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Report for 1981 - Part 1

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Statistics Department

J. A. Nelder

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STATISTICS DEPARTMENT

J. A. NELDER

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Introduction

A large part of our work continues to be of a consulting or collaborative kind. The Department plays a part in the deliberations of all the Commodity Groups within the Station, allocates liaison statisticians to some departments (though lack of staff precludes a full coverage), and provides a rota-statistician service for day-to-day queries. Responsibility continues for the design and analysis of experiments in the large ADAS programme for both arable crops and livestock, and for providing a biometric service for ODA-linked projects overseas.

Our computer programs are being used increasingly throughout the world, and local interest in them is also growing. A relatively small but none the less important component of our work is devoted to new methodology, of a kind likely to find immediate use in the interpretation of data from experiments and surveys.

Practical applications

As usual, day-to-day consultancy work has covered a range of topics, some indication of which is given by the following examples.

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Work with the Soils and Plant Nutrition Department included the preparation of a paper on the relationship between the nitrogen content of winter wheat and various agronomic treatments (Lane, with Benzian of Soils and Plant Nutrition Department), and the development of a model for the evolution of CO_2 from plant roots. The fitting of this model to observations from individual plants gave evidence of differences between roots with and without mycorrhizal infection. (Lane, with Snellgrove, Soils and Plant Nutrition Department)

Work has continued on the simulation model for the transport of pesticides in soil. Help has been given in constructing a computer program, in Basic, for computing the persistence of pesticides in soil. (Baker, with Nicholls, Insecticides and Fungicides Department, and Bromilow, Chemical Liaison Unit)

The identification of strains of *Rhizobium* species by a 'finger-printing' technique was shown by cluster analysis to be unreliable because of the variation in the 'fingerprints' of typical strains. An alternative method of identifying strains of *Rhizobium* species based on intrinsic antibiotic resistances provided sufficient differentiation between individual strains for identification purposes. (White, with Bromfield, Stein and Dye, Soil Microbiology Department)

A contribution has been made to a paper describing the likely flight behaviour of pea moths responding to a point pheromone source in open country, assuming that the wind carries pheromone from the source in straight lines. There are data suggesting that the effect of a standing crop may be to create a more continuous volume of pheromone, and classical diffusion equations have been adapted to describe the concentration at any position downwind of the source. Mathematical models have been derived to describe a moth's behaviour in such conditions. Experiments with lines of four and nine traps aligned with the mean wind direction confirmed that interactions between traps caused catch profiles similar to those previously reported; however, other experiments indicated that the nature of the interactions changed systematically within trapping periods, probably because moth response thresholds changed with time and altered the relative proportions of trapping zones to appetitive flight zones. A factorial experiment comparing interactions between traps with factors representing dose, trap spacing and trap position lent support to this idea, as did observations that the proportion of moths flying was often independent of the proportion responding to the pheromone. These ideas emphasise the need for stochasticisation of the definitions of terms like 'trapping zone', to account for differing probabilities of capture between individuals, and differing periods of trapping. Further experiments were done to determine the extent of absorption and release of pheromone by vegetation, indicating that an exposure of vegetation for as little as half an hour can lead to significant increases in attractiveness for two or more hours. (Perry, with Wall, Entomology Department)

Work for ADAS. Recruitment during the year, including that of head of the group dealing with our work for ADAS, has enabled some backlog to be cleared and improvements made in our service. The making of inferences from groups of experiments, covering both sites and years, has continued to be important. The scope of the work, covering both arable crops and livestock is illustrated in the following paragraphs.

