930. I show that horticulture involved beekeeping and the rearing of poultry and small animals besides the growing of crops and explore how horticultural science was shaped by the Board of Agriculture and Fisheries (BAF), that later became a Ministry (MAF), state funded research stations, universities, colleges and farm institutes, scientists, politicians, private institutions and societies and the commercial sector. I discuss in more detail the horticultural investigations of four research stations (presented as case studies), the development and work of farm institutes, the influence of horticultural research on allotment growers and consumers of fruit and vegetables and the support given by the government to apiculturists.

The focus is England as most of the horticultural science research was conducted in this part of the UK and many of the government funded research stations were located there. To examine the horticultural science research carried out in Wales, Scotland and Ireland would have extended the scope beyond the time limit of this project.

1.1 Research Questions, Arguments and Methodology

I raise two main questions in my discussion of horticultural science in England in the early twentieth century: what influenced its development and what was its subject matter? Scientists and commercial growers involved in horticultural investigations in this period emphasised the increasing importance of the horticultural industry to the economy and this growing economic role helped determine funding for horticultural science investigations. Research findings were not only made use of by producers, they were also incorporated into the syllabi of horticultural courses designed to train future researchers and growers. In order to address these questions I develop three arguments. Firstly, I claim that horticultural science was characterised by marked diversity between 1910-1930, both in the range investigations that were conducted and in the types of institutions that were involved, which shaped its development. When historians of science and agriculture have considered horticultural science in the United Kingdom, in most cases fleetingly only, it has been covered selectively and has been associated with breeding, genetics, classification and nomenclature, and other areas of investigation have not been addressed.[1] Developments in plant physiology, pest, disease and weed control, rootstock manipulation, soil science, plant nutrition, control of glasshouse environments and post-harvest crop treatment are examples of these omissions. By adopting a wider perspective, this thesis has benefited from being able to take account of the extensive nature of horticultural science research. Additionally, horticulture and horticultural science in these decades were not concerned solely with food and ornamental crops - flowers fruit, vegetables, trees and shrubs – as the keeping of bees and the raising of poultry, pigeons, hares, goats and pigs, as I have stated, were regarded as horticultural activities and were the subject of scientific

[1] Historians in the United States have shown more interest in horticulture. See, for example, P. J. Pauly, *Fruits and Plains: The Horticultural Transformation of America*, London: Harvard University Press, 2007; D. L. Opitz a), '"A Triumph of Brains over Brute'': Women and Science at the Horticultural College, Swanley, 1890-1910', *Isis* (2013), 104, (1), pp. 30-62; D. L. Opitz b), '"The sceptre of her pow'r": Nymphs, Nobility, and Nomenclature in Early Victorian Science', *The British Journal for the History of Science* (2014), 47, (1), pp. 67-94.

investigation.[2]

Secondly, I argue that horticultural science between 1910 and 1930 was characterised by various tensions. A number of scientists and civil servants wanted to demarcate horticulture and horticultural science from agriculture and agricultural science whilst others saw horticulture as an adjunct of agriculture. Additionally, friction was caused by a struggle between the BAF and the newly appointed Development Commission (DC) over who should administer the governments system of horticultural and agricultural research introduced in 1910. There was also a bitter dispute between the BAF and the Board of Education (BOE) for the control of the system of horticultural science education at universities, colleges and farm institutes. These were played out, in part, through endeavours to claim status.

Thirdly, I maintain that fundamental science and applied science played a key strategic role in the development of this system of horticultural science research and education. The discussions by government scientists in 1910 involved in its construction predate the positions taken by scientists and civil servants during the First World War over the stance they wanted the Department of Scientific and Industrial Research to take regarding the function and funding of fundamental and applied science.

I refer to horticulture as a working world and explain how various sections of the commercial sector were receptive to horticultural science innovation, as both consumers and initiators. I also outline the part played by politicians, civil servants, local authority officials and scientists in the system of science and

[2] Frederick Keeble a), The position of Horticulture in the Board of Agriculture. Part 1 – The Horticultural Division of the Food Production Department, 22nd November 1918, Lloyd George Papers, F/70/28/1, PA; V. E. Wilkins, *Research and the Land: An Account of Recent Progress in Agricultural and Horticultural Science in the UK*, London: HMSO, 1926, pp. 243-252; Opitz a), op. cit. (1).

education that developed.

To gather evidence in support of this thesis I surveyed archives and reports of seed firms, research stations, the BAF and the MAF, the reports published by these organisations, journals of the commercial and scientific press, magazines and pamphlets published for domestic gardeners, seed catalogues, the correspondence of scientists, civil servants and seed houses and publications of those involved in horticultural science investigation.

The secondary literature that is the focus of section 1.3, helped give direction to the chapter themes that are outlined in section 1.4. But first I discuss the issue of demarcation.

1.2 Horticulture and Agriculture Described

This section discusses the attitudes of contemporaries towards horticulture and agriculture. In the nineteenth century agricultural scientists sometimes undertook horticultural investigations and horticultural scientists on occasions examined agricultural problems. In the early twentieth century a number of commercial horticulturalists, government officials and scientists argued horticulture was an economic activity distinct from agriculture and required substantial government support whilst others saw it as a branch of agriculture. The development of both was more often dissimilar and they were not always affected in the same way by national policy and economic trends.

Domestic horticulture today is regarded as the cultivation of fruit, vegetables, annual and perennial flowers, trees and shrubs, with or without the aid of a greenhouse and commercial horticulture is viewed as the intensive production of flowers, fruit, vegetables, trees and shrubs in the open and under protected structures that could be extensive in number, and of a scale generally smaller than the hectares cultivated by farmers. Farming is seen as a more extensive operation that could involve growing cereal and fodder crops and rearing cattle, sheep and poultry without the use of glasshouses and polytunnels.

This was not the case in the nineteenth and the early twentieth century. In the 1820s commercial horticulture, as Loudon has shown, concentrated mainly on the production of fruit, vegetables and ornamental plants and there was little commercial glasshouse production.[3] Agriculture consisted of arable and pastoral farming and it was linked with poultry rearing. Beekeeping was not associated firmly with either horticulture or agriculture.

At the end of the century the boundaries had changed and poultry and apiculture were becoming associated closely with horticulture. In the early twentieth century apiculture had become part of the gardening syllabus of elementary schools and featured in government recommended horticultural textbooks and was a component of official inspections and some authors published books on apiary that were aimed at schools, domestic gardeners, cottagers and smallholders.[4] Farm institutes in England in the 1900s, catering for older pupils and young adults, offered courses in poultry and domestic beekeeping to those wanting to acquire or develop their horticultural skills.[5] Between 1910 and 1930 A. D. Hall, Chief Scientific Adviser to the Ministry of Agriculture and Fisheries, F. W. Keeble, Controller of Horticulture in the Food

[3] J. C. Loudon, *An Encyclopaedia of Gardening; Comprising the Theory and Practice of Horticulture, Floriculture, Aboriculture and Landscape-Gardening*, London: Longman, Hurst, Rees, Orme and Brown, 1822.

[4] Somerset School Garden Inspection. Summary of Report, 1911, ED 77/6, NA; Board of Education, *List of Textbooks recommended by Chief Examiners*, Harrow: HMSO, 1924, ED 77/208, NA; W. P. Wright, *Scientific and Practical Gardening for School and Home*, London: George Allen and Unwin Limited, 1928, p. 38; W. Herrod Hempstall, *Bee-keeping Simplified for the Cottager and Smallholder*, London: Simkin, Marshall Limited, 1929.

[5] Education Committee. Farm School, 21st March 1910, MAF 33/50, NA.

Production Department, and others reinforced these associations. Keeble In his 1918 update report to the Prime Minister, David Lloyd George, explained that in the Horticultural Division of BAF bees were part of the fruit section and pointed out there was also a separate section for the small livestock that could be reared in domestic gardens and on allotments and smallholdings such as rabbits, hares, goats. Pigeon rearing for food was also classed as a horticultural activity.[6] W. J. Lobjoit, BAF Controller of Horticulture, in making a case for horticulture being a 'distinct entity', believed managing orchards of 1000 acres was a feature of commercial horticulture. Some horticultural activities, therefore, could be extensive and labour requirements were greater than in agriculture.[7] By the 1920s there had been a notable expansion in the quantity of high value crops grown in commercial greenhouses for the domestic market, such as tomatoes, cucumbers and ornamental plants.[8] Glasshouse cultivation had become such an important sector of horticulture that a Glasshouse Research Station was established at Cheshunt in Hertfordshire in 1914 to conduct research on behalf of glasshouse growers locally and in other regions. Horticulture in the early twentieth century, therefore, was an activity quite distinct from agriculture in terms of the scale and techniques of production, workforce requirements, skills and knowledge of operatives, technology used, products grown, reared and marketed and product value. It is for these reasons that horticulture merits separate consideration and treatment.

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[6] Keeble a), op. cit. (2); F. Keeble b), 'Intensive Cultivation', *Nature* (1920), 106, (2661), pp. 293-296.

[7] Conference on Horticultural Education, Wye College, 17th September 1920, ACC 1096 1/4, MERL.

[8] J. Thirsk, *Alternative Agriculture. A History from the Black Death to the Present Day*, Oxford: Oxford University Press, 2006, pp. 161-187; W. F. Bewley, *Commercial Glasshouse Crops*, London: Country Life Limited, 1950, p. 469.

1.3 Secondary Literature

This thesis was written partly in response to secondary literature that provided information about British agriculture and horticulture during the period 1870-1940. In discussing these works I have grouped them into manageable categories: general histories of England, histories of horticulture, histories of agriculture, general histories focussing on the life sciences, histories of horticultural science and histories of agricultural science. Historians have tended to regard horticulture as a component of agriculture and few have addressed their differences and the implications of their distinct identity. As a result, horticulture has remained a shadowy presence. The same can be said for horticultural science and agricultural science, although recently the latter has received attention, deservedly, from a small number of historians of science. There is some overlap between these two disciplines which is worthy of investigation, although this line of enquiry has not been pursued in this thesis. Historians of science generally have not discussed this commonality and dissimilarity.[9]

[9] For example, see the following: R. Olby a),' Scientists and Bureaucrats in the Establishment of the John Innes Horticultural Institution under William Bateson', *Annals of Science* (1989), 46, (5), pp. 497-510; R. C. Olby b), 'Social Imperialism and State Support for Agricultural Research in Edwardian Britain', *Annals of Science* (1991), 48, (6), pp. 509-526; P. Brassley, 'Agricultural Research in Britain, 1850-1914: Failure, Success and Development', *Annals of Science* (1995), 52, (5), pp. 465-480; R. C. Olby c), 'Horticulture: The Font for the Baptism of Genetics', *Nature Reviews. Genetics* (2000), 1, pp. 65-70; B. Charnley and G. Radick, 'Intellectual Property, Plant Breeding and the Making of Mendelian Genetics', in C. MacLeod and G. Radick (eds.), *Studies in History and Philosophy of Science Part A* (2013), 44, (2), pp. 222-233; D. Berry a), 'Plant Breeding Industry after Pure Line Theory: Lessons from the National Institute of Agricultural Botany', *Studies in the History and Philosophy of Biological and Biomedial Sciences* Part C (2014), pp. 25-43.

1.3.1 General Histories of England

The following general histories have given agriculture consideration but horticulture has attracted less attention. Both A. J. P. Taylor and R. C. K. Ensor in their broad accounts of English history have examined agriculture briefly but have not extended their discussion to include agricultural science or horticultural production.[10] An exception is J. H. Clapham who in discussing horticulture, agriculture and the growth and output of commercial horticulture has commented on horticultural and agricultural science. Clapham indicated the expansion of different branches of commercial horticulture and believed the numbers employed, 'was uncommonly significant', although he did not explore further the implications of this growth.[11] I build on Clapham's observation and argue in subsequent chapters that the development of commercial horticulture and horticultural science were closely connected.

1.3.2 Histories of Horticulture: General and Specific

Few general books have been written about British horticultural history and those published have not covered fully the scientific aspects of the subject and instead have concentrated more on the personalities involved and their work and social networks.[12] Webber writing about market gardening noted the existence of research stations and Fletcher and Elliot in their valuable histories

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[10] A. J. P. Taylor, *English History 1914-1945*, Oxford: Oxford University Press, 1976, p. 77; R. C. K. Ensor, *England 1870-1914*, London: Oxford University Press, 1968, pp. 284-286.

[11] J. H. Clapham, *An Economic History of Modern Britain. Machines and National Rivalries (1887-1914) with an Epilogue (1914-1929)*, Cambridge: Cambridge University Press, 1963, p. 1, pp. 90-95, pp. 100-120.

[12] M. Hadfield, *A History of British Gardening*, London: John Murray, 1969; D. Ottewill, *The Edwardian Garden*, New Haven: Yale University Press, 1989.

of the Royal Horticultural Society have drawn attention to horticultural science by describing some of the investigations of the Society and have illustrated the extent of the research. The work of these authors, though, has been more descriptive than analytical. Webber has not considered interactions between growers and horticultural scientists and Elliot has not offered a comparison of the scientific achievements of the Society with similar institutions.[13]

A number of books have been written about the history of allotment cultivation and have focussed on their provision, the personalities involved, the activities of allotmenteers and the social interactions that took place. Some of these authors have alluded to horticultural science issues but have not addressed them specifically and at length.[14]

1.3.3 Histories of Agriculture

J. Thirsk in a pioneering work on alternative agriculture has outlined its history from the Middle Ages to recent times and documented practices in the cultivation of crops and the rearing of animals and poultry that have not appeared in more traditional narratives of agriculture. Thirsk saw horticulture as, ‘a specialist branch of farming’ and described the development that occurred after 1890 in the commercial production of vegetables, fruit, flowers and

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[13] H. R. Fletcher, *The Story of the Royal Horticultural Society 1804-1968*, Oxford: Oxford University Press, 1969; R. Webber, *Market Gardening. The History of Commercial Flower, Fruit and Vegetable Growing*, Newton Abbot: David and Charles, 1972, p. 12. References to science are scattered throughout the book; B. Elliot, *The Royal Horticultural Society. A History 1804-2004*, Chichester: Phillimore and Company Limited, The Royal Horticultural Society, 2004, pp. 229-323.

[14] C. R and H. C. Fay, *The Allotment Movement in England and Wales*, London: HMSO, 1936; D. Crouch and C. Ward, *The Allotment. Its Landscape and Culture*, London: Faber and Faber, 1988; D. M. Moran, *The Allotment Movement in Britain*, New York: P. Lang, 1990; S. Poole, *The Allotment Chronicles: A Social History of Allotment Gardening,* Kettering: Silver Link Publishing Limited, 2006.

decorative plants and in the use of glasshouses. She believed there was a ‘horticultural revolution’ in England in the years between 1880 and 1939, characterised by an increase in the scale of production, changes in business management techniques, a marked rise in the amount of capital invested and the development of different methods of cultivation.[15]

Unlike Thirsk I show, firstly, that various contemporaries regarded horticulture as an activity independent of agriculture and, secondly as I have stated, that the government viewed poultry and pigs rearing not as agricultural activities but as components of horticulture.[16] Thirsk implies science assisted the storage of horticultural produce but does not discuss how it might have supported other horticultural practices.

Robinson and Perren, also highlighting the growth of horticulture in the early twentieth century, have outlined the output of orchard fruit, small fruit, market garden crops, nursery garden products, vegetables and jam and, importantly, emphasised that patterns of production varied according to geographical region and downturns in cereal prices. Perren identified the government’s support of agricultural research and education but has underemphasised supply side factors relevant to horticulture, for example, the products of research station science that earlier works of Sykes and Collins had mentioned. Like Thirsk, both Robinson and Perren have not examined the relationship between science and technology and horticultural development.

B. A. Holderness gives a valuable summary of market gardening, vegetable and flower growing, nursery stock raising and glasshouse production in England in the period 1850-1914. He has connected poultry production between 1910-

[15] Thirsk, op. cit. (8), pp. 169-170, pp. 180-189.

[16] Horticultural Education Association, *Education in Horticulture*, Lyminge: Walter P. Wright, 1912, p. 13.

1930 with smallholding. I develop this idea, although Holderness has not stated explicitly that it was part of horticultural output and has not differentiated fully between the horticultural and agricultural industries.[17]

1.3.4 General Histories of Science Focussing on the Life Sciences

There have been three independent, edited volumes published between 1990-2009 addressing the life sciences, each commissioning articles on various science subjects and topics having associations with horticulture, such as biology, botany, biochemistry, microbiology, natural history, botanic gardens and field stations. They contain few references to horticultural science. Articles in the volume edited by R. C. Olby and others have not drawn attention to horticultural science.[18] In *Cultures of Natural History* there is one relevant entry; a piece by D. Allen outlining horticultural tastes and crazes.[19] The most recent publication, edited by P. J. Bowler and J. V. Pickstone, contains a number of articles that have addressed very briefly several aspects of horticultural science but the authors have not indicated they were writing about scientific horticulture.[20] Although Bowler and Pickstone pointed out the neglect of certain plant sciences they did not, disappointingly, mention horticulture specifically.[21]

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[17] B. A. Holderness, 'Specialised Cropping Systems' in E. J. T. Collins and J. Thirsk (eds.), *The Agrarian History of England and Wales, Volume VII, 1850-1914*, Cambridge: Cambridge University Press, 2000, pp. 479-494.
[18] R. C. Olby, G. N. Cantor, J. R. R. Christie and M. J. S. Hodge (eds.), *Companion to the History of Modern Science*, London: Routledge, 1990.
[19] N. Jardine, J. A. Secord and E. C. Spary (eds.), *Cultures of Natural History*, Cambridge: Cambridge University Press, 1996.
[20] P. Bowler and J. V. Pickstone (eds.), *The Cambridge History of Science. Volume 6. The Modern Biological and Earth Sciences*, Cambridge: Cambridge University Press, 2009.
[21] P. Bowler and J. V. Pickstone, 'Introduction' in P. Bowler and J. V. Pickstone (eds.), *The Cambridge History of Science. Volume 6. The Modern Biological And Earth Sciences*, Cambridge: Cambridge University Press, 2009, p. 1.

Jon Agar in a broad survey of twentieth century science explains that, 'science solves the problems of 'working worlds'. These 'are arenas of human projects that generate problems', for example 'projects to build technological systems'. He discusses the working worlds of agriculture, transport, communication, electric power and light, computers, although the working world of horticulture is not described.[22] I adopt this concept to explain developments in horticultural science between 1910 and 1930. A characteristic of working worlds were the interactions that took place between scientists and industry in order to solve problems that were putting a brake on efficiency or preventing the adoption of new techniques. I claim that such interactions, between scientists involved in horticultural research and commercial growers, were a feature of early twentieth century horticultural science in England. Agar has explained that scientists addressing working world problems made use of current theories to design small-scale experiments in controlled conditions. The outcomes were then trialled on an industrial scale. This methodology of problem solving was a characteristic of research stations funded in part by those commercial growers who were lobbying the government for scientific assistance. I illustrate this in subsequent chapters, particularly 3, 4 and 7.

1.3.5 Histories of UK Horticultural Science

Historians of science have only very recently begun to examine aspects of UK scientific horticulture and have focussed mainly on the nineteenth century. D. L. Opitz, writing innovatively about Swanley Horticultural College that became an institution for female students, has explained how courses provided a

[22] J. Agar, *Science in the Twentieth Century and Beyond*, Cambridge: Polity Press, 2012, pp. 3-6, pp. 60-62.

scientific and practical education, outlined the work of the College and traced the careers of students. Significantly, he has identified the importance of the role played by education in the development of horticultural science and has suggested relationships between horticultural science, the economy and the Empire. Whilst noting some of the experimental work conducted at the College before 1900, Opitz has not offered a comparative analysis with the investigations taking place at Swanley in the decades after 1910.[23] The focus of investigation at Swanley was applied research and the College was encouraged by BAF and the DC to carry out this type of work.

His work on the giant Amazonian water lily is instructive. He uses the lily to discuss features of early Victorian horticultural science such as the impact of systematic investigations on horticultural practice, the focus on nomenclature, the significance of private patronage, the role played by status and the influence of scientific networks.[24] I draw on a number of the ideas in this analysis of early Victorian horticultural science, particularly the discussion of the role played by patronage and education, the pursuit of status, the development of scientific networks and the effect of economic factors to explore influences shaping early twentieth century horticultural science.

J. Endersby, in a forthcoming account of the cultural history of orchids, has linked orchidology with the work of scientists such as Charles Darwin and Hugo De Vries. He considers the role of orchids in popular culture and makes associations with climate change. Although I have not examined in detail the fate of individual plants in this thesis, Endersby's work illustrates effectively the value of investigating horticultural science history and demonstrates the potential that is offered for further research.

[23] Opitz a), op. cit. (1).
[24] Opitz b), op. cit. (1).

1.3.6 Histories of UK Agricultural Science

Since the publication in 1966 of E. J. Russell's, *A History Of Agricultural Science In Great Britain*, no other comprehensive general history of agricultural science in the UK has been written. Russell's book was in part a first hand account of some of the work he conducted whilst at Rothamsted Experimental Station and of some of his interactions with other scientists at the station and elsewhere. The book is valuable because of this, but a characteristic is the lack of reference to horticultural science. The term 'horticulture' is never used to describe a number of the developments and activities outlined in the book that contemporaries regarded as features of horticultural science and commercial horticulture.[25]

P. Brassley, writing about agricultural science in the years between 1850-1914, has shown the importance of examining in detail the experiments carried out by agricultural scientists in order to evaluate their influence on cultivation practice and has drawn attention to investigations of manures, weeds, pests and diseases. His definition of agricultural science as the application of techniques and skills not generally available to the farmer by disinterested professionals and his belief that little progress was made until after 1890 is contentious.[26] By taking this position he omits the work of a range of institutions and scientists promoting scientific investigations between 1850-1890 in a number of plant sciences. Additionally, Brassley does not differentiate between the work that

[25] Sir E. John Russell, *A History of Agricultural Science in Great Britain 1620-1954*, London: George Allen and Unwin Limited, 1966. Russell's reluctance to give recognition to horticultural science is puzzling, as Rothamsted conducted experiments relevant to horticulture and agriculture. It is likely he regarded horticulture and horticultural science as components of agriculture, although this does not explain why he did not use these terms when discussing the scope of agricultural development.
[26] Brassley, op. cit. (9).

was being carried out in pure and applied agricultural science and does not ascertain whether the scientists carrying out experiments believed their work helped expand output and knowledge.

Brassley in several articles in the *The Agrarian History of England and Wales, Volume VII, 1850-1914,* continues his earlier researches and E. Whetham writing in *The Agrarian History of England and Wales, Volume VIII, 1914-1939* has also addressed developments in agricultural science. Both have revealed the work carried out by researchers investigating agricultural crops and meat and milk production, although they give less consideration to the scientific work that was carried out to support forestry, managed until 1919 by the Board of Agriculture and then by the Forestry Commission, and the fishing industry. Brassley calls attention to work on plant nutrition and rightly emphasises the importance to growers of improved cultivation practices, as they influenced yield. He does not consider, however, their responses to the techniques and products generated by scientists and the willingness of some producers to develop their own investigations. However, he overestimates the efficacy of Mendelian breeding techniques, provides a brief outline only of the work of scientists investigating the relationship between plant growth, nutriments and the soil and does not take into account the pioneering work on weed control by W. Brenchley and others at Rothamsted Research Station in the 1900s.[27] Whetham gives instructive comments about the differences in the pattern of production in the regions and the enterprise of scientists working in research stations, although does not discriminate between horticultural and agricultural institutions. Additionally, the connection between pig raising and horticulture

[27] P. Brassley, 'Agricultural Science and Education' in Collins and Thirsk (eds.), op. cit. (18), pp. 594-649; P. Brassley, 'Farming Techniques' in Collins and Thirsk (eds.), op. cit. (18), pp. 522-532; P. Brassley, 'Weeds and Pest Control' in Collins and Thirsk (eds.), op. cit. (18), pp. 548-554.

has not been referenced: as I have indicated, during the 1910s and 1920s pig rearing was regarded by the government as a horticultural activity.[28]

A number of historians of science writing about agricultural science in Britain in the early twentieth century have, like Brassley and Whetham, discussed initiatives and activities that have relevance to horticultural science, although most have not examined this connection explicitly. R. Olby is an exception and in a perceptive and pioneering paper showed that the Liberal Government's patronage of agricultural, horticultural and forestry research after 1909, involving the DC and the Development Fund (DF), set a precedence for further state involvement in other areas of science.

His belief that a feature of the structure of Edwardian science was, 'its cosy character' creates difficulties, as his description is not applicable to all areas of Edwardian science and to all scientists. [29] For example, practitioners of horticultural science were endeavouring to establish their specialism as a legitimate academic discipline, a problem faced to a lesser degree by agricultural scientists, and entomological and mycological scientists were striving hard to establish the usefulness of their subject to other scientists and to industry in general. Harwood has commented on the problems faced by scientists teaching agriculture in education and research institutions in Germany and other countries, in trying to obtain academic recognition from members of other faculties who regarded them as 'second class citizens'. To improve their academic status and that of their department, members of agricultural departments began to import more academic rigour into the courses

[28] E. H. Whetham (ed.), *The Agrarian History of England and Wales, Volume VIII, 1914-1939*, Cambridge: Cambridge University Press, 1978, pp. 87-88, pp. 273-295.
[29] Olby b), op. cit. (9).

they taught.[30] Moreover, like-minded scientists sharing similar educational experiences, background and political beliefs did not always agree about matters of policy, the purpose of science and the direction in which it should develop.

In a key article about the DF, K. Vernon sheds light on its dispute with the BAF over the structure of the government's system of agricultural and horticultural research, details its support of the work of Rothamsted in soil and plant nutrition, discusses research in dairying and supports Olby by arguing the DF created an influential system of science promotion. In subsequent chapters I develop further several of the points raised by Vernon to discuss the development and influence of the government's research system. In assessing the effects of DC funded research, Vernon claims it underfunded dairy research, whereas in reality the story is more complex. In evaluating the influence of research on producers he does not show how responses of horticulturalists, agriculturalists and foresters differed according to operational factors, demand, resources at their disposal and personal commitment.[31]

A. Rogers has written the first book about the DC and covers its foundation in 1910, its transformation in the late 1930s into a body promoting social and economic projects in rural areas and its demise in 1999. Rogers supports the view of Olby and Vernon that the scheme that was set up influenced later state initiatives in science funding. He assesses the influence of A. D. Hall, a lead Commissioner, and the DC in promoting research and points out rightly that education was an important component of this system and that on occasions

[30] J. Harwood, *Technology's Dilemma: Agricultural Colleges between Science and Practice in Germany, 1860-1934*, Bern: Peter Lang, 2005, p. 13, p. 29, pp. 224-227, p. 236.

[31] K. Vernon, 'Science for the Farmer? Agricultural Research in England 1909-36', *Twentieth Century British History* (1997), 8, (3), pp. 310-333.

the credit for innovation went to the BAF because it fronted initiatives whereas it should have gone to the DC, the originator. The picture Rogers provides is somewhat incomplete as he does not explain the dispute between the DC and the BAF over the structure of the state system of research and gives very few details about the actual investigations that were carried out.[32] In contrast, I discuss the experiments that were conducted and refer to the response of commercial growers to horticultural science research. In doing so, I offer an original contribution to the historiography of state funded research of the plant sciences.

The work of the county council advisory service, part of the system of science research and education supported by the DF, is assessed by C. J. Holmes. He stresses, appropriately, that the feedback from the advisers on county council investigations and the information passed on to research stations about the practical problems faced by growers helped structure subsequent research investigations. Holmes indicates, helpfully, what it could be like to be a county council advisor: sometimes facilities were poor, there was understaffing, data collection lacked a uniform system, there was disparity in service provision between county councils, and on occasions the workload was unmanageable. He believes some farmers mistrusted academics but had faith in education and the college system and identifies horticulturalists as being more responsive than agriculturalists to the work of research institutes. Not enough is known about individual farmers and horticultural growers to confirm these judgements. Holmes states there were many farmers in the period 1918-1939 managing

[32] A. Rogers, *The Most Revolutionary Measure. A History of the Rural Development Commission 1909-1999*, Salisbury: Rural Development Commission, 1999.

small acreages and research was not geared to their needs.[33] The role of farm institutes in the advisory service ought to be considered. They were introduced specifically to demonstrate the efficacy of techniques developed by research stations and their relevance to local soil and climatic conditions and attempted to cater for the practical needs of growers operating on a small or large scale and the owners of small and large gardens - some of the horticultural work of these institutes was applicable to agriculture and some of their agricultural research had horticultural relevance.

DeJager takes a different position to Holmes and believes the agricultural scientists who planned agricultural research between 1910-1937 gave the same importance to the views of practical farmers views as they did to the opinions of their research colleagues.[34] DeJager explains that many contemporaries believed the DC's policy was too practical, although he does not draw on the establishment of farm institutes, which were of a practical orientation, to support this claim. He cites W. Bateson, Director of John Innes Horticultural Institution (JIHI) as refusing a DC grant because it would have shaped research in an economic direction.[35] Little has been written about the horticultural research at JIHI beyond genetic investigations to be able to judge whether pure science research dominated or the extent and nature of applied research. Possibly the reason for JIHI being refused a grant in 1911 was that it was a privately financed body and so failed to meet DC criteria, although Woburn Abbey Experimental Research Station funded privately by the Duke of Bedford was given a grant in 1911 - JIHI did get its grant in 1920. DeJager, like Holmes,

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[33] C. J. Holmes, 'Science and the Farmer: the Development of the Agricultural Advisory Service in England and Wales, 1900-1939', *Agricultural History Review* (1988), 36, (1), pp. 77-86.

[34] T. DeJager, 'Pure Science and Practical Interests: The Origins of the Agricultural Research Council, 1930-1937', *Minerva* (1993), 31, (2), pp. 129-150.

[35] DeJager, op. cit. (35).

raise a number of issues in need of further clarification and more case studies of producers are required before some of these judgements can be confirmed. S. Richards has discussed the development of Wye College (1894) that became the school of agriculture for the University of London in 1904 and a recipient of DC funds. It was part of the expansion of universities and university colleges that occurred after the 1890s as a result of government funding. He has informatively detailed the appointment to the staff of scientists and the rejection of the practice of appointing practical agriculturalists, drawn attention to the scope of the research that included investigations of bees and poultry, remarked on the production of research papers and textbooks and noted the 'university reputation' gained by the College. Additionally, Richards contends that British agricultural institutes were not comparable to those in the United States, Denmark and Germany and suggested, contrary to established views, that in the First World War the DF structure enabled valuable research to be carried out on farm and horticultural machinery, minimum cultivation standards and weed and pest control. Some contemporaries, however, were exasperated by the fact that the War put research on hold. Clearly, further information is needed about the pure and applied research work that was conducted at UK research stations and at those in other countries in order to make a detailed comparative analysis and about the complex effects of war on agricultural and horticultural research; it acted as both brake and accelerator.[36]

A number of historians of science have examined aspects of the history of plant breeding and genetics in the early twentieth century and provided important insights about the organisation of science, its conduct and the motives of

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[36] S. Richards, 'The South-Eastern Agricultural College and Public Support for Technical Education, 1894-1914', *The Agricultural History Review* (1988), 36, (2), pp. 172-187.

interest groups.[37] Although these writers have focussed mostly on agriculture, their work has relevance for horticulture. Palladino has considered the part played by plant breeders, particularly those using Mendelian techniques, in agriculture in Britain and the United States. He has discussed the role of the DC and the commercial sector in supporting and influencing research into the genetics of plant breeding and has drawn attention to the importance of examining the contributions of institutions and their scientists by outlining the work carried out at Cambridge University, the National Institute of Agricultural Botany (NIAB), the Welsh Plant Breeding Station and the Scottish Plant Breeding Station, all receiving government grants. His assertion that Mendelian varieties generally did not benefit the British farmer has some resonance for horticulture. His belief that a problem for plant breeders was the absence of legal protection for new varieties produced did not seem, as far as I can find, to have prevented horticultural seed firms from turning out different varieties of flowers and vegetables based on traditional methods.[38] Some large seed firms produced for the horticultural and agricultural markets and this duality of role is

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[37] P. Palladino a), 'The Political Economy of Applied Research: Plant Breeding in Great Britain, 1910-1940', *Minerva* (1990), 28, (4), pp. 446-468; P. Palladino b), 'Between Craft and Science: Plant Breeding, Mendelian Genetics and British Universities, 1900-1920', *Technology and Culture* (1993), 34, (2), pp. 300-323; P. Palladino c), 'Wizards and Devotees: On the Mendelian Theory of Inheritance and the Professionalization of Agricultural Science in Great Britain and the United States, 1880-1930', *History of Science* (1994), 32, (3), pp. 409-444; P. Palladino d), 'Science, Technology and the Economy: Plant Breeding in Great Britain, 1920-1970', *Economic History Review* (1996), 49, (1), pp. 116-136; P. Palladino e), *Plants, Patients and the Historian: (Re)membering the Age of Genetic Engineering*, Manchester: Manchester University Press, 2002; B. Charnley a), *Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930*, University of Leeds, PhD thesis, 2011; B. Charnley b), 'Experiments in Empire-building: Mendelian Genetics as a National, Imperial and Global Agricultural Enterprise', *Studies in History and Philosophy of Science* (2013), 44, (2), pp. 292-300; D. Berry b), *Genetics, Statistics, and Regulation at the National Institute of Agricultural Botany, 1919-1969*, University of Leeds, PhD thesis, 2014; Berry a), op. cit. (9).

[38] Palladino a), op. cit. (38); Palladino b), op. cit. (38).

perhaps worth exploring and reinforces the need to examine the variations in both the development and impact of horticultural, agricultural and forestry science.

Palladino compares responses in the USA and Britain towards Mendelian plant breeding. He points out that genetic researchers in agricultural colleges in the USA and breeders welcomed Mendelian methods whereas in the agricultural units in UK universities there was little agreement of the utility of this research. He discusses the willingness of English seed firms to invest in plant breeding, although little is known currently about the preferred methods of the many seed houses that were located in all parts of the UK.[39] Palladino has also emphasised the importance of wealthy amateurs in the period 1880-1930, who were conducting breeding experiments using different techniques and believes they might be more important as a group than civil agricultural scientists. He discusses the amateur status of this far from homogeneous group, raises the issue of what defines amateur status, a problem that still is contestable, and notes the tensions that developed between the scientists using Mendelian methods and those breeders using traditional techniques.[40]

His view that British research stations up to 1920 had more freedom than their USA counterparts to explore a wider range of scientific issues may be apposite.[41] British scientists at these stations were encouraged to pursue pure science research without the expectation of associated practical benefits, a view promoted by a number of influential scientific movers and shakers in the plant sciences. Of course, there were pressures from growers and their associations and from farm institutes for practical results and we do not yet know fully how

[39] Palladino b), op. cit. (38).
[40] Palladino c), op. cit. (38); Palladino d), op. cit. (38); Palladino e), op. cit. (38).
[41] Palladino c), op. cit. (38).

far these pressures influenced the research work of individual scientists. Palladino discusses the JIHI as a trainer of geneticists but does not categorise it as a horticultural or an agricultural institution. If it belongs to the former, a new dimension is added to discussions about developments in the plant sciences.[42] Charnley and Berry, building on the work of Olby, Palladino and others, have discussed other facets of plant breeding and reaffirmed the importance of examining plant breeding history and institutional aspects of early twentieth century science. Charnley has traced the significance of the Empire to plant breeders and discussed the application of Mendelian methods in the colonies in attempts to improve yields and reduce decimation from diseases. Contemporaries regarded the cultivation of plantation crops as horticultural activities, because of their scale and the nature of the operations that were involved in maintenance. Besides Charnley's 'agricultural Empire' it seems there was also a horticultural Empire and a number of techniques and pest, disease and weed control methods were common to both.[43] Charnley discusses the importance of the JIHI in the development of Mendelian breeding programmes and draws attention to the promotion of agricultural science by the DC, that was also promoting horticultural science research, and the influence of Roland Biffen, Professor of Agricultural Botany at Cambridge University. Perceptively, he notes that some researchers working in agriculture gave selfless public service, in part motivated by the belief that science could provide food for the masses and contribute to rural stability – science acting as an agent of social control.[44] This view was shared by a number of other researchers

[42] Palladino d), op. cit. (38).
[43] Charnley a), op. cit. (9); Charnley b), op. cit. (38).
[44] Charnley b), op. cit. (38).

working in different branches of science, such as horticulture, and by some politicians.

Berry in examining the development of the NIAB, founded in 1919, has illustrated how the competing motives of government officials, scientists, the seed trade and its Director influenced its establishment and subsequent development and has highlighted convincingly the importance of considering contemporary debates about the way experiments ought to be conducted. He takes an agricultural perspective, despite the fact that some of the Institutes work involved horticulture, and shows the importance of the influence exerted by the DC. By the mid 1920s NIAB was performing to criteria set by the DC and conducted seed testing and encouraged the development of disease resistant plants.[45]

H. A. Curry has provided an addition to horticultural science knowledge by focussing on breeding investigations carried out in the USA by scientists and later by domestic gardeners or amateurs - those individuals who were not professional scientists - from the 1920s to the 1960s. Curry explores how, in conjunction with methods of selection and hybridisation, x-rays, the chemical colchicine and then later radiation were used to try and alter the gene structure of plants in order to produce new and improved varieties.[46] I have been unable to find examples of such work in England between 1920 and 1940 but in Chapter 7 I explain the investigations conducted between 1912 and 1922 by 'amateurs' and scientists, who used radioactive ores not as aids to breeding but as plant growth stimulants - a proprietary fertiliser based on these kinds of ores

[45] Berry b), op. cit. (38).

[46] H. A. Curry, *Accelerating Evolution, Engineering Life: American Agriculture and Technologies of Genetic Modification, 1925-1960*, Yale University, PhD thesis, 2012; H. A. Curry, 'From Garden Biotech to Garage Biotech: Amateur Experimental Biology in Historical Perspectives', *The British Journal for the History of Science* (2014), 47, (3), pp. 539-585.

was manufactured for the use of domestic gardeners and allotment holders. Similar experiments were conducted in the USA and may have been the prelude to the use of x-rays and radiation for genetic modification.

Attitudes towards pure and applied science changed during the nineteenth and twentieth centuries. Several historians of science have demonstrated the importance of understanding what contemporaries meant by these terms, contrasted attitudes of UK scientists with those in other countries and reflected on the value of these terms in helping to generate discussion and understanding about science in these centuries. Most attention has been directed towards chemistry, engineering, geology, medicine and physics and this bias has meant the plant sciences generally, and horticulture in particular, have not been included.[47]

Gooday in his discussion of these issues has referred in passing to plant breeding and agriculture whilst omitting the breeding of vegetables and flowers undertaken by those involved in horticulture.[48] Clarke, Gooday and Schauz have noted the increased interest shown by UK scientists during the First World War in 'fundamental' science but have not referred to the work carried out by A. D. Hall in 1910 who was developing his role as scientific consultant to the

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[47] R. Kline, 'Construing "Technology" as "Applied Science": Public Rhetoric of Scientists and Engineers in the United States, 1880-1945', *Isis* (1995), 86, (2), pp. 194-221; S. Clarke, 'Pure Science with a Practical Aim: The Meanings of Fundamental Research in Britain, circa 1916-1950', *Isis* (2010), 101, (2), pp. 285-311; J. K. Alexander, 'Thinking Again about Science in Technology', *Isis* (2012), 103, (3), pp. 518-526; P. Lucier, 'The Origins of Pure and Applied Science in Gilded Age America, *Isis* (2012), 103, (3), pp. 527-536; R. Bud, '"Applied Science": A Phrase in Search of a Meaning', *Isis* (2012), 103, (3), pp. 537-545; G. Gooday, '"Vague and Artificial": The Historically Elusive Distinction between Pure and Applied Science', *Isis* (2012), 103, (3), pp. 546-554; E. Schatzberg, 'From Art to Applied Science', *Isis* (2012), 103, (3), pp. 555-563; R. Pielke, 'Basic Research as a Political Symbol', *Minerva* (2012), 50, (3), pp. 339-361; D. Schauz, 'What is Basic Research? Insights from Historical Semantics', *Minerva* (2014), 52, (3), pp. 273-328.

[48] Gooday, op. cit. (48).

government and was making the case for fundamental and applied science to underpin the governments system of horticultural and agricultural research and education.[49] I have built on the work of these historians and will show that an examination of these issues from the perspective of researchers in the plant sciences offers opportunity for further analysis and debate.

1.4 Chapter Summary and Themes

The foregoing has indicated the rather sparse coverage of horticultural science in the early twentieth century and, in fact, for most periods in history. One possible explanation is that historians of science have viewed horticulture as part of agriculture, although this seems insufficient justification for discounting horticultural science. This dissertation, by examining horticultural research and investigation and by addressing some of the gaps in knowledge identified in Section 1.3.6, is offered as an original contribution to the history of science.
I give In Chapter 2 a summary of some of the major topics nineteenth century investigators of horticultural science believed to be important. This provides the backcloth for the chapters about the early twentieth century that focus on the growth and work of research stations, the investigations conducted by the commercial sector, the provision of horticultural education and consumer-oriented policies of the government. I develop the theme that support for horticultural science came from a range of private institutions, the commercial sector and individual devotees and show that until the 1890s there was little government support for horticultural science research. In focussing on the development of horticultural science subject matter I will demonstrate the

[49] Clarke, op. cit. (48); Gooday, op. cit. (48); Schauz, op. cit. (48).

subject accrued knowledge and methodological procedures from a range of other sciences and was influenced by researches in plant physiology and the rise of laboratory science. I conclude by indicating that by the 1900s the state was supporting research and education in horticulture at universities, colleges and farm institutes and the commercial sector was lobbying for further state support of scientific investigation. This sets the scene for later chapters.

To illustrate the theme of state patronage of horticultural science I discuss the growth of state funded research stations in Chapters 3 and 4, explain the subject matter of their enquiries and link their development to the growth of commercial horticulture and its increasing importance to the economy. I will show how it differed from agriculture and will argue that demarcation boundaries changed in the early twentieth century as bees, poultry, pigeons, rabbits, hares and pigs now became associated with horticulture.

Chapter 3 discusses the origins of the system of horticultural research that developed after 1910 and I propose that a group of loosely associated reformers, scientists and politicians were instrumental in this development. To support my argument that various tensions characterised horticultural science, I explain that discussions concerning the role of fundamental science and applied science in this system led to a bitter internecine dispute over the nature and conduct of state horticultural science research. The arguments used by BAF and the DC to claim that horticultural scientists were similar to doctors and consultants in the medical profession is also considered in this chapter.

I present in chapter 4 a more in-depth examination of research station science by discussing the work of four research stations to provide additional evidence that horticultural science was characterised by diversity and use these case studies to show horticultural science research was not confined to plot experiments and that agricultural stations could also conduct horticultural experimentation. This chapter further illustrates my argument that fundamental science and applied science played a key role in the development of state funded horticultural science research and education.

Chapter 5 documents the creation of a government Horticultural Department in the BAF and continues the theme of state patronage of horticultural research. By discussing the work and influence of the Department I make an original contribution to the history of the plant sciences. I illustrate how this Department liaised with research stations, commercial growers and the public to safeguard crops, raise output and provide guidance and advice.

My argument that demarcation disputes were a reoccurring issue for those involved in horticultural science in the years between 1910-1930 is continued in Chapter 6. The associated theme, status acquisition, is further developed and builds on the discussions begun in Chapter 3. This argument and theme are considered in an examination of the development of horticultural science education at farm institutes and universities and colleges, respectively the bottom and top tier of this system of education. I will show that the struggle between the BOE and the BAF for the control of educational provision depended on which department best demonstrated gravitas, which possessed the skills, experience and qualified scientists to ensure the government’s system of research and education got off to a good start and which could best raise the status and standing of horticultural science in academic circles, amongst scientists working in other disciplines and in the eyes of commercial growers.

A further theme, horticultural science education, is developed mainly in Chapter 6 but is also picked up in Chapters 2, 8 and 9. For A. D. Hall, education was a vital element in his system of horticultural science research. It was the major conduit for conveying the findings of fundamental and applied science to the commercial sector, allotment holders and home gardeners and he saw it as the essential means to ensure the supply of future researchers and skilled growers. In this thesis I refer to commercial horticulture as a 'working world', a concept developed by J. Agar that draws attention to a research methodology that characterised the sciences in the twentieth century.[50] This theme is discussed in Chapter 2 and in Chapter 7 I show how research stations supported the working world of horticulture and argue that some members of the commercial sector were eager to make use of the findings of research station science. Here the theme of private sponsorship of horticultural science research that was developed in Chapter 2 is continued in order to illustrate how the commercial sector contributed to the development of horticultural science by financing experiments on their own land. I provide a case study of the patronage of horticultural science by one leading seed firm, Suttons and Sons of Reading, in order to identify more specifically the role that was played by the commercial sector.

Finding primary source material to assist the process of judging whether research station science led to the production of fruit and vegetables that satisfied demand and if research station products enhanced cultivation or generated dissatisfaction, proved elusive. My focus became the consumer-oriented policies of the government and its research stations. The response of consumers to the fruit and vegetables raised using research station science and of allotment holders to the research station products is examined. I will suggest that although horticultural science research did influence consumption patterns

[50] Agar, op. cit. (23), pp. 3-6, pp. 60-62.

and cultivation practices of allotment holders in England, the picture that emerges is far from complete. Significant variations in patterns of consumption occurred in urban and rural areas and in geographical regions and the response of allotmenteers could be influenced by the nature of local authority support, the nearness of research stations and the commitment of those organising allotment societies.

I continue this final theme in the discussion of apiculture in Chapter 9 to support the argument that horticultural science involved more than just the consideration of plants. Apiculture, as I have emphasised, was a horticultural activity and serious outbreaks of bee disease led to the creation of several research stations to investigate epidemics and the techniques of hive management. Historians of science have not documented the history of the science of apiculture in England, 1910-1930, and this chapter is offered as a contribution to apicultural history.

Although I have treated these themes separately, I want to indicate briefly some interconnections. In the nineteenth century there was comparatively little state support for science and the patronage of private institutions, organisations and individuals assisted the development of horticultural science research. The work of researchers either affiliated to these institutions or acting independently defined the subject matter of horticultural science. Their careful, systematic and methodological approach to horticultural experiments helped raise the academic standing of horticultural science amongst their peers and with the wider scientific community.

In the early twentieth century the state became a significant patron of science. The working world of horticulture generated requests to the government to fund scientific experiments that addressed production problems. Growers saw experiments and investigations as the only effective means of solving these problems. After 1910 the government funded an increasing number of research stations to support growers, allotment holders and home gardeners. The success of various consumer-oriented policies of the government, based on the work of the research stations receiving government funds, helped to improve the standing and status position of those working in horticultural science in the eyes of commercial producers. Products and techniques developed by research stations proved popular and this, coupled with accumulated fundamental and applied science research findings, helped raise the academic standing of horticultural research and horticultural researchers.

Additionally, the government sought to raise the status of horticultural science and the horticultural scientists and horticultural inspectors in its own Horticultural Department by appointing well-qualified staff and introducing programmes of training. The creation of a hierarchical system of research and education involving universities, research stations, colleges and farm institutes and the introduction of horticultural qualifications, underpinned by fundamental science, helped demarcate horticulture from agriculture and assisted status acquisition. The following chapters will discuss how the commercial sector, scientists, the state, institutions and societies and private individuals shaped horticultural science.

Chapter 2

Science Applied to Horticulture, 1800-1910: Setting the Scene

This chapter examines nineteenth century and very early twentieth century scientific horticulture in order to provide the background for the discussions in subsequent chapters of horticultural science initiatives and investigations in the period 1910 to 1930, which form the major part of the thesis subject matter. The years between 1800-1910 have been divided, the division occurring in 1885.[1] During the first period J. C. Loudon, prolific gardening writer and trained horticulturalist, included in his *An Encylopaedia of Gardening* (1822) a section entitled, 'Gardening considered as a science'. He observed, accurately, that horticulturalists were making use of the findings of taxonomy, plant physiology, chemistry, zoology, mineralogy, arithmetic, geometry and glasshouse and other technologies. By 1850 the term 'horticultural science' had been coined.[2] The government gave little support to scientific investigations and activities in horticulture in this period and research was financed mainly by private individuals and organisations. During the second period, 1885-1910, the involvement of central government in horticultural and agricultural science increased markedly and a number of botanists, chemists, entomologists, mycologists and other scientists believed that horticultural and agricultural science research and teaching now provided improved opportunities for professional development.

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[1] The intention is to discuss some key factors rather than provide a comprehensive history of horticultural science.

[2] J. C. Loudon, *An Encyclopaedia of Gardening; Comprising the Theory and Practice of Horticulture, Floriculture, Aboriculture and Landscape-Gardening*, London: Longman, Hurst, Rees, Orme and Brown, 1822; 'Preface', *The Gardeners' Magazine of Botany, Horticulture, Floriculture and Natural Science* (1850), 1, p. v.

M. Laird, focusing mostly on the middle and upper classes and activities that took place mainly in the south of England, has argued that horticulture in the early nineteenth century became separated from botany, entomology and natural history.[3] I will show that what was characteristic of scientific gardening and horticultural science, a part of the generic term ‘horticulture’, was the opposite of this separation. Scientific horticulture built up areas of knowledge from the contributions of botanists, chemists and those interested in climatology and natural history. Some of the gardens of the landed aristocracy in the early nineteenth century contained collections of natural history, birds and a range of plants from the Americas and Africa and were maintained by skilful head gardeners with knowledge of botany, chemistry and glasshouse technology. Scientific gardening and horticultural science in this period was an amalgam of a variety of subject areas.

2.1 Horticulture as a Science, 1800-1885

Significant influences shaping scientific horticulture 1800-1885 were firstly, the patronage of scientific, arts and manufactures, agricultural and horticultural societies that helped define fields of enquiry. Secondly, the scope of horticultural investigation was extended by the rise after 1840 of laboratory science in both chemistry and plant physiology, assisted in part by the search for mineral and other substances that could be used to make nitrogen, phosphate and potash fertilisers for the agricultural and horticultural industries of Europe, the United States and Canada that were supplying an expanding

[3] M. Laird, *A Natural History of Gardening 1600-1800*, New Haven: Yale University Press, 2015. See chapter 7.

population. There was an increasing dependence on these fertilisers, particularly as popular guano manure fluctuated in price and it was believed supplies would run out.[4]

The laboratory work on fertilisers and plant physiology at Rothamsted Experimental Station (Rothamsted) and physiology by John Lindley, Professor of Botany at University College and supervisor of The Horticultural Society of London's (THSL, 1804) garden at Chiswick, helped establish such investigations as important components of scientific horticulture and contributed to the demand for the services of chemists and botanists.

Horticulturalists were beginning to create sub-branches of scientific horticulture. The Horticultural Society promoted the association of meteorology with plant cultivation. Since 1826 daily, extensive meteorological observations were taken at its Chiswick garden, 'to aid the science of open-air horticulture'.[5] Chemistry when used to assist the cultivation of flowers became, 'the chemistry of floriculture'.[6]

Thirdly, the efforts made by staff at botanic gardens, private horticultural

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[4] Anon, *The Gardener's and Farmer's Reason Why containing Reasons for the Principles of Scientific Cultivation applicable to Gardening and Agriculture*, London: Houlston and Wright, 1860; J. B. Morrell, 'The Chemist Breeders: The Research Schools of Liebig and Thomas Thomson', *Ambix* (1972), 19, (1), pp. 1-46; G. J. Leigh, *The World's Greatest Fix. A History of Nitrogen and Agriculture*, Oxford: Oxford University Press, 2004, pp. 78-120; K. R. Benson, 'Field Surveys and Stations' in P. J. Bowler and J. V. Pickstone (eds.), *The Cambridge History Of Science. Volume 6. The Modern Biological and Earth Sciences*, Cambridge: Cambridge University Press, 2009, pp. 76-89; J. Harwood, 'Universities' in Bowler and Pickstone, op. cit. (4), pp. 90-107; E. Cittadino, 'Botany' in Bowler and Pickstone, op. cit. (4), pp. 225-242; D. Cordell, Jan-Olof Drangert and S. White, 'The Story of Phosphorous: Global Food Security and Food for Thought', *Global Environmental Change* (2009), 19, pp. 292-305; G. T. Cushman, *Guano and the Opening of the Pacific World. A Global Ecological History*, Cambridge: Cambridge University Press, 2013, pp. 28-102.

[5] J. Glaisher, *Reduction of the Meteorological Observations made at the Royal Horticultural Gardens Chiswick in the years 1826-1869*, London: Royal Horticultural Society of London, 1871, p. 2. The book contains 80,000 observations.

[6] 'The Chemistry of Floriculture', *The Gardener's Weekly Magazine, and Horticultural Cabinet* (1863), V, (10), p. 360.

collectors and nurserymen to introduce plants from different geographical regions of the world made it important for horticulturalists curating such collections to become familiar with systems of plant classification and nomenclature and establish effecient cultivation practices based on systematic observation and effective manipulation of growing conditions. The increasing number of orchid imports stimulated experiments on growing mediums and the aerial environment of glasshouses that became aspects of, ‘the science of orchidology’.[7]

Fourthly, seed houses developed improved varieties of plants and were investigating methods to improve seed purity. A number carried out experiments to find ways of accelerating plant growth.

2.1.1 Scientific Societies

The Royal Society of London (RS, 1660) through its promotion of plant physiology, the Society for the Encouragement of Arts, Manufactures and Commerce by its patronage of agricultural innovation (SEAMC, 1754), the Linnean Society of London (LS, 1788) with its focus on taxonomy and physiology and the British Association for the Advancement of Science (1831, BAAS) by funding botanical research added to the body of knowledge available to horticultural experimenters. The publications, meetings and talks of these societies provided scientific horticulturalists with material for discussion and reflection. The following examples illustrate their patronage of scientific horticulture.

[7] Sir T. Lawrence, ‘Address to the [Orchid] Conference’, *The Journal of The Horticultural Society of London* (1886), III, (1), pp. 11-22.

Between 1801-1812 the *Transactions* of the RS became a vehicle for papers on plant physiology written by T. A. Knight, wealthy horticultural experimenter and President of THSL. Supported by Sir Joseph Banks, President of the RS, Knight wrote on bees, the movement and fate of sap in trees, the formation and role of bark and internal vessels, the effects of ageing on trees, bud progression, the development and growth pattern of roots and the movement of tendrils.[8] In the years 1812-1885 the Society sponsored biological expeditions that gathered horticultural science information and published papers of value to horticultural investigators on the effects of light on plants, respiration, the source, influence and assimilation of nitrogen, crop rotation, lichens, actions of acids on plants, the anatomy of water lilies, substances found in trees, plant excretions, the behavior of vessels in trees, leaf morphology, 'electromotive ' properties of leaves and the response of grasses to fertilisers. There were also comments on flowering plants, ferns and fungi.[9] Premiums used by the SEAMC fostered improvements in cultivation methods. In the 1830s gardening became sufficiently important to be included in the Society's agricultural section. The Society encouraged land reclamation, the production of more efficient cultivation implements, improved methods of raising trees and culinary potatoes, the development of techniques to combat pests and diseases, the development of ways to prevent frost damaging orchard blossom, the raising of better-quality fruit trees and ornamental shrubs and enhanced glasshouse management techniques. Articles in Its *Transactions* dealt with manures, soil analysis, seed purity, allotments, cultivation methods

[8] Between 1801-1811 Knight wrote 14 papers for the *Transactions*; J. Brown, 'Knight, Thomas Andrew (1759-1838)', *Oxford Dictionary of National Biography*, *Volume 31*, Oxford: Oxford University Press, 2004, pp. 930-931.
[9] See the yearly *Transactions* covering this period; M. B. Hall, *All Scientists Now. The Royal Society in the Nineteenth Century*, Cambridge: Cambridge University Press, 1984, pp. 210-212.

and greenhouse heating systems.[10]

In the publications of the LS new plant imports were publicised and discussed. At the general meetings, open to all classes of society, talks and lectures about these varieties were given and specimens were displayed. Topics in the *Transactions* of the Society included the effects of ivy on trees, de-oxidation in leaves, the formation of epidermis, properties of new plants, the natural system of plant classification, root parasites and monographs on various garden plants.[11]

Morrell and Thackray in discussing the BAAS give little attention to scientific botany and its application to horticulture, even though the Association funded such investigations.[12] For example, in the 1850s C. G. B. Daubeny, Professor of Chemistry and Botany at Oxford University, received a grant to carry out experiments on ferns to discover whether ‘carbonic acid’ in the air promoted growth. Other grants were given for investigating the destruction of tropical rain forests, ascertaining the existence of sexual organs in certain plants and exploring the influence of solar radiation on plants growing in different ‘atmospheres’.[13] Since 1841 an annual grant had been given to Lindley, Daubeny and others for a long-term research project involving experiments on the germination performance of horticultural and agricultural seed stored over periods of time. The *Notices of the Association* incorporated information about

[10] H. T. Wood, *A History of the Royal Society of Arts*, London: John Murray, 1913, p. 116, pp. 235-236. These appeared in the *Transactions* in the 1820s and 1830s, volumes 39-53. See *Transactions* Volume 11, 1813 to Volume 19, 1845.

[11] A. T. Gage and W. T. Stearn, *A Bicentenary History of the Linnean Society of London*, London: Academic Press Limited, 1988, pp. 148-153.

[12] J. Morrell and A. Thackray, *Gentlemen of Science: Early Years of the British Association for the Advancement of Science*, Oxford: Oxford University Press, 1981. They cite the unwillingness of Professor Daubeny of Oxford University to undertake a research programme relating Cambridge flora to local soils that would have received BAAS funding.

[13] See the annual *Report* for each of the years 1851-1855, covering the twentieth meeting to the twenty-fourth meeting.

fungi, different ‘monstrous’ garden flowers, wood formation, sap descent, venation in leaves, plant classification, plant disease remedies, new mosses, the influence of coloured glass on plant growth and the arrangement of air canals in water lilies.[14]

2.1.2 Horticultural Institutions: The Horticultural Society of London

In the first half of the nineteenth century THSL, the Royal Caledonian Horticultural Society (RCHS, 1809) and the Royal Horticultural Society of Ireland (RHSI, 1816) were founded to encourage horticultural improvement through scientific enquiry. They constructed experimental gardens, financed investigations, built up collections of imported and native plants, produced journals, encouraged the presentation of papers, held shows, awarded medals or certificates and supported plant collectors: all of this expanded knowledge of scientific horticulture.[15]

A central aim of THSL was to support and publicise experiments to improve varieties of flowers, vegetables and fruit, reveal details of plant physiology, enhance glasshouse performance, increase understanding of the effects of manures and expand knowledge about the qualities of soils. Honorary premiums were awarded to successful researchers and its

[14] *Report of the twentieth meeting of the British Association for the Advancement of Science*, London: John Murray, BAAS, 1851, p. 160, p. 168; See annual *Report*, op. cit. (13).

[15] Anon (2012) History [Online] Royal Caledonian Horticultural Society. Available: www.rchs.co.uk/about-us/history [Accessed 5 August 2015]. Pages are unnumbered; H. R. Fletcher, *The Story of the Royal Horticultural Society 1804-1968*, Oxford: Oxford University Press, 1969, p. 59, pp. 87-89, p. 98, p. 105, p. 130, pp. 146-147; B. Elliot, *The Royal Horticultural Society. A History 1804-2004*, Chichester: Phillimore and Company Limited, The Royal Horticultural Society, 2004, p. 182, pp. 229-235; F. W. Robertson, *Patrick Neill 1776-1851: Doyen of Scottish Horticulture*, Dunbeath: Whittes Publishing Limited, 2011, pp. 48-50.

Transactions and papers read to the Society raised awareness of aspects of scientific horticulture.[16] By 1830 the Society had initiated investigations in a number of these fields of enquiry and its Council believed they constituted scientific horticulture.

The Society was the role model for the RCHS and, as seems likely, the RHSI.[17] Several members of THSL were influential in society, either by their scientific standing or their social or political position such as Sir Joseph Banks, the Parliamentarian C. F. Greville, Vice Chamberlain of the Household, the Earl of Dartmouth, Lord Chamberlain, and T. A. Knight. In the 1840s THSL appointed a horticultural chemist E. Solly, later becoming its Professor of Chemistry, to give lectures and along with others conduct investigations into the constituents of plants, soil exhaustion, seed steeping, lawn fertilisers, manures and growing media.[18] Compared to the period 1805-1860, the appearance of papers on plant physiology at the end of the century was occasional rather than regular

All of these societies, and others, encouraged, conducted and publicised scientific horticultural research that defined subject matter and prescribed areas for investigation and experiment.

2.1.3 Agricultural Institutions

Agricultural institutions established in part to develop scientific agriculture, such as the Bath and West and Southern Counties Society (BWSCS, 1777), the Royal Agricultural Society of England (RASE, 1838) and the Royal Agricultural College (RAC, 1845) promoted investigations relevant to

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[16] Fletcher, op. cit. (15), pp. 44-50.
[17] Anon, op. cit. (15). Banks and Knight were honorary members of the RCHS.
[18] Fletcher, op. cit. (15), p. 157.

scientific horticulture.[19] All three encouraged experiments in manures (including sewage), soil, particular crops, machinery and pests and diseases that had horticultural application and their meetings, journals, reports, papers, premiums and medals fostered investigation and dialogue in scientific agriculture and horticulture.

2.1.3.1 The Bath and West and Southern Counties Society

Originally founded to encourage agriculture, arts, manufactures and commerce, the BWSCS quickly developed into a society promoting agriculture. It had employed a chemist since 1805 and in 1855 its consultant chemist, Dr. A. Voelker, who was Professor of Chemistry at the RAC, analysed soil and manures for members. Its *Journal* after 1859, with a new editor, reflected a wider range of activities and in the mid 1860s the BWSCS established a Department of Horticulture to encourage gardeners more efficiently than previously.[20]

The Society specialised in those branches of agriculture and horticulture practiced in the south west of England. The results of nationally based research were communicated to members via its meetings and publications.[21] Attention was given to fruit cultivation as there were many orchards in the region and plantations dedicated to the cider industry and the domestic market received particular consideration.[22]

[19] In Scotland The Highland and Agricultural Society (1874), performed a similar function.
[20] K. Jordon, A. Cotton and P. Bryant (2015) The Bath and West. A Short History [Online] The Royal Bath and West of England Society. Available: www.bathandwest.com/history/41/ [Accessed 25 August 2015]; Forthcoming Meeting of the Horticultural Department, *Journal of the Bath and West of England Society* (1867), 15, p. lxiii.
[21] Jordon, Cotton and Bryant, op. cit. (20).

2.1.3.2 The Royal Agricultural Society of England

From the 1850s the RASE supported work relevant to horticulture, particularly commercial fruit growing, and initiated specific horticultural science investigations. It encouraged the application of chemistry to destroy insect pests and weeds in orchards and on cultivable land, analysed topsoil, subsoil and farmyard manure to ascertain the elements that were necessary for plant growth and offered prizes for blight resistant potatoes.
A consulting chemist and consulting botanist were employed to assist this work and soils, manures, seeds and plants were analysed for members.[23] In 1871 consultant botanist, William Carruthers, conducted experiments on seed longevity and recorded germination rates over successive years. Experiments to determine the value of manure from animals given different types of feed were begun in 1876 in conjunction with the Woburn Experiment Station, Apsley Guise, Bedfordshire, financed by the Duke of Bedford.[24] Such investigations were germane to the science of horticulture. RASE liaised with horticultural and other agricultural societies over scientific matters and to promote ventures, as these were part of its aims. For example, arrangements were made with the Royal Horticultural Society (formerly THSL) to organise jointly a show at Bury St Edmunds in 1867.[25]

[22] Sir E. J. Russell a), *A History of Agricultural Science In Great Britain 1620-1954*, London: George Allen and Unwin Limited, 1966, p. 227.
[23] Russell a), op. cit. (22), pp. 110-128; H. M. Jenkins, 'The Royal Agricultural Society and the potato disease', *Nature* (1874), 11, (267), p. 109.
[24] J. A. Scott Watson, *The History of the Royal Agricultural Society of England 1839-1939*, London: Royal Agricultural Society of England, 1939, p. 119, p. 122, p. 130.
[25] Fletcher, op. cit. (15), p. 21.

2.1.3.3 The Royal Agricultural College

Located in Cirencester, Gloucestershire and funded privately, the Royal Agricultural College had a 450-acre farm, gardens and a laboratory based on the principles of Justus von Liebig, Professor of Chemistry at the University of Giessen and pioneer in applying chemistry to agriculture and botany.[26] It also possessed a library and museum with specimens of insects harmful to crops. These facilities were used to deliver a scientific education that included botany and plant physiology, subjects that were also part of the horticultural courses that used science to underpin practice.[27]

Between 1848-1852 James Buckman, Professor of Geology, Botany and Zoology, constructed a botanic grass garden and conducted experiments in the College gardens on carrots and parsnips. The aim was to produce garden varieties that did not succumb to troublesome club root disease. Seed collected from wild types was sown and the best roots produced were used to provide seed for further sowings.

This work was intended to be of more value to horticulture than agriculture. Buckman planned to extend his research to other garden roots and wanted to produce, 'early, succulent turnip crops' but his plans failed. He concluded that, 'the mystery of finger-and-toe [a plant disease], to which parsnips and carrots of our own garden culture have always been particularly liable' had rendered the work 'futile'.[28]

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[26] Morrell, op. cit. (4).

[27] Anon, *Royal College of Agriculture Prospectus*, Cirencester: Royal College of Agriculture, 1846, pp. 5-6; Farm Manager, *A guide to the Royal Agricultural College, Cirencester*: Bailey and Jones, 1852, p. 15, p. 17; R. B. Sayce, *The History of the Royal Agricultural College Cirencester*, Stroud: Alan Sutton Publishing Limited, 1992, p. 47.

[28] J. Buckman, 'On finger-and-toe in root crops', *Journal of the Royal Agricultural Society of England* (1855), 15, (33), pp. 125-135. The botanic grass garden was later

2.1.4 Plant Physiology and Horticulture

Plant physiology occupied a central position in botanical science. The activities by J. B. Lawes at Rothamsted, John Lindley at University College and M. T. Masters at Rothamsted and the RHS, are examined in this section, as their work led to a firmer association of physiological botany with scientific horticulture. Both Lawes and Lindley in their writings acknowledge their debt to the eighteenth century physiological botanist and contributor to scientific horticulture Stephen Hales and Lindley saluted T. A. Knight for his plant physiology investigations.

2.1.4.1 Rothamsted

Under J. B. Lawes and J. H. Gilbert the private research station of Rothamsted, established in 1843 and influenced by the research of Justus von Liebig, developed an international reputation. This was achieved partly through its work on plant nutrients, fertilisers and the interrelationship between their uptake by crops and the composition of the soil.[29]

In 1849 John Lindley worked with Rothamsted on the exploration of the loss of water from plants. The research was at the instigation of Lindley and indicates the respect his work on plant physiology had achieved in certain scientific circles. Lawes used trees in experiments to determine water evaporation from the leaves and provided much statistical data to conclude that, ‘evaporation depends on vitality, influenced by heat, light, and other causes’.[30]

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destroyed completely at the request of the Principal, who opposed strongly Buckman’s support of the ideas of Charles Darwin.

