Woburn Experimental Farm — A hundred years of Agricultural Research

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The agricultural background

Woburn Experimental Farm owes its existence to the Agricultural Holdings Act (England) 1875 which affected some of the relations between landlord and tenant. The need for this legislation arose gradually during the eighteenth and early nineteenth centuries as progressive tenant farmers sought to improve the productivity of their holdings. Such farmers soon found that increased productivity could only be achieved if money was spent on new and improved buildings, fences, draining, marling and chalking and on the purchase of extra feedingstuffs for their stock and manures for their crops. Tenant farmers were deterred from making such improvements because the existing laws of agricultural tenures gave no security for any capital invested. However, in various parts of the country, notably Lincolnshire, customs had arisen whereby landlords compensated tenants leaving their holdings for the value of any unexhausted improvements.

The value of this custom, often known as the 'custom of the country', was appreciated by Philip Pusey (1799–1855). The Pusey estates extended to about 5000 acres (2025 ha) in Berkshire and Philip Pusey was a founder member in 1838 of the English Agricultural Society which in 1840 became the Royal Agricultural Society of England (RASE). He was President of the Society in 1840–41 and again in 1853–54 and the first Chairman of the Society's Journal Committee and the effective editor of the Journal until 1855. Many of his articles and editorial comments show that Pusey was an advocate of 'Farmers Tenant Right'. He first introduced the term 'tenant right' in the House of Commons in the late 1840s after bills designed to give an agricultural tenant compensation for unexhausted improvements had been introduced without success in the House of Lords in the early 1840s. Pusey saw that, partly as a result of the Napoleonic Wars, there had for long been too little capital invested in agriculture. His remedy was to encourage tenant farmers to invest their money and he saw the Lincolnshire Covenants as a way of financially compensating a tenant for any improvement, the benefit of which could not have been fully realised when he gave up the tenancy. The report of Pusey's Agricultural Customs Committee (1848) formed the basis of subsequent legislation on tenant right, first in the Landlord and Tenant Act of 1851, which gave only a few rights to the tenant, and then in the much more comprehensive Agricultural Holdings Act (England) 1875.

The 1875 Act was preceded by the Irish Land Act of 1870 which awarded compensation to an outgoing tenant for 'tillages, manures and other like farming works, the benefit of which is unexhausted at the time of the tenant quitting his holding'. If landlord and tenant could not agree on the compensation then arbitration was necessary and J. B. Lawes of Rothamsted was called as a scientific witness in one such case. This experience led him to comment that 'the Act is very explicit in all that related to the legal machinery by which claims may be tried or established; but it gives no information as to what constitutes unexhausted value, or how that value is to be estimated'. Pusey's Committee report shows that most local customs awarded compensation based on cost, but as early as 1862 Lawes thought that this had little merit for

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purchased feedingstuffs given to animals.

Lawes and his co-worker Gilbert are now best remembered for their experiments on crops but they also did work on animal feeding at Rothamsted. They showed that only a small proportion of *plant nutrients* (N, P and K) in feedingstuffs were retained in the increased bodyweight of fattening stock or removed from the farm in dairy produce. The excess was in the dung and urine. Lawes and Gilbert estimated the amounts of N, P and K excreted by stock when they consumed a ton of each feedingstuff. The cost of buying these amounts of N, P and K at the current prices of purchased manures was calculated and called the original manure value of the feedingstuff. In 1875 Lawes published his first table of such values which, in some cases, bore little relation to the cost of the feedingstuff. Foods rich in carbohydrate or oil, highly esteemed for feeding to fattening stock, were costly but the dung produced contained little N, P and K. For example, in 1876 the purchase price per ton of linseed cake, decorticated cotton cake and barley meal was £12.50, £10.00 and £9.25 respectively; Lawes calculated their original manure values to be £4.62, £6.50 and £1.10.

Thus Lawes and Gilbert provided experimental evidence for paying compensation for purchased feedingstuffs and showed that this should be on the basis of manure value and not initial cost. In 1875 Lawes also pointed out that deductions should be made from the original manure value not only for losses, especially of N, that occurred in making manure but also for the number of crops grown after its application to the land. He tentatively suggested a 20% decrease for losses and writing off the manurial effect over three years.

The 1875 Act divided improvements which might be undertaken by a tenant into three classes.

Class 1 included drainage of land, erection or enlargement of buildings, laying down permanent pasture, making roads, bridges, fences.
Class 2 included chalking of land, clay burning, claying, liming and marling of land.
Class 3 was (1) application to land of purchased artificial or other purchased manures.
(2) consumption on the holding by cattle, sheep or pigs of cake or other feedingstuff not produced on the holding.

