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The Long Term Experiments

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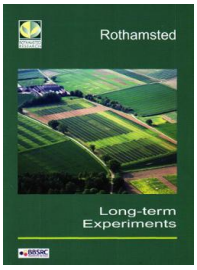

Introduction

Rothamsted Research

Rothamsted Research (2006) *Introduction ;* The Long Term Experiments, pp 5 - 7 **- DOI: https://doi.org/10.23637/ROTHAMSTED-LONG-TERM-EXPERIMENTS-GUIDE-2006**

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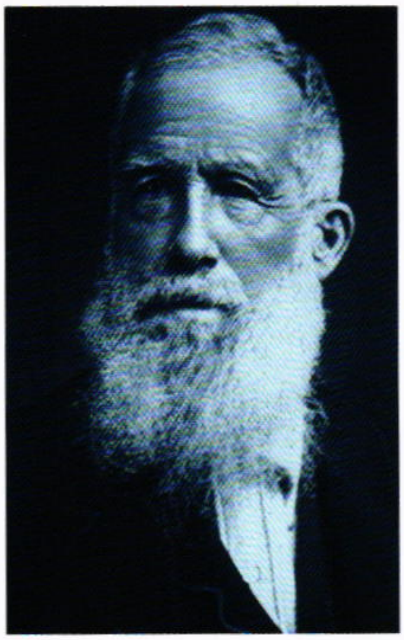
INTRODUCTION

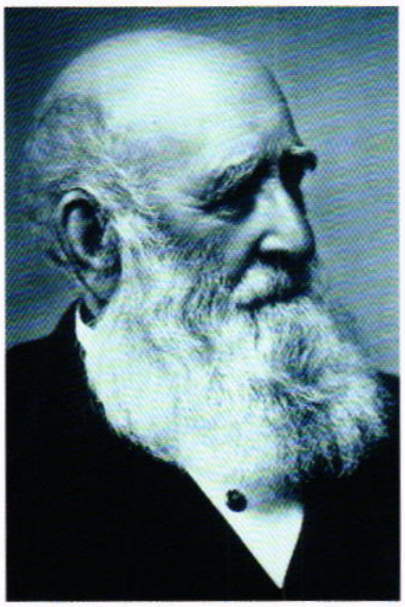
Between 1843 and 1856, Lawes and Gilbert started nine long-term field experiments, of which they abandoned only one, in 1878. Some treatments were changed during the first few years and, later, further changes were made to answer specific questions raised by the results. When Lawes died in 1900, the eight remaining experiments were continuing more or less as originally planned; these are now known as the "Classical" experiments. They are the oldest, continuous agronomic experiments in the world.



Sir John Bennet Lawes

Their main objects were to measure the effects on crop yields of inorganic compounds containing nitrogen, phosphorus, potassium, sodium and magnesium (N, P, K, Na and Mg), elements known to occur in considerable amounts in crops and farmyard manure (FYM), but whose separate actions as plant nutrients had not been studied systematically. The materials used were superphosphate (first made at Rothamsted by treating bones with sulphuric acid), the sulphates of K, Na and Mg (often referred to then, and in this Guide, as minerals), and ammonium salts and sodium nitrate (as alternative sources of nitrogen). The effects of these inorganic fertilisers were compared with those of FYM and rape cake in most of the experiments. The inorganic fertilisers were tested alone and in various combinations. Nitrogen was often applied at two or more rates.

Growing the same crop each year on the same land was a feature of many of the experiments. Considered bad farming in the nineteenth century, Lawes and Gilbert realised that it was the best way to learn about individual crop nutrient requirements. Lawes and Gilbert recorded the yields of all produce harvested from each plot and samples were kept for chemical analyses. These results, together with details of the quantity and composition of each fertiliser applied, enabled a balance sheet for the major nutrients to be compiled for each plot. Analyses of soil samples showed how N, P and K accumulated or diminished in soil depending on fertiliser applications, offtakes in crops and losses in drainage water.



Sir Joseph Henry Gilbert

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The results were of immediate importance to farmers, showing which nutrients had the largest effects on different crops. However, the value of later results to farmers diminished as the contrasted processes of depletion and enrichment of nutrients went on. In addition, the annual applications of FYM caused the soil organic matter contents of fertiliser- and FYM-treated soils to become increasingly different. Until *c.*1950 the best yields on each experiment were similar to the average yields of the same crops grown on English farms. After 1950, with higher yielding cultivars and increased use of fertilisers, farm yields in England exceeded those of the Classicals until changes to the latter were made in the 1960s.