[29] Russell a), op. cit. (22), pp. 105-106, p. 147, pp. 156-157.

Lawes, Gilbert and the botanist M. T. Masters studied the effects of manures on grasses, an investigation begun in the 1850s. Masters and Gilbert later held the Chair of the RHS Scientific Committee whose main object was to, 'promote and encourage the application of physiology and botany to purposes of practical culture, and to originate experiments which may assist the elucidation of horticultural subjects'.[31] In this exhaustive study, aspects of morphology and 'physiology' were discussed.[32] Other studies by Lawes and Gilbert looked at nitrogen assimilation by crops. All of these investigations produced data and ideas for evaluation by those involved in horticultural plant physiology.

2.1.4.2 John Lindley: 'pointing out…the fundamental principles' of horticulture[33]

A number of commentators writing about John Lindley, the indefatigable Assistant Secretary of THSL, have ignored or underplayed how he shaped and gave direction to horticulture as a scientific subject.[34] In 1855 Lindley wrote:

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[30] J. B. Lawes, 'Report upon some experiments undertaken at the suggestion of Professor Lindley to ascertain the comparative evaporating properties of evergreen and deciduous trees', *Journal of The Horticultural Society of London* (1851), VI, pp. 227-242.

[31] 'Scientific Committee', *The Gardeners' Chronicle And Agricultural Gazette For 1868* (1868), 1, (10), pp. 235-236.

[32] J. B. Lawes, J. H. Gilbert and M. T. Masters, 'Agricultural, Botanical, and Chemical Results of Experiments on the Mixed Herbage of Permanent Meadow, Conducted for more than Twenty Years in Succession on the same Land', *Philosophical Transactions of the Royal Society of London* (1882), B, 173, pp. 1181-1413. Topics included the antagonism of plants towards other species, the internal structure and function of leaves and the microscopic examination of roots to determine structure and function.

[33] J. Lindley a), *An Outline of the First Principles of Horticulture*, London: Longman, Reeve, Brown, Green and Longman, 1832, p. 7.

[34] Fletcher, op. cit. (15); Elliot, op. cit. (15); W. T. Stern (ed.), *John Lindley 1799-1865: Gardener, Botanist and Pioneer Orchidologist*, Woodbridge: Antique Collectors' Club, 1999; R. Drayton, 'Lindley, John (1799-1865)', *Oxford Dictionary of National Biography, Volume 31*, Oxford: Oxford University Press, 2004, pp. 824-826. In D. R. Hershey, 'John Lindley (1799-1865)', *HortScience* (1992), 27, (9), pp. 960-961, a brief statement is made that *An Outline of the First Principles of Horticulture* was an important book.

> Indeed the enormous difference that exists between the skill of the present race of gardeners and their predecessors can only be ascribed to the general diffusion, that has taken place, of an acquaintance with some of the simpler facts in vegetable physiology[35]

This was a justifiable reference to his books on horticulture and science and his training of students. Lindley was an important, innovative contributor to the process that he described and strove to show plant physiology was the core of scientific horticulture. Through books, talks and lectures, he made public his beliefs that horticulture was composed of two branches, art and science, that the science branch, 'explains the reasons upon which practice is founded' and that its major component was plant physiology.[36]

In his *Vegetable Physiology* (1827) the beginnings of this emphasis can be detected and in *An Outline of the First Principles of Horticulture* (1832) he covered plant anatomy and physiology and attempted to reference horticultural tasks to their underlying 'fundamental principles'.[37] His *Theory of Horticulture* (1840) contained coverage of his 'horticultural physiology' and the illustrated extended second edition (1855) provided, 'the physiological principles upon which the operations of horticulture essentially depend'.[38] With positions at THSL and University College, Lindley used the Society's Chiswick garden to help convey his physiological approach to the students at both institutions, who were examined in various aspects of plant physiology, and to the Fellows of the

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None of these essayists have drawn attention to the contribution of Lindley in helping to establish the subject matter of scientific horticulture.

[35] J. Lindley b), *The Theory and Practice of Horticulture*, London: Longman, Brown, Green and Longman, 1855, p. 133.

[36] Lindley b), op. cit. (35), p.1.

[37] J. Lindley c), *Vegetable Physiology*, London: Society for the Diffusion of Useful Knowledge, 1827; Lindley a), op. cit. (32). Lindley believed agriculture was a branch of horticulture, see p. 11. He edited the comprehensive *Gardener's Chronicle* (1841) and made it a record of <u>all</u> matters that had a bearing on horticulture.

[38] Lindley b), op. cit. (35), p. xiv.

Society.[39] Lindley's academic position as Professor of Botany at University College London and the investigations he undertook in this role helped associate horticulture with the science of plant physiology and demonstrated that scientific investigations in horticulture were careful, rigorous, systematic and dependable.

2.1.4.3 M. T. Masters

Maxwell. T. Masters did not confine his researches just to issues of physiology. He carried out morphological investigations, classified flora from Africa and India for the Royal Botanic Gardens Kew (RBGK) and examined the effect of manures on different types of plants. In addition, Masters edited the *Gardeners' Chronicle*, became Secretary of THSL, wrote books and articles and gave lectures about his investigations and used these positions to publicise his research.

He wrote about abnormalities in plants, contrasting normal and abnormal functions and drew attention to the purpose of monstrosity in flowers. Although Masters took a morphological approach, aspects of physiology were discussed.[40] His investigations of the structure and function of membranes and hairs in the flowers of certain insect eating plants, a topic attracting little attention, provided explanations for their existence.[41]

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[39] Fletcher, op. cit. (15), pp. 88, p. 128, p. 153.
[40] M. T. Masters, *Vegetable Teratology, An Account of the Principal Deviations from the Usual Construction of Plants*, London: The Ray Society, 1868.
[41] B. D. J, No title given for the obituary notice of M. T. Masters, *Proceedings of the Linnean Society of London* (1907-1908), 120, (1), pp. 54-56; W. Botting Hemsley, 'Botanical works of the late Dr. Masters', *Gardeners' Chronicle* (1907), 41, (Series 3), pp. 376-377, pp. 418-419.

2.1.5 Classification, Nomenclature and Cultivation: Botanic Gardens, Private Collectors, Nurserymen and Seedsmen

Botanic gardens in the UK, the Empire and other parts of the world served as repositories for plants and created networks of scientists, private collectors and transport officials and a flow of plants and technical information.[42] A number of nurserymen exploiting fads, aesthetic tastes, the search for novelty and the desire for prestige of private collectors composed of the aristocracy, the medical profession, industrialists, merchants and others, built up collections of choice and rare specimens for sale and sponsored plant collecting.

2.1.5.1 Botanic Gardens

Botanic gardens contributed to scientific horticulture by classifying and naming new plant imports and the taxonomic science carried out in these gardens promised horticulturalists an ordered and systematised plant world. Additionally, plants new to science created challenges that led to investigations involving the management of pests, diseases, nutrition, temperature, moisture and light and helped build up knowledge of scientific aspects of plant cultivation.[43]

A number of botanic gardens went through various difficult periods during the nineteenth century but many of these survived and the work of their staff added to horticultural knowledge. For example, the RBGK in the late 1830s was near closure but the efforts of Lindley, the Sixth Duke of Bedford and associates

[42] Major botanic gardens included those at Oxford (1621), Edinburgh (1670), Kew (1759), Cambridge (1762), Glasgow (1817) and Birmingham (1832) and in the colonies at Cape Town (1652), Calcutta (1787), Ceylon (1810) and Singapore (1822).
[43] A. W. Hill, 'The History of Botanic Gardens', *Annals of the Missouri Botanical Garden* (1915), 2, 1/20, pp. 185-240.

enabled it to survive. Under its Director, Sir Joseph Hooker, facilities were extended and plant-hunting expeditions were financed that added more specimens and reinforced the need for accurate classification.[44] The botanic garden at Edinburgh in 1820 was in a dilapidated state but a new Keeper expanded the site from 5 acres in 1820 to 68 acres by the late 1830s. In 1834 government funds led to the creation of a new tropical palm house to accommodate the increasing flow of plant imports and served as a plant laboratory.[45]

2.1.5.2 Private Collectors, Nurserymen and Seedsmen

The gardens of wealthy private plant collectors, particularly those from the aristocracy, functioned as small-scale botanic gardens. Skilful head gardeners supervised the care of imported plants and developed methods to ensure they flourished, heated glasshouses were devoted to particular varieties, arboretums of choice shrubs and trees were constructed and special borders were devoted to unusual and choice perennials. The Marquis of Blandford at Whiteknights Park, Reading, went bankrupt trying to accumulate exotic collections.[46] The Sixth Duke of Bedford at Woburn Abbey, Bedfordshire, was an extravagant patron of the science of horticulture and his scientifically minded head gardeners wrote books on the tender and hardy collections at the Abbey,

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[44] J. Endersby, *Joseph Hooker and the Practices of Victorian Science*, Chicago: University of Chicago Press, 2008, pp. 150-151, pp. 184-185.

[45] J. A. Rutter, 'Three hundred years of botany in Edinburgh', *Nature* (1970), 226, (5249), pp. 904-907.

[46] Anon (2003) George Spencer Churchill, Duke of Marlborough (1766-1840) [Online] David Nash Ford's Berkshire History. Available: www.berkshirehistory.com/bios/gschurchill_5dofm.html [Accessed 16 August 2015].

designed for libraries and like-minded collectors.[47] Cumulatively, such activity created ideas and knowledge that was circulated by books, journal articles, the horticultural press, lectures, shows, exhibitions and fairs.

Nurserymen catered for the demands of the richer classes and built up collections of exotics, imported from many countries, that were placed in heated greenhouses and looked after carefully by experienced employees. Some funded plant-hunting expeditions, bearing in mind the tastes of their wealthier customers. Seed firms bred new varieties of flowers and vegetables for domestic gardeners and set up facilities to improve seed purity. A number conducted experiments on fertilisers and used gases and chemicals to try and stimulate seed and plant growth. Both nurserymen and seedsmen fed the demand for the improved, the new, the interesting and the unusual.

Summary

A body of scientific horticultural knowledge was built up between 1800-1885 by those involved in horticultural activities utilising the findings of botanists, particularly taxonomists and physiologists, chemists, meteorologists, those carrying out investigations on soils and fertilisers, scientists conducting experiments in agriculture and investigations of enterprising nurserymen and seed houses. The growth of the horticultural press and the writings of horticultural commentators, such as the influential John Claudius Loudon, ensured this knowledge was placed in the public domain. Loudon in his *An Encyclopaedia of Gardening* (1822) devoted a substantial section to ‘Gardening considered as a science’ and in 1850 the term ‘horticultural science’ was

[47] The Sixth Duke published books on heaths, willows, pines, camellias and before he died had commissioned a volume on cacti.

used.[48]

By the late 1860s THSL Committee members believed scientific horticulture was influencing other sciences as horticultural experimental work, particularly that carried out by the Society, had made available a body of, ‘trustworthy’ scientific evidence’. M.T. Masters cited Darwin’s *Origin of Species* to show the reliance of science on horticulture and, pressing his case a little too strongly, argued that there was, ‘scarcely a page that does not abound in references to the practices and discoveries of horticulturalists’.[49]

Botanic gardens, private collectors and enterprising nurserymen and seed houses contributed to the science of horticulture by building up collections of plants that required naming, classifying and precision cultivation, experimenting with growth stimulants and raising new varieties of culinary and ornamental plants. John Lindley, M. T. Masters and others promoted the adoption of plant physiology investigations when teaching students of horticulture and lecturing members of institutions and societies and staff at agricultural institutions used chemistry and botany to underpin their horticultural research work.

Nearly all horticultural science was funded privately. After 1870 there was growing criticism from the commercial sector, educators and scientists that horticulture needed more guidance from science and assistance from a government that possessed the resources to ensure horticultural research and education was carried out effectively and on a large scale.

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[48] Editors, Encyclopaedia Britannica (No date) John Claudius Loudon: Scottish landscape architect [Online] Encyclopaedia Britannica. Available: www.britannica.com/biography/John-Claudius-Loudon [Accessed 16 August 2015]. Loudon’s *An Encyclopaedia of Gardening*, London, op. cit. (2) and his *Gardener’s Magazine* (1826-1843) were extremely informative and gave a wide range of information.

[49] Maxwell T. Masters, ’The Royal Horticultural Society’, *Journal of the Royal Horticultural Society* (1887), 37, (947), pp. 176-177. The role of Darwin as horticultural scientist has not been explored fully.

2.2 Horticultural Science, 1885-1910: The Role of the Government

The previous section showed how knowledge from different areas of scientific investigation contributed to the subject matter of horticulture. For example, THSL promoted investigations in plant physiology and in 1841 conducted 'some experiments in Horticultural Chemistry', a Chemical Committee was set up and in 1842 Edward Solly was appointed chemist to the society.[50] After 1880, as Elliot has remarked, the focus on plant physiology began to wane. The Society gave more attention to taxonomy, nomenclature, the provision of advice and horticultural education and organised regular conferences on different aspects of horticulture that brought together growers, affluent home gardeners and scientists.[51]

In the late nineteenth century the state became further involved with horticultural science. Besides funding premier botanic gardens, it set up Royal Commissions and enquiries to examine agriculture as an industry and agricultural and horticultural education and passed legislation that led to the establishment of horticultural courses and experimental work.

2.2.1 Enquiries and Legislation, 1885-1910

Up to 1890 there was some state provision for formal agricultural education but I have not found any for horticultural education. Several Royal Commissions, established in the last quarter of the nineteenth century, reported on various

[50] Fletcher, op. cit. (15), p. 157. Solly carried out experiments on the constituents of plants, soil exhaustion and seed steeping.

[51] After 1880 the Society inaugurated annual conferences on a wide range of topics and reported work in plant physiology rather than initiate its own experiments. The *Journal* between 1880-1905 reflected this development.

aspects of agriculture including the provision of agricultural education. The report about the fruit industry of England (1905), requested by BAF, addressed horticultural education and the Reay Report (1908) examined agricultural and horticultural education in England and Wales. Legislation passed between 1889-1891 resulted in the liberation of funds to assist the creation of institutions, and the support of those already in existence, to provide horticultural and agricultural education and conduct research.

2.2.1.1 Enquiries

Agricultural depression in the last quarter of the nineteenth century concerned successive governments and a response were the Royal Commissions of Agriculture set up in 1879, 1881, 1887 and 1893. The 1887 Commission criticised existing state provision of agricultural education, arguing that education was thinly spread and did not take account of the needs of workers.[52] Volume 2 of the 1884 Royal Commission on Technical Instruction examined agricultural education and although its suggestions were not considered practicable, they signaled the increasing interest of the state in agricultural education and an interest in horticultural education. The National Campaign for the Promotion of Technical Education worked vigorously to get the government to take responsibility for technical education. Founded in 1886 by A. H. D. Acland, it was made up of a disparate group of academics and politicians with a range of economic, political and social agendas. In 1889 and 1891 the Technical Instruction Acts were passed to promote technical education for a

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[52] P. Cheesbrough, 'A Short History of Agricultural Education up to 1939', *The Vocational Aspect* (1966), XVIII, (41), pp. 181-200.

range of subjects that included agriculture, but not horticulture.[53]

The 1905 *Report* investigating the nation's fruit industry examined horticultural science, highlighted the need for horticultural education and pointed out a lack of scientific knowledge amongst growers: 'ignorance appears to exist as to the proper treatment of trees'. It recommended the teaching of horticulture in elementary schools, the establishment of colleges in major fruit growing districts, the foundation of an experimental fruit farm for demonstrating up-to-date scientific methods and the creation by the Board of Agriculture and Fisheries of a sub-department of horticulture composed of scientific experts.[54] Witnesses influential in education, science and commercial horticulture were interviewed. It was very likely to have been taken into consideration by the government and A. D. Hall, the architect of the state system of horticultural, agricultural and fishery research and education funded by the Development Commission (DC), as almost all of its proposals were adopted after 1910.

The compilers of the 1908 Reay Report argued government funding for horticultural and agricultural education was 'wholly inadequate' and believed the adoption of scientific methods, supported by government investment, would expand home food production, increase employment and create in England and Wales, 'a system of scientific and practical education equal or superior to other countries'. The main recommendations were the promotion of research into local growing conditions, the investigation of grading and packing of produce,

[53] M. Sanderson (1993) Education and the economy, 1870-1939 [Online] ReFRESH 17. Available: www.ehs.org.uk/dotAsset/aac1283a-ce2e-441c-8a00-6637f39c334c.pdf [Accessed 3 September 2015]. One activist was Sydney Webb who became an influential member of the Development Commission. Acland assisted Webb and Lloyd George in DC work.

[54] Board of Agriculture and Fisheries, *Report of the Departmental Committee appointed by the Board of Agriculture and Fisheries to Inquire and Report upon the Fruit Industry of Great Britain*, *with Copy of the Minute appointing the Committee*, London: HMSO, 1905, pp. 8-12, RAIL 1124/158, NA.

the expansion of farm institutes, winter schools and demonstration plots to cater for agricultural and horticultural trainees, the establishment of a London institute for horticultural research and training, the provision of horticultural courses for secondary school teachers, the introduction of postgraduate research scholarships in horticulture and agriculture and the placing of the administration of horticultural research and education with the BAF.[55] This *Report*, like the 1905 *Report*, provided central government and A. D. Hall with ideas to assist the formulation of a national system of research and education.

2.2.1.2 Legislation

The Department of Science and Art (1853) developed a network of Science Schools after 1858 that by 1872 offered 21 subjects, including mathematics and physical and biological sciences. Functioning on the principle of payment by results, evening classes were held in existing schools throughout England, examinations were offered and scholarships were awarded.[56] Technical instruction in agriculture was given and poultry production and bee keeping were constituents of the syllabus.[57] Provision for horticultural crop growing was not made and those wanting to specialise in this subject could gain scientific

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[55] Board of Agriculture and Fisheries, *Report of the Departmental Committee appointed by the Board of Agriculture and Fisheries to Enquire into and Report upon the subject of Agricultural Education in England and Wales*, London: HMSO, 1908, p. 8, pp. 27-38, ED 24/170b, NA.

[56] P. S. Uzzell, 'The Science and Art Department and the teaching of Chemistry', *The Vocational Aspect of Education* (1977), XXIX, (74), pp. 127-132.

[57] H. Clements, *The Fields of Great Britain*, London: Crosby Lockwood and Son, 1890. This textbook of agriculture covered the syllabus of the Science and Art Department; *South Kensington Progressive Questions in Elementary and Advanced Principles of Agriculture Classified from the Examination Papers containing all the Questions set by the Science And Art Department from 1876-1889, Arranged By John Pilley*, London: G. Gill and Son, 1889, p. 4.

knowledge by attending a related science or agricultural course.[58] Specific national provision of horticultural education by the state developed in a systematic way only after 1890.[59]

Four distinct pieces of legislation were instrumental in the creation of state supported horticultural and agricultural science research and education after 1890. The first was the establishment of county councils, by the Local Government Act of 1888. They became key providers of this type of education and scientific investigation during the 1890s and after 1910 played an important role in the scientific system of the DC.[60]

Secondly, in 1889 responsibility for agriculture was taken from the Land Commissioners, the Board of Trade and the Privy Council and vested in the Board of Agriculture. The Board was made responsible for addressing animal and plant diseases, producing statistics and promoting education and research in agriculture and forestry.[61] It contributed markedly to horticultural education and research after 1900, particularly when it worked in conjunction with the DC.

Thirdly, the Technical Instruction Acts of 1889 and 1891 allowed county councils, borough councils and urban district councils to help with or create technical and manual instruction for agriculture and horticulture, tailor provision

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[58] *Department of Science and Art of the Committee of Council on Education. Directory with Regulations for Establishing and Conducting Science and Art Schools and Classes*, London: HMSO, 1899. There were no exam questions for horticulture; See the *Report of the Science and Art Department of the Committee of Council on Education and Art Department, with appendices*, London, HMSO for 1875, 1888 and 1893. Exam questions did not include horticulture.

[59] Botanic gardens such as Kew and Edinburgh, which were aided by the government, did provide instruction in the sciences that underpinned horticulture for trainees, although the extent of provision could depend on the involvement of the Director or Keeper. See H. R. Fletcher and W. H. Brown, *The Royal Botanic Garden Edinburgh 1670-1970*, Edinburgh: HMSO, 1970, p. 216.

[60] Cheesbrough, op. cit. (52), p. 190.

[61] Sir J. Winnifrith, *The Ministry of Agriculture, Fisheries and Food*, London: George Allen and Unwin Limited, 1962, pp. 23-24.

to local needs, levy a rate not exceeding 1d in the £1 to pay the costs, set up scholarships, assist fee payments and, if necessary, support institutions outside agreed administrative areas.[62]

Fourthly, the Local Taxation (Custom and Excise) Bill of 1890 led to the availability of income for technical education. By 1890 only one county council had made provision and it was the fortuitous release of funds, given the appellation 'whisky money', which stimulated county councils into action. The Act was intended to increase duties on the import and manufacture of spirits, as the government wanted to reduce alcohol sales. An additional liquor tax was going to compensate publicans because the Bill was accompanied by a plan to reduce their number by not extending all licenses. Revenue was collected but the Bill for compensation was dropped and A. H. D. Acland proposed that it should be used to either support technical education or reduce rates. The Chancellor of the Exchequer G. J. Goschen, in a surprising move, earmarked it for technical education.[63]

In 1900 nearly £1 million was allocated to local authorities for technical instruction from this source, although distribution was not based on educational need. The funds assisted young teenagers and those attending colleges, universities and teacher training institutes to pursue a large range of technical subjects that included horticulture and agriculture.[64] Section 2.2.2 outlines the creation and work of some of these institutions.

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[62] D. J. Culley, *''Whiskey Money". The Implementation of the Technical Instruction Acts of 1889 and 1891 in North Surrey*, Ilfracombe: Arthur H. Stockwell Limited, 1965, unnumbered pages.

[63] P. R. Sharp, 'The Entry Of County Councils Into English Educational Administration, 1889', *Journal of Educational and Administration History* (1968), 1, (1), pp. 14-22.

[64] Sharp, op. cit. (63), pp. 20-22; Ministry of Agriculture and Fisheries, *Report of the Committee on Post-War Agricultural Education in England and Wales*, London: HMSO, 1943, p. 11.

2.2.2 The Establishment of Educational and Research Institutions and Examples of their Work

Local authorities, using the ‘whisky money’, gave grants to the following and other institutions: University of Cambridge (1209), University College of Wales, Aberystwyth (1872), University College, Nottingham (1877), Durham College of Science (1883), University College of North Wales, Bangor (1884), Yorkshire College of Science (1891), Essex Institute of Agriculture, Chelmsford (1892), University College, Reading (1892), Lancashire College of Agriculture (1892), Uckfield Agricultural and Horticultural College (1894), South Eastern Agricultural College (1894), Holmes Chapel College of Agriculture (1895) and Harper Adams Agricultural College (1901). By 1899 four state funded farm institutes had been established in England to provide formal horticultural and agricultural instruction, demonstrate best practice and illustrate current horticultural and agricultural investigations.[65]

Some of these institutions provided teachers with horticultural and agricultural training and offered students certificates and diplomas in horticulture and agriculture. A number carried out experiments and provided advice. For example, Essex Institute of Agriculture was originally a farm institute but developed a much wider brief enabling it to acquire 3 chemistry and 3 biology laboratories, a demonstration room, a dark room, a museum, a reference library, a reading room, displays of experiments and a 3-acre garden with glasshouses and botanical plots. Its staff gave instruction to commercial growers as well as its horticultural students, carried out trials and experiments

[65] *Report of the Committee*, 1943, op. cit. (64), p. 12. The Institutes were at Chelmsford in Essex, Old Basing, Hampshire, Hutton in Lancashire and Newton Rigg, Cumbria.

on manures and crops and gave advice on pests and diseases.[66] The Principal of South-Eastern Agricultural College (SEAC), A. D. Hall, inaugurated experiments that were of relevance to horticulture and agriculture. Careful investigations were undertaken on 119 insects pests of fruit, flowers, vegetables, hops and trees and their treatment and on manures and soils. The College established a national reputation and also functioned as a horticultural and agricultural advisory centre, giving information to commercial growers and the government.[67]

2.2.3 Alfred Daniel Hall

A. D. Hall (1864-1942), a scientist trained at Oxford University in natural sciences (chemistry) with left wing beliefs and Principal of SEAC, Director of Rothamsted (1903), a Commissioner of the Development Commission (1910), Chief Scientific Adviser to the Ministry of Agriculture and Fisheries (1919) and Director of the John Innes Horticultural Institution (1926), worked consistently to ensure that horticulture and agriculture developed on scientific principles and promoted ‘fundamental’ research.

A keen naturalist and horticulturalist as a schoolboy, he joined local naturalist and gardening groups and developed an interest in fruit, flowers and vegetables and as an adult wrote scientific books on the soil (1903), fertilisers and manures (1909), the science of the nutrition of plants and animals (1911),

[66] ‘The County Technical Laboratories, Chelmsford’, *Nature* (1903), 69, (1777), pp. 66-67; J. Bryce, *A Short History of the Essex Institute of Agriculture*, Writtle: Essex Institute of Agriculture, 1953, pp. 3-6.

[67] R. N, ‘Agricultural and horticultural research’, *Nature* (1908), 77, (1998), pp. 345-346.

tulips (1929) and apples (1933).[68] The view of the civil servant H. E. Dale, who worked closely with Hall, that he, 'was more of a gardener than a naturalist and … more of a gardener than a farmer' and that his, 'approach to farming was through gardening' seems an accurate judgment.[69]

After graduation Hall spent five years as a schoolteacher before joining the New University Extension Courses and was sent by the University Extension Board to be an itinerant lecturer for Kent, Surrey and Sussex in chemistry applied to agriculture.

Here, he developed good relationships with commercial growers and this skill was utilised at SEAC and Rothamsted. At both institutions he built up teams of qualified scientists, which was in opposition to the existing practice of allowing specialists in agriculture and horticulture to develop some scientific knowledge, and broadened the approach to problems by including in the team soil scientists, botanists, mycologists, entomologists and bacteriologists.[70]

His wide experience convinced him lectures on their own were not an effective way to persuade commercial growers of the importance of science and believed organised, systematic courses were more ideal and teamwork in research was more productive than having isolated departments. His belief in the importance of education never left him. He became Principal of Lord Wandsworth College in Hampshire at the age of 75, which helps explain why education played a significant role in the system of science and education he designed for the government in 1910 as a key member of the DC.

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[68] E. J. Russell b), 'Alfred Daniel Hall. 1864-1942', *Obituary Notices of Fellows of the Royal Society* (1942), 4, (11), pp. 228-250.

[69] H. E. Dale, *Daniel Hall, Pioneer in Scientific Agriculture*, London: John Murray, 1956, p. 197.

[70] Russell b), op. cit. (68); P. Brassley, 'Hall, Sir Alfred Daniel (1864-1942), *Oxford Dictionary of National Biography*, Oxford: Oxford University Press, 2004, pp. 602-603.

Summary

After 1880 a series of state initiated enquiries and investigations was the prelude to its involvement in the provision of technical education in agriculture and horticulture and in associated experiments and enquiries that were necessary to enhance courses. A key factor leading to the further government involvement was the fortuitous availability of funds arising out of the government's efforts to control the number of licensed premises.

Up until the 1890s, when the influence of 'whisky' money began to have an impact, institutions that were run privately played an important role as providers of horticultural and agricultural research and education. For example, the Royal Agricultural Society, the Royal Society of Arts, Manufacturers and Commerce, the Royal Horticultural Society, Rothamsted, Aspatria College, Cumberland (1874), Downton College, Wiltshire (1880) and the Countess of Warwick's collegiate centre (1898) in Reading supported investigations and the colleges provided instruction in agriculture and horticulture.[71] Some seed firms and plant nurseries, with the necessary capital, also contributed to horticultural science by carrying out investigations in seed testing, the efficacy of manures and growth stimulants, the production of new varieties and cultivation techniques.

Although the funds given by the Chancellor of the Exchequer did not have to be used for technical education, most local authorities did cooperate with central government in a responsible and committed fashion. It marked a more protracted relationship between central and local government over the promotion of horticultural and agricultural teaching and experimentation, though

[71] Russell a), op. cit. (22), pp. 186-187. Downton College was formed by John Wrightson, a Professor at the RAC who took several staff with him in a sort of breakaway movement. Little is known about other private college providers.

not always a cordial one.

Despite the state's intervention, it was not yet committed wholly to the support of these subjects. When Hall became Director of Rothamsted he found some of the facilities, 'more like a museum than a laboratory'. On asking BAF for funds for facilities and equipment to conduct high quality research, he was informed it was his responsibility to raise the necessary finance.[72]

When setting up a national system of horticultural, agricultural and fishery education and research for Lloyd George, Chancellor of the Exchequer and later Prime Minister, Hall made use of some of the ideas that had developed after 1890 about horticultural education and research and some of the systems that were already in place.

2.3 Conclusion

Between 1800-1885 scientific investigations in horticulture were conducted or encouraged by a range of private institutions and societies and this work helped shape scientific horticulture. In particular, several committee members of THSL were associating scientific horticulture with research in plant physiology. An important and growing strand of scientific horticulture was plant classification and nomenclature, in part a response to the large number of plants imported from Empire countries.

A characteristic of scientific horticulture in the nineteenth century was that it used methods, ideas and research findings from a range of other scientific areas, such as climatology, botany, chemistry, mathematics, natural history, geology and agriculture in order to better understand plant behaviour and these

[72] Russell a), op. cit. (22), p. 233.

approaches helped to give the subject rigour. By the late nineteenth century horticulture had also become associated with apiary and poultry rearing. After 1900 this link strengthened when BAF and others reinforced this association, as Chapter 3 will illustrate.[73]

The state became increasingly involved in the provision of horticultural education and the conduct of horticultural research after 1885 and allocated funds on a regular basis for these purposes. Some of this provision was administered by the newly created BAF. One example of the influence of government patronage was the closure of the privately funded Downton College in 1904, as it could no longer compete with state supported Institutions that offered similar courses.[74]

Efforts to improve the academic standing of agriculture in the late nineteenth century met with opposition, as scientists in established disciplines saw it as a practical subject. Horticulture faced similar difficulties but it also had a battle with agriculture for independence. As the economic importance of horticulture increased, growers and scientists involved with horticulture argued that it was a completely distinct activity from agriculture, needing special support and encouragement from the state. This was one of the main arguments used in the *Report* of the investigation into the countries fruit industry.[75]

Many, though, continued to see horticulture as a component of agriculture. Reay and his co-authors wrote of, 'agriculture in all of its branches including forestry, gardening, fruit growing, poultry and bee keeping'.[76] The battle was long term. Horticultural science gained academic status more quickly than it

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[73] It was as though commentators were not sure initially how to categorise these activities. They were placed with horticulture as bees pollinated crops and chickens ate crop pests.

[74] J. R. A.-D, 'Prof. John Wrightson', *Nature* (1916), 98, (2459), p. 294.

[75] *Report of the Departmental Committee*, 1905, op. cit. (54), p. 12.

[76] *Report of the Departmental Committee*, 1908, op. cit. (55), p. 4.

achieved its independence from agriculture. The enquiry into post-war agricultural education in 1943 stated unequivocally, ‘agriculture includes horticulture’ and horticulture, ‘has always been treated as falling within the scope of agriculture’.[77]

[77] *Report of the Committee*, 1943, op. cit. (64), p. 6.

Chapter 3

The State and Horticultural Science: The Government Research Stations, 1910-1930

This chapter examines the growth and impact of government funded horticultural science research stations, a feature of horticultural history in the period 1910-1930 and refers briefly to the development of agricultural research stations. Wilmot has suggested that agricultural science in the early twentieth century began to influence productivity increasingly. I extend this idea to early twentieth century horticultural production and show that between 1910-1930 the practices of some commercial growers and domestic gardeners were influenced notably by horticultural science principles and methods developed at government funded research stations.[1]

Historians of science in the UK who have written about plant science aspects of agriculture have examined mostly the field of genetics, leaving virtually unexplored other important aspects of plant science history.[2] Hadfield and Ottewill, historians of horticulture, have provided valuable insights into the

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[1] S. Wilmot, *The Business of Improvement: Agriculture and Scientific Culture in Britain, c.1770-c.1870*, Bristol: Institute of Historical Geographers, Historical Geography Research Group, 1990, p. 12, p. 19, p. 28, p. 80. In the nineteenth century commercial horticulturalists may have been better positioned to utilise aspects of science than agricultural producers, in part because of the nature of the crops grown and the methods of cultivation required, although further research is needed in order to confirm such a comparison.

[2] R. Olby a), 'William Bateson's Introduction of Mendelism to England: A Reassessment', *British Journal of the History of Science* (1987), 20, (4), pp. 399-420; P. Palladino a), 'The Political Economy of Applied Research: Plant Breeding in Great Britain, 1910-1940', *Minerva* (1990), 28, (4), pp. 446-468; P. Palladino b), 'Between Craft and Science: Plant Breeding, Mendelian Genetics, and British Universities, 1910-1920', *Technology and Culture* (1993), 34, (2), pp. 300-323; P. Palladino c), 'Wizards and Devotees: on the Mendelian Theory of Inheritance and the Professionalisation of Agricultural Science in Great Britain and the United States, 1880-1930', *History of*

activities of the horticultural community but have not extended their analysis to consider scientific issues and Elliot's informative survey of the scientific work of the Royal Horticultural Society, unfortunately, does not offer a comparative analysis.[3] Several historians offering a broader perspective of agricultural science have made reference to the scope and nature of the work of some of these government funded research stations and I develop their contribution by discussing the number of stations involved and the range of horticultural science investigations they carried out.[4]

I treat commercial horticulture as a working world, a concept developed by J. Agar and, as I have noted, described for agriculture but not horticulture.[5] State funded horticultural science research stations worked on the problems of

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Science (1994), 32, (3), pp. 409-441; P. Palladino d), 'Science, Technology and the Economy: Plant Breeding in Great Britain, 1920-1970', *Economic History Review* (1996), 49, (1), pp. 116-136; R. C. Olby b), 'Horticulture: The Font for the Baptism of Genetics', *Nature Reviews. Genetics* (2000), 1, pp. 65-70; B. Charnley, a) 'Experiments in Empire-building: Mendelian Genetics as a National, Imperial and Global Agricultural Enterprise' in C. MacLeod and G. Radick (eds.), *Studies in History and Philosophy of Science* (2013), Part A, 44, (2), pp. 292-300; B. Charnley and G. Radick, 'Intellectual Property, Plant Breeding and the Making of Mendelian Genetics' in C. MacLeod and G. Radick (eds.), *Studies in History and Philosophy of Science* (2013), Part A, 44, (2), pp. 222-233; D. Berry a), 'The Plant Breeding Industry after Pure Line Theory: Lessons from the National Institute of Agricultural Botany', *Studies in the History and Philosophy of Biological and Biomedical Sciences* (2014) Part C, 46, pp. 25-43.

[3] M. Hadfield, *A History of British Gardening*. London: John Murray, 1969; D. Ottewill, *The Edwardian Garden*. New Haven: Yale University Press, 1989; B. Elliot, *The Royal Horticultural Society: A History 1804-2004*, Chichester: Phillimore and Company Limited, 2004.

[4] See, for example, E. H. Whettam (ed.), *The Agrarian History of England and Wales. Volume VIII. 1914-1939*, Cambridge: Cambridge University Press, 1978, pp. 75-87, pp. 273-294; T. DeJager, 'Pure Science and Practical Interests: The Origins of the Agricultural Research Council, 1930-1937, *Minerva* (1993), 31, (2), pp. 129-150; P. Brassley, 'Agricultural Research in Britain, 1850-1914: Failure, Success and Development', *Annals of Science* (1995), 52, (5), pp. 465-480; K. Vernon, 'Science For the Farmer? Agricultural Research in England 1909-1936', *Twentieth Century British History* (1997), 8, (3), pp. 310-333; P. Brassley b), 'Agricultural Science and Education' in E. J. T. Collins and J. Thirsk (eds.), *The Agrarian History of England and Wales 1850-1914, Volume VII,* Cambridge: Cambridge University Press, 2000, pp. 594-649.

[5] J. Agar, *Science in the Twentieth Century and Beyond*, Cambridge: Polity Press, 2012, pp. 3-6, pp. 60-62.

commercial and also domestic horticulturalists, used station facilities to conduct small-scale experiments in controlled conditions, utilised current theories and later conducted larger commercial trials, often using the land of commercial producers.

These research stations ranged from extensive establishments with a large number of scientists and substantial grounds to units located within a university or college department employing several researchers. They shaped horticultural science by expanding knowledge and developing techniques and products derived from their research. Large, well-equipped and well-staffed stations were able to use their status and authority as research organisations to define and legitimise areas appropriate for research. The stations created career opportunities for scientists and enabled horticultural science to move forward from a position of low academic regard. Harwood has described elegantly the similar attempts made by agricultural scientists to overcome this 'status deficit' by making agricultural science more of an academic discipline as, 'academic drift'.[6] New ground is covered in addressing horticultural science and I offer an additional perspective to the historiography of early twentieth century plant science.

The guide and inspiration for the following sections were firstly, two articles by R. Olby drawing attention to horticultural research stations and their funding body, the Development Commission (DC). Olby's short, pioneering paper on state support for science reveals the importance of the DC but historians generally have not examined fully the extent of its promotion of science. Secondly, the chapters on American agricultural and horticultural experiment stations in C. E. Rosenberg's book on science and social thought draws

[6] J. Harwood, *Technology's Dilemma: Agricultural Colleges between Science and Practice in Germany, 1860-1934*, Bern: Peter Lang, 2005, p. 13, p. 29.

attention to the importance of government funds for research, the efforts made to ensure research met the needs of growers, the emphasis that was put, eventually, on pure research and the work of institutions to create professional career opportunities and provide evening classes, lectures and consultation visits for commercial growers. The research stations in England had a similar history. Rosenberg, by noting the importance of the work of a range of research institutions and also Olmsted and Rhodes, by emphasising the breadth of research in American agriculture in a discussion of pests and diseases, irrigation, machinery and fertilisers, have widened perspectives and drawn attention to topics other than breeding and genetics.[7]

I focus on the origin of the Development Fund (DF), the work of the DC and contemporary attitudes towards the pure and applied science carried out at the research stations. The influential A. D. Hall wanted those universities and colleges with their own research stations, or those affiliated to research stations, to conduct 'fundamental' or pure research or 'research proper' that was 'free' of obligations in order to 'acquire new knowledge' and the colleges and research stations to carry out applied research or 'investigations into a particular subject with a practical end': for Hall, the former gave direction to the latter and the latter could provide ideas for the former to pursue.[8]

The status of horticultural science, a reoccurring theme related to 'fundamental' science research, is examined. Kraft has explored the efforts of

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[7] R. Olby c), 'Scientists and Bureaucrats in the Establishment of the John Innes Horticultural Institution under William Bateson', *Annals of Science* (1989), 46, (5), pp. 497-510; R. C. Olby d), 'Social Imperialism and State Support for Agricultural Research in Edwardian Britain', *Annals of Science* (1991), 48, (6), pp. 509-526; C. E. Rosenberg, *No Other Gods. On Science and American Social Thought*, Baltimore: The John Hopkins University Press, 1997; A. L. Olmsted and P. W. Rhodes, *Creating Abundance: Biological Innovation and American Agricultural Development*, Cambridge: Cambridge University Press, 2008.

[8] A. D. Hall a), Memorandum on agricultural research, 2nd December 1910, D4/1, NA.

biologists in the early twentieth century to raise the status of their subject in the eyes of their peers by demonstrating the utility of ‘economic biology’ to important sectors of the economy such as agriculture.[9] I develop this idea and show firstly, that the scientists at the horticultural research stations made great efforts to demonstrate the utility of their research by indicating how it could help solve the problems faced by commercial and domestic growers. Secondly, the focus on pure science investigations at some of the stations helped their scientists to gain prestige and status from the academic community. These themes are continued in Chapter 4, which investigates four research stations as case studies, providing a fuller examination of the work and influence of the state’s patronage of horticultural science research.

3.1 The Development Fund and Development Commission

Chapter two outlined the pressure placed on central government by growers, organisations and various enquiries in the years between 1885-1909 to provide further support for horticultural science and horticultural science education. This support was given eventually by the new Liberal Government, which came into power in 1908 with an agenda for social reform. Under the direction of the Prime Minister H. H. Asquith and the Chancellor of the Exchequer David Lloyd George, a key player, the government set up a national system of horticultural, agricultural and fishery research stations, achieved through the introduction of the Development and Road Improvement Funds Acts of 1909 and 1910. The income source was the DF and its money came

[9] A. Kraft, ‘Pragmatism, Patronage and Politics in English Botany: The Rise and Fall of Economic Biology 1904-1920’, *Journal of the History of Biology* (2004), 37, (2), pp. 213-258.

from the Treasury who obtained its resources from the budget. Budget revenue was derived from land taxes, direct taxes, a supertax and death duties.[10]

The DC, chosen by Lloyd George, administered the scheme. It was composed of eight members to ensure horticulture, agriculture and forestry were represented and the interests of Scotland and Ireland were taken into account besides the needs of England and Wales.[11] Lloyd George believed that science could contribute to the amelioration of economic and social conditions. He had sketched a scheme to develop employment opportunities, attract labour to the land and improve community cohesion in rural areas and wanted science to play a strategic role. A. D. Hall, given the task of firming up this plan, developed a system of horticultural and agricultural research and education centered initially around 12 designated research stations in England and Wales that would assist growers to improve output and so create employment opportunities. The DC was also to encourage road building to improve the infrastructure of rural areas, but this function became overshadowed quickly as the system of research and education expanded.

There were few alternatives for the government. Growing social unrest meant some initiative was necessary. It is possible that unemployed labour could have been directed towards government funded regional schemes of employment, administered by local labour exchanges. Extended schemes of municipal relief work had been tried, however, and were found to be inadequate as it was believed they were inefficient and expensive. The introduction of

[10] R. B. McCallum, *Asquith*, London: Duckworth, 1936, pp. 64-65; B. Murray, *The People's Budget 1909/1910: Lloyd George and Liberal Politics*, Oxford: Clarendon Press, 1980, pp. 292-293.

[11] *First Report of the Proceedings of the Development Commission for the period from 12th May, 1910, to the 31st March, 1911*, pp. 3-5, D3/1, NA.

schemes of a similar nature carried the danger of stigmatizing and demoralizing participants, arousing opposition from Trades Unions and causing outbreaks of public disorder.[12] It seems the government believed job creation through the expansion of horticultural and agricultural output was a proposition less likely to arouse the criticism of organised labour.[13]

To create research stations, the Commission approached selected existing institutions that were carrying out work that was deemed relevant or appropriate by Hall and negotiated an agreement. Once this was settled, the institution was invited to make an application for a grant for resources. Applications were usually sent initially to the Board of Agriculture and Fisheries (BAF) and were then passed to the DC for approval. The Commissioners considered the application in relation to the award criteria. If institutions other than the designated research stations wanted funds for research, they applied for grants in the same way. The Commission endured until 1999 but by 1940 it had lost its role as administrator of science research and education and became an agency concerned with developing industries and community projects in rural areas.[14]

3.1.1 The Influence of Left Wing Views

Robert Olby has indicated Lloyd George's sympathy for the plight of the poor, coupled with a belief that science could be used to ameliorate their condition by increasing agricultural output, was instrumental in the introduction of the

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[12] E. P. Hennock, *The Origin of the Welfare State in England and Germany, 1850-1914: Social Policies Compared*, Cambridge: Cambridge University Press, 2007, pp. 293-302, p. 340.

[13] Horticulture was an expanding and labour intensive industry.

[14] A. Rogers, *The Most Revolutionary Measure: A History of the Rural Development Commission 1909 1999*, Salisbury: Rural Development Commission, 1999, p. 41.

Development and Road Improvement Funds Acts.[15] Webster has demonstrated how an informal group of Puritan reformers in the seventeenth century, the Invisible College, desired to improve the lot of the poorer classes by utilising Baconian science to raise agricultural productivity.[16] Both historians connect beliefs about improving the life of the poorer classes with a conviction that science could help to bring about the necessary improvements.

I build on their idea by suggesting, firstly, that in the first decade of the twentieth century an informal and diverse group made up of Liberals and socialists, and probably others, saw an urgent need to improve the condition of the working class and believed that science could help achieve this through increasing both the quantity and quality of food. Secondly, these convictions contributed, in ways that are currently difficult to quantify, to the establishment of the Liberal Government programme of horticultural and agricultural science research and education. The Government was mindful of social unrest, the extent of ill health and poverty amongst the working class and the growing problem of rural unemployment.[17] Turner has characterised these years, with a certain aptness, as an 'age of anxiety' and the rejection by the House of Lords of Lloyd George's budget in 1909 was seen by commentators at the time as the

[15] Olby b), op. cit. (2).

[16] C. Webster, *The Great Instauration. Science, Medicine and Reform 1626-1660*, London: Gerald Duckworth, 1975, pp. 469-483. Webster's radical reformers were pioneering advocates of applied science, saw agricultural improvement, including forestry, as the means to help the poorer classes, held a range of beliefs, wanted to establish colleges to provide training in agriculture and desired state involvement in agricultural development and education. Some members, on an individual basis, interacted directly with the poor. These were all characteristics of the left wing radicals involved with the work of the DC.

[17] P. Clarke, *Hope and Glory. Britain 1900-2000*, London: Penguin Books Limited, 2004, p. 69; In the minutes of the Cabinet Papers for the years leading up to 1909, pauperism and unemployment was discussed regularly.

prelude to social revolution.[18] Central government wanted the DF to create employment through the scientific development of horticulture and agriculture, afforestation and fisheries, promote smallholdings, provide educational opportunities, foster co-operative marketing and expand rural transport facilities in the expectation that labour would be attracted to the land.[19]

The debate about the motives of the Liberal Government is ongoing. Harris rightly draws attention to the idea that New Liberal economic theory offered more support to measures that would improve income levels and expand consumer demand than to schemes that artificially created work and this idea is discussed further in Chapter 8.[20]

The Chancellor of the Exchequer was given complete responsibility by the Prime Minister for the progress of the Development and Road Improvement Funds Acts and the Budget. Lloyd George was shrewd, persistent, hostile to the landed classes for their land monopoly and for living off the unearned increase in land values, sympathetic to land nationalisation and a radical Liberal with socialist ideals. In addition, his passion for the land, an aesthetic appreciation, and his belief that the countryside offered opportunities for a healthy lifestyle also influenced the decision to pilot through Parliament the Development and

[18] J. Turner, ''Experts and Interests': David Lloyd George and the Dilemmas of an Expanding State, 1906-1919' in R. MacLeod (ed.), *Government and Expertise. Specialists, Administrators and Professionals, 1860-1919*, Cambridge: Cambridge University Press, 1988, p. 203. Amongst Turner's anxieties were the growing working class electorate, a deterioration in industrial relations and a fear of economic decline.

[19] J. Harris a), *Unemployment and Politics*. *A Study of English Social Policy, 1886-1914*, Oxford: Oxford University Press, 1972, pp. 340-341; J. B. Poole and K. Andrews, *The Government of Science in Britain*, London: Weidenfield and Nicolson, 1972, pp. 10-11; Murray, op. cit. (10), pp. 147-148.

[20] J. Harris b) (2010) The Liberal Empire and British Social Policy: Citizens, Colonials, and Indigenous Peoples, circa 1880-1914 [Online], Histoire@Politique 2, (11), Available: https://www.cairn.info/revue-histoire-politique-2010-2-page-3.htm [Accessed 10 December 2015], pp. 1-14.

Road Improvement Funds Acts.[21]

He appointed to the DC several holding left wing beliefs.[22] A key appointment was the scientist Alfred Daniel Hall who resigned his post as Director of Rothamsted at Harpenden when his position as Commissioner became salaried. Hall was a life long socialist advocating strongly state ownership of land and co-operative enterprises.[23] He ensured a number of cooperative schemes were given DC funds, although generally they proved unsuccessful. Another appointee was Sydney Webb, an influential Fabian socialist supporting social reform, land nationalisation and the principle of collective ownership of the soil. Webb believed an efficient government was one that that based its enquiries on the use of scientific and mathematical methods.[24] Hall and Webb worked closely together in the DC on horticultural and agricultural matters and the Commissioners paid deference to Hall's views on these issues.[25] Lloyd George had made a special visit to Rothamsted when Hall was Director, attracted by the horticultural and agricultural scientific research that was being carried out. The Chancellor was impressed with Hall's scientific ability and judgement and the research work he saw there helped reinforce his belief in the potential of science and created ideas that led to the formation of the DF. Lloyd

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[21] C. Cross (ed.), *Life with Lloyd George. The Diary of A. J. Sylvester 1931-1945*, London: Macmillan, 1975, p. 256.

[22] T. Jones, *Lloyd George*, Oxford: Oxford University Press, 1951, p. 38; A. J. P. Taylor (ed.), *Lloyd George: Twelve Essays*, London: Hamish Hamilton, 1971, p. v; H. V. Emy, *Liberals, Radicals, and Social Politics*, Cambridge: Cambridge University Press, 1973, p. 211; G. R. Searle, *The Quest for National Efficiency: A Study in British Politics and Political Thought, 1899-1914,* Oxford: Basil Blackwell, 1971, pp. 172-180.

[23] A. D. Hall b), *Agriculture after the War*, London: John Murray, 1916, p 112, pp. 127-131; E. J. Russell a), 'Alfred Daniel Hall. 1864-1942', *Obituary Notices of Fellows of the Royal Society* (1942), 4, (11), p. 244.

[24] S. Webb*, Practicable Land Nationalisation*, London: Fabian Society, 1890; Searle, op. cit. (22), p. 63, p. 172.

[25] The Annual Reports of the Development Commission show clearly Hall's influence on matters of horticultural and agricultural science and how his views and judgements were invariably accepted. See D3/1-D3/30, NA.

George wanted Hall, 'to go and help to parcel out the straw from which others could make the bricks' and clearly Hall was chosen to play a key, formative role as a Commissioner.[26] This high regard can be seen in the efforts Lloyd George made to secure a knighthood for Hall in 1918.

William Haldane was another Commissioner with socialist views and he supported Hall and, like Webb, had developed plans for social reform.[27] E. J. Russell, who became Director of Rothamsted Agricultural and Horticultural Research Station after Hall, was also a socialist and was appointed originally by Hall – they became close friends. Russell when he was a student at the City of London College, had studied political economy under Sydney Webb.[28] Rothamsted, a major, if not the most important, research station at the time, received generous funds and much support from the DC and had a significant impact on horticultural science. Russell wanted to set up a land co-operative for the destitute in order to give them some control over their destiny, wrote several tracts on poverty and in 1893 when at Manchester University worked amongst the poor of the city.[29] It is likely that Lloyd George, and possibly Russell, had read the book *Progress and Poverty* (1879) by the American economist Henry George containing criticisms of the land rents obtained by landowners and proposing a tax on land. An important essay by Harris argues convincingly that models for social reform offered by Europe, particularly Germany, and the Empire, exemplars of urban improvement given by garden cities in Belgium and the belief that a strong navy safeguarded the Empire and free trade and led to

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[26] Sir John Russell b), *The Contribution of Sir A. Daniel Hall to the Development of Agricultural Science*, Wye: Wye College, 1954, p. 13. This can be found in HERT 11/8/247, MERL.
[27] Harris a), op. cit. (19), p. 267.
[28] Sir E. J. Russell c), *'The way in which I have come'*, p. 4, HERT 11/8/21, MERL.
[29] Russell c), op. cit. (27), pp. 5-9; Sir E. J. Russell d), *'Life in a Manchester slum*', HERT 11/7/4 and HERT 11/7/5, MERL.

the creation of jobs and the provision of food for the British population, influenced the nature of the social and economic reforms introduced by the Liberal government and its advisors.[30]

Lloyd George and Asquith were interested in science. Asquith was a Fellow of the Royal Society and Lloyd George was a Vice President of the British Science Guild and helped ensure Russell was knighted in 1922. Hall, Russell and Webb were members of the Science Guild.[31] The Guild wanted to encourage the public to appreciate the role and value of science and lobbied for a closer union between government and science.[32] Lloyd George, Webb, Haldane and Hall saw science as a means of raising the output of horticultural and agricultural produce so that the working class could be provided with cheap, wholesome food; a provision they regarded as an essential right.

The diversity of the group is illustrated by the following. Lloyd George wanted landowners to pay for this ownership, Hall and Webb believed in state control of horticulture and agriculture with Webb confident that science could increase government efficiency and Hall who was convinced that Britain could and should be self- sufficient in food along with Russell had genuine sympathy for the conditions of the poor. They influenced in different ways and in varying degrees the nature and direction of horticultural science. It is likely that when the various beliefs of these social actors overlapped, as they did when the

[30] Harris b), op. cit. (20).

[31] The Annual Reports of the Guild indicate the various roles played by these members, from committee activist to ordinary member; Letter from the British Science Guild to Fletcher at the Medical Research Council, 26th April, 1919, FD 1/4764, NA. Lloyd George was also a member of a small committee that examined ways in which the government could give more assistance to scientific and industrial research. This led to the creation of the Department for Scientific and Industrial Research. See E. Ashby and M. Anderson, *Portrait of Haldane at Work on Education*, London: The Macmillan Press, 1974, p. 119.

[32] Searle, op. cit. (22), pp. 83-84; R. MacLeod, 'Science for imperial efficiency and social change: reflections on the British Science Guild, 1905-1936', *Public Understanding of Science* (1994), 3, (2), pp. 155-158.

potential of the land to provide food and employment was discussed, commitment, support and collegiality was boosted. Collectively, they could be viewed as a forerunner of Werskey's 'visible college', a group of scientists and socialists in the 1930s who wanted greater state and private investment in science in order to progress horticulture, agriculture, other industries, medicine and the military.[33]

3.1.2 Creating the State System of Pure and Applied Science

The government's support of both horticultural and agricultural science was demonstrated by the commitment of £2,500,000 for the first five years of the whole scheme. A. D. Hall along with other leading scientists, such as E. J. Russell, Rowland Biffen Professor at Cambridge University School of Agriculture, V. H. Blackman Professor of Botany at Imperial College and W. Hardy Director of the Cambridge University Low Temperature Research Station, believed in the importance of pure science research and acknowledged the benefits of applied science. For these scientists, pure science underpinned applied science. The system developed by Hall, as I have stressed, was based on his belief about the significance of 'fundamental' science and of the utility of applied science or 'economic research' and these attitudes are now examined more fully.

Vernon has noted that Hall became involved in a dispute with T. H. Middleton, Assistant Secretary of the Board of Agriculture and Fisheries, over the best way to set up the state programme of research in horticultural and agricultural

[33] G. Werskey, *The Visible College. A Collective Biography of British Scientists and Socialists of the 1930's*, London: Free Association Books, 1988, pp. 28-39.

science and I build on these initial observations.[34] Bud, Gooday, Lucier and Kline have shown how the meaning of the terms pure science and applied science for scientists and technologists changed frequently between 1840-1930 and indicate how definitions were manipulated in order to assist a range of motives and personal ambitions.[35] Kline, writing about physicists and engineers in the United States, suggests that a significant reason for the blurred boundaries between these terms were anxieties about the status of these subjects and makes a plea to extend investigation into other areas such as biological and agricultural science.[36] This section is such an extension, though a brief one. For Lucier, these terms represent a tension between the search for knowledge and the quest for profit.[37] The status anxieties of Kline and the tensions indicated by Lucier are considered in this sub-section and in Chapter 4.

In the acrimonious disagreement with T. H. Middleton, the arguments for Hall revolved around the issues of designing a system that would attract scientists to conduct pure research and providing an environment that would allow this research to be sustained.[38] In Hall's plan, government funds were for the creation of designated research stations that needed to be well equipped to support high-level research. He argued there was a chronic shortage of suitable, university-trained scientists and so the stations had to act as a magnet

[34] Vernon, op. cit. (3).
[35] R. Kline, 'Construing "Technology" as "Applied Science": Public Rhetoric of Scientists and Engineers in the United States, 1880-1945', *Isis*, (1995), 86, (2), pp. 196-221; R. Bud, 'Introduction', *Isis* (2012), 103, (3), p. 515; R. Bud, ''Applied Science': A Phrase in Search of a Meaning', *Isis* (2012), 103, (3), pp. 537-545; G. Gooday, ''Vague and Artificial': The Historically Elusive Distinction between Pure and Applied Science', *Isis* (2012), 103, (3), pp. 546-554; P. Lucier, 'The Origins of Pure and Applied Science in Gilded Age America', *Isis* (2012), 103, (3), pp. 527-536.
[36] Kline, op. cit. (35), p. 221.
[37] Lucier, op. cit. (35), p. 536.
[38] Hall a), op. cit. (8); T. H. Middleton, Statement, 30th December, 1914, MAF 33/72, NA.

to attract these scarce resources. Hall believed that scientists educated at university in the pure sciences would be able to pick up knowledge of horticulture and agriculture as they progressed in their work. Middleton disagreed completely and proposed that existing educational institutions could initially function as temporary research stations. Here, scientists could be given a thorough training in horticulture, agriculture and research methods so that they became competent researchers and if they did not have an aptitude for research, the training provided would enable them to become teachers instead.[39] Hall made the point that good selectors would be able to spot potential and so the right person would be chosen. He believed young researchers in pure science were a temperamental, anarchical and argumentative group who would flourish best and be most productive in a research station environment where the cut and thrust of argument and the taking of contradictory views would not be frowned upon. It was because of these reasons that Hall did not want research to be controlled and conducted by a government department, such as the BAF.[40] This was the sub-text for the dispute.

Hall defined three levels of research: ‘free’ or ‘fundamental’ research to produce new knowledge that might or might not have later practical benefits, research into a particular subject with practical outcomes, and research which demonstrated known principles applied to local circumstances and conditions.[41] He acknowledged that in this hierarchical system all three were important and

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[39] Middleton op. cit. (38).

[40] Hall a), op. cit. (8); A. D. Hall c) ‘The Administrative Problem’, *Annals of Applied Biology* (1920), 6, (4), pp. 317-321; A. D. Hall d), ‘The Present Position of Research in Agriculture’, *Journal of the Royal Society of Arts* (1921), 69, (3567), pp. 300-312. Hall used the history of science to justify his beliefs and argued that out of apparently unpromising research there sometimes arose important discoveries.

[41] Hall a), op. cit. (8).

that it was difficult to distinguish always between them, as differences were more in the method of carrying out the work and in the longevity of the investigations. An essential element of ‘free’ research and one not addressed by historians commenting on this system of research, was that researchers were not expected to produce results of economic value, as Hall believed this had a negative impact on research ideas and undermined morale.[42] Hall was resolute about the need to regard ‘fundamental’ science as central because in his system it was the force that drove the other components. The findings of pure research were to be taken up by university and college staff and used to direct their experiments and feed into their teaching. In turn farm institutes, also part of Hall’s system and providing lower level courses and demonstration plots, used these findings to illustrate their application to local conditions.

For Middleton, what was at stake was the marginalisation of the BAF by the DC. It is likely that Middleton saw an opportunity for the Board to play a significant role in directing a national system of horticultural and agricultural research. For Hall it was the credibility of the groundbreaking system that he had created and his status as government expert in horticultural and agricultural science. If the BAF had been successful in winning the argument and gaining control of the situation, a different research and education structure would have developed.

3.1.3 The Influence and Work of A. D. Hall

A. D. Hall drew on his experiences as a schoolmaster, a Surrey County Council itinerant lecturer in agriculture, Principal of South Eastern Agricultural College, Wye and Director of Rothamsted Research Station to develop the state

[42] Hall, (b), op. cit. (23).

system of horticultural and agricultural education and research and to guide his judgements when he was a leading member of the DC.[43] The research stations in horticulture and agriculture were established partly on a geographical basis to ensure the network covered, and could serve, all parts of England, Wales and Scotland. Another consideration was to establish a relevant station in a region that specialised in the production of a particular crop, such as fruit or vegetables. A third factor was the presence of a university or college that could function as a research station and already had, ideally, relevant research experience which was judged by referral to academic publications.[44] Originally, Hall chose twelve institutions in England and Wales for research in horticulture and agriculture and envisaged setting up a station in Scotland.[45] Hall's final plan was logical but was one of best fit, and was amended as the system evolved. Hall had investigated the research stations in Europe and America and was convinced that some features of the United States system should not be emulated. He rejected the idea of establishing one organisation to conduct all research, preferring to have investigations spread over a number independent institutions to give researchers more freedom and control and did not want research to be dictated by monetary considerations.[46]

The understanding that pure research did not have to produce results of economic value was innovative as it gave researchers greater freedom than their counterparts in the USA and protected them from the pressure of being

[43] Russell b), op. cit. (26), pp. 228-250; Anon, *Agriculture in the Twentieth Century: Essays on Research, Practice and Organization to be Presented to Sir Daniel Hall*, Oxford: Oxford University Press, 1939, p. v.
[44] Hall a), op. cit. (8); *Second Report of the Development Commissioners being the report for the year ended the 31st March 1912*, London: HMSO, 1912, p. 7, D3/2, NA.
[45] *Third Report of the Development of the Development Commissioners, being the report for the year ended the 31st March 1913*, London: HMSO, 1913, pp. 13-14, D3/3, NA.
[46] Hall a), op. cit. (8); Hall (c), op. cit. (40).

subject to state bureaucratic performance criteria. However, the system did produce different tensions and some of these are discussed in Chapter 4. In the 1920s professional pressures, and to a degree friendly rivalry, all helped generate the appearance regularly of academic papers from research stations. Hall's work as an educator helps explain why educational provision was an essential element of the research system he had created. Hall wanted to convey the results of pure and applied research to growers in order that higher yields of food of improved quality could be achieved. His plan located advisory officers at universities and colleges so that they could utilise the most up-to-date findings from the researchers working there. This also ensured that researchers were kept in regular contact with the practical problems of growers - Hall believed this was crucial as it stimulated research creativity. The knowledge gained by advisory officers was to be made use of when handling enquiries from market gardeners and farmers and when making advisory visits. In the counties, posts for horticultural and agricultural advisers were created and the government provided subsidies to encourage authorities to promote their establishment. Many of these personnel were based at farm institutes and they too addressed enquiries and helped organise applied science experiments and demonstrations.[47]

Hall and the other Commissioners could not direct research stations to begin particular experiments and investigations. To encourage researchers to apply for grants they provided advice about how to submit an application and sent grant criteria to institutions and local authorities for distribution. The

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[47] *Tenth Report of the Development Commissioners for the year ended the 31st March, 1920, with a review of the work of the Commissioners during the past ten years,* p. 27, p. 98, p. 105, D3/10, NA; *Report of the work of the Intelligence Department of the Ministry of Agriculture for the two years 1919-1921*, London: HMSO, 1922, p.12, pp. 118-125.

Commissioners awarded capital grants for land, buildings and equipment in order that a station could be set up. A condition was institutions had to find an equal sum from other sources. Maintenance grants were given, mainly for staffing costs, also on a matched basis. Hall's introduction of special research grants for topics that were not covered in the original scheme widened the range of investigation and the submission and selection process gave the DC more direct control over the type of research that they wanted to support.

To encourage science graduates to choose a career in horticultural science, Hall set up a postgraduate scholarship scheme whereby students with high marks in pure science degrees were offered scholarships at a research institute. Three years training was given, the last year being spent in another country learning from a scholar with a reputation in a particular field of horticultural or agricultural science. Employment was not guaranteed at the end of the training and there was no obligation for the postgraduate to apply for a job at the home station. Hall believed this would help provide researchers, 'who were capable of advancing the industry'. The system of references from colleagues with similar vested interests in the life sciences, and the interview process enabled Hall and other Commissioners to manage what they believed were important areas for investigation and training. Hall also encouraged some research stations to offer support and training for a London University PhD, thus creating an additional incentive for graduates. By establishing a formal career progression route in horticultural science, Hall helped raise the academic profile and status of the subject. Between 1911-1925, 97 postgraduate studentships were awarded and excluding those who died or could not be traced, approximately 41% gained employment in research institutes or the advisory service in the UK, 18% took up jobs in the horticultural and agricultural service in the colonies and dominions, 16% became teachers of horticulture or agriculture in the UK and 11% went into commercial horticulture. Hall felt this record justified fully the scheme he initiated.[48]

Summary

The new Liberal government of 1908, led by H. H. Asquith, introduced as part of their programme of social and economic reform an innovative system of horticultural and agricultural research with the aim of improving food supplies, creating employment in rural areas and stemming the migration of rural population into the towns. The Development and Road Funds Improvement Acts of 1909 and 1910 allowed the creation of horticultural and agricultural research stations and extension to the provision of science-based horticultural and agricultural education. These Acts established the DF, which financed the scheme, and the DC who were the administrators. The government's commitment to horticultural science research at the research stations was a significant step in enhancing the status of the subject.

Several politicians and scientists, holding a range of left-wing beliefs and collectively making up a loose informal group, influenced the development of this system of research and education. Most notable were David Lloyd George who, as Chancellor of the Exchequer, piloted through Parliament the Acts that allowed the creation of this system and the scientist A. D. Hall who, as a member of the DC, was the system's main architect. Lloyd George created vague statements of intent and the Acts lacked specific details and Hall made them reality with a logical and detailed strategic plan.

[48] A. D. Hall e), 'The Research Scholarship Scheme', *Journal of the Ministry of Agriculture* (1930), XXXVII, 3, pp. 213-218.

During the planning stages an acrimonious dispute developed between Hall and Middleton of the BAF, over the procedure for obtaining and training the necessary scientists and about the means of establishing the stations. This dispute provided a context for contemporaries to rehearse their beliefs about education and the value of and relationship between pure and applied science. It was a matter of emphasis and in some ways the final system was a compromise, although weighted heavily towards the beliefs of Hall. The stations were chosen and allocated using a method that took into account regional crop specialisms, the major geographical areas and the existence of centres where research of a related nature was being carried out.

Because the DC could not initiate experiments or hire and train scientists it used as incentives research grants, special project grants and postgraduate scholarships that contributed to status enhancement. The range of investigations that took place as a result of these strategies is examined in the following section.

3.2. The 'research factories'

In the 1920s Lord Bledisloe, trained agriculturalist, Conservative politician and Parliamentary Secretary to the Ministry of Agriculture and Fisheries, referred with a degree of accuracy to the state run horticultural and agricultural research stations as, 'research factories'.[49] A relatively large number of horticultural and agricultural stations were established between 1910-1930, most patronised by the state but some funded privately, creating a complex system.

