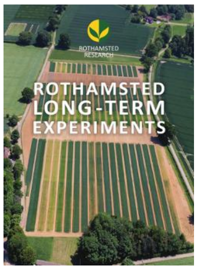
Guide to the Classical and Other Long-term Experiments, Datasets and Sample Archive



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Other Long-term Experiments

Rothamsted Research

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OTHER LONG-TERM EXPERIMENTS

In addition to the Classical experiments started by Lawes and Gilbert, there are several other long-term experiments at Rothamsted and at Woburn on contrasting soil types. Some of these are described below.

At Rothamsted

Highfield and Fosters Ley-arable Experiments

The Ley-arable experiments at Rothamsted, on Highfield and Fosters fields, started in 1949 (Johnston, 1973). Their purpose was to look at the effects of different cropping systems on yield and soil organic matter. The two sites have the same soil type but very different cropping histories. Highfield had been in permanent grass since 1838; on this site some plots stayed in permanent grass, others went into continuous arable cropping and some alternated between leys and arable. Fosters had been in arable cropping for several centuries; on this site some plots stayed in continuous arable, some went into permanent grass and others alternated between leys and arable. Although we no longer measure yields we continue to monitor SOM. Figure 10 shows that, it has taken about 60 years for soils to approach a stable equilibrium following changes in the cropping systems. Thus, in soils ploughed out of permanent grass or put into permanent grass after arable cropping the SOM is now relatively constant.

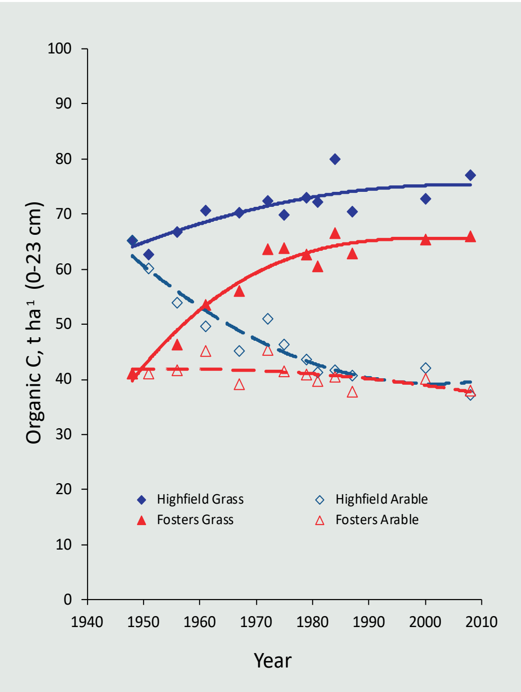

Fig. 10 Highfield and Fosters Ley-arable; changes in the amount of soil carbon in the top-soil (0-23 cm), 1949-2008. Data has been adjusted for changes in bulk density.

The Long-term Miscanthus Experiment

Other work at Rothamsted has focussed on non-food crops, including Miscanthus, a perennial grass originating mainly from east Asia. *Miscanthus* x *giganteus* is a naturally occurring hybrid between *M. sinensis* and *M. sacchariflorus* thought to have originated in Japan. It was first recorded in European botanical gardens in the 1930s but it wasn't until 50 years later that researchers interested in renewable energy began to take an interest in its suitability as an energy crop.

Miscanthus utilises the C4 pathway for photosynthesis but unusually amongst C4 grasses shows good low temperature adaptation. For cooler northern areas of Europe this introduced the possibility of capitalising on the advantages of the C4 pathway, namely; lower nitrogen requirement, greater water use efficiency and greater ability to utilise high light intensities, when compared to C3 grasses. As a perennial, *M.* x *giganteus* offered savings on cultivation costs plus the potential for increasing soil carbon content, giving the crop a favourable Life Cycle Analysis compared to annual crops. When research work began, it became evident that the perennial cycle also involved nutrient

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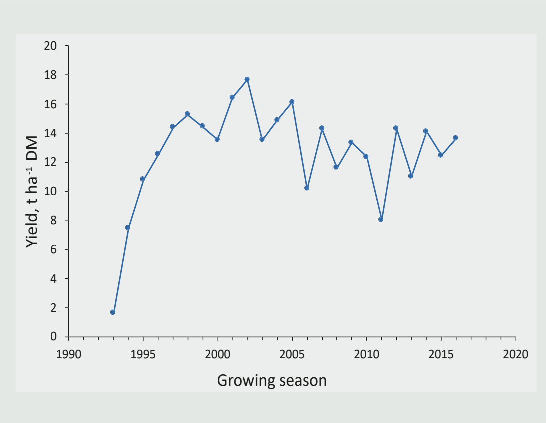

Fig. 11 Rothamsted; yield of *Miscanthus x giganteous*, 1993-2016.

remobilisation between the rhizome and shoots and *vice versa*. The nett effect being efficient utilisation of nutrients, especially N, and, if harvested when fully senesced (early spring of the year following growth) a biomass fuel low in contaminants such as N, K, S and Cl.