The Classical experiments have been modified occasionally since Lawes's death. Daniel Hall, in 1903-06, added a few plots to Broadbalk, Park Grass and Barnfield; mainly to test the effects of P in the presence of NKNaMg, which had been omitted from these experiments. Hall also started the first regular liming scheme on Park Grass; the only Classical experiment not sited on a neutral or slightly calcareous soil. Most of the arable experiments were on fields that had received the traditional heavy dressings of locally-dug chalk, a practice not followed on grassland.

By the late 1940s there was increasing concern that the soils in a number of plots getting ammonium sulphate in the Classical experiments were becoming so acid that yields were adversely affected. Thus, comparisons of ammonium sulphate and sodium nitrate as N sources were compromised. In the Agdell experiment, acidity was so severe on the NPK plots that the disease club root so decreased yields of turnips that the experiment had to be extensively modified in 1951. Over the next few years soil acidity on the arable experiments was corrected by differential lime (chalk) applications and a schedule of liming was started to prevent acidity developing again. Following these changes it was decided to assess the value of the reserves of soil P and K accumulated in the Agdell and Exhaustion Land experiments by both soil analysis and crop yield. On Barnfield, not only the value of the P and K reserves but also the benefit of the extra soil organic matter (SOM) in the FYM-treated soils was tested. These tests were made by sub-dividing the original large plots into sub-plots to test fresh applications of N, P and K as appropriate.

These changes provided much new and valuable information. Consequently, in the mid-1960s, discussions started about further modifications to the Broadbalk, Hoosfield Barley and Park Grass experiments to make the treatments and the results more relevant to farming practice at that time. The management, cropping and treatments on these experiments were reviewed critically and modifications introduced to ensure that, as far as possible, the experiments remained relevant without losing their long-term integrity. One important change, made on all the cereal experiments, saw the replacement of long-strawed, with modern, short-strawed cultivars that had greater potential grain yield. Another change, introduced in 1968 except on Park Grass, was the replacement of ammonium sulphate and sodium nitrate by ammonium nitrate, initially as 'Nitro-Chalk', now as 'Nitram'. Recent changes are detailed later.

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In addition to the Classical experiments started by Lawes and Gilbert, there are several other long-term experiments at Rothamsted and at two other sites, Woburn and Saxmundham, on contrasting soil types. On the sandy loam soil at Woburn Experimental Farm, the Royal Agricultural Society of England started experiments in 1876 comparing different animal feeds, and their residual value to crops (to test the validity of Lawes' and Gilbert's findings), and on wheat and barley grown continuously. On a heavy sandy clay loam soil at Saxmundham, Suffolk, two long-term rotation experiments were started by East Suffolk County Council in 1899. These were extensively modified when Rothamsted took over the site in 1964, and have provided much valuable data on crop responses to P and K on a heavier soil.

With remarkable prescience, Lawes and Gilbert retained samples of crops and soils once the initial analyses were completed. Successive generations of scientists at Rothamsted have continued to add to the collection and the resulting Archive now comprises > 300,000 samples. This unique resource is of immense value; new analyses of archived material continue to provide insights into changes occurring over more than 160 years.

The collection of long-term datasets is not confined to the field experiments. Meteorological measurements have been made since the 1850s, when Lawes and Gilbert first collected and analysed rain-water. With current concerns over climate change, the long-term weather records provide invaluable information about the climatic conditions under which the crops have been grown. Rothamsted also has a long history of monitoring insect populations. The Rothamsted Insect Survey comprises national networks of light traps, to record moths, and suction traps, to monitor migrating aphids. It provides the most extensive long-term quantitative datasets on insect populations in the world and is used for a range of research purposes.

Archived samples

Rothamsted is one of the lead sites within the Environmental Change Network (ECN), which comprises 12 terrestrial sites and > 40 freshwater sites across the UK. The ECN sites monitor a large number of pollutants and climate change variables and associated effects on soil, vegetation, insects and mammals.

The Electronic Rothamsted Archive (e-RA) is being developed to hold meta-data and data from the long-term experiments, the Insect Survey and the ECN. In time this will allow ready access to the large volume of data that has been accumulated at Rothamsted since 1843.

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