Vernon's comment that the research stations generated much new knowledge

[49] Hall d), op. cit. (40) p. 306.

is perceptive and informative and later I use a number of examples to illustrate the accuracy of this observation.[50] His view that the science produced did not have any real impact on producers and his claim that Hall and Russell were unclear on the value of this science to farmer presents a number of difficulties. Vernon supports his views by referring to the passing on by Rothamsted Research Station of its soil inoculation technique to a consortium of market gardeners, to translate into a useable form, and to the handing over of a method of composting to the commercial sector. I take a different view and claim the horticultural science knowledge that was produced did have an impact on growers and domestic gardeners. Hall and Russell were very clear about the utility of research station findings and the hierarchical system of education developed by Hall was designed to convey the results of the stations to the farmer, commercial horticultural grower, allotment holder and home gardener. Rothamsted was not abrogating its responsibility to growers by passing on some of its research findings; there were reasons for this based on scientific rationale. For example, the consortium of market gardeners, as Chapter 4 shows, on Russell's advice founded a new glasshouse research station so that their needs could be more fully addressed and Rothamsted acted as a long term consultant and monitored very carefully the research that was conducted. To indicate the scope of the research and some of its utility, the next section provides a general survey of state and privately funded research stations.

3.2.1 Research Stations, 1880-1930: A General Survey

The fifty-year period 1880-1930 has been chosen in order to illustrate the

[50] Vernon, op. cit. (4).

marked expansion in the number of research stations that occurred between 1910 and 1930. It is not possible to provide a final figure of the total number of state and privately funded stations in horticulture, agriculture and fisheries in this period. Not all of those privately funded were documented and some state and privately financed stations had sub-stations, not always traceable. On occasions, research stations gave material to commercial growers and private individuals for investigation and documents illustrating this outsourcing have not always survived. For these reasons the list is not definitive.

The system for forestry research was structured differently as Hall wanted to establish training schools for forestry before setting up research stations. If there was a pressing need for fundamental forestry research it was sub-contracted to the universities of Oxford and Cambridge on a temporary basis.[51] A School of Forestry was set up in the Forest of Dean in 1915 and its school, laboratory and demonstration area functioned for several years as a sort of unofficial research station, of limited scope.[52] An important influence on forestry policy was the Development Commissioner for forestry, Sir Sainthill Eardley-Wilmot. Between 1903-1909 he had been Inspector General of Forests in India and in 1906 became Principal of the renowned Dehra Dun Forestry School that provided scientific and practical training to suit the needs of the different grades of forester. At Dehra Dun he established a Forest Research Institute and introduced six research posts in order to form a strong unit of scientific forestry.[53] Eardley-Wilmot, extremely critical of European forestry management systems, supported the view that European trainees could benefit

[51] Report from H. E. Dale, Secretary to the Development Commission, 13th October, 1911, MAF 33/476, NA.
[52] *Fourth Report of the Development Commissioners, being the report for the year ended 31st March 1914*, London: HMSO, 1914, p. 33, D3/4, NA.
[53] Anon, *100 Years of Indian Forestry 1861-1961*, Dehra Dun: Forestry Research Institute, 1961, p. 154, p. 160.

by studying the system that had been developed in India.[54] Some of the features of forestry management system fostered by the DC are identical to those developed by Eardley-Wilmot in India. These included the use of systematic surveys based on statistical criteria, the formation of research teams with qualifications in a range of science and science related disciplines, teaching syllabus based on science and the use of trial and demonstration areas. These centres have not formed part of my list, although they are a reminder that the official stations were not the only institutions conducting research on behalf of the government and form a sub-set of their own. They also are an example of how knowledge was transferred from the Empire to the mother country.

The information in 'Table 3.1: UK Research Stations in horticulture and agriculture and fisheries founded between 1880-1909' and 'Table 3.2: UK Research Stations in horticulture, agriculture and fisheries founded between 1909-1930' show a significant number of stations and I have placed them in one of four categories to indicate the focus of their work: horticultural research stations (H), agricultural research stations (A), stations were research was relevant to both horticulture and agriculture (HA/AH) and fishery research stations (F). At the time, as indicated in Chapter 2, the government regarded poultry keeping and apiary as horticultural activities.

Between 1880-1930, approximately 72 research stations were founded.

[54] Sainthill Eardley-Wilmot, 'Indian State Forestry', *Journal of the Royal Society of Arts* (1910), 58, (2993), pp. 493-508; G. A. Barton*, Empire Forestry and the Origins of Environmentalism*, Cambridge: Cambridge University Press, 2006, p. 72.

Table 3.1: UK research stations in horticulture, agriculture and fisheries founded between 1880-1909

NAME	TYPE	FUNDS	YEAR	LOCATION	SPECIALISM
Coopers Hill Forestry School	A/H	P	1885	Cooper's Hill Surrey	Forestry
Marine Biological Laboratory	F	P & S	1888	Plymouth Devon	Fish
Central Veterinary Laboratory	A	S	1894	Whitehall London	Cattle
Woburn Experimental Fruit Farm	H	P Later S	1894	Ridgmont Bedfordshire	Fruit & some vegetables
Barley Research Station	A	P	1895	Warminster Wiltshire	Cereals
Cockle Park Experimental Station	H/A	P Later S	1896	Morpeth Northumberland	Vegetables, fruit, trees, fertilisers, pasture & cattle
Irish Government Seed Testing Station	A/H	S	1902	Dublin Leinster	Seeds for agriculture & horticulture
Wisley Research Station	H	P Later S	1905	Wisley Surrey	Fruit & vegetables
Burbage Research Station	H	P Later S	1908	Burbage Leicestershire	Plant & animal breeding
Norfolk Agricultural Station	A/H	P Later S	1908	Little Snoring Norfolk	Cereals, animals, vegetables & poultry
Cooper's Research Laboratory	H/A	P	1909	Berkamstead Hertfordshire	Pests and diseases of plants & animals
'The Times' Experimental Station	H	P	1909	Sutton Green Surrey	Horticultural crops

<u>Key</u>: Year = Date when Founded; H = Horticulture; A = Agriculture; HA = Horticulture and Agriculture; AH = Agriculture and Horticulture; F = Fisheries; P = Privately Funded; S = Received Funds from the State

Table 3.2: UK research stations in horticulture, agriculture and fisheries founded between 1910-1930

NAME	TYPE	FUNDS	YEAR	LOCATION	SPECIALISM
John Innes Horticultural Institution	H	P Later S	1910	Merton South London	Flowers, fruit trees, vegetables and poultry
Institute for Animal Nutrition	A	S	1911	Cambridge University	Cattle
Scottish Seed Testing Station	A/H	S	1912	Edinburgh Lothian	Farm & garden seeds
Dairy Research Institute	A	S	1912	Shinfield Berkshire	Dairy cattle
Plant Breeding Institute	A/H	S	1912	Cambridge University	Cereals
Long Ashton Research Station	H	S	1912	Long Ashton Somerset	Fruit & vegetables
Scottish Bee Research Station	H	S	1912	Aberdeen University	Bee disease
Institute of Plant Physiology	H	S	1913	Imperial College	Plant physiology & electric stimulation
Research Institute in Agricultural Zoology	A	S	1913	Birmingham University	Animal & plant nematodes
Agricultural Economics Research Institute	A/H	S	1913	Oxford University	Economics applied to agriculture & horticulture
Cheshunt Experimental Station	H	S	1914	Cheshunt Hertfordshire	Glasshouse crops
Institute of Plant Pathology	H/A	S	1914	Kew Surrey	Plant pests & diseases
Food Science Laboratory	H/A	S	1914	Norwich Norfolk	Storage of foodstuffs
Institute of Pathology and Epizoology	A	S	1917	New Haw, Weybridge Surrey	Animal pathology
Official Seed Testing Station	A/H	S	1917	Whitehall London	Agricultural & horticultural seeds
Fruit and Vegetable Preservation Station	H	S	1918	Chipping Campden Gloucestershire	
Bee Research Station	H	S	1919	Cambridge University	Bee culture

Bee Research Station	H	S	1919	Oxford University	Bee disease
Kirton Experimental Station	H	S	1919	Kirton-in-Lindsey, Lincolnshire	Vegetables
Welsh Plant Breeding Station	A	S	1919	Aberystwyth Cardiganshire	Grasses & cereals
National Institute of Agricultural Botany	A/H	S	1919	Cambridge University	Agricultural & horticultural seeds
The Rowett Institute for Animal Nutrition	A	S	1920	Aberdeen University	Cattle
Imperial Bureau of Mycology	A/H	S	1920	Kew Surrey	Plant diseases
Scottish Plant Breeding Station	A/H	S	1920	Corstorphine Lothian	Cereals & vegetables
Molteno Institute	A	S	1921	Cambridge University	Animal diseases
Olympia Research Station	A/H	P	1921	Offchurch Warwickshire	Cattle food, plant breeding & fertiliser testing
Dove Marine Laboratory	F	S	1921	Cullercoats Northumberland	Fish
Port Erin Biological Station	F	S	1921	Port Erin Isle of Man	Fish
Lowestoft Research Station	F	S	1921	Lowestoft Suffolk	Fish
Low Temperature Research Station	H/A	S	1922	Cambridge University	Fruit & vegetables
Horticultural Research Station	H	S	1922	Cambridge University	Vegetables & fruit
Willow Research Station	A/H	S	1922	Long Ashton Somerset	Willows
Silver Leaf Investigating Station	H	S	1923	Cambridge University	Fruit tree disease
Botley Fruit & Horticultural Station	H	S	1923	Botley Hampshire	Fruit & vegetables
Scilly Isles Bulb Experimental Station	H	P Later S	1923	St Mary's Isles of Scilly	Bulbs
Institute of Agricultural Helminthology	A/H	S	1923	School of Tropical Medicine London	Nematodes
Potterne Biological Station	H/A	P	1924	Potterne Wiltshire	Cereals
Cottenham Packing Station	H	S	1924	Cottenham Cambridgeshire	Fruit & vegetable packing

Imperial Forest Institute	A/H	S	1924	Oxford University	Forests
Cereals Research Station	A	P	1924	St Albans Hertfordshire	Cereals
Northern Poultry Breeding Experimental Station	H	S	1924	Reaseheath Cheshire	Poultry
Southern Table Poultry Experimental Station	H	S	1924	Wye Kent	Poultry
Institute of Agricultural Engineering	A/H	S	1924	University of Oxford	Agricultural & horticultural machinery
Pirbright Experimental Station	A	S	1924	Pirbright Surrey	Foot & mouth disease of cattle
Research Institute in Animal Pathology	A	S	1924	Camden London	Cattle
Ellbridge Horticultural Experimental Station	H	S	1924	Ellbridge Cornwall	Vegetables, fruit & flowers
National Poultry Institute for Education and Research	H	S	1925	Newport Shropshire	Poultry
Poultry Nutrition Research Station	H	S	c1925	Cambridge University	Poultry
Poultry Breeding Research Station	H	S	c1925	Cambridge University	Poultry
Poultry Disease Research Station	H	S	c1926	Weybridge Surrey	Poultry
Dartington Hall Laboratory	H/A	P	1926	Totnes Devon	Soils, fertilisers & cattle
Potato Virus Research Station	A/H	S	1926	Cambridge University	Potatoes
Agricultural Research Institute Northern Ireland	A/H	S	1927	Hillsborough County Down	Livestock and crops
Forests Products Research Laboratory	A/H	S	1927	Princes Risborough Oxfordshire	Timber
Hannah Dairy Institute	A	S	1928	Kirkhill Ayrshire	Dairy
Jealott's Hill Research Station	A/H	P	1928	Jealott's Hill Berkshire	Agricultural and horticultural crops
Torry Research Station	F	S	1929	Aberdeen Aberdeenshire	Fish

St Ives Research Station	H	P	1929	Bingley West Yorkshire	Lawns
Macaulay Soil Institute	A/H	S	1930	Craigbuckler Aberdeenshire	Soil
Ditton Laboratory	H	S	1930	East Malling Kent	Fruit and vegetable storage

Key: Year = Date when Founded; H = Horticulture; A = Agriculture; HA = Horticulture and Agriculture; AH = Agriculture and Horticulture; F = Fisheries; P = Privately Funded; S = Received Funds from the State

Table 3.3: Increase in staff numbers in the period 1910-1930 at ten research stations undertaking, cumulatively, a range of horticultural science experiments

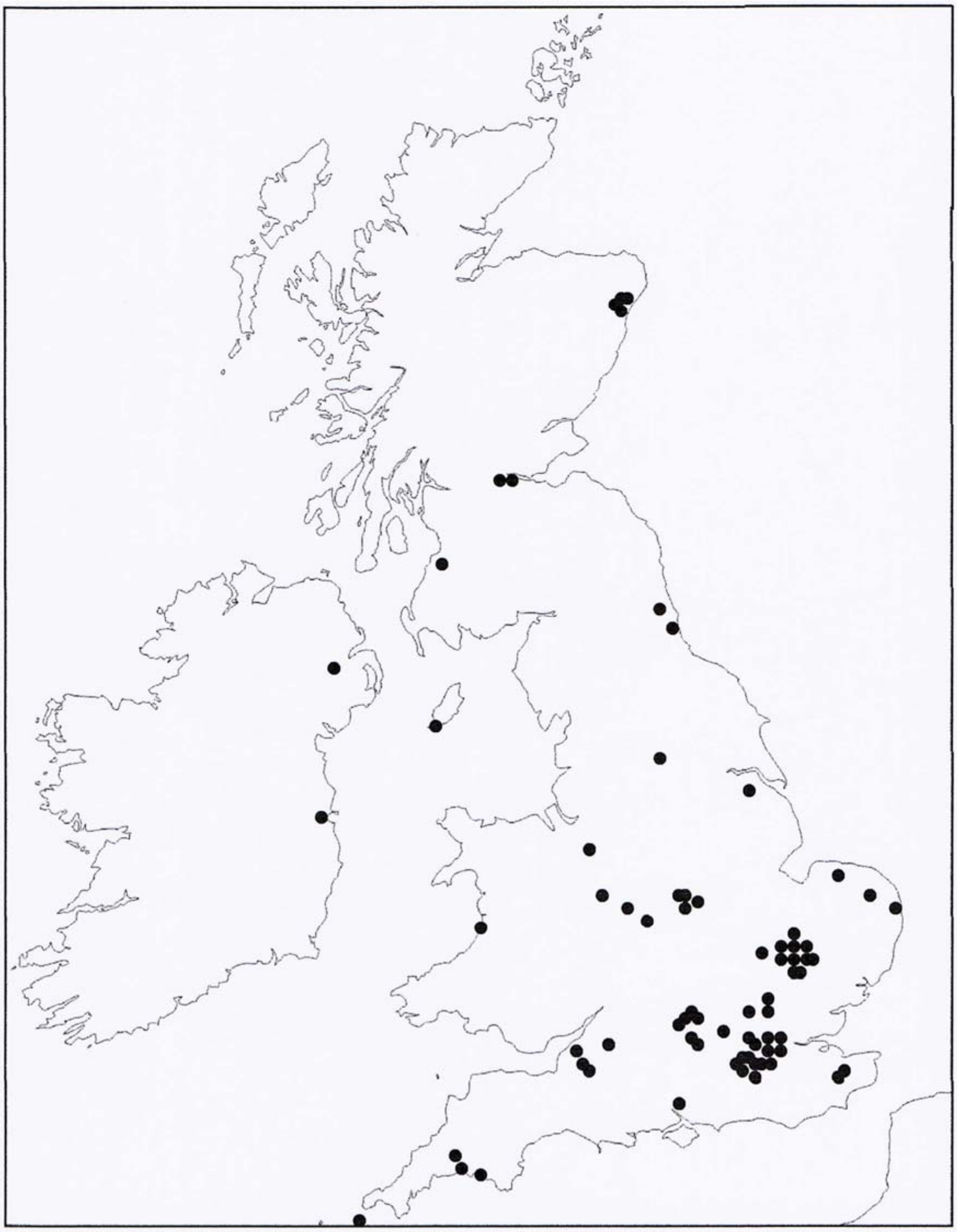
Research Institute	**Year and Staff**		**Year and Staff**		**Percentage Increase**
Rothamsted	1910	17	1930	171	906%
Long Ashton	1913	7	1930	42	500%
East Malling	1924	16	1931	40	250%
Chipping Campden	1918	2*	1930	7	250%
National Poultry Institute	1925	4	1930	13	225%
Scottish Bee	1912	1	1922	3	200%
John Innes+	1911	8	1930	18	125%
LTRS	1922	8	1930	16*	100%
NIAB	1919	6	1930	10	67%
Cheshunt	1916	12	1930	19	58%

*** = estimate, + = excludes gardeners and volunteer scientists**

Rothamsted Experimental Station was already in existence.[55] There were 18 stations funded privately and 1 of these was given state support from the beginning and 7 were later awarded government grants. Some 62 received

[55] Rothamsted was a private institution founded in 1843 and received substantial state funds after 1910. The following sources were extremely useful when compiling the table: Sir E. John Russell e), A History of Agricultural Science in Great Britain 1620-1954, London: George Allen and Unwin Limited, 1966; G. W. Cooke (ed.), *Agricultural Research 1931-1981. A History of the Agricultural Research Council and a Review of Developments in Agricultural Science During the Last Fifty Years*, London: Agricultural Research Council, 1981; C. de Silva (2012) *A Short History of Agricultural Education and Research* [Online] Newport, Harper Adams University College. Available: www.harper-adams.ac.uk/staff/profiles/files/…Ag-Education-History.pdf [Accessed 10 February 2015].

Figure 3.1: Distribution in the UK of state and privately funded horticultural, agricultural and fishery research stations founded between 1880-1930*



***Excludes Rothamsted (founded before 1880)**

state financial support at their foundation or during their growth. Figure 3.1 indicates the geographical distribution of the research stations founded between 1880-1930. Most of the stations were located in the Midlands and the southern areas of the country, possibly illustrating the influence of favourable soil and climate. There was a noticeable cluster around both London and Cambridge, most likely reflecting the importance and influence of scientific networks.

In the period 1910-1930, 60 research stations were founded (Rothamsted is excluded), the greatest number occurring between 1920 and 1930 and 54 received government funds, 53 from the DC and 1 from the Department of Scientific and Industrial Research and 6 were entirely self-financing. There were 4 stations conducting fishery research, 22 stations dedicated wholly to horticultural enquiry, 11 focusing on agricultural matters and 23 stations carrying out research that had relevance for the working worlds of horticulture and agriculture, for example, pests and diseases, soil, manures, fertilisers and machinery, and this versatility is shown in the table by the use of two letters, the first letter in the paring indicating the major emphasis of the work of the station. Of these, 17 had an agricultural bias and 6 had a horticultural emphasis. The largest share of the funds went to Rothamsted (not included in these figures), the Low Temperature Research Station and the National Institute of Agricultural Botany as their work was perceived by the DC, with A. D. Hall having a major influence, to be of great importance both to the nation and to science.

Clearly, a great deal of state sponsored horticultural science research was taking place that makes it important to differentiate between horticultural and agricultural research activities to better appreciate developments in early twentieth century plant science. Although the researchers responded similarly to events and circumstances, they were not always affected in the same way by common social, economic, political and scientific influences. The commercial horticulturalists and the scientists endeavouring to support them and farmers and the scientists helping them did not always share the same experiences or agendas.

Tables 3.1 and 3.2 show how private and state funds supported scientific research in horticulture, agriculture and fisheries. As a result of this commitment, as Harwood has observed, a wide range of experiments were initiated.[56] The examples of the investigations in horticultural science that follow, along with the more detailed study of the work of four state funded research stations, serve to illustrate and give substance to Harwood's observation. Genetic science for a number of contemporaries was an important area for investigation and several of the research stations endeavoured to produce improved varieties of fruit, vegetables and flowers using Mendelian principles. Success, though, was limited as few serviceable varieties were produced and it was not until well after the Second World War that new knowledge, particularly in cytology, helped shape developments in plant breeding.[57]

Much effort was expended on investigating ways to raise crop yields. Consequently, much attention was given in the period 1910-1930 to controlling or eradicating diseases and insect pests because of the loss of income they caused growers. Besides efforts to improve the efficacy of washes and sprays, emphasis was placed on examining the life cycles of pests and diseases and developing associated biological controls. A search was made to find effective growth stimulants and investigations were carried out using electrical currents and radioactive ores. In glasshouses carbon dioxide, temperature and light

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[56] J. Harwood, *Commentary on the Session 'Experiments in Twentieth-Century Agricultural Science'*, The British Society for the History of Science Annual Conference, University of St Andrews, 3-6 July 2014.

[57] B. Charnley b), *Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930*, University of Leeds, PhD thesis, 2011, p. 3, p. 257; D. Berry b), *Genetics, Statistics, and Regulation at the National Institute of Agricultural Botany, 1919-1969*, University of Leeds, PhD thesis, 2014, pp. 13-14, pp. 243-247.

levels were manipulated. Research was conducted into the action of fertilisers and into substances that had fertilising qualities. The soil was an area of much scientific interest and surveys of the soils of crop growing regions were undertaken and attention was given to the soil's microorganisms, its weed seeds, its structure and its receptivity to mechanical means of cultivation. Methods used to store crops after harvest to minimise spoilage and to manage seasonal gluts were inadequate and resulted in cold storage and modified atmosphere research. A research station was set up to examine ways of preserving fruit and vegetables by dehydration, canning, pickling, bottling and jamming: in part a response to the wastage that occurred during times of glut. Experiments were made on different rootstocks in order to control fruit tree size. Attention was given to the development of scientific methods for lawn maintenance and forest and woodland management. Research stations were set up to investigate the cause of the Isle of Wight bee disease, the structure of hives and the management of colonies. Stations were established to investigate the best diet for poultry destined either for the table or egg production and to find methods to control diseases. Research was conducted on the toxic properties of roots, the origins of colour in flowers and the factors that determined the time it took for a crop to produce a harvest. The influences determining seed germination and growth were examined and various methods of irrigating glasshouse soil were trialled. All of these examples illustrate the diversity of the horticultural science research topics investigated at the stations. In 'Table 3.3: Increase in staff numbers in the period 1910-1930 at ten research stations undertaking, cumulatively, a range of horticultural science experiments' the figures used are those currently available and in some cases are approximations. All of these stations received government funds at some stage in their development and increased their staff in this period. Stations underwent significant expansion because, generally, government grants were always renewed. Rothamsted had the greatest number of staff in 1930; it received comparatively generous government funding. This expansion created employment opportunities and enabled their support of the working world of horticulture to continue and develop.

Summary

Between 1880-1930, approximately 72 research stations were established for horticulture, agriculture and fisheries. The total up to 1909 was 12 and between 1910-1930 it was 60. Acceleration in growth began after 1902 and between 1910-1930 the pace was substantial. In this latter period, of the total number of stations 37% were dedicated to horticulture, 18% were entirely agricultural, 7% specialised in fishery research and 38% of the stations conducted research that could be utilised by horticultural and agricultural sectors. State funding was received by 90% of the stations which is an indicator of the commitment of the government to this type of research and to the importance it placed on the horticultural and agricultural industries. A little over half of the stations were located in an area stretching from the Midlands to the southern regions, possibly a reflection of climate, soil and the influence of the science networks in and around London and Cambridge.

A striking feature is the diversity of the research investigations, although detailed knowledge of the work of many individual stations is not known. The system of forestry research, probably based on the model used in India, was planned differently in that training provision was given priority rather than the establishment of research stations. Some institutes carried out the role of a research station but were not officially designated as such. Several research stations received disproportionately large grants and it is suggested that one reason for this was the influence and opinions about research of the DC Commissioner A. D. Hall.

3.3 Conclusion

I have shown the government funded a relatively large number of research stations between 1910-1930 covering a diverse range of topics, in order to support the working worlds of horticulture, agriculture and fisheries. The definitive number is not known yet and there is little published information detailing the work of many of the stations. There are gaps in our understanding of the circumstances and events that led the Liberal government to support and fund horticultural and agricultural science. Few political historians of Edwardian society have addressed the issue of science or provided a detailed study of the various interest groups that wanted greater government involvement in scientific affairs, particularly horticultural and agricultural research. I have identified one group of left wing politicians and scientists who believed the land could improve the lot of the poorer classes by offering employment opportunities and increased supplies of cheap, quality food – provided the correct system of administration and support was in place. Harris is right to state that further exploration is needed of the attitude of Liberal politicians and reformers towards the New Liberal theory of Empire, innovative economic and social developments in Europe and the introduction of economic and social reform in

Britain. I suggest this analysis is extended to include an investigation of the attitudes of both Liberal politicians and scientists supporting horticultural research towards the work in scientific horticulture that was taking place in Europe, the United States and the colonies and dominions.[58]

The emphasis on ‘fundamental’ science research work at the research stations resulted in additions to scientific knowledge and this and the applied science research assisted those in commercial horticulture, agriculture and fishing. Many of the horticultural researchers published the results of their investigations regularly in academic journals. They shared ideas with other institutions, met at conferences and meetings organized by the DC and the BAF and welcomed post-graduates and researchers from other countries. These activities addressed ‘status deficit’. As Chapter 6 outlines, several universities and colleges introduced degrees and post-graduate qualifications in horticulture and colleges, farm institutes and the Royal Horticultural Society established certificate and diploma courses for commercial growers. By 1930 horticultural science had undergone significant transformation.

[58] Harris b), op. cit. (20).

Chapter 4

Research Stations: Four Case Studies

Chapter 3 provided a general survey of research stations. In this chapter the investigation of the range of experiments that were conducted is extended to provide a more focussed discussion of the influence of the horticultural science investigations conducted at state funded research stations. I examine the activities of four stations: Cheshunt Experimental and Research Station (CERS), East Malling Research Station (EMRS), Rothamsted Experimental Station (Rothamsted) and the Low Temperature Research Station (LTRS).
All of these stations were regarded by contemporaries as important research institutes. CERS was the only station founded to assist the glasshouse industry, a growth sector. EMRS very recently became part of the National Institute of Agricultural Botany and was one of two stations dedicated to the science of fruit growing and built up an international reputation for research. Rothamsted is regarded as an agricultural research station but its role in shaping horticultural science, both as a research centre and as a consultant to other research stations, is little known and I offer new material about this work. The science to do with the care of crops prior to harvest and their journey from harvest to consumers has received scant attention from historians of science. The post-harvest work of the horticultural section of the LTRS, funded not by the Development Commission (DC) but by the Department of Scientific and Industrial Research (DSIR), is examined. It is a branch of horticultural science that is currently a major focus of research.

4.1 Cheshunt Experimental and Research Station

In 1910 a party from the Lee Valley Growers Association, a group raising commercial crops in glasshouses, visited Rothamsted Research Station to seek advice about the serious problem of 'soil sickness' that was causing poor crop growth. Advised by John Russell to sterilise the greenhouse soil, the growers

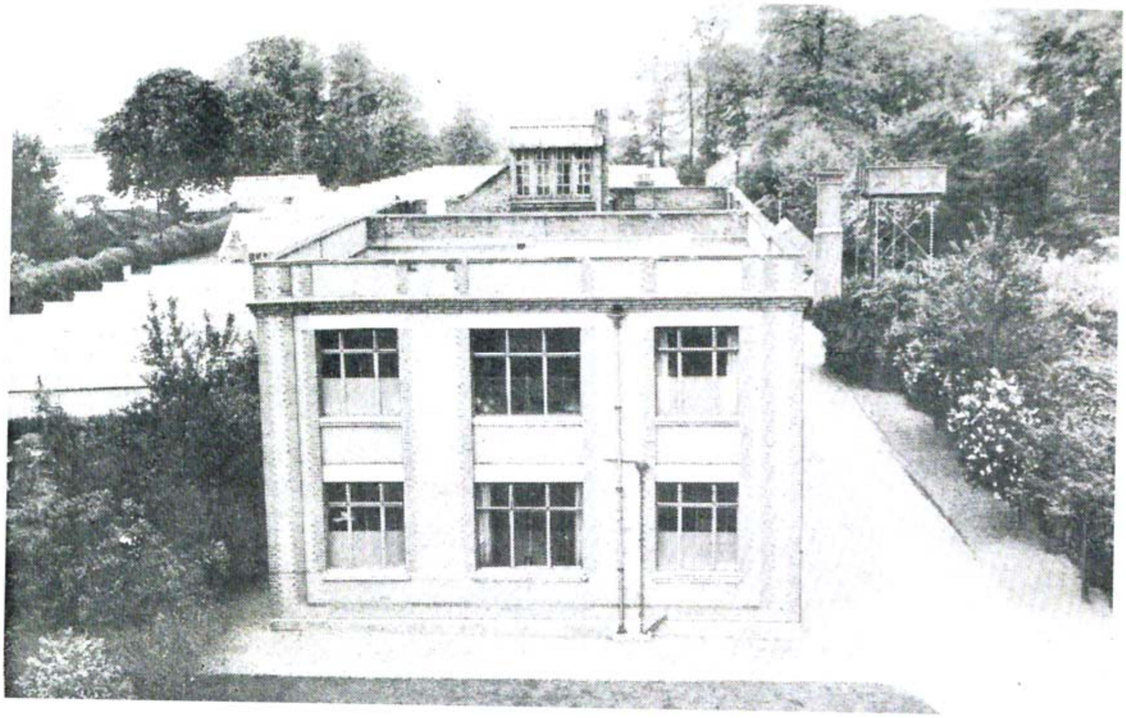

Fig 4.1, Cheshunt Experimental and Research Station c1933, *Annual Report 1935* Cheshunt: Nursery and Market Garden Industries Development Society Limited, Experimental and Research Station, 1936, opposite staff listings, unnumbered page.

arranged for experiments to be carried out at Rothamsted, importing their affected soil. After a number trials and modifications, the Rothamsted process of steam sterilisation became widely adopted and its success led a deputation of growers to approach the county council and the Ministry of Agriculture and Fisheries (MAF) for help in establishing a research station to serve the needs of the glasshouse industry.[1] Income from growers, the Duke of Bedford, Essex County Council and the Development Fund (DF) led to the formation of the station in 1914. The DF provided the bulk of the grants and the new laboratories and other facilities, opened in 1925 by Lord Bledisloe, were DF supported. Rothamsted Research Station was allocated a supervisory role and Russell became a member of the Management Committee.[2] The 2-acre site had 17 glasshouses that were used initially for tomato and cucumber research.[3]

4.1.1 Early Work

The physiological investigations were directed and supervised by Professor V. H. Blackman, also a member of the Management Committee, whose 'fundamental' research in the laboratories of Imperial College provided the steer for the applied research at CERS. Under the first Director A. B. Lister, comparative trials of manures and fertilisers, particularly a product known as 'bacterised peat' that for a short while received general attention, were made on tomato and cucumber crops. Investigations were also carried out into the effects on growth and yield of pinching out growing tips, of applying regularly overhead water sprays and of growing a different crop in the same soil prior to planting

[1] Replant disorder or 'soil sickness' resulted from growing tomatoes and cucumbers continuously in the same greenhouse soil. One prohibitively costly remedy was to remove regularly the affected material and replace it with fresh soil; C. E. Hudson, 'Commercial Horticulture in Hertfordshire' in R. T. Pearl (ed.), *The HEA Year Book. The annual publication of the Horticultural Education Association*, *Volume I*, Wye: Horticultural Education Association, 1932, pp. 53-61; *Sixth Annual Report 1920. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1921, pp. 52-53.
[2] W. F. Bewley, 'Twenty-one Years' of Glasshouse Research at Cheshunt', *Scientific Horticulture* (1936), IV, pp. 114-125.
[3] In the late 1920's the Station began to branch out and investigate protected cultivation of runner beans, lettuce, mushrooms, strawberries, roses, lilies, and cyclamen.

tomatoes. Records were kept on the amount of CO_2 in the atmosphere and the effects on the plants of temperature and humidity.

It is not altogether clear why Lister left in1920 to work for the Lee Valley Growers Association as an Advisory Officer. As well as conducting investigations with the help initially of one other researcher, Lister between 1917-1920 made 1404 advisory visits to growers in the Lee Valley and elsewhere, compiled 8739 scientific and technical reports and letters in response to local and national queries and received 5449 growers and interested persons for a conducted tour of the station.[4] This was a demanding schedule, an expectation that came with DF support, and probably diverted energy from the development of innovative research and the production of articles for scientific journals. The latter was a criterion of Hall when deciding which institutions should be DF key research centres. Russell, on the Cheshunt Management Committee and a friend and colleague of Hall and sharing the same views as Hall on the importance of high research standards and the need for scholarly publications, seems to have been unimpressed with the research skills of Lister.[5] This may have contributed to the appointment in 1921 of W. F. Bewley as Director. Bewley's skills and abilities were known because he had been previously appointed by Russell to work at Rothamsted as a bacteriologist and specialised in soil organisms.

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[4] *Third Annual Report 1917*. *Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1918; *Fourth Annual Report 1918*. *Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1919; *Fifth Annual Report 1919*. *Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1920; *Sixth Annual Report 1920,* op. cit. (1).

[5] Sir E. J. Russell a), *A History of Agricultural Science In Great Britain 1620-1954*, London: George Allen and Unwin Limited, p. 377; *Nineteenth Annual Report 1933. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Waltham Cross: The Cheshunt Press, 1934, Appendix A.

4.1.2 The Influence of Pests and Diseases and the Drive to Increase Yields in the 1920s

The scope of the work increased with the appointment of the mycologist, W. F. Bewley, and the entomologist Ll. Lloyd in 1920 and developed significantly when Bewley was made Director. Bewley obtained a science degree and doctorate from Durham University and this, ‘man of character and strong will’ devoted the rest of his working life to the glasshouse industry.[6]

He increased the number of research staff and gardeners. In 1922 there were 4 researchers and 4 gardeners, by 1930 there were eight scientists that included entomologists, a chemist, a mycologist, physiologists and virus disease researchers and 9 gardeners: this team approach was a feature of research stations in the 1920s. A new research area was the investigation of plant virus disease: viruses had not been identified fully in the previous century. Research staff were encouraged to pursue higher degrees and publish their findings. Under Lister 5 papers had been published between 1914-1921 whereas Bewley’s influence led to the production of 34 papers for scientific journals between 1922-1930.[7]

Growers were alarmed at the damage caused by the disease damping off, that could wipe out thousands of seedling plants once an outbreak started, and foot rot which led to stem collapse and the pests white fly and red spider mite. Developments in microscopy enabled Bewley and others to add fuller details about life histories, building on the information developed in the nineteenth century, in order to find stages when pests and diseases would be most vulnerable to control. He experimented with existing fungicidal chemicals to

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[6] Obituary of W. F. Bewley, *Nature* (1977), 265, pp. 571-572.

[7] *Nineteenth Annual Report*, op. cit. (5).

control damping off disease and developed the remedy ‘Cheshunt Compound’, a mixture of copper sulphate and ammonium carbonate. It was very successful and was used widely, so much so that it was felt later that growers were misusing the product. To reduce the incidence of stem rot Bewley devised growing and cultivation regimes (cultural factors) as current fungicides were not proving effective.[8]

A number of the researchers at CERS studied tomato and cucumber mosaic disease and worked initially on methods of classification and identification. To aid knowledge of structure and function, researchers treated virus cultures with mild electric currents and exposed them to different coloured light. The discovery at Cheshunt that unclean seed could transmit the disease was of great importance to the glasshouse industry. The station acted as a commercial supplier of clean seed and two greenhouses were dedicated to its selection, propagation and distribution to growers.[9]

Although the scientists at the station were familiar with Mendelian techniques for breeding new varieties, it was a low priority well into the 1930s as there was little public success in horticulture in the production of new varieties using these methods. The concern at the station was to assist commercial growers with workable innovations and the improved varieties produced at Cheshunt, such as Butcher’s Disease Resister cucumber and Cheshunt Early Giant lettuce, were the result not of a Mendelian breeding programme but of accidental crosses achieved by wind or insects. Mr Butcher of Dunstable found several of

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[8] *Seventh Annual Report 1921. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1922, pp. 38-39; Bewley, op. cit. (2).

[9] Bewley, op. cit. (2), pp. 118-119; *Fifteenth Annual Report 1929. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1930, p. 51; *Sixteenth Annual Report 1930. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1931, pp. 64-65.

his cucumber plants had a natural resistance to two leaf spot disease. This disease had caused much crop damage in the Lee Valley and one grower offered a £1000 reward for an effective control. Cheshunt obtained seed from Butcher, grew more plants and distributed the resultant seeds.[10] The lettuce was discovered accidentally at Cheshunt as a result of good observation and the ability to spot potential. Five promising plants, dark green and of good heart, were potted on and one of these was selected to produce more plants and their seed was sent to growers in the UK and the United States.[11]

Other researchers worked on insect pests. Ll. Lloyd developed effective control for the caterpillar of the tomato moth, which was causing £40,000 of damage annually to Lee Valley producers. Bewley believed it was so successful that, 'it impressed growers with the value of scientific investigation and helped strengthen the bonds between scientist and grower'.[12] White fly led to annual losses of £25000 in the area and cyanide sprays, although effective, caused scorching in glasshouses, particularly to cucumbers. Lloyd produced a safe method of using cyanide gas and a non-cyanide liquid fumigant. Aware of the dangers of cyanide, his successor E. R. Speyer developed the use of a biological control, the wasp *Encarsia formosa,* which was given to the station by the editor of the *Gardeners' Chronicle* who received it from L. Hawkins of Elstree, Hertfordshire.[13] A breeding programme was instituted with the aid of a grant from the Empire Marketing Board, a short-lived body founded in 1926 with

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[10] Bewley, op. cit. (2), p. 117.

[11] *Nineteenth Annual Report 1933*, op. cit. (5*)*, pp. 34-35; *Twenty First Annual Report 1935. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1936, p. 35.

[12] Bewley, op. cit. (2), p. 115.

[13] E. R. Speyer, 'An Important Parasite Of The Greenhouse White-Fly (*Trialeurodes vaporariorum*, Westwood)', *Bulletin of Entomological Research* (1927), 17, (3), pp. 301-308. The source were seed pods imported from India.

a limited supply of funds.[14] By 1929 Cheshunt had supplied 1 million fresh parasitized scales to nurserymen and other research institutes in the UK, the Scilly Isles and Canada.[15] This was an innovative approach to pest control in glasshouses and I have not found evidence to suggest that biological controls were used in nineteenth century commercial greenhouses.

Red spider mite was partially controlled. The recently imported petroleum based sprays from the United States caused blistering and discolouration of tomato leaves so Lloyd developed emulsified cresylic acid as a disinfectant and a spray of liver of sulphur and flour paste that gave limited reduction. Sulphur was widely used as a component in fungicides and had been the focus of research since 1919 but scientists could not agree on the reason for its toxicity.[16] Speyer produced a naphthalene fumigant that, although effective against adults and eggs, tainted fruit and damage foliage. It did, however, become the standard method for end of season control.[17]

In order to improve yields, investigations took place in the use of various gases, influenced by the 'fundamental' research of V. F. Blackman of Imperial College, and in the treatment of soils, influenced by the 'free' research undertaken by Russell and co-workers at Rothamsted. Trials were undertaken with CO_2

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[14] P. J. Atkins (2006), 'Food and the Empire Marketing Board in Britain, 1926-1933 [online] 8th Symposium of the ICREFH Prague. Available: https:www.academia.edu/316504/The_Empire_Marketing_Board [accessed 24 February 2015].

[15] *Twelfth Annual Report 1926. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1927, p. 55; *Fourteenth Annual Report 1928. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited*, Cheshunt: The Cheshunt Press, 1929, p. 12, p. 97; *Fifteen Annual Report 1929,* op. cit. (9), pp. 56-57; *Sixteenth Annual Report 1930*, op. cit. (9*),* pp. 11-12. The insect could not survive the winter so a special heated glasshouse at Cheshunt became the breeding and distribution hub.

[16] *Eighteenth report of the Development Commissioners for the year ended the 31st March, 1928*, London: HMSO, 1928, p. 62, D3/18, NA.

[17] Bewley, op. cit. (2), p. 116.

enrichment of the glasshouse atmosphere using portable apparatus and it was found to increase yields by 30%, but no method was found to apply enrichment on a commercial scale. Work began in 1929 using ethylene to speed the ripening of tomatoes but the results did not show any advantage.[18] Soil investigations found that the incorporation of grass cuttings and straw encouraged beneficial organisms and increased yields. Warming the soil by buried electric cables increased yields by 21% but proved costly on a commercial scale and so a system of hot water pipes was substituted, which increased yields and led to earlier harvests.[19]

The foregoing has outlined how Cheshunt established an international reputation as a glasshouse research station where science produced successful outcomes. Bewley was correct in believing that its standing was not attributable, 'to any single line of research' but to the variety and breadth of the investigations and to the insistence that quality was not to be sacrificed to quantity.[20] It raised the status of horticultural science among growers who became increasingly willing to cooperate with Cheshunt scientists in research and practice. By liaising with prestigious institutions such as Imperial College and Rothamsted on matters of pure science, by demonstrating how this science could be used to solve the problems of growers and by supplying other scientists with CERS generated knowledge and products, the station contributed both to the development and academic standing of horticultural science.

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[18] Bewley, op. cit. (2), p. 123; *Seventh Annual Report 1921*, op. cit. (8), pp. 57-58, p. 615; *Twelfth Annual Report,* op. cit. (15), p. 70; *Sixteen Annual Report 1930*, op. cit. (9), p. 83. In later years CO_2 and ethylene were used commercially.

[19] *Twelfth Annual Report 1926*, op. cit. (15), p. 88; *Fifteenth Annual Report 1929*, op. cit. (9), p. 80; Bewley, op. cit. (2), p. 123.

[20] Bewley, op. cit. (2), pp. 124-125.

Summary

CERS was established by the efforts of growers who were concerned that the glasshouse industry was not being supported by science. Initially, capital came from a variety of sources but later the DC became the largest fund provider. The station conducted applied science and was guided by the pure science research of Imperial College and Rothamsted. The second Director, W. F. Bewley, established the reputation of the station by focussing directly on the needs of growers and providing techniques to address their problems. He built up a research team that shaped the direction of horticultural science through its investigation of a range of problems. By developing effective fungicides that were tailored to glasshouse crops, by introducing and posting out a biological control of whitefly, by distributing virus free seed, by finding a method to overcome ‘soil sickness’ and by presenting ideas for raising yields by using carbon dioxide to enrich the greenhouse atmosphere, ethylene to hasten ripening, hot water pipes to warm soil and fresh grass cuttings to improve crop beds, CERS provided an extensive body of work in horticultural science that was extended by its own researchers in the 1930s and beyond.

4.2 East Malling Research Station

The predecessor of EMRS, Wye College Fruit Experimental Station, was a 22 acre experimental fruit research out-station for South-Eastern Agricultural College (SEAC). Kent County Council purchased the site in 1913 at East Malling, Kent, in part as a result of pressure from commercial fruit growers in the nearby regions for a scientific institution that would address their problems; a deputation had presented their case to the MAF.[21] At the outset the Director, Captain Wellington, and his staff of one, with a hut to serve as a laboratory and office, were intent on carrying out fundamental investigations into the growth of fruit trees. Professor V. H. Blackman gave advice to Wellington on physiological matters, suggested how to set up some of the investigations in pure science and later seconded Dr R. C. Knight and other staff to work on physiological and predation problems. The information gained from this work directed the more extensive applied science research that was carried out throughout the 1920s.[22]

In 1921 the Fruit Experimental Station became the EMRS, independent of

Figure 4.2 East Malling Research Station 1924, courtesy of NIAB EMR

SEAC and managed by the Kent Incorporated Society for Promoting Experiments in Horticulture: today it still serves the needs of the horticultural

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[21] F. R. Tubbs, 'East Malling Research Station', *Proceedings of the Royal Society of London* (1951), Series B, 139, (894), pp. 1-18; S. Richards, *Wye College and its World: A Centenary History*, Wye: Wye College Press, 1994, p. 115; East Malling Fruit Station, 31st May 1919, MAF 33/11, NA.

[22] Tubbs, op. cit. (21); Russell a), op. cit. (5), p. 373.

industry. The Society was a group of fruit growers, county council representatives, members of scientific institutions such as the Royal Society, academics from universities and East Malling staff.[23] Income came from the growers and the County Councils of Kent, Sussex and Surrey. The DC had regarded the Wye College Fruit Experiment Station as a useful but minor player and an adjunct to SEAC, one of its major research centres. Its main station for fruit research was Long Ashton Horticultural Research Station (LARS), affiliated to Bristol University. By the mid 1920s it was regarded as an important research institute in its own right and it occupied a key place in the Commission's network of stations and received regular funding to assist land acquisition, the building of laboratories and additions to staff and equipment.

4.2.1 The Influence of the first Director R. G. Hatton

East Malling's first Director, R. G. Hatton, graduated in history from Oxford University and after working as an agricultural labourer enrolled as a student of horticulture and agriculture at SEAC. Hatton was a lifelong champion of the plight of the farm labourer. Along with Lloyd George, A. D. Hall, E. J. Russell and S. Webb, who all held a range of socialist principles, Hatton believed that the education, housing and living conditions of farm labourers needed improving.[24] At Wye College Fruit Experiment Station Hatton took charge when Wellington went on war service and began to improve facilities and planned

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[23] M. Solomon, *A Century of Research at East Malling 1913-2013*, East Malling: East Malling Research, 2014, p. 9; Russell a), op. cit. (5), p. 374. On the Committee were the movers and shakers A. D. Hall (Ministry of Agriculture), V. H. Blackman (Imperial College), R. Biffen (Cambridge University), W. Bateson (John Innes Horticultural Institution) and F. W. Keeble (Oxford University).

[24] E. J. Salisbury, 'Ronald George Hatton. 1886-1965', *Biographical Memoirs of Fellows of the Royal Society* (1966), 12, pp. 250-258. Hatton became a lecturer for the Workers Education Authority.

to recruit a botanist and chemist and this experience helped him to develop the new station.[25]

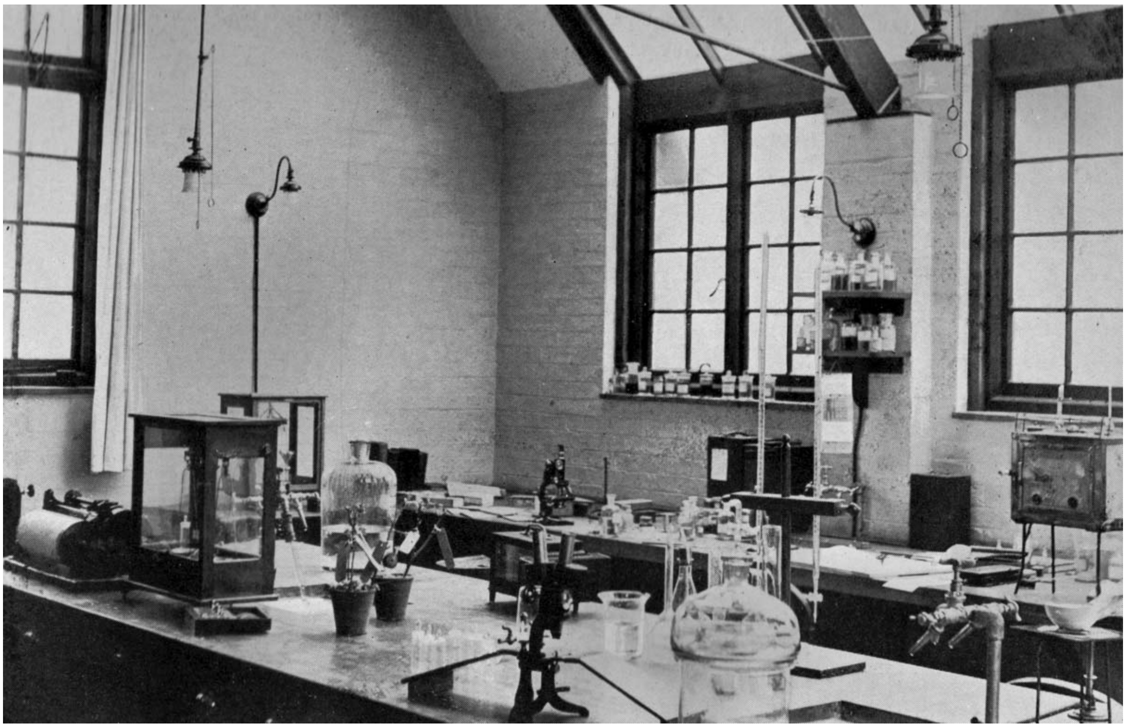

Figure 4. 3 East Malling Research Laboratory 1921, courtesy of NIAB EMR

A. F. Posnette, plant pathologist, geneticist and Director of EMRS 1972-1979, believed Hatton '…transformed horticulture, and fruit growing especially, from folklore to a science'.[26] As little is known about horticultural science in earlier periods or the science and practice of fruit growing it is difficult to substantiate the view that fruit growing was based entirely on local beliefs and customs.[27] Hatton did originate and direct important and original work in pomological science at East Malling. Hatton and Wellington ensured a huge array of detailed

[25] Letter from R. G. Hatton to A. D. Hall, 9th January 1919, MAF 33/11, NA.

[26] A. F. Posnette, 'Hatton, Sir Reginald George (1886-1965)', *Oxford Dictionary of National Biography*, Oxford: Oxford University Press, 2004, p. 832.

[27] A great deal of scientific work was carried out in the early nineteenth century on fruit growing by Thomas Andrew Knight. John Lindley in the 1850's was attempting to base horticulture on scientific principles and Spencer Pickering along with the Duke of Bedford established an influential fruit experiment station in 1894 at Ridgmont, Bedfordshire. Little, too, is known of the various fruit growing practices over the country.

statistical material was compiled on the growth habits, over time and at different seasons, of hundreds of varieties of fruit trees and particular attention was paid to the characteristics and behaviour of the root system. This could not have been achieved without the assistance of the nursery trade that sent regular supplies of trees to the station.[28] This made it possible, 'to provide the fruit grower with uniform, high-quality, disease-free, true-to-name plants', laid the foundations for the use of standardised material in experiments and secured an international reputation for the station.[29] Hatton helped found in 1919 *The Journal of Pomology,* which became the *Journal of Pomology and Horticultural Science* in 1922. Under Hatton's editorship it became a vehicle for publishing the research conducted at the station and elsewhere. During discussions over the role of the new institute, some supporters wanted the station to focus entirely on applied science but Hatton, the scientists on the management group and others argued successfully that fundamental research was an essential part of the work of the station as it provided the impetus for applied science investigations.[30]

Like the Director at Cheshunt Research Station, Hatton stayed at his post until retirement and developed the facilities and increased the scientific staff, particularly entomologists, pomologists and chemists, to ensure horticultural science research was addressed effectively and communicated to a wide audience. In doing so, both Directors were responding to the conditions governing loans set up by the DC and to the influence of A. D. Hall and his views on the importance of pure research.

[28] A.1. Paradise Stocks Part 1, Apple Paradise Stocks Book No II, A3 Apple Free Stocks Record Book, A4 Paradise Stocks Book, NIAB EMRL. These covered the period 1913-1919.
[29] Letter from A. D. Crowe to M. J. Bukovac, 15th July 1988, 75th Birthday Celebration File, NIAB EMRL.
[30] Solomon, op. cit. (23), p. 10.

By 1930 Hatton had extended the site and introduced laboratories, preparation rooms, orchard houses, propagation houses, fumigation chambers and insect proof facilities to support fundamental and applied science investigations. He increased the output of research papers, was keen to have postgraduate students, developed staff exchanges, employed former research scholars of the DC scheme and accommodated volunteers.[31] Visitor books in the 1920s show a considerable amount of engagement with universities, colleges, schools, advisors, research stations, gardening and scientific societies, private companies and commercial growers.[32]

Although the station was to focus on investigation, the staff like the researchers at CERS, responded to queries and despite Hatton's belief that such activities got in the way of research and was not the role of the station, he tolerated them. In the early 1930s his solution was to appoint more administrative staff to field the enquiries. Research staff realised the importance of liaising with commercial growers and home gardeners as they were the recipients of the work at East Malling and a practical query could provide an idea for pure research. Some staff gave up part of their annual leave to visit fruit growers in Scotland and carry out inspections of the crops and give advice. This energy, reflected in the following figures, indicates the faith that the scientists had in the value of their work, their commitment to communicate science to those who would benefit and an increase in the willingness of the public and the commercial sector to receive scientific information.[33] The number of basic science lectures to the public remained constant throughout the 1920's but

[31] See the *Annual Report, East Malling Research Station, East Malling: The Kent Incorporated Society for Promoting Experiments in Horticulture*, for each year between 1923 and 1930.
[32] Visitors Book 1921, 1925-1928 and 1928, NIAB EMRL.
[33] Dr R. C. Knight, seconded from Imperial College, gave a very successful course of evening lectures at the station on basic plant physiology.

there was an increase in enquiries and visitors. In 1923 the number of letters sent in response to enquiries was 400 and rose to 1288 in 1930; there were 40 visits to growers to address problems in 1923 and in 1930 there were 122; the number of visitors received for these years was 789 and 1767 respectively. Often, several hundred telephone queries were taken annually; the busiest year was 1926 when 5000 calls were answered.[34]

4.2.2 The Research Work at the Station

Four aspects of the research at East Malling Research Station influencing the development of horticultural science knowledge are examined: roots and rootstocks, statistical analysis of data, pest and disease control and pruning methods.

With assistance from Imperial College and the John Innes Horticultural Institution (JIHI), research on the roots of different kinds of fruit trees was conducted throughout the 1920s. Data was collected on root structure and root system characteristics by measuring and photographing the roots of lifted trees and using glass-lined trenches to observe live material.[35] An innovation was the extensive research on the resistance of the rootstock to pests and its influence on the scion (grafted shoot), such as the effects on flowering time, the number of blossoms and the flavour of the fruit. To achieve this, the first step was to grow thousands of fruit trees in order to scrutinise and document their characteristics to reduce synonyms and guarantee true varieties. Pickstone has noted that along with the expansion of laboratory science in Western Europe in

[34] *Annual Report (Fourteenth Year) 1926. East Malling Research Station,* East Malling: The Kent Incorporated Society for Promoting Experiments in Horticulture, 1927, p. 25.
[35] *Annual Report (Eighteenth Year) 1930. East Malling Research Station,* East Malling: The Kent Incorporated Society for Promoting Experiments in Horticulture, 1931, p. 31.

the early twentieth century, there was an increasing interest in description and classification amongst researchers in the life sciences, in part stimulated by a renewed interest in the Empire.[36] At East Malling, the attention given by horticultural scientists to description and classification was the prelude to an ambitious programme of research, involving liaison with a number of institutions and the export of rootstocks to the Dominions.

The result was the production of a number of rootstocks that were resistant to certain pests and diseases and which could control the height and behaviour of the grafted scion, so guaranteeing uniformity.[37] The JIHI provided assistance by raising seedlings from East Malling rootstocks and analysing their genetic characteristics. Prior to this the great variability in the behaviour of Paradise rootstock used in experiments and trials raised doubts amongst researchers about the reliability of the ensuing data.[38] Thousands of EMRS rootstocks were distributed annually to growers and research stations in the UK and other countries, which helped establish East Malling's scientific reputation internationally.[39]

Associated work by the newly appointed biochemist from Rothamsted, W. Roach, involved analysis of the ash of scion and root tissue using spectrographic methods. This in turn led to a more detailed identification of the chemical elements present in fruit trees to determine which were important for growth and to detect deficiencies which could be then addressed. The findings

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[36] J. Pickstone, *Ways of Knowing: A New History of Science, Technology and Medicine*, Manchester: Manchester University Press, 2000, p. 75, p. 122.

[37] Woolly aphis and silver leaf disease could be controlled in this way. The Malling rootstocks were known, in ascending order of tree height, as M27, M9, M26, M106 and M25.

[38] Salisbury, op. cit. (24), pp. 253-254.

[39] The importance to the fruit growers of the rootstock investigations made at the East Malling Research Station, undated, MAF 33/194, NA. Rootstocks were sent to Canada, Australia, South Africa, India and Egypt.

contributed to the biochemistry research that was being carried out at Cambridge University, Bristol University and the JIHI.[40]

T. N. Hoblyn, a former Rothamsted researcher influenced by the statistical work carried out there by R. A. Fisher, developed Fisher's methods at East Malling in order to achieve more precise analysis of the results from investigations. Hoblyn used the smaller, faster growing M27 Malling rootstock to overcome the delays caused previously by the slow growth of the trees, which speeded up data accumulation.[41] In 1930, after two years planning, one of the first large-scale experiments on the fertiliser requirements of apple trees began using the randomised blocks advocated by Fisher. It added to the previous work at SEAC and LARS by confirming potassium was important for the growth of young trees and, uniquely, demonstrated that potash deficiency was the cause of the disorder leaf scorch.[42] This was part of early twentieth century research on fertilisers that extended the work of nineteenth century investigators who had indicated the importance of nitrogen, phosphates and potassium to crops, and an example of the search for other chemical elements essential for plant growth.

A broad range of pest and disease research was conducted. A significant initiative was the correlation of insect appearance and weather conditions in order to predict predation and indicate appropriate spraying times. Similar to the

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[40] R. G. Hatton, 'Landmarks in the Development of Scientific Fruit Growing' in Anon, *Agriculture in the Twentieth Century: Essays on Research, Practice and Organisation to be Presented to Sir Daniel Hall*, Oxford: Oxford University Press, 1939, pp. 349-350; *Annual Report (Sixteenth Year) 1928*. *East Malling Research Station,* East Malling: The Kent Incorporated Society for Promoting Experiments in Horticulture, 1929, p. 93; Russell a), op. cit. (5), p. 374. The work involved injecting the trees with chemicals and the researchers at East Malling liaised closely with these institutes.

[41] T. N. Hoblyn, *Field Experiments in Horticulture*, East Malling: Imperial Bureau of Fruit Production, 1931, p. 5, p. 13.

[42] *Annual Report (Sixteenth year) 1928*, op. cit. (40), pp. 38-40; Russell a), op. cit. (5), p. 375; Hatton, op. cit. (40), p. 347.

CERS and LARS, research was conducted on the new tar distillate and petroleum based washes and sprays to determine toxicity, their mode of action, the possibility of combining sprays safely, the efficacy of accompanying wetting agents and the appropriate systems for delivery. In 1926, 80,000 eggs of pests were reared to provide laboratory material for spray tests. Virus research, using equipment that was able to provide more detailed information on tissue structure, focussed on strawberries and raspberries although by 1930 resistant varieties had not been developed and Hatton acknowledged the complexity of the research.[43]

Research on pruning at East Malling helped develop scientific principles for this operation. Work continued throughout the 1920s on trees, bushes and roots to establish an understanding of what processes were at work and the research suggested the presence of substances in leading buds which held back growth in other buds: the beginnings of the idea of apical dominance. It was believed the research had shown cropping depended on pruning the side-shoots in the period of early development and pruning leading shoots when the tree was older.[44] This advice which had been tested out in the field and shown to be effective, coupled with programmes of demonstration, benefited growers and gardeners who had relied, in part, on methods based on guesswork.

Amongst the other investigations that were conducted was research on cross-pollination, soil moisture, the soils of regions and the physiology of flower buds. The work outlined indicates the variety of research that was undertaken and to cope with the huge amount of regular observations that were needed

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[43] Russell a), op. cit. (5), p. 374; Hatton, op. cit. (40), pp. 358-359; *Annual Report (Fourteenth Year) 1926*, op. cit. (34), p. 63.

[44] Hatton, op. cit. (40), pp. 329-330; R. T. Pearl and R. Hart,' Twenty-one Years of Fruit Research at East Malling', *Scientific Horticulture: the Journal of the Horticultural Education Association* (1935), III, pp. 55-64.

and the careful recording of this information, a field telephone system was set up in 1924 so that the researcher could communicate with a recorder sitting at an adding machine or typewriter in one of the research buildings.[45] Hatton believed the stations work to establish the life histories of pests and diseases and the demonstrations given to show the importance of this knowledge, 'quickened faith in horticultural research generally' and his judgement that the work at East Malling and other research stations enabled the activity of fruit growing to change from an art to a science summed up his faith in the impact of fundamental and applied science research work, although it is difficult to ascertain fully the influence of science on growers and home gardeners.[46] Hatton's work was held in regard by contemporaries and his appointment as Director of the Imperial Bureau of Horticulture and Plantation Crops in 1929 was recognition of the value of the pure and applied science investigations conducted by the research team at the station.[47]

<u>Summary</u>

East Malling Research Station was established as a result of commercial fruit growers lobbying for science support. Initially seen as a minor research institute by the DC, by 1930 they regarded it as one of its key research stations. An important factor was the decision to conduct pure research and allow this to influence the direction of applied research. Assistance in fundamental research given by Imperial College, Bristol University, Rothamsted

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[45] *Annual Report (Fourteenth Year) 1926*, op. cit. (34), p. 17.
[46] Hatton, op. cit. (40), p. 356 and p. 360.
[47] Solomon, op. cit. (23), pp. 12-13. The Imperial Bureau of Horticulture and Plantation Crops was based at East Malling and the Empire Marketing Board provided funds for additions to staff and a new laboratory.

and the JIHI was crucial for the development of the East Malling research schemes.

The drive and commitment of the Director and staff enabled a comprehensive programme of research to develop. The station, focussing initially on taxonomic issues but later on physiology, developed a range of uniform rootstocks that were distributed in the UK and abroad and it helped to extend and promote new ways of designing experiments, based on the work of R. A. Fisher at Rothamsted. Pest and disease research resulted in the production of improved sprays and washes and models correlating climate and the appearance of predators were explored. Rootstocks immune to certain insect attacks were developed successfully and virus research was undertaken, although the Director had reported little progress by 1930. A great deal of information about the physiology of roots, shoots and buds was acquired which underpinned the development of improved practical methods for efficient maintenance of commercial holdings of soft and top fruit, such as pruning and fertilising.[48] Research results were communicated in scientific papers, demonstrations, lectures, conducted tours, personal visits and in replies to letter and telephone queries. The importance of its work was recognised in 1929 when part of the station became the Imperial Bureau of Horticulture and Plantation Crops.

4.3 Cambridge University Low Temperature Research Station

C. M. Simmons in his talk on the commercial refrigeration of fruit, bulbs and plants in the UK at the First International Congress of the Refrigerating Industries in Paris in 1908, stated pessimistically, 'As far as this country is

[48] Letter from Bill Greenhalgh to M. J. Bukovac, no date, c1988, 75th Birthday Celebration File, NIAB EMRL.

concerned, the refrigeration of plants is of no commercial value; and the same applies to vegetables'.[49] In 1917 scientists involved in the cold storage of horticultural produce were concerned that Britain was lagging behind the United States and other European countries. Ten years later Britain was the world leader in the storage of fruit and vegetables after harvest, with an international reputation.

I discuss the role played in this development by the horticultural section of the LTRS. The remit of the section was to investigate the storage of horticultural crops. The LTRS is different from the organisations in the other three case studies as it received the majority of government funds from the DSIR and not from the DC.[50] Initially researchers examined how to extend the storage life of fruit and vegetables using cold chambers. This led to an exploration of the use of gases in storage facilities, which involved manipulating levels of oxygen and carbon dioxide in addition to controlling temperature. I focus mainly on the development of this significant innovation that was known initially as 'gas storage' and in the 1940s was given the label 'controlled atmosphere storage'. To explain the emergence and growth of the LTRS and how the horticultural section influenced commercial horticulture and shaped horticultural science, I adopt the model of the 'cold chain' used by Rees to account for the growth of the ice and refrigeration industries in the USA. Rees has described the cold chain as the, 'linked refrigeration technologies needed to preserve and transport perishable food from its point of production to its point of consumption'. Although the station developed both gas and cold storage methods for different crops the model provides a helpful framework in which to place the evolution of

[49] C. M. Simmons, 'Refrigeration of fruits, bulbs, plants', *Paris: Congress of Refrigerating Industries*, 3, 1908, pp. 5-8.
[50] The wide range of experimental work of the DSIR and the outcome of its teamwork approach has yet to be evaluated fully by historians.

the LTRS, and I indicate later that the horticultural section made contributions to the development of the cold chain. The four elements of Rees's model are employed: the efforts to produce the required storage conditions, the management of these conditions in a particular space, the development of precision control and the work to extend the volume and reach of the chain.[51] Additionally, there is a consideration of the attitudes of the researchers at the station towards pure and applied science that influenced the investigations

4.4 Low Temperature Research Station 1922, courtesy of the Institute of Food Research

that were carried out.

[51] J. Rees, *Refrigeration Nation: A History of Ice, Appliances, and Enterprise in America*, Baltimore: The John Hopkins University Press, 2013, pp. 2-5. Rees, dealing mainly with developments after 1806 and ending with a discussion of recent innovation, shows how science and technology expanded the reach of the chain.

4.3.1 Origins of the LTRS

The origins of the LTRS can be traced to the First World War. Poor harvests in 1916, the German U-boat attacks on ships carrying food imports and the realisation that valuable horticultural produce decayed in transport and was wasted in times of glut, led to major fears that it might not be possible to feed the populace. Hutchinson has described how the Ministry of Food and a deputation from the Cold Storage and Ice Association met officials from the new DSIR and explained that the principles of refrigeration were poorly understood, requested government support and persuaded the Department to organise investigations into fruit, vegetable, fish and meat storage.[52] The DSIR eventually set up the Food Investigation Board (FIB) and appointed as Director the mover and shaker William Bate Hardy, Lecturer in Histology at Cambridge University and influential figure in the Royal Society. Hardy ensured that Franklin Kidd, a botanist who had worked as a pure science researcher at Imperial College and Cambridge University, was given the task of examining for the FIB the storage of horticultural crops.[53]

Growers of apples both at home and in the Empire also wanted a solution to the problem of seasonal glut. Several UK apple producers had built their own storage facilities to address the problem but disease was spoiling the fruit. Kidd made a number of attempts to produce appropriate storage conditions so that research could proceed. He obtained and altered several cold stores in London but found that the apples were prone to a physiological disorder called brown

[52] E. Hutchinson, 'A Fruitful Cooperation between Government and Academic Science: Food Research in the United Kingdom', *Minerva*, 10, (1), 1972, pp. 19-50.
[53] Kidd had carried out work that was directly relevant to fruit and vegetable storage and as a Quaker and conscientious objector, he was available at this period of the War as many researchers had been called up or had volunteered to fight.

heart. To reduce its incidence, Kidd investigated gas storage only on a commercial scale and was able to prevent the disorder.[54] He found storage life in gas chambers was prolonged if the temperature was also controlled. The DSIR recognised that Kidd had developed a body of technical knowledge about storage facilities and this coupled with the realisation that it was frustrating and inconvenient for its researchers to keep using scattered outposts with unreliable equipment, led to the decision to create a new station to centralise investigations. The outcome was the LTRS, which opened in 1922. Franklin Kidd became head of the horticultural section and Cyril West was appointed his deputy.

Hardy wanted the station to be located at Cambridge because he felt the University had facilities and contacts to best set up and support the station and believed the station's resources would enhance the pure and applied research programmes of several schools. Hardy felt strongly that the state should support pure research in order to add to the body of knowledge that guided practical or applied science. He was against a state run LTRS on government land because he felt it would become more bureaucratic than scientific and would not be a suitable environment for young, temperamental and highly critical pure science researchers who would feel more at home in the accommodating but intellectually challenging environment of an independent research station. Hardy framed his arguments so as to make Cambridge University, with its reputation for pure science research, the only possible option. A rival was Professor W. Anderson of Liverpool University who wanted the government to fund a cold storage facility at his university. Once Hardy was made Director of the FIB he gained more control and influence and his loyalty and devotion to

[54] It was estimated that the disorder was costing the industry £250,000 annually. Externally the apples looked healthy but the centres were dead and brown.