Rothamsted Research first planted *M.* x *giganteus* in spring 1993. The belief at that time was that a crop may remain productive for 20 years. As Figure 11 shows, following an establishment phase of 3 years the Rothamsted crop has remained productive for a total of 24 years. Seasonal variation is clear, but there is no sign of a yield decline. Very few of the experimental crops planted around Europe between 1988 (the earliest known planting as a crop) and 1993 remain in place. The Rothamsted crop is certainly one of the oldest stands in the world, if not the oldest. This experiment is maintained to determine how long a single planting may remain productive and to monitor for pests and diseases that may threaten that productivity.

The Large-scale Rotation Experiments (LSREs): new long-term experiments

The Rothamsted long-term experiments have proved to be a unique resource for understanding the behaviour of agricultural systems over decadal time scales. However, the potential to use the existing experiments to answer new questions is sometimes limited by the need to maintain the original treatment structure, the lack of replication and plot size. To address these constraints, a new long-term experiment, supported by the Lawes Agricultural Trust, has been set up on the Rothamsted farm at Broom's Barn (Suffolk). The new experiment compares contrasting farming systems with multiple interacting factors. Treatments were chosen that would impact on a wide range of agronomic and environmental response variables as well as addressing issues relevant to modern farming systems. The experiment was established at Broom's Barn in autumn 2017 and a similar experiment started at Harpenden in autumn 2018.

The main treatment is crop rotation with large 24 x 24m plots in one of three rotations: a three-year rotation aiming at short-term economic return, a five-year rotation with a greater diversity of crops (including cover crops) and a seven-year rotation designed for increased environmental sustainability (also including cover crops and a two-year ley). A second treatment of contrasting soil cultivation is also included: either annual ploughing or zero tillage (using a direct drill). The main plots are also split with half receiving organic amendments. Each phase of each rotation is present in every year in all treatment combinations. The design also includes the flexibility to test contrasting crop protection strategies. These new LSREs will serve as valuable experimental platforms in the coming years for integrating the breadth of science covered by Rothamsted Research and informing the design of future farming systems with the aim of increasing yields while reducing the impact on the environment.

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At Woburn

Experiments at Woburn began in 1876 under the auspices of the Royal Agricultural Society of England. The principle aim was to test the residual manurial value of two contrasting feedstuffs fed to animals in covered yards or on the land. Rothamsted took over the management of the farm in the 1920s. In contrast to the silty clay loam at Rothamsted, which, typically, contains 20-40% clay, much of the soil at Woburn is a sandy loam containing about 8-14% clay (Catt *et al*,1977, 1980). It is much more difficult to maintain or increase SOM on this soil, and several of the long-term experiments at Woburn were established to study the effects on yield and SOM of including grass leys and applying organic amendments in arable rotations.

The Woburn Ley-arable Experiment

The Ley-arable experiment was started in 1938 to compare the effects of rotations with or without grass or grass-clover leys on the yield of two arable test crops and on SOM. Soils at Woburn that have been in continuous arable cropping since 1876 contain about 0.8-0.9 % C, and % C is still declining, slowly; soils which have alternated between 3-year leys and 2-years arable since 1938 contain about 1.2 % C (Figure 12).

Changes in the amounts of C in the soil over > 70 years have been modelled. In the rotation where the ley was originally grazed (Ln3), only about 5% of the estimated C input was retained in the soil; in the other rotations > 98% of the input was lost (Johnston *et al*.,2017). Typically, where no fertiliser N is applied, yields of test crops are greater following the grass leys than

