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ROTHAMSTED RESEARCH

Report for 1982 - Part 1

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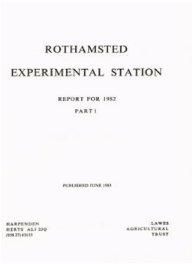

Statistics Department

J. A. Nelder

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STATISTICS DEPARTMENT

J. A. NELDER

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Introduction

The Department continues to play its tripartite role of (i) providing a statistical service for the design, analysis and interpretation of data from experiments and surveys, (ii) devising applicable statistical techniques, and (iii) providing the computing tools necessary for (i) and (ii). We have continued to provide a service to ADAS for the design and analysis of both arable and animal experiments, and to house the ODA-supported biometrics unit. The newly formed Rothamsted Computing Unit is associated with the Department, and we look forward to fruitful collaboration at the interface between computing and statistics.

Practical applications

The number of analyses of data has increased for both Rothamsted and ADAS work, with a reduction in turn-round time (averaging 5·8 days), despite problems with the Jacquard J100 minicomputer and a shortage of data-processing staff.

The multidisciplinary experiment on factors limiting yield of wheat has involved much data preparation and analysis, and all data are being retained on backing store for easy future reference. (Todd and Church, with Prew, Plant Pathology, and many others)

A mathematical model was developed of the flight of the pea moth through a crop to several equally spaced pheromone traps aligned along the mean wind direction. Initial results suggested that the trap interactions predicted by the model mimic the available data well. The model assumes that classical diffusion equations hold instantaneously within a crop, that concentrations of pheromone within the trapping zone are greater than zero everywhere, that moths fly up the mean wind direction as long as concentrations are greater than a threshold, that they cast at such a threshold and that they may be captured by a trap if they fly within a certain distance of it. Appetitive flight is allowed. A program to simulate this model was written in Genstat. Analysis was completed of data concerning catches of pea moth in a line of three interacting pheromone traps along the wind. Catches from 255 occasions were analysed. The centre trap caught a constant proportion of the total within an afternoon flight-period. Catches covered a greater range of trinomial proportions than with previous data. The proportion of the total catch from the upwind and downwind traps which were caught in the upwind trap seemed to vary systematically during a flight period. These observations provide important data to match against the model described above. (Perry, with Wall, Entomology)

Results presented in previous papers on the relationship between grain N%, yield and fertilizer N were updated. Grain yield and N% from recent experiments at Rothamsted were compared with results from Belgian experiments. Some large yields, from Rothamsted experiments receiving pesticide treatments, lay outside the range of previous results, but these were associated with low N%. Grain N% still showed a linear relationship with fertilizer N. (Lane, with Benzian, Widdowson, Darby, SPN and Dr L. H. J. Verstraeten, University of Louvain)

Soil P measurements have been made over 14 years on the Rotation II Experiment at Saxmundham. A single form of curve for the decline in soil P was fitted to data from plots with very different initial soil P levels. Parallel curves were fitted for each plot and the differences in initial soil P levels were expressed as effective time lags between the plots. The best relationship between soil P and time was log linear, and the variability of soil P was roughly constant, so a generalized linear model with Normal errors and a log link function was used. (Lane, with Johnston and Poulton, SPN)

Dr R. J. Russell and Dr A. B. Wells (Goldsmiths' College, London) are investigating the social behaviour of Lister rats. They need to compare rats in pairs, making all comparisons in the least possible time. Suitable designs have been generated for these experi-

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ments and the methods involved have been generalized to answer some related questions recently posed in the literature. (Bailey, with Dr D. F. Holt, Warwick University and Mr D. C. Goldrei, Open University)

Work for ADAS

Crop experiments. Dr A. Lloyd (ADAS, Newcastle) is national sponsor for the SB15 trials comparing the effects of urea and ammonium nitrate, and two different timing regimes, at different levels of nitrogen, on the yield of winter wheat. Collaboration with Lloyd on the design of these trials produced a restricted randomization scheme with enough layouts for all the sites involved in 1982. Analysis showed that the yield with ammonium nitrate is usually at least as great as that with urea, at all levels of nitrogen; however, because of the relative costs of the two types of fertilizer more profit from a given outlay may be obtained by applying urea. Also, it is nearly always beneficial to apply 40 kg ha^{-1} (of the total spring nitrogen application) at GS21 in addition to that applied at GS30 rather than all at GS30; the benefit increases linearly with the total amount of nitrogen applied. (Bailey)