Cambridge led to a promotion campaign that left Anderson marginalised and upset.[55] Hardy appraised his colleagues harshly as he applied high standards when weighing up their academic merit. He believed the United States and Canada were ahead of the UK in cold storage research and wanted the right calibre of person to be involved in fundamental research work in order to improve Britains position. It seems likely that Anderson, an engineer and not a physiologist and more involved in applied science, was judged unsuitable. At Cambridge there were researchers with expertise in fundamental science such as F. G. Hopkins in the Department of Biochemistry and T. B. Wood in the Department of Agriculture that could maximise the use of the facilities and the university had the requisite generators to provide the necessary power. Hardy offered the site to the Treasury at no cost as he judged, correctly, that his gesture would be received favourably.

Hardy worked behind the scenes and convinced a number of departments that the station would serve their needs and the university authorities that the acquisition of a LTRS would enable Cambridge to be at the frontier of biological science.[56] Moreover, Sir K. Anderson of the FIB was the brother of H. K. Anderson who was the Master of Gonville and Caius College to which Hardy belonged. Hardy was a close friend of H. K. Anderson who was also a physiologist: they shared similar biological and college interests. Significant reasons for Hardy's success was his utilisation of his social contacts and the fact that he sold the concept of the LTRS to a number of interest groups who had something unique to gain from the new research station. Harwood in discussing the drift towards pure science in some German agricultural colleges

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[55] Letter from W. Anderson to Professor Ramaden, 17th June 1917, DSIR 6/1, NA; Letter from W. Anderson to W. B. Hardy, 4th December 1918, DSIR 6/1, NA.

[56] Letter from W. B. Hardy to T. B. Wood, 14th August 1919 a), DSIR 6/24, NA; Letter from F. G. Hopkins to W. B. Hardy, 25th August 1919, DSIR 36/3800, NA.

has suggested that personality and the policy of the overseeing body influenced decisions about the adoption of pure and applied science research work and this is germane to the LTRS.[57] Hardy established with the DSIR, the fund holder, the principle that research had to benefit the nation as a whole, which gave him the flexibility to interpret the DSIR brief to suit his own beliefs and the needs of the university. Hardy's passion for fundamental research, his energy and his skill at conducting negotiations behind the scenes helped him engineer the establishment of the LTRS at Cambridge were there was increasing support for pure research in the natural sciences. The forgoing suggests that the funding source, ambition, personality, politics and attitudes towards pure and practical science need to be incorporated into Rees's cold chain model.

4.3.2 Developments in gas and cold storage

The sustained technical realisation of gas storage and cold storage, in dedicated chambers, was achieved with the creation of the LTRS and with the design improvements that were made throughout the 1920s. Its construction needed the support of the National Physical Laboratory, the National Engineering Laboratory, the Forest Products Research Laboratory, the military, universities, growers, the refrigeration industry and other research stations. The choice of a method to control temperature in gas storage chambers was problematic. The Lawton system, using refrigerated coils to cool filtered gas pumped from a stove, was considered but the inventor was killed accidently when he was setting up his storage chamber on a voyage and confidence was lost. The favoured system developed by Dr Kapadia, which combined gas and

[57] J. Harwood, *Technology's Dilemma: Agricultural Colleges between Science and Practice in Germany, 1860-1934*, Bern: Peter Lang, 2005, pp. 172-173.

cold storage, was rejected as Kapadia had refused a thorough trial of his method. Eventually a contract to develop a method of controlling temperature was given to J. E. Hall Limited of Dartford, Kent, a firm with a great deal of experience in constructing refrigeration equipment.

Another difficulty was finding reliable instruments to record gas levels and relative humidity as well as temperature. Kidd and West developed their own portable instruments for recording gases, the NPL produced a device for measuring humidity, and a way to control temperature within a narrow range around freezing point was developed.[58] After eight year's work precision control was achieved. By 1930 the management of gas storage conditions had been accomplished after many alterations to the chambers as a result of technical problems and many carefully designed experiments to work out appropriate gas combinations. Kidd and West had discovered the oxygen and carbon dioxide combinations and optimum temperature for the storage of eleven fruit and vegetables. This illustrates how far removed from field trials some of the experimental work in horticultural science had become.

4.3.3 Influence

This section discusses the influence of the work of Kidd and West, firstly, on horticulture and horticultural science and, secondly, on the adoption of both gas and cold storage facilities by the commercial sector and by other research institutes.

The work at the LTRS put the spotlight on the fate of the crop in the period

[58] Note headed Fruit and Vegetable Committee, undated, DSIR 6/12, NA.

between leaving the field or glasshouse and reaching the consumer, a consideration ignored by growers, and showed this was a legitimate area for scientific investigation. Variables were identified that influenced the storage life of crops over which growers could exert some control, such as variety, picking time, soil type, irrigation regime, pruning method and fertiliser manipulation. Attention was drawn to the fact that if disease was present on produce prior to storage, shelf life was limited. Hardy summed this up by saying, 'The Food Investigation Department started with storage problems but to solve them we had to push back our enquiries further and further to the orchard and to the farm'.[59] Growers and dealers could bring their problems to the station and Hardy on occasions sent staff to make investigations on the spot.[60]

Under traditional storage methods, growers expected to lose between 20%-30% of the crop whereas with gas storage the loss was minimal. For those producers with the necessary capital, this method of storage helped mitigate gluts, reduce storage losses and maintain a regular sales income. By 1935 five large commercial gas stores had been constructed in the UK and in 1938 there were over two hundred commercial gas stores for apples. As a direct result of the work of Kidd and West, gas storage was introduced into New York and Canada in 1934 and Denmark and South Africa in 1935. These and the later examples I give illustrate how the horticultural department of the LTRS helped to extend the volume and reach of the cold chain.

Investigations by LTRS researchers on crop diseases and disorders, the process of ripening, the tissue structure of fruit and vegetables and the respiration of harvested crops extended scientific understanding. It added to

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[59] W. B. Hardy a), 'Presidential Address', *Proceedings of the British Association of Refrigeration*, XXVII, (1), 1931, pp. 7-18.

[60] 'The Cambridge Low Temperature Research Station', *Science* (1929), 70, (1821), p. 494.

the body of knowledge of horticultural science and shaped it by developing a new area for scientific enquiry, the use gas and temperature in controlled conditions.

LTRS research was promoted when Kidd and a colleague, A. J. Smith, went on visits to Europe, the United States and Empire countries to engage with scientists and growers and discuss common difficulties and technical issues concerning both cold storage and gas storage. Shippers were particularly interested in methods of cold storage developed by the horticultural section for the transport of fruit in the hold of vessels. It seems likely that this promotional work and Kidd's efforts to address specific, practical applied science problems helped to convince scientists, growers, importers and shippers to investigate the gas and cold storage techniques for fruit and vegetables developed by LTRS scientists.[61] As a result of such advisory work a LTRS using gas storage methods was built on the Cambridge model at St Augustine, Trinidad in 1928 for bananas and other tropical fruit, using imported cylinders of gas.[62]

The facilities at the LTRS helped other scientists conducting research in related areas. Rowland Biffen, Professor of Agricultural Botany at Cambridge and Head of its Horticultural Research Station, sought the help of the LTRS in 1924 to find out if strength in wheat depended on winter cold. Kidd and West supported the Vitamin C studies of Bracewell, Hoyle and Zilva at the Lister Institute by supplying differently treated apples, assisted poultry producers by carrying out investigations on the cold storage of eggs and poultry and a small canning plant at the station investigated some of the fruit and vegetable preservation problems faced by the scientists at the Chipping Campden Fruit and Vegetable

[61] Kidd built up a sufficient body of knowledge from his researches to be able to offer in the late 1940s a course in food science, a term which he coined.
[62] C. W. Wardlaw, *Observations on Internal Gas Concentrations in Fruit*, Trinidad: Imperial College of Tropical Agriculture, 1936, p. 667.

Preservation Research Station and by growers and canners.[63] The Empire Marketing Board (EMB) funded a research unit that incorporated commercial scale facilities for investigating further the cold storage methods used in the hold of ships, the Ditton Laboratory. It opened in 1930 at East Malling Research Station with Kidd's co-worker Cyril West as Director and had been designed by Kidd. The work that was carried out subsequently helped to extend the volume and reach of the cold chain.

4.3.4 Tensions

This section is presented as an episode in early twentieth century relationships between pure and applied science and I extend the model of Rees through a consideration of these relationships. Gooday and Lucier, acknowledging the importance of addressing what these terms meant for contemporaries, have demonstrated the complexity of defining their meaning and have argued for further investigation.[64] Additionally, Lucier has observed that pure science and the pursuit of knowledge and applied science and the search for profit were not independent but co-existed in a relationship characterised by tension. What follows is a response to the request by Gooday and Lucier for additional material concerning contemporary attitudes towards pure and applied science and a development of Lucier's observation that such attitudes could generate tension.

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[63] Twelfth meeting of the Committee of Management of the Low Temperature Research Station, 22nd July 1927, DSIR 6/22, NA; *Report on Egg Marketing in England and Wales*, London: HMSO, 1926, p. 119; *Report on the Marketing Of Poultry in England and Wales*, London: HMSO, 1926, p. 94; 'The Cambridge Low Temperature Research Station', op. cit. (60).
[64] G. Gooday,'"Vague and Artificial": The Historically Elusive Distinction between Pure and Applied Science', *Isis* (2012) 103 (3), 546-554; P. Lucier, 'The Origins of Pure and Applied Science in Gilded Age America', *Isis* (2012), 103 (3), 527-536.

There were differences of opinion amongst staff in the horticultural section of the LTRS in their attitudes to pure and applied research. Hardy and A. D. Hall, an influential shaper of horticultural science at the time and Chief Scientific Advisor to the Ministry of Agriculture and Fisheries, believed it was in the national interest to acquire additions to scientific knowledge. Hardy felt passionately that the LTRS should be a laboratory for ‘fundamental science’ research and, like Hall, argued pure research findings had to underpin ‘applied science’. At a meeting of the British Association of Refrigeration (formerly the Cold Storage and Ice Association), Hardy likened fundamental or pure scientific work to ‘abstract’ or ‘academic science’ and pointed out that experiment, by increasing the general body of ‘fundamental knowledge’, contributed to ‘utility’. For Hardy, fundamental science was needed by industry in order to give direction to its practical work.[65]

Hardy was confident that he could find pure science researchers in Cambridge as he thought botanists would find fundamental research on fruit and vegetables intrinsically interesting. What did concern him was ensuring that the core work at the LTRS was pure science and that there was a ‘natural balance’ between pure and applied research. When this happened, claimed Hardy, pure and applied science became, ‘two sides of one operation’.[66] For Hardy, work was balanced when there was a sufficient body of theoretical knowledge available so that ‘rational’ judgments could be made about observations taken in the field or in the storage chambers. There was imbalance if observations could not be related to an existing body of theoretical knowledge. Hardy was confident that at the LTRS the research of the horticultural section was in

[65] Hardy a), op. cit. (59), p. 12.
[66] W. Hardy b), Notes on the general position of the work under the Board, 12th October 1923, DSIR 6/10, NA.

balance but was concerned that undue emphasis on applied science would be detrimental. When Hardy gave reports about the work of the section to members of the governing committee, he provided them with a list of research work, with fundamental and applied science in separate columns. For example, plant respiration, oxidation, metabolism and the chemistry of ripening was demarcated fundamental science whereas applied research was listed as gas and cold storage, the control of brown heart and bitter pit and the permeability of the storage chamber walls to carbon dioxide.[67]

Franklin Kidd, on the other hand, aligned himself publicly to applied science and in his associations with growers and scientists almost made it a virtue by promising to address their practical problems. On his visits in the UK or abroad he stressed the value of his applied science research and publicised the work of the LTRS and its success in solving the practical problems of growers. Kidd regarded pure science as 'academic' science and the purpose of practical science was 'application'. Hardy warned Kidd and other research workers at the LTRS not to organize and carry out applied work as it would be against his wishes and would compromise gravely their scientific reputation. He advised them that it would reduce their chances of becoming Fellows of the Royal Society because the novel character of the LTRS work would make it difficult to obtain proper recognition. He judged the research work of Smith to be of Fellowship standard but believed his researcher had deliberately sacrificed the chances of building up an academic reputation by giving too much focus to applied work.[68]

Hardy once favoured patents because he felt it was a civic duty that income

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[67] Agenda of the Food Investigation Board, 15th November 1923, DSIR 6/6, NA.

[68] W. B. Hardy c), Low Temperature Station Research Staff, 19th December 1925 and letter from W. B. Hardy to H. Tizzard, 12th January 1926, DSIR 6/27, NA.

should be directed by scientists to the organization that employed them. By the mid-1920s he had changed his mind and argued that it would be more useful to the pursuit of knowledge if they were banned.[69] Hardy and the Cambridge University Authorities believed that the results of the work of the station should be freely available. Giving an example of what he meant, Hardy referred to the stance taken at Rothamsted Research Station. The increasing shortage of dung led the Director E. J. Russell and his team to develop 'Adco', an agent which when applied to straw turned it into manure. The results of the experiments were published for all to benefit and the patent was handed over to a non-profit making company. Here, Lucier's tension between the pursuit of knowledge and monetary gain is evident. Hardy was completely against knowledge from pure research being used as a market place commodity because its benefits belonged to the community, the nation, and not to individuals. Kidd and Smith took out patents despite Hardy's views. Kidd patented the use of selectively permeable rubber in storage chambers, the injection of acetaldehyde into storage chambers and the use of wrappings for apples in storage.[70] It is difficult to know whether monetary gain influenced Kidd's attitude towards applied science, although superficially it seems that he was not against financial benefit. Hardy welcomed the proposal by the EMB, impressed by the pure and applied science being carried out, to provide funds to set up a research facility within the LTRS to assist and enhance commercial horticultural and agricultural opportunities in the dominions and colonies. In 1927 two new wings were added to the LTRS housing laboratories, equipment and controlled atmosphere storage facilities. Later, it was feared that this would enable the EMB, a patron of applied science, to have supreme control of the research programme and

[69] Letter from W. B. Hardy to L. S. Lloyd, 5th December 1923 e) , DSIR 6/27, NA.
[70] Patents, Application Number 35613 and 337422, DSIR 36/2379, NA.

cause the ‘natural balance’ achieved by Hardy to be affected.[71] Much discussion took place between officials at the DSIR and the EMB and Hardy exerted pressure behind the scenes. The outcome was that full control over finance and hence the research programme, one of Harwood’s factors influencing research decisions, was given to the DSIR enabling Hardy to continue to promote the ‘natural balance’ between pure and applied research.

Summary

The horticultural section of the LTRS used methods of investigation different to the traditional procedures for carrying horticultural and agricultural experiments - the field trial – and conducted research in a laboratory environment. By experimenting with combinations of gases and temperature, Kidd established a new method of prolonging significantly the shelf life of horticultural crops that initially was called gas storage but in the 1940s became known as controlled atmosphere storage. Pure science research at the LTRS extended understanding of respiration, tissue structure and maturation of fruit and vegetables and added to the existing body of horticultural science knowledge. By addressing the fate of the crop in the period between harvest and reaching the consumer, the LTRS researchers contributed to the development of the cold chain and established a new field of investigation in the working world of horticulture, that later became known as post-harvest science.

The work carried out by the section also added knowledge to the body of established horticultural practice by showing that treatment of the crop during and immediately after harvest influenced storage life and that the physiological

[71] Minute sheet note headed ‘Secretary’, L. S. Lloyd, 8th January 1929, DSIR 6/99, NA.

disorders that could develop in storage had their origins in cultivation methods and soil and climatic conditions. Stations similar to the LTRS and gas storage facilities expanded nationally and internationally after the 1930s. One horticultural scientist from the USA in 1988 succinctly summed up the significance of this method of controlling the atmosphere of storage chambers for perishable goods by writing, 'it was a "biggy" for horticulture'.[72] Kidd's attitude towards the value and significance of his pure and applied science work is indicated in the talk he delivered to the British Association of Refrigeration in 1932 when he stated:

> The full development of the inherent possibilities of gas storage will take many years. This country is at present a pioneer and the leader in this matter of fresh food preservation. It is, I think, of not inconsiderable national importance that we should reap the benefits of the start that we have made[73]

An important factor explaining the nature of the work in the horticultural section of the LTRS were the tensions created by differing attitudes towards pure and applied science and towards the value of patents. Out of these tensions arose research in fundamental and applied science that supported growers and scientists, gave direction to horticultural research and helped horticultural science acquire academic status.

4.4 Rothamsted Experimental Station: 'a research machine ready to act'

E. J. Russell, Director of Rothamsted, believed his brilliant group of young

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[72] Letter from W. E. Ballinger to M. J. Bukovac, 20th July 1988, File on 75th Birthday Celebration, NIAB EMRL.
[73] F. Kidd, 'Gas Storage: A Review of the Present Position.' *Proceedings of the British Association of Refrigeration* (1932), XXIX, (2), pp. 130-146.

scientists, the good laboratories and the many contacts with producers had turned it into, ‘a research machine ready to act’.[74] The following section shows this was an apt summing up. The station has been portrayed as an institution concerned with the development of agricultural science.[75] I show that a significant number of the investigations that took place had relevance to horticulture as well as agriculture, particularly research on soils, weeds, plant nutrition, pests and diseases and ways to plan experiments and interpret data. Berry’s judgment that research at the RES was independent rather than collaborative and that the work of its statistician R. A. Fisher was not influential, is problematic.[76] What follows outlines the station’s collaborative involvement in horticultural science initiatives with institutions like Woburn Experiment Station, Imperial College of Science and Technology, CERS and EMRS. Rothamsted staff liaised with centres conducting field trials of crops and communicated with other research stations and commercial growers. As a recipient of DF grants, it was expected to collaborate with other scientists in order to share ideas and prevent duplication of research and the DC kept a watchful eye to ensure this did happen.[77] Moreover, Fishers’ ideas were adopted at East Malling Research Station and in the colonies.

The station, founded in 1843, maintained a predominantly agricultural science

[74] Sir E. J. Russell b), *The Land Called Me. An Autobiography*, London: George Allen and Unwin Limited, 1956, p. 135.
[75] Lord Ernle, *English Farming Past and Present*, London: Heinemann Educational Books, 1961, pp. 440-444. This section was a later addition by Alfred Daniel Hall; Russell a), op. cit. (5), see chapters 8 and 10; G. Parolini a), *“Making sense of figures”: Statistics, Computing and Information Technologies in Agriculture and Biology in Britain, 1920s-1960*, University of Bologna, PhD thesis, 2013, p. 12, p. 31, p. 36, pp. 40-46, p. 87.
[76] D. Berry, *Genetics, Statistics, and Regulation at the National Institute of Agricultural Botany, 1919-1969*, University of Leeds, PhD thesis, 2014, p. 89, p. 102, p. 115.
[77] *Report of the work of the Intelligence Department of the Ministry of Agriculture for the two years 1919-1921*, London: HMSO, 1922, p. 101.

profile until the end of the century.[78] Few historians of agricultural science have acknowledged the important changes that occurred in the nature of the research at Rothamsted in the early twentieth century.[79] Under the Directorship of A. D Hall, 1902-1912, and E. J. Russell, 1912-1943, botanists, mycologists, bacteriologists, entomologists, physicists and additional chemists were appointed and laboratories were improved and extended and up-to-date equipment was acquired which created new research opportunities in horticultural as well as agricultural science.[80] It became the most significant station between 1910-1930 of all the DC funded research institutes in Hall's system, in terms of facilities, staff numbers and research output. As a

Fig 4.5: Rothamsted Research Station New Laboratory 1915-16, *Annual Report 1915-17*, Harpenden: Rothamsted Experimental Station, 1918, p. 2.

Development Commissioner, Hall ensured the station was well supported.

[78] Russell a), op. cit. (5). See chapters 3 and 5.
[79] Russell a) op.cit. (5), See chapter 10; Parolini, op. cit. (75), has shown how R. A. Fisher transformed the way experiments at Rothamsted were conducted and analysed.
[80] Sir E. J. Russell c), *British Agricultural Research: Rothamsted*, London: Longman Green and Company, 1946, pp. 7-12.

Although consideration needs to be given to the fact that Hall was a former Director and had appointed his successor E. J. Russell, who was a friend sharing similar left wing beliefs, a key reason for this patronage was that was managed efficiently and gave direction to applied science. As I have indicated, Hall regarded pure science as the engine driving the system of Rothamsted for Hall represented the ideal research station where pure science research that he had created.[81] Under Russell's management staff were not directed as, 'as each had complete freedom to pursue his interests wherever they might lead'.[82] There was no other station that focused so effectively on pure science research and used the results to direct applied science investigations. The great output of research papers, an indication of the range of work carried out, served as the benchmark for the other stations in Halls system.

4.4.1 Soil and Plant Nutrition Research

In the nineteenth century the plant foods contained in the soil were studied at Rothamsted. The plant physiologist J. Lindley in 1840 believed 'spongioles' (new vascular tissue) on the roots absorbed liquid or gaseous 'food' that was composed of carbonic acid, nitrogen, certain earths and salts. J. B. Lawes at Rothamsted in the second half of the century promoted superphosphate as fertiliser and by the 1880s it was accepted generally that nitrogen, phosphate

[81] *Second report of the Development Commissioners, being the report for the year ended the 31st March 1912*, London: HMSO, 1912, pp. 7-8, D3/3, NA.
[82] A. G. Norman, 'Sir E. John Russell and the Call of the Land', *Soil Science* (1962), 94, (4), pp. 200-203.

and potassium were the major nutrients that plants needed.[83] A difficulty was finding adequate supplies of minerals that could supply these necessary nutrients.

During the late nineteenth and early twentieth century population expansion in industrialised nations had led to more intensive cultivation methods and a dependency on artificial fertilisers. As I have discussed in Chapter 2, existing sources of nitrates, also essential for making explosives, were declining rapidly and deposits of guano, a popular manure, were being depleted. Scientists in the United States, Canada and countries in Western Europe sought ways to supply nitrogen cheaply to growers and industrialists and were investigating sources of potash and phoshates.[84]

At Rothamsted between 1910-1930 a number of scientists investigated manures and fertilisers as part of fundamental research work. The declining horse population, caused partly by the rise of motorised transport and the deployment of horses in the First World War, had led to a shortage of dung for market gardeners, nurserymen and domestic gardeners. Russell believed dung conditioned soil used for intensive cultivation in a way that artificial fertilisers could not and directed his researchers to address the problem. They experimented with a range of 'natural ' fertiliser substitutes. Eventually, 'Adco' was developed, a product that turned straw into manure and was adopted

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[83] J. Lindley, *The Theory of Horticulture; or, an Attempt to Explain the Principle Operations of Gardening upon Physiological Principles*, London: Longman, Orme, Brown, Green and Longmans, 1840, p. 12, p. 20.

[84] F. Keeble a), 'Intensive Cultivation', *Nature* (1920), 106, (2661), pp. 293-296; Sir F. Keeble b), 'The Nitrogen Hunger of the World', *Proceedings of the Royal Institution of Great Britain* (1931-1933), XXVII, (131), pp. 824-848; E. H. Tripp and S. W. Cheveley, *A Century of Fertiliser Progress*, London: Dangerfield Printing Company, 1939, pp. 6-7, p. 29; G. J. Leigh, *The World's Greatest Fix. A History of Nitrogen and Agriculture*, Oxford: Oxford University Press, 2004, p. 20, pp. 120-151; G. T. Cushman, *Guano and the Opening of the Pacific World. A Global Ecological History*, Cambridge: Cambridge University Press, 2014, pp. 16-102.

widely by those unable to keep livestock.[85]

Winifred E. Brenchley, a graduate of Swanley Horticultural College and University College London and according to Russell, the first woman scientist to be appointed to an agricultural institution in the country, examined the effect on horticultural and agricultural crops of the application of minute doses of stimulants, labelled ‘catalytic fertilisers’.[86] This focus on the importance of the effect of applying very small doses of nutrients can be seen in the work being carried out on vitamins by nutritionists and physiologists. Researchers in horticulture, medicine and animal and insect physiology shared patterns of thinking about living things. The nutritional needs of plants, humans, animals, poultry, fish and bees were being compared as it was believed they all required small doses of substances, later called vitamins, that had beneficial effects disproportionate to their size.[87] Although progress had been made by the 1920s, despite seminal research by F. Gowland Hopkins between 1910-1922 and the investigations of others, in the mid 1920s vitamin research was, ’in a state of flux’.[88]

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[85] Russell c), op. cit. (80), p. 121-123; Sir John Russell FRS d) ‘Rothamsted and agricultural science’, *Nature* (1923), 111, (2788), pp. 466-470. Russell believed that, over time, dung was more effective than ‘artificials’ and introduced investigations to explore the differences.

[86] W. E. Brenchley a), *Inorganic Plant Poisons and Stimulants*, Cambridge: Cambridge University Press, 1914, p. 61.

[87] F. Gowland Hopkins, ‘A Lecture on the Practical Importance of Vitamines’, *The British Medical Journal* (1919), 1, (3043), pp. 507-510; Russell d), op. cit. (85), pp. 466-479; J. S. McHarge, ‘The association of manganese with vitamins’, *Journal of Agricultural Research* (1924), XXVII, (6), pp. 417-426; G. Samuel and C. S. Piper, ‘Manganese as an Essential Element for Plant Growth’, *Annals of Applied Biology* (1929), 16, (4), pp. 493-524; *Vitamins: A Survey of Present Knowledge*, London: HMSO, 1932, pp. 3-22; E. F. Burdett, ‘Vitamin E’, *The Bee World* (1932), XIII, (12), pp. 136-137; Professor Sir L. Hill and E. F. Burdett, ‘Fertility of bees and vitamin E’, *The Bee World* (1932), XIII, (12), pp. 137-138; H. H. Dale, ‘Frederick Gowland Hopkins 1861-1947’, *Obituary Notices of Fellows of the Royal Society* (1948), 6, (17), pp. 115-145.

[88] S. S. Zilva, ‘Recent Progress in Vitamin Research’, *Journal of The Society Of Chemical Industry* (1925), 36, pp. 445T-450T.

J. Davidson in the Entomology Department continued the work on plant micronutrients or vitamins in the search for fertilisers to improve crop yields. Brenchley had discovered in 1915 that both boron and magnesium produced some improvement in plant growth but her cautious approach did not lead to further investigations. In 1923 Davidson and staff in the Botany Department found, fortuitously, that in small quantities boron, later known as a trace element, was important for plant growth. Initially, it was found that in tiny amounts it enabled broad beans in water cultures to flourish and later it was discovered necessary for carrots and then all plants. This work stimulated investigations at Rothamsted into other elements that continued throughout the 1930s and 1940s.[89]

W. F. Bewley, H. B. Hutchinson and H. G. Thornton extended the Rothamsted investigations into ways to produce nitrogen cheaply by researching the bacteria Rhizobium that produced nodules on legume crops. Thornton, building on earlier laboratory investigations, found that legume root secretions stimulated Rhizobium to produce a secretion causing root hair deformity. The deformities became inhabited by the bacteria and some of these Rhizobium developed into 'bacteroids' (nodules) that were able to produce nitrogen for the legume. It was found that an absence of boron inhibited 'bacterioid' development. Further work led to the inoculation of the seed of lucerne, a common crop, with a specific form of this bacteria as it was discovered that lucerne bacteria was not distributed widely. Distribution was given to a firm of chemists and the inoculated seed became popular with farmers.[90]

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[89] Russell a), op. cit. (5), p. 305. A borax spray used to deter aphids was found to stimulate broad bean growth; 'Inorganic plant poisons and stimulants', *Nature* (1915), 95, (2377), pp. 314-315; K. Warrington, 'Boron in agriculture', *Nature* (1937), 140, p. 1016.

[90] Russell a), op. cit. (5), pp. 309-310.

Under Hall and Russell much of the soil research work at Rothamsted focused on how soil organisms and soil structure affected plant growth. Russell's team, composed of physicists, chemists, mathematicians and biologists, discovered that protozoa, algae and fungi inhabited the soil besides bacteria.[91] X-rays were used to study inorganic soil colloids and in the Physics Department soil-water relations were examined resulting in the discovery that water moved through the soil not via capillary tubes but through the cellular structure of pore spaces.[92] This pure research was an addition to the subject matter of both horticultural and agricultural science and provided a springboard for applied research, as the following two examples illustrate.

The earlier section on CERS explained that Russell acted as supervisor to the work that was carried out. There he solved the Lee Valley glasshouse industries' soil sickness problem by utilising the pure science research on soil microorganisms and made monthly visits to a glasshouse of one of the growers to check the progress of an applied science research programme that had been set up.[93]

Rothamsted staff worked with Woburn Fruit Farm Experiment Station, financed by the Duke of Bedford, on the topic of relationships of plants to the soil and shared data and specimens. At Woburn, research facilities were poor so scientists at RES analysed in their laboratories experimental plants in pots from Woburn in order to investigate toxic substances excreted by roots, which was seen as a promising area for enquiry.[94]

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[91] Sir E. J. Russell e), 'Soil Science in England 1894-1938', in Anon, *Agriculture in the Twentieth Century: Essays on Research, Practice and Organization to be Presented to Sir Daniel Hall*: Oxford: Oxford University Press, pp. 171-172.
[92] Russell c), op. cit. (80), p. 24.
[93] Russell b), op. cit. (74) p. 124.
[94] *Programme of the work at the Rothamsted Experimental Station for the years 1919-1920*, Rothamsted Experimental Station 1918-1944, 4/R/8/1, ARBGK.

4.4.2 Weeds, Pests and Diseases

Weeds reduced the yield of the crops cultivated by commercial horticulturalists, farmers, allotment holders and domestic gardener by competing for water, light and nutrients and they could offend the eye. Investigators at Rothamsted addressed this problem and their work contributed to a branch of horticultural research that later became known as weed science. Winifred Brenchley specialised in this aspect of horticultural science and became a leading weed scientist in the UK.[95] Brenchley, stationed in the Botany Department, collaborated with the Plant Physiology Department that in turn worked with the School of Botany at Imperial College in order to carry out pure science research on the physiology of plants growing in field conditions.[96] Russell had provided land at the station to accommodate the scientists from Imperial and allowed them to construct a small laboratory to undertake experiments not possible in London.[97] Using this research as a starting point, Brenchley investigated chemicals to find those that were most toxic to weeds. She developed and promoted cultural control methods that involved sowing weed free seed, preventing weeds from forming seeds and cleaning equipment and her methods of eradication encompassed mechanical cultivation, spraying with copper, sulphur, arsenic and salt and the deployment of insect and fungal weed parasites.[98] A national weed survey was undertaken and she liaised with schools and colleges in order to obtain data for analysis.

An innovative piece of research resulting from Benchley's extensive and

[95] E. J. Russell f), 'Dr. Winifred Brenchley O.B.E', *Nature*, (1953), 172, p. 936.
[96] *Programme of the work at the Rothamsted Experimental Station*, op. cit. (94).
[97] Russell a), op. cit. (5), p. 306.
[98] W. E. Brenchley b), *Weeds of Farm Land*, London: Longman, Green and Company, 1920.

meticulous study of weeds in grass plots was the investigation of weed seed populations in the soil, their spread vertically and their dormancy and longevity. The idea of a weed seed bank developed from this work and led to efforts to determine appropriate tillage depths in relation to the various weed seed strata in the soil.[99]

A great deal of pure and applied research was undertaken to obtain a better understanding of the life cycle and migratory behaviour of pests and diseases and develop effective means of control using insecticides, fungicides and 'natural' methods. Rothamsted scientists worked with the Imperial Bureau of Entomology to develop biological controls, as the Bureau was keen to promote natural methods on dominion plantations.[100]

Attempts were made to understand the nature of the virus diseases affecting fruit and vegetable crops, using up-to-date microscopes to examine plant tissues. Potato leaf curl was causing yield losses and aroused a great deal of attention, as spray programmes were proving ineffectual. At the International Potato Congress in 1921, A. D. Hall stated that he believed the way forward was to search for immune varieties and after 1922 a marked number of research stations and sub-stations endeavored to find resistant varieties of potato.[101] The virus research at Rothamsted was part of this upsurge in interest and J. Henderson Smith and others, using new facilities that had been financed by the EMB, began more detailed investigations in 1928.[102] By 1930 it had been established that aphids were a vector and it was believed that aphid control

[99] Russell a), op. cit. (5), pp. 303-304.
[100] *Programme of the work at the Rothamsted Experimental Station*, op. cit. (94).
[101] R. N. Salaman, 'Outlines of the History of Plant Virus Research' in Anon, *Agriculture in the Twentieth Century: Essays on Research, Practice and Organization to be Presented to Sir Daniel Hall*: Oxford: Oxford University Press, 1939, pp. 261-289; A. D. Hall, 'Inaugural Address,' in W. R. Dykes (ed.), *Report of the International Potato Conference*, London: Royal Horticultural Society, 1921, pp. 12-15.
[102] Russell a), op. cit. (5), p. 323.

could help reduce virus outbreaks.

4.4.3 The Design of Experiments

A number of horticultural and agricultural scientists in the first decade of the twentieth century, including Spencer Pickering of the Woburn Fruit Farm Experimental Station, T. B. Wood Professor of Agriculture at Cambridge, A. D. Hall and E. J. Russell had raised doubts about the way horticultural and agricultural experiments were designed and analysed.[103] They spoke at a one-day symposium on the subject organized in 1911 by the British Association for the Advancement of Science and in a report of the day, *Nature* commented that designing and interpreting experiments was more difficult for scientists working in horticulture than it was for agricultural scientists because there was more variation in the subject matter that was being examined.[104]

E. J. Russell was eventually able to establish a statistical department at Rothamsted in 1919 with R. A. Fisher as Head of Department. Fisher was given the task of interpreting the data of agricultural experiments that had begun in the nineteenth century and concluded that it was not possible to ascertain whether the differences between experimental plots was because of the treatment or because of factors such as soil and variety.[105] To overcome this, Fisher used a design based on Latin squares where a process of randomization assigned treatments to the plots in the square and developed

[103] 'Experimental error in agricultural investigations', *Nature* (1912), 89, (2213), p. 97. Often, analysis of data was based on principles of correlation.
[104] *Experimental error in agricultural investigations*, op. cit. (103).
[105] Sir John Russell h)**,** *The contribution of Sir Daniel Hall to the development of agricultural science*, Wye: Wye College, 1954, p. 16, HERT 11/8/247, MERL.

a method of interpreting results that relied on analysis of variance.[106]

Initially Rothamsted scientists were sceptical about this use of mathematics to plan investigations but Fisher had many one to one discussions with the different departments and his methods gradually became accepted and adopted.[107]

Fisher gave a great deal of assistance to H. J. Hoblyn at East Malling Research Station and fruit tree experiments were set up based on Fisher's methods and Hoblyn visited Rothamsted often to observe Fishers' work and discuss ideas.[108] Scientists from other countries came to see Fisher at Rothamsted to learn about his methods and after being used in experimental work on rubber plantations in Malaysia they were adopted in Africa and India.[109]

Summary

Rothamsted willingly responded to requests from the government and other research establishments and became ' a research machine ready to act'. Under the direction of Hall and then Russell, it began a range of new investigations that emphasised the importance of understanding the factors affecting the growth and yield of crops and became a model for all other research stations that were funded by the DC. It was the largest of these institutions in terms of facilities and staffing and this enabled it to undertake investigations in

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[106] E. M. Crowther, 'The techniques of modern field experiments', *Journal of the Royal Agricultural Society of England* (1936), 97, pp. 54-81.

[107] J. F. Box, *R. A. Fisher: The Life of a Scientist*, New York: John Wiley and Sons, 1978, pp. 131-132.

[108] D. J. Finney and F. Yates, 'Statistics, computing and agricultural research' in G. W. Cooke (ed.), *Agricultural Research 1931-1981. A History of the Agricultural Research Council and a Review of Developments in Agricultural Science During the Last Fifty Years*, London: Agricultural Research Council, 1981, pp. 219-236.

[109] Finney and Yates, op. cit. (108), p. 229; Crowther, op. cit. (106), p. 76.

horticultural science besides its work in agricultural research. Much of the latter also had relevance for horticulture.

The work on soil science established the presence of other organisms besides bacteria and showed how water moved through the soils cellular structure. Research on plant nutrition led to the development of a method of turning straw into manure, the discovery of the importance of boron and showed how bacteria on legume roots helped make nitrogen available for plants. Pest and disease research presented ideas for the control of weeds and showed how weed seeds could remain active in the soil for long periods. Biological control methods were developed for weeds and insect pests and it was found that aphids were a vector for some virus diseases. New ways of designing and interpreting experiments were promoted.

The examples of the research that took place, a sample only of the range of investigations, were governed by the principle that pure science informed applied science research. The information and ideas that resulted were used to assist scientists at other institutions and commercial growers. Far from being an institution that desired isolation, its function was enriched through the interaction it fostered with scientists in other research establishments and with cultivators in the commercial sector.

4.5 Other Research Stations

To complete the picture of research station activity I give a brief summary of the work of the research stations conducting horticultural science investigations between 1910-1930, that I have listed but not discussed fully. Forestry research at Oxford University focused on forestry management, physiology, morphology and pest and disease control. A number of stations, such as those at Wisley, Norfolk, Kirton, Botley, Ellbridge and Cockle Park specialised in fruit and vegetables. Work here covered the production of new varieties and trials of existing varieties to establish reliable nomenclature and pest and disease management and some undertook various investigations for other research stations. The Imperial Bureau of Mycology and the Silver Leaf Research Station focused on plant diseases of commercial crops and examined aspects of prevention and cure.

The John Innes Horticultural Institution, with an international reputation, undertook research on breeding flowers, fruit and poultry and investigated plant pests and diseases and methods of control, soil capability, techniques of heating soil and pigments in flowers.[110] At Dartington Hall, Jealott's Hill and the Macaulay Institute, researchers examined the characteristics of soils and the fertilisers that were most beneficial for certain crops and soil types. The life history, variety and control of soil nematodes was the subject of research at the Institute of Agricultural Helminthology and at the Willow Research Station investigators focused on nomenclature, varieties suitable for making baskets and cricket bats and the control of pests and diseases of willows.

Tillage machinery for cultivating top soil, sub-soil and controlling weeds and machines for crop harvesting were developed and tested at the Institute of Agricultural Engineering whilst at St Ives Research Station investigators looked at the most appropriate grass mixtures for different types of lawn and different types of soil, fertilizer regimes and pest and disease management.

The growth, reproduction and preparation for market of bulbs and their pests and diseases were main lines of research at the Scilly Isles Station.

[110] The John Innes Horticultural Institution 2, 1909-1915, ARBGK.

Summary

I have shown that a wide range of investigations and experiments took place in horticultural science at experimental stations that were expanding in number. The scope of investigation was extensive but little detailed information is known about the origin and work of a large number of these stations. In particular, there is a lack of detail about the overlap with investigations carried out at agricultural science research stations.

4.6 Conclusion

The research structure created by A. D. Hall was influenced considerably by his belief in the importance of pure and applied science research. Pure science provided a fund of knowledge that researchers made use of when designing applied science investigations.

A variety of applied science investigations were conducted at the research stations, ranging from the electrification of crops and insect pests to the use of carbon dioxide to stimulate plant growth, as the working world of horticulture looked to science to solve production problems. Researchers devoted a great deal of attention to factors that influenced yield and output, such as nomenclature, soil conditions, plant nutrients, pest and diseases, weeds, rootstocks, pruning methods and the storage of produce before reaching the consumer. There were also attempts to use Mendelian techniques to produce new varieties but the lack of progress caused researchers to look instead for varieties with a natural resistance to pests and diseases and to raise these for distribution.

My work on horticultural research institutions has shown the importance placed on communication in the period 1910-1930. There were strong lines of communication between Imperial College, Rothamsted, CERS, EMRS and LARS. Some of this interaction was about the relationship between fundamental research and applied science investigation, although not a great deal is known about these channels and further research is needed to gain a more comprehensive picture of the nature of the work discussed and the hierarchical relationships that developed.

A feature of many of the government stations were the efforts made to accommodate visitors, give lectures to growers and amateur gardeners on aspects of their research, answer queries and make personal visits to assist with problems: this was additional to research schedules. By popularising science in this way the researchers at these stations raised their profile with growers and gained goodwill and status. These interactions and the other lines of communication mentioned in the foregoing were a significant feature of horticultural science research in the period 1910-1930.

F. W. Keeble, a champion of horticultural science as a distinct discipline, wrote in 1920 that he hoped the research stations would become, ‘a living, plastic, resourceful, directive force - a horticultural cerebrum’ capable ‘of bringing horticulture to a pitch of perfection undreamed of, either in this country or elsewhere’.[111] As the foregoing has shown, by 1930 the research stations had produced, cumulatively, some of the impact Keeble desired.

[111] Keeble a), op. cit. (84).

Chapter 5

The Horticultural Branch of the Board of Agriculture and Fisheries

Chapter 5 details the role played by the Board of Agriculture and Fisheries (BAF) created in 1903, which became the Ministry of Agriculture and Fisheries (MAF) in 1918, in the promotion of horticulture and horticultural science in England. Historians who have written about the Board and the Ministry have paid little attention to the part both played in the patronage of experimental horticulture.[1] I show that the government established a Horticultural Branch in 1912 in the Intelligence Department of BAF, which became a Horticultural Division in 1919, in order to control more effectively pests and diseases of horticultural crops and carry out its own horticultural investigations and research. Chapters 3 and 4 indicated how BAF assisted the Development Commission (DC) to create a national system of horticultural, agricultural and fishery research and education. I now examine the work of BAF in more detail. Chapter 6 continues this narrative by considering the part played by the

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[1] The following literature on agricultural history and agricultural science history has not dealt with this aspect of the governments work: Lord Ernle, *English Farming Past and Present*, London: Heinemann Educational Books, 1961; Sir J. Winnifrith, *The Ministry of Agriculture, Fisheries and Food*, London: George Allen and Unwin Limited, 1962; R. C. Olby, 'Social Imperialism and State Support for Agricultural Research in Edwardian Britain', *Annals of Science* (1991), 48, (6), pp. 509-526; Sir E. J. Russell, *A History of Agricultural Science in Great Britain 1620-1954*, London: George Allen and Unwin Limited,1966; E. H. Whetham (ed.), *The Agrarian History of England and Wales. Volume VIII. 1914-1939*, Cambridge: Cambridge University Press, 1978, pp. 75-87, pp. 273-294; P. Palladino, 'The Political Economy of Applied Research: Plant Breeding in Great Britain, 1910-1940', *Minerva* (1990), 28, (4), pp. 446-468; P. Brassley, 'Agricultural Research in Britain, 1850-1914: Failure, Success and Development', *Annals of Science* (1995), 52, (5), pp. 465-480; K. Vernon, 'Science for the Farmer? Agricultural Research in England 1909-1936', *Twentieth Century British History* (1997), 8, (3), pp. 310-333; P. Brassley, 'Agricultural Science and Education' in E. J. T. Collins and J. Thirsk, (eds.), *The Agrarian History of England and Wales, Volume VII, 1850-1914*, Cambridge: Cambridge University Press, 200, pp. 594-649.

Board and Ministry in horticultural science education.

I explain how the BAF and the MAF encouraged a wide range of horticultural science activities and show the government was instrumental in associating apiary, discussed in more detail in chapter 9, and the rearing of poultry with horticulture and horticultural science. As I have stated, apiary and poultry were included in the brief of the Horticultural Branch because it was felt they were 'more closely related to horticulture than to agriculture'.[2] Bees pollinated orchards and provided marketable honey, poultry ate insect pests on cultivated land and were a source of eggs and meat. Smallholders, market gardeners and domestic horticulturalists could manage both on a small scale. I have also indicated the government believed the maintenance of goats, pigs, rabbits, hares and pigeons were horticultural activities.[3] Commercial poultry raising remained with the Division well into the second half of the century. The encouragement of the hobby activities of allotment cultivation, bee keeping and rabbit and goat rearing became later the responsibility of the Ministry of Land and Natural Resources, whilst the Division looked after their commercial production.

The administrative area of the Board and the Ministry was England and Wales and in order to promote and support research in horticultural and agricultural science in Scotland, the government created the Board of Agriculture for Scotland (BAS) in 1911. In Ireland, the Department of Agriculture and Technical Instruction (DATI), founded in 1899, performed a similar role.[4] Not a great deal

[2] File headed, Horticultural Branch August 1912, MAF 39/88, NA.

[3] The Government wanted to encourage small-scale rural industries. Goats gave milk, which could be consumed or turned into cheese and provided wool and meat, rabbits were a source of meat and fur and hares, pigeons and pigs were for consumption.

[4] Both organisations encouraged research into aspects of horticultural science, produced and distributed horticultural science literature and funded horticultural science education. Their relationship with the Board and Ministry of Agriculture staff

has been written about the history of the Scottish Board and the Irish Department and little is known about the part they played in shaping horticultural science. To fully include their work in this chapter would mean, as I have emphasised previously, extending too far both the time and word limit of the thesis. Although reference will be made to the activities of these two institutions, there is not a detailed examination of their support of horticultural science.

The Board and Ministry and its Horticultural Branch and Division interacted closely with growers to address the problems of this working world and resources were directed to provide solutions. The laboratory of the Horticultural Branch set up by the Board was geared towards solving difficulties faced by those cultivating fruit, vegetables, flowers and ornamental plants for the market. Government officials were mindful of the need to improve quality and yield to increase the nation's food supply.

In the first section I discuss the Horticultural Branch and later Division and their work in pest and diseases control and the remaining sections consider briefly poultry rearing, the establishment of the Official Seed Testing Station and the investigation of manures and fertilisers. By outlining these aspects I provide further illustration of the wide range of horticultural science activities undertaken in this period. Additionally, focussing on these problem-generating areas helps to reveal government attitudes towards horticultural science and the strategies the Board and Ministry used to achieve their aims.

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and the Development Commissioners was generally amicable, although on occasions they were not always as co-operative as the Commissioners had wanted. Some of the work carried out by the Board and the Ministry of Agriculture and these two institutions was identical, for example, promoting horticultural education, enforcing pest and disease legislation, conducting research into soils, manures, pests and diseases, seed purity and germination, supporting research stations and fostering scientific forestry.

5.1 The Horticultural Branch

T. H. Middleton, Assistant Secretary of the BAF, welcomed the Horticultural Branch. He believed, with justification, that the Board of Agriculture (1889-1903) in the past had lost sight of the specific needs of the horticultural industry in its pursuit of purely agricultural matters. Middleton wanted the Branch to disseminate knowledge about plant varieties, the nature of the soil, the effects of manures, the treatment of fruit trees, the techniques for controlling diseases and pests, manage pest and disease legislation and develop the horticultural industry, particularly its export trade. It was also directed to collect and co-ordinate information and data, publish articles and leaflets based on scientific research aimed at commercial and household growers and answer horticultural queries.[5]

Commercial growers approved of the new Branch and press comments were mostly favourable. *The Times* in June 1912 was enthusiastic and congratulated the President of the BAF for recognising horticulture as an industry separate from agriculture and advised that officials needed to be experienced in science and *The Standard* in May 1912 stated that for the first time horticulture would be acknowledged by the Board of Agriculture as being of the same importance as animals and agriculture, although it doubted that very little of what was proposed was new and considered the grant given was too small to be

[5] Memorandum from T. H. Middleton to the Secretary of the Treasury, 22nd May 1912, Proposed Horticultural Branch, MAF 39/88, NA. Middleton was an experienced and capable scientist, having been a Professor of Agriculture at Baroda College, India, Durham College of Science and Cambridge University and held degrees in engineering and agriculture. The Branch had to address also the feeding habits of birds in order to identify crop predators.

effective.[6] The doubts of *The Standard*, as this section will show, proved to be unfounded.

The Horticultural Branch had two main divisions, an administrative unit based in London that dealt with pest and disease legislation and a pathological laboratory, located initially at Kew, Richmond and later at Harpenden, Hertfordshire, which acted as a coordinating centre, but also undertook some experimental and investigatory work in the laboratory and the surrounding grounds. The Director and his team referred to it in minutes and journal articles as the, 'Phytopathological Service'. Staff in the Intelligence Division of the Board who had previously worked on pest and disease legislation transferred to the new Branch. An entomologist, an inspector with horticultural qualifications and an inspector with scientific qualifications were recruited.[7] Later, the number of laboratory scientists was increased. The Board wanted the Branch to have able, well-qualified staff with the ability to specialise in a particular aspect of horticultural science, such as apiary, and keep up to date with technical developments. It engineered a mix of experienced staff to act as role models and younger staff possessing the potential to develop their role. The majority of key personnel possessed a degree in natural science from Cambridge or Oxford University.[8]

Staff made use of the findings of the laboratory work in entomology and mycology carried out at research stations set up by the Development Fund (DF) and utilised the aboricultural work on pests and diseases conducted by institutions given grants for forestry research by the DC and the scientific

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[6] Information from the newspaper cuttings pasted in the Memo file, MAF 39/88, NA. With Development Commission funding, the concern expressed by *The Standard* turned out to be exaggerated. Almost all of the trimmed cuttings do not show the date.

[7] Letter from W. Runciman to T. Elliot, 15th May 1912, MAF 39/88, NA.

[8] Document headed, 'Mr Middleton. Papers attached', 28th June 1912, MAF 39/88, NA.

investigations of the Forestry Commission. The horticulture branch was in contact with officials in the counties who had been appointed to oversee the application of pest and disease legislation or provide horticultural and agricultural advice. The horticultural division drew upon the resources, expertise and findings of all of these components to inform its policies, procedures and initiatives and its interactions with growers.[9]

5.1.1 Government Concerns about Plant Pests and Diseases

The references made to contagious diseases of cattle and crops and the pests of plants in the BAF minutes and memorandum of the early 1900s show these matters were of increasing concern. Cattle plague, potato blight and the vine fungal disease caused by the *Phylloxera* aphid were of particular interest. There was no effective preventative treatment or cure for these plant diseases despite the, 'great increase in spraying in recent years'.[10] To protect cattle the government introduced the 1869 Contagious Diseases (Animals) Act and an additional Act in 1878. Clarke has shown governments feared potato crops would be ruined if the Colorado beetle entered the ports on imported parts of the potato plant and sightings occurred at the docks of Liverpool in 1877 and at Tilbury, London in 1901. The Destructive Insects Act of 1877 empowered the government to prevent potato imports and destroy any infected crops and the Act was enforced at Tilbury.[11]

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[9] J. C. F. Fryer and G. H. Pethybridge, 'The Phytopathological Service of England and Wales', *Journal of Ministry of Agriculture* (1925), 31, pp. 331-340.
[10] In particular, see the files and the note headed, Synopsis of Case for a Destructive Insects Act, MAF 43/3, NA.
[11] J. M. F. Clark, 'Beetle Mania: The Colorado Beetle Scare of 1877', *History Today* (1992), 42, (5), pp. 5-7; J. M. F. Clark, *Bugs and the Victorians*, New Haven: Yale University Press, 2009, pp. 132-152.

Outbreaks of virulent American gooseberry mildew in the UK in the years 1904-1907 devastated this important economic crop and stimulated government action. In 1907 the Destructive Insects and Pests Act was passed which extended the Act of 1877 by including, 'any insect, fungus, or other pest destructive of agricultural and horticultural crops'. Acts were reinforced by Orders that applied to individual crops and were an attempt to control local outbreaks.[12] This pest and disease history and the response of previous governments were eschewed by the BAF when developing policy and strategies to control horticultural pests and diseases in the period 1910-1930. It was anticipated that scientists in the laboratory unit would keep the service abreast of current knowledge of pests and diseases through intelligence gathering, the encouragement and support of experiments conducted by other institutions and its own experiments and investigations.

The Liberal Government and officials in BAF who were setting up this protective legislation recognised the increasing importance to the economy of fruit growing, market gardening and nursery production and wanted to safeguard commercial growers from financial loss. Additionally, pest and disease legislation was one strategy that could be used by the government to disadvantage competing horticultural industries in other countries. It was pointed out in 1913 that the value of bulbs, plants and roots exported was worth £105,000 and the value of potato exports was £1,400,000 and that much of this trade had been lost because disease had ruined crops. Epidemic and endemic diseases, it was claimed, was causing as much injury to the growth of plants as cattle diseases had caused to stock raisers. It was argued that thanks to the BAF, great effort had been made to safeguard successfully livestock exports

[12] MAF 43/3, NA. This contains information about the 1907 Act.

through disease legislation, yet the value of the protected animals had never exceeded £500,000. Some believed the same help should be extended to horticulture, which generated greater income.[13]

Board officials were also critical of the existing system of pest and disease control, which relied heavily on local authority policing. One commentator thought it ineffective, cumbersome and wasteful because it depended too much on county council staff who could not devote all of their time to pests and diseases because of the varied requirements of their post. Another stated that in six counties the inspectors appointed to carry out inspection work had done very little. Although these critics were advocating more extensive central government control and so had a vested interest in the Board of Agriculture and Fisheries administering the system, they were right to draw attention to the lack of efficient co-ordination, the absence of central government authority at the local level and the potential of a team of full-time, well organised, well-trained and accountable central government officers.[14] It was feared imported fruit, vegetables and ornamental plants could harbour pests and diseases that could cause serious outbreaks.[15] Others pointed out there was a real possibility that insects or fungal spores could escape from the laboratories of the research stations in the country and it was suggested that private collectors could smuggle in insects, which if released accidentally, could damage crops

[13] Note by T. H. Middleton 29th January 1913 on the memorandum headed, 'Destructive Insects and Pests Act' and the typed memorandum note unsigned and undated, MAF 43/3, NA.
[14] Memorandum note covering local authority staff, unsigned and undated, MAF 43/3, NA.
[15] *Report of the work of the Research and Education Division for the year 1926-27* a), London: HMSO, 1928, p. 85; *Report of the work of the Research and Education Division for the year 1928-29* b), London: HMSO, 1930, p. 9.

considerably.[16]

5.1.2 The plant 'doctors'

The statement by T. H. Middleton that the Inspectors appointed to monitor and enforce pest and disease legislation were plant 'doctors' was a status claim. Veterinary surgeons were employed in the Animal Division of the BAF and Middleton argued that in plant disease work, 'there is no profession corresponding to Veterinary Surgeons'.[17] Middleton and his colleagues had chosen well-qualified candidates which meant they could cope with the technical nature of the work and planned extensive training was going to turn them into experts, equal to veterinary surgeons. It was important the new branch possessed high quality staff that could contribute to successful outcomes. The core team of plant 'doctors', proficient at diagnosing outbreaks of disease and pests by being able to recognise symptoms not just in a laboratory but out in the field amongst a large population of growing plants and possessing current knowledge of the characteristics and life history of pests and diseases and pest and disease legislation of other countries, provided the new Branch with scientific credibility.[18]

It was recognised there was a shortage of scientists willing to enter this type of employment and so candidates with horticultural knowledge were appointed

[16] Note by J. C. F. Fryer, 14th January 1927 on the memorandum sheet, note by G. H. Pethybridge 14th January, 1927 on the memorandum sheet, note by J. C. F. Fryer, 28th February 1927 on the memorandum sheet and the note by J. C Fryer, 27th April 1929 on the memorandum sheet, MAF 43/32, NA.

[17] Document headed, 'Mr Middleton Papers Attached' 28th June 1912, MAF 39/88, NA.

[18] Memorandum from T. H. Middleton, 1912, op. cit. (5).

as sub-inspectors and training was provided.[19] Twenty-five of these were employed in 1914, increasing to thirty by the mid 1920's. After one year of training they sat civil service examinations covering elementary arithmetic, plant pests and diseases, legislation concerning pest and disease control, English composition and writing from dictation.[20]

The inspectors enforced the Acts mainly at the ports, to prevent entry of pests and diseases, and the Orders were applied on a regional or more local basis to prevent transmission of pests or diseases to nearby crops.[21] Documents were issued to certify that stock was clean if a grower wanted to move crops or stock out of a contaminated area. Inspectors had to be satisfied that stock identified as infected was disposed of in accordance with the regulations. After 1914 the Branch was solely responsible for this work as it was taken out of local authority control. Diseased areas needed visiting several times and required monitoring over one or two growing seasons to ensure that orders were being followed. To carry out this work efficiently a plant 'doctor' needed, besides powers of observation, the skill of diplomacy and the ability to persuade growers and local authority officials of the need for action. Inspectors issued health certificates for plants or produce being exported and examined imports for signs of infestation and carried out documentation checks.

Vigilance was necessary as pests and diseases on mainland Europe that could invade the UK had to be tracked, dialogue with other governments had to take

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[19] T. H. Middleton memorandum note, Proposed appointment of sub-inspectors, 24th November 1913, MAF 43/3, NA.

[20] Memorandum note, Destructive Insects and Pests Acts. Administration, 20th December 1913, MAF 43/3, NA.

[21] Both the Acts of 1907 and 1927 and the Orders identified the horticultural products that needed protection. Some Orders were very similar to the Acts in having a broad perspective whilst others focused more on local procedures. In one sense, the Acts were statements of intent addressed to the international community whose horticultural industries were seen as competitors and rivals whereas the Orders were statements of intent aimed at home producers and local authorities.

place and both actual and contingency plans had to be drawn up. In 1921 when the inspection system, the 1907 Act and some of the Orders were beginning to show results, Alfred Daniel Hall, Chief Scientific Adviser to the Ministry, believed much more needed to be achieved because he felt the country was a dumping ground for all of the diseased stock of the Continent and envisaged it was possible that new diseases could be introduced at any moment.[22] The monitoring of the outbreak of Colorado beetle on potato crops in France in 1922 and Canada in 1924, the mapping of the movement of raw cherries throughout France because the fruit and containers were infested with cherry fruit flies and the action taken to prevent the entry of imported apples from the USA containing fruit fly larvae, illustrate this vigilance.[23]

The diseases that generated the greatest concern and captured most of the attention of the plant 'doctors' were onion smut, celery leaf spot, potato blight and wart disease, silver leaf disease of plums and American gooseberry mildew. Virus infections were also a problem. Significant pests were apple sawfly, big bud mite of blackcurrants, white fly, red spider mite, bulb eelworm and aphids. All of the aforementioned could attack crops outdoors or under glass. Although insects pests were problematic and caused considerable crop damage, most of the Orders were concerned with fungus disease.[24] Possibly, scientists and growers felt more secure with sprays and powders to combat pests but were less confident about attack by fungi and felt that legislation to

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[22] Memorandum headed Agricultural Advisory Committee for England and Wales, 13th April 1921, MAF 43/3, NA.

[23] See the memorandum notes, letters and reports in MAF: 43/3, 43/4, 43/5, 43/6, 43/13 and 43/14, NA; *Report of the work of the Intelligence Department of the Ministry of Agriculture for the two years 1919-1921* a), London: HMSO, 1922, p. 152; *Report of the work of the Intelligence Department of the Ministry for the three years 1921-24* b), London: HMSO, 1925, p. 142; *Report of the work of the Research and Education Division for the year 1926-27* a), London: HMSO, 1928, p. 5; *Report of the work of the Research and Education Division for the year 1928-29* b), London: HMSO, 1930, p. 9.

[24] See the memorandum notes, letters and reports in the listed MAF files, op. cit. (23).

promote demarcation areas and crop destruction were the only practical methods to deal with outbreaks. All of the crops noted above were grown widely and had much commercial value. The amount and focus of legislation (and research investigations) varied according to the economic importance of the crop - when onions were in great demand and growers were very vocal in calling for government action the crop received much legislative protection but when onion acreages fell markedly and celery became a highly marketable product, the government put onion legislation on hold and introduced Orders to safeguard celery crops, effectively responding to working world problems.[25]

Summary

The Horticultural Branch and Division of the BAF and MAF were part of the comprehensive system of state horticultural science research and education designed to support commercial horticulture. The Destructive Pests and Disease Act of 1907 and the Act of 1927, which included virus diseases, and the 40 Orders passed between 1907-1930 added to knowledge of pest and disease control. Horticultural science was shaped, firstly, by the emphasis given to studying and monitoring the movement of pest and diseases nationally and internationally and secondly, through the recognition of the need to have a much greater knowledge than was currently available of their life cycles, in order to protect growers from financial loss.[26]

Officials in the Ministry felt, justifiably, that achievements had been made and it

[25] Ministry of Agriculture and Fisheries, *Agricultural statistics, Volume 51, Part 1*, London: HMSO, 1927, p. 20.

[26] It was thought the inclusion of viruses would make pest and disease control secure. See the note by Taylor on the Minute Sheet 23rd January 1925, MAF 43/3, NA. The government also began a scheme to certify that certain plants were from virus free stock.

was pointed out that the Orders were innovative because for the first time a 'clean seed policy' had been inaugurated for plants and produce.[27] H. E. Dale, Secretary to the Development Commissioner, author of the official reviews of horticulture and agriculture that appeared after 1927 and a reliable observer, believed the incidence of potato wart disease had been reduced, there were fewer prosecutions for flouting the Destructive Insects and Diseases Act and the Orders and, in an uncharacteristically humorous but telling aside, reported that one research station could not find sufficient diseased plant material for an experiment and so had to abandon the research.[28] This state commitment to horticulture is revealed in the comment of an official who stated, 'one of the most important functions of government is to provide adequate protection from the inroads of the disease of plants'.[29]

5.1.3 The 'Phytopathological Service'

I have indicated that the Director and chief mycologist of the pathological laboratory described their unit as the 'Phytopathological Service'. I build on the

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[27] A flavour of the nature and extent of this work is indicated by the following. Inspections of wart free potato varieties in England 1918-1920 covered 20,656 acres, between 1928-1930 approximately 6500 visits were made to nurseries, markets and auctions to monitor the sale of diseased plants, 545,660 black currant bushes were inspected for big bud mite in 1928-29 and 82,573 health certificates covering imports and exports of plant and horticultural produce were issued between 1929-1930. See: *Report of the work of the Intelligence Department* a), op. cit. (23), p. 10, p. 29; *Report of the work of the Research and Education Division*, a), op. cit. (23), p. 29; *Report on the work of the Research and Education Division* b), op. cit. (23), p. 32, p. 35; *Report of the work of the Research and Education Division for the year 1929-30* c), London: HMSO, 1931, p. 37. Often, though, Orders for the same disease or pest were attempts to shore up loopholes that the compilers of previous orders had not anticipated.

[28] *Report of the work of the Intelligence Department* b), op. cit. (23), pp. 18-19; *Report of the work of the Research and Education Division* a), op. cit. (23), p. 29; *Report of the work of the Research and Education Division* b), op. cit. (23), p. 37.

[29] *Agricultural Policy*, London: HMSO, 1926, p. 6, in papers of the Cabinet Agricultural Sub-Committee 1927-28, MAF 53/78, NA.

work of Brassley who has drawn attention to scientists investigating the pests and diseases of British agricultural crops in the period 1850-1914 and has considered how investigators perceived the problems they faced and how they dealt with them.[30] The focus here is horticulture rather than agriculture, although pests and diseases that attacked both horticultural and agricultural crops are discussed. I extend Brassley's ideas about what contemporaries understood about the biology of these pests and show that by 1930 central government had developed a well-organised system of plant pest and disease control that was based on a number of sciences, including horticultural science.

In 1918 the Horticultural Division established a laboratory in two cottages on Kew Green. It functioned predominantly as a station for collecting and distributing information about pests and diseases. Prior to this the BAF had developed a special arrangement to use the entomologists and mycologists at the Royal Botanic Garden, Kew. Chapters 3 and 4 indicated the research stations conducted a range of long-term experiments and investigations and some addressed the action of insecticides and fungicides, the identification and life cycle of pests and diseases and the nature of disease resistance. The Laboratory scientists, through their investigations and a small number of their own experiments, provided the crucial scientific basis for the Acts and Orders. In 1922 the unit moved to the new Laboratory at Harpenden and used the improved facilities to extend this work.

[30] P. Brassley, 'Weeds and Pest Control' in Collins and Thirsk, (eds.), op. cit. (1), pp. 548-554. Historians of science have paid little attention to entomology and mycology has been neglected. This is surprising considering their importance to horticultural and agricultural science.

5.1.3.1 Advisory Work

At Harpenden the senior entomologist and mycologist set up a pest and disease monitoring system covering England and Wales. Designated centres, that were part of the DF research station programme, reported monthly to Harpenden on special forms about the pests and diseases in their area, describing the organisms and the nature of outbreaks. The documentation and tracking data were used to inform both laboratory investigations and policies on control and containment. In the mid 1920's G. H. Pethybridge succeeded J. C. Cotton as chief mycologist, the chief entomologist was J. C. F. Fryer and there was an assistant entomologist and an assistant mycologist. This small team managed the pest and disease work, with Fryer later becoming Director. Regular conferences were held for the chemists, entomologists, mycologists and plant physiologists employed as regional advisers at colleges and universities and local authority officers engaged in pest and disease control. The team supported new staff in the London section and at local authority colleges and farm institutes. The conference format was favoured as horticultural scientists and growers could be brought together conveniently. The network of correspondents included Ministry advisers and civil servants, the Official Seed Testing Station, researchers and professors in colleges and universities, the John Innes Horticultural Institution, private individuals and phytopathological services abroad; it kept the laboratory up-to-date with current research. In discussions with senior civil servants about the framing of legislation the plant 'doctors' utilised this intelligence gathering.[31]

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[31] E. C. Large, 'Obituary notice. Dr Geo. H. Pethybridge', *Annals of Applied Biology* (1949), 36, (3), pp. 414-417; A. E. M, 'Dr George Herbert Pethybridge, O.B.E; PhD;

Work was carried out on disease and insect identification. Specimens were sent to Harpenden by inspectors in the administrative arm, domestic gardeners, gardeners associations, allotment societies and commercial growers, research station staff and local authority officials for examination and cultures were made from the disease organisms for further study. The laboratory analysed the results of experiments carried out independently by institutions in order to provide verification. The team advised scientists at research centres on the planning and design of experiments and suggested topics for investigation. Laboratory staff helped prepare leaflets for commercial growers and the public about legislation and councelled local authorities on how best to publicise new pest and disease acts and orders. It liaised with the BAS and the DATI in order to share ideas and gain information. With some accuracy, it was described as, 'the maid of all work of the service'.[32]

In order to publicise its work and provide knowledge that was based on scientific investigation it set up horticultural science exhibitions at regional and national horticultural and agricultural shows and Imperial Conferences. These consisted of displays of potatoes susceptible to and immune from wart disease and examples of the insecticides and fungicides that had been tested and given official approval. There were also examples of manures suitable for allotment holders, lime appropriate for horticulture, models of insect and fungal pests to aid identification, a supply of information leaflets on horticultural topics and exhibits of the work that was carried out by research stations aided by the Development Fund.[33]

1871-1948', *Transactions of the British Mycological Society* (1950), 33, pp. 161-165; Fryer and Pethybridge, op. cit. (9).

[32] Fryer and Pethybridge, op. cit. (9).