Crop experiments. Further work has continued the investigation begun by Wimble on the prediction of nitrogen status of soils. Data from ADAS winter-wheat and barley experiments in 1975–77 have been analysed to determine an appropriate functional form to fit adequately the yield response to level of nitrogen application. For most sets of data an exponential plus linear function was adequate. A few sets of data were so scattered that no simple function was clearly appropriate. Even these sets of data could be accom-

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modated by fitting a family of related exponential plus linear curves varying in horizontal and linear positioning but with the same shape. From the fitted curves the optimum applied nitrogen level and apparent nitrogen status of the soil were estimated and compared with the results of several methods of soil nitrogen analysis provided by K. Shaw (ADAS). As previously found by Boyd and Wimble, none of the analytical results provided good predictors of the nitrogen status of the soils, the best being the anaerobic digestion of soil, which accounted for over 50% of the variation in the estimated nitrogen status.

Similar curve fitting and estimation of nitrogen status for winter-wheat and barley experiments in 1978–80 has been unsuccessful in repeating even this modest level of prediction. Further work is in progress to compare the apparent nitrogen status estimated from the field experiments with a combination of soil nitrogen analyses, plant analyses, the results of growing rye grass in soil samples in laboratory conditions, and physical data from the sites. First indications are that accurate prediction of nitrogen status for UK conditions is still not possible, despite claims of success from some continental biometricians. (George and Murray)

In the series on the timing of nitrogen for winter wheat, 32 sites were used, and the main interest was in assessing whether it is better to apply N all at once or split into two or three separate dressings.

The 1980 results showed that it is worthwhile putting 40 kg ha^{-1} N on early at growth stages 21–25, but that no benefit is afforded by putting any N on at growth stage 39. The response to nitrogen was generally more consistent than in 1979; in addition, the response was more pronounced, with virtually all sites showing an effect up to about 125 kg ha^{-1} and 13 sites still showing an effect up to the highest level of nitrogen tested. (Dyer)

Livestock experiments. Our work for ADAS animal experiments has been hampered by staff losses, but nevertheless a substantial throughput has been achieved. Six whole-lactation dairy experiments and 41 other experiments with beef cattle, calves and sheep were analysed and interpreted, in addition to extensive work on pigs and hens. Numerous requests for advice on design were received and there is a growing interest in developing models which can summarise the results of past research and be used both for prediction and for deciding on research priorities. More details of some of the work follow.

A trial was started in the winter of 1980 to test the possibility of reducing the tick population in certain areas of the Lancashire fells by a programme of serial dipping of sheep over a period of 4 years. The results from the preliminary year, which served as a pilot study, were analysed using a log-linear model. The analyses showed that counts from undipped sheep at farms where serial dipping occurred prior to 1980, were smaller than those from sheep at farms where no serial dipping had occurred. This was most evident early and late in the season, when tick numbers generally peak. (Altman)

It is generally accepted that Friesian dairy heifers should attain a target weight of 300–330 kg prior to mating at 15 months of age. A study was made of 189 Friesian heifers weighing between 225 and 348 kg at insemination to see if this target weight was realistic. The results indicated that weight had little effect on pregnancy rates or survival to the fifth lactation, but that heifers weighing less than 260 kg produced less milk in their first lactation. (Altman, with Mrs S. B. Drew, ADAS)

The second year of an experiment to compare leafy and root forage crops in terms of their potential to finish grazing lambs was completed. This experiment had two feeding phases. The results show that during Phase 1 growth rate was severely inhibited by feeding folded swedes. Changing diet from a leafy to a root forage when crop losses are high for the former was not detrimental to the lambs. (Pooley and Altman)

The technique of ultrasonic fat-depth measurement is widely used with fattening pigs.

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Recently ADAS workers have been interested in this technique as an aid to the management of sows. Two preliminary trials have assessed measurement variability, using sets of operators and sows of widely differing body conditions. Considerable operator variability was found with consistent differences between trained and untrained operators. However, it was confirmed that sows of differing condition can be adequately differentiated by ultrasonic fat probe measurement. (Spechter, Bailey and ADAS staff)

We participated in the design, analysis and reporting of a series of experiments conducted at Gleadthorpe EHF to evaluate different feeding systems and feeding frequencies for laying hens housed in battery cages. The hopper-trough system with grid dispenser and sleeve feeders reduced feed intake without loss of production, indicating that feed wastage was reduced. The labour-saving chain feeding system, widely adopted in large poultry units, was also very efficient. However, food intake was highest with the spiral feeder system. (Spechter)