It was suggested that unexhausted values for improvements in class 3 would probably be written off over a period not exceeding two years and would not be payable if applied for a crop of corn, potatoes, hay or seeds or other exhausting crop. The small amounts of purchased artificial manures used at that time were probably applied to exhaustive crops and so were automatically excluded from claims for compensation. The restrictive clause did not appear in the 1883 Act, which repealed all existing Acts, but it is unlikely that this led immediately to a large number of claims. However, as fertiliser use increased, claims became more numerous and in the early years of this century the Central Association of Agricultural and Tenant-Right Valuers asked Voelcker and Hall if they could produce a table of compensation for artificial manures. Voelcker and Hall's table, which was headed 'From such data as are available the following Scale of Compensation may be taken as some guide', was first published in 1913; it included a range of artificial manures, fertilisers and lime.

Thus the 1875 Act gave a tenant the right to compensation but the amount had to be settled by agreement or arbitration. The manurial value of feedingstuffs became a much debated topic, not least within the RASE, because landlords and tenants wished to know if Lawes's

tables could be relied on. Early in 1876 Dr. J. C. A. Voelcker, Consulting Chemist to the RASE (p. 2 1), published a paper supporting Lawes's calculation of manurial values but suggested that the deduction for losses of N should be much nearer 50% rather than Lawes's 20% (Voelcker, 1876).

The RASE and the Duke of Bedford

At an RASE Council Meeting in November 1875, Mr. C. Randell stressed the desirability of settling the matter of manurial values by direct experiments on different soils and under different conditions. The matter was referred to the Chemical Committee of the RASE; they acted with praiseworthy speed. In February 1876 they heard statements from scientific witnesses, Lawes and Voelcker amongst them, and from various 'practical' men, farmers and valuers. The Committee reported to Council in April that there was general support for Lawes's table but they stressed the need for supporting experimental evidence. It was suggested that this might be got by ordinary farmers making experiments during the course of their farm practice but the majority view was that these experiments would not be sufficiently accurate for the results to command confidence. At the same time there were few people with the necessary expertise to make field experiments.

The situation was resolved, as so often, by a compromise. The then Duke of Bedford (Hastings Russell, the 9th Duke), who was a Vice-President of the RASE, was aware of the value of experiments; records show that from as early as 1811 experiments with various manures had been made at Woburn. The Duke offered the RASE possession of a farm on the Woburn Estate and money to pay for experiments if the Society would be responsible for them and for the management of the farm. The offer was accepted, the Chemical Committee, renamed the Chemical and Woburn Committee, was made responsible and Lawes and Voelcker were asked to design suitable experiments.

Crawley Mill Farm, Husborne Crawley, with a granary and brick-kiln ground (now the large lake near the farm buildings) was selected. Letters in Estate archives suggest that the outgoing tenant requested what was considered to be excessive compensation for loss of tenancy and tenant right.

However no single field on the farm was large enough to make the proposed experiment on the manurial value of different feedingstuffs. The Duke therefore arranged to rent Stackyard Field from the tenant of Birchmore Farm. Although a mile from Crawley Mill Farm this was the only suitable field in the district. The original arrangement was for the Duke to pay £2 per acre each year for seven years but the tenant died during this period and the Estate apparantly took the opportunity of adding Stackyard Field to Crawley Mill Farm.

Correspondence in the archives shows that nearly all the preliminary arrangements with the Duke's agent were made by Lawes. The Chemical Committee of the RASE became tenants at will of Crawley Mill Farm and Stackyard Field from Michaelmas 1876 at an agreed rent, paid to the Estate, which was about average for the class of land. The farm then consisted of 90 acres (36 ha) of which 67 acres were arable and 23 grass; Stackyard Field was just over 26 acres (10.5 ha). The acreage was increased again, at Michaelmas 1879, when Warren Field (about 14 acres) was made available for experiments on soluble and insoluble P fertilisers applied to arable crops. The account of this experiment shows that steam tackle was used for the preliminary cultivation of this heavy land. There were no buildings at the farm suitable for animal feeding experiments but during 1876 a building containing eight feeding boxes, each with cemented floor and

rendered walls to prevent seepage, was built at the Duke's expense. In addition a weighbridge was installed. The first feeding experiments were made during the winter of 1876–77. The feeding boxes have only recently been demolished to make way for a potato store.

The accounts show that requests to the Duke for money were always met promptly. The 10th Duke continued to support the farm and so did the 11th Duke until 1912; the reasons for withdrawing are given later (p. 22). The cost to successive Dukes of Bedford was about £600 a year during the period 1876–1912.