[33] *Report of the work of the Intelligence Department* b), op. cit. (23), p. 12, p. 16, p. 19, p. 45, p. 125; Ministry of Agriculture and Fisheries, *Report of the work of the*

5.1.3.2 Experimental Work

Harpenden scientists developed laboratory infection tests for potato wart disease that were used in conjunction with field tests, worked with the Midland Agricultural College and several other centres on experiments to eliminate a disease of celery seedlings and ascertained if field inspection of Cumberland grown seed potatoes could be used as a method to select virus-free stock.[34] Using half-acre plots in the laboratory grounds at Harpenden, scientists carried out pyrethrum investigations in conjunction with Rothamsted. Data was obtained about cultivation and harvesting costs, flowers were analysed for insecticidal properties and yield and experiments were conducted to find the stage of maturity when flowers gave the best insecticide yield. To test growth, yield and economic potential in regions with different soils and climate the seeds were distributed to institutes in the UK and the Empire.[35] Seale Hayne Agricultural College staff co-operated with Harpenden on slug control experiments and the Laboratory researchers advised that aluminium sulphate was fine for small-scale control but for commercial use recommended Paris green bait and bran, as it was cheaper and easier to apply on a large scale. The Laboratory also bred a parasite of the woolly aphid pest for distribution to

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Intelligence Department for the two years 1924-26 c), London: HMSO, 1927, p. 29; *Report on the work of the Research and Education Division* b), op. cit. (23), p. 84; File on onion smut order, memo sheet HD2687/21, comment by G. H. Pethybridge 1st March 1926, MAF 43/5, NA.

[34] *Report of the work of the Intelligence Department* c), op. cit. (33), p. 24; *Report of the work of the Research and Education Division* a), op. cit. (15), p. 30; *Report of the work of the Research and Education Division for the year 1928-29* b), op. cit. (15), p. 84.

[35] Ministry of Agriculture and Fisheries, *Reports of the Work of the Agricultural Research Institutes and on Certain Other Agricultural Investigations in the UK*, London: HMSO, 1931, p. 99.

growers.[36]

Two further examples are given to illustrate the range of work conducted by the Laboratory and the degree of liaison that took place with staff from other research institutions. The first concerns potato leaf curl disease and the second is about the connections being made between climate and pests and disease outbreaks.

In 1919 A. C. Cotton conducted a series of experiments in small plots at the Kew site on the transmission of potato leaf curl by insects and the transmission of mosaic disease in 1920. Selected varieties were grown in special beds, some being under insect proof cages, in consultation with the advisory mycologist E. Holmes-Smith and advisory entomologist K. M. Smith from Manchester University. Cotton arranged that the twelve centres of the Development Fund's regional system would conduct trials to gain further information and demonstrate to gardeners and farmers the seriousness of the diseases. The results showed the diseases reduced yields and revealed susceptible varieties. The work affected growers as demonstrations that leaf curl was contagious were met with incredulity initially. The resultant national survey on the distribution and intensity of these diseases led Laboratory scientists to conclude potatoes in north Scotland were free of the symptoms and was an area in which to raise seed potatoes for distribution in England.[37] At the 1921 International Potato Conference held at the Royal Horticultural Societies Hall in London, A. D. Hall in his inaugural address acknowledged research was on-going as little was known why potato seed from colder climates gave this advantage and

[36] V. E. Wilkins, *Research and the Land: An Account of Recent Progress in Agricultural and Horticultural Science in the UK*, London: HMSO, 1926, p. 47, p. 202.
[37] A. D. Cotton, 'The Situation with regard to Potato Leaf Curl and Potato Mosaic in Britain', in W. R. Dykes (ed.), *Report of the International Potato Conference*, London: Royal Horticultural Society, 1921, pp. 153-168.

what caused potato degeneration.[38]

The exploration of the relationship between climate, pests and diseases and crop performance was a more detailed and sustained Laboratory project. The Ministry, the Board of Agriculture for Scotland and the Meteorological Office of the Air Ministry joined forces, forming a supervising committee to co-ordinate research. By the early 1920’s twenty-two designated stations were sending data on these relationships to the Laboratory. [39] Interest had been sparked by Dr Hopkins work at the Bureau of the Department of Agriculture in the United States. In 1918 Hopkins announced his Bioclimatic Law, that become widely accepted by scientists, that introduced the idea there were early and late limiting times and optimum times for sowing seed. Hopkins suggested indigenous indicator plants could be used to show the best time to sow commercial crops. It was believed the idea had much potential and phenological gardens equipped with native indicator plants and meteorological apparatus were suggested.[40] Some recognised that Britain lagged behind Russia, France, Germany and the United States in this work and its perceived potential stimulated the Ministry into action. In 1926 it set up an Agricultural and Meteorological Conference for those British researchers who were working on the relationships between crop growth and climate. In the late 1920’s it sent out a questionnaire to 200 workers and research centres throughout the Empire to ascertain what work was being carried out in this field and in conjunction with the Royal Meteorological Society introduced a training course for research station staff to enable them to pass on data that was accurate and reliable. It

[38] A. D. Hall, ‘Inaugural Address’ in Dykes (ed.), op. cit. (37), pp. 12-14.
[39] *Report on the work of the Intelligence Department* b), op. cit. (23), p. 41. A few years later there were 26 stations.
[40] A. Roebuck, ‘The Value of Phenomenological Observation in Practical Agriculture’ in *Report of the Agricultural and Meteorological Conference 1926*, London: Ministry of Agriculture and Fisheries, 1926, p. 32.

inaugurated an annual paper reading conference to foster the sharing of ideas and organised the agricultural section of the 1929 Empire Meteorological Conference, in part to help publicise this work.[41]

The statistician Dr J. O. Irwin, of Rothamsted, was employed to analyse the large amount of data produced and it is possible his colleague R. A. Fisher was involved in the early stages and could have provided initial guidance.[42] The reports were distributed to libraries and foreign correspondents and Alfred Daniel Hall claimed, ‘it could no longer be said Great Britain lagged behind in field or agricultural meteorology’.[43]

J. E. Clark of the Royal Meteorological Society in a paper at the 1926 Agricultural and Meteorological Conference stated that phenology could be regarded as a special branch of horticulture or agriculture or biology, observing shrewdly it attempted to find relationships between these sciences. He drew comparisons with those working in the late nineteenth century in the UK to correlate plant, bird and insect behaviour with patterns of temperature, rainfall and sunshine and the work on climate currently taking place at Rothamsted. In his conclusion, Clark predicted growers in about ten years time would reap the first fruits of the efforts made by this MAF initiative.[44] Clark’s paper anticipated some of the developments that were to take place several decades later in the

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[41] *Report of the work of the Intelligence Department* b) op. cit. (23), p. 17; *Report of the work of the Research and Education Division* a), op. cit. (15), p. 37; *Report of the work of the Research ands Education Division*, b), op. cit. (15), p. 6, p. 16; *Report of the work of the Research and Education Division* c), op. cit. (27), p. 19.

[42] F. T. Brooks (ed.), *Report of the Proceedings of the Imperial Botanic Conference*, Cambridge: Cambridge University Press, 1925. R. A. Fisher presented a paper on the analysis of weather crop data.

[43] *Report of the Work of the Intelligence Department* c), op. cit. (33), p. 17; Hall believed that the collection of the data represented much self-sacrifice for scientists.

[44] J. E. Clark, ‘The Value of Co-ordination in Phenological Observations’ in *Report of the Agricultural and Meteorological Conference 1926,* London: Ministry of Agriculture and Fisheries, 1926, pp. 26-29. Clark wanted one set of very reliable data as he thought the whole seasonal phenology of a crop could then be predicted.

prediction of crop harvest dates but the civil servant H. E. Dale, less impressed, warned that the Ministry might find competing claims more deserving of funds.[45] The investigations at the research stations and the Laboratory contributed markedly to the growing appreciation that fungi attacking fruit and vegetables had several phases in their life cycle and that effective treatment involved applying fungicides to plants or to soil when a disease was at a vulnerable stage of development. The Laboratory was involved in trials to find varieties with a natural resistance to fungal attack, as it was accepted that this would be more effective than continuing with fungicides of limited efficacy and needing costly repeat applications. The life history of insects was of similar interest and the Laboratory scientists were concerned to identify as many insects and fungi as possible in order to build up a comprehensive body of knowledge, a task that was recognised as very long term.[46]

Through personal discussion and correspondence, the team raised the profile of the Laboratory and its work and obtained strategic information. Their involvement with groups promoting horticultural science and related scientific subjects is an indication of the academic respect gained by the Phytopathalogical Laboratory. Consultations took place between Inspectors in the Board and Ministry, the BAS and the DATI over issues such as procedures for rationalising nomenclature and the development of standardised methods in plant trials.[47] Laboratory staff in the 1920's attended the British Mycological

[45] *Report of the work of the Research and Education Division* c), op. cit. (27), p. 19.
[46] A. E. Shipley, 'Research in entomology, especially in relation to disease and colonial development', 18th January 1909 and *Entomological Research Committee. Correspondence relating to the development of entomological research in the British Colonies and Protectorates*, London: HMSO, 1912, MAF 43/16, NA; File on Black Currant Mite (Norfolk) Order of 1928 in MAF 43/6, NA. The *Transactions of the British Mycological Society* for the 1920's have articles covering these aspects.
[47] The information on inter-department conferences and minute extracts shows the involvement of these bodies. See: MAF 43/3, MAF 43/6 and MAF 43/32, NA.

Society Conference, the Imperial Agricultural Research Conference, the Agricultural and Meteorological Conference organised by the Ministry, the International Potato Conference, the Imperial Botanic Conference, the Imperial Entomological Conference and the Imperial Fruit Conference and in 1930 the first Imperial Horticultural Conference. Here they participated in discussions and sometimes chaired sessions.

Fryer arranged the visits for the delegates at the 1925 Imperial Entomological Conference and was on the Committee of Management of the 1930 Conference and organised for attendees an excursion to the Pathology Laboratory. He became an Associate Editor of the *Journal of Pomology and Horticultural Science*, the prestigious and only academic journal specifically for horticultural science in the UK, and later served on its Publications Committee. Along with Pethybridge, he helped establish the Virus Disease Plants Committee of the Ministry and both were serving members, Pethybridge later becoming Chairman. Both were invited to join the Agricultural Research Council of Great Britain and were council members of the British Mycological Society and served on its Sub-Committee for Plant Pathology, and in 1926 Pethybridge became its President. Pethybridge also was a member of the influential Development Commission's Advisory Committee for Agriculture and belonged to its Science and Scholarship Sub-Committee. These latter two groups consisted of key personnel who were influencing the direction of horticultural research, its funding and the allocation of postgraduate research studentships, giving Pethybridge the opportunity to present the case for additional resources for the Pathological Laboratory. In all of these arenas, horticulture was brought to the attention of a scientific audience and one result of the discussions and interactions that occurred was the spread of knowledge of horticultural science activities amongst a wider scientific community.

Summary

In 1909 part-time consultants were hired by the BAF to investigate and disseminate information about pests and diseases and by 1930 the government had created a team of full-time scientists to carry out this work. Many believed the phytopathological service was an essential prerequisite in the efforts to raise national food output. Some officials saw the legislation that the team helped develop as a response to the attempts by other countries to protect their horticultural industry, and trade rivalry with other countries influenced the framing and timing of pest and disease legislation.

Though Fryer and Pethybridge believed the service was 'loosely organised' and F. W. Keeble, Director of Horticulture for the BAF and the Food Production Department, thought the Branch was, 'a sort of Lazarus fed on the crumbs which fell from the White Hall table' it nevertheless contributed to the shaping of horticultural science.[48] It created opportunities for staff from the formal (plant 'doctors' and civil servants) and informal (research stations) components of the phytopathological service, along with growers, the public, local authorities and foreign correspondents to discuss issues of pest and disease control. It established a scientific rationale to justify and legitimise the action of the inspectors in the administrative arm. It contributed to the search for insecticides that were considered less harmful to users than sprays based on arsenic and other substances, for example pyrethrum, promoted and conducted more detailed studies of the complex life cycles of pests and diseases and organised

[48] Fryer and Pethybridge, op. cit. (9), p. 337; F. W. Keeble, The position of horticulture in the Board of Agriculture, 22nd November 1918, F/70/28/1, PA.

investigations into the relationships between climate, pest and diseases outbreaks and crop performance and stressed the importance of scientific investigation to the working world of horticulture. These areas of investigation and these strategies were part of the subject matter and agenda of horticultural science research between 1910-1930.

5.2 Poultry Research, Testing Seeds and Investigating Manures

This section provides further examples of the scope of horticultural science research promoted by the BAF and the MAF by outlining investigations and enquiries to do with poultry, seeds and manures. Poultry production in the early twentieth century became an increasingly important economic activity and the Official Seed Testing Station was established in response to the concern felt during the First World War that impure seed could affect the yield of crops for humans and animals and to the pressure from commercial horticulture and agriculture for government action. As Chapters 2 and 4 have indicated, population expansion, the growth of intensive cultivation, the decline of the horse on farms, the rise of motor transport and the increasing reliance on ‘artificial’ fertilisers led to a search for ways to produce nitrogen fertilisers relatively cheaply. Plant nutrition was an ever-present concern of horticultural and agricultural departments of successive governments since 1893.

5.2.1 Poultry Research

In the nineteenth century poultry rearing was characterised by diversity, as there were fanciers, domestic gardeners keeping small numbers and producers rearing for the egg and meat markets. Commercial poultry rearing was seen by some as an agricultural activity but by the early twentieth century commercial production was becoming more associated with horticulture, in part as a result of the work of the BAF and the DC and smallholders, market gardeners and allotmenteers were contributing to the rising output of poultry products. BAF, A.D. Hall, F. W. Keeble and others had set out the boundaries between horticulture and agriculture and besides poultry they included as horticultural activities, as I have explained, apiary and the raising of pigeons, rabbits, hares and goats.

As the poultry industry was growing in importance, the DC in the 1920s provided scientific support by creating 6 poultry research stations. This was in opposition to the BAF that wanted one large research institution but the DC felt that scientists working in other institutions studying similar problems were capable of undertaking poultry experiments and this avoided relocation upheaval.[49]

During the First World War F. W. Keeble, was endeavouring to transform the Horticultural Branch into a more dynamic Horticultural Division. Keeble defended the inclusion of poultry and rabbits in the Division by claiming that although there was a shortage of experts in these fields, BAF scientists did posses the necessary expertise and their experience in this area justified this inclusion. Keeble in his report to the Prime Minister, Lloyd George, acknowledged this diversity and explained that poultry and rabbits were part of

[49] M. E. Telford, P. H. Holroyd and R. G. Wells, *History of the National Institute of Poultry Husbandry*, Newport: National Institute of Poultry Husbandry, 1986, pp. 5-9; Wilkins, op. cit. (36), p. 243. In the early twentieth century a range of experiments were carried out on poultry to investigate ways of increasing their weight. In some investigations chickens were given mild electric shocks or fed irradiated milk to see if growth could be stimulated.

the system of cultivation practiced on smallholdings, allotments and domestic gardens.[50]

In 1920 MAF encouraged the formation of the National Poultry Council and both worked with the DC to promote poultry science. The Sub-Committee of the MAF Poultry Advisory Committee recommended a programme of fundamental investigations into breeding, feeding and management, the study of poultry disease and the provision of education in poultry management.[51] As a result, with DC agreement and funding, Reaseheath School of Agriculture in Cheshire began in 1924 a series of experiments on the effects of in-breeding and out-breeding on the egg-laying qualities of poultry and the role of vitamins in flesh and egg formation. At Harper Adams Agricultural College in Newport, Shropshire, the National Institute of Poultry Husbandry (NIPH) was officially opened in 1926 and poultry disease research was undertaken and experiments were made to ascertain the value of proteins and Vitamin D for egg laying. Additionally, at South-Eastern Agricultural College at Wye, Kent, poultry experiments began in 1925 to find the best method of feeding table birds, Cambridge University had two stations, one for poultry nutrition and one for breeding and at the MAF Veterinary Laboratory at Weybridge in Surrey, experiments were conducted to find ways of reducing outbreaks of fowl pox disease, bacterial diarrhoea and associated infections.[52]

These and other research findings were communicated to students through educational courses and the NIPH provided a diploma and certificates in poultry husbandry. At some Farm Institutes, County Poultry Stations were established

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[50] Keeble, op. cit. (48).

[51] Wilkins, op. cit. (36), p. 243.

[52] 'Current topics and events', *Nature* (1924), 113, (2833), p. 246; Wilkins, op. cit. (36), pp. 243-249; R. T. Parkhurst, 'A Progress Report of Poultry Education and Research Work at the National Institute of Poultry Husbandry', *Report of the Advisory Department 1929-1930*, XV, (4), pp. 176-179.

to give advice to commercial and domestic producers, based on the findings of poultry research. At Padeswood Hall Horticultural Centre in Flintshire, part of the University College of North Wales, horticultural and poultry demonstration areas founded on science, were introduced in 1926 to showcase best practice. This reinforced the efforts of the DC and BAF to establish poultry raising as a horticultural activity.[53]

By 1935 poultry production was an important industry and between 1924-1934 UK egg production had risen from 2,590 million to 4,764 million. It was estimated that in 1935 in England and Wales there were 65 million head of poultry on smallholdings of over an acre and on farms and 15 million head kept on smallholdings of less than an acre and on the gardens belonging to cottagers and suburban householders. A feature of this period was the rise of small-medium scale specialist producers who also cultivated fruit. In the 1930s poultry science was becoming rapidly a distinct subject and although very large-scale poultry production began to be regarded as an agricultural activity rather than an aspect of horticulture, the Horticultural Division of MAF was still responsible for poultry in the 1960s.[54]

5.2.2 Seed Testing

In 1917 the BAF established the Official Seed Testing Station for England and Wales at Streatham Hill, London, a comparatively late introduction compared

[53] 'Report from the National Institute of Poultry Husbandry', *The Journal of the National Poultry Institute* (1925), XI, (1), pp. 9-13; Minute Sheet 12th December 1919, MAF 33/14, NA; *Report on the work of the Research and Education Division* b), op. cit. (15) p. 55.

[54] *Eggs and Poultry. Report of Reorganisation Commission for Great Britain*, London: HMSO, 1935, p. 3; *Eggs and Poultry. Report of Reorganisation Commission for England and Wales*, London: HMSO, 1935, pp. 2-6.

with Scotland and Ireland.[55] The DATI had established an official station as early as 1901 and the Board of Agriculture for Scotland set up a station soon after its own foundation. The Board of Agriculture had been making enquiries into the seed trade since 1900 and encouraged agricultural colleges to offer seed testing services from their botanical laboratories. These arrangements did not satisfy growers and seed houses and they pressured the government for assistance. Poor yields resulting from the presence of weed seed, old seed or a combination of both affected the profits of growers and some seed houses depended heavily on supplying vegetable seeds to other houses and adulterated seed caused yield loss. Seed firms advertised their dependability and trustworthiness and unreliable seed jeopardised their reputation.

In the years just before the First World War, the Board conducted systematic enquiries and found a deterioration in seed offered for sale, as a result of adulteration and an official was sent to continental seed testing stations to compile an investigatory report. During the First World War it was found that seed quality had deteriorated further and affected growers were now making strong representations to the government.[56] Government concerns over food shortages were made worse by the German U-boat campaign in 1916 and the Food Production Department was established to increase the output of home grown food by working through county council Agricultural Executive Committees.[57]

One outcome was the Official Seed Testing Station and R. G. Stapledon, seconded from University College Aberystwyth where he was conducting

[55] *Fourth Annual Report. The Official Seed Testing Station for England and Wales*, Cambridge: National Institute of Agricultural Botany, 1922, p. 4.
[56] Letter from L. Weaver to Mr Middleton 7th October 1914, MAF 33/22, NA.
[57] Winnifrith, op. cit. (1), pp. 24-25; Copy of the original Notes as to the relations between the Food Controller and the Board of Agriculture. Duties of Lord Davenport, appointed Food Controller, December 1916, MAF 60/54, NA.

research on grasses for pasture, was made Director. In the first year the station tested over 14000 seed samples destined for horticultural and agricultural use. It dealt with a wide range of seeds of trees, flowers, and vegetables and provided an official guarantee of germination rates and reduced contamination from old seed and weed seed. The research work on seed coats and storage conditions were additions to the body of horticultural science knowledge and later investigations were conducted on germination rates of hard coated seeds and the retention of vitality of seeds stored under different conditions.[58] At the official opening, the President of the Board of Agriculture predicted the Station would in the future evolve into an institute of applied botany. Two years later, in 1919, the National Institute of Agricultural Botany was founded with grants from the DF and the Official Seed Testing Station became subsumed within this new Institute.[59]

5.2.3 Investigations of Manures

Between 1910-1930 the Board and Ministry encouraged investigations of manures and fertilisers in efforts to improve the yield of horticultural and agricultural crops. Great interest was shown by the government in the use of basic slag as a fertiliser and the DC and the Ministry encouraged laboratory analysis and field trials. Basic slag provided superphosphate and was used on vegetable root cops and cereals and the trials that the Board and Ministry

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[58] E. J. Russell, 'Reginald George Stapledon 1882-1960', *Biographical Memoirs of Fellows of the Royal Society* (1961), 7, pp. 249-270; *Fourth Annual Report. The Official Seed Testing Station for England and Wales*, Cambridge: National Institute of Agricultural Botany, 1922, p. 9; Wilkins, op. cit. (36), p. 87. A wide range of vegetable seeds were tested. The work at the Station provided some of the scientific foundations for the 1920 Seed Act that laid down conditions for seed purity and germination rates.
[59] L. Weaver, Memorandum on the establishment of a National Institute of Agricultural Botany, November 1918, MAF 33/22, NA.

funded of the different types and grades of the fertiliser attempted to find the cheapest and most effective product The work of the research stations and colleges on fertilising agents was given publicity in the Board's and Ministry's *Journal* and government scientists were given column space to provide advice on a regular basis about the function and application of both manures and fertilisers.

Attention was given to radioactive ores in the first two decades of the century, as it was believed they had potential as growth stimulants. The DATI supported investigations in the very early 1900's at the University of Dublin and Trinity College Dublin on the effects of radium bromide on the germination of cress seed.[60] Despite the negative results produced by the researchers some growers and scientists became curious about radioactive material as a manure or germination aid and a proprietary fertiliser based on these ores was aimed at domestic and commercial growers. For a short period in the early 1920s the Principal of Harper Adams Agricultural College, P. H. Foulkes, began experimenting with radioactive ores and it is likely that the MAF transported them to Foulkes at the College for his experimental work. [61] The interest of experimenters and the Board in these substances waned temporarily when the results of investigations indicated the ores were not effective.

Summary

I have provided further examples of the range of horticultural science work

[60] H. H. Dixon and J. T. Wigham, 'Preliminary note of the action of the radiation from radium bromide on some organisms', *The Scientific Proceedings of the Royal Society of Dublin* (1904), XIX, pp. 178-192; E. J. Russell c), 'The effect of radium on the growth of plants', *Nature* (1915), 96, (2397), pp. 147-148.
[61] 'Radioactive manure', *Journal of the Board of Agriculture* (1916), 12, p. 68.

funded by the state that was in response to the concerns of the working world of horticulture. The needs of allotment holders and domestic gardeners were also taken into consideration. Government scientists helped to associate poultry rearing with horticulture after 1900 and poultry research stations were established in the 1920s. Here, experiments were conducted to find out how to increase the weight of table birds economically and how to improve egg-laying capacity and researchers investigated breeding, nutrition and disease. It is not clear why the government took so long to establish the Official Seed Testing Station when Ireland and Scotland had set up seed government testing establishments a number of years earlier. Some seed firms had a reputation for product reliability and this may have given the impression that problems were being addressed or were not as acute as some growers had implied. The Board and Ministry were entrepreneurial when it came to new and potentially promising fertilisers, such as basic slag and radioactive ores. Fertiliser experiments carried the promise of improving yields and fertiliser trials and investigations were relatively cheap and comparatively straightforward to conduct.

5.3 Conclusion

In 1880 the government showed little interest in horticultural science, by 1912 it was providing sustained funding for horticultural research and by 1930 the system of research, designed by the DC and assisted by the BAF, was almost fully operational. This chapter has shown that the BAF and MAF supported a wide range of horticultural science investigations, although a central concern was the development of pest and disease management. Besides providing income for an array of investigations, the government and A. D. Hall were encouraging its scientists and administrators to make direct contact with growers by face-to-face meetings, as Hall believed this was the best way to ensure that applied science was taken up. Increasing food output was an important government objective and Ministers acknowledged the growing importance to the domestic economy and the export trade of the products of commercial horticulture.

To assist producers the government created the Horticultural Branch, a new department that later became a Division, to help administer and encourage horticultural science research. The administrative arm enforced pest and disease legislation introduced to safeguard the horticultural industry and its pathological laboratory liaised with other scientists in the UK and in other countries, conducted experiments with institutions funded by the DC and carried out its own experimental work.

The Board, Ministry, Branch and Division shaped horticultural science by developing new areas of investigation and expanding existing lines of enquiry, focussing in particular on: the national and international movement of pests and diseases, the complex life cycles of pests and diseases, the use of safer insecticides that were part of broader investigations into biological controls, the relationships between climate, pest and disease outbreaks and crop yield, the breeding, nutrition and diseases of poultry, the investigation of new fertilisers and the germination and storage of seeds.

I have shown how investigations and research promoted by BAF and MAF between 1910-1930 gave direction to and influenced the subject matter of horticultural science. The work of the Branch and Department was mainly applied science and scientists there took their cue from the fundamental research conducted at the state funded research stations, a number being located at universities. Government patronage established the potential of experimental horticulture as a science capable of contributing to the prosperity and well being of the country. This, along with the government's creation of employment opportunities and career prospects for horticultural scientists, the output of the stations themselves and the work of the Horticultural Department and Division of BAF, was instrumental in assisting horticultural science gain status in scientific communities.

Chapter 6

Horticultural Science Education

Chapter 6 explores an aspect of horticultural science that has received very little attention from historians: horticultural science education. Education was a key component in the system of horticultural science research created by A. D. Hall for the state. The government and Hall wanted to ensure that horticultural qualifications would be underpinned by science, recognised nationally and accepted by the scientific community. As I have previously explained, Hall considered that education determined the supply of trained horticultural scientists and skilled practitioners and influenced the take-up by commercial growers, home gardeners and allotment holders of the methods and products to improve cultivation developed by researchers. Additionally, both Hall and the government believed horticultural qualifications played a crucial role in defending the status of horticulture and horticultural science.

6.1 Horticultural Education, 1900-1930

I provide a broad survey of horticultural education in England for the period 1900-1930 and consider the establishment of the National Diploma in Horticulture and the involvement of the Board of Agriculture and Fisheries (BAF) in the compilation and publication of leaflets aimed at commercial and household growers. This sets the scene for a discussion in 6.2 of farm institutes, the bottom tier of the system of education developed by Hall, and in this section I focus on the bitter dispute between the BAF and the Board of Education (BOE) for the control of their administration.

6.1.1 Survey of Horticultural Education

In this brief survey I consider the provision of horticultural education at schools and evening classes, the training of apprentices, certificate courses and higher education opportunities.

6.1.1.1 Schools and Evening Classes

The BOE promoted the establishment of gardening classes in elementary and secondary schools and encouraged both practical and scientific training by laying down guidelines about the size of school gardens and the scientific textbooks suitable for the use of teachers and pupils. Inspectors noted the expansion of interest that that had occurred by 1920 in school gardens, particularly in infant schools, and believed they gave older children opportunities to develop knowledge of plant physiology. Courses at training colleges and universities were provided for teachers to improve their knowledge of horticulture and horticultural science, with practical work being carried out on a Saturday.[1]

For those who had left school, horticultural instruction was offered between October and March at evening and continuation classes, often located in schools and taught by schoolteachers. Simple science lessons and physiological experiments were part of the syllabus of these relatively short

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[1] T. S. Dymond, *The Education of the Cottage and Market Gardener in England and Wales*, London: HMSO, 1907, pp. 1-5; F. W. Keeble, 'A Foreword' in *Contributions to the Reconstruction of Horticultural Education*, Canterbury: Horticultural Education Association, 1919, p. 8, p. 13; Report by HM Inspectors on School Gardens in London, January 1913, ED 77/208, NA; H. M. Richards, Board of Education. Copy of some recent correspondence on the size of school gardens, 1st December 1924, ED 77/208, NA; Board of Education. *List of textbooks recommended by Chief Examiners as specially suitable for use in Public Elementary Schools,* Harrow: HMSO, 1924.

courses.[2]

6.1.1.2 Training for Apprentices

The landed estates, private houses, botanic gardens and commercial enterprises provided on the job training for apprentice gardeners.[3] Head gardeners supervised this training and in large establishments the trainee spent time in the fruit garden, the vegetable garden, the glasshouses and in maintaining plants grown for ornament and display. It is not possible to generalise at present how much exposure apprentices had to scientific principles. It is likely that some apprentices were given scientific training. At botanic gardens, for example, scientific aspects of horticulture were emphasised, at some landed estates head gardeners were carrying out horticultural experiments and as I will show in Chapter 7, innovative commercial establishments conducted scientific investigations.

6.1.1.3 Certificate Courses

Private colleges and institutes supported by county councils and the Royal Horticultural Society provide examined courses and successful students were awarded in-house certificates. Full-time courses lasted between 2-3 years.[4] The RHS and county council colleges emphasized the importance for students of acquiring an understanding of the sciences that were relevant to horticulture. At

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[2] Keeble, op. cit. (1), pp. 12-13.
[3] W. B. Little, 'Introduction' in *Education in Horticulture*, Lyminge: Horticultural Education Association, 1912, p. 1.
[4] R. Wilkins, *The Work of Educated Women in Horticulture and Agriculture*, London: Jas Truscott and Sons Limited, 1915, pp. 2-7.

present, we lack a comprehensive picture of private college activities but those documented indicate scientific instruction was provided alongside practical experience.[5]

Research stations and the BAF encouraged colleges to conduct investigations. Usually, pure research carried out at the stations raised issues that needed practical investigation and colleges undertook this type of work.

6.1.1.4 Higher Education

Institutions offering diplomas and degrees in horticulture were given grants by the BAF and the Ministry of Agriculture and Fisheries for education and research, and the work of their own researchers and the investigations of research station scientists were incorporated in taught syllabi.

London University offered a degree in horticulture in 1915 which was taken by students attending university colleges and colleges and by 1919 had introduced a PhD degree in the subject. Initially, horticulture was at pass standard only and university or university college departments of horticulture were usually part of an agricultural faculty. University College Reading, Cambridge University, South East Agricultural College and Swanley Horticultural College began to offer degrees and diplomas during this period and Seale Hayne College awarded diplomas only. The London BSc course was started at Reading in 1919 and shortly after becoming a university it offered in 1928 an MSc degree in horticulture.

The number of students taking a higher education diploma in 1911 at different

[5] For example, see D. Opitz, '"A Triumph of Brains over Brute": Women and Science at the Horticultural College, Swanley, 1890-1910', *Isis* (2013), 104, (1), pp. 30-62.

institutions was 70 and 7 began a degree course in 1919. By 1927 there were 105 diploma students and 22 were taking the BSc.[6] Degree courses were dominated by the natural sciences and F. W. Keeble argued that the zoology content of the London degree needed replacing with physics because it helped students, 'better understand vegetable physiology and has application in garden practice'.[7] Degrees and diplomas assisted horticultural science to gain academic status, as it was now a component of a higher education award. Little is known, however, about the development of horticultural education at this level.

6.1.2 The National Diploma In Horticulture

The BAF and MAF and the Department of Agriculture and Technical Instruction in Ireland promoted horticultural education but the extent of the involvement of the Board of Agriculture for Scotland is a topic in need of further research. Neither the Scottish Board nor the Department in Ireland, however, were involved in the development of the National Diploma of Horticulture and it was the BAF that grasped this opportunity.[8]

The RHS initiated the idea and although it had been administering lower and higher-grade general exams in horticulture since the early 1890s and schoolteacher and public park examinations since the early 1900s and had built

[6] Documents relating to students and courses and 'Agricultural Education (England and Wales) Historical Notes' 2nd June 1927, T 161/645, NA; *Report on the work of the Intelligence Department for the two years 1924-26*, London: HMSO, 1927, pp. 69-76; *University of Reading Calendar Session 1928-1929*, Reading: University of Reading, 1928-29, MERL.

[7] Keeble, op. cit. (1). pp. 3-4.

[8] Sir Patrick Laird, 'The Department of Agriculture for Scotland', *Public Administration* (1949), 27, (4,) p. 259; V. P. Gill, Department of Agriculture and Technical Instruction 4th May 1920 and Proposals for agricultural education and research in Ireland 21st December 1918, T1/12564, NA.

up some experience, it sought the advice of the Horticultural Branch of the BAF about the idea.[9] The organisation of a national examination, envisaged as being similar in status to the respected National Diploma in Agriculture, carried much responsibility and the Society wanted this to be shared - especially as the government had to give approval for the use of the word 'national' in the title. The Society was also hoping that the Board might defray some costs.

On being approached by the Society, the BAF's civil servants sought the advice of its Horticultural Branch and helped steer the project to fruition. The Board wanted the diploma to be a qualification that was demanding, of 'merit' but not of degree standard and through discussion, debate and the adoption of a firm position, it ensured that the examination achieved the desired rigour.

The BAF was successful in ensuring the Diploma had academic respectability. Students wishing to pursue a London University degree in horticulture had to possess the National Diploma. The government civil servants set up a nominated committee of nine members to develop the examination, ensuring that membership was representative of the government, the Society, the scientific community, professional gardeners and the horticultural trade. Civil servants disagreed with the Society's proposal that fees should be partly subsidised by the Board and when the horticultural trade thought the charges were reasonable the idea was dropped. The Board believed gardeners ought to understand the scientific reasons behind practical actions and wanted the syllabus to reflect this. It had to remind the Society that a syllabus was needed before approval could be given and there were a few minor niggles over the meaning of several words used in the publicity information about the examination. When these requirements had been addressed the civil servants

[9] Royal Horticultural Society, *Papers set at the Examination in Horticulture 1893-1916*, London: Royal Horticultural Society, 1916, p. 2.

gave their approval.[10]

The Daily Telegraph, Country Life, Gardener's Chronicle and *The Field* all supported the new qualification. *The Daily Telegraph* noted the importance of science for gardeners and suggested, knowledgeably, that possession of the new diploma would improve the prospect of employment in a range of horticultural trades as well as in the education service and the government inspectorate.[11] It was a realistic alternative to a college diploma in horticulture, was at a level higher than a certificate from a farm institute and was not in competition with the diplomas and degrees offered by universities and university colleges; these were more advanced and there was a greater emphasis on chemistry and physics and fundamental science. The syllabus required candidates in the second year to choose a special subject and options included horticultural inspection work and teaching horticulture at a college or farm institute.[12] Through this patronage the BAF ensured research station science and its own science initiatives and those of the DC would be kept in mind by examination candidates. It was hoped that some examinees might be future applicants for positions in horticultural research and education.

6.1.3. Publications

In order to report the results of experiments and investigations, the Department

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[10] File headed Royal Horticultural Society Diploma in Horticulture, MAF 43/17, NA. The file has memorandum and correspondence covering the development of the National Diploma in Horticulture.

[11] MAF 43/17, NA.

[12] MAF 43/17, NA. The Diploma was a two-year course and combined practical work with horticultural science. The syllabus indicates that science was the foundation for the practical work. As well as sitting written papers, examinees took a practical and a vive voce examination. Candidates needed to be over the age of 21 and had to have worked for 4 years as a gardener in a public or private garden, a nursery or in an approved horticultural institution.

of Agriculture and Technical Instruction for Ireland, the Board of Agriculture for Scotland and the Board and Ministry of Agriculture introduced journals.[13] These publications were aimed at commercial horticulturalists, farmers and to a lesser degree academics and home gardeners. The articles were of a scientific nature but the authors wanted to convey the information in a form that horticulturalists and agriculturalists could understand without recourse to reference books. If some of the intended audience wanted to learn about the actual experiments and investigations that were the foundation for these articles, they could go to the annual reports published by the research stations to obtain more detail.[14] Information to assist civil servants in other departments with their government planning and enable scientists in research institutes to follow the work carried out in other stations was included in the volumes of the Board's and Ministry's *Agricultural Statistics* or from the Ministry's regular *Reports of the Intelligence Department* - this Department later became the Research and Education Division. For the professional and domestic horticulturalist and the farmer, the leaflets and the *Journal of the Board of Agriculture* contained concise summaries of research along with practical information. Leaflets dealt with topics of common concern and focused on subjects such as the eradication of a pest or disease, the treatment of a named weed, the use of a particular manure, the cultivation of a fruit or vegetable and the function of a particular type of machine.

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[13] The Board of Agriculture for Scotland produced the *Scottish Journal of Agriculture* and in 1927 the Ministry of Agriculture for Northern Ireland produced a journal. The content and format of these journals were similar.

[14] The annual reports of the government funded research stations were extremely comprehensive and gave detailed information of experiments and investigations. The *Philosophical Transactions of the Royal Society of London*, the *Transactions* of the Linnaean Society and British Mycological Society and the volumes of the different entomological societies in the country all contained information about horticultural science.

Articles by the senior staff of the Board and Ministry, the Horticultural Division and the research stations appeared in the *Journa*l - Sir E. John Russell, of Rothamsted, wrote a column regularly on manures. Re-occurring topics in the period 1910-1930 were pests and diseases and their control, manures and fertilisers, fruit, vegetables, flowers, soils, experimental methods, plant breeding and the introduction of new varieties. There were also articles that gave publicity to novel or cutting edge ideas and research, for example, the use of radium ores and electricity as growth stimulants. The *Journal* provided information suitable for professional producers of horticultural products. It listed and commented on exhibitions, shows, conferences and gatherings, gave market prices, provided book reviews, detailed grants and scholarships and reported on Development Fund and research station news. It was a compendium of horticultural and agricultural science, articles of general interest, information about educational matters and trade and market news.[15]

There were other publications besides those of the Board and Ministry that fulfilled a comparable function and were competing for a similar audience, for example: the *Journal of the Royal Agricultural Society of England*, *Journal of the Royal Horticultural Society*, *Transactions of the Highland and Agricultural Society of Scotland* and *Transactions of the Scottish Horticultural Association*.[16] It is difficult to know fully how many of these were read by growers and whether they had loyalties to particular publications. Little is known of the number of growers who used the information in the *Journal* of the Board and the Ministry to guide their practical operations and there is a lack of information about the

[15] The *Journal* had 12 parts to each volume. It was a very useful guide for growers who wanted to learn about recent developments in a wide range of horticultural science activities and to keep in touch with what was happening in other parts of the country and in other countries.

[16] Not a great deal is known about the origin, subject matter and impact of these publications.

composition of the readership. Innovative and progressive growers were likely, however, to be a receptive audience for government and institution publications and several examples suggest this may have been the case. D. Porlock, a market gardener from Preston, Lancashire, kept and used a bound volume of 100 leaflets produced by the Phytopathological Laboratory of the MAF and the nursery and seed business Pennells of Bracebridge Heath, Lincoln, an innovative firm that was proactive in its communication with the government, purchased copies of the BAF publications and a scheme to help allotment holders and gardeners in Ireland provided for them 99 leaflets on horticulture and agriculture produced by the DATI.[17]

Perhaps a clue about what the Board and Ministry believed to be the best way of communicating with producers is given by the strategies used by the Horticulture Branch. To ensure that the findings of horticultural research reached the growers and was considered by them, the Board and Ministry put great emphasis on face-to-face contact. A great deal of effort was made in making personal visits, giving individual or group demonstrations and providing short courses. Receptive growers were approached and encouraged to carry out investigations for the Branch and were persuaded to allow other growers to visit and view what was taking place. It was believed, correctly, that this was an extremely effective way of convincing sceptics or waverers and aspects of this work are considered in Chapters 7, 8 and 9.[18]

[17] Letter from D. Porlock to Moore 30th August 1930, MAF 190/142, NA; Pennells Cash Books/Bracebridge, 1913-1919, LIA; County Kildare Committee Agricultural Report on the working of the agricultural livestock and other schemes, 1920, F18/7, NA.

[18] In the first two decades of the twentieth century the issue of how best to encourage market gardeners and farmers who used more traditional methods to adopt practices based on scientific research was discussed often by Board and Ministry personnel.

Summary

The encouragement of the development of creditable qualifications in horticulture by BAF would have had the effect of improving the status of horticulture and horticultural science amongst the public, institutions and the scientific community and of ensuring a supply of qualified personnel for research, teaching and commercial production. Horticultural education could be obtained by being employed by landed estates, wealthy middle class private householders, botanic gardens and commercial enterprises and by attending schools, private and state financed colleges and higher education institutions. Horticultural science accrued academic recognition by becoming part of a diploma and a degree subject offered to undergraduate and postgraduate students. On advanced courses much emphasis was placed on the findings of fundamental science rather than practical knowledge. Between 1920-1927 there was a steady increase in diploma students and whilst numbers taking degrees were relatively steady between 1922-1926, they had peaked in 1923. By 1930 there were horticultural departments at universities and in 1933 Reading became the first university in Great Britain to appoint a professor of horticulture.[19]

The government wanted instruction to be based on scientific principles and accepted that it was not always possible to guarantee that education received on the job or from private colleges addressed science or covered it rigorously and systematically. The BAF steered the development of the National Diploma in Horticultural administered by the RHS in order to overcome some of these problems. The Diploma was influential as a qualification. It was based on the

[19] 'University and Educational Intelligence', *Nature* (1933), 131, (3303), p. 248.

principle that science had to guide practice, was accepted as good training for those teaching horticulture below university level and helped to give horticultural science academic credibility because it was based on an accumulated body of reliable knowledge produced by scientific investigation and experiment. It was part of BAF's strategy to raise the standard of entrants to an industry that was growing in economic importance.

Technical pamphlets and the regular *Journal* produced by the BAF and the MAF were aimed at a wide audience. They were a vehicle for presenting scientific information, coming increasingly from the research stations, to an audience of academics and commercial and amateur growers. The leaflets covered a range of major problems occurring in crop production and the *Journal* kept the horticultural trade up-to-date with trade news and scientific developments. The market for such publications was competitive and it is not known how many growers, seedsmen or nurserymen read them. Those with a regional or national reputation were very likely to receive the *Journal* and other similar publications but overall it is difficult to gauge the extent of the readership. For the government farm institutes, discussed next, were an essential component of the developing state system of horticultural science education and research. They provided the state with the reassurance that the practical methods shown on the farm institute demonstration plots were based on the findings of scientific research. The BAF and A. D. Hall saw these demonstration areas as a major means of convincing growers and the public of the value of improved methods that were based on science.

6.2 Farm Institutes: ‘the essential part of a powerful instrument’.

Farm institutes, introduced in 1910, provided horticultural education for those who had left school and for older students that involved the delivery of horticultural science theory and practical horticulture. They also looked after demonstration plots targeted at students, growers and domestic gardeners that showcased the methods and products developed by the research stations. Arrangements governing them were flexible. They could be independent with their own grounds or have a base in an existing college. Students could be boarders or institutes could function as a non-boarding establishment. Additionally, they could provide the headquarters for the county Agricultural Organiser, who directed the work of the Horticultural Supervisor and the Horticultural Instructor.

6.2.1 The Dispute between the Board of Education and the Board of Agriculture and Fisheries

The belief of the BOE and the BAF that they alone were the most suited to administer the farm institute scheme drove the dispute. It took the intervention of the Prime Minister, A. H. Asquith, to achieve a resolution. The fact that the Prime Minister became involved illustrates just how strategically important the role of the institutes were in the government’s national scheme of horticultural and agricultural research. For the BAF, A. D. Hall and Asquith the dispute was not simply about the provision of lower-level horticultural education in England and Wales. Rather, it was more to do with ensuring the success of the government’s recently launched horticultural and agricultural science research programme. The farm institutes were an essential element because they were a vital communication link between research station scientists and commercial and domestic growers. The arguments and issues about this function were as crucial to the government as the arguments about the importance of fundamental investigations at research stations, universities and colleges. A great deal was at stake. The government had allocated a relatively large amount of money to horticultural science to ensure it assisted growers to expand the production of cheap, quality food to supply an increasing population, to support an industry that was economically important and to create employment opportunities in rural areas. Asquith and Hall did not believe BOE staff had the skill and experience to run these institutes.

Moreover, the government and Hall wanted to raise the status of horticulture as a scientific subject and believed the BAF rather than the BOE had the personnel who could best achieve this goal. Hall was endeavouring to develop the academic profile of horticultural science to attract a scarce resource - the able recruits needed to work at all levels of the horticultural research scheme.[20] In the dialogue between research stations and the BAF there were often comments about development being restrained by a shortage of the, 'right sort of man'. Hall insisted research station staff engage in fundamental science and publish their results in scientific journals in order to enhance their worth in the eyes of scientists in related and other fields. Hall believed the recruits that he wanted would be attracted only if the research station programmes were of high quality, run competently, offered salaries comparable to universities, showed clear routes of career progression, awarded postgraduate and travel grants and provided PhD supervision.[21]

In his efforts to improve the status of workers in horticultural science Hall

[20] A. D. Hall, Memorandum on agricultural research, 2nd December 1910, D4/1, NA.
[21] The government met all of these requirements.

called the County Organisers, brought in later to administer the institutes at the regional level, ‘general practitioners’ as they were the immediate and official figure growers could turn to for problem solving. Harwood noted this strategy of comparability was used also by agricultural scientists in universities striving to get their subject accepted by other academics and in 1943 the Luxmoore Report on agricultural education advised that agricultural advisers, ‘must be specialists and of the same calibre as in medicine’.[22] Hall in the 1920s had called the advisory mycologists, entomologists and chemists stationed at colleges and the research stations and possessing specialist skills, ‘consultants’, as they provided the Organisers with specialist advice.[23] Hall, similar to T. H. Middleton who compared the inspectors of the Horticultural Branch with veterinary surgeons, wanted the growers and scientific community to acknowledge his scientists were equivalent in professional status to doctors and consultants in medicine.

Relations between the BAF and the BOE became strained over events that had taken place in the build up to the compilation of the 1908 Reay Report. Reay’s team examining the provision of technical and scientific horticultural education in England and Wales, considered the importance of horticulture to the economy and the need for horticultural science education and called witnesses. After protests by the BOE that it was not asked to provide witness evidence, its representative F. G. Ogilvie was invited to prepare an account for attachment as an appendix. A. E. Brooke-Hunt, a Chief Education Inspector for the BAF

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[22] J. Harwood, *Technology’s Dilemma: Agricultural Colleges between Science and Practice in Germany, 1860-1934*, Bern: Peter Lang, 2005, p. 236; *Report of the Committee on Post-War Agricultural Education in England and Wales*, London: HMSO, 1943, p. 16.

[23] *Report of the work of the Intelligence Department of the Ministry of Agriculture for the two years 1919-1921*, London: HMSO, 1922, p. 10; *Report of the work of the Intelligence Department of the Ministry for the three years 1921-24*, London: HMSO, 1925, p. 13.

and tasked with organising the appendix, portrayed BAF's work favourably but omitted the BOE's accomplishments.[24] This sparked off the dispute.

Sir Robert Morant of the BOE blamed the BAF for creating divisions in an attempt to gain administrative control whereas BAF officials felt, 'we don't really come out of the controversy at all badly, seeing how handicapped we are – our own consciences are clear and we cannot change Morant's skin or Ogilvie's spots'.[25] This disagreement and animosity never really dissipated and remained in the background well into the 1920s. Despite the Reay Report being favourable to the BAF, the BOE continued to administer a significant part of horticultural and agricultural education for those up to the age of 16, which included farm institutes, whilst the BAF administered advanced courses in horticulture and agriculture taken at colleges and universities. Reay had attempted to introduce a more rational system of administration by eliminating existing overlap in responsibilities, but one remained.[26] Although the BOE was responsible for the education of students attending farm institutes, the BAF had

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[24] Controversy between the Board of Education and the Board of Agriculture, ED 24/147b, NA. No mention was made of horticultural instruction aided by the BOE, particularly fruit growing. See the general notes and letters in the file. Here Brooke-Hunt gave the excuse that Ogilvie's appendix contained inaccurate information and would have put, unwisely, the dispute between the two Boards in the public domain. It may be that Reay was biased in favour of the BAF, who sponsored his Report.

[25] See the following: letter from Sir Robert Morant to T. Elliot 7th June 1910, letter from T. Elliot to T. H. Middleton 24th August 1909 and 'Developing Agricultural Education', *The Farmer and Stockbreeder*, 4th April 1909 pasted in the memorandum file, MAF 33/58, NA; See the general notes and letters, ED 24/147b, NA.

[26] *Memorandum of Arrangements between the Board of Agriculture and Fisheries and the Board of Education in regard to Agricultural Education in England and Wales*, London: HMSO, 1909, in ED 24/170b, NA; Board of Agriculture and Fisheries, *Report of the Departmental Committee appointed by the Board of Agriculture and Fisheries to Inquire into and Report upon the Fruit Industry of Great Britain, with a copy of the Minute appointing the Committee*, London, HMSO, 1905. The BOE took from the BAF the administration of lectures in horticulture and garden plots at local centres to schoolboys, youths and older men and the BAF took over from the BOE the provision for courses in horticulture for elementary and secondary school teachers provided by universities and colleges.

to oversee the maintenance of the farms or gardens belonging to these institutes.[27]

The announcement in 1910 that Development Commission (DC) funding would be expanded and that some would be allocated to farm institutes fuelled the dispute and by 1912 the disagreements between the two Boards had intensified. The BAF used both the criticisms made by the 1905 national survey of the fruit industry that the BOE had wasted money by not inspecting as ‘horticultural experts’ and the Reay Report statement that, ‘provision of low-grade horticultural and agricultural instruction was inadequate’.[28]

The BAF and the DC argued that growers needed advice based not on general principles or textbooks but on a diagnosis that took account of local conditions and felt BOE inspectors were not experienced in these practical matters. The belief of the BOE that farm institutes needed farms of 150 acres was used as evidence of this inexperience - the DC and the BAF stressed that areas of 20 acres were quite sufficient for experimental and demonstration work. In 1912 the Treasury noted that as agricultural colleges were not going to be transferred to the BOE, it made economic sense to give the administration of farm institutes to the BAF and that as the BAF was promoting research stations and scientific research, this investigatory work needed to be linked closely with education in order to create a ‘connected whole’.[29]

The BOE informed Asquith it had inspectors who could judge the work and progress of farm institutes better than those employed by the BAF.[30] Sir Robert Morant, Permanent Secretary to the Board of Education, in his memorandum to

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[27] Minute note by T. H. Middleton 24th August 1912, MAF 33/66, NA.

[28] *Report of the Departmental Committee*, op. cit. (26), p. 11.

[29] Letter from T. Heath Treasury Chambers to the Secretary of the Board of Agriculture 15th January 1912, MAF 33/66, NA.

[30] Letter from Sir Robert Morant to Elliot, op. cit. (25).

the Prime Minister emphasised farm institutes were integral to the work carried out by local education authorities and they continued the instruction started at elementary schools.[31] Stating to Asquith that there was no sharp line of division between teaching agriculture and teaching other subjects probably lost Sir Robert the argument.

The dispute revealed fundamental differences in attitudes to horticultural education and horticultural science. The Board of Education had not fully appreciated the sea change that had occurred in the promotion of horticultural and agricultural science research and education by the government. The DC was emphasising the importance of conducting pure science for the benefit of the grower and to extend horticultural science knowledge. The BOE seemed unable to respond to the opportunities presented by changing circumstances. W. Runciman and T. H. Middleton at the BAF summed up the situation perceptively. Runciman believed research, experimentation, advice and instruction were connected and if administered by different bodies would weaken efficiency and Middleton thought the BOE viewed experimental work at farm institutes as educational in purpose and had not linked it to the governments national horticultural and agricultural research programme. He pointed out BAF regarded the experimental work of the institutes as actual research, designed to produce results that could benefit growers and research station scientists and be illustrated in demonstration plots.[32]

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[31] Sir Robert Morant, Board of Education. Control and distribution of grant given by the Development Commissioners for the promotion of farm institutes. Reference to the Prime Minister, T1/11530, NA. Morant emphasised the importance of academic instruction.

[32] Memorandum note by T. H. Middleton 14th March 1911, ED24/170b, NA; W. Runciman, Memorandum for giving reasons for placing the administration of farm institutes under the Board of Agriculture 11th December 1911, TI/11530, NA. Middleton believed the Board of Education approached matters from an academic standpoint.

The Prime Minister settled the matter by explaining to both Boards that agricultural education was the foundation of an industry in which the state had made, 'extra-ordinary provision'. As the research stations and colleges were controlled by the BAF and as education was so closely linked with research, it was important to maintain a connected whole by transferring the administration of farm institutes to the BAF. Asquith believed that farm institutes for the BAF were, 'an essential part of a powerful instrument by which it has to do its specific work'.[33]

6.2.2 The Work of the Farm Institutes

In 1912 farm institute supervision was vested in the BAF, whose brief was to expand numbers by establishing an institute in every county using £325,000 made available for their development. After 1913 the existing 9 farm institutes came under the control of Advisory Councils, set up in each county in England and Wales with state assistance, although the First World War stopped expansion. After the War MAF requested all local authorities in England and Wales to prepare a comprehensive scheme of horticultural and agricultural education, which included farm institutes and 17 had been established by 1919. In 1921 part of the £850,000 made available by the Corn Production Repeal Acts that withdrew government subsidies for wheat growing, was allocated to the farm institute programme enabling MAF to provide more staff and additional facilities and by 1930 there were 19.[34]

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[33] Letter from A. J. Asquith to Sir R. Chambers 4th January and letter to the Secretary of the Board of Agriculture 8th January 1912, TI/11530, NA. Asquith used the term generically and included horticulture.

[34] Agricultural Education (England and Wales) Historical Notes, 2nd June 1927, T 161/654, NA; RW, Memorandum on important changes in agricultural education since

The BAF and MAF could not compel Council members to follow its scheme and could rely only on powers of influence and persuasion. Grants and subsidies were offered to enable farm institutes to play the essential part that was expected of them.[35] The Ministry paid 80% of the Agricultural Organisers salary because the role was regarded as crucial. A. D. Hall saw the Organiser as, 'the channel by which the stream of knowledge can most surely and easily flow to its destination'.[36]

Before conducting experiments, institute staff had normally to consult with the Organisers to ensure the work complimented research station investigations. Research station results were utilised by the institutes in their own experiments and the following list provides a sample of the range of enquiries, experiments and investigations that took place: variety trials of fruit and vegetables for earliness of the crop or disease immunity; methods of under-soil watering in glasshouses; comparative trials of storage conditions and planting depths for flower bulbs; meteorological observations and data on plant growth and pest appearance for the Phytopathalogical Service; comparative trials of manure on certain crops; experiments on pruning methods and investigations of sprays to combat insects and fungi on willows, vegetables and fruit.[37]

Short courses conveying some of the results of the institutes own investigations and those of the research stations were held during the autumn or winter

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the service was taken over by the Board (now the Ministry) of Agriculture, 1st September 1933, MAF 33/62, NA. Walter Runciman went on an exhaustive programme in 1912 of city and town visits to outline to local authorities the government's scheme for horticultural and agricultural education.

[35] *Memorandum as to the Constitution of the Advisory Councils for Agricultural Education in England and for the Agricultural Council for Wales*, London: HMSO, 1913; Sir F. L. C. Floud, *The Ministry of Agriculture and Fisheries*, London: G. P. Putnam's Sons Limited, 1927, p. 98.

[36] *Report of the work of the Intelligence Department…1921-24*, op. cit. (23), p. 13.

[37] This list is a sample only and was obtained from a range of MAF files in the MAF 33 series held at the National Archives, which contain information about farm institutes.

months in the evenings for the sons of growers, in the spring for women, during the summer for teachers or students and throughout the academic year for students enrolled on one or two year full-time courses. The eight-week course programme at Oaklands Farm Institute, Herefordshire, informed students that the instruction emphasised the application of science to horticulture. Students could choose one from the following: market gardening, commercial fruit growing, commercial glasshouse growing and domestic gardening. There was a common core for each course consisting of the general facts of plant life, soils, manures, the principles of immunity and susceptibility to pests and diseases, horticultural tools and machinery and plant breeding.[38] At Cannington Court Farm Institute in Somerset, several students on the one year course gained employment after graduation at Long Ashton Research Station and some became assistants in manurial experiments on potatoes.[39] Several farm institutes, such as Plumpton in East Sussex, offered the Royal Horticultural Society certificate that was based on horticultural science principles.[40] The demonstration plots at the farm institutes showed practical techniques, mainly for fruit, vegetable and glasshouse crops, that were underpinned by research station investigations. Besides being for the benefit of students, allotment holders and home gardeners they were also aimed at those growers who might not visit a research station.[41]

If judged by the Board and Ministries criteria of success, a farm institute in every county, the initiative was not an overwhelming achievement. By 1930 the Ministry of Agriculture could claim that only three small counties out of a total of

[38] Oaklands Farm Institute, St. Albans. Prospectus and Syllabus of Instruction, 1921, MAF 33/25, NA.
[39] Report of the Horticultural Superintendent 4th September 1928, MAF 33/9, NA.
[40] Letter from the Director of Agriculture to the Secretary, Ministry Agriculture, 6th December 1929, MAF 33/367, NA.
[41] Large groups were not uncommon.

58 lacked an Agricultural Organiser but only 19 farm institutes had been established.[42] The Reay Report of 1908 had recommended the establishment of 50 or 60 and the 1943 Luxmoore Report, in its review of horticultural and agricultural education, arrived at a similar recommendation.[43] Government funding was not consistent always and during years of economic difficulty, funds were unavailable for new additions to existing programmes. The plan was elaborate and perhaps too ambitious. The Board and Ministry had no influence over the appointment of directors or other staff and so could not be certain that the right choice had been made. Some of the institutes were very successful in their work but in others performance was perfunctory rather than dynamic or innovative. The system was patchy because local authorities had different attitudes, agendas and policies and could not be coerced by central government.[44] The type of pressure that the government exerted on research stations could not be used with local authorities. Moreover, Agricultural Committees could be idiosyncratic in their approach. Some allowed officials to use valuable funds for fact-finding visits abroad before establishing an institution, others were parsimonious, some allowed the purchase of unnecessary extra land or glasshouses and others neglected the needs of growers.[45]

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[42] *Report of the work of the Research and Education Division for the year 1929-30*, London: HMSO, 1931 p. 24.

[43] Ministry of Agriculture and Fisheries, *Report of the Committee on Post-War Agricultural Education in England and Wales*, London: HMSO, 1943, pp. 15-17, p. 34. Luxmoore believed funding was inadequate; H. E. Dale, *Daniel Hall: Pioneer in Scientific Agriculture*, London: John Murray, 1956, p. 89.

[44] *Report of the work of the Research and Education Division for the year 1928-29*, London: HMSO, 1930, p. 15; Dale, op. cit. (43), p. 90. Dale thought some local authorities were indifferent to education and others feared a rise in rates if they were too generous with financial support.

[45] Letter from Professor J. R. Ainsworth-Davies to the Secretary of the Board of Agriculture, 30th July 1912, MAF 70/12, NA; PGD Internal Memorandum 27th June

Summary

Farm institutes were an essential component in the government's scheme of horticultural research and education. Decisions about their administration led to a power struggle between the BOE and BAF. At stake was the preservation of the newly created system of horticultural and agricultural science, planned by A. D. Hall and funded by the government, and it took the intervention of the Prime Minister to ensure it was not blown off course.

There was a two-way flow of horticultural science information between farm institutes and the research stations. Experimental results from the stations fed into educational courses offered by the institutes and were transmitted by Agricultural Organisers, Horticultural Supervisors and Horticultural Instructors to growers, nurserymen, allotment holders, domestic gardeners, students and other interested members of the public. Farm demonstration plots, displaying methods and techniques based on these experiments, were popular and attracted the attention of growers who were reluctant to visit a research station or lacked the time to be able to study station reports. The Organisers and Supervisors fed experimental results from the institutes back to the research stations for discussion or action.

6.5 Conclusion

Government finance helped schools, farm institutes, colleges and universities to

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c1921, MAF 33/39, NA; Letter from G. C. Gough to E. Garnsey 5th July 1929, MAF 33/326, NA. One complainant believed that Ministry funding could depend on the forcefulness of county council officials when interacting with Whitehall staff at meetings and felt that deserving cases could lose out if county council representatives were less proactive.

make provision for horticultural education and the efforts made by the DC and the BAF and MAF to develop the subject enabled horticultural science to gain academic status. The BAF guided the development of the National Diploma in Horticulture and the support of the government in the creation of college and university diplomas and degrees in horticulture and the measures introduced to enable scientists at research stations to gain parity with academic researchers at universities were significant factors in this process.

The Board and Ministry produced educative leaflets, an informative *Journal* and later analytical reports, although further investigation is needed in order to more fully understand the purpose and influence of these and other state horticultural science publications that were being produced in increasing numbers in the late 1920s. Little is known of the make up of their readership during this phase of more extensive government patronage of horticultural science.

The intervention of the Prime Minister in the administration of farm institutes indicates the importance of horticultural and agricultural science to the state. The farm institutes fulfilled a vital function in conveying examples of best practice to growers, although the number created was far short of the anticipated target.

In order to gain a more comprehensive picture of horticultural research in the period 1910-1930, a fuller picture is needed of horticultural investigations and horticultural education at universities and colleges, undertaken with and without government funds. Examples of this work given in preceding chapters show a wide range of topics were investigated, a feature of UK horticultural science, that shaped the discipline by helping to define subject matter, procedures and techniques and provided material for the development of a range of courses.

Chapter 7

Horticultural Science and the Commercial Sector

The working world of commercial horticulture in the period 1910-1930 is examined in this chapter. I state its main sectors and show it was a growth industry. As I have outlined in chapters 3 and 4, the industry faced a number of problems, for example, pest and disease attacks, weed growth, 'soil sickness' in glasshouses, poor quality fruit tree rootstock, a shortage of stable manure, issues of nomenclature, crops having a short storage life and variability in crop quality. I continue the exploration of the support given by the Development Fund (DF), Development Commission (DC), the Board of Agriculture and Fisheries (BAF) and the Ministry of Agriculture and Fisheries (MAF) to growers. The second half of the chapter discusses the research and investigations conducted by some commercial horticulturalists that helped shape horticultural science.

Writers on the history of genetics, particularly those investigating the impact of Mendel, have faced a shortage of primary source material concerning the scientific work of commercial growers. Some have focused on the catalogues of seed firms that were involved in plant breeding, to good effect.[1] The emphasis, though, has been on agricultural rather than on horticultural science. Webber noted that the history of market gardening is patchy because historical material is not readily available and this is true for certain sectors of the horticultural

[1] For example, see B. Charnley, *Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930*, University of Leeds, PhD thesis, 2011, p. 29, pp. 129-133; D. Berry, *Genetics, Statistics and Regulation at the National Institute of Agricultural Botany*, University of Leeds PhD thesis, 2014, pp. 143-144.

seed trade in the period 1910-1930.[2]

Palladino has claimed DC supported research was ineffectual in meeting the concerns of farmers.[3] More needs to be known about the work of the great number of research stations funded by the DC shown in Tables 3.1 and 3.2 in Chapter 3, to be able to confirm this judgment. I will demonstrate, however, that a number of these research stations were able, with some degree of success, to address problems presented by commercial horticulture.

Webber claimed the scientific side of the horticultural industry was well established by the 1920s, Holderness commenting about growers between 1840-1910 stated there was much scientific activity involving seed breeding, production of new varieties and acclimatization of imported plants and Palladino has remarked on the research facilities of seed firms in the first half of the twentieth century.[4] These authors provide limited details of the actual scientific work carried out by the commercial growers and I build on their observations and examine some of the investigations and experiments that were conducted by the commercial horticultural sector. By demonstrating this work focused not just on plant breeding and acclimatisation but also on a range of other problems that the commercial sector wanted science to solve, I extend the discussion.

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[2] R. Webber, *Market Gardening. The History of Commercial Flower, Fruit and Vegetable Growing*, Newton Abbot: David and Charles, 1972, p. 11. A number of seed firms have discarded their early twentieth century records. Some documentary material exists, although there are often gaps in these records.

[3] P. Palladino, *Plants, Patents and the Historian. (Re)membering in the Age of Genetic Enquiry*, Manchester: Manchester University Press, 2002, p. 56, p. 95.

[4] Webber, op. cit. (2), p.122; B. A. Holderness, 'Specialised Cropping Systems' in E. J. T. Collins and J. Thirsk, (eds.), *The Agrarian History of England and Wales. Volume VII, 1850-1914*, Cambridge: Cambridge University Press, 2000, pp. 479-486; P. Palladino, 'Science, Technology and the Economy: Plant Breeding in Great Britain, 1920-1970', *Economic History Review* (1996), 49, (1) pp.116-136.

7.1 The Growth of Commercial Horticulture

The fortunes of the agricultural and horticultural industries between 1880-1940 were not similar and need differentiating. Although the definitive history of agriculture in this period has yet to be written, several writers have stated agriculture was generally depressed and faced decline: the exception were the years of the First World War when food shortages and government support kept prices buoyant.[5] They are right to suggest that some sectors of agriculture were more profitable than others: for example, dairy farmers prospered as did some meat producers while cereal growers did not.[6] Their suggestion that distress was caused by falling prices as a result of relatively cheap imports of grain and the repeal in 1921 of the 1917 Corn Production Act, a wartime measure guaranteeing wheat and oat prices, needs the confirmation of further research. A revisionist article by Cooper outlines how farmers opposed the 1917 Act and favoured its repeal.[7] Less contentious is the claim that farmers who moved out of agriculture into horticulture often benefited financially.[8] There is a paucity of statistical information about the development of the horticultural industry in different regions, although Robinson's study of the

[5] P. J. Perry, *British Farming in the Great Depression 1870-1914: An Historical Geography*, Newton Abbot: David and Charles, 1974, pp. 22-23; G. M. Robinson a), *Agricultural Change: Geographical Studies of British Agriculture*, Edinburgh: Northern British Publishing, 1988, p. 96; M. Tracy, *Government and Agriculture in Western Europe 1880-1988*, Hemel Hempstead: Harvester Wheatsheaf, 1989, p. 119; R. Perren, *Agriculture in Depression, 1870-1940*, Cambridge: Cambridge University Press, 1995, p. 14; P. Allanson and A. Moxey, 'Agricultural land use change in England and Wales, 1892-1992', *Journal of Environmental Planning and Management* (1996), 39, (2), pp. 243-254.

[6] Perry, op. cit. (5), p. 23; Robinson a), op. cit. (5), p. 13; Allanson and Moxey, op. cit. (5), p. 250.

[7] A. F. Cooper, 'Another Look at the "Great Betrayal": Agrarian Reformers and Agricultural Policy in Britain', *Agricultural History* (1986), 60, (3), pp. 81-104.

[8] Perry, op. cit. (5), p. 23, p. 120; Robinson a), op. cit. (5), p. 13; Perren, op. cit. (5), p. 13.