Surveys

Fertiliser practice. This series of annual surveys, done in collaboration with ADAS soil scientists and representatives of the Fertiliser Manufacturers' Association, was continued and in 1981 information was obtained for a representative sample of nearly 1400 farms in England and Wales. Preliminary results on half the samples were available by the end of September and those on complete data by mid-December. Some rephasing of ADAS fieldwork in arable regions helped in keeping to a tight time schedule for data processing. Existing programs for analysing these surveys were revised to use the facilities of RGSP Mark 2, particularly those for data validation. An abstract of the results is given in Part 2 of the *Rothamsted Report*. (Church, Elsmere and Leech)

Representative soil sampling. Samples for this monitoring exercise, which is primarily based on resampling the same fields at intervals of 5 years, are now being supplemented and cyclically replaced by fields on farms in the current fertiliser surveys. The most recent data were verified, checked and reformated for input to existing programs on the Jacquard data entry equipment and an interim report was produced updating the information on soil acidity. (Church, Elsmere and Todd)

Calf rearing study. A behavioural study of calves in 70 herds under different rearing systems was done by the ADAS Veterinary Service in collaboration with the Department of Animal Husbandry, Bristol. The main aim is to compare rearing systems, and the behaviour of calves at different ages and throughout the day. Data were validated at Rothamsted as they came to hand during the year, and tabular summaries have been prepared as a first step towards determining what form of critical analysis may be useful. (Church and Gnanasakthy)

Other surveys. Our collaboration with British Sugar and Broom's Barn on planning, analysis and interpretation of BSC field surveys was continued, and results of a survey of the use of anthelmintics in cattle were published (Paper 25). (Church and Leech)

Routine analysis. We have now completed a full year's use of the Jacquard J100 system for word processing and data entry. Use of the system has increased steadily and at times it has become overloaded for adequate response times to the data-entry users. Possible remedies for this slowness are being investigated. Use of the system has cut the time to prepare the book of yields of the field experiments by about 6 weeks and has improved the standard of presentation. (Todd and Dunwoody, with J. McEwen, Field Experiments Section)

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Advantages of its use are seen also in the handling of large amounts of data from complex experiments such as the two multidisciplinary experiments on factors limiting the yield of wheat. (Todd)

Use has been made of the data-processing service by 142 workers from other departments and from eight outside stations. The total data handled amounted to 1·75 million items, about the same as last year. There was an increase of 31% in the number of items processed for Rothamsted users (0·95 million compared with 0·73 million in 1980) and 88% for Overseas Development Administration (ODA). By contrast, work for ADAS decreased by 22% (0·79 million compared with 1·02 million). The average turnround time was 7 days, about the same as in the previous 2 years. (Dunwoody, Todd, Smith and Dyer)

Theory

Covariance and prediction. The analysis of covariance is widely used in the analysis of designed experiments for adjusting treatment means for variation in concomitant variables inadequately balanced by the design. Similarly standardisation techniques are widely used in demographic work to adjust estimated differences in proportions between populations to allow for, say, different age structures in those populations. These two procedures can be integrated, within the context of generalised linear models, by the use of the idea of a predictive phase in the analysis, analogous to the forecasting phase in time-series analysis. Model terms are split into two categories, predictive and standardising, and standardisation may be made conditional on a particular value of the standardising variable or averaged over a distribution of that variable. A paper has been prepared. (Lane and Nelder)

