Long-term Experiments As a Resource

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3 kg $ha^{-1}yr^{-1}$, respectively. Estimates of N in dry deposition are available for the last 20 years. In 1996, it amounted to 34 kg N $ha^{-1}yr^{-1}$; about three times that in rainfall. The total input, for wet and dry deposition, of 43 kg N $ha^{-1}yr^{-1}$ agrees well with other estimates; calculated total inputs ranged from 30-50 kg N $ha^{-1}yr^{-1}$ during the late 20th century. We estimate that, in the mid-1850s, total N inputs were about 10 kg $ha^{-1}yr^{-1}$.

Concentrations of carbon dioxide (CO_2) are not measured at Rothamsted but the rise in atmospheric CO_2 concentrations worldwide has been well documented; increasing from about 280 ppm in 1850 to *c*.380 ppm in 2005.

LONG-TERM EXPERIMENTS AS A RESOURCE

Maintaining soil quality and fertility is of worldwide importance; any changes in the factors influencing soil quality and soil processes can take decades to have any measurable effect. Similarly, the effects of agriculture on the wider environment may take years to become obvious. Long-term experiments with their contrasting treatments and management are an invaluable resource, which we can use to examine these effects in greater detail.

Thus, Broadbalk, Hoosfield and Park Grass have been used for detailed work on N cycling in our temperate climate using the stable isotope, ^{15}N, applied to microplots within each experiment. Results show that, on average *c*.50% of the applied fertiliser N was recovered by the crop, 25% remained, as organic N, in the soil and 25% was not accounted for. Most of the nitrate present in the soil profile in the autumn, and therefore at risk of loss by leaching, was derived from SOM, not from unused fertiliser N. Exceptions are where excessive amounts of N have been applied, in relation to potential crop yield, or where the crop has failed. On Park Grass labelled N, as either $^{15}NH_4$ or $^{15}NO_3$, was applied in 1980 and 1981. After 18/19 years, 67% of the $^{15}NH_4$-N had been removed in successive grass harvests (mostly in the first year) but a further 17% still remained, in organic forms, in the soil. Less of the $^{15}NO_3$-N could be accounted for; 60% in the herbage plus 14% in the soil. Labelled N has also been used to assess losses of N by denitrification and leaching, and to measure gross N mineralisation.

Other work has focussed on the soil's ability to act as a sink for methane (CH_4), an important greenhouse gas. For example, on the arable plots on Broadbalk, less CH_4 was oxidised in the soil where fertiliser N had been applied, compared with soil receiving FYM or the control soil receiving neither fertiliser nor manure. In the adjacent woodland (Broadbalk Wilderness) the rate at which CH_4 was taken up was 6 times faster than on the FYM soil. However, in the acid soil of the Geescroft Wilderness there was no CH_4 uptake. Similarly, on Park Grass, CH_4 oxidation was inhibited on soils with a pH of *c*.5 or less.

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The progressive acidification of the Geescroft Wilderness and some soils on Park Grass has also resulted in the mobilisation of heavy metals, particularly aluminium.

Broadbalk has been used to investigate the influence of both amount and form of N on gene expression in wheat grain. Clustering of gene expression profiles separated high and low N treatments. In addition, where the crop was accessing N derived from an organic source (FYM) there was a unique gene expression pattern and separate clustering. Analysis of this profile indicated the presence of genes encoding N assimilation components, seed storage proteins and several unknowns. These patterns were confirmed in successive years on Broadbalk and on the Woburn Ley-arable experiment where gene expression differed between wheat receiving fertiliser N and that receiving N derived from the mineralisation of grass ley residues. The most recent studies are combining both transcriptome and metabolome profiling to gain insights into processes relating to nitrogen use efficiency in wheat.

SAMPLE ARCHIVE

The unique Sample Archive was established by Lawes and Gilbert in 1843 and its scientific value has been, and continues to be, immense. The Archive comprises, predominantly, soil and plant samples from the long-term field experiments at Rothamsted, Woburn and Saxmundham described in this guide. Plant samples consist of oven-dried, unground wheat and barley grain and straw and herbage from Park Grass, as well as more finely ground material from many other crops. Soils (air-dried) have been taken from top-soils/plough layer (generally 0-23 cm) and from sub-soils. They are usually stored as either 6.35mm, 2mm or more finely ground samples. There are also dried samples of organic manures and fertilisers that have been applied to the experiments, and several thousand soils from different locations in the UK and from other countries. Samples are stored in sealed glass bottles or jars, airtight tins, glass vials or card boxes.

Archived soils from Park Grass, 1876

There is a written record of samples that have been archived and, increasingly, information on the samples is being stored electronically in the Electronic Rothamsted Archive (see below).

The Sample Archive has been used extensively by Rothamsted staff and by scientists from other research institutes and universities in the UK and abroad. The retrospective analysis of archived material allows us to look back more than 160 years at, for example, many aspects of plant nutrition and soil fertility,

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