West Midlands shows the amount of land under horticulture increased by approximately 31% between 1914-1930, lending support to the claim that the horticultural industry was an expanding and wealth generating area of the economy.[9] Robinson comments that although fruit acreage in these years fell, the level of output was maintained or increased. This reflects more efficient production methods and the utilisation of applied science research, a feature noted by a number of writers.[10] As the importance of commercial horticulture to the economy increased, additional state funds for horticultural science research were made available to the research stations. When research expanded the stations were able to acquire new laboratories and equipment and extend other facilities. Innovative producers in the horticultural sector were aware of research station investigations and appreciated that science could help capture a greater market share and sought the advice of scientists and some hired chemists and financed their own investigations.

As I have indicated previously, horticulture like agriculture had a number of distinct sectors. These included fruit growing, market gardening, glasshouse production, flower growing and the nursery trade. Because information about flower growing and the nursery trade is particularly scarce, the following sections focus mainly on fruit output, market gardening and glasshouse production.

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[9] G. M. Robinson b), *West Midlands Farming 1840's to 1970's: Agricultural Change in the period between the Corn Laws and the Common Market*, University of Cambridge: Department of Land Economy, 1983, p. 73, p. 76.

[10] A. W. Ashby, *Allotments and Smallholdings In Oxfordshire: A Survey made on behalf of the Institute for Research in Agricultural Economics*, *University of Oxford*, Oxford: Oxford University Press, 1917, p. 190; R. H. Stoughton, 'Science and Fruit Growing' in R. T. Pearl (ed.), *Scientific Horticulture*, (1935), III, pp. 6-12. This was the President's address; Lord Ernle, *English Farming Past and Present*, London: Heinemann Educational Books, 1961 pp. 390-391, p. 439, pp. 461-462. A. D. Hall revised some chapters and included new sections to update the history; Robinson b), op. cit. (9), p. 76.

7.1.1 Fruit Growing

The increasing importance to the economy of the expanding commercial horticultural industry can be gauged, in part, by an official report about the fruit industry published in 1905.[11] Commercial horticulturalists had been lobbying the government over a number of years for support and the publication was a strong signal by the government to growers that the economic importance of horticulture was being recognised by the state. The fruit industry was regarded as 'progressive' and A. E. Brooke-Hunt, Superintendent Inspector of Education for the BAF giving witness evidence, commented that with regard to the attitudes of growers towards the work of county councils in education and science, 'resistance was almost overcome in horticulture'[12]. The investigation indicated there were 148,221 acres of fruit in the country in 1873 and 243,008 in 1904.[13] Lord Ernle, President of the Board of Agriculture 1916-1919 and history graduate, had calculated that the acreage of soft fruit in England and Wales had risen by approximately 43% between 1891 and 1914.[14] R. G. Hatton, Director of East Malling Research Station (EMRS), estimated there were 310,000 acres of top and soft fruit in England in 1939.[15] The main top fruit areas were the Clyde Valley, Somerset, Wisbech and the Pershore district of Gloucestershire and whilst soft fruit were more widely distributed, Middlesex, the Vale of Evesham, Kent, Cheshire and Blairgowerie developed as important

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[11] Board of Agriculture, *Report of the Departmental Committee appointed by the Board of Agriculture to Inquire and Report upon the Fruit Industry of Great Britain*, *with Copy of the Minute appointing the Committee,* London: HMSO, 1905.
[12] *Report of the Departmental Committee,* op. cit. (11), p. 8.
[13] *Report of the Departmental Committee*, op. cit. (11), p. 2.
[14] Ernle, op. cit. (10), pp. 440-444, pp. 513-514.
[15] R. G. Hatton, 'Landmarks in the Development of Scientific Fruit Growing', in Anon, *Agriculture in the Twentieth Century: Essays on Research, Practice and Organization to be Presented to Sir Daniel Hall*, Oxford: Oxford University Press, 1939, p.p. 309-360.

locations.[16]

7.1.2 Market Gardening

Between 1880-1930 market garden acreage expanded and output increased. Robinson noted the rise in the amount of land devoted to market gardening in the country generally and calculated that for the Vale of Evesham between 1879 and 1914 the number of smallholdings increased by 72% and Pam has charted the growth of market gardening around Edmonton and Enfield in Middlesex for the years 1880-1939.[17] Lord Ernle observed the acreage of carrots increased by approximately 10% in the period 1901-1918 and Brassley has pointed out that the land devoted to potatoes grew by 38% between 1910-1930.[18] In the decade 1921-1931 the amount of male and female gardeners, seedsmen, nurserymen and florists increased by nearly 9%, the number of gardeners labourers increased by approximately 54% and in 1931 there were 139,201 females and males aged 14 and over in England and Wales working in market gardening, fruit growing, flower and seed growing, nursery gardening and undefined gardening, roughly 2.5% of the working population.[19]

This expansion in market gardening occurred in Sandy in Bedfordshire, Huntingdonshire, the Thames Valley, North Kent, the Vale of Evesham,

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[16] E. A Pratt, *The Transition in Agriculture*, London: John Murray, 1906, p. 47, p. 64; Robinson (a), op. cit. (5), p. 104; J. Thirsk, *Alternative Agriculture. A History from the Black Death to the Present Day*, Oxford: Oxford University Press, 2006, p. 175.

[17] Robinson a), op. cit. (5), p. 68; Robinson b), op. cit. (9), p. 41; D. Pam a), *A History of Enfield Volume Two – 1837-1914: A Victorian Suburb*, Enfield: Enfield Preservation Society, 1992, p. 95, p. 146; D. Pam b), *A History of Enfield Volume Three - 1914-1939: A Desirable Neighbourhood*, Enfield: Enfield Preservation Society, 1994, p. 22, p. 58, p. 102.

[18] Ernle, op. cit. (10), pp. 513-515; P. Brassley, 'Output and Technical Change in Twentieth-Century British Agriculture', *Agricultural History Review* (2000), 48, (1), pp. 60-84.

[19] Ernle, op. cit. (10), pp. 508-509.

Spalding and Wisbech, the Dee Valley in Cheshire, the Lancashire peatlands, parts of Cornwall and Somerset and areas of Perthshire.[20] Besides growing vegetables and soft fruit, some producers specialised in the production of flowers and the main areas were Hounslow, Edmonton, the Kent marshes, Colchester, Biggleswade, Cambridgeshire, Lincolnshire, Cornwall and the Scilly Isles.[21] Thirsk rightly attributes some of this expansion to the development of glasshouses, that helped extend the growing season and provided protection for the flowers of ornamentals that could be damaged by low temperature, wind and rain.[22]

7.1.3 Glasshouse Cultivation

In 1913, 86% of the UK's glasshouse produce came from the Lea Valley, particularly the areas around Enfield in Middlesex, Walthamstow in Essex and Cheshunt in Hertfordshire.[23] Commercial glasshouses first appeared in this region in the 1880s and expansion was marked. Around Cheshunt in 1900 there were 264 acres of glasshouses, by 1929 there were 667 acres of glass and in the late 1940's there were 1500 acres.[24] Besides the Lea Valley, other notable areas were Worthing, the second largest production area, Blackpool, Guernsey, North-West Kent, Dorset, Norfolk, Staffordshire, Lancashire and the

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[20] Pratt, op. cit. (16), p. 47, pp. 71-143; Perren, op. cit. (5), pp. 13-14; Robinson a), op. cit. (5), pp. 96-117; Robinson b), op. cit. (9), pp. 38-44.
[21] Pratt, op. cit. (16), pp. 71-83; Thirsk, op. cit. (16), p. 179-180. The main flowers were asters, carnations, chrysanthemums, cornflowers, daffodils, dahlias, lilies, lily of the valley, marguerites, pansies, poppies, roses, stocks, sweet peas, violas and wallflowers.
[22] Thirsk, op. cit. (16), p. 179; W. F. Bewley, *Commercial Glasshouse Crops*, London: Country Life Limited, 1950, p. 469. Improvements in design to allow better light penetration and more efficient boilers were some of the developments.
[23] Pam b), op. cit. (17), p. 151; J. G. L. Burnby and A. E. Robinson, *' "Now turned into fair garden plots" ',* Edmonton: Edmonton Hundred Historical Society, 1983, p. 13.
[24] Bewley, op. cit. (22) p. 476.

Clyde Valley.[25]

Important crops were pot plants, flowers, grapes, melons, peaches, nectarines, figs, cucumbers, tomatoes, mushrooms and forced vegetables and salads.[26] The major glasshouse crop in the Lea Valley was tomatoes and by 1940, 80% of Lea Valley glasshouses were used for tomato production. H. V. Taylor, Assistant Horticultural Commissioner of the Ministry of Agriculture and Fisheries, believed the value of the tomato crop grown in the country in 1925 was £2,350,000.[27] Tomatoes had risen in popularity since being grown as a luxury item in the 1870s, and in 1935, 'over the whole country it represented 36% of the total value of glasshouse crops sold in the market'.[28]

Summary

The economic performance of commercial horticulture and of agriculture differed in the period 1900-1930 although caution is needed, as definitive histories of both have yet to be written. The amount of land given over to commercial horticulture expanded, banks were willing to make loans to those setting up market gardens and nurseries and prices were relatively buoyant.[29] Wheat growers, in contrast, suffered from periods of falling prices and some farmers facing financial difficulties converted part of their land to the production of horticultural crops.

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[25] Bewley, op. cit. (22), pp. 468-476.

[26] H. Rider Haggard a), *Rural England being an Account of Agricultural and Social Researches carried out in the Years 1901 and 1902*, *Volume I*, London: Longman, Green and Company, 1902, pp. 72-75; Pratt, op. cit. (16), pp. 88-90; Ernle, op. cit. (10), p. 391; Bewley, op. cit. (22), pp. 468-476.

[27] 'Mr H. M. V. Taylor at Cheshunt', *The Market Grower and Salesman* (1928), V, (24), p. 11.

[28] Bewley, op. cit. (22), p. 470.

[29] Bewley, op. cit. (22), p. 479. Growers setting up glasshouse complexes faced relatively high capital costs.

Major sectors were fruit growing, glasshouse crops, market gardening, ornamental plant production and flower cultivation. Although orchard acreage declined, output was maintained through efficient production methods based on scientific research and the demand for top and soft fruit enabled the sector to prosper. Demand for market garden crops expanded as the population was rising and much of this produce could not be frozen and needed consuming fresh.[30] A noticeable feature was the growth of commercial glasshouse production, particularly in the Lea Valley and around Worthing, Sussex. The major crops were tomatoes and cucumbers. More acres were devoted to tomatoes, originally a luxury crop but in 1930 part of the diet of all classes.

7.2 'Grasping the Hand of Science': Horticultural Science and Growers[31]

In an article about 'The Trade and Science' in *Commercial Horticulture* in 1929, the editor wrote:

> We are leaving behind us the unreasonable prejudice of the generation of horticulturalists who would have nothing to do with science…Only in exceptional cases can a commercial horticulturalist pursue research to an extent his calling requires, and for the good of all it is necessary that a well-equipped establishment shall be devoted to research and experimental work…Commercial horticulturalists have good ground to be grateful that science is dealing with its many important problems

The writer noted the development of horticultural research stations and the

[30] Between 1901 and 1931 the population of Great Britain and Ireland rose by 7,640,169, an increase of nearly 5%.
[31] 'The trade and Science', *Commercial Horticulture* (1929), 1, (916), p. 275.

willingness of some commercial establishments in the period 1910-1930, particularly the larger concerns with capital resources, to engage with horticultural science and with horticultural scientists and to adopt some of the techniques that developed out of the research.[32] The annual reports of the research stations, the articles in commercial trade journals, accounts describing meetings held by the commercial trade and the communication by officials in the Horticultural Division of the BAF with the commercial sector show that a number of growers, as yet an unquantifiable figure, saw science as a means of solving production problems.[33] Growers with extensive resources established their own research stations, for example East Malling, Long Ashton and Cheshunt; these later received government funds.

This adoption by growers of methods based on scientific research can be attributed partly to the state system of horticultural science research and investigation set up by A. D. Hall. This was discussed in Chapters 3 and 4 and I have explained that results from pure science research were utilised by scientists conducting applied science investigations and that their results were conveyed to colleges and farm institutes who used them to conduct comparative trials and experiments for the benefit of growers.[34] Emphasis was

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[32] 'The trade and science', op. cit. (31), p. 275.

[33] The following were examined: *Allotments and Gardens* (1918), *Commercial Horticulture* (1929), *The British Gardener* (1901), *The Journal of the British Gardener's Association* (1907), *The Fruit Grower, Fruiterer, Florist and Market Gardener* (1896), *The Gardener's Chronicle* (1841), *The Market Grower and Salesman* (1923), *The Nurseryman and Seedsman* (1894), the annual reports of Cheshunt Experimental and Research Station, East Malling Research Station, Long Ashton Research Station, Rothamsted Experimental Station and documents at the NA concerning the Chamber of Horticulture and the work of the Horticultural Division of the Board and Ministry of Agriculture and Fisheries giving details of some of the meetings and interactions with growers.

[34] A. D. Hall, Memorandum on agricultural research, 2nd December 1910, D4/1, NA; *Second Report of the Development Commissioners, being the report for the year ended the 31st March 1913*, pp. 13-14, D3/3, NA.

placed on adapting investigations to local conditions to maximise relevance, using demonstration plots to illustrate how pure research could be translated into practice and persuading growers to conduct investigations.[35] The MAF Controller of Horticulture, W. J. Lobjoit, who was also a well respected commercial producer, in an address to horticulturalists and agriculturalists in 1923 believed that, 'every discovery made at research stations was a benefit' to cultivators.[36]

I now discuss the influence of horticultural science on growers by examining firstly, the products and techniques developed by research stations, secondly the services provided by some of the research stations, for example, lectures, demonstrations and answering queries and, thirdly, the work involving pure seed provision and synonym reduction.

7.2.1 Using the Techniques and Products Developed by Research Stations

This section develops further the work of the research stations discussed in Chapter 4. A charge was generally made for the products developed by research stations and in some cases a non-profit making manufacturing company was formed with the aim of supplying the product at low cost. Highly regarded fruit stock was distributed to growers from East Malling Research Station for stock propagation at prices fixed by a Committee and later rootstocks were distributed nationally and internationally.[37] Rothamsted developed the successful product Adco, that converted straw into manure, and

[35] *Report of the work of the Intelligence Department of the Ministry of Agriculture for the two years 1919-1921*, London: HMSO, 1922, p. 92, p. 122; *Second Report of the Development Commissioners*, op. cit. (34), pp. 7-8.
[36] 'The Ministry's policy', *The Market Grower and Salesman* (1923), 1, p. 27.
[37] 'Distribution of surplus pedigree fruit tree stocks at East Malling', *The Gardeners' Chronicle* (1923), LXXIV, (1919), p. 198.

the chosen manufacturing company was soon operating on a very large scale and growers in different parts of the country were producing thousands of tons annually. Rothamsted's technique of inoculating lucerne seed with bacteria to improved the supply of nitrogen to the soil was also given to a company to market.[38]

W. F. Bewley at Cheshunt Experimental and Research Station produced the fungicide 'Cheshunt Compound' and in an interview for the *Market Grower* in 1923 stated confidently that growers all over the country were using the product.[39] The station distributed biological controls for pests to growers and gave much assistance to producers in Worthing and in 1930 provided a service to the expanding glasshouse industry located around Manchester.[40] The products of Cheshunt were given a favourable reception because Bewley and his team listened to growers, made use of their findings and involved them by using their glasshouses as research outposts for investigations. One Lea Valley producer, W. B. Randall, paid for a research assistant for soil sterilisation and growers over the country invited Bewley and his colleagues to give talks about glasshouse problems that could be managed by techniques based on scientific principles.[41]

Some textbooks aimed at commercial growers incorporated the investigations

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[38] Sir John Russell, F.R.S, 'Research and Agricultural Science', *Nature* (1923), III, (2788), pp. 466-470; Sir E. John Russell, F.R.S, 'Present-day Problems in Crop Production', *Nature* (1924), 114, (2864), pp. 434-437.

[39] 'Market Grower Interviews. Dr. W. F. Bewley', *Market Grower and Salesman*, (1923), 4, p. 9.

[40] *Development Commission. Minutes of one hundred and eighty eighth meeting, 8th[th] May 1930*, D1/4, NA.

[41] *Third Annual Report 1917. Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited, Cheshunt*: The Cheshunt Press, 1918, p. 6; *Twelfth Annual Report 1926*. *Experimental and Research Station, Nursery and Market Garden Industries Development Society Limited, Cheshunt*: The Cheshunt Press, 1927, p. 9. Bewley in 1925 set up a popular course of evening lectures in the winter months on the application of science to glasshouse production.

of research stations ensuring products were brought to their attention, for example the tar distillate washes and other sprays developed at Long Ashton and East Malling.[42] Trade journals gave wider publicity to the work of the research stations and the pest and disease control methods that had been developed. The growth in numbers of these journals - although some were short lived - is evidence of an expanding readership. Research findings at Long Ashton and East Malling were reported regularly in some of these journals.[43] Several contained articles written by staff at research stations and colleges on pest and disease life cycles and their control and a number contained statistics, technical language and scientific diagrams and were more like sections of

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[42] Volume 1 of the book by H. J. Wright, *The Fruit-Grower's Guide*, London: Virtue and Company Limited, 1924, gives examples of rootstocks produced by East Malling and Long Ashton, a lime-sulphur wash used by East Malling and the investigations by Professor Salmon of South East Agricultural College on leaf scorch disease. The book, Anon, *Commercial Cucumber Culture*, London: Ernest Benn Limited, 1924, refers to the work conducted at Cheshunt Research Station.

[43] *The Fruit Grower, Fruiterer, Florist and Market Gardener* provided updates for its readers on the scientific work that took place at the research stations of Rothamsted, Long Ashton and East Malling , the Ministry of Agriculture Seed Testing Station, the National Institute of Agricultural Botany, Ormskirk Potato Experiment Station, the research stations in other countries and on the experimental plots of county councils. *Allotments and gardens* (1918), 'a monthly journal for cultivators of small plots and food producers', provided the occasional article on horticultural science, for example, the work at Rothamsted to convert straw into a useful manure. *The Nurseryman and Seedsman* reported the scientific work of research stations, commercial horticulturalists and universities. *The Market Grower and Salesman* referred regularly to the work of Cheshunt Research Station and encouraged readers to apply to the station for the latest information on techniques that had been developed and also outlined the activities of other research stations such as the National Institute of Agricultural Botany and the Tamar Valley Experimental Station. *Commercial Horticulture* covered work at Cheshunt Glasshouse Research Station, Long Ashton Research Station, East Malling Research Station, the Low Temperature Research Station, the John Innes Horticultural Institution and Cheshire School of Agriculture. *The Gardeners' Chronicle*, a journal aimed at commercial growers, associated trades and professional and amateur gardeners, referred throughout the 1920's to the work undertaken at Rothamsted, the Mycology Department at Edinburgh University, the Tamar Valley Experimental Station, the School of Agriculture at Cambridge University, Seale Hayne Agricultural College, Cheshunt Glasshouse Research Station, Long Ashton Research Station and to the investigations carried out by growers.

biological textbooks than practical guides for growers.[44]

Receptivity of growers to science and the willingness to consider and adopt techniques developed at Long Ashton Research Station (LARS) can be gauged by the following. In 1929 L. N. Staniland gave a lecture on strawberry pest and disease control to East Sussex Growers Association and there were 'gratifying numbers'.[45] A comment in 1929 about LARS tar distillate washes in *Commercial Horticulture* noted they were initially met with 'incredulity' but had proved themselves and were now 'very extensively employed by market growers' and the writer considered them to be, 'the greatest advance in orchard spraying'.[46] In the same year the journals fruit diarist wrote that the tar distillate formula developed by Long Ashton Research Station gave 'splendid control' and because its commercial launch led other production companies to reduce prices, 'Long Ashton has done the grower a great service in this matter for we have paid fancy prices for tar distillate wash for too long'.[47] P. A. Bottomley, of the University of Reading, writing in *The Gardeners' Chronicle* in 1930 thought, 'the Long Ashton wash gives better control of insect pests… and can be used at lower concentrations ...and will not damage trees or buds in the slightest degree' and in 1933 an article in *The Guardian* gave the spray a very

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[44] For example, see the following articles, written by academics: K. Smith and J. T. Wadsworth, 'Carrot and onion flies', *The Fruit Grower, Fruiterer, Florist and Market Gardener* (1921), LI, (1322), pp. 575-578. Smith and Wadsworth were at Manchester University; J. C. M. Garcher, 'The celery fly. Life history; damage to plants; and control', *The Fruit Grower, Fruiterer, Florist and Market Gardener* (1921), LI, (1328), pp. 829-831. Garcher was from Imperial College; Sir J. C. Bose, 'Photosynthesis', *The Gardeners' Chronicle* (1924), LXXIX, (1947), p. 215. Bose was Director of the Bose Institute, Kolkata, India; M. J. F. Wilson, 'Disease of Douglas fir and other conifers'. *The Gardeners' Chronicle* (1928), LXXXIII, (2146), p. 105. Wilson was based at Edinburgh University.

[45] Sussex Correspondent, 'What is wrong with strawberries?', *Commercial Horticulture*, (1929), 1, (2), p. 36.

[46] Tar distillate washes', *Commercial Horticulture* (1929), 1, (1), p. 16.

[47] J F, 'From a fruit growers diary', *Commercial Horticulture* (1929), 1, (34), p. 584.

favourable report.[48]

I have been unable to find complaints from growers that these products were of little value. This, in conjunction with the forgoing, suggests that research station science impacted on some commercial growers, sometimes in significant ways, although the picture is far from complete.

Summary

Growers used a number of products of applied science developed at research stations because they solved problems successfully and were sold at reasonable prices, generally by non-profitmaking companies established for the purpose. Cheshunt Experimental and Research Station, East Malling Research Station, Long Ashton Research Station (LARS) and Rothamsted benefited growers by developing products in this way. It is clear there were growers interested in horticultural science and willing to adopt the products developed by research stations, as long as these methods were cost effective or posed no danger to human health.

The work of the research stations appeared in textbooks produced for the industry and some of the methods developed became part of standard practice. Trade journals regularly featured research station work and endorsed the scientific enquiries that the stations conducted. Articles by research workers reinforced the message that science could help solve production problems.

[48] P. A. Bottomley, 'The Long Ashton tar oil wash', *The Gardener' Chronicle* (1930), LXXXVII, (2253), pp. 172-173; BL, 'Winter Spraying In the Orchard', *The Guardian,* 2nd December 1933, p. 10.

7.2.2 Services Provided by Research Stations

Research stations staff gave talks to growers and received parties of commercial horticulturalists who were shown around the facilities. In 1921 R. D. Hatton, Director of EMRS, addressed the Rochester branch of the National Farmers Union on fruit tree stocks and explained the research work that was being carried out. This was 'of absorbing interest to fruit growers'.[49] At the stations Open Day in 1929, 150 producers attended to hear brief lectures in the laboratories on the subjects under investigation, which was the usual procedure, but on this occasion they spent most of the time in the open watching the spraying programmes that were taking place.[50] The address by H. V. Taylor about the glasshouse industry to Cheshunt growers in 1928 had a 'large attendance' and in 1929 a good number of growers visited the laboratories and glasshouses at Cheshunt and discussed with the scientists the research work being carried out.[51]

Chapter 4 described how the research stations responded to postal and telephone enquiries from growers, which over a year could number several thousand, and showed that between 1920-1930 requests increased steadily. *The Times* in 1927 noted the increase in telephone enquiries received at LARS and the expansion in the number of visits made by its scientific staff to growers. In 1929 one of the papers correspondents was worried that responses by research stations to calls for advice and assistance would hamper the

[49] 'Fruit tree stocks', *The Fruit Grower, Fruiterer, Florist and Market Gardener* (1921), LI, (1319), p. 462.

[50] 'From a fruit growers diary', *Commercial Horticulture* (1929), 1, (15), p. 252.

[51] 'Mr H. V. Taylor at Cheshunt', *The Market Grower and Salesman* (1928), V, (24), p. 11; 'A practical station', *Commercial Horticulture*, (1929), 1, (5), p. 91.

experiments and investigations of staff.[52]

This demonstrates the confidence and trust placed in research station scientists by the commercial sector. The personal visits of scientists to premises in response to requests to solve problems brought advantages that were difficult to achieve by any other method. By interacting with growers in this way, scientists built up goodwill, established professional relationships, created opportunities to discuss the scientific work that they were carrying out and brought back ideas for fundamental research.

<u>Summary</u>

Research station scientists in addition to their research commitments, gave talks to grower's societies and associations about their work and the research of their colleagues and gave visitors conducted tours to see experiments that were taking place. There was a commitment by the scientists to answer queries by post, telephone or personal visit that helped develop confidence in horticultural science work and promoted goodwill towards the scientists.

7.2.3 Trialing Varieties and Reducing Synonyms

In this section the work carried out by several institutions to assist growers cope with the problem of synonym proliferation is discussed. Much of the discussion is given over to the work of the National Institute of Agricultural Botany (NIAB), founded in 1919. Charnley and Berry in their accounts of the Institute have

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[52] 'Horticultural Research. Activities at Kent Station', *The Times*, (13th June 1927, 44606), p. 19; 'From a correspondent. Advice For Fruit Growers. State Assistance', *The Times*, (1st July 1929), 4523, p. 20.

shown that in the lead up to its foundation and in the very early years a number of interest groups had different expectations of its role and as part of this analysis they examined the aspirations of various sections of the agricultural community.[53] I suggest that another element also needs exploring, the interests of the horticultural community. In the beginning, the NIAB received considerable support from the DC and the DF and was not created to serve agriculture exclusively as its work was meant to benefit also horticultural producers.[54] Market gardeners and nurserymen gained from the work of the Institute by the assurance they were not wasting money on varieties that were not true to type. Seed firms benefited by having the plants raised from their horticultural and agricultural seeds subjected to trials: their approach to these different markets, though, was not always the same.[55]

The DC hoped that NIAB trials of varieties introduced by seed firms and individuals and subsequent distribution of seed from varieties of proven worth, would introduce growers and gardeners to new stock.[56] Influential members of the seed trade welcomed the role of the NIAB as seed trialler, but nothing more, as this would save them the expense of having to carry out this function. This and other influences meant the major role of the NIAB throughout the 1920s was as trialler of varieties.[57] The DC gave a grant for a threshing machine in order to avoid contamination when seed was collected from trialled plants in

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[53] Charnley, op. cit. (1), pp. 67-75; Berry, op. cit. (1), p. 25, p. 56, p. 75.

[54] *Development Commission. Minutes of Eighty-first Meeting, 11th December 1918*, D1/2, NA.

[55] Some of the large seed firms such as Suttons and Carters had separate catalogues and separate departments for horticulture and agriculture and different policies. It would be useful to have information about the various strategies adopted by the groups that made up the commercial sector.

[56] *Ninth Report of the Development Commissioners, being the report for the year ended the 31st March 1919*, p. 5, D3/9, NA.

[57] Berry, op. cit. (1), p. 57, p. 60, p. 76.

order to undertake further trialling.[58] A. D. Hall was critical of some of these activities, believing the use of private farms by the NIAB was unsatisfactory as farmers, 'could not give close and accurate attention, particularly at harvest time' and stated that, 'farmers and market gardeners must be authoritatively informed as to the value of certain crops'.[59] Despite these criticisms, work at the NIAB continued in the way that the Director believed was best. To reassure critics, NIAB supervised the crop variety testing stations established at four agricultural and horticultural colleges (Harper Adams College, Lord Wandsworth Agricultural College, East Anglia Institute of Agriculture and Seale Hayne College) whose qualified staff had the expertise and time to ensure the work was conducted accurately. At these stations, 'Rigorous tests were carried out to ascertain the value of new and improved varieties of crops as against standard varieties' and, 'the small scale work demanded minute accuracy at every stage of cultivation and harvest', with 'recorders specially trained'.[60]

The work of the NIAB's Potato Testing Station at Ormskirk and its potato testing sub-stations in Shropshire, Norfolk, Essex, Hampshire and Devon was of equal value to commercial growers.[61] Here, trial work was carried out to find varieties with a natural immunity to wart disease and part of this research entailed establishing true varieties: in some years a hundred varieties would be investigated.[62] The knowledge gained about immune varieties and the reduction

[58] *Twelfth Report of the Development Commissioners for the year ended the 31st March 1922*, p. 37, London: HMSO, 1922, D3/12, NA.
[59] *Development Commission. Minutes of one hundred and nineteenth meeting, 24th January 1924*, D1/3, NA. Hall wanted trained staff to use the analytical techniques developed by R. A. Fisher at Rothamsted when conducting trials.
[60] *Report on the work of the Intelligence Department for the two years 1924-26* a), London: HMSO, 1927, pp. 18-19.
[61] *Seventeenth Report of the Development Commission for the year ended the 31st March, 1927*, London: HMSO, 1927, D3/17, NA.
[62] *Fourteenth Report of the Development Commissioners for the year ended the 31st March, 1924*, London: HMSO, 1924, D3/14, NA.

in synonyms that resulted was of great benefit to growers in terms of convenience and cost saving as previously, ‘growers had wasted time trying new sorts to find they are old varieties under new names’. The variety British Queen, for example, was found to have 94 synonyms and there were 10 different names for Epicure, bred by Sutton and Sons.[63]

The Royal Horticultural Society, aided by the DF, began a 10-year series of trials of fruit trees in 1921 at the request of MAF to test market potential. The scheme, with 10 sub-stations, was controlled by a Committee of 11 consisting of growers, scientists and Ministry staff and chaired by W. Bateson. Commercial horticulturalists could send to Wisley the top fruit, soft fruit and nuts they had raised for trialing and, if successful, receive certification. In 1929 at Wisley, 270 varieties were grown and 60 promising types had been sent to the sub-stations for further trials. Four of the sub-stations were research institutes - East Malling Research Station, Long Ashton Research Station, Cambridge University Horticultural Research Station and the John Innes Horticultural Institution (JIHI) - and the rest were fruit stations of county councils.[64] Commercial horticulturalists benefited from the reduction in nomenclature and the reassurance that details of habits and performance of certificated varieties were reliable. This assisted assessments of economic potential.

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[63] *Thirteenth Report of the Development Commission for the year ended the 31st March, 1923*, London: HMSO, 1923, D3/13, NA; R. N. Salaman, *Potato Varieties*, Cambridge: Cambridge University Press, 1926, p. 226, p. 251.

[64] *Report on the work of the Intelligence Department of the Ministry for the three years 1921-1924* b), London: HMSO, 1925, p. 131; *Report on the work of the Intelligence Department* a), op. cit. (60), p. 18, p. 60; *Report on the work of the Research and Education Division for the year 1928-29*, London: HMSO, 1930, p. 13.

<u>Summary</u>

Scientists and commercial growers gave attention to the production of new varieties of plants that had a natural resistance to diseases difficult to control using standard fungicides. Part of this work entailed synonym reduction to ensure trialed varieties were true to type. The NIAB was involved in this type of research and besides agricultural investigations, it undertook also horticultural enquiries as its main funding body, the DC, envisaged that the Institute would serve horticulturalists and agriculturalists. Throughout the 1920's the NIAB trialled varieties that had been bred by seed firms. Some large seed firms served both horticultural and agricultural markets and further research is needed to see if approaches to these markets differed and if the NIAB treated these markets differently. The Royal Horticultural Society carried out a programme of research to evaluate the commercial possibilities of new varieties of hard and soft fruit. This also involved reducing synonyms.

A noticeable feature of the period was the use of sub-stations based at research stations, colleges, universities and county council farm institutes. Both NIAB and the RHS relied heavily on the data produced by such stations in order to produce findings which growers and other scientists made use of. The extent and impact of this complex network of research and communication has yet to be evaluated. The research is an example of the bottom tiers of the system of horticultural and agricultural science research developed by A. D. Hall. The DC did not envisage the NIAB or the RHS as locations of pure research and their role was to use the findings of fundamental research to design applied science work and produce data that pure research scientists could evaluate.

7.3 The Shaping of Horticultural Science by the Commercial Horticultural Sector

As I have mentioned previously, knowledge of the scientific work of commercial nurserymen, seed firms and horticultural growers in the first 30 years of the twentieth century is patchy. Webber in his book on commercial horticulture noted the scientific side of the industry was well established by the 1920s but was referring not to the investigations of commercial growers but to the scientific work of horticultural research stations.[65] This section begins by examining the scientific activities of nurserymen growing unusual plants, is followed by a discussion of the investigations of fruit growers and ends with a study of the research undertaken by the seed firm of Sutton and Sons.

The DC did not normally allocate funds to growers to conduct scientific investigations. In the first few years of the Commission, applications were received from the commercial horticultural sector but they were always turned down and after several years applications ceased.[66] Growers who wanted to conduct their own investigations needed to have the necessary capital and it

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[65] Webber, op. cit. (2), p. 122.

[66] Letter headed, Application for grant from the Development Fund for field experiments, 3rd January 1912, T1/11406, NA; Letter from the Secretary of the Board of Agriculture to the Secretary of the Development Commission, 28th February 1912, T1/11406, NA; Pershore and District Fruit Growers and Market Gardeners Association. Report on the application for grants, 3rd April 1912, T1/11406, NA. Often the reason given for refusing a grant was that similar work was taking place at county council research plots or at colleges and universities. The Pershore Fruit Growers and Market Gardeners Association applied for a grant to conduct horticultural and agricultural field trials. The aim was to test the results of experiments carried out by agricultural research institutes and the government on a large scale and then adopt the new methods if they proved successful. The application is revealing as it indicates the scepticism shown towards some of the very early work of the DC and it had anticipated the next strategy of the Commission. The request was refused because the DC was about to ask each research institute to indicate the subjects that were thought important to test by field trials and had growers lined up who would conduct large-scale trials for free.

was only the larger enterprises that could afford the costs associated with experiments.

7.3.1 The Scientific Activities of Nurserymen Specialising in Exotic Plants

In order to create demand for unusual plants and to satisfy the collectors who were looking for something different or rare, firms like J. Veitch and Sons of Chelsea, Sander of St Albans and Charlesworth and Company of Haywards Heath built up large holdings of glasshouse plants and used science to assist their work.

Veitch specialized in orchids and employed botanical collectors to bring back unusual plants and hybridists and selectors to generate new varieties.[67] In the firms' glasshouses the plants underwent botanical classification. Techniques of cultivation were worked out which depended on systematic observation of the plants responses to different growing media that were tested and to the different regimes of temperature, humidity and irrigation that were tried.

Sander, another orchid trader, financed nurseries with greenhouses in St Albans, Hertfordshire, at Bruges in Belgium and New Jersey, USA. The firm won regularly gold medals at the Royal Horticultural Societies orchid shows, employed 23 collectors in Asia and South America, introduced many specimens

[67] J. H. Veitch, *Hortus Veitchii: A History of the Rise and Progress of the Nurseries of Messrs. James Veitch and Sons, together with an Account of the Botanical Collectors and Hybridists employed by them and a list of their most remarkable introductions*, London: James Veitch and Sons Limited, 1906, pp. 5-7. The collection consisted of: orchids, insectivorous plants, ferns, lilies, climbing plants, stove plants, begonias, amaryllis, streptocarpus, rhododendrons, conifers and herbaceous perennials. The firm also was interested in developing a range of hard and soft fruits and vegetables; E. J. Wilson, *West London Nursery Gardens: The Nursery Gardens of Chelsea, Fulham, Hammersmith, Kensington and a part of Westminster, founded before 1900*, Fulham and Hammersmith: The Fulham and Hammersmith Historical Society, 1982, pp. 50-55. It was estimated that at its peak, 400 gardeners a year passed through the nursery.

that were new to science, sent plants to the Royal Botanic Gardens Kew for their scientific collection and developed cultural techniques based on systematic observation. Sander built up a skilled team, constructed a laboratory for orchid seed raising, developed a gelatinous culture medium to aid plant propagation and introduced an international registration system for orchid nomenclature in response to the expansion of names for orchid hybrids and the lack of standards in usage.[68]

The orchid nursery of Charlesworth and Company in the 1920's was experimenting with chemical solutions to mimic the mycorrhiza fungi that in nature stimulated orchid seed germination. The nursery was a pioneer in the UK in successfully germinating millions of seeds in culture flasks using this method.[69]

Summary

Some UK nurserymen specialised in the collection and breeding of unusual and rare species and in this way fostered a demand amongst wealthier customers. Large firms with the income and resources sponsored botanical collectors, hybridizers and selectors. The firms of Veitch, Sander and Charlesworth built up a body of knowledge about the behavior of exotic plants as a result of systematic observation, contributed towards their botanical classification and developed scientific methods to aid breeding, propagation and cultivation.

[68] A. Swinson, *Frederick Sander: The Orchid King*, London: Hodder and Stoughton, 1970, p. 119, p. 1349, p. 212, p. 236; Anon (2000-2015) Sander, Henry Frederick Conrad (1847-1920) [online] JStor, Global plants. Available: plants.jstor.org/stable/10.5555/al.ap.person.bm000007355 [Accessed 11 April 2015].

[69] J. Ramsbottom, 'Orchid mycorrhiza', *Gardeners' Chronicle* (1922), LXXI, (1843), p. 200.

7.3.2 The Scientific Activities of Fruit Growers

W. P. Seabrook, an innovative fruit grower and nurseryman, based near Chelmsford in Essex, promoted applied science investigations and adopted modern production methods. He was a member of the Executive Committee of the Chamber of Horticulture and of the Horticultural Advisory Council, bodies that encouraged horticultural science research. Visiting groups of growers and members of the Horticultural Education Association were given personal conducted tours of his business to see the scientific investigations being undertaken.

Seabrook trialed different fruit tree and fruit bush rootstock, made a comparative analysis of the different ways of raising fruit trees, tested tar distillate washes for Long Ashton Research Station and the oil wraps used on stored apples for the Low Temperature Research Station (LTRS).[70] He carried out experimental breeding on apples using his 'apple museum' containing 200 varieties, built fumigation chambers to treat plants and fruit stock for pests and diseases before being sent to customers and demonstrated the latest apple grading machinery imported from America.[71]

In these ways Seabrook illustrated the advantages of applied science to his peers. His popular book, *Modern Fruit Growing*, referred to the work of EMRS, the JIHI and the LTRS. His recommendations for pest and disease control, fertiliser application and choice of rootstock and his experiments and his investigations on fruit trees reflected the influence of these institutions,

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[70] 'Apples, paper and paraffin', *The Fruit Grower, Fruiterer, Florist and Market Gardener* (1926), LXI, (1576), p. 169; 'Tar distillate washes', *The Fruit Grower, Fruiterer, Florist and Market Gardener*, (1926), LXII, (1596), p. 73.

[71] Ranger, 'Messrs W. Seabrook and Sons Limited. Chelmsford Fruit Growers and Nurserymen', *The Fruit Grower, Fruiterer and Market Gardener* (1921), LII, (1345), pp. 343—346.

particularly the first two research stations.[72]

A. G. Britten at his Beck Mill Nurseries, Langwathby, Cumberland, conducted, 'the most extensive trials yet undertaken in the four northern counties to find comparative values of winter washes on insect life upon the fruit trees'.[73] Britten liaised closely with Armstrong College, Newcastle upon Tyne, which taught horticulture and agriculture and was carrying out fruit tree investigations as part of a DF initiative. Britten had designed a sprayer on wheels to deliver the mix, controls were used and notes were kept of the effects of the four sprays that were trialed on insect pests and diseases and on the strawberries, rhubarb, gooseberries, black and red currants and daffodils that were grown under the trees in order to maximize land use and profit.[74] As joint author of an article about this work in the *Gardener' Chronicle*, Britten helped to publicise the results of horticultural science investigations and drew the attention of growers to the relevance of the horticultural research at Armstrong College.

<u>Summary</u>

P. Seabrook and A. G. Britten were inventive growers and part of a group of commercial horticulturalists that were sought out by research stations and colleges conducting regional investigations to undertake large-scale trials to examine the effects of local conditions on the products of research such as rootstocks, fertilisers and other growth stimulants, pest and disease sprays, soil

[72] W. P. Seabrook, *Modern Fruit Growing*, London; Ernest Benn Limited, 1944, p. iv, p. 55, pp. 102-103, pp. 170-173, p. 130, p. 145. The first edition was published in 1918 and the fourth in 1933.

[73] R. A. Harper Gray and A. G. Britten, 'Tar oil spraying trials in a Cumberland nursery orchard', *The Gardeners' Chronicle* (1926), LXXXVI, (2245), pp. 16-17.

[74] Harper Gray and Britten, op. cit. (73), pp. 16-17.

sterilisation, immune varieties, aids to storage and horticultural machinery. Both growers influenced colleagues by offering conducted tours of their nurseries to discuss the investigations that were taking place, by publicising their research through writing textbooks or articles in trade journals and by assisting the experimental work of research institutes by carrying out large--scale trials. This type of scientific endeavor, undertaking trials in conjunction with a research institute, was a factor in encouraging growers to understand and appraise the value of horticultural science research.

7.3.3 Sutton and Sons of Reading

Table 7.1: Engagement with science of major seed firms, 1910-1930*

Seed Company	Lab	Scientists on staff	State approval for seed testing	Trialling	Producing new varieties	Other research	Personal letters to scientists	Letters to scientific institutions
Suttons	+	+	+	+	+	+	+	+
Carters	+	+	+	+	+	+	?	?
Pennells	+	+	+	+	+	?	?	+
Bees	x	x	x	+	+	+	+	?
Kings	+	+	x	+	+	?	?	?
Clucas	x	x	+	+	+	x	?	?
Unwins	x	x	x	+	+	x	+	?
Webbs	x	x	x	+	+	+	?	?
Hursts	x	x	x	+	+	?	?	?
Dobbies	x	x	x	+	+	?	?	?
Sharp	x	x	x	+	+	x	x	?
Toogood	?	?	?	?	?	?	?	+

***The table reflects the paucity of information available currently about seed firms in this period**

Key: + = Supported by Firm Evidence; X = Suggested by Available Evidence; ? = Insufficient Evidence

Table 7.1: Engagement with science of major seed firms, 1910-1930 indicates the involvement of some of the important seed houses with science in this period. The names of these firms appeared regularly in trade journals and advertisements during these years and this was a major criterion for selection. Although an imperfect indicator, it shows Sutton and Sons as a leading firm with

Carters of comparable importance. Some seed firms, for example Unwins and Sharpe, acquired laboratories and employed scientific staff only later, in the 1950s and 1960s.

Sutton and Sons of Reading in Berkshire, founded in 1806, involved itself extensively in horticultural science activity. By 1860 it had become an important firm known for testing the vigour of its seeds and the production of new varieties of vegetable. Between 1880-1900 it had established a grass garden and communicated with scientists on the botanical and chemical analysis of grasses, investigated the effects of CO_2 on plant growth and treated seeds with chemicals to enhance germination.[75] Members of the family continued this tradition of innovation after 1900.

This case study is divided into a review of the involvement of Suttons in horticultural science generally and an examination of the work and experiments of one of its directors, M. H. F. Sutton. The importance of plant trials, discussed in section 7.2.3, is developed further.

7.3.3.1. Breeding and Trialling

To develop its reputation for reliability and dependability amongst growers and domestic gardeners Suttons established trial grounds at Reading, Slough, Scotland and India where new varieties of flowers and vegetables, from other companies or their own selection and crosses, were trialed thoroughly over several years.[76] Suttons entered the Indian market in 1916, initially supplying high yielding flower and vegetable seeds tested at the 50 acre Langley grounds

[75] G. Westall and R. Butler, *Suttons Seeds: A History 1806-2006*, Earley: Earley Local History Group, 2006, pp. 16-51.
[76] Westall and Butler, op. cit. (75), p. 1, p. 61, p. 167.

at Slough: India relied on imported seed up until the Second World War.[77] In 1918 trial grounds were established at Chinsurah, West Bengal, to ascertain whether the seed of plants grown there were suitable for the Indian climate.[78] Extensive, systematic records were compiled in trial books, the successes appearing in Suttons horticultural and agricultural catalogues.[79] Trialling was of great importance to companies like Suttons and to firms that grew seed for them such as Charles Sharp and Company, a Sleaford, Lincolnshire seed firm with a global market, because it was the only known commercial method of ensuring that varieties were properly named. Seed firms in their advertisements pushed the message of reliability and dependability and mistakes in nomenclature could cost a firm its reputation with the trade and the public. The rapid growth of vegetable canning in the late 1920s made it imperative that seeds were all 'true to type' (giving the same growth habits and yield as the original stock) because production schedules were geared to uniform crop maturity and a batch of seeds containing different varieties coming to fruition at different times could not be accommodated in harvesting and canning schedules.[80]

Methods used by the trial appraisers employed by Charles Sharp were scientific, although subjective comments were included in commentaries, as the following example indicates. Employees were hired to rogue (remove from the ground those not exhibiting the identified characteristics of the variety that was being grown) the plants in the trial grounds to guarantee the varieties left in the

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[77] P. S. Arya, *Off Season Vegetable Growing in Hills*, Darya Gary, New Delhi: A. P. Publishing Corporation, 2000, p. 128; Westall and Butler, op. cit. (75), p. 25, p. 61.
[78] Westall and Butler, op. cit. (75), p. 167.
[79] Sutton and Sons a), *Suttons' Royal Seed Establishment at Reading England*, Reading, Sutton and Sons, 1907, p. 75.
[80] National Institute of Agricultural Botany, Food and Fodder Crop Trials, Cambridge 19th October, 1960, SHARPES Acc 87/52, Box 46, LIA.

field were as named. This operation helped canners to maintain efficient production schedules. Appraisers possessed a simple botanical knowledge of all of the varieties in the trial and compiled extensive, systematic and careful records of flower and vegetable plants, giving details of flowers, colour, foliage, height, size, vigour, anomalies and similarities with other types and it was this methodology that safeguarded their reputation. When giving an overall appraisal of a particular trial, qualitative judgments were made such as 'poor', 'fair', 'quite good' and 'very good', that were not based on standardised criteria but this did not detract from the value of the comments based on careful observation. J. L. Clucas, a customer of Sharpe with a similar reputation and comparable specialisms, conducted several thousand trials annually and also relied heavily on meticulous checking and systematic recording of data.[81] Suttons introduced also a seed testing station and an Experimental Station. In the seed station laboratories tests were conducted for purity and germination rates using high-powered microscopes and certificates of purity were issued.[82] Equipment was regularly updated, some was designed to meet special requirements and the company believed its facilities were, 'unique of its kind and the most complete in existence' - the firm was given permission by the MAF to conduct its own seed tests.[83] Growers could also send in soil samples to the laboratory for testing and farmers could ask for the sugar content of root crops used as cattle fodder to be calculated in order to determine the most nutritious

[81] Trial books covering 1919-1932 in boxes 1, 2, 3, 4, 6, 7, 2 SHARPE, LIA; C. D. Morgan, *The Centenary of the House of Clucas. Eighteen Hundred & Sixty-Nineteen Hundred & Sixty*', Ormskirk: J. L. Clucas, 1960, p. 13, UDOr 15/54, LAA.
[82] Sutton and Sons b), *Suttons at Reading*, Reading: Sutton and Sons, 1924, pp. 42-44, TR SUT P9/16, MERL.
[83] Sutton and Sons Limited c), *The Value of Clean Seed*, Reading: Sutton and Sons Limited, 1937, p. 3. Suttons stressed the importance of high standards of purity and their machines separated out weeds, worthless seed, chaff, soil and other matter and pea and bean seed was hand sorted.

crops and varieties. All of this innovation gave purchasers the assurance that scientific work had confirmed the integrity of the seeds.

At the Reading Research Station selection was the method used to produce varieties of flowers for effective colour and long flowering period and vegetables for table quality and length of cropping.[84] Crosses with primula based on Mendelian principles were carried out although the company after 1910 focused additionally on other aspects of horticultural research. Possibly the results did not meet expectations, as out of the 22,000 primula plants produced by Mendelian methods 2 only featured in their catalogue.[85] Suttons believed Mendelian methods could not be used to raise commercial potatoes immune to wart disease as they felt that because so many variations occurred in individual crosses, at variance with the parent plants, it was impossible to know which characteristic conferred immunity. The firm tried to locate wild immune varieties of potato and wild pea plants because they were convinced these would breed true but later felt this 'pure' stock did not exist and, 'it very largely prevents our employing Mendels Law and working on Mendelian lines'.[86]

7.3.3.2 Supporting Others

Suttons supported horticultural science experimental work carried out elsewhere. The company provided plants and assistance to the JIHI to assist pioneering work on the origins of colour in flowers and gave scientific and technical assistance to enable sugar beet seed to be produced for the

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[84] Sutton and Sons b), op. cit. (82), pp. 83-87.
[85] Westall and Butler, op. cit. (75), p. 61; M. H. F. Sutton a), *The Raising of Seedling Potatoes by Hybridization*, Reading: Sutton and Sons, 1921, p. 3.
[86] M. H. F. Sutton a), op. cit. (85), p. 3.

government sugar beet factory, as seed could not be obtained from abroad.[87] The firm helped John Percival, Professor of Agricultural Botany of University College Reading, to conduct experiments to produce crosses in brassicas by artificial pollination, W. J. Malden, Professor of Agriculture of Downton College, who required critical comments on a manuscript and H. Maxwell-Lefroy, Professor of Entomology at Imperial College, by carrying out tests of insecticides at Reading on crops in trial plots.[88] Suttons contributed to horticultural research and investigations at institutions by making donations. In 1911 half the cost was given of building a new hall of residence at University College Reading, one of the first to provide courses in horticulture, and in 1918 £1000 was donated towards the establishment of the NIAB to carry out investigations in seed purity, germination and synonym reduction and donations of trial seed were given yearly.[89]

Suttons gave commercial growers, domestic gardeners, scientists and horticultural educationalists an open invitation to tour its trial and experimental grounds, laboratories and research station and welcomed visitors from scientific institutions in the UK and abroad. For example, in 1924 the scientists A. D. Hall and W. Bateson and Ministry of Agriculture officials H. V. Taylor and W. J. Lobjoit, in a party of 40, were given a personal tour and viewed the plant breeding work, the variety trials, manurial experiments and the research on

[87] G. M. Robinson and R. Robinson, 'A survey of anthocyanins. 1.', *Nature* (1931), 25, (1687), pp. 1687-1705; 'Mr Walter F. Giles', *Gardeners' Chronicle* (1930), LXXXVIII, (2276), p. 102. W. F. Giles was loaned out by Suttons.
[88] A. W. Sutton, *Brassica Crosses*, Reading: Sutton and Sons, 1908, pp. 1-2; Letter from M. F. H. Sutton to Professor W. J. Malden, 16th February 1917, TR SUT SP4/105, MERL; Letter from M. F. H. Sutton to Professor Lefroy, 16th December 1918, TR SUT SP4/105, MERL.
[89] The annual issues of *The Journal of the Institute of Agricultural Botany* between 1922-1930 thanked Sutton and Sons for their assistance.

lawn grasses.[90] This helped its research work reach a wider audience, had an educative function and was good publicity for the business.

Summary

Sutton and Sons patronised a wide range of horticultural science activities. They were innovative in their applied science investigations and had the necessary capital to undertake sustained experimental work and introduce cutting-edge equipment. The firm trialed flowers and vegetables, bred new varieties and tested seed for purity and germination. A portable exhibition demonstrating the principles of lawn science was developed along with other scientific cabinets and these were loaned out to educational institutes and exhibited at shows in order to educate the public in scientific horticulture, advertise the company and demonstrate that its products had the endorsement of science. The company attempted to produce new varieties based on Mendelian principles and believed the method had potential but concluded it was unsuitable for some crops. Amongst commercial breeders there was not a great deal of support for Mendelian methods and the Editor of *Commercial Horticulture*, a very pro-science trade journal, probably spoke for the majority when he commented in 1929 that plant hybridisers ought to concentrate on re-selection and improvement of type rather than hybridizing a distinct species as a 'hybrid never makes a satisfactory plant'.[91]

Suttons welcomed growers, scientists and domestic gardeners to the trial

[90] 'Plant breeding at Reading', *The Gardeners' Chronicle* (1924), LXXV, (1955), p. 353. Suttons were crossing peas to produce varieties that were drought and mildew resistant, crossing beans to produce a non-climbing runner bean and trying to produce a weather-resistant broccoli.

[91] The Editor, 'A plant breeding problem', *Commercial Horticulture* (1929), 1, (2), p. 30.

grounds, experimental station and laboratories partly out professional pride and partly because word of mouth advertising was effective. Suttons also assisted others engaged in horticultural science work, for example professors at university colleges and universities and gave funds to support institutions that carried out horticultural research and investigation.

7.3.3.3 The Research of M. H. F. Sutton

As a member of the business and later, a senior Director, M. H. F. Sutton was able to harness the resources of the company to direct its research schedule and he corresponded with some of the leading plant scientists of the day, which enhanced Suttons reputation as a patron of horticultural science investigation.[92] Martin Sutton was responsible for the employment of a chemist in the laboratories to work on plant stimulant and fertiliser experiments and soil and seed analysis because, ‘I have felt for a long time this addition has to come if we are to keep up to date’.[93] Sutton’s enquiries reflect a strong commercial motive, as the products under investigation offered the prospect of improving plant performance, stealing a march on rivals and maintaining or enhancing

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[92] Correspondents included the following movers and shakers and influential scientists: Professor D. A. Gilchrist, Director of Cockle Park Experimental Station and Professor of Agriculture at Armstrong College; Alfred Daniel Hall Scientific Adviser to the Board/Ministry of Agriculture and Fisheries; Professor F. Keeble of University College Reading and Oxford University; Professor Malden Downton College; Professor Percival of University College Reading; Dr Pethybridge Ministry of Agriculture and Fisheries Harpenden Laboratories; Lord Prothero, President of the Board of Agriculture and Fisheries; Dr E. J. Russell, Director Rothamsted; W. Somerville, Assistant Secretary of the Board of Agriculture and Fisheries ; R. G. Stapeldon, Director of the Welsh Plant Breeding Station; Dr H. V. Taylor, Assistant Controller of Horticulture Ministry of Agriculture and Fisheries; Sir H. Veitch, nurseryman; Dr J. A Voelcker consultant agricultural chemist and Director Woburn Experimental Station, L. Weaver, Director of the National Institute of Agricultural Botany and H. M. Lefroy, Professor of Entomology, Imperial College.

[93] Private and confidential, 29th January 1914, TR SUT SP4/102, MERL.

market share. His comment about a major rival, Carters Tested Seeds Limited, reveals how confident he was about the firm's standing and its ability to utilise science, 'Carter's Lab is no doubt chiefly humbug but we want the real thing that will lead to continuous success and keep us in our position at the head of the trade'.[94]

He initiated breeding programmes to develop in potatoes wart and blight resistance and to improve red clover as a fodder plant: the latter involved examining whether the different ripening and harvesting stages influenced seed quality - of relevance to horticultural seed collection - and conducted comparative trials.[95] Lectures were given to horticultural and agricultural societies, including the Royal Horticultural Society, on this and other research that reinforced the scientific integrity of the company.

Four aspects of Suttons research work are now examined: lawn science research, the use of electricity to stimulate plant growth, the testing of radioactive ores as a stimulant and the trialing of the fertilising agent 'bacterised peat'.

7.3.3.3.1 Lawn Science

Sutton carried out investigations and experiments between 1900-1930 in order to build up scientific knowledge about suitable grass mixtures for different types

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[94] Private and confidential, op. cit. (93).

[95] M. H. F. Sutton a), op. cit. (85); M. H. F. Sutton b), *The Future of the Potato Crop, with Special Reference to Wart Disease and Immune Varieties*, Reading: Sutton and Sons, 1921; M. H. F. Sutton and D. J. Columbus Jones, *Red Clover and the Possibilities of Improved Strains by Breeding*, Reading: Sutton and Sons, 1925; M. H. F. Sutton and D. J. Columbus Jones, *Red Clover: An Investigation into the Varying Stages of Seed-ripening and Harvesting, as Affecting the Value of the Seed Crop*, Reading: Sutton and Sons, no date; M. H. F. Sutton c), *Red Clover: Comparative Trials with Thirteen Different English and American Strains, 1926-1928*, Reading: Sutton and Sons, no date.

of lawn, pests and disease control and fertiliser efficacy. Early research work led to the production of a book on turf for golf courses that dealt with the subject scientifically.[96] A chapter by A. D. Hall, the horticultural and agricultural scientist of international repute whom we met in chapter 3, on manuring gave prestige to the enterprise and the book review in *The Gardeners' Chronicle* was

Figure 7.1 – Sutton's Lawn Science Exhibition 1920s, from Sutton and Sons Limited, *The Value of Clean Seed*, Reading: Sutton and Sons Limited, 1937, p. 24.

very favourable, the reviewer believing the section by Hall was 'remarkable' as Hall was, 'a master of the subject'.[97] The grounds at Reading were used to conduct one-week intensive examined courses in turf management for

[96] M. H. F. Sutton d), (ed.), *The Book of the Links: A Symposium on Golf*, London: W. H. Smith and Sons, 1912. The book is in part a summary of the lawn science research and investigations conducted by Suttons.
[97] 'Review of M. H. F. Sutton. The Book of the Links', *The Gardeners' Chronicle* (1912), LII, (1341), p. 196.

professionals and amateurs. Successful candidates were awarded Suttons Certificate in General Turf Management.[98] A scientific exhibition was developed, shown in Figure 7.1, to demonstrate the science of lawn production and was intended for the use of lecturers, colleges, schools and illustrations of lawn treatments and information on seed cleaning and museums and was exhibited at horticultural shows.[99] It contained botanical descriptions, mounted specimens of grasses and weeds, examples of seeds, illustrations of lawn treatments and information on seed cleaning and testing.[100]

Summary

M. H. F. Sutton's turf experiments helped develop a body of scientific knowledge about lawn science. The section by A. D. Hall in Sutton's book on the subject provided academic endorsement and enhanced the reputation of the firm as patron of horticultural science. The firm also contributed to horticultural science education by developing an exhibition of lawn science that could be loaned out and offering an examined courses in turf management.

7.3.3.3.2 Electro-horticulture: Electricity as a Growth Stimulant

Clark, indicating the use of electricity in crop production since the 1860s as motive power, illumination source, weed killer and growth stimulant and

[98] Westall and Butler, op. cit. (75), p. 54.
[99] M. H. F. Sutton d), op. cit. (96). In the appendix is a photograph and description of the exhibition; Sutton and Sons Limited c), op. cit. (83), p. 24. The exhibition was displayed at the Chelsea Show of the Royal Horticultural Society. Suttons developed a small range of Gold Medal Educational Cabinets with specimens of seeds and crops and insects that caused damage.
[100] M. H. F. Sutton d), op. cit. (96). See the appendix with the information about the exhibition; Sutton and Sons Limited c), op. cit. (83), p. 24.

Kinahan, explaining how the Electro-Culture Committee of MAF supported Imperial College field trials and pot culture experiments using electricity to stimulate growing crops, have both focused on agriculture.[101] I add to these studies by examining the use of electrical stimulation in horticulture as well as agriculture and show an experiment could be partly outsourced because of the restrictions of patent laws.

Responding to customer enquiries about the electrification of seeds using the Wolfryn Electrochemical Process, Sutton initiated investigations for several years under controlled conditions. Because this process was patented, seeds of mainly horticultural vegetables and some agricultural roots were sent to one of the patentees, Mr. Fry, for treatment and were then trialed at Reading using untreated seed as the control.[102] Germination experiments were conducted in the laboratory and later field tests were made. The treated seeds showed no advantage except for mangolds, that exhibited a slightly higher germination rate.[103]

Similar work was taking place at Rothamsted at the same time using pot experiments only and Suttons field trials added further knowledge about the use of electricity as a growth stimulant.[104] Despite negative conclusions from

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[101] C. C. Spence, 'Early Uses of Electricity in American Agriculture,' *Technology and Culture* (1962), 3, (2), pp. 142-160; D. Kinahan 'Struggling to Take Root: The Work of the Electro-Culture Committee of the Ministry of Agriculture and Fisheries Between 1918 and 1936 and its Fight for Acceptance', *Reinvention: an International Journal of Undergraduate Research*, 2, (1), 2009.

[102] M. H. F. Sutton e), *The Electrification of Seeds by the Wolfryn Process. A Report carried out at Reading In 1919*, Reading: Sutton and Sons, 1919, p. 2. Mr Fry and a Liverpool merchant Mr De Woolf patented the process in 1917. Seeds were immersed in a solution of common salt and water for 4 hours, the solution was subjected to an electric current and the seeds were dried at 100 degrees Farenheit in preparation for sowing.

[103] M. H. F. Sutton e), op. cit. (102), pp. 6-7.

[104] E. J. Russell (1920) 'Report on the proposed electrolytic treatment of seeds (Wolfryn Process) before sowing' [Online] *Journal of the Ministry of Agriculture*. Available:

Reading and Rothamsted the Electro-Culture Committee continued to fund this research until the late 1930s, buoyed by results in the early 1920s from work by Imperial College scientists that showed significant yield increases in crops exposed to high-tension electric discharges and endorsements of the potential of the stimulus by A. D. Hall and Imperial College scientists.[105] Thereafter, the results failed to show any increase in crop growth and by the late 1930s the project was wound up.

<u>Summary</u>

M. H. F. Sutton introduced experiments in the electrification of horticultural and agricultural seeds using the Wolfryn Electrochemical Process in response to queries from customers and because the process offered the prospect of increased sales. Because the process was patented, seeds were sent for treatment to one of the patentees and then laboratory experiments and field trials were conducted at Reading. Evidence from field trials added to the knowledge of electricity as a plant stimulant as similar work at Rothamsted used pot experiments only but government research continued partly because the work of respected Imperial College scientists showed positive results in the early 1920s and A. D. Hall believed the technique had potential.

7.3.3.3.3 Radioactive Ores as a Growth Stimulant

The use of radiation as a plant stimulant between 1913 and 1914 was

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https://archive.org/stream/…/journalofministr261ogrea_djvu.txt [Accessed 21 April 2015].

[105] *Report on the work of the Intelligence Department* b), op. cit. (64), p. 17. An error in the procedures produced very positive results and raised expectations.

innovative as no other firm or individual in England at the time was carrying out extensive radiation investigations as controlled experiments.[106] Curry has shown that in the USA professional and amateur horticulturalists from the late 1920s used X-rays to assist plant-breeding initiatives.[107] I will demonstrate that, in contrast, this was not the case in the UK as experimental horticultural work in radiation was very limited, radioactive material was used as a fertiliser not as a tool to assist plant breeding and by 1930 the show was almost over. In the 1950s a resurgence of interest occurred in treating plants with radioactive material as a result of the development of the UK atomic energy programme.

Figure 7.2 – Assessment of the effects on vegetables of radioactive ores at Reading in 1915, from M. H. F. Sutton, *The Effects of Radio-Active Ores and Residues on Plant Life*, Reading: Sutton and Sons, 1915.

[106] M. H. F. Sutton f), *The Effects of Radio-Active Ores and Residues on Plant Life*, Reading: Sutton and Sons, 1914, p. 4; M. H. F. Sutton g), *The Effects Of Radio-Active Ores and Residues on Plant Life*, Reading: Sutton and Sons, 1915, p. 1, pp. 7-19.
[107] H. A. Curry, *Accelerating Evolution, Engineering Life: American Agriculture and Technologies of Genetic Modification, 1925-1960*, Harvard University, PhD dissertation, 2012, p. 68, p. 96, p. 136; H. A. Curry, 'From Garden Biotech to Garage Biotech; Amateur Experimental Biology in Historical Perspective, *The British Journal for the History of Science* (2014), 47, (3), pp. 539-565.

The experiments of Martin Sutton were designed to develop scientific knowledge by finding out if radioactive material was beneficial to plant life, ‘as the value of radium for treatment of certain (human) diseases had been established’ and to find a ‘plant fertiliser which will prove superior to farmyard dung’.[108] During planning help was given by Professor Duffield of University College Reading and Dr Keeble, Director of the Royal Horticultural Society’s Wisley Gardens. Sutton considered the views of Monsieur Truffant of Paris who suggested radium might release additional nitrogen in the soil for the use of plants and agreed with letters received from Professor Rushley of Columbia University who stated radium was of value to plant life as a stimulant not as a fertiliser. He examined work in the USA on the effects of using radium ores to fertilise plants and took particular note of the radium ore investigations of Dr C. Hopkins of the University of Illinois Experimental Station.[109]

Over two years extensive experiments were conducted at Reading with seeds of grasses, flowers, rape and a range of vegetables sown in pots and boxes and reared in the laboratory, in cold frames and the open ground to see if germination and subsequent growth was enhanced. Figure 7.2 shows the assessment of one of the trials that took place. Nine different grades of radioactive ore were compared with the effects of farmyard manure and complete fertiliser: plain soil was the control. It seems likely radioactive ores were obtained from the British Radium Company, Finsbury Park, London and the radium mine at South Terras near Truro, Cornwall, owned by Société Industrielle du Radium Limited. Sutton concluded the, ‘experiments indicate no

[108] M. H. F. Sutton f), op. cit. (106), p. 1; M. H. F. Sutton g), op. cit. (106), p. 20.
[109] M. H. F. Sutton g), op. cit. (106), p. 5, p. 20. Sutton took note of statements made in the USA that noticeable changes in flavour occurred in vegetables given radium ore as fertiliser. He got Dr Keeble to cook and taste marrows to test the claim that they acquired the flavour of a pineapple – which was refuted.

hope of successful employment of radium as an aid to horticulture or agriculture'.[110]

His investigations received favourable publicity. E. J. Russell, Director of Rothamsted writing in *Nature* regarded them as careful, well conducted research, although added condescendingly they were of service to science because the staff at research stations were busy, sceptical and unwilling to conduct that sort of investigation, and *The Times* in September of 1915 commented the Reading results were seen as, 'conclusive by competent botanists and chemists' and of great importance to gardeners as they had shown, 'the value of farmyard manure and complete artificial fertilisers'.[111] Although this avenue was effectively closed as a result of these findings, Sutton, ever the enquirer, believed that in the search for a superior plant fertiliser, 'the door was still open to an investigator'.[112]

<u>Summary</u>

M. H. F. Sutton conducted innovative experiments on the use of radium ores as a plant growth stimulant between 1913-1915. He consulted with scientists in Britain and in the USA to give direction to the investigations and followed the work with radium ores and plants taking place in the USA. The experiments, reviewed favourably by E. J. Russell, a staunch advocate of pure science research, and by *The Times*, showed radium ores were of little value as a plant

[110] M. H. F. Sutton f), op. cit. (106), p. 1; M. H. F. Sutton g), op. cit. (106), p. 20; M. H. F. Sutton, Diary entry, 7th April 1915, TR SUT SP4/113, MERL.
[111] . E. J. Russell, 'The effects of radium on the growth of plants', *Nature* (1915), 96, (2392), pp. 147-148; M. H. F. Sutton f), op. cit. (106), p. 20.
[112] M. H. F. Sutton f), op. cit. (106), p. 20. It is possible that work on radioactive ores was undertaken at Seale Hayne College in 1921. Interest in these ores had waned by this time and the testing of radiation as a plant stimulant was soon abandoned temporarily.

stimulant and were a major factor in causing interest in the subject to wane and the search for a product superior to farmyard manure to continue.