Distance in multivariate analysis. Properties of Euclidean distance matrices, which underlie many multivariate methods of analysis, have been studied. Conditions for a matrix to represent Euclidean distances have been found which generalise known results and lead to a method of characterising statistical estimates of centres of location. The details of some interesting special cases have been worked out (Paper 20.) Further developments have established the relationship between the rank of a distance matrix and the number p of dimensions amongst the points that generate the distances. The rank turns out to be $p+1$ or $p+2$ depending on whether or not the points lie on a hyper-sphere. Several other properties have been established, and an investigation of non-Euclidean distances has led to a proof of the conjecture that the maximum dimensionality attainable by fitting distance matrices by least-squares scaling cannot exceed the maximum number of real dimensions in a principal-coordinates analysis. (Gower)

Individual-differences scaling. A new method has been developed for individual-differences scaling. The problem is that of expressing the multidimensional scaling of several distance (or dissimilarity) matrices, one pertaining to each of several individuals, in terms of an 'average' configuration of points pertaining to all individuals, plus an indication of how each individual departs from this average. Previous methods have been iterative and computationally expensive. The new method is non-iterative and efficient. (Gower)

A Genstat macro has been written and first results of using it are encouraging. An example of the new analysis is given in a paper where the 'individuals' are different regions of the human skull and distances are estimated between a number of fossil humanoid populations. (Digby, Harding and Gower)

Effective replication. How do data points influence predictions from a fitted model?

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If a curve, $y=f(x)$ is fitted to observations of y for various values of x, the predicted value of y given x has variance V_f, say. This can be compared with the variance of y obtained from n repeated observations at the given value of x, which is σ_e^2/n, where σ_e^2 is the residual error variance. This result can be used to estimate $n(x)=\sigma_e^2/V_f$, a number which may be called the 'effective replication' at x provided by the data in predicting y.

Plots of n_r against x reveal the effect of the choice of x values in making observations suitable for fitting the curve. The value of n_r at an isolated data point may be close to 1, showing that the fitted curve is almost bound to pass very close to the observed value. The idea may be extended to more general models and to models with error distributions other than Normal. (Ross)

Parallel curve analysis. The standard analysis of parallelism in linear regression constrains the regression coefficients to be equal while allowing the intercepts to differ for each subset of the data. This idea was extended in MLP to allow 'parallel curves' to be fitted in which non-linear parameters are constrained to be equal. However, what many users would like would be an analysis in which the curves in each subset are exactly the same except for a displacement in either the x or y directions. These two displacements are equivalent for straight lines, but different for all other curves. A shift in the x-axis is required in assay analysis, whereas a shift in the y-axis is required in fertiliser response studies. Methods of fitting such models have been devised. (Ross)

Models with split lines. In ecology, split lines are often appropriate to describe processes, in which insect numbers appear to increase linearly with time to a peak, and then suddenly decline with a different linear relationship. The size and time of occurrence of this peak may be economically important. Certain forms of split-line model allow direct estimation of these parameters as well as of the rates of increase to and decline from the peak. These have been developed to estimate parameters simultaneously from several datasets (which might represent different sites or species), and tests have been derived which facilitate specification of the simplest model that will adequately describe all the datasets. By contrast the information derived from a standard analysis of variance would be less informative, since inevitably significance of interaction terms could not be directly associated with individual interpretable parameters. Certain results concerning the least-squares estimates have been derived. (Perry)

Population dynamics of cyst nematodes. Further research has used the four parameter simulation model constructed in previous years. Data from the rotation-fumigation experiment at Woburn Experimental Farm (*Rothamsted Report for 1978*, Part 1, 47–65) were analysed using the program MLP to investigate likelihood surfaces. Sensitivity analyses were carried out and quadratic approximations tested. Stochastic modelling is in progress using Genstat. Initial results indicate that within-field heterogeneity will not greatly alter predicted population levels obtained from deterministic estimates. (Clark and Perry)

Statistical programming

Genstat. Use of the program throughout the world has continued to increase and the number of sites with licences has risen from 136 to 178, these in 32 countries. The second Genstat Conference was held in Wageningen, Holland, during 7–10 October, and was attended by 85 people from nine countries. The use of the program in a variety of fields of application was described by speakers, and a general discussion was held on future developments. The conference was organised by Alvey with the help of Mr J. C. A. Zaat and Mr A. Keen of IWIS-TNO in the Netherlands.