The opportunity for making experiments on the light sandy loam soil at Woburn led Lawes and Voelcker to propose not only an experiment on the manurial value of different animal feedingstuffs but also experiments on the continuous growing of both winter wheat and spring barley. There was much discussion at that time whether Lawes and Gilbert's success in growing corn crops continuously on the heavier clay loam soils at Rothamsted could be repeated on light land. Today many farmers enjoy freedom of cropping and husbandry not allowed to the tenant farmer of the 1870s. Then the tenancy agreement often dictated the rotation to be followed and restricted what could be sold off the farm. There is a copy of a letter in the Woburn archives which refused a tenant permission to take a second successive cereal crop after a crop of sainfoin.

The first crops of wheat and barley were harvested in 1877 and in that year the feeding experiment was started on half of the 16 acres it was to occupy. Lawes and Voelcker reported the results in detail in the RASE Journal in 1878, the only report signed by both of them. Lawes seems to have resented interference by the Woburn Committee which had appointed a Mr. Cathcart to superintend the experiments under the direction of Lawes. Cathcart was apparently censured for devoting too much effort to the experiments on Stackyard Field and not enough to making a commercial success of the rest of the farm, which was in a poor condition when taken over. Cathcart left to become Professor of Agriculture at Cirencester and Voelcker assumed responsibility for the experimental programme. Although both Lawes and Gilbert continued their interest in the results from Woburn, neither became personally involved again.

The Voelckers, father and son

Dr. J. C. Augustus Voelcker (1822–84) was born in Germany, studied chemistry at Göttingen and worked for a short while with Liebig at Giessen and in Holland. In 1847 he was persuaded to go to the Agricultural Chemistry Association of Scotland's laboratory in Edinburgh, where he was both analyst and consulting chemist. He was appointed Professor of Chemistry at the Royal Agricultural College, Cirencester in 1849 and Consulting Chemist to the RASE in 1857. During 1857–62 he retained his professorship at Cirencester and this gave him the opportunity to make field experiments there whilst the associated laboratory work was done in London. In this period he studied both the effects of storage on the composition of farmyard manure (FYM) and the capacity of soils to absorb ammonia, potassium and sodium. During the early 1860s he worked extensively on milk and dairy products. One of his major analytical studies was on the composition of drainage waters from soils given different manurial treatments on Broadbalk at Rothamsted. These analyses established that nitrate, sulphate, chloride, calcium and magnesium were lost in land drainage but that phosphorus and potassium were largely retained by the clay loam soil.

As Consulting Chemist to the RASE he analysed purchased feedingstuffs and manures for

members. His reports, often exposing cases of adulteration or poor value for money, were published in the Society's Journal and so did much to raise the standard of materials offered for sale. He also had his own laboratories and did consultancy work. Voelcker and Gilbert were both extremely competent analysts and well acquainted professionally.

When Voelcker died in 1884 his son, John Augustus, succeeded him both as Consultant Chemist to the RASE and as Director of the Woburn Farm. J. A. Voelcker (1854–1937) graduated from University College, London and then studied for his Ph.D. at Giessen. He too quickly gained a reputation as an analyst and was at one time President of the Society of Public Analysts. He represented the interests of the RASE on many occasions. Not least of these was the various revisions (with A. D. Hall) of Lawes and Gilbert's tables (1897, 1898) of manurial values of feedingstuffs and the introduction, already mentioned, of the first table setting out residual values for artificial fertilisers and lime (Voelcker and Hall, 1902, 1913).

The Hills Bequest

Between 1877 and the late 1890s all samples taken from experiments at Woburn had to be analysed at the Society's London laboratory. Then in 1896 the RASE accepted a bequest of £10,000 from Mr. E. H. Hills, a member of a firm of chemical manufacturers and makers of artificial manures, who also farmed in Sussex. He wanted the RASE to make experiments on the value of the 'rarer forms of ash' (trace elements) for agricultural crops. It was decided that this could be done best by pot culture techniques currently being developed in Germany. Buildings for a Pot-Culture Station, the first to be built in this country, were started at Woburn in April 1897 and completed early in 1898 (Voelcker, 1900). They consisted of a laboratory for analytical work, with office and store room, a large glasshouse and an area enclosed by small mesh wire netting supported on a metal frame, 'the cage'. The zinc or earthenware glazed pots in which the experimental crops were grown stood on trucks which could be moved between glasshouse and cage on rails. The laboratory building, now converted to offices, still stands; the glasshouse, much modified, is used as a workroom but the cage and railway have been dismantled.