7.3.3.3.4 Trialing Bacterised Peat

Pot experiments were conducted on the product 'bacterised peat' or 'humogen', developed by W. B. Bottomley, Professor of Botany at Kings College London.[113] Unlike the trials of radium ores, tests on 'bacterised peat' were also being carried out at other research institutions as Bottomley's product aroused a great deal of interest amongst scientists and questions were asked about its importance in the House of Commons on a number of occasions. This pressure encouraged the government to state that trials were needed to ascertain its importance, point out that Professor Bottomley was in agreement and contact research stations, via BAF, to request trials.[114]

F. W. Keeble noted the product offered the possibility during the First World War of raising crop yields in the country, particularly when farmyard manure

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[113] W. B. Bottomley, 'Some effects of organic growth promoting substances (Auximones) on the growth of *Lemma Minor* in mineral culture solutions', *Proceedings of the Royal Society of London* (1917), Series B, 89, (621), pp. 481-507. Bottomley incubated peat for 14 days at 26°C with a mixed culture of aerobic soil organisms. The product was 'bacterised peat' which he originally believed released nitrogen for plant growth but later thought that plant growth promoting substances or 'auximones' were formed in the processed peat.

[114] *Parliamentary Debates (Hansard)*, House of Commons. 14 October 1915, col. 1469-1470; *Parliamentary Debates (Hansard)*, House of Commons. 21 October 1915, col. 2005-2006; *Parliamentary Debates (Hansard)*, House of Commons. 22 February 1916, col. 575. The government was asked about the action it was taking, given the potential of Professor Bottomley's discovery. The city of Manchester looked proactive by comparison as its Council were going to undertake trials. There was some concern as Bottomley had been approached by a German professor on behalf of the German government to secure the product for the German nation. Bottomley indicated it was for the use of his own country. Trials of 'bacterised peat' were made at Kew Botanic Gardens, Wisley Research Station, Rothamsted, Cheshunt Research Station and by the West of Scotland Agricultural Society and Eton College.

was, ‘constantly increasing in price and decreasing in amount’ and artificial fertilisers were not giving the soil, ‘those physical properties which plants need’.[115] It is likely Sutton was influenced by the ideas of Keeble, a friend and dining companion, and began trials of bacterised peat to be ‘of service’ not just to horticulturalists and agriculturalists but also to the country during a time of war.[116]

Sutton worked in conjunction with Professor Bottomley and Mr Macken, Bottomley’s assistant who visited regularly, to trial the product. ‘Bacterised peat’ manufactured in Manchester scorched and stunted the plants and a second trial was started using the product from the production line at Bottomley’s laboratory in Greenford, Kent.[117] Vegetables, mustard and grasses were used and comparisons were made with farmyard manure, a complete fertiliser, common peat, and ‘Rito’ (Peruvian guano), with plain soil as the control. Sutton had visited Rothamsted to see their trials which had produced negative results and concluded that at Reading the results showed the, ‘hope of Humogen was not realised’ and questioned whether the product could be produced cost-effectively on a commercial scale and without mishap.[118] The trials at other research centres also reached the same conclusion and ‘bacterised peat’ after a promising launch rapidly lost its attraction.

Summary

M. H. F. Sutton used the Reading Experiment Station to research a promising

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[115] F. Keeble, ‘Bacterised peat as a fertiliser’, *Nature*, (1915), 96, (2406), pp. 399-400.
[116] M. H. F. Sutton h), *Experiments with Humogen in Comparison with other Fertilisers*, Reading: Sutton and Sons, 1916, p. 2.
[117] M. H. F. Sutton h), op. cit. (116), pp. 2-3.
[118] M. H. F. Sutton h), op. cit. (116), pp. 3-9, p. 12.

fertiliser, ‘bacterised peat’ and wanted the investigations to be of scientific value to horticulture and agriculture and, out of patriotism, to contribute to efforts made during the First World War to find ways of increasing the nations food output. Sutton was probably influenced to consider such an investigation by his friend and adviser F. W. Keeble, of the government’s Food Department. The Reading trials confirmed the results of other research institutions investigating ‘bacterised peat’ that it was not of value and contributed to the abandonment of the product as a commercial proposition.

Overall summary

Sutton and Sons was an innovative and influential horticultural and agricultural seed house that established trial grounds in England, Scotland and India and a seed testing laboratory and research station at Reading. It conducted investigations and experiments in applied horticultural science that were reported in scientific journals, national newspapers and the gardening press. These included flower and vegetable breeding, seed testing, lawn maintenance and the use of plant stimulants. Members of the company communicated with key players in the plant science community and this association strengthened Suttons standing as a patron of horticultural science.

Suttons assisted the work of scientists by providing ideas and specimens and conducting trials on their behalf and made donations of money and seed to scientific institutions such as University College Reading and the National Institute of Agricultural Botany. Visits from domestic gardeners, growers and scientists were welcomed and visitors were shown the scientific work that was being carried out, reinforcing Suttons' role as science patron.

7.4 Conclusion

Between 1900-1930 the horticultural sector in general was expanding and prices were mainly buoyant. As a result, the government was willing to finance horticultural research to assist commercial horticulture. In contrast, agricultural prices showed more variation and arable farmers, except during the First World War, faced depressed prices and some turned part of their land over to large-scale vegetable growing.

Some horticultural growers with the necessary capital resources used part of their income to finance horticultural science investigations, publish their findings and give talks and lectures, in order to enhance their standing in the trade and maintain or expand their position in a competitive market. A number of seed firms with the required resources were also patrons of scientific horticulture. Sutton and Sons, for example, financed both research and education. Although M. H. F. Sutton and other family members corresponded with academics on matters of horticultural science, they could direct the resources of the firm to set up experiments and trials and use the results to dispute and challenge the opinions of particular individuals and ensure the firms production methods were not wasteful. Martin Sutton during his time with the company knew who to work with and trust and to an extent modelled his investigations on the methods used by the research stations.

Commercial growers made use of research station science and the stations factored in to their own work the requests and investigatory work of growers.

Information about the uptake of scientific methods, though, is extremely patchy. Not a great amount is known about the commercial and scientific activities of the main sectors of the horticultural industry to be able to generalise confidently and the willingness of growers to 'grasp the hand of science' was influenced by many factors. One of the most successful research institutes with regard to the impact on producers was Cheshunt Glasshouse Research Station and in an interview for *The Market Grower and Salesman* in 1923, the Director commented on the 'keen spirit of co-operation' among growers and stated:

> We have always found in the Lea Valley complete co-operation between the practical man and the scientist. The practical man is always willing to test the suggestions of the scientist.[119]

To judge whether this was typical of the commercial sector as a whole requires more detailed investigation of the different sectors of production. This chapter further illustrates that horticultural research covered a wide range of state and commercially financed activities and was characterised by diversity.

[119] 'Market Grower Interviews', op. cit. (39), p. 9.

Chapter 8

Government Consumer-oriented Policies, Research and Consumption: Allotment Holders and Consumers of Fruit and Vegetables

In this Chapter I intended to examine the influence of consumers on horticultural science research, as I wanted to investigate if consumers were unhappy with products developed by research stations and if they were demanding something different. A survey of the *Journal of the Royal Horticultural Society*, journals for allotmenteers, trade magazines for growers, the Sainsbury Archive, the Marks and Spencer Company Archive and material in the Mass Observation Archive showed that information about the consumer voice was limited, although there was material to do with consumer-oriented policies of the government and the research stations. This chapter was re-focussed and discusses what I found out about the response of members of the public to the horticultural products developed by those horticultural science research stations aided by the Development Fund (DF). I examine two consumer groups, allotment holders and buyers of fruit and vegetables and consider these in relation to government policy and research.

Harris, Trentmann and Hennock have indicated how efforts of successive governments in the early twentieth century to encourage economic development, using revenue from taxation, helped stimulate consumer demand. Resources allocated to create employment opportunities and provide disadvantaged sections of the population with benefits and services contributed to this demand and helped shape spending patterns.[1] A number of writers have shown how in the 1920s and 1930s governments in Russia, Japan, China and Germany were stimulating demand for particular products using fiscal policies and Trentmann has termed this, 'the politics of consumption'.[2] I provide a further example by showing how government funded research institutions provided allotment holders with products that improved cultivation and output and consumers with better quality food and different types of food. Additionally, I suggest that the provision of educational facilities for allotmenteers is part of Trentmann's 'bundles of goods, practices and representations' and is a component of what Fine has labelled, 'non-commodity consumption'.[3] The government was spending significantly on education and by 1910 this expenditure had become, 'second in the national balance sheet only to the armed services'.[4] Efforts by British governments to satisfy and stimulate demand in these ways can be seen as an aspect of the consumerism identified by these writers.

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[1] J. Harris, *Private Lives, Public Spirit: A Social History of Britain 1870-1914,* Oxford: Oxford University Press, 1993, p. 6; E. P. Hennock, *The Origin of the Welfare State in England and Germany, 1850-1914: Social Policies Compared*, Cambridge: Cambridge University Press, 2007, p. 11; F. Trentmann, 'Knowing Consumers – Histories, Identities, Practices: An Introduction' in F. Trentmann (ed.)*, The Making of the Consumer: Knowledge, Power and Identity in the Modern World*, Oxford: Berg, 2006, pp. 1-27.

[2] F. Trentmann (ed.), *The Oxford Handbook of the History of Consumption, Oxford:* Oxford University Press, 2012, p. 19. See section 6, 'State and Society', particularly pp. 399-547.

[3] F. Trentmann, 'Introduction', in F. Trentmann (ed.), *The Oxford Handbook of the History of Consumption*, Oxford: Oxford University Press, 2012, p. 3, p. 8; B. Fine, 'Addressing the Consumer' in F. Trentmann (ed.), *The Making of the Consumer: Knowledge, Power and Identity in the Modern World,* Oxford: Berg, 2006, pp. 291-311.

[4] Harris, op. cit. (1), p. 200.

8.1 Allotment Holders

Little has been written about science and the allotment holder, while authors of books on the development of allotments in the UK have not emphasised this aspect of the history of the subject. The following is a contribution to help redress this imbalance.[5]

Between 1910 and 1920 cultivating an allotment had become a popular pastime and the number of allotments increased noticeably. The First World War provided a stimulus, as householders were encouraged to grow their own vegetables and fruit to support the government's drive for self-sufficiency in food production.[6] It was estimated by F. Forbes, General Secretary of the National Union of Allotment Holders, that in 1922 there were 250,000 plot holders in England and Wales producing an estimated 700,000 tons of vegetables.[7] By the late 1920s, however, allotments were less popular and the number of different types of holdings had fallen, particularly as land brought under temporary cultivation during the war was being reclaimed for house building. G.W. Giles, Secretary of the National Allotment Society, believed that between 1920 and the late 1930s half a million allotments had been lost.[8]

The research and teaching institutions funded by the Development Commission

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[5] J. Stoney, *Allotments; their Acquisition and Cultivation*, London: HMSO, 1936; C. R and H. C. Fay, *The Allotment Movement in England and Wales*. London: National Allotments and Gardens Society, 1942; D. Crouch and C. Ward, *The Allotment. Its Landscape and Culture*, London: Faber and Faber, 1988; D. M. Moran, *The Allotment Movement in Britain*, New York: P. Lang, 1990; S. Poole, *The Allotment Chronicles: A Social History of Allotment Gardening*, Kettering: Silver Link Publishing Limited, 2006.

[6] Poole, op. cit. (5), pp. 118-131.

[7] Poole, op. cit. (5), p. 138.

[8] *Annual Report of the Allotments Organisation Society and Small Holders Limited* (1925), p. 6; *Annual Report of the Allotments Organisation Society and Small Holders Limited* (1928), p. 38; Poole, op. cit. (5), p. 141; G. W. Giles, 'Wanted: new allotment holders', *The Listener*, 21st December 1939, p. 1236; SXMOA1/2/67/1/G, TKMOA. In the Second World War the number of allotments increased.

(DC) and the horticultural branch of the Board and later Ministry of Agriculture and Fisheries (BAF and MAF) offered support to allotment holders. The following sections discuss this support and the initiatives taken by some allotment societies to engage with horticultural science. Although it is not possible currently to generalise about the response of the many allotment societies to developments in horticultural science because little is known of their history, it is possible to offer specific comments about the reactions of some individual societies.

8.1.1 Pest and Disease Control

To help allotment holders cultivate healthy crops and encourage demand for allotment holding the government passed Destructive Insects and Pests Acts in 1907 and 1927. They were designed to prevent the entry of designated pests and diseases on imported plants fruit and vegetables. These imports, mainly from Europe and the United States, needed an accompanying certificate of health.

To contain outbreaks on allotments and elsewhere in England, Orders were passed regularly. They were started in 1907 and in 13 of the 19 years between 1911-1929 an Order was introduced in an attempt to contain pests and diseases in infected areas. If specified insects or diseases were found by government plant inspectors on crops on allotments or elsewhere, infected plants had to be destroyed. These measures provided a degree of protection from predation for some allotment crops.[9] Government trained inspectors

[9] J. C. F. Fryer and G. H. Pethybridge, 'The Phytopathological Service of England and Wales', *Journal of Ministry of Agriculture* (1925), 31, pp. 331-340; F. L. C. Floud, *The*

visited allotments regularly to check for outbreaks and this assisted monitoring and provided the opportunity to give prior warning to allotment holders in adjacent regions.[10]

The Harpenden pathological laboratory, run by the Ministry of Agriculture, kept inspectors up-to-date about current research. The Laboratory introduced a pest and disease service and judgments about received specimens were sent to enquirers in the form of short reports. Allotment Associations used the service as their members were anxious to learn whether plots were harbouring virulent invaders.[11]

Staff from colleges and universities receiving DC grants also made personal visits to allotment holders to give advice. For example, scientists from the University of Manchester went to local plots to give their considered opinions and the lecturer in horticulture and botany at Harper Adams College, G. T. Malthouse, gave advice on pests and diseases, particularly potato wart disease.[12] Armstrong College (later Newcastle University) staff identified 28 diseases after a number of visits mainly to allotment holders and one of its lecturers advised on insect control through the pages of *Allotments and Gardens.*[13]

Ministry of Agriculture and Fisheries, London: G. P. Puttnam's and Sons Limited, 1927, pp. 170-176.

[10] Letter from T. H. Middleton to C. L. Stocks, 12th November 1914, T1/11839, NA.

[11] Letters of enquiry sent by various allotment associations to the Phytopathological Laboratory can be found in MAF 190/122, NA.

[12] *Report of the work of the Intelligence Department for the two years 1919-1921* a), London: HMSO, 1922, p. 100; *Report of the distribution of grants for agricultural education and research in the year 1910-1911*, London: HMSO, 1911, p. 28, in T1/11839, NA.

[13] *Report of the work of the Intelligence Department* a) op. cit. (12), p. 98; *Allotments and Gardens* (1922), VI, (6), p. 89.

8.1.2 Education

The DF Commissioners and the BAF (later MAF) believed that it was vital the results of research and experimental work were conveyed to the allotment holder by ‘the system of advice’ that was part of the governments support structure for horticultural and agricultural science, created and developed by A. D. Hall.[14] The Commissioners and the BAF and MAF made a continued effort between 1910-1930 to provide basic horticultural science education to allotment growers in order to ensure food quality and output was improved and encouraged local authorities to expand their provision to create and satisfy demand. Some allotment societies were keen to obtain scientific advice and to provide opportunities for their members to learn about horticultural science and arranged their own educational provision. The fact that a representative of the National Union of Allotment Holders was a member of the MAF’s 1920s Potato Advisory Committee, that provided a range of advice on disease control, is an indication of the economic importance of allotment holders to the government and the value the state placed on working with their professional body.[15]

8.1.2.1 Central and Local Government Provision of Education for Allotment Holders

During the First World War the BAF promoted horticultural instruction classes in different parts of England in allotment gardening, insisted on qualified horticultural instructors and used as venues technical schools, colleges and

[14] *Report of the work of the Intelligence Department of the Ministry for three years 1921-24* b), London: HMSO, 1925, p. 15.
[15] *Report of the work of the Intelligence Department* a), op. cit. (12), pp. 119-121.

evening institutes.[16] Although this was a temporary arrangement, designed to expand wartime output of home-produced food, another more long lasting initiative that developed in the 1920s and continued throughout the 1930s was the MAF display at county shows, although the exhibitions were not aimed solely at allotment holders. At the Royal Lancashire Show in 1938, for example, *The Allotmenteer* commented favourably on the informative horticultural display at the MAF stand.[17] The government distributed leaflets about allotments to encourage their uptake and 90,000 were handed out in 1920 at events like the Royal Agricultural Society Show, regional horticultural shows and from the demonstration plot at the Ideal Home Exhibition.[18]

Of long term impact was the support given by BAF, then MAF, to county councils to encourage farm institutes to use their grounds to set up model allotments and to also establish plots elsewhere if they thought it desirable. The demonstration plots were introduced expressly to act as a conduit for the results and products of research institute science and, as I have emphasised in previous chapters, were regarded by A. D. Hall as a vital link between research station and allotment owner. Horticultural inspectors of BAF and later MAF monitored this farm institute work and reported on the nature and quality of the provision and recommended modifications if tactics were not having an impact. County Agricultural Advisers provided advice and instruction based on horticultural science research to allotment holders.

Those who ran model allotments grew fruit and vegetables, demonstrated a

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[16] Letter from T. H. Middleton to C. L. Stocks, op. cit. (10); Letter from the Secretary of BAF to the Secretary of the Treasury, 5th August 1915, T1/11839, NA.

[17] 'A preliminary glimpse of the Royal Lancashire Show', *The Allotmenteer. Official Organ of the Liverpool and District Council of Allotment Associations* (1938), 3, (3), p. 9. The journal provided a list compiled by MAF of 50 potatoes immune from wart disease.

[18] *Report of the work of the Intelligence Department* a) op. cit. (12), p. 125.

range of techniques and methods and gave advice and the following examples illustrate some of their work. Moulton Farm Institute displayed new varieties, methods of intensive cultivation and disease control measures and the Horticultural Superintendent at Kingsham Farm Institute provided guidance on how to set up allotment schemes.[19] Staff at Cannington Court Farm Institute visited allotments to give technical advice on manures, pests and diseases and crop failure, liaising with Long Ashton Research Station (LARS) over difficult problems.[20] In 1920 there were 109 model allotments in 16 counties in England and by 1926 there were 122.[21]

Some county councils provided talks and lectures for allotment societies. In the late 1920s the County Horticultural Instructor for Somerset gave short presentations to allotment societies and lectures about allotments.[22] In Norfolk, the Instructor for Horticulture in 1930 provided appropriate training for existing and potential allotmenteers and in the mid-1930s Walsall Council arranged for its Park Superintendent to give a summer class for beginners and special lessons in winter and the Local Education Authority provided lectures for plot holders.[23]

Additionally, Institutions funded by the DC were encouraged to support allotment associations by hosting visits or responding to enquiries. In 1925 lecturers from the University of Reading Faculty of Agriculture and Horticulture

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[19] Northamptonshire County Council Education Committee. Scheme for agricultural education, undated, MAF 33/22, NA; Report of the Horticultural Superintendent, 1st October to 31st December 1931, MAF 33/16, NA.

[20] Report of the Horticultural Superintendent, 4th September 1928 in MAF 33/9, NA.

[21] *Report of the work of the Intelligence Department* a) op. cit. (12), p. 125; *Report of the work of the Intelligence Department for the year 1926-27* c), London: HMSO, 1928, p. 53.

[22] *Report of the work of the Intelligence Department* c), op. cit. (21), p. 118.

[23] Norfolk County Council. Agricultural Education. Report of the sub-committee on the Conference on Agricultural Education, February 1930 in MAF 33/25, NA; Poole, op. cit. (5), p. 146.

assisted the County Council by giving guidance at 2 demonstration fruit plots and 5 demonstration allotments.[24]

8.1.2.2 Allotment Associations Arranging their own Horticultural Science Education

Bresalier and Worboys in their history of canine distemper vaccine showed how the Field Distemper Fund allowed the public to engage with science.[25] They call for further examples of public involvement and the following illustrates the engagement with science of allotment holders. Some allotment associations sought actively horticultural science knowledge by arranging lectures and visits to institutions that taught horticultural science and conducted horticultural research. It seems reasonable to assume, given this desire for knowledge, that the members of such associations would have been receptive to the horticultural science education described in 8.1.2.1. The following two sections illustrate this enthusiasm.

8.1.2.2.1 Lectures and Classes

Coventry and District Federation of Allotments, Floral and Horticultural Association, founded in 1909, formed a library and inaugurated a series of lectures on horticulture for members and started a summer show in 1911.[26]

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[24] *Bulletin XXXIV. The University of Reading Annual Report of the Faculty of Agriculture and Horticulture. Session 1925-26*, Reading: University of Reading, 1926, p.18.
[25] M. Bresalier and M. Worboys, ‘‘Saving the lives of our dogs’: The Development of Canine Distemper Vaccine in Interwar Britain’, *British Journal for the History of Science* (2014), 47, (20), pp. 305-334.
[26] Coventry and District Federation of Allotments, Floral and Horticultural Association 1911, T1/11308, NA.

Letchworth Allotments and Horticultural Association, established in 1906, booked the Hitchin Beekeeping Association to give a display and secured the bee expert W. Herrod Hempstall, who later became the BAF bee advisor, to present a lecture demonstration in 1911. The Association, with the County Councils help, started a demonstration plot in 1925, arranged for a series of winter lectures by horticultural staff from Oakland's Institute of Agriculture, Hertfordshire to be delivered to members over 1928-29 and produced in May 1929 a special allotments and gardens exhibition.[27]

During the 1920s Lincolnshire and District Allotment Holders Association introduced weekly evening classes in horticulture at 3 city locations, in addition to its well-attended fortnightly meetings.[28] In 1930 Boston Allotment Holders Association and Agricultural Institute organised a lecture by Captain J. C. Wallace of the Agricultural Institute, Kirton, at the Assembly Rooms in Boston on potato eelworm and wart disease. This 'striking' lecture delivered to 'a crowded audience of allotment holders and gardeners', covered history, symptoms, their spread, life history and control, along with a report of the scientific trials conducted at Kirton.[29]

This enthusiasm can be seen in the 1930s. Two schoolteachers who were members of the Liverpool and District Council of Allotment Associations were proposing in 1934 to provide children with tuition in horticultural theory in winter and summer practical work. Southdean Allotment Society wanted to run weekly night classes during winter to pass on knowledge from practical experience and

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[27] K. Johnson, *Gardener's City. A History of the Letchworth Allotments and Horticultural Society Association 1906-1996*, Letchworth: Letchworth Allotments and Horticultural Association, 1996, p. 29.

[28] G. Tan, *Lincoln's Allotments: A History*, Lincoln: The Survey of Lincoln, 2008, pp. 17-18.

[29] 'Eelworm and wart disease', *Lincolnshire Standard*, 23rd January 1930, MAF 43/14, NA.

The Allotmenteer was encouraging allotment holders to attend a January lecture on fertilisers organised by a local horticultural society.[30]

8.1.2.2.2 Visits

Maidstone Allotment Society initiated a group visit to East Malling Research Station (EMRS) in 1927 for a conducted tour of the grounds and laboratory.[31] The station was carrying out pioneering work on fruit rootstocks and investigating pests and diseases. A party of 200 allotment holders visited Plumpton Farm Institute in 1932. The Institute garden contained a range of glasshouses for fruit, rotations suitable for glasshouse cultivation were being investigated, stocks of disease resistant strawberries and raspberries were being built up in conjunction with investigations at EMRS and new varieties were being trialed.[32]

Letchworth Allotments and Horticultural Association organised a guided tour of Oaklands Institute of Agriculture in 1935, building on the association they had developed with the Institute in the 1920s. As well as seeing the investigations that were taking place the party viewed an exhibition of local weeds and harmful and beneficial insects.[33]

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[30] 'Allotments and youth', *The Allotmenteer* (1934), 5, unnumbered; 'Southdean Allotment Society', *The Allotmenteer* (1938), 3, (2), unnumbered; *The Allotmenteer* (1939), 4, (1), p. 3.

[31] *Annual Report, 1927, East Malling Research Station*, East Malling: The Kent Incorporated Society for Promoting Experiments in Horticulture, 1928, p. 25.

[32] A. H. Hoare, East Sussex Horticultural Sub-Committee, 3rd December 1930 and A. H. Hoare, East Sussex Council Horticultural demonstration plots, 5th August 1932 in MAF 33/367, NA.

[33] Johnson, op. cit. (27), p. 45.

8.1.3 Research Station Products

The influence on allotmenteers of research station plant material and cultural products, developed in order to increase crop yields, is examined in this section. Research institutes wanted the products and practices developed by their scientists to be adopted by allotment holders and to stimulate demand and uptake they welcomed visitors to see and discuss the experimental work. Allotmenteers could contact stations to obtain scientific advice about cultivation problems and catch up on the latest developments. The forgoing sections have indicated the willingness of some allotment associations to embrace horticultural science and to adopt techniques, methods and products developed by research institutions. A number of Associations set up their own demonstration plots to educate potential and existing members by showcasing methods and products developed by research institutions.

These products were obtainable from seed firms and leading seed companies introduced some into their catalogues.[34] Such firms regarded allotment associations as valuable customers and offered favourable discounts. Additionally, the National Allotments Society had its own seed catalogue that offered several of the products of research stations and included their own vegetable varieties as well as flower and vegetable seeds raised by others.[35]

[34] Between 1910-1940 the following were dominant seed or nursery companies nationally or regionally in terms of market share, size, facilities and investigatory work: Bunyards (Kent, 1796), Carters (London, 1804), J. L. Clucas (Ormskirk, 1860), Hurst and Son (1857, London), Laxton Brothers (Bedford, 1888), Sutton and Sons (Berkshire, 1806), Pennells (Lincolnshire, 1780), Toogood and Sons Limited (Hampshire, 1815) and Unwins (Cambridgeshire, 1903). Many advertised in horticultural journals and magazines and some in allotment periodicals.

[35] The National Allotment Society established National Horticultural Supplies (NHS) as its trading organisation and its own vegetable varieties went under the 'NHS' brand.

8.1.3.1 Plant Material

Three examples of plant material developed by research institutes are discussed: fruit tree rootstock, Cheshunt Early Giant lettuce and Roscoff broccoli.

8.1.3.1.1 Fruit Tree Rootstocks

The various rootstocks developed at EMRS, distributed to the commercial sector in stages after 1912, began to appear in the catalogues of some nursery companies in the mid 1920s, making them available to allotment holders.[36] Initially, researchers at EMRS were more concerned to get growers to adopt rootstocks and allotment holders were less of a priority but later the station distributed small quantities of their rootstocks to County Councils so that they could be used on allotment demonstration plots for experimental purposes and to illustrate the advantages of the different types.[37]
The respected nursery firm Laxton Brothers of Befordshire reported in their 1925 catalogue that they had been using some of the EMRS rootstocks for a number of years and by 1937 had increased their usage.[38] Bunyards nursery in Kent praised the EMRS rootstocks in their 1932-1933 catalogue and Pennells, an influential seed firm in Lincolnshire, started selling apple trees on stocks

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[36] Anon (2014) Rootstock research at East Malling: a history [Online] East Malling Research. Available: www.emr.ac.uk/projects/rootstock-research-east-malling-history/ [Accessed 4 July 2015]. By 1924 rootstocks M1-M24 had been released and it was calculated that 15000 rootstock for commercial horticulture were produced in 1921 and 500,000 in 1936.

[37] 'East Malling Research Station', *The Kent Farmer's Journal* (1927), 22, (4), pp. 114-117.

[38] Laxton Brothers, *Laxton's New Fruits*, Bedford: Laxton Brothers, 1925, p. 60 and Laxton Brothers, *Laxton's Fruit Trees and Small Fruits*, Bedford: Laxton Brothers, 1937, p. 64, RHSLL.

pioneered at EMRS in 1934.[39] Pennells 1938 catalogue noted that, ‘Bush trees grown on selected East Malling strains are recognised as the best and most productive stock available today’.[40]

For allotment holders the EMRS rootstocks brought several benefits. Unlike the Paradise rootstocks used to produce apple trees, EMRS rootstocks ensured varieties were uniform, true to type, disease free and of high quality and enabled the cultivator to select a tree of appropriate height and girth to fit available allotment space.[41]

8.1.3.1.2 Cheshunt Earl Giant Lettuce

Cheshunt Experimental and Research Station (CERS) bred Cheshunt Early Giant lettuce to heart up in February and March, normally a period of dearth as most varieties did not crop at this time. It was not untypical for allotmenteers to construct greenhouses on their plots. *A Practical Guide to School, Cottage and Allotment Gardening* (1908) dealt with small greenhouses, *Allotments: Their Acquisition and Cultivation* (1936) covered forcing under glass and adverts for greenhouses were appearing in allotment society publications. Sheffield and District Allotments Federation offered insurance cover against fire damage for greenhouses and allotment groups, such as the Liverpool Allotment Council,

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[39] G. Bunyard and Company, *Bunyard’s Catalogue of Fruit Trees 1932-33*, Maidstone, G. Bunyard and Company, 1932, p.3, RHSLL; Pennells, *Trees: Hardy Fruits, Ornamental Trees, Flowering Shrubs, Number 509*, Lincoln: Pennells, 1934, p. 6, PGCCC.

[40] Pennells, *Trees: Hardy Fruits, Ornamental Trees, Flowering Shrubs, Number 589*, Lincoln: Pennells, 1938, p. 6, PGCCC.

[41] Letter from A. D. Crowe to M. D. Bukovak, 15th July 1988, East Malling Research 75th Birthday Celebration File, NIAB EMRL; J. H. Walker, ’Rootstocks’, *Food and Agriculture Technical Information Service Review Supplement* (1956), pp. 5-6, History of East Malling Research Station file, NIAB EMRL.

were reporting on the construction of greenhouses and sheds.[42] Some County Councils promoted glasshouse cultivation. For example, Hastings Corporation opened their Manual Training Centre free of charge to enable allotment holders o use the most up-to-date machinery at the Centre to make greenhouses.[43] Cheshunt Early Giant was very highly regarded by the seed trade because it formed a solid head and, 'was selected to heart in short daylight days'.[44] It appeared in the catalogues of seed firms such as Clucas, Hurst and Son, Pennells, Sharpe and Company, Toogoods and Unwins during the 1930s and once incorporated, had a continuous run. Sharp and Company regarded it as a valuable variety and trialed it regularly into the 1950s, in order to supply seed to other houses.[45] In the 1940 flower and vegetable seeds and sundries catalogue of the National Allotments Society, the lettuce was described as 'fine for greenhouses' and was 'in great demand' and it was advertised in the 1963 catalogue of a major seed firm of the 1960s, Thompson and Morgan of Ipswich.[46]

[42] J. Weathers, *A Practical Guide to School, Cottage, and Allotment Gardening*, London: Longman, Green and Company, 1908. Weathers was a lecturer in horticulture for Middlesex County Council; J. Stoney, *Allotments: Their Acquisition and Cultivation*, London: HMSO, 1936. Stoney was Horticultural Superintendent for Staffordshire; National Allotments Society Limited; *First Annual Report and Year Book of the National Allotments Society Limited*, London: National Allotments Society Limited, 1930, pp. 21-22; *Third Annual Report of the National Allotments Society Limited*, London: National Allotments Society Limited, 1932, p. 21.
[43] *First Annual Report and Year Book*, op. cit. (42), pp. 29-30.
[44] Hurst and Son, *Hurst and Son General Trade Catalogue*, London: Hurst and Son, 1937, p. 41. In 1938 Hurst offered Cheshunt Early Ball lettuce, designed for frames and cloches.
[45] Pennells catalogues are at PGCCC and the others mentioned are kept at RHS LL. Trial books of Sharp and Company are kept at LIA.
[46] National Horticultural Supplies, *Catalogue of Vegetables and Flower Seeds, Manures and Sundries*, Huddersfield: National Allotments Society, 1940, p. 10, SxMOA 1/2/67/1/G, TKMOA; Stock Book 1941. Vegetable Seeds, SHARPE Addnl Acc 87/73, uncatalogued, LIA; Sales Book 1953-54, 2 SHARPE Box G, uncatalogued, LIA; Thompson and Morgan, *Choice Flower and Vegetable Seeds, 1963*, Ipswich: Thompson and Morgan, 1963, TMCC.

8.1.3.1.3 Roscoff Broccoli

Seale Hayne Agricultural College (SHAC) near Newton Abbot in Devon and Cambridge University Vegetable Research Station, both recipients of DC funding, undertook research into developing broccoli that would crop in the winter months to extend the season. Seale Hayne was given the task of raising a variety suitable for mild weather conditions in the south west of England and Cambridge was to produce a strain suitable for colder eastern areas with good foliage protection for the head.[47]

Seed firms welcomed the varieties that were raised and introduced a number of them in their catalogues throughout the 1930s and Sutton and Sons and Toogood and Sons introduced their own strains.[48] Once incorporated in catalogues the broccoli appeared continually and Unwins of Histon, Cambridgeshire, commented in 1935 that, ‘no broccoli has more favourably impressed us, after extensive trials’.[49]

The uptake by seed firms was strong, and this endorsement would have encouraged some allotment holders to grow Roscoff broccoli, particularly as it enabled a crop to be produced at a time when allotment vegetables were in short supply.

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[47] A. H. Hoare, ‘Vegetable crops on the farm’ in J. A. Hanley (ed.), *Progressive Farming. The Maintenance of High Production*, London: Caxton Publishing, 1948, pp. 160-185.

[48] Some of the seed firms that sold Roscoff broccoli were: Carters, Clucas, Hurst and Son, Laxton Brothers, Suttons and Sons, Toogood and Sons and Unwins. Altogether five Roscoff varieties were produced, which extended the cropping season.

[49] Unwins, *Sweet Peas, Garden Seeds, Gladioli, Dahlias and Roses*, Histon: Unwins, 1935, p. 65, RHSLL.

8.1.3.2 Products to Increase Crop Yields

Three products pioneered by research stations to increase crop yield - Adco, which turned straw into manure, the fungicide Cheshunt Compound and the pesticide, tar-oil wash - have been examined in Chapters 4 and 7 and are noted here briefly.

Adco was valuable to allotment cultivators as a variety of soft allotment waste could be composted using Adco Accelerator whilst tougher refuse from plots was turned into manure with Adco Standard. Little maintenance was required during the composting process and the breakdown of material was relatively speedy. The product was given creditable endorsement through its appearance in the catalogue of the National Allotments Society.[50]

Cheshunt Compound was a commercial success and seven of the larger seed and nursery firms between 1936-1941 sold it in their catalogues. Amongst these were Toogood and Sons and the large and influential seed houses of Carters and Sutton and Sons, who all courted allotment groups with offers of special collections of vegetable seed and with the promise of high quality, pure and reliable flower and vegetable seed.[51] The product was valuable for allotment owners, particularly those raising both flowers and vegetables and using protective structures, and this is partly why the National Allotment Society recommended the product.[52]

LARS tar-oil winter wash was more effective than that originally produced in the Netherlands, as proprietary tar-oil washes based on the latter were generally disappointing and EMRS had ‘constant enquiries regarding the safety and

[50] National Horticultural Supplies, *Catalogue*, op. cit. (46), p. 24.
[51] Clucas, Hurst and Sons, Unwins and Laxton Brothers also sold Cheshunt Compound.
[52] National Horticultural Supplies, *Catalogue,* op. cit. (46), p. 24.

efficacy of tar-distillate washes on the market'.[53] In the 1920s a number of firms developed proprietary tar-oil washes and seed and nursery firms, well aware of the popularity of fruit growing on allotments and home gardens, particularly apples and plum cultivation, sold these brands in their catalogues from the late 1920s.[54] Carters, Bunyards and Pennells developed a slightly different formula to existing brands and marketed the wash under their own name.[55] In this way plot holders could purchase tar-oil winter wash that was designed originally for commercial growers.

Summary

Government legislation safeguarded allotments to some degree from pests and diseases arriving on imported plant material. Government plant inspectors visited allotments and gardens to reinforce the Orders and Acts to do with the movement and destruction of plants found with targeted pests and diseases and inspectors, members of the Phytopathological Laboratory and staff from horticultural departments in state funded institutions visited plots to give advice, monitor outbreaks and help enforce legislation. Diseases were difficult to eradicate and in the medium term the most effective action by the government to control their appearance on allotments was to encourage the certification of potatoes and fruit plants as free of certain disease, support the identification and development of stock which had a natural resistance to fungal and virus

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[53] A. M. Massee, 'Preliminary field trials of tar distillate washes', *Annual Report East Malling Research Station*, East Malling: Kent Incorporated Society for Promoting Experiments in Horticulture, 1925, pp. 143-144.

[54] Clucas, Hurst and Son, Laxton Brothers, Suttons and Toogood and Sons sold proprietary tar-oil washes.

[55] Bunyards, *Garden Seeds and Sundries*, Maidstone: Bunyards, 1929, p. 46, RHSLL; Carters, *Garden and Lawn*, London: Carters, 1930, p. 72, RHSLL; *Pennells Seeds*, Lincoln: Pennells, 1934, p. 69, PGCCC.

disease, ban the planting of non-immune varieties in infected areas and prohibit the sale of infected plants.[56]

Fruit tree roots stocks, Cheshunt Early Giant lettuce and Roscoff broccoli provided allotmenteers with a greater range of plants to cultivate and, along with Adco, Cheshunt Compound and tar-oil winter spray, were brought to the attention of the public via nursery and seed catalogues. The National Allotment Society encouraged allotment holders to widen their horizons and attend horticultural lectures and classes that incorporated basic science in the presentations. Soil testing kits were promoted by the Society and in 1935 it distributed a leaflet written by an agricultural analyst to plot holders that gave Instructions on how to carry out the tests and interpret the results.[57] If the Society believed some of its members were interested in horticultural science and had faith in their grasp of basic science then it is likely that the products of the research stations proved attractive to certain plot holders; although the scarcity of evidence prevents generalisation.

8.2 Consumers of Fruit and Vegetables

This section explores the relationship between the horticultural science research undertaken at some of the institutes funded by the DC on fruit and vegetable consumption in the UK. Four areas are examined: controlled atmosphere storage, fruit and vegetable canning, the marketing of fruit and vegetables and improvements in cultivation practice.

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[56] It was costly for allotment holders to carry out repeat sprayings and legislation could not prevent wind or rain from carrying fungal spores to new areas. Orders and Acts ratified these measures.

[57] National Allotments Society, *Soil Testing and its Importance to Every Grower*, National Allotments Society, 1935, RHSLL.

8.2.1 Fruit and Vegetable Acreage

During the last quarter of the nineteenth century the amount of land devoted to commercial fruit and vegetables production expanded noticeably. Brown calculated that the acreage under orchard in England and Wales had increased 50% between 1875-1900, the acreage of soft fruit had expanded between 1890-1915 by 25% and the acreage of market garden land had risen by nearly 300% between 1870-1900.[58] Rider Haggard in his travels in England at the turn of the twentieth century noted the wide range and extent of commercial horticulture and E. A. Pratt in 1906 remarked on the increase in fruit and market garden acreage and observed the variety of commercial horticultural activity.[59] In the 1968 reprint of *English Farming Past and Present* it was estimated that between 1891-1914 small fruit acreage rose by 43%.[60]

This expansion continued after 1914 and O. J. Beilby believed that between 1923-1935 fruit production had increased by 27% and vegetable production by 29%.[61] Several writers have emphasised the part played by rising demand in the growth of commercial fruit and vegetable production and Oddy has stated that the market was largely unaffected by technical advance.[62] I argue

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[58] J. Brown, *Agriculture in England: A Survey of Farming, 1870-1947*, Manchester: Manchester University Press, 1987, p. 51.

[59] H. Rider Haggard a), *Rural England; being an Account of Agricultural and Social Researches carried out in the Years 1901 and 1902*, *Volume 1*, London: Longman, Green and Company, 1902, pp. 72-75; Rider Haggard b), *Rural England; being an Account of Agricultural and Social Researches carried out in the Years 1901 and 1902*, *Volume II*, London: Longmans, Green and Company, 1902; E. A. Pratt, *The Transition in Agriculture*, London: John Murray, 1906, pp. 4-193.

[60] Lord Ernle, *English Farming Past and Present*, London: Heinemann Educational Books, 1961, pp. 512-514.

[61] O. J. Beilby, 'Changes in agricultural production in England and Wales', *Journal of the Royal Agricultural Society of England* (1939), 100, (II), pp. 62-73.

[62] P. J. Perry, *British Farming in the Great Depression 1870-1914: An Historical Geography*, Newton Abbot: David and Charles, 1974, p. 120; G. M. Robinson,

the opposite and show that an aspect of the supply side, the work of research stations, was important also in this expansion and suggest that the scientific and technological developments of research institutions influenced demand for certain crops.

8.2.2 Fruit and Vegetable Consumption

T. C. Barker noted in the mid-1960s that British historians had paid 'little systematic attention' to food.[63] His comment is relevant for the period 1910-1930, particularly when the diet preferences of the different social classes and their regional variations are considered. Whilst it is clear that fruit and vegetable production at this time expanded, there is much less confidence about consumption patterns.

Atkins has stated that historians cannot be sure before 1920 what proportion of the vegetable crop was sold for human consumption. For example, in 1899 the tenderest and best quality table beetroot was being used in dog biscuit manufacture and contemporary statistics about domestic production and food consumption were either absent or unreliable.[64] Also, within social classes consumption patterns varied not only between urban and rural areas but within

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Agricultural Change: Geographical Studies of British Agriculture, p. 98; R. Perren, *Agriculture in Depression, 1870-1940*, Cambridge; Cambridge University Press, 1995, p. 13; D. J. Oddy a), *From Plain Fare to Fusion Food: British Diet from the 1890s to the 1990s*, Woodbridge: The Boydell Press, 2003, p. 178.

[63] T. C. Barker, 'Nineteenth Century Diet: Some Twentieth Century Questions' in T. C. Barker, J. C. Mckenzie and J. Yudkin (eds.), *Our Changing Fare. Two Hundred Years of British Food Habits*, London: Macgibbon and Kee, 1966, pp. 18-29.

[64] P. Atkins, 'The Production and Marketing of Fruit and Vegetables 1850-1950', in D. J. Oddy and D. S. Miller (eds.), *Diet and Health in Modern Britain*, Beckenham: Croom Helm Limited, 1985, pp. 102-133; W. W. Glenny. *The Fruit and Vegetable Markets of the Metropolis*, London: Spottiswoode and Company, 1896, p. 12; J. C. Drummond and A. Wilbraham, *The Englishman's Food: A History of Five Centuries of English Diet*,

regions.[65]

If as Glenny suggests, labourers in London in 1896 were purchasing vegetables at reasonable prices that were once a luxury for the wealthy and were now 'a prime necessary of life', they seem to be an exception.[66]. Figure 8.1 indicates the fruit and vegetables available to consumers at Derby market in c1927 but material providing information about variations in consumption patterns is

Figure 8.1 - Derby Market c1927, showing fruit and vegetable displays, from *Report on Markets and Fairs in England and Wales Part 1: General Review*, London: HMSO, 1927, opposite p. 25.

presently a scarce resource. There is agreement amongst a range of writers that consumption of fresh vegetables and fruit was, in part, related to income - their consumption increased as income increased - and the poorer working class until the 1930s had a diet that generally was lacking in both, with the exception of potatoes.[67]

London: Jonathan Cape, 1957, p. 459; A. Torode, 'Trends in fruit consumption' in T. C. Barker, J. C. Mckenzie and J. Yudkin (eds.), *Our Changing Fare. Two Hundred Years of British Food Habits*, London: Macgibbon and Kee, 1966, pp. 115-134.

[65] Oddy a), op. cit. (62), p. 57.

[66] Glenny, op. cit. (64), p. 12.

The next sections discuss the influence of research station science on patterns of fruit and vegetable consumption of the working and middle classes.

8.2.3 Gas Storage

Most of the research at the horticultural section of Cambridge University Low Temperature Research Station (LTRS) up to the 1930s focused on fruit. Scientists gave advice and assistance to fruit growers in the UK and in other countries and developed gas storage techniques for apples, pears, plums, oranges, grapefruit and pineapples, enabling produce to be stored much longer than previously.[68] This lengthened the period of availability to consumers and ensured regularity of supply of quality fruit as diseases that had periodically ruined consignments in transport were investigated and methods were

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[67] Drummond and Wilbraham, op. cit. (64), p. 460; J. B. Orr, *Food, Health and Income: Report of a Survey of Adequacy of Diet in Relation to Income*, London: Macmillan and Company Limited, 1937, p. 36; Rowett Research Institute, *Family Diet and Health in Pre-War Britain: A Dietary and Clinical Survey*, Dunfermaline: Carnegie United Kingdom Trust, 1955, p. 10; Ministry of Food, 'The urban working class household diet 1940-1949' in *First Report of the National Food Survey Committee*, London: HMSO, 1951, p. 5; D. J. Oddy b), *The Working Class Diet*, University of London, PhD degree, 1971, p. 2; N. Branson and M. Heinemann, *Britain in the Nineteen Thirties,* London: Panther Books Limited, 1973, pp. 224-241; J. Stevenson, *Social Conditions in Britain between the Wars*, London, Penguin Books Limited, 1977, p. 139; M. Barnett, *British Food Policy during the First World War*, London: George, Allen and Unwin, 1985, p. 107; J. Burnett, *Plenty and Want: A Social History of Food Production in England from 1815 to the Present Day*, London: Routledge, 1989, pp. 183-184; D. M. Amos [2000] *Working class diet and health in Nottingham, 1850-1939* [Online] University of Nottingham PhD. Available: eprints.nottingham.ac.uk/12755/1/364423.pdf [Accessed 10 July 2015]. In particular, see pp. 119-144; I. Gazely and A. Newell, 'Urban working-class food consumption and nutrition in Britain in 1904', *The Economic History Review* (2015), 68, (1), pp. 101-122.

[68] D. R. Dilley, 'Historical aspects and perspectives of controlled atmosphere storage' in M. Calderon and R. Barkai-Golas (eds.), *Food Preservation by Modified Atmospheres*, Boca Raton: CRC Press, 1990, pp.187-196; A. Keith Thompson, *Controlled Atmosphere Storage of Fruits and Vegetables*, Wallingford: CABI, 2001, pp. 7-9.

developed to reduce their incidence. I discuss the work of the station on banana and apple storage and the impact on consumption.

8.2.3.1 Banana Storage and Consumption

Bananas gained in popularity since the late nineteenth century when they were a fruit eaten by the middle class and occasionally, when prices were low, by the waged urban working class.[69] Various imported and home-grown fruit in England went to distributers in London and the provincial cities and so bananas could not be easily bought in rural areas.[70] Improved production and improved methods in gas and cold storage lowered prices and Oddy noted that the decline in the fear that the fruit caused fevers and bowel disorders led to a rapid growth in their popularity in the early twentieth century.[71]
By 1931 Marks and Spencer were selling bananas in their stores to its middle and upper working class customers and constructed lavish window displays using real fruit and featuring a life-sized figure of Fyffes Banana Boy.[72] By the1930s and early 1940s eating bananas had become habitual for someworking class consumers, including unemployed members, as well as

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[69] *Report of the Departmental Committee appointed by the Board of Agriculture to Inquire and Report upon the Fruit Industry of Great Britain*, *with a Copy of the Minute appointing the Committee*, London: HMSO, 1905, p. 12. The Director of Kew, W. T. Thistleton-Dyer, was a witness and complained that the paths of Kew Gardens were strewn with the skins of bananas; D. E. Lindsay, *Report Upon A Study of the Diet of the Laboring Classes in the City of Glasgow carried out during 1911-1912 Under the Auspices of the Corporation of the City*, Glasgow: Carnegie Trust/University of Glasgow, 1913, see Appendix VI; B. Seebohm Rowntree, *Poverty: A Study of Town Life*, *Volume VI*, London: Routledge and Thoemmes Press, 1998, pp. 288-293; Torode, op. cit. (64), p. 126.
[70] Torode, op. cit. (64), p. 117.
[71] Oddy b), op. cit. (67), p. 179.
[72] Photograph of Fyffes bananas with Banana Boy model, Window Display Photographs, Acc/11/1723, MSCAUL.

middle class buyers and was consumed as a healthy fruit snack, in a sandwich with sugar for tea and as a partner with custard for dessert.[73]

The LTRS influenced these consumption patterns by initially developing methods to cold store bananas and later developed gas storage, which helped to reduce losses in transport, lower production costs and ensure regularity of supply. LTRS researchers in the horticultural section responded to problems faced by wholesalers. In the early 1920s one Covent Garden wholesaler commented on the damage to bananas that occurred when they had been in chilled storage as it made them unavailable for purchase and caused heavy losses to shippers and dealers.[74] Staff at the LTRS worked with scientists in Trinidad on the gas storage of the fruit and assisted in the construction of a LTRS for banana research at St Augustine in 1928.[75] A consequence was that bananas reached the UK without chill damage and both supply and quality improved.

8.2.3.2 Apple Storage

In the second half of the nineteenth century apples were a popular fruit amongst middle class consumers and contemporary cookery books were encouraging the use of apples at breakfast and dinner.[76] This popularity

[73] Diary Accounts in response to Directives, 1937, SxMOA1/3/9/1, TKMOA; Surveys by interview of members of the working class 1937, SxMOA1/5/7/32/E/2, TKAC; Food most missed, *Mass Observation Special Report, May 1941*, SxMOA1/2/67/4/A, TKMOA; Questions about fruit and vegetables in the 1940s, SxMOA1/2/67/2/13, TKMOA.

[74] *Weekly Price List and Covent Garden Market Report issued by W. Dreyheller, Wholesale Fruit Merchant and Florist*, London: W. Dreyheller, 1923, p. 1.

[75] Letter from W. Hardy to the Secretary of the Imperial College of Tropical Agriculture, 4th June 1928, CO 758/4/2, NA; C. W. Wardlaw, 'The storage of tropical fruits', *Nature*, (1939), 144, (3639) pp. 178-181; Keith Thompson, op. cit. (68), p. 10.

[76] Torode, op. cit. (64), p. 117.

continued into the next century and in the 1930s and early 1940s some of the middle class used apples as part of their lunch and regarded them highly.[77] The picture of working class consumption is less clear. It may be that Oddy is correct in stating that imported apples entered working class diets in the earlytwentieth century only occasionally, being transported initially in refrigerated conditions.[78] Differences in urban and rural consumption need taking into account. Torode suggests that the working class in rural areas tended to eat more apples than the urban working class yet the affluent working class could use grocers, greengrocers, the regular markets in large towns and cities such as the Derby market illustrated in Figure 8.1 and the multiple shop retailers that carried a wide range of fruit.[79] Those using Marks and Spencer in the early 1930s could buy fresh apples. Between 1931 and 1939 some 162 new stores had been built and a number began to sell fresh fruit and vegetables.[80] However, Mass Observation literature does not indicate an urban working class preference for apples in the late 1930s.[81] Until further work is carried out on variations in working class diet in the first half of the twentieth century, a cautious conclusion is that there was some working class demand for apples and possibly for fresh fruit generally but it was limited. It seems that working class consumption of fruit was mostly in the form of jam, which was

[77] Diary Accounts in response to Directives, op. cit. (73); 'Food most missed' op. cit. (73); 'Questions about fruit and vegetables', op. cit. (73).
[78] Oddy a), op. cit. (62), p. 28; Burnett, op. cit. (67), p. 256. Burnett does not consider controlled atmosphere storage.
[79] *Report on Markets and Fairs in England and Wales, Part I: General Review*, London: HMSO, 1927, pp. 25-33; *Report on Markets and Fairs in England and Wales, Part II: Midland markets*, London: HMSO, 1927, p. 8, 105-161; J. B. Jefferys, *Retail Trading in Britain, 1850-1950*, Cambridge: Cambridge University Press, 1954, pp. 244-252. Waterworth Brothers of Liverpool, the largest retail multiple, had 100 branches each with clean and attractive displays of clearly priced fruit.
[80] A. Briggs, *Marks and Spencer, 1884-1984*, London: Octopus Books Limited, 1984, p. 39, p. 53.
[81] Surveys by interview of members of the working class, op. cit. (73).

spread on bread.[82]

Both UK growers and importers of varieties from the Empire and the United States in the early twentieth century faced storage problems, as apples either succumbed to disease in the storage facilities or were damaged by chilling injuries. Staff at the LTRS horticultural section and at its smaller affiliated laboratories worked on these problems and in the 1920s provided solutions for growers and shippers. Key researchers at the station met growers and scientists in the UK and other countries to publicise LTRS research and instructions for maximising the life of stored produce were well received.[83] Gas storage facilities expanded from the mid 1920s into the 1930s in England and other countries[84]. By 1939 combined gas and cold storage plant for apples in Great Britain outnumbered cold storage facilities.[85] These developments ensured consumers of apples were able to have more regular supplies of domestic and imported fruit of the best possible quality.

[82] Torode, op. cit. (64), p. 122; Oddy a), op. cit. (62), p. 187; L. Margaret Barnett, *British Food Policy during the First World War*, London: George Allen and Unwin, 1985, p. 107; P. J. Atkins, 'Vinegar and Sugar: The Early History of Factory-made Jams, Pickles and Sauces in Britain' in D. J. Oddy c) (ed.), *The Food Industries of Europe in the Nineteenth and Twentieth Centuries*, Farnham: Ashgate, 2013, pp. 12-13. Jam manufacture took up a great deal of the fruit produced by growers, see C. Smith, *Britain's Food Supplies in Peace and War. A Survey Prepared by the Fabian Society*, London: George Routledge and Sons Limited, 1940, pp. 177-182.

[83] Fruit and vegetables. Draft programme of research for 1927-28, DSIR 6/21, NA; H. B. S. Montgomery and A. F. Posnette, 'Franklin Kidd, 12 October 1890 - 7 May 1974', *Biographical Memoirs of Fellows of the Royal Society* (1975), 21, pp. 407-427; Keith Thompson, op. cit. (68), p. 5.

[84] Dilley, op. cit. (68).

[85] H. R. K, 'Recent Work In Food Preservation', *British Food Journal* (1939), 41, (4), pp. 37-38.

8.2.4 Fruit and Vegetable Canning

The work of the Fruit and Vegetable Preservation Research Station (FVPRS), founded in 1919 at Chipping Campden in Gloucestershire, influenced the consumption of UK canned fruit and vegetable. Investigations on preservation, which covered dehydration, jamming, bottling and later canning, began in 1914 at Studley, Broom and Dunnington in Warwickshire and in 1919 the research was transferred to Chipping Campden as the factory facilities needed to continue the research had become available.[86]

The FVPRS worked closely with EMRS and LARS to obtain technical assistance and Wisley Gardens of the Royal Horticultural Society, Kirton Experimental Station and growers provided varieties of different fruits and vegetables in order to investigate and identify the varieties suitable for canning.[87]

Demand for tinned fruit and vegetables developed in the UK in the late nineteenth century. Mrs Beeton's cookery book of 1901 featured a meal made completely of tinned produce and Sainsbury's, founded in 1869, was selling canned fruit and vegetables in its 100 branches in 1903.[88] The taste for English fruit was noted in the 1905 investigation of the fruit industry commissioned by

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[86] Vegetable drying and fruit preservation experiments, 33/628, NA. Valuable experimental work was carried out on strawberries, raspberries, plums, marrowfat peas, broad beans and runner beans. Difficulties in getting supplies of tin hindered initially development on a commercial scale.

[87] *Report on the work of the Research and Education Division for the year 1929-30* a), London: HMSO, 1931, p. 54; *Twentieth Report of the Development Commissioners for the year ended the 31st March, 1930* a), London: HMSO, 1930, p. 73, D3/20, NA; 'Varieties of fruit suitable for canning', F. Hirst and W. B. Adam, *Canners' Bulletin* (1931), 3, Acknowledgements, p. 11.

[88] *Mrs Beeton's Cookery Book*, London: Ward Lock and Company Limited, 1901, p. 186; Current price list, J. Sainsbury, 6 Station Parade, Epsom 1903, SA/MARK/ADV/3/3/1/43, TSAML.

BAF and in the 1920s British canners preferred to process UK grown fruit.[89]

8.2.4.1 Fruit and Vegetable Preservation Research Station

Without the work of the FVPRS the UK canning industry would not have developed so rapidly. Between 1926-34 the number of canners in Scotland, Wales and England increased from 6 to 80 and the FVPRS in 1929 was helping 40 canners in England and Wales and putting the results of research, 'at the disposal of commercial firms'.[90]

The station, with the assistance of facilitating research stations and sub-stations, investigated the problems faced by canning firms and their solution helped to give consumers confidence in canned produce. Much attention was given to comparing metal and glass as containers, can corrosion and food poisoning and experiments were undertaken on flavour, the colour of canned produce and the time and temperature needed for effective sterilisation.[91] Research at the FVPRS assisted commercial canners to produce canned fruit and vegetables that were in demand. Plummer estimated that the output of British canned fruit between 1924-1932 rose by 734%, although vegetable canning did not accelerate until after 1930.[92] Burnett may well be correct in believing that all classes bought canned fruit, though only occasionally by the

[89] *Report of the Departmental Committee*, op. cit. (69), p. 3; 'Fruit canning', *The Kent Farmers' Journal* (1930), XXVII, (5), p. 167; Vegetable drying and fruit preservation experiments, op. cit. (86). Major canners in the early twentieth century were Baxter's, Chivers, Hartley's and Smedley.
[90] A. Plummer, *New British Industries in the Twentieth Century: A Survey of Development and Structure*, London, Sir Isac Pitman and Sons Limited, 1937, p. 231; *Report on the work of the Research and Education Division for the year 1928-1929*, London: HMSO, 1930, p. 8.
[91] Vegetable drying and fruit preserving experiments, op. cit. (86); *Twentieth Report of the Development Commissioners*, op. cit. (87), p. 73; 'Further canned food studies', 9th June 1924, DSIR 6/67, NA.
[92] Plummer, op. cit. (90), p. 242.

unemployed sector of the working class or those on very low incomes.[93] Marks and Spencer did not join Sainsbury's in selling canned fruit and vegetables until after 1931 and both served the middle class and the more affluent working class, who according to Torode 'were getting used to fresh or tinned fruit and vegetables'.[94] In the early 1930s Sainsbury's was selling 12 different canned English fruits and in 1935 advertised English canned carrots, stringless beans and macedoine of vegetables and by the late 1930's Marks and Spencer was offering a more limited range of English canned fruit.[95]

There is tentative evidence from the Mass Observation Survey. Some middle class consumers in the late 1930s and early 1940s ate tinned plums, probably English and possibly canned by Hartley's. A small grocery store in a working class area of London sold canned English plums, although some working class respondents indicated they liked imported canned pineapples.[96]

8.2.4.2 Pea Canning

A great deal of experimental work was undertaken at the FVPRS by F. Hirst in order to solve the problem of peas losing their fresh green colour when canned.[97] Because of this problem canned peas were not selling well and canners were anxious for a solution.[98] The station was supported in part by

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[93] Burnett, op. cit. (67), p. 259.

[94] Torode, op. cit. (64), p. 118.

[95] 'Good food a), J. S. Sainsbury November 6th, 1933', p. 7, SA/MARK/ADV/3/3/1/17, TSAML; Good food b), J. Sainsbury September 23rd, 1935, p. 20, SA/MARK/ADV/3/3/1/21, TSAML; 'Canned fruits', 13/1/20/3, MSCAUL.

[96] Surveys by interview of members of the working class 1937, op. cit. (73); 'Food most missed', op. cit. (73); Diary Accounts in response to Directives, op. cit. (73); Questions about fruit and vegetables in the 1940s, op. cit. (73). Approximately two thirds of the plum harvest was canned in the late 1930s.

[97] *Seventeenth Report of the Development Commissioners for the year ended the 31st March, 1927*, D3/17, NA, p. 52; M. J. Smedley, *What Happened to Smedley's?: Pioneers*

subscriptions from the canning industry and early subscribers were Chivers and Sons and Smedleys, the former being represented on the Management Committee of the station.[99] Hirst could not use copper salts as they were not allowed by food regulations and so found a solution by utilising a safe green dye and made a contribution to the expansion of pea canning, with production rising from one and a half million cans in 1928 to fourteen million in 1930.[100] Smedley had added 1600 more acres for pea growing by 1932 so that demand could be met.[101] H. E. Dale, civil servant to the DC and MAF, commented that public, 'prejudice against tinned food is disappearing' now that consumers were, 'realising preserved fruit and vegetables are very good' and shrewdly noted that growers and canners, 'owe much to the Fruit and Vegetable Research Station at Chipping Campden'.[102]

Dale ought to have added consumers to the list of the indebted. Middle class shoppers were able to buy canned British peas at Sainsbury's in the 1920s and at Marks and Spencer in the late 1930s. In 1933 Sainsbury was offering both Smedleys and Baxters canned peas and in 1939 Marks and Spencer stocked

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of British Canned and Frozen Foods: An Industrial History, 1925-1975, Layerthorpe: Michael J. Smedley, 2012, pp. 8-9.

[98] Smedley, op. cit. (97), p. 8.

[99] *The Annual Report of the Fruit and Vegetable Preservation Research Station*, Bath: University of Bristol, 1931, p. 47; *The Annual Report of the Fruit and Vegetable Preservation Research Station*, Bath: University of Bristol, 1932, see information on the unnumbered pages before the start of the report.

[100] Smedley, op. cit. (97), p. 8. The dye was used in crème de menthe manufacture; *Eighteenth Report of the Development Commissioners for the year ended the 31st March, 1928,* London, HMSO, 1929, p. 66, D3/18, NA.

[101] Special correspondent, 'The amazing growth of the canning industry', *The Grocers' Assistant* (1932), 11, (7), pp. 10-12.

[102] *Report on the work of the Research and Education Division for the year 1926-27* c), London: HMSO, 1928, p. 75; *Report on the work of the Research and Education Division* a), op. cit. (87), p. 10. Dale believed that favourable medical opinion towards canned food was a factor in the change in consumer attitudes.

canned peas from Stratford-on-Avon Produce Canners.[103] Astor and Rowntree observed that lower income groups replaced dried peas with canned peas although this may have applied to those on a regular income as there is some evidence that unemployed working class consumers and those on very low incomes in the late 1930s still favoured the dried product.[104]

8.2.5 Marketing Fruit

Consumers benefited from voluntary controls in marketing introduced in the 1920s by MAF, which addressed the standardisation of containers used in the sale of fruit and in the grading and quality of fruit in order to stimulate demand for home grown produce. Voluntary control depended on the goodwill of growers and sellers and adherence to MAF's recommendations was influenced by professionalism and the prospect of repeat sales. The Board and Ministry of Agriculture believed that British growers lagged behind producers in North American and Canada in the methods of packing and grading fruit as damaged, misshapen and top quality produce was mixed together regularly.[105]

8.2.5.1 Containers and Grading

H. V. Taylor, who became Horticultural Commissioner for MAF, wrote in *The Fruiterer's Review* in 1925 of his concern to stimulate the public to eat more fruit and noted the complaint of retailers that chip baskets contained less than the

[103] 'Good food' a), op. cit. (95), p. 10; 'Peas,' 11th April 1939, 13/1/20/1, MSCAUL.
[104] Viscount Astor and Seebohm Rowntree, *British Agriculture: The Principles of Future Policy*, London: Longman, Green and Company, 1938, p. 147; Surveys by interview of members of the working class 1937, op. cit. (73).
[105] *Report of the work of the Intelligence Department* a), op. cit. (12), pp. 128-129; *Report of the work of the Intelligence Department* b), op. cit. (14), pp. 127-130.

expected weight of produce. This, he believed, would discourage consumers.[106] To persuade growers to improve their marketing, MAF funded investigations that examined systematically the containers in use and recommended materials, size and cubic capacity. The resultant recommendations were accepted and later amended.[107]

This was followed in 1928 by the use of the 'National Mark', which growers could adopt if they adhered to agreed standards. The 'National Mark' had its own logo, based on a map and the national flag, and was used for fruit and vegetables and later jars of honey and jam and canned fruit and vegetables. The scheme was based on levels of quality and it was expected the mark would be used to indicate top grade produce.[108] Uptake of the scheme was not universal and immediate and in 1929 a commentator in *Commercial Horticulture* exclaimed the, 'majority of consumers know nothing at all about the National Mark'.[109] It is difficult to ascertain the degree of exaggeration here but it seems that the scheme evolved gradually and information about participating growers and the uptake in different regions in the early years is patchy.

In order to encourage growers to adopt grading, MAF collected information about techniques and machinery used in other countries and organised fact-finding tours. Once agreement had been reached about standards between officials and the trade, MAF's team of horticultural and agricultural inspectors embarked on a demonstration and training programme to generate interest and uptake.[110] MAF funded temporarily the Fruit Grading and Packing Station at

[106] H. V. Taylor, 'The retailer's task', *The Fruiterer's Review* (1925), 1, (1), p. 5.
[107] Ministry of Agriculture and Fisheries, *Report on the Preparation of Fruit for Market*, London, HMSO, 1928, p. 12, p. 86; Ministry of Agriculture and Fisheries, *Vegetable Marketing in England and Wales*, London: HMSO, 1935, pp. 90-93.
[108] *Vegetable Marketing in England and Wales*, op. cit. (107), pp. 48-69.
[109] 'The National Mark', *Commercial Horticulture* (1929), 1, (4), p. 74.
[110] *Report of the work of the Intelligence Department* a), op. cit. (12), pp. 128-130.

Cottenham, Cambridgeshire and imported the latest grading machine from the United States for use in demonstrations. This machine was later bought by an apple growers cooperative and several individual growers ordered machines from the USA.[111]

Those growers who realised that improvements in marketing were needed in order to compete with imported fruit, such as the apple growers cooperative, were probably keen to sell produce that was of good standard consistently. Clearly, in such cases, waged middle class and working class consumers buying fruit at markets were able to benefit from this improvement in quality and were able to buy produce of the expected weight.

8.3 Improvements in Cultivation Practices

Surveys of the cultivation practices of growers regionally or nationally have not been compiled by historians so it is not possible to generalise about the impact of cultivation methods on the fruit that reached consumers. Individual examples, though, can provide some help as the following two examples suggest.

Control of pests helped to improve the supply, quality and yield of fruit for market. Fifteen firms were given the formula to manufacture the tar distillate wash for fruit trees developed by LARS to control aphids and other insects and a writer in *Commercial Horticulture* in 1929 believed, ‘they were very extensively employed by market growers’. Another commentator noted these washes had transformed the area around Evesham, Worcestershire, out of all recognition

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[111] *Fifteenth Report of the Development Commissioners for the year ended the 31st March, 1925* b), London: HMSO, 1925, p. 123, D3/15, NA; ‘Grading and packing of apples’, *The Fruiterer’s Review* (1926), 2, (15), p. 73.

and it was calculated that 2 million gallons had been applied nationwide during the 1929-1930 winter season.[112]

As I have explained in 8.2.3, scientists at the LTRS drew the attention of growers to cultural practices that influenced markedly the storage life of apples in controlled atmospheres. The expansion in Britain of gas storage facilities for apples between 1928-1939 illustrates that some in the commercial sector were willing to alter their methods and, by implication, their practices in order to maintain or increase profits.

Consumers benefited from the work at LARS and at the LTRS by being able to purchase apples of good quality and also beyond the normal season. It seems reasonable to suggest that the cumulative effect of all the UK research station science on growers had an impact on consumers that was positive.