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Releases. Conversions of release 4.03 of Genstat for the CDC 7600 (Mr J. D. Lloyd-Jones, University of Manchester), the ICL 2980 (Mr B. J. Fletcher, University of Edinburgh) and the DEC-10 (Mr J. C. Byrne, University of York) were completed early this year, as predicted in last year's report. During the year further conversions were completed for the DEC-20 (Mr I. D. Griffiths, Trent Polytechnic, Nottingham), Univac (Mr J. Wasniewski, RECKU, Copenhagen), Burroughs 6700 (Dr B. E. Niven, Otago) and—a newcomer to the Genstat scene—the Modcomp Classic 7870 (Dr R. Bauer, Institut für Numerische Statistik, Cologne). Conversions for the Cray, Perkin-Elmer (Interdata) and SEL were begun.

Changes to the operating system of our own System 4 have allowed an interactive version of a subset of Genstat to be made available. Alain Williams and James Malcolm of the Computer Department provided respectively a user-code routine to handle input/output from the terminal and a macro to allow the program to be simply invoked. This version has given us useful experience in running Genstat interactively. (Simpson)

The specification of the next release (4.04) was agreed at the end of the year, and implementation is under way. No major additions are planned; internal changes include the rewriting of the input routines to improve portability, together with others to improve efficiency. Extensions will allow formats to be set dynamically and provide for the input and output of data in binary form. Mixed-mode arithmetic will be available in the CALCULATE directive, and a new alternative algorithm for optimisation will remove the existing limit on the number of parameters.

For regression and generalised linear models a new directive PREDICT will form predictions from a fitted model, summarising the effects of some factorial treatments, while adjusting for the effects of others. New options in the stepwise regression directives will allow control over the criteria for deletion or addition of variables. A new directive FOURIER will be implemented to allow spectral analysis via fast Fourier transforms. The GRAPH directive will be extended to allow output to devices other than a line printer with accompanying enhancements to the facilities available. (Alvey, Lane, Leech, Payne, Ross, Simpson and White)

Documentation and support. A second video-tape introducing Genstat was completed. Called 'FITTING MODELS', it presents the regression analysis of a medical experiment, and demonstrates also the flexibility of input to Genstat and the graphical facilities. A third video-tape was filmed at the Genstat conference, where Alvey and Lane interviewed ten well-established users of the program. (Alvey and Lane, with Dr D. Clark and Mr A. Cottom of the London University Audio-visual Unit)

A primer for Genstat has been written. It provides a step-by-step introduction to the basic facilities of the program, illustrated by carefully chosen examples from a wide range of statistical applications. Care has been taken to make the book self-contained, and to encourage readers to write programs as exercises and run them on a computer. (Alvey and Lane, with Dr N. Galwey of Cambridge University)

Substantial progress has been made with the provision of documentation in languages other than English. During the year a manual in Italian was written and published by Dr C. Brambilla and Dr P. Gherardini of the Istituto per le Applicazioni del Calcolo, Rome. Professor R. Tomassone of the Institut National de la Recherche Agronomique has completed the material for a French manual, and publication is expected in 1982. Finally we are indebted to Professor Leser of the University of Leeds for a German translation of the manual, which is now being prepared for publication.

Courses on Genstat were given, for the United Kingdom in London, Guildford (ADAS), Oxford, and Edinburgh, and abroad in Dublin, at the Istituto per le Applicazioni del Calcolo in Rome, Michigan State University (USA), and Brasilia (Brazil).

