ROTHAMSTED RESEARCH

Guide to the Work of the Departments 1984

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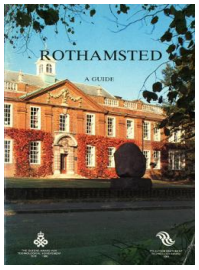

Biomathematics Division

Rothamsted Research

Rothamsted Research (1985) *Biomathematics Division ;* Guide To The Work Of The Departments 1984, pp 14 - 16

different environments and to determine the sensitivity of growth to changes in various physiological processes. Possible uses of such models are in studying global effects of increased atmospheric carbon dioxide concentration and proposals for optimal economic strategies in agriculture. Modelling will also be used to integrate our knowledge of the influence of the major variables, temperature, water and nutrient on the physiology of leaf growth in sugar beet in order to provide a stronger diagnostic basis for analysing crop performance.

Technical equipment and routine meteorology

The Department has two field laboratories equipped for the computerized collection and processing of data from crops. One is associated with plots that can be protected from rain by an automatic movable shelter. The Department also uses growth rooms in which temperature, humidity and radiation can be varied. Commercial instruments are not available for many of the measurements we require so suitable sensors and instruments are designed, some incorporating microcomputer systems developed in the Department.

The Department is also responsible for collecting and reporting the weather records from Rothamsted and for reporting the records from Woburn. The earliest records at Rothamsted go back to 1807, before the Station was founded.

BIOMATHEMATICS DIVISION

The Division has two components, the Statistics Department and the Computing Unit.

Statistics at Rothamsted began with the appointment of R. A. (later Sir Ronald) Fisher in 1919 to study the accumulated results of the Rothamsted Classical Experiments. Fisher soon realized the need for better statistical techniques in agricultural and biological research, and the groundwork for modern statistics was done by him during the 1920s and 1930s. Under F. Yates, who retired in 1968, the size and responsibilities of the Department expanded considerably and now, besides its service for Rothamsted, it provides advice and assistance for workers at many other research stations both at home and overseas. The Department also cooperates with the Agricultural Development and Advisory Service (ADAS) in designing experiments and surveys and provides numerical analyses of the results.

It is responsible for developing statistical software, but the main responsibility for computing lies with the Computing Unit. This was formed in October 1982 in recognition that modern scientific research as undertaken at Rothamsted can derive great benefit from using computers to control experimental apparatus, to capture data both in the field and in the laboratory, and to analyse and manipulate such data. Graphical display facilities are supplied and are being increasingly used. Most scientific projects use computers at some stage and many, including plant growth modelling and statistical investigations, involve major use.

COMPUTING UNIT

Computer systems are not new to Rothamsted. The first computer, installed in 1953, was used primarily for statistical analyses. Rothamsted has steadily increased its use of computing facilities since then, and now has a DEC VAX

11/750 minicomputer which provides a general-purpose interactive computing environment for all research staff at Rothamsted. This computer is connected to the AFRC network of VAX computers which also allows access to computer systems located at most Universities and those of the Scientific and Engineering Research Council. All laboratory automation and equipment for automatic data collection is based on microcomputer systems which are being developed for deployment in large numbers throughout the Station.

The provision of computing support for the diverse range of problems and equipment is the task of the Computing Unit, who work in close collaboration with research workers in other departments, in addition to undertaking more fundamental investigations into computing methodology in the areas of graphical display software, data-capture systems and human interfaces to computing packages.

STATISTICS DEPARTMENT

Design and analysis of experiments

The efficiency of an experiment can be measured by the accuracy with which the effects that are of interest can be determined. Good design can greatly increase that efficiency, and so lead to better use of experimental resources. Many important ideas in the theory of the design of experiments came from Rothamsted, and now find application in all branches of experimental science. The Department helps in the planning of field experiments on the Station, and deals with the subsequent handling and analysis of the data they produce.

Because the results of the crop experiments on a single site, such as Rothamsted, may not be typical of results of comparable experiments done elsewhere, an important activity is the design and analysis of series of experiments done at experimental and commercial farms throughout the country. This work is done jointly with ADAS and with careful planning can produce much more reliable information for advising farmers than an experiment at a single site. As well as giving estimates of average treatment effects for a range of sites and seasons, the aim is to explain and, if possible, predict differences in effect from site to site from records of other environmental factors not under test.

The design and analysis of animal experiments produces problems associated with allowing for the effect of previous feed regimes on subsequent ones, and with making the best use of scarce, but variable, material. This work is another part of the statistical service we give to ADAS.

Design and analysis of sample surveys

Survey techniques, nowadays so familiar in public opinion polls and market research, have for many years had important applications in agriculture. They are used to study the activities of farmers and also what may be called the natural history of crop plants, and of animals and their parasites. For example, the Survey of Fertilizer Practice (a continuing survey started in 1942) shows how farmers use fertilizers on different crops. This can help to give advice likely to be most profitable to farmers, enable series of fertilizer experiments to be planned which compare practice recommendations, and help to put fertilizer use in a proper perspective in relation to other factors that can contaminate water supplies and the environment. Trends in fertilizer use on individual crops are also used to forecast future requirements.

Much of this work is done jointly with ADAS and some in collaboration with the Agricultural and Food Research Council Institutes and with other organizations such as the British Sugar Corporation and the Fertiliser Manufacturers Association.

Methodology

The application of statistical methods constantly exposes areas where current theory is deficient, and this provides the stimulus for the Department's research work. We have an active interest in developing and using multivariate analysis, that is statistical methods of analysis that combine information on the many traits observable for any biological unit such as an experimental plot or an animal. Typical applications are in taxonomy, plant breeding, and the analysis of experiments involving many subjective judgments such as occur in assessing the qualitative aspects of foodstuffs.

We also collaborate with other departments in the development of mathematical models for the description of physical and biological systems. These aim to replace qualitative predictions about the behaviour of such systems with more precise quantitative ones.

Statistical computing

The many statistical calculations, of great variety, are almost all done by computer. To allow us to write down quickly the instructions required for a particular analysis we have developed special computer programs, each with a problem-oriented language. Thus the Genstat system provides a language specially constructed to help in specifying the analysis of designed experiments, multiple regression and its extensions, and multivariate analysis. Other programs are MLP, especially useful in the fitting of non-linear models to data; GLIM, which extends regression analysis to generalized linear models; and Genkey, which deals with the construction of diagnostic keys, such as occur in taxonomy. We are major users of the Rothamsted General Survey Program, originated by F. Yates.

All the programs can be used interactively from a terminal to explore experimental data and associated models, and all have been written in a way that helps their conversion to run on machines other than our own. A licensing system covers their distribution to centres throughout the world.

Overseas work

The Department contains a unit supported by the Overseas Development Administration, the function of which is to provide a service of statistical advice and computing to agricultural research workers in developing countries. We respond to continuing requests for help from all over the developing world and consultancy visits are paid to these countries from time to time.

CROP PROTECTION DIVISION

In the UK 10–15% of the potential yield of arable crops is lost annually through pests and diseases, and on a world scale the losses are even greater. It is essential to protect growing crops from the many agents that contribute to these losses