A resident research chemist was appointed to make laboratory and glasshouse experiments and take meteorological observations with instruments first installed in 1898. The chemist was responsible to Voelcker and in 1898 H. H. Mann (1872–1961) was appointed. He was only there a short time when he accepted an appointment in India in 1900. However, when he retired from India in 1928 after a distinguished career in tea research and agricultural education, Mann returned to Woburn and worked there until 1956 as director in charge.

Late in 1909 the Development Commission was set up by the Government of the day and one very relevant power given to it was that of providing money for research and education in agriculture. With public money now available, the Duke of Bedford withdrew his financial support from the Woburn Farm and, after discussion between the RASE, the Commissioners and the President of the Board of Agriculture, an annual grant of £500 per year was made to Woburn.

About this time the RASE had doubts about whether or not to continue with the Woburn experiments but it was not until late in 1920 that the subject was raised again, after a large financial loss on the Darlington Royal Show. A proposal was made to give up Woburn, debated with some heat, approved and notice to quit the farm at Michaelmas 1921 given to the Duke.

Voelcker decided to continue with the experiments and took over the tenancy of the farm.

The work done under the Hills Bequest was transferred to Cambridge University. Voelcker had the use of buildings and equipment – the live and dead stock was sold in September 1921, realising £635!

The RASE, having given up the farm, set up a Research Committee and provided funds for work to be done at Rothamsted. The Ministry of Agriculture (it replaced the Board in 1919) continued its £500 annual grant towards the Woburn Farm, conditional upon supervision being exercised from Rothamsted's governing body – the Lawes Agricultural Trust. Voelcker continued to run the experiments for five years but gave up because of the cost and the Trust took over in 1926. From then to 1936 the Rothamsted Farm Manager was responsible for all operations at Woburn.

Because of the inadequate laboratory facilities at Woburn the post of chemist, occupied by T. W. Barnes from 1928, was not filled after 1966. The increasing ease of road transport resulted in all laboratory work being transferred to Rothamsted during the 1950's. The experimental programme increased so much that more land was acquired from the Woburn Estate and the farm is now 77 hectares (190 ac) in extent.

EARLY EXPERIMENTS

Occupying 16 acres of Stackyard Field, the rotation experiments were started in 1877 and compared the residual values of feeding stuffs, a "rich" one, cotton cake and a "poor" one, maize meal. Early results were summarised by Voelcker and demonstrated that "rich" feeding stuffs had very little extra benefit over poorer ones. This unexpected result led to a series of attempts between 1885 and 1937 to produce the results which had been expected but all failed.

The rotation experiment continued at Woburn, in various forms, until 1910. Major changes were made in 1911 and the experiment ended after the wheat crops of 1936 and 1937.

Continuous growing of wheat and barley began in 1876 and were reviewed by Lawes in 1888 – he reported that wheat and barley could be grown continuously on light land provided sufficient fertiliser was given and weeds controlled. A few years later yields began to decline where ammonium sulphate was used: this was cured by the use of lime and Voelcker claimed that this was the first experimental evidence in this country on the beneficial effects of liming. In fact, he went so far as to claim that, had this been Woburn's only contribution to British agriculture, its existence would have been justified.

Green manuring experiments have been carried out since 1892 and experiments on grass and fodder crops were started in 1889. Maize and potatoes have been under observation since 1894; "finger and toe" on swedes was cured by the use of lime. Principles of silage making were established as early as 1884. Experiments on cattle and sheep feeding started in 1876 and were reported in the Society's Journal; N losses in making farmyard manure were measured from 1899 to 1901 and the results confirmed assumptions made earlier by Lawes and Gilbert.

Experiments on trace elements sponsored under the Hills Bequest failed to follow up leads indicated in the early years and the information obtained was not understood until later experiments, not at Woburn, shed light on the role of trace elements in plant nutrition.

RECENT EXPERIMENTS

Woburn is one of four farms controlled by the Lawes Agricultural Trust: these are not treated

as separate farms but all farms are used for experiments sponsored by groups of individuals each from a different discipline. Some departments have been more heavily committed at Woburn than others because of the problems encountered on that farm.

One of the problems in Stackyard Field, referred to earlier, was the unexplained failure of crops to respond to cake-fed FYM in the Rotation experiment. Enquiries showed that the field had been under grass before the 1830's and arable crops grown in the 1840's and 1860's were given generous dressings of FYM; these two factors perhaps explaining why the soil had so high an organic matter content in the 1870's. In the 1930's and 1940's, when humus in the soil was declining, no evidence of deterioration in crop yields could be found; amounts of fertiliser and yield potential of varieties were more important limiting factors.