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The distribution and conversion of the program was the subject of a poster at the 43rd Session of the International Statistical Institute held in Buenos Aires. (Alvey, Digby, Lane, Nelder, Payne and Simpson)

Genkey. Release 3.02 has been converted for use on IBM 370 and similar machines, and on Prime computers. (Payne and White)

Maximum Likelihood Program (MLP). The number of sites using versions of MLP now exceeds 30, and conversions are in progress on the following machine ranges in addition to those reported in 1980:

Range	Converter
DEC-10	University of Western Australia
DEC-20	Clinical Research Centre, Northwick Park
IDRI80	INRA, Paris
VAX	University of St Andrews
ICL2905	Huntingdon Research Centre
Perkin-Elmer	Royal Postgraduate Medical School
Harris	Lanchester Polytechnic, Coventry

Development of Version 3.07 has continued, aimed at release in 1982. Input has been simplified by allowing the dimensions of the data matrix to be assumed implicitly unless altered by the user, and by allowing assignment statements to be separate from directives. The handling of data for frequency distributions has been reorganised so that the data array is entirely under control of the user. New facilities in FIT CURVE include split lines and splines fitted directly, the extension of parallel-curve analysis to estimation of horizontal and vertical displacements, the analysis of heterogeneity for replicated data, and composite plots of parallel curves. (Ross and White)

Generalised linear interactive modelling (GLIM). This program (release 3) is now available at 421 sites in 31 countries. Its name often appears in the references of scientific papers in a range of disciplines, and it is increasingly used as the basis of courses in universities and polytechnics. As ideas on the successor to GLIM have developed it has become clear that a new name is required, and developments are reported below under that name.

Programs for interactive statistical modelling (PRISM). This system will include a kernel of housekeeping routines plus three self-explanatory modules GLIM4, AOV and GRAPH. Kernel routines written this year include a new tabulation facility, an array-calculation directive with APL-like features, enhanced debugging facilities and new structure-declaration directives, etc. (Baker and Harding, with Dr M. Green, Polytechnic of North London)

The GLIM4 module deals with the fitting of generalised linear models and contains extensions for dealing with models conditional on a given margin, and models applied to the margin of a table. Two algorithms will be available, based on the Givens and Gauss–Jordan methods. Model formulae now have a powerful notation for specifying contrasts for factors, and numerous other improvements to GLIM3 will be incorporated. (Baker, with Mr M. B. R. Clarke of Queen Mary College)

The AOV code follows closely that of Genstat, with appropriate syntactic changes in the way that the model is specified. A common algorithmic kernel will allow simultaneous updating of the code in both systems. (Payne and White, with Dr J. D. Henstridge, University of Western Australia)

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The GRAPH module is a new project started in the summer after many months of investigating the options available. It was decided that portability of the module could be ensured only by basing it on a graphics standard—in this case GKS, which is now the draft ISO standard. This approach allows the user to ignore details of the particular graphics device he is working on, since GKS performs all necessary adjustments to the output. The user language will contain high-level commands, such as one to draw a histogram, and low-level commands, such as those to move the pen and draw markers, characters, etc. The module will simplify the production of routine graphs as well as the drawing of high-quality material for publication. It is to be a fully interactive system that allows pictures on a monitor to be altered and rearranged before printing them. (Baker and White, with Mr M. Slater of Queen Mary College)

Microcomputers. During the year the Department acquired a Midas microcomputer with 256K bytes of core-store, two disc drives and graphical hardware driving a 12-in. graphics screen. The software includes a screen editor, compilers for four languages and a graphics package. A link to the local Prime 550 has been established and will allow files to be transferred between the two machines. We intend to use the Midas

1. to assess the viability of some modern computer languages for writing statistical software,
2. to make a preliminary study of statistical graphics,
3. to discover the feasibility of running some of our smaller programs (e.g. MLP) on microcomputers.

