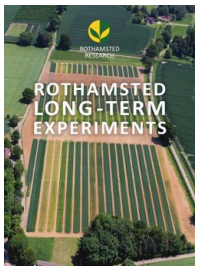
# Guide to the Classical and Other Long-term Experiments, Datasets and Sample Archive

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# Introduction

## Rothamsted Research

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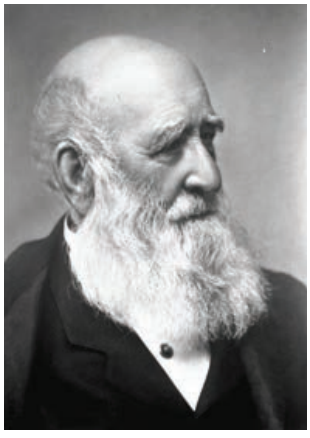
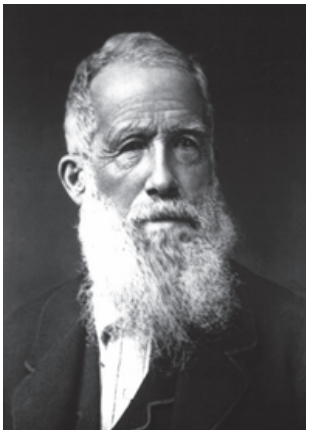
# INTRODUCTION

The Classical experiments is the name now given to those experiments started by Lawes and Gilbert between 1843 and 1856, and which still continue. Although they were not intended to be long-term, Lawes and Gilbert realised that much useful information could be gained by continuing them over many growing seasons. Nine experiments were continued 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. In particular, two Wilderness studies were established in the 1880s to examine the effects of abandoning arable land. When Lawes died in 1900, the eight remaining experiments were continuing more or less as originally planned. Modifications have been made to the experiments since Lawes died, in some cases discontinuing the original treatments. Seven of the Classical experiments continue today. They are the oldest, continuous agronomic experiments in the world.

Their main objectives 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



Sir Joseph Henry Gilbert



Sir John Bennet Lawes

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 reasoned 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 or manure applications, offtakes in crops and losses in drainage water.

The results were of immediate importance to farmers, showing which nutrients had the largest effects on different crops. However, the



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value to farmers of later results 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.*1939 the best yields on each experiment were similar to the average yields of the same crops grown on English farms. After 1939, with the introduction of 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 instigated 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 are 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 receiving 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 no longer possible. In the Agdell rotation experiment, acidity became so severe on the NPK plots that the fungal disease club root (*Plasmodiophora brassicae*) 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 was the value of the P and K reserves tested but also the benefit of the extra soil organic matter (SOM) in the FYM-treated soils. 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 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 and modifications introduced to ensure that, as far as possible, the experiments remained relevant to farming practice but without losing their long-term integrity. One important change, made on all the cereal experiments, was the replacement of long-strawed cultivars with modern, short-strawed varieties that had greater potential grain yield. Another major change, introduced in 1968, except on Park Grass, was the replacement of ammonium sulphate and sodium nitrate by ammonium nitrate, initially as 'Nitro-Chalk' (calcium ammonium nitrate), now as 'Nitram' (ammonium nitrate). More recent changes are detailed later.

In addition to the Classical experiments started by Lawes and Gilbert, there are (or were) several other long-term experiments on the flinty silty clay loam (Avery & Catt, 1995) at Rothamsted and at two other sites, Woburn and Saxmundham, on contrasting soil types. On the sandy loam soil (Catt *et al*. 1975, 1977, 1980) at Woburn Experimental Farm, the Royal



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Agricultural Society of England (RASE) started experiments in 1876 to compare different animal feeds, and assess the residual values of the dungs as sources of plant nutrients (to test the validity of Lawes and Gilbert's findings). In addition, RASE started other experiments on wheat and barley grown continuously. On a heavy sandy clay loam soil at Saxmundham, Suffolk (Hodge, 1972), 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. Rothamsted relinquished the lease on the Saxmundham site in 2010. Although now discontinued, samples and data from these and other discontinued experiments are retained for future use.

With remarkable prescience, Lawes and Gilbert retained samples of crops and soils taken for chemical analysis once the initial analyses had been completed. Successive generations of scientists at Rothamsted have continued to add to the collection and the resulting Rothamsted Sample Archive (RSA) now comprises > 300,000 samples. This unique resource is of immense value; analyses of archived material allow us to generate new data stretching back more than 175 years.

The collection of long-term datasets is not confined to the Classical and other long-term 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 has also been monitoring insect populations since 1964. The Rothamsted Insect Survey comprises national networks of light traps, to record moths, and suction traps, principally to monitor migrating aphids. It provides the most extensive long-term quantitative datasets on insect populations in the world.

Sample archive, 1930s

Rothamsted (and North Wyke Research, which merged with Rothamsted Research in 2009) are two of the lead sites within the Environmental Change Network (ECN), which comprises 11 terrestrial sites and > 40 freshwater sites across the UK. The ECN sites monitor a large number of pollutants and climate change variables and the associated effects on soil, vegetation, insects and mammals.

The Electronic Rothamsted Archive (e-RA) is being continually updated to increase the amount of numerical and descriptive data included from the long-term experiments and 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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