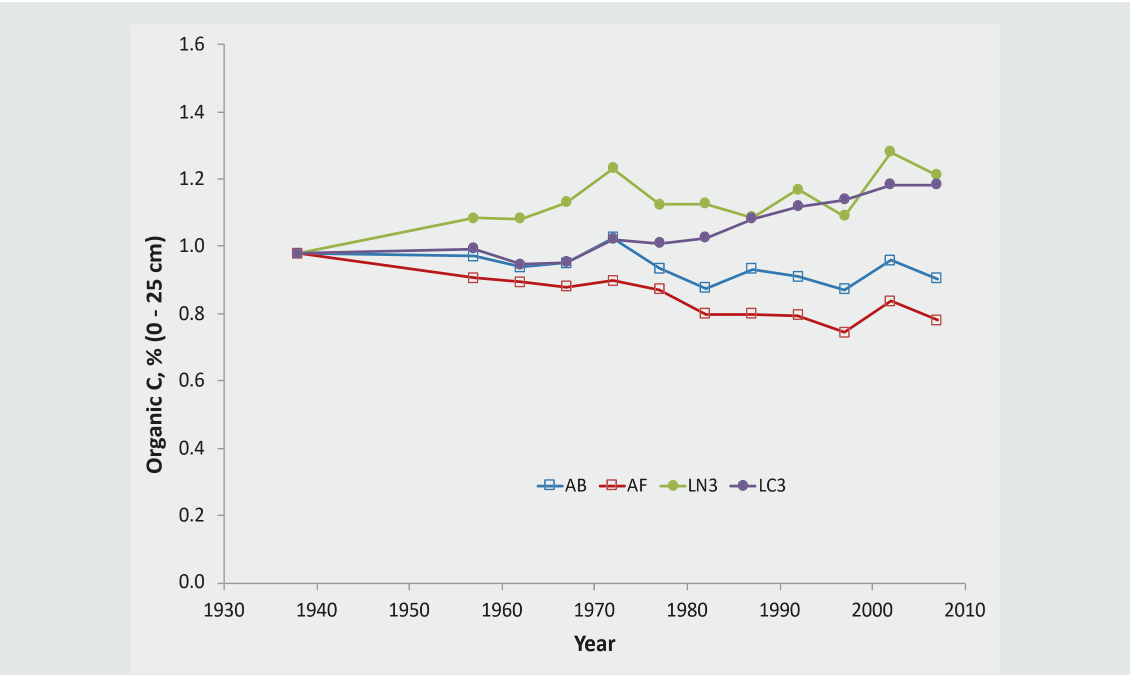

Fig. 12 Woburn Ley-arable; changes % organic C in the top-soil (0-25 cm), 1938-2009. Treatments are: (AB) continuous arable; (AF) continuous arable with root crops or fallows; (LN3) 3-year grazed grass/clover (later grass + N) leys + 2-years arable; (LC3) 3-year lucerne (later grass/clover) leys + 2-years arable.

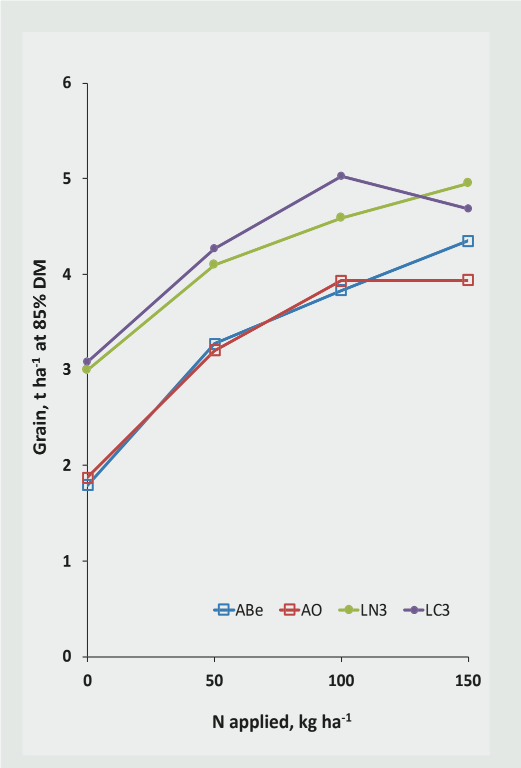

Fig. 13 Woburn Ley-arable; mean yields of winter rye, 2011-2015. Data are yields of the 2nd Test crop after: (ABe) beans in continuous arable rotation [previously AB]; (AO) oats in continuous arable rotation [previously AF]; (LN3) 3-year grass ley + N; (LC3) 3-year grass/clover ley.

in the continuous arable sequence because more N is available from the mineralisation of SOM. Following grass-clover leys, yield is increased further because of the extra N being made available from the breakdown of the leguminous residues. Even in the second cereal after the leys have been ploughed-in a larger yield is often achieved, with less fertiliser N, compared with continuous arable cropping (Figure 13).

The Woburn Organic Manuring Experiment

The Woburn Organic Manuring experiment was started in 1964 to test the effects of different types of organic matter inputs on crop yields and SOM. Initially, six organic treatments (grass or grass/clover leys and arable crops with FYM, peat, straw or green manures) were compared with arable crops receiving fertilisers only. Arable crops were then grown in rotation with an eight-level N test from 1973 to 1980, to assess the effects of the organic amendments. During this period, no organic manures were applied. There was another treatment phase from 1981-1986, when further organic manures were applied. Again, SOM increased with the organic treatments and the grass leys but continued to decline slowly where only fertilisers were applied. This treatment phase was followed by another test phase, 1987-1994, when six rates of N were tested on arable crops, and no further organic manures were applied. From 1995-2002 arable test cropping continued but only two rates of N were tested. In 2003 another treatment phase started. All plots, except for the permanent grass-clover leys (and beans when grown) were split to test six rates of N on arable crops grown in rotation. Currently, the experiment contains 32 plots divided into four blocks. Of these, 28 are in a five-course arable rotation (Wheat, Maize/Cover Crop, Rye, S. Barley/Cover Crop, Beans) with different organic amendments (FYM, Straw, Compost, None). The remaining four plots continue in permanent grass/clover, without N. The arable plots are split so that N can be applied in spring at six rates for all crops, except beans which receive no N. Yields are recorded each year and soils are taken every 5 years.

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