A start has been made on each of these projects. In particular a special routine has been written to control the segmentation of large Fortran programs such as MLP. It is hoped that the technique involved will transfer easily to other machine ranges, so enabling us to meet the growing demand from micro users for more sophisticated software. (Baker, Digby, Harding and Ross)

A general-purpose program for dynamic modelling on a microcomputer has been written for the Midas. It will cope with up to 400 equations, with a range of built-in functional forms including difference equations, switch and step functions, linear interpolation in tables, exponential smoothing and simple algebraic manipulations. The program will accept data in any order and test for completeness and uniqueness of solution. It can then be run for any chosen time period to produce both tabular and graphical output of selected variables. It is now available on a trial basis to assess its usefulness in modelling dynamic systems. (George)

Cluster Analysis Program (CLASP). Conversions have been completed for the CDC Cyber series by Dr D. Ratcliff of CSIRO and for DEC-10 by ADP Network Services. A Hewlett-Packard version is in preparation. An implementer's guide has been written to aid converters. (Ross and White)

Simple curve fitting algorithms. Algorithms for exponential and hyperbolic curves have been substantially improved to ensure optimal convergence properties for a wide range of data sets. The most difficult cases are those for which the data points are very unevenly spaced, or for which the fit is extremely poor. (Ross and White)

Overseas

Our ODA-funded unit survives, to continue its important work of providing a biometry service for agricultural research workers overseas.

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Overseas visits. Ryder visited Nairobi for a week in March to advise Mr J. B. W. Matata (Senior Biometrician, Ministry of Agriculture) on the statistical computing needs of the Ministry and on the training of junior statistical staff. He went to Botswana for 4 weeks where his visit was divided almost equally between the Agricultural Research Station, Gaborone, and the Central Statistics Office, Gaborone. Ryder gave seminars on experimental design and advice on the design and analysis of agricultural experiments that were being planned or were in the ground. At the Central Statistics Office, Ryder gave a course on our general statistical program Genstat, and helped staff to program their own analyses.

In September Riley visited the Falkland Islands for 4 weeks in order to (a) review proposals for pasture agronomy trials, (b) examine and report on 'cooperative' trials run by the Grassland Trials Unit (GTU), (c) form a view on proposals for a research programme on Falkland Islands geese, and (d) provide the GTU with general statistical assistance and advice. On her return journey she stopped off in Barbados for 2 days to look at intercropping work in the Caribbean.

Work on ODA projects. Ryder analysed various maize trials for the Ghurka Reintegration Scheme, Pakhribas, Nepal, and continued to produce analyses of agricultural trials in the Upper Region Development Project, Bolgatanga, Ghana. He also continued to handle the analysis of the data from the balanced-lattice cotton experiments organised by the Cotton Research Project, Ukiriguru, Tanzania.

Riley continued to handle the analysis of data from Burley tobacco trials in Malawi, and to analyse grass-species data from fertiliser-maintenance experiments in the Falkland Islands. Preece continued to analyse data from tobacco and sugar-cane trials in Paraguay, and analysed some maize and rice trials for the Toledo Rural Development Project, Belize.

Ryder analysed a large body of data from two sheep trials (surveys) run in Colombia by Mr and Mrs I. W. Skea. F. Yates (Computer Department) and Preece advised ODA on some agricultural research proposals for part of the United Kingdom/India Fertilizer Education Project (FEP) to be run by the Hindustan Fertilizer Corporation (HFC).

Microcomputers and data entry. Ryder had discussions with Mr I. M. Johnson (Deputy Head of the Overseas Division, National Institute of Agricultural Engineering, Silsoe) about microcomputers' potential for data-entry and data-tabulation in agricultural research in developing countries. The discussion related particularly to an Atom microcomputer, which uses a form of the Basic programming language, and to the possible use of floppy discs and cassettes for transferring data and supplementary information (on field plans, etc.) from the research site to the United Kingdom. Ryder has strong reservations about the use of the Atom in such work, and has the more general concern that satisfactory checking and validation of data may prove difficult to incorporate in such a data-entry system.

Other cooperative work. Work continued for Dr J. Bolton (Bangladesh Agricultural Research Council) for whom Riley analysed data from intercropping trials at six sites. Statistical work was resumed for the Mahaica-Mahaicony-Abary Agricultural Development Authority, Guyana, for whom various rice experiments were analysed by Preece. Ryder analysed some crop-spacing experiments for Sebele Research Station, Botswana.