<u>Summary</u>

This section explored the relationship between horticultural science research at DC funded research institutions and the consumption of vegetables and fruit. A striking feature of the research institutions work to develop new methods to raise the output, quality and availability of fruit and vegetables for consumers was the belief in the necessity of working cooperatively and of the importance of sharing results that had been obtained by careful and sometimes prolonged investigation. The end product of a research investigation usually depended on data that was supplied by other research stations and sub-stations. Frequently, the final product was given to a commercial grower or a firm to produce and then market. The conviction of the necessity for the products of investigation to

[112] 'Tar distillate washes. Their use and effect', *Commercial Horticulture* (1929), 1, (1), p. 16; *Twentieth Report of the Development Commissioners* a), op. cit. (87), p. 66.

have a social benefit was one of the features of the system of horticultural science research and education that A. D. Hall had developed for central government.

LTRS work on banana and apple storage and the identity of key cultural practices influencing longevity of produce in storage, the FVPRS research on fruit and vegetable canning (particularly peas), the efforts of scientists at LARS, EMRS, CERS and SHAC to develop products and new varieties and the work of MAF to use science to improve marketing by designing containers used in fruit selling and introduce grading criteria for apples, indicate how supply side factors could influence demand. By enabling growers to improve produce quality and extend its availability, these research institutions and MAF helped widen consumer choice that led to variations in middle and working class patterns of consumption.

A full consideration of these issues is influenced by the paucity of data on consumption habits of the different sub-groups of the middle and working class living in urban and rural areas and in different geographical regions. Nevertheless, it does appear that certain consumers were influenced by:

> the most significant development of recent years, and one which by no means has reached its culmination…the detailed application of scientific knowledge and scientific methods to the problems of fruit production.[113]

8.4 Conclusion

The efforts by the government to redistribute income through welfare measures

[113] Astor and Rowntree, op. cit. (104), p. 172.

influenced consumption patterns. Horticultural science research by addressing the needs and wants of two consumer groups - allotment holders and those who purchased fruit and vegetables – also needs to be taken into account. I have indicated supply side factors contributed to changes in consumer demand for horticultural education, fruit and vegetables and products to improve cultivation. Additionally, I have shown the extent to which central government relied on science and scientific experts when formulating and managing horticultural policy and when attempting to encourage the population to consume home grown produce and allotment holders to improve their techniques. The message to allotmenteers that scientific research enhanced practice, was reinforced by the overall success of this product development and educational provision. In 1927 H. E Dale commented that with regard to the system of horticultural science research and education of the DC and MAF, consumer 'demand for services continues to increase'.[114]

The extent of the influence on consumers of fruit and vegetables produced by commercial growers using research station products is difficult to judge as consumption varied according to income, taste, availability and geographical area. Available evidence suggests demand increased for apples, bananas, jam and canned produce, particularly peas and English and tropical fruit, especially from those urban dwellers accessing local markets, shops and retail stores. This exploration of consumption patterns, research station products and techniques and County Council education provision indicates the need for further investigation of supply and demand factors. Whilst the initial idea of examining the consumer voice and ascertaining whether there was dissatisfaction with research station products had to be amended, there still

[114] *Report of the work of the Intelligence Department for the two years 1924-26* d), London: HMSO, 1927, p. 66.

remains the possibility of finding further archive material to justify such an investigation.

Chapter 9

Apicultural Science

This chapter continues the discussion of consumer-oriented policies begun in Chapter 8. As I have outlined, apiary was seen as an aspect of horticulture, unlike the position today. Flowers in gardens and orchards facilitated the honey harvest and bees contributed to fruit pollination.[1] I discuss the support given to apiarists and the bee industry by the Board (BAF), Ministry (MAF) of Agriculture and Fisheries and several research stations funded by the Development Commission (DC). Demand for honey was buoyant and central government wanted to develop honey production by placing it on a more scientific footing and drew upon its scientific consultants and its own experts to make this possible. Clark and Ebert have written individually about the history of beekeeping and have discussed scientific aspects of apiculture, although end their accounts before 1910. By examining state patronage of bee research between 1910-1930 I extend their work and make an addition to the history of apicultural science.[2]

9.1 Apiarists and their 'most effective assistants'

Ritvo has revealed perceptions of nineteenth century society concerning wild and domesticated animals and has explored the function of a number of these

[1] 'Somerset School Garden Inspection. Summary of Report, 1911', ED 77/6, NA. In the official reports of the Intelligence Department of MAF, bees were always placed in the section on horticulture; W. P. Wright, *Scientific and Practical Gardening for School and Home*, London: George Allen and Unwin Limited, 1928, p. 38.
[2] J. M. F. Clark, *Bugs and the Victorians*, New Haven: Yale University Press, 2009; A. W. Ebert, *Hive Society: The Popularization of Science and Beekeeping in the British Isles, 1609-1913*, Iowa State University, PhD thesis, 2009.

animals in social, cultural, economic and political contexts.[3] Although insects await such a detailed and perceptive treatment, some writers have discussed them in relation to human and animal diseases and have tended to emphasise their negative impact.[4] I consider this later in section 9.3.

The positive role of bees in crop pollination and fertilisation was clearer amongst scientists than commercial growers in 1910. At the Welsh Plant Breeding Station, Aberystwyth, bees were used by scientists in grass hybridisation experiments and were regarded as, 'the most effective assistants' when working as, 'a co-worker with human hybridisers'. The seed house of Sutton and Sons also used captured and cleaned bees to assist plant breeding work.[5] Despite the fact t the period, although

hat *The Gardeners Magazine* in 1910 noted that Charles Darwin had drawn attention to the importance of bees in pollination, the gardening and commercial horticulture press felt it necessary to remind growers periodically between 1910-30 of the importance of the insect for fruit setting and in 1926 MAF warned Kent growers of the danger to bees from using lead arsenate sprays at the wrong

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[3] H. Ritvo, *The Animal Estate: The English and Other Creatures in the Victorian Age*, Cambridge, Massachusetts: Harvard University Press, 1987.

[4] L. Fabian Hirst, *The Conquest of Plague. A Study of the Evolution of Epidemiology*, Oxford: Oxford University Press, p. 400; J. R. Busvine, *Disease Transmission by Insects; its Discovery and 90 years of Effort to Prevent It*, Berlin: Springer-Verlag, 1993, preface, p. 7, p. 75, p. 132; S. Watts, *Epidemics and History. Disease, Power and Imperialism*, New Haven: Yale University Press, 1997, p. xi; R. Chandavarkar, 'Plague, Panic and Moral Epidemic Politics in India, 1896-1914' in T. Ranger and P. Slack (eds.), *Epidemics and Ideas. Essays on the Historical Perceptions of Pestilence*, Cambridge: Cambridge University Press, 1999, pp. 203-240; L. Wilkinson, *Animals and Disease: An Introduction to the History of Comparative Medicine*, Cambridge: Cambridge University Press, 2005, pp. 209-10.

[5] *Thirteenth Report of the Development Commissioners for the year ended the 31st March, 1923*, London: HMSO, 1923, p. 16, D/13, NA. Suttons used a watering can and jam jar system to clean the bees.

time.[6]

The following sections indicate that the government's stance towards beekeepers and its industry, which was composed of many individual honey producers who sold jars of honey locally as well as smallholders who kept bees as a secondary income source, was supportive but cautious. For example, during the First World War when sugar was rationed in an attempt to ensure fair distribution, the government eventually acquiesced to pressure from the British Beekeepers Association (BBA) and allowed beekeepers extra sugar supplies so that colonies could be maintained. Many bees had died as apiarists could not afford the price of candy, a substitute, and there was an acute need for sugar in autumn when hive brood combs were full and clover had finished flowering. In order to receive ration vouchers, beekeepers had to be registered with their local County Horticultural Sub-Committee.[7] In 1919 MAF helped the industry to re-stock after disease had wiped out hives by providing full colonies and queens from Italy, at reasonable prices. This helped push up honey supplies and ensure orchards were pollinated.[8]

No official figures were kept of the total output of UK honey producers during the period. Commentators believed demand was increasing and between 1909 and 1926 imports of honey rose by approximately 137% and domestic output

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[6] W. B. Little, 'Action of bees in pollination', *The Journal of the Board of Agriculture* (1911), XVII, pp. 974-977; 'Bees in relation to gardening', *The Gardeners' Magazine* (1910), LIII, (2934), p.75; 'From a fruit growers diary. The importance of bees', *Commercial Horticulture* (1929), 1, (15), p. 268; 'Spraying of fruit trees with arsenate of lead', *The Kent Farmers' Journal* (1926), 19, (4), p. 130.

[7] H. Mace, *Bee Farming in Britain*, Harlow: Beekeeping Annual Office, 1936, p. 75; T. W. Cowan, *British Bee-Keeper's Association Jubilee. History of the Association Representing Fifty Years of Bee-Keeping Progress*, London: British Bee-keepers Association, 1923, p. 127.

[8] Note by R. Wellington, 9th October 1919 entitled Foul brood and other bee diseases. Reports as to legislation, MAF 43/1, NA; Cowan, op. cit. (7), pp. 17-19, p. 126. BAF supplied 1647 full colonies and 2720 queens.

had increased.[9] My estimate of output in 1925 for England and Wales only, using various MAF figures, is 531.25 tons and it is likely I have underestimated production figures. Contemporary estimates of output in the UK in 1928 and 1935, based partly on existing official data, were 1000 tons and 8,500 tons respectively.[10]

9.2 Educational Support

The DC grant to the BBA, founded in 1874, enabled its experts to visit scientific apiaries in France. Part of this grant helped the Association to set up an experimental and educational apiary in the gardens of the Zoological Society of London at Regents Park. This approach was new to Britain. Showcases were, 'fully equipped with every modern appliance and dissectible models' and free lectures and demonstrations were organised for members and the general public at the apiary during winter and at other parts of the country in the summer.

In 1916 a better site was obtained at Golders Green. Here, educational courses were so well attended that extra tuition was organised and a paper on bee disease research, conducted at Aberdeen University, was distributed as beekeepers had shown, 'much interest' in the work.[11]

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[9] Imperial Economic Committee, *Report of the Imperial Economic Committee on Marketing and Preparing for Market of Foodstuffs Produced within the Empire. Seventh Report, Honey*, London: HMSO, 1928.

[10] *Seventh Report of the Imperial Economic Committee on Marketing and Preparing for Market of Foodstuffs Produced Within the Empire: Honey*, London: HMSO, 1928, p. 70; R. O. B. Manley, 'What is our production and how is it absorbed?', *The Bee World* (1935), XVI, (1), pp. 4-6. The numbers of beekeepers in the different regions in the UK were not known and there is much variation in estimates of the annual yield of an individual hive. Officials believed UK honey had a reputation for quality.

[11] *Fourteenth Report of the Development Commissioners for the year ended the 31st March, 1924*, London: HMSO, 1924, p. 61, D3/14, NA; Cowan, op. cit. (7), p. 123.

In 1920 BAF appointed the Secretary of the Association, W. Herrod Hempsall, to be technical adviser on beekeeping to its Horticultural Division. Herrod Hempsall set up for BAF and later for MAF a programme of lectures, instruction and demonstrations for local and central government horticultural instructors and inspectors so that they could advise apiarists effectively.[12] MAF established a Bee Library based on the collection of apiarist T. W. Cowan (1,800 volumes in 1928) that government advisers could use to assist them answer enquiries from beekeepers in England and Wales.[13] Although the number of beekeepers seems to have decreased in these two regions between 1925 and 1929, bee colonies had increased from 70,000 to 100,000.[14]

Twenty seven County Councils in England and Wales, supported by BAF, organised visits from experts, set up popular lectures given as one offs or in a series and provided a specially equipped touring bee van to give demonstrations. The average attendance for single lectures in 24 centres was 80 and 200 for lectures and demonstrations at 30 centres.[15]

Local and central educational support was received favourably by apiarists, in some cases enthusiastically. Some, whilst welcoming this educational support, believed the BAF and MAF could have done more to ensure legislation was passed to prevent the spread of bee diseases.

[12] Cowan, op. cit. (7), p. 126, p. 419. Commercial growers were also invited to attend.
[13] *Report of the work of the Research and Education Division for the year 1926-27*, London: HMSO, 1928, p. 75.
[14] *Report on the work of the Research and Education Division for the year 1929-30*, London: HMSO, 1931, p. 47.
[15] 'Instructions in bee-keeping provided by County Councils in England and Wales during the year, 1907-08', MAF 43/1, NA.

9.3 Isle of Wight Bee Disease

In 1904 the Isle of Wight bee disease made its first appearance in the UK on the Isle of Wight, near the Hampshire coast. It was regarded as a new disease, not previously recorded in the UK or in other countries and developed quickly into an epidemic and persisted in virulent form.[16] In 1911 T. H. Middleton of the BAF thought the disease was so serious that, 'it may destroy all the bees in the country as it has done in the Isle of Wight'.[17] The part played by the government to introduce legislation to control outbreaks and create bee research stations to investigate disease and management methods is discussed in the following sections.

9.3.1 Background

The Board of Agriculture, the BAF and the BBA had liaised since 1895 over the control of foulbrood disease and sought the advice of scientists about its cause and treatment.[18] The BBA wanted a bill introduced for the protection of bees and the BAF suggested a private members bill and encouraged the Association to carry out all of the lobbying to ensure success. The BBA was unsuccessful as it failed to get the support of MPs and acrimoniously blamed the Board for lack of action, whereas BAF thought the BBA were lackluster in their effort and believed the extent of the disease had been exaggerated.[19]

When Isle of Wight bee disease became epidemic, BAF drew on its experience

[16] The disease attacked adult bees and left them paralysed.

[17] Long note by T. H. Middleton, 8th July 1911 in the file 'Bee Disease. Investigations into characteristics and causes', MAF 43/1, NA.

[18] This decimated bee colonies as the larva in cells were killed.

[19] 'Foul Brood Legislation' in the file headed 'Foulbrood and other diseases of bees. Reports as to legislation', MAF 43/1, NA; Cowan, op. cit. (7), p. 77.

of foulbrood disease and organised as consultants A. D. Imms and later G. Smith of Cambridge University.[20] There was little agreement about the cause and Smith and his co-worker W. Malden eschewed sea fogs, poisoning from artificial manures or certain types of plant, insecticide sprays, starvation and blood poisoning from accumulated toxins whilst some non-scientists blamed weedkiller sprays and infected imported foreign queens.[21]

Interestingly, there are some similarities with the causes suggested for human and animal diseases in earlier periods by those regarded as non experts and the views of non-scientists about the Isle of Wight bee disease and foulbrood and the treatment recommended by scientists in earlier periods with the treatment advocated by experts for the Isle of Wight disease. The editor of the *British Bee Journal* wrote in 1907 that foulbrood, 'to the bee expert is as terror inspiring as anthrax to the cattle man'.[22] Public health arguments were being projected onto bees. Suggested causes, common to humans, animals and insects, were the condition of the air, uncleanliness and foreigners importing disease whilst common treatments were isolation and the use of fire, particularly disinfection by charring and burning the dead.[23] Imms, Smith, Malden and

[20] 'Bee disease in the Isle of Wight Report', 7th November 1908, MAF 43/1, NA.
[21] G. S. Graham Smith and W. Malden, 'Interim Report. Bee disease in the Isle of Wight', undated in MAF 43/1, NA; Letter from Tickner Edwardes a), 'Isle of Wight bee disease', *Evening Standard*, 2nd May 1907, MAF 43/1, NA; T. Edwardes b), 'The Honey-bee and Her Troubles', *British Beekeepers Journal*, 2nd May 1907, MAF 43/1, NA.
[22] 'Editorial notices', *British Bee Journal*, June 6th 1907, pp. 221-223, MAF 43/1, NA.
[23] Fabian Hurst, op. cit. (4), p.119; Busvine, op. cit. (4), p. 7, p. 76, p. 129; Wilkinson, op. cit. (4), p. 39, p. 40, p. 47, pp. 52-53; Watts, op. cit. (4), p. xi; P. Slack, 'Introduction' in T. Ranger and P. Slack (eds.), *Epidemics and Ideas. Essays on the Historical Perceptions of Pestilence*, Cambridge: Cambridge University Press, 1999, p. 3; R. J. Evans, 'Epidemics and Revolutions: Cholera in Nineteenth-century Europe' in T. Ranger and P. Slack (eds.), *Epidemics and Ideas. Essays on the Historical Perceptions of Pestilence*, Cambridge: Cambridge University Press, 1999, p. 171; Chandavarkar, op. cit. (4), pp. 203-240; Edwardes b), op. cit. (21); A. D. Imms, 'The Isle of Wight Bee Disease', *Journal of the Royal Agricultural Society of England* (1914), 75, pp. 62-70; Board of Agriculture and Fisheries, *Foul Brood or Bee Pest*, Leaflet Number 32, London:

others by 1913, after extensive research encompassing bacteriological study and microscopic examination, were arguing that the cause was a microscopic organism (*Noma apis*), 'allied to bubonic plague', and this became for a time an accepted view.[24]

9.3.2 Legislation

Two unsuccessful attempts were made to secure legislative protection for apiarists. The Council of the BBA in 1909 began lobbying the government to modify the 1907 Destructive Insects and Pests Act by incorporating protection against bee disease. The Association wanted the appointment of inspectors skilled in the recognition of bee disease, the compulsory destruction of infected hives, fines for miscreants and the award of compensation to apiarists whose hives had to be destroyed by inspectors. But T. H. Middleton, Assistant Secretary to the BAF, thought that until the cause of the diseases was finally established the compulsory destruction of infected hives was not justified.[25] The Bill was given its first reading in 1912 but was it was talked out, notably by the Conservative MP Charles Bathurst.[26]

Prior to the Bill, the state had been criticised for inactivity over the disease in 1911 by *Country Life*, *The Daily Mail*, and the *Fruit, Flowers and Vegetable Trades Journal*, which drew comparisons with proactive European and empire

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HMSO, 1908, p. 4; *Abstract of the Proceedings of the Zoological Society of London* (1911), 94, pp. 21-24. Cornwall Agricultural Executive Committee issued a poster appealing to Cornish beekeepers to destroy dirty hives.

[24] 'Bee disease in the Isle of Wight Report', op. cit. (20); Imms, op. cit. (23); G. S. Smith, 'Further Report of the Isle of Wight bee disease', *Supplement to the Journal of the Board of Agriculture* (1913), XX, (4), pp. 1-44.

[25] Memorandum note, T. H. Middleton, 11th April 1911, MAF 43/1, NA.

[26] 'Bee disease', A. D. Hall, 13th October 1919, MAF 43/1, NA; Cowan, op. cit. (7), p. 110, p. 116.

governments and the US Senate.[27] The BAF behaved in a cautious and professional manner, restricted somewhat by the time its bureaucrats took to reach decisions, and it was in a dilemma. By 1911 there were doubts raised internally about the findings of its own scientific consultants as to the cause of the epidemic. T. H. Middleton believed, 'there may be a pest carrier in the case of bees which has not yet been discovered'.[28] Middleton was influential within BAF but the government wanted to be seen to support the British Beekeepers Association yet it was accountable to the Treasury and so followed its traditional, measured and consultative approach. These doubts most likely reduced the commitment of the government towards legislation and because outbreaks of the disease in 1912 were very much fewer than those in 1911, 'the feeling in favour of the Bill has therefore diminished'.[29]

In 1919 the BBA again lobbied the government to introduce bee legislation. Despite the careful work of BAF to introduce a Bill in 1920 it was unsuccessful and J. C. Bee Mason writing in 1922 in the *Beekeepers Gazette* probably summed up the opinions of some of those who were discontented with the government by accusing, 'the new army of paid officials' of being 'ill informed and misled' by scientists who 'know little'.[30]

This was not quite the case as the influential A. D. Hall believed there was a

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[27] 'Bee malady losses. Appeal to the government for aid and legislation', *Daily Mail*, 8th April 1911, MAF 43/1, NA; 'Agriculture at Cambridge', *Country Life*, 26th August 1911, MAF 43/1, NA; 'The bee disease', *Fruit Flower and Vegetable Trades Journa*l, 27th May 1911, MAF 43/1, NA.

[28] Long note by T. H. Middleton, op. cit. (17); Memorandum note by T. H. Middleton, 11th April 1911, MAF 43/1, NA. Imms, Smith and Malden believed a microscopic, spore-generating organism originated the Isle of Wight bee disease whereas Middleton thought an insect or mite was the cause. Smith and co-workers carried out research using a greenhouse in which experimental hives were located.

[29] 'Bee Disease Bill,' comment by unknown civil servant made on 6th May 1913, MAF 43/1, NA.

[30] J. C. Bee Mason, 'The menace of legislation', *Beekeepers Gazette*, February 1921, MAF 43/1, NA.

strong argument for legislation and the Bee Diseases Bill had been progressing carefully and purposefully under MAF's direction. Because the Parliamentary session was full there were doubts whether it would be given space and ultimately it was not successful, its failure being blamed on the government's economy drive.[31]

Before the legislation campaign, BAF and MAF had started to change its strategy towards the promotion of the bee industry through the protection of bees and the focus was moving from legislation to a more structured programme of research to examine the cause of disease and the development of scientific methods of beekeeping. The work of J. Rennie, head of the bee research station set up in 1914 at Aberdeen University with DC funds, gave an impetus to this re-focussing. Additionally, Rennie by 1919 had revealed that his team believed the Isle of Wight bee disease was caused by a mite (*Tarsonemus woodi)*. For a time Rennie's results were accepted by the government and they provided strong support for the horticultural staff who had been pushing the idea that a sustained programme of research was needed to find preventative and curative measures.[32]

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[31] Note by A. D. Hall, 20th October 1919, MAF 43/1, NA; Note by Captain Whyte, 1st December 1920, MAF 43/1, NA; Cowan, op. cit. (7), p. 127.

[32] Note by Herrod Hempsall, 3rd November 1920, MAF 33/64, NA; J. Rennie, P. Bruce White and E. J. Harvey, 'The Etiology of the Disease', *Transactions of the Royal Society of Edinburgh* (1921), 52, (4), pp. 737-754; P. Bruce White, 'The Pathology of the Isle of Wight Disease in Hive Bees' *Transactions of the Royal Society of Edinburgh* (1921), 52, (4), pp. 755-764; E. J. Harvey, 'Isle of Wight Disease in Hive Bees - Experiments on Infection with *Tarsonemus woodi, n. sp*', *Transactions of the Royal Society of Edinburgh* (1921), 52, (4), pp.765-767; J. Rennie, 'Isle of Wight Disease in Hive Bees - Acarine Disease: The Organism associated with the Disease - *Tarsonemus woodi*, *n. sp*', *Transactions of the Royal Society of Edinburgh* (1921), 52, (4), pp. 768-779. Rennie ran a small, effective team and showed that brood sealed in cells were not affected by the mite and this necessitated a different approach to current hive destruction. Experiments to produce immune 'varieties' of bee were conducted on the Isle of Lewis.

9.4 Bee Research Stations

To the BAF, MAF and Hall, the Aberdeen University bee station demonstrated effective research could be conducted by a small but highly efficient and cooperative team: teamwork was one of the elements of Hall's national research system. It was expected that the new bee research stations at the Universities of Cambridge and Oxford, both established in 1918, would liaise with each other and with the Aberdeen Station regularly over research matters. This, it was believed, would maximise efficiency by avoiding unnecessary duplication and so better serve apiarists. Later, another station was founded at Rothamsted.

At Cambridge University Bee Research Station the life history of healthy bees and practical beekeeping techniques was studied because it was felt the beekeepers 'expert opinion was divided' on these issues whilst the Oxford Research Station concentrated on the Isle of Wight bee disease.[33] The Cambridge researchers produced data on the effects of weather on overwintering bees, winter weight loss of the hive and temperature distribution, the comparative values of sugar and candy as a feed and the drifting of bees within and outside of the hive. This work gave others examining the problem of disease useful contextual information. Consultation visits were made to apiarists, when requested, to provide advice about hive management problems.[34]

At Oxford there was a crisis of confidence. An inspection of the work by Herrod

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[33] Letter from A. D. Hall to the Treasury, 22 April 1918, MAF 33/64, NA. A Joint Bee Committee was formed to oversee the research and consisted of representatives from MAF, the bee industry and the Oxford and Cambridge Stations.

[34] Bee Institute. 3rd Meeting of the Management Committee on 20th February 1920, MAF 33/64, NA.

Hempsall, MAFs technical advisor on bees, revealed the research after nearly two years was not proceeding as expected. Research Director Dr Helen Goodrich had not liaised with Cambridge and only fitfully with Aberdeen, was not keeping apiaries of diseased bees for investigation, had produced a single paper only which merely repeated known information and was seeking a bacteriologist at a salary higher than her own to undertake work that was really her responsibility. Hempsall recommended the transfer of all of the research to Cambridge and concluded in 1919, 'My impression is that very little, if any, good is being done towards elucidating the causal agent of Isle of Wight bee disease'.[35] A. D. Hall fully supported these findings but the Oxford Station was allowed to continue for a short period until termination.

The promising start at the Cambridge Station rapidly deteriorated and in 1923 its bee research work was taken over by Rothamsted and bees and appliances were transferred. MAF were not satisfied with the supervision of the research and believed the Entomology Department at Rothamsted had the staff that could carry out the work skillfully.[36] It is possible the research was regarded as being insufficiently challenging intellectually and academically. At Rothamsted further apiaries were established, staff went on fact finding visits to Canada and the United States to study bee research, experiments were carried out on metal frames (combs) and their location in the hive and comparisons were made with sugar feed derived from cane and beet.[37]

In 1930 there were two bee research stations. The station at Aberdeen

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[35] Visit to Oxford, 28th November 1919, MAF 33/64, NA; Typed details on a minute sheet by Herrod Hempsall, 24th September 1920, MAF 33/64, NA.

[36] *Thirteenth Report of the Development Commissioners*, op. cit. (5), p. 30.

[37] *Fourteenth Report of the Development Commissioners*, op. cit. (11), p. 61; *Fifteenth Report of the Development Commissioners* for *the year ended 31st March, 1925*, London: HMSO, 1925, p. 34, D3/15, NA; *Seventeenth Report of the Development Commissioners* for the year ended 31st March, 1927, London: HMSO, 1927, pp. 26-27, D3/17, NA.

continued its work on the mite causing Isle of Wight bee disease epidemics. Rothamsted carried out experiments covering practical beekeeping and in 1929 was allowed to start research on disease. It was beginning to be realised there were a number of different but related bee diseases, all requiring full identification and different treatments.[38]

Summary

Beekeeping was regarded as an aspect of horticulture by the BAF and MAF. Between 1910 and 1930 the number of hives and output of honey increased and this growing branch of the working world of horticulture was promoted and supported by the government The main support strategies of the government were the provision of advice and education, the introduction of legislation to protect hives and the creation of bee research stations. The government were keen to involve the BBA in these initiatives and the emphasis placed on carrying out investigations at research stations to solve theoretical and practical problems, communicating findings, sharing ideas and using legislative 'persuasion' were characteristics of the system of horticultural and agricultural science education and research developed by A. D. Hall.

9.5 Conclusion

I have show how the government viewed one type of insect, the bee, benevolently, and how in the period 1910-1930 the state acted as patron of apicultural science - an aspect of horticulture - by funding education initiatives,

[38] *Nineteenth Report of the Development Commissioners, being the Report for the year ending the 31st March 1929*, London: HMSO, 1929, p. 36, D3/19, NA.

disease research, bee research stations and promoting bee disease legislation. This supports one of my main arguments that horticulture and horticultural science research embraced a diverse range of activities.

The efforts by the government to introduce protective legislation for apiarists was less successful than the work carried out to protect beekeepers by the Department of Agriculture and Technical Instruction for Ireland that introduced the Bee Pest Prevention (Ireland) Act of 1908, empowering county councils to employ inspectors, destroy infected stocks and compensate apiarists.[39] The reasons for the performance of the British government are unclear. Possibly, it did not want to act until scientific research had shown conclusively the cause of the Isle of Wight bee disease, it may have relied too much on the BBA to carry out investigatory and publicity work and the BBA, a group with members holding a range of opinions towards legislation, may have depended too much on the government to carry out the necessary preparatory work. It is likely that economic considerations were important as the BAF were concerned about the costs involved in appointing bee inspectors for all of the counties if a Parliamentary act had been passed.[40] Further investigation here would help establish how far the government was prepared to use science to steer policy and would be a starting point to compare attitudes and approaches towards horticultural science, and other sciences, held by governments in England, Scotland and Ireland in the period 1910-1930.

[39] Ebert, op. cit. (2), pp. 203-204.

[40] Memorandum on Destructive Insects and Pests Acts, T. H. Middleton, 29th January 1913, MAF 43/3, NA.

Chapter 10

Conclusion

10.1 Introduction

This thesis has examined the development of horticultural science, horticultural education and horticulture in the period 1910-1930. I have shown that horticulture was more than the cultivation of plants: it also involved the rearing of bees, poultry, pigeons, hares, goats and pigs. I argued that the subject matter of horticultural science was extremely diverse and discussed how it was shaped by the state, private institutions and societies, politicians, scientists, the commercial sector and economic, social and political events. I considered the influence of horticultural science on commercial growers, allotment holders and consumers of fruit and vegetables. A unifying force was the state system of horticultural research and education that was created between 1909-1910.
The history of horticultural science in the United Kingdom has not attracted a great deal of attention from either historians of science or historians of agriculture and a comprehensive account of its development in the UK has yet to be compiled.[1] Bowler and Pickstone in their introduction to *The Cambridge History of Science, Volume 6* acknowledge they were, ‘Particularly conscious that agriculture and related sciences are barely present’, although their label ‘related sciences’ tends to mask rather than identify the presence of horticultural science.[2] In making an inroad into this area of history of science, I

[1] Historians of science in the United States, in comparison, have written more extensively about horticultural science.
[2] P. J. Bowler and J. V. Pickstone, ‘Introduction’ in P. J. Bowler and J. V. Pickstone (eds.), *The Cambridge History of Science. Volume 6. The Modern Biological and Earth Sciences*, Cambridge: Cambridge University Press, 2009, p. 1.

have offered an original contribution to historical knowledge and in discussing the involvement of commercial growers and the state in horticultural science, I presented a new addition to the history of the life sciences, including an analysis of the Horticultural Branch, later becoming a Division, of the Board of Agriculture and Fisheries (BAF).

Commentators on agriculture and botany have given little recognition to the work carried out by horticultural scientists and often matters horticultural have been subsumed within botany or agriculture. Generally, horticultural science has not been on the historian’s radar. For example, some writers commenting on agricultural research stations have either ignored the existence of horticultural research stations or regarded them as agricultural stations, others writing about botanic gardens have discussed work on plant classification and acclimatization but have not identified explicitly the nature of horticultural science research. When historians of science have addressed horticultural experimentation and investigation they have emphasised breeding, genetics, classification and nomenclature mostly, leaving aside a significant range of other horticultural science research topics important to contemporaries, for example, pest, disease and weed control; the correlation of weather conditions with outbreaks of pests and diseases; the efficacy of manures and artificial fertilisers; the use of radioactive ores, electricity and carbon dioxide as growth stimulants; root and shoot physiology; crop storage in controlled atmospheres; harvest date predictions; poultry nutrition; the relationship between soil conditions and plant nutrition; the composition of soils and their microorganism populations; seed longevity and storage; the development of optimum glasshouse environments and apiary management techniques.

I have described how the brief of a number of agricultural research stations was wider than just agricultural concerns. Some carried out agricultural work that had relevance to horticulture or conducted horticultural science investigations. Rothamsted is a case in mind: historians have tended to regard it as an agricultural research station but its investigators also conducted horticultural science experiments and I suggest a revision of the role played by Rothamsted and other agricultural research stations in the promotion of horticultural and agricultural science.[3]

I have presented three main overlapping arguments in discussing the development of horticultural science in the period 1910-1930: firstly, that horticultural science was characterised by significant diversity, and secondly, that its development was shaped, in part, by the outcomes of tensions caused by disputes between those involved in the creation of the state system of horticultural research and education - this was associated with endeavours to gain status for the subject and its practitioners - and thirdly, that influential movers and shakers in the plant sciences shaped horticultural science through their efforts to ensure fundamental science underpinned research and that the results were utilised by those carrying out applied science experiments.

Many of the chapters discussed what contemporaries regarded as horticultural experiment and investigation. Parolini in a significant commentary on

[3] M. D. Glyne and H. V. Garner, 'Research at Rothamsted of Importance to Horticulture' in R. T. Pearl (ed.), *Scientific Horticulture. The Journal of the Horticultural Education Association*, (1935), Volume III, pp. 215-221; Sir E. J. Russell a), *A History of Agricultural Science In Great Britain 1620-1954*, London, George Allen and Unwin Limited, 1966, pp. 143-175, pp. 289-332; L. Lowden, 'Science in Crop Production', in G. W. Cooke (ed.), *Agricultural Research 1931-1981. A History of the Agricultural Research Council and a Review of Developments in Agricultural Science During the Last Fifty Years*, London: Agricultural Research Council, 1981, pp. 140-159; G. Parolini a), *"Making sense of figures": Statistics, Computing and Information Technologies in Agriculture and Biology in Britain, 1920s-1960s*, University of Bologna, PhD thesis, 2013, pp. 40-93.

agricultural experiment has stressed the importance of investigating purpose, practitioners and place and has considered experiments in horticulture and suggested they were located mainly on plots, of long-term duration, used perennial plants and investigated, 'growth, output quality, and productivity of fruit trees or shrubs'.[4] In contrast, I have shown there was a great variety of horticultural experimentation, often of a short-term nature, and a range of methods were used, for example, horticultural seed firms favoured yearly field trials. Experiments covered bees, poultry, annual flowers and vegetables as well as perennials. As I have stated, this work involved the investigation of the effects of climate on pests and diseases, the efficacy of pesticides and fungicides, the use of biological controls of pests, the origin of bee disease epidemics, the development of dietary regimes to increase egg laying capacity of poultry and the post-harvest storage of fruit and vegetables in controlled atmospheres. The Low Temperature Research Station at Cambridge (LTRS) and the Ditton Laboratory at East Malling Research Station and those in other countries were sites of horticultural experiment and some of the work conducted could not possibly have taken place on plots. I have considered just a fraction of this diversity and have acknowledged the contributions of just a small number of horticultural scientists.

Joan Thirsk has argued a horticultural revolution occurred in England between 1880 and 1940 and cites as evidence the development of new management techniques, the marked expansion in the scale of production, the notable increase in capital investment and the emergence of different methods of

[4] G. Parolini b), 'Charting the History of Agricultural Experiments', *History and Philosophy of the Life Sciences* (2015), 37, (3), pp. 231-241.

production, although she does not consider the role played by science.[5] In this thesis I have indicated that in the early twentieth century science played a substantive role in horticultural change. Research stations generated products and techniques were adopted by the commercial sector. I do not claim, like Thirsk, that the period witnessed a horticultural revolution: the term is emotive, is open to a wide range of interpretations and the events do not seem to merit the label 'revolutionary'. But, I adapt Thirsk's idea and claim instead that these years were characterised by a horticultural transformation, a transformation brought about in part by the influence of scientific research undertaken by the Horticultural Division of BAF, research stations, colleges, farm institutes and the commercial sector. The development of glasshouse science at Cheshunt and the production there and at other research stations of plants and materials for the use of commercial and domestic horticulturalists and the networks of horticultural science communication that developed between the state, research stations, universities, colleges, farm institutes and the working world of horticulture are examples of some of the influences that determined this transformation.

10.2 Summary

I showed horticultural science consisted of a range of subject areas, explained it underpinned horticultural courses offered by universities, colleges, farm institutes and the Royal Horticultural Society and illustrated how it gained academic status long before it stopped being viewed as an adjunct of agricultural science.

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[5] J. Thirsk, *Alternative Agriculture. A History from the Black Death to the Present Day*, Oxford; Oxford University Press, 2006, pp. 161-188.

The private sector was an important source of funding for horticultural science research between 1800-1890. Chapter 2 has explained how the commercial sector and independent scientific, agricultural and horticultural institutions supported and initiated investigations and how after 1890 the state became increasingly involved in horticultural science, in part because of the availability of 'whisky money' used to finance technical education in horticulture and other subjects. Chapters 3, 4, 5, 6, 8 and 9 provided a commentary about this involvement.

I argued in Chapters 2 and 4 that the scope of horticultural investigation was extended firstly, by the rise in the middle of the nineteenth century of laboratory science in both chemistry and plant physiology and secondly, by the search for mineral and other substances that could be used to make nitrogen, phosphate and potash fertilisers for the horticultural and agricultural industries of Europe, the United States and Canada that supplied an expanding population. There was an increasing dependence on these fertilisers, initially prompted by the growing use of the manure guano and later spurred by the belief that supplies of this popular product could run out.[6] These changes contributed to the shift that occurred in perceptions of scientific investigations in horticulture – from 'scientific gardening' in the 1820s to 'horticultural science' in 1850.

In Chapters 3 and 6 I discussed how Government funding for and support of horticultural science after 1905 led to internecine disputes between the BAF

[6] J. B. Morrell, 'The Chemist Breeders: The Research Schools of Liebig and Thomas Thompson', *Ambix* (1972), 19, (1), pp. 1-46; G. J. Leigh, *The World's Greatest Fix. A History of Nitrogen and Agriculture*, Oxford: Oxford University Press, 2004, pp. 78-120; K. R. Benson, 'Field Surveys and Stations' in Bowler and Pickstone, op. cit. (2), pp. 76-89; Harwood, 'Universities' in Bowler and Pickstone, op. cit. (2), pp. 143-175; E. Cittadino, 'Botany' in Bowler and Pickstone, op. cit. (2), pp. 225-242; D. Cordell, Jan Olof Drangert and S. White, 'The Story of Phosphorous: Global Food Security and Food For Thought', *Global Environmental Change* (2009), 19, (2), pp. 292-305; G. T. Cushman, *Guano and the Opening of the Pacific World. A Global Ecological History*, Cambridge: Cambridge University Press, 2014, pp. 28-102.

and the Board of Education (BOE) and the BAF and the Development Commission (DC) for the control and supervision of horticultural education and research. One outcome was the strengthening of BAF's role in horticultural science, particularly with the creation of its Horticultural Branch, and it was given strategic control of farm institutes and maintained its supervision of college and university horticultural education. Its freedom to be innovative was limited, as it had to follow policies set by the DC and performed an administrative role for the Commission by assisting in the allocation of the Development Fund (DF). The BAF set up a system of pest and disease monitoring, control and research for England and Wales and influenced the syllabus content of the new National Diploma of Horticulture. The DC had relatively more freedom to direct the nature of the investigations at research stations as it could award or withhold funds and was keen to support a wide range of horticultural science research.

The scope of horticultural investigation widened when the BAF and DC included beekeeping, poultry rearing and raising small animals as horticultural activities. Chapter 5 outlined state patronage of poultry science and Chapter 9 indicated the government's involvement in apicultural science.

Chapters 3, 4 and 7 detailed how state funded research stations supported the working world of horticulture and how privately funded societies and institutions and the commercial sector financed horticultural research. Examples of how various nurserymen, fruit growers and seed houses inaugurated investigatory work were provided in Chapter 7 and I argued that these entrepreneurs, such as M. H. F. Sutton of Sutton and Sons, often worked in conjunction with research stations and colleges and consulted with scientists. Suttons trialed products developed by research stations, produced new varieties of fruit, flowers and vegetables, experimented on growth stimulants, researched lawn grasses and offered certified courses in lawn management and built up a network of communication with scientists. I emphasised that research by innovative members of the commercial trade, along with research station experiments, shaped horticultural science by defining and legitimising subject matter and procedures. I gave examples of this commitment and enthusiasm and explained that receptive growers attended talks, lectures and guided tours offered by research station staff, received personal visits from station scientists and utilised plants and cultural products developed by the stations; an affirmation of the value of research station science.

Chapter 8 explained how government consumer-oriented policies led to state funded research stations developing improved varieties of vegetables, and fruit tree rootstocks, compost activators, insecticides and fungicides that were offered in seed catalogues, initially aimed at growers but later targeted at allotment holders and domestic gardeners. I suggested consumer-oriented policies assisted allotmenteers to manage pest and disease control and raised their awareness of research station techniques and products. BAF Inspectors checked regularly allotment plots for pests and diseases, staff from colleges and universities receiving DC funds made personal visits to give advice, instruction classes covering basic horticultural science were offered during the First World War and farm institutes funnelled research station science into demonstration allotments.

I also linked these policies with patterns of food consumption and discussed how the LTRS helped ensure apples and bananas supplies were more regular and how the Fruit and Vegetable Preservation Research Station contributed to the popularisation of canned fruit and vegetables. Advice by LTRS researchers about improving cultivation techniques to ensure longer storage life of crops and MAF (Ministry of Agriculture and Fisheries) packing and grading initiatives supported this applied science.[7] Chapter 9 showed how government consumer-oriented policies addressed the needs of beekeepers. By funding bee disease control and research into improved management and by providing educational facilities for beekeepers, the government shaped apicultural science.

10. 3 Themes

The theme of Chapter 2 was the support given to horticultural science research by private institutions and societies, independent individuals and the commercial sector. I continued this theme in Chapters 3, 4 and 7, examining the role of the commercial sector in more detail in Chapter 7 and indicating how a number of growers and seed firms were significant patrons of horticultural science. The commercial sector, like the stations, shaped horticultural science by establishing legitimate fields of enquiry and appropriate methods of conducting experiments and investigations.

A second theme the patronage of horticultural science by the state, was begun at the end of Chapter 2 and developed further in Chapters 3, 4 and 5. Chapter 3 provided a discussion of the influence of the DC and a general survey of state supported research stations and 4 case studies were used in Chapter 4 to illustrate in greater detail the range of research work that was carried out with the support of state funds. Chapter 5 discussed the establishment of a

[7] The MAF did a great deal of research to establish a voluntary system of packaging based on containers of guaranteed size, capacity and weight, with an accompanying MAF label of approval. Additionally, MAF developed the 'National Mark' label guaranteeing that produce grown in England or Wales was of a certain quality. See, Ministry of Agriculture and Fisheries, *Economic Series. No. 25. Vegetable Marketing in England and Wales*, London: HMSO, 1935, pp. 90-93.

Department of Horticulture in the BAF and explained how it gave direction to horticultural science. It monitored and managed outbreaks of pests and diseases and conveyed the findings of research station science and its own experiments to commercial growers, allotment holders and domestic gardeners and, along with the DC, helped define the fields of research and recommended which were the best institutions to conduct particular lines of enquiry.

A third theme developed in a number of chapters, particularly Chapters 3 and 4, was the importance placed by A. D. Hall, T. H. Middleton, F. W. Keeble, W. Lobjoit and others on improving the academic status of horticultural science and of those engaged in horticultural science research. They worked consistently to ensure the subject gained academic recognition from the scientific community and wanted horticultural researchers to have the same status as medical doctors and veterinary surgeons. For some protagonists, gaining status was also to do with horticulture and horticultural science being recognised as being quite distinct from agriculture and agricultural science.

I addressed the theme of horticultural science education in Chapters 2, 8 and 9 and developed it more fully in Chapter 6 by explaining how and why the government and A. D. Hall considered education a key component of the system of horticultural science research that they were developing. Education was regarded as the major means of informing the commercial sector, allotment holders and home gardeners of the findings of fundamental and applied science. Because it involved mainly face-to-face contact, it was believed to be more effective than publications. Hall, concerned that his system would falter because of a shortage of personnel, envisaged horticultural education as the means of guaranteeing a supply of future researchers and skilled growers.

I proposed horticulture was a working world, generating problems for horticultural scientists, and also growers, to solve and addressed this theme in Chapters 3, 4, 5 and in more detail in Chapter 8. It is an apposite description of the horticultural industry in the years between 1910 and 1930 and helps identify the influences shaping horticultural science research. The noticeable expansion of the horticultural industry, that was becoming increasingly important to the economy, had created production problems and some, such as soil sickness found in commercial glasshouses and the ravages of high value crops by pests and diseases, threatened profitability. These and other problems were addressed by horticultural and agricultural scientists who carried out investigations in their laboratories, utilised their knowledge of theories generated by pure science research, conducted experiments, trialed the findings on a commercial scale and presented the end product to the commercial sector.

My final theme, consumer-oriented policies, also acted as a reminder that a number of politicians, government administrators and scientists wanted to improve the diet of the population, particularly the poorest members, by providing commercial and domestic growers with the means to produce cheap, wholesome food. I showed in Chapter 8 that research station science contributed to dietary change and influenced the practices used by allotment holders. In chapter nine consumer-oriented policies supported bee keepers to control disease and manage their hives.

As I have explained in Chapter 1, these themes interconnect and I showed in Chapter 2 how nineteenth century patronage of horticultural science research by private institutions and individuals and the commercial sector was instrumental in defining the subject matter of horticultural science. The researchers working for these bodies or acting independently adopted systematic, careful and detailed methods of investigation and this was instrumental in helping horticultural science achieve academic recognition and acquire status.

In the early twentieth century the state became a significant patron of horticultural science. Commercial horticulturalists lobbied the government for support and wanted it to fund scientific research to help overcome production problems. An increasing number of research stations assisting growers, allotment holders and home gardeners were state funded after 1910. These stations developed successful techniques and products that brought to fruition various state consumer-oriented policies and their success contributed to an improvement in the position and standing of those working in horticultural science and helped gain the trust and respect of commercial producers. Some state supported stations generated highly regarded fundamental and applied science research findings that raised the academic standing of horticultural research in the scientific community and secured international reputations.

I showed how the government appointed well-qualified staff and introduced training programmes in order to raise the status of horticultural science and the horticultural scientists and horticultural inspectors in its Horticultural Department. Fundamental science underpinned newly introduced horticultural qualifications and the hierarchical system of research and education involving universities, research stations, colleges and farm institutes introduced after 1910 supported efforts to demarcate horticulture from agriculture and strengthened the claims that horticultural science was an academic discipline.

As I have demonstrated, by 1930 the innovative, comprehensive, vigorous and influential system of horticultural education and research that had been established in England had shaped the subject matter and methodology of horticultural science.

10.4 Alternatives, Limitations and Further Research

I have focused on the state funded system of horticultural science research and education that developed in England only and many of the horticultural research stations were located in the Midlands and the southern counties. Although climate and soils in these regions may have provided favourable growing conditions and the scientific societies and institutions of the capital and Cambridge University offered opportunities to discuss ideas and hear about new developments, these explanations are not fully convincing. Further research will be needed to examine why this was the case and to also move beyond this geographical limitation. Pursuing these lines of enquiry would have made the thesis a bigger project than was anticipated.

The Department of Agriculture and Technical Instruction in Ireland supported initiatives in scientific horticulture and started investigations in seed testing and the use of radioactive material as a growth stimulant some years before the BAF became involved in these areas of enquiry and the Scottish agricultural and horticultural societies and the Board of Agriculture for Scotland were known to have encouraged horticultural investigation. Little is known about horticultural science research that took place in Wales. The horticultural science promoted by institutions in Ireland and Scotland and horticultural investigations carried out in Wales do merit further examination, particularly work that was a direct response to policy and directives issued by central government in London. Members of the commercial sector in England, Wales, Ireland and Scotland fit

Nyhart's group of economically motivated independents that formed 'non-university sites of research'.[8] Except for growers and seed firms based in England, little is known about the contribution of members of the commercial sector located in these other regions or their interaction with scientists. Now that I have indicated how growers in England helped shape horticultural science I could argue that contributions of the commercial sector in these other regions were likely to be as significant. The application of prosopographical methods could provide a more nuanced interpretation of their role, indicating influences affecting their perception of the value of horticultural experimentation and of science generally. For example, their education and training, their membership of networks, the situations that conferred authority on those making influential decisions in these networks, shared norms and values and other factors that affected cohesion in such networks.[9]

The original aim of chapter 8 was to focus on the fruit and vegetables wanted by consumers, examine whether this demand related to the work conducted by research stations and ascertain if home and allotment gardeners were dissatisfied with the research station products developed to assist cultivation. Finding this consumer voice was problematic as primary sources about aspects of consumer food choice were of a 'fugitive' nature – both scattered and fragmentary - and so the focus of the chapter became the consumer-oriented policies of the BAF, MAF and research stations.[10] During the First World War the government attempted in 1917 to listen to the consumer voice and

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[8] L. K. Nyhart, 'Natural History and the "New" Biology' in N. Jardine, J. A. Secord and E. C. Spary (eds.), *Cultures of Natural History*, Cambridge: Cambridge University Press, 1996, pp. 426-443.

[9] The education and social position of seedsmen M. H. F. Sutton and A. J. Bulley seems to have assisted their contact and subsequent correspondence with particular scientists. They also had in common certain views about the utility of horticultural science.

[10] Personal communication, Emeritus Professor P. J. Atkins, 29th May 2015.

representatives from the labour movement and domestic consumers were invited to participate in the administration and supervision of the food supply by becoming members of The Consumers Council of the MAF. Although the concerns here were rationing, profiteering and food prices and did not involve research stations and domestic and allotment gardeners, it does suggest the possibility of discovering more substantive archive material of relevance and the consumer voice as originally intended remains an area of possible investigation.[11]

Not a great deal is known about the nature of the professional and social interactions between horticultural scientists in Britain, Europe, the United States and Empire countries - there was an element of competitive rivalry –and how this affected horticultural science in the UK. The system of cultivation and research in Denmark might have influenced policy makers in Britain and British low temperature storage and soil science gained acclaim internationally, particularly in the USA. A. D. Hall toured research stations in the United States and believed that because researchers had been busy responding to requests for soil, crop and fertiliser analysis and had been heavily influenced by the demands of influential producers they had little time for carrying out fundamental research. Hall was adamant that the USA model was inappropriate for the UK. It is not clear, though, if the US system of horticultural and agricultural education provided Hall with insights.

I have not discussed horticultural science and the empire. The short-lived Empire Marketing Board promoted horticultural science in the late 1920s, staff at government research stations were appointed by this Board to carry out contract work in addition to their other duties and some postgraduates at

[11] Note FHC Mr McCurdy, 5th October 1920, MAF 60/150, NA; L. M. Barnett, *British Food Policy during the First World War*, London: George Allen and Unwin, 1985, p. xviii.

research stations took up posts in the empire. I discussed in chapter 3 the views of government officials towards horticultural science and based these comments partly on internal minutes and memoranda. They indicate empire concerns were rarely offered as a justification for state support for horticultural investigation. Officials recognised that horticultural research would be able to benefit the empire and some work was carried out with this aim in mind, but generally empire considerations do not seem to have been a major driver of horticultural science experimentation at research stations between 1910-1930. I suggest that the interactions between horticultural scientists and commercial growers conducting experiments in England and their counterparts in the empire are worthy of further study. The DC commissioner for forestry, Saint Eardley-Wilmott had been an innovative government forester in India where he had set up a Forest Research Institute and DC forestry policy reflected some of the methods developed and practiced in India. The seed firm Sutton and Sons worked with agents in India and South Africa to acclimatize flowers and vegetables that had been originally raised in England. There was an extensive number of botanical gardens, botanical stations, horticultural gardens and agri-horticultural stations in the empire.[12] Staff at some of these exhibited the same zeal in dealing with enquiries as the scientists at research stations in England and some of the research, but not all, was similar. For example, investigations were undertaken on the following: acclimatization, mulching, jam making, fruit tree rootstocks, soils, pests and diseases and their treatment, weeds, hybridization, fruit ripening, vegetative propagation and tree rejuvenation – it

[12] See, L. H. Brockway, *Science and Colonial Expansion: the Role of the British Royal Botanic Gardens*, New York; London: Academic Press, 1979; D. P. McCracken, *Gardens of Empire: Botanical Institutions of the Victorian British Empire*, London: Leicester University Press, 1997.

seems drought resistance was an exception.[13] Research stations in England welcomed scientists from the empire and they were allowed to stay until their investigations had been completed. Knowledge of the communication resulting from this work and these interactions and the goals and interests that were shared could contribute to enhancing our understanding of how horticultural science was shaped in the UK and in the empire.

Likewise, little attention has been paid in the foregoing chapters to those individuals with private means and no affiliation to government research institutes or commercial concerns. I suggest there were still opportunities in the early twentieth century for 'wealthy amateurs' with glasshouses and large gardens to conduct horticultural science experiments on flowers, fruit and vegetables. Some, possessing the requisite resources, founded research stations of their own.[14] Information about the response of horticultural scientists to these players and their initiatives and the reaction of government research stations to privately funded stations would inform discussions about the development of horticultural science as a discipline and its acquisition of status. Additionally, I have not considered the significance of those research stations

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[13] *Report On The Government Agri-Horticultural Gardens, Lahore for the year 1913-1914*, Lahore: Government Printing, 1914; *Report on the Government Botanical Gardens, Saharanpur for the Year Ending 31ST March 1915*, Allahabad: Government Press, 1915; *Report on the Government Horticultural Gardens, Lucknow, for the Year Ending 31ST March, 1920*, Allahabad: Government Press, 1920; W. Burns, *A Short Report in the Experimental Work in the Ganeshkhind Botanical Garden Kirkee for the Years 1916-1920*, Poona: Government Press, 1921; *Report on the Working and the Administration of the United Provinces Government Gardens for the Year 1923-24*, Allahabad: Government Press, 1924; J. Carruthers, 'Trouble in the Gardens: South African Botanical Politics ca. 1870-1950', *South African Journal of Botany* (2011), 77, (2), pp. 258-267.

[14] For example, Redcliffe Salaman used his own garden to experiment on potatoes during a period when he was not associated with state institutions and C. C. Hurst, nurseryman and geneticist, used his laboratories to breed orchids. Lord Northcliffe, the newspaper magnate, founded a horticultural research station. Bowler and Pickstone have noted the part played by wealthy amateurs in the late nineteenth century.

funded entirely by industrial concerns. The first station was opened in 1929 at Jealott's Hill in Berkshire by Imperial Chemical Industries and these types of institute developed noticeably in the period 1930 to1960, that is to say beyond the time scale of this thesis.

The scope of horticultural science research undertaken by universities, funded by the government or from elsewhere, merits further examination. In the 1920s the Universities of Manchester, Leeds, London, Cambridge and Reading established horticultural departments, or units, that undertook a range of research, supported by DC funding. V. H. Blackman, for example, at Imperial College directed horticultural science experiments that influenced DC policy and the work of several research stations. Little has been written about the nature of much of this work, the concerns, personal aims and ambitions of the scientists involved and the extent of possible cooperation.

One aspect of state sponsored research station science in the early twentieth century is striking – the dedication and enthusiasm exhibited by researchers in communicating their findings to the public. I have shown this involved hosting visits, conducting guided tours, answering numerous postal and telephone queries, making personal visits to growers and delivering talks and lectures to the commercial sector, allotment associations and horticultural societies. It created a great deal of work and was carried out alongside research responsibilities. Some stations welcomed suitably qualified members of the public to come and work in a voluntary capacity on a particular line of enquiry. This contrasts sharply with research institution practices of today. How widespread such practices were in the 1920s and whether this was typical of research stations in other disciplines is not known.

A feature of horticultural science research in England that has received little attention was work that involved ‘scaling down’ of entities under investigation, and ‘scaling up’ of instrumentation. This was an aspect of American science noted by J. Agar – its focus was macromolecules and ultramicroscopes and ultracentrifuges were deployed.[15] In England improved microscopes were used in plant physiology research that informed investigations concerning the storage of vegetable and fruit crops and minute doses of stimulants or ‘catalytic fertilisers’ were applied to horticultural and agricultural crops and was paralleled in the search for substances, later called vitamins, by biochemists and others to incorporate into the diet of poultry, animals and humans. It was believed small doses of ‘catalytic fertilisers’ and vitamins had a beneficial impact disproportionate to their size.[16] Soil analysis focused on the identification and function of a range of minute soil organisms that had only recently been discovered with the aid of improved microscopes and this equipment was utilised in research on plant disorders that led to the recognition of the existence of viruses. It is likely scientists working in these related fields exchanged ideas and results and these possible intersections seem worth investigating.

I regret the history of UK soil science, a hugely important, exciting and complex branch of both horticultural and agricultural science, is so fragmentary. I argued in Chapter 4 the Rothamsted research team, composed of physicists, chemists, mathematicians and biologists, made significant observations about soil structure and microorganisms. The success of investigatory teams depended on members having sufficient breadth of knowledge to design experiments effectively and interpret results competently. The role of physicists and mathematicians in these and other horticultural science investigations has not

[15] J. Agar, *Science in the Twentieth Century and Beyond*, Cambridge: Polity Press, 2012, pp. 229-255.
[16] W. E. Brenchley, *Inorganic Plant Poisons and Stimulants*, Cambridge: Cambridge University Press, 1914, p. 61.

been appreciated fully. Further research is needed to explore both soil research at other research institutions in the UK and the methods of working adopted by their scientists.

By focusing on horticultural science only, I have presented an incomplete history of the scientific work of the DC between 1910-1930. It funded research stations that investigated dairy farming and the production of meat and not a great deal is known about the outcomes of DC funding on fishery experiments. From the evidence I have given of DC support of horticultural science, I can suggest it had a significant influence on research in these other areas. However, until this part of its history has been documented, it is not possible to offer a comparative analysis of its patronage of agricultural, fishery and horticultural science.

An examination of horticultural science in the period 1910-1930 only has been presented and this narrative needs continuing to provide a more complete picture of its history. C. E. Hudson, Head of the Department of Horticulture at Hertfordshire Institute of Agriculture, at the 1931 Annual General Meeting of the Horticultural Education Association argued, ‘just as universities have got chairs of agriculture, it was necessary to have chairs of horticulture’.[17] A few decades later there were more departments, some universities employed two professors, honours degrees were offered and postgraduate courses had expanded.[18] By the 1960s the system of state funded horticultural science, still exhibiting a

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[17] C. E. Hudson, ‘Comment in the after-dinner section’ in *Report of the Annual General Meeting*, Canterbury: Horticultural Education Association, 1931, p. 24, AD2/5 in SR3MS/096, MERL.

[18] Letter from H. A. D. Neville to the Vice Chancellor, 18th August 1943 in the file ‘Committee on post-war developments’, Box 95, MERL; B. Cottle and J. W. Sherborne, *The Life of a University*, Bristol: University of Bristol, 1951, p. 60, p. 89; *University of Reading Calendar Session 1952-53*, Reading: University of Reading, 1952, MERL; B. H. Tolley, *The History of the University of Nottingham*, Volume 1, Nottingham: Nottingham University Press, 2001, p. 126.

number of features created in 1910 by A. D. Hall, may have reached its peak. Research stations specialising in vegetables, raspberries, mushrooms and virus disease had been built and services appreciated by growers continued.[19] For example, the reports of the scientists from the influential seed house of Charles Sharpe of Sleaford who attended regularly open and special days at a number of these institutes in the 1960s indicate the research they observed was regarded as valuable and ideas and details of techniques and apparatus were brought back for discussion.[20] By the 1990s many research establishments had closed or were funded by the commercial sector partly as a result of government policies, particularly the programme of privatization.[21] By 2015 nearly all of the original university departments that had offered horticultural science and undertaken research in the 1920s and 1930s had also closed. Today, a significant focus of horticultural institutions is the science of landscape and amenity horticulture and garden design. The influences shaping these aspects of horticultural science history merit investigation.

10.5 Concluding Comments

I have explained how a range of problems unique to horticulture helped shape the pure and applied research of scientists carrying out horticultural science investigations and illustrated how the range of work conducted helped build up a significant body of science knowledge. Some commercial growers also set up their own experiments in order to overcome production problems. Now that we

[19] A. G. L. Hellyer, *The Amateur Gardening Diary and Horticultural Directory 1953*, London: W. H. and L. Collingridge, 1952, pp. 21-22.
[20] See the reports in the pink coloured cardboard wallet, Box 46 uncatalogued, SHARPE ACC 87/52, LIA.
[21] P. J. Bowler and J. V. Pickstone, 'Introduction', op. cit. (2), p. 10.

know this, I argue horticultural science made a significant contribution to the development of the plant sciences and related sciences. For example, knowledge was gained of the organisms involved in breaking down composted material, the physiological processes that took place when a plant was pruned and when roots developed, the specific action of biological controls used against glasshouse pests, the complex life cycles of fungal pests, the limitations of Mendelian breeding techniques, and the pre-harvest cultivation practices needed to ensure crop longevity in storage. The role played by horticultural science in initiatives that have taken place in agriculture, botany, botanic gardens, medicine, biochemistry and ecology has yet to be acknowledged fully. Additionally, I extend this idea and claim the system of horticultural science that was created in 1910 and supported by the government had a transforming influence that was far reaching. David Lloyd George, Chancellor of the Exchequer, and A. D. Hall set the precedent for substantive state funding of science research among politicians and scientists. The funds allocated initially to the DC were £2½ million for 5 years and a significant amount went to research – for investigations that were not concerned with warfare or threats to national sovereignty - and more it seems than those allocated to the Medical Research Council. The funding for Rothamsted was roughly comparable to those allocated to the National Physical Laboratory (NPL, 1900) between 1910-1918 and both were endeavouring to build up staff numbers and establish a range of investigations. In the 1920s the Treasury treated both comparatively generously, although because the NPL was perceived to be more strategically important for the nation’s industries and for defence, it began to receive a significantly greater allocation of funds.[22]

The belief of Edgerton and Horrocks that research patronised by the government was inadequate compared to in-house investigations conducted by firms seems not to apply to state sponsored horticultural science research.[23] I have looked at research stations established by industry in the period that were independent of the state, such as Jealott's Hill in Berkshire, and their influence on growers at this time was comparatively small – only after the 1930s did the products from research laboratories of firms begin to shape commercial practices. As Chapters 4 and 7 have shown, innovative growers adopted the products and techniques that research stations spent a great deal of time developing.

It has been argued that the creation of the DF, and by implication the DC, was an unprecedented and innovative measure and Olby and Vernon believe this system of research was a model for the MRC and the Department of Scientific and Industrial Research.[24] I support their claims and also claim the Agricultural Research Council of 1931 was guided by a number of the principles established by the DC.[25] The impact of the Commission's system was long lasting and as I

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[22] R. Mosely, 'The Origins and Early Years of the National Physical Laboratory: A Chapter in the Pre-history of British Science Policy', *Minerva* (1978), 16, (2), pp. 222-250.
D. Edgerton, *Science, Technology and the British Industrial 'Decline', 1870-1920*, Cambridge: University of Cambridge, 1996, p. 42.

[23] D. E. H. Edgerton and S. M. Horrocks, 'British Industrial Research and Development Before 1945', *Economic History Review* (1994), XLVII, (2), pp. 213-238.

[24] R. C. Olby, 'Social Imperialism and State Support for Agricultural Science in Edwardian Britain', *Annals of Science* (1991), 48, (6), pp. 509-526; S. Richards, 'The South-Eastern Agricultural College and Public Support for Technical Education, 1894-1914', *The Agricultural History Review* (1988), 36, (3), pp. 172-187; K. Vernon, 'Science for the Farmer? Agricultural Research in Britain, 1850-1914', *Twentieth Century British History* (1997), 8, (3), pp. 310-333.

[25] Vernon, op. cit. (23); Letter from A. D. Hall to B. A. Keen, 16th November 1931, MS ADD 297, UCSC. Hall was consulted about the development of the Council and influenced its structure and aims.

have stated, features were still discernable in the 1960s in the horticultural research stations that had developed after the Second World War.

Moreover, I suggest the DC's organisational methods and strategies may have influenced the Rockefeller Foundation (1913). A. D. Hall, architect of the state system of horticultural and agricultural research, established the necessity of accessing up-to-date equipment, the value of both fundamental and applied research, the need to give to researchers the freedom to explore research hunches, the importance of career structure and post-graduate training and qualifications, the value of interdisciplinary team work, team meetings and conferences and the importance of liaising with scientists at other institutions. He helped run a very tight grant allocation system for the DC that adhered strictly to allocation criteria, yet was encouraging and supportive to applicants. I propose these attitudes, beliefs and ways of working could have provided a model for the Foundation, with its emphasis on interdisciplinary teamwork, grants and fellowships.[26] Karl and Katz writing about research in US private philanthropic organisations, observed the pursuit of fundamental science had European antecedents. In the early 1920s W. Rose the Director of the International Education Board at the Rockefeller Foundation, awarded grants for fundamental research to individuals who were free to decide on the topic of research, a feature of Hall's system.[27]

My thesis has contributed to a broader history of Britain by drawing attention to an economically important industry of the 1920s, commercial horticulture, whose evolution and economic and social importance has not yet been

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[26] For the reference, see: Agar, op. cit. (15), pp. 170-171.

[27] R. Kohler, 'A Policy for the Advancement of Science: The Rockefeller Foundation, 1924-29', *Minerva* (1978), 16, (4), pp. 480-515; D. Karl and S. N. Katz, 'The American Private Philanthropic Foundation and the Public Sphere 1890-1930', *Minerva* (1981), 19, (2), pp. 236-270.

addressed rigorously or comprehensively. Whilst commercial horticulture did not produce the same amount of wealth generated by other industries, in the 1920s and 1930s the production of fruit, vegetables, flowers, poultry and honey offered arable farmers better prospects than dependency on cereals.

This work has relevance to British social history, particularly the studies examining the attitudes of different social class groups towards work and leisure. Charnley noted the commitment of scientists to, 'selfless public service' and Chapters 3 and 4 and the earlier part of this chapter provided details of the dedication and work ethic of horticultural scientists at research stations in the 1920s.[28] These scientists made notable efforts, additional to their research duties, to help growers, allotment holders and gardeners and to demonstrate how science could assist practice. The Director of Rothamsted, E. J. Russell, who was part of this group and also a member of the informal group of left-wing scientists and Radical-Liberal and Fabian politicians described in Chapter 3 as the forerunner of Werskey's 'visible college', was influenced formatively by T. Carlyle's *Past and Present*. Carlyle stressed the 'importance of work' and wrote that, 'work is alone noble' and, 'in idleness alone there is perpetual despair'. Russell believed strongly in the value of hard and purposeful work, enjoyed it and despised idleness.[29] Horticulture was a popular pastime in the early twentieth century and brought its practitioners enjoyment and satisfaction and today it is one of Britain's important leisure activities. In Chapter 8 I illustrated how allotment holders were supported by science and actively sought scientific

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[28] B. Charnley,'Experiments in Empire-building: Mendelian Genetics as a National, Imperial, and Global Agricultural Enterprise', *Studies in History and Philosophy of Science* (2013), 44, (2), pp. 292-300.

[29] T. Carlyle, *Past and Present*, New York: New York University Press, 1965, p. 155, p. 196. The book was first published in 1843 and Carlyle regarded soil as a gift of God. Russell, a religious person, contemplated entering the clergy but instead became a soil scientist; Sir E. J. Russell b), *The Land Called Me. An Autobiography*, London: George Allen and Unwin Limited, 1956, p. 31; Russell a), op. cit. (3), p. 8.

information but little is known about household gardening. Both work ethics and household gardening are aspects of 1920s British life that have not received sustained attention from historians and the attitudes towards work shown by scientists and towards leisure demonstrated by allotmenteers and home gardeners offer possible starting points for a more comprehensive history.

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