Many experiments at Woburn occupy the same site each year to monitor changes in pests, diseases or soil nutrients and proportionately there are many fewer annual experiments at Woburn than at Rothamsted. The land not used for long-term experiments is farmed on a six-course rotation – beans, wheat, barley, two-year break, wheat. The break period can be fallow, ley or non-cereal crops. Most fields in this rotation are dressed with 7.5t/ha of dolomitic limestone once in the rotation, usually between the beans and wheat.

BOTANY DEPARTMENT

Until 1955 the Department's main interest at Woburn was the types of weeds characteristic of acid soils – mainly poppy, corn spurrey, annual nettle, wild chamomile and common bent. Since then, important work on the irrigation of sugar beet has been carried out and the growth and development of arable crops studied in some detail, particularly, on Woburn's light, stone-free soil, the factors affecting root growth.

CHEMISTRY DEPARTMENT

Changes in soil organic matter and plant nutrients due to cropping and manuring have been determined over many years, starting in 1876 and continuing, at irregular intervals, until the 1960's. Much valuable information on the relationship between crops, manures and organic matter in the soil was obtained and in 1965 a new experiment was started, carefully balancing P.K.Mg additions to the soil while differing amounts of organic matter were added. Since 1972 wheat, barley, potatoes and sugar beet have been grown, each given eight different N treatments. Yields of all four crops at all levels of N have benefited from extra organic matter. Other experiments at Woburn have involved exchangeable K, showing that imbalance can be quickly rectified, a study of the effects of liming – started in 1962 – and the response over a five-course rotation to FYM and NPK fertilisers.

Drainage is not essential on this light land but drainage flow rates have been estimated and drainage samples analysed from six land drains put in at various times.

FIELD EXPERIMENTS SECTION

In Voelcker's Green Manuring experiments the green crop occupied the land for one growing season. Nowadays the catch crops are used in farming systems, occupying the ground for the autumn and winter before being ploughed in for a spring-sown crop. Less N was found to be needed where green manures had been ploughed in but it is doubtful whether the returns justify the extra expense.

Work has been done on the effect of dazomet and N on spring beans, resulting in increased yields of about 20%. In 1974 an experiment was started to determine the effects of subsoiling and enriching the subsoil with P and K.

Because maize was expected to become an important crop a continuous-growing experiment was started in 1971. Yields have been maintained so far.

Other experiments include a study of the effects of mouldboard ploughing verses deep cultivations or rotary cultivations and the effects of direct drilling of wheat against mouldboard ploughing on the population of earthworms.

INSECTICIDES AND FUNGICIDES DEPARTMENT

Much work has been done on pyrethrins and one of the first studies of the effect of DDT was undertaken at Woburn. It has been found also that certain chemicals applied to potato foliage offer the prospect of controlling potato scab and other soil-borne diseases.

NEMATOLOGY DEPARTMENT

Woburn suffers much more than Rothamsted from nematodes, perhaps as the result of differences in soil structure. The work involves both free-living and cyst-forming nematodes associated with cereals and potatoes. Much useful information has been obtained on means of measuring nematode populations and their control by rotation changes or resistant varieties.

PHYSICS DEPARTMENT

For almost twenty years the work of this Department centred on an irrigation experiment started in 1951. A full range of crops was grown and the results used in helping to compile various MAFF bulletins.

PLANT PATHOLOGY DEPARTMENT

Soil-borne diseases, particularly of cereals and potatoes, have been studied in recent years in line with similar experiments at Rothamsted. Assessments showed that there was most take-all in the third consecutive crop of wheat, less in wheat grown continuously and least when wheat follows a break.

The use of formalin on barley against both take-all and nematodes is under investigation.

Potatoes have received much attention at Woburn for over 80 years, mainly for means of controlling blight in the early years but more recently in relation to pathogenic fungi on tubers.

MICROBIOLOGY DEPARTMENT

As far back as 1896 Voelcker was studying the effects of inoculation on legume yields: more recently, attention has been devoted to "new" legume crops and to the inoculation of beans. Work has been done on "clover sickness" but without reaching a satisfactory conclusion.

SOIL

The soil at Woburn is very complex and this has had its effect on the interpretation of experimental results since the experiments often straddled soil boundaries. A recent re-classification of the soils has made it possible to study results in relation to soil type and, most importantly, to ensure that new experiments are sited in relation to the soil boundaries.

This article is a précis of a report prepared by Mr. Johnston for the Woburn Centenary.