Methodology. Preece completed a major review of the state of the art of the design and analysis of experiments.

Riley continued compiling her bibliography of intercropping, in collaboration with Drs R. Willey and C. Floyd (ICRISAT). She examined the merits of different graphical

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presentations of statistical indices (e.g. the Land Equivalent Ratio, and the more general Effective Land Equivalent Ratio) used to indicate the benefit gained from intercropping.

Training and visitors. Three overseas biometricians visited the ODA Unit for training, particularly in the use of statistical computer programs developed at Rothamsted. These visitors were: Mr J. E. Chiria, biometrician, Namulonge Research Station, Uganda (November 1980 to February 1981); Mr Chow Chee Sing, statistician, Palm Oil Research Institute of Malaysia (2 weeks, summer 1981); Señor M. A. Rodríguez Peña, Head of the Biometric Unit, Centro de Investigaciones Agricola del Golfo Centro, Mexico (1 week, August 1981). All three were especially interested in the general statistical program Genstat and in the program GLIM for fitting ordinary and generalised linear models. All three received detailed instruction and supervision from Ryder.

Some 35 visitors were received, who were concerned with agricultural work in Bangladesh, Colombia, the Falkland Islands, the Gambia, India, Kenya, Malawi, Malaysia, Mexico, Papua New Guinea, Sudan, Tanzania, Thailand, Trinidad and Tobago, and Zambia.

Staff and visiting workers

J. H. A. Dunwoody retired after 34 years service with the Department and Mrs Doris A. C. Court retired after 33 years service. J. Wood and Catherine M. Garnett left to take up other posts; Susan Greenland, Geraldine F. Kirby, Janice R. Messer and Mandy McCarthy left during the year. B. J. George, Rosemary A. Bailey, A. Gnanasakthy, Annette M. Pooley, S. A. Harding, Suzanne J. Clark and A. W. A. Murray joined the Department. Lilian B. Robertson, Valerie Payne and Sheila Neale joined the secretarial staff.

J. A. Nelder gave a series of lectures on Generalised Linear Models at the Institut für Höhere Studien und Wissenschaftliche Forschung, Vienna. In June he was awarded an Honorary Doctorate by the Université Paul Sabatier, Toulouse. He attended two conferences in the United States of America; in Pasadena on the computing Environment for Mathematical Software and in Boulder, Colorado, on the Relationship between Numerical Computation and Programming Languages. In November he spent 2 weeks with the statisticians of EMBRAPA in Brasilia and afterwards went on to the 43rd Session of the International Statistical Institute in Buenos Aires.

J. C. Gower visited Australia in May as a guest of CSIRO and lectured at the Australian National University and at the Universities of Western Australia, Adelaide, Melbourne, and Brisbane, etc. In June he gave the keynote lecture at the Annual Meeting of the Classification Society in Toronto, and lectures at Bell Laboratories and IBM in the United States of America; in December he was invited to lecture in Delhi and Calcutta (including the Golden Jubilee Meeting of the Indian Statistical Institute).

In March G. J. S. Ross lectured in Copenhagen and went on to the 6th Biometric Colloquium in Templin and the 5th International Summer School in Statistics in Sellin, both East Germany. J. N. Perry read a paper at the first meeting of the International Association of Science and Technology for Development, held in Lyon.

The Department was well represented at the Genstat Conference in Wageningen, Netherlands, in October. Talks were given by N. G. Alvey, P. G. N. Digby, P. W. Lane, J. A. Nelder, R. W. Payne and H. R. Simpson. J. C. Gower and D. A. Preece gave talks to local groups of the Royal Statistical Society in Avon, Hertfordshire and Bedfordshire respectively. Rosemary A. Bailey gave an invited paper to the York meeting of the British Association for the Advancement of Science.

Janet Riley, with Mr R. Mead of Reading University, read a paper on intercropping to a Research Section meeting of the Royal Statistical Society.

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