A review of past ADAS experiments on the nitrogen fertilization of winter wheat involved organizing data preparation and analysing the data using Genstat. Curves were fitted to characterize the yield-nitrogen response function at each of 152 sites. Where possible, an estimate of the economic optimum level of nitrogen application was derived from the fitted curve for each site, together with a correction for bias and an estimated standard error. Histograms of optimum nitrogen application have been used to explore the relationship of optimum level with known features of the sites. No clear picture has emerged so far. There is much variation in optimum fertilizer application; for many sites, economic returns from additional fertilizer might be expected at levels above the maximum tested. Although the experiments tested the effects of splitting the fertilizer application between different times, curves were fitted only to means over timing treatments. A simple three-parameter curve was used at all sites. Experience with these data suggests that the model used is not entirely adequate. (Murray, with Dr R. Sylvester-Bradley and Mr P. M. R. Dampney, ADAS)

The PA31 series of experiments, testing four times of spraying fungicide on winter wheat in a 2^4 structure with 3 blocks, continued for a third year in 1981. Summaries were produced for the 15 sites in 1981, and the total of 42 sites for the 3 years. The results for 1981 tended to agree with those for previous years, with the two middle times of spraying, at GS37 and GS51, being the most effective and the other two, at GS31 and GS71, not producing much increase in yield. Various site factors were considered in an attempt to form a predictive model for the response to the sprays, but little consistency could be found in the results. Work is continuing. (Dyer)

Sylvinite, a mixture of potassium and sodium salts, is likely to be an important source of potassium fertilizer in the future. The SA67 series of experiments was set up to test whether potassium present in sylvinite was used as effectively by grass as potassium contained in more usual mineral fertilizer. The general conclusions were that potassium increased yield at virtually all sites, although some sites took longer to exhaust their initial soil potassium than others, and that responses to sylvinite were comparable with those from the usual potassium source. (Dyer)

Livestock experiments. Work included the analysis of the results from a trial investigating the effect of sequential Ralgro implants in the ear on the growth of Friesian bull calves. The trial commenced with calves approximately 7 days old, and Ralgro, a growth promoter, was implanted on one or more of the following three times during the trial: on arrival, at 90 days and at 180 days. Since the Ralgro had no effect on the animals that

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were implanted on arrival the treatments could be divided into two groups, those that received an implant at 90 days and those that did not. The animals that were implanted at 90 days grew 0·11 kg day^{-1} faster from 90 days to slaughter (MLC Fat Class 2, 288 to 351 days) than those that were not, and this was unaffected by the further implant at 180 days. (Pooley)

The effect on the microbiological population of milk of changing all the rubber of the plant in a milking parlour was investigated. Counts of total thermoduric, psychrotrophic and coliform bacteria were monitored weekly. At the 14th week of monitoring the whole plant was re-rubbered and then clusters 1 to 5 were re-rubbered after weeks 23, 31, 39, 46 and 51 with all cluster-rubbers being changed again after week 69. To try to smooth out some of the high variability of this microbiological data, 5 week moving-averages were calculated, transformed and plotted so that any trends could be seen. Transformed data taken from time periods between the re-rubberings were analysed to see if the counts dropped after each rubber change but inconsistencies in the results for different clusters made conclusions difficult. It appeared that thermoduric bacteria were affected more than psychrotrophs or coliforms, although many of the significant differences found did not bear any relation to any re-rubbering. For plant rinses, some periods were more variable than others and the periods of high variability were also not consistent across the separate counts. Similar results were shown for milk, milk tank and milk tank bung counts, suggesting that frequent re-rubbering of milking parlours is not justified. (Pooley and Altman)

A ring 'test' was set up to investigate the repeatability within a laboratory and reproducibility between laboratories of the Tilley and Terry technique used to determine the *in-vitro* digestibility of straw. Five laboratories were involved and each was allowed to use its own particular refinement of the technique on 22 straws. Unfortunately, the design of the trial was unbalanced so that the estimation of the components of variance for repeatability and reproducibility was far from straightforward. The analysis showed that while the repeatability was acceptable, one laboratory could not reproduce the results of another with any accuracy. Further work showed that the *in-vitro* method was a poor predictor of *in-vivo* digestibility. (Altman)

An analysis has been completed of a large trial to investigate the source of errors in the dacron bag technique for estimating protein degradability, and to estimate the type of animal and bag that should be used. Two forages and two protein supplements were each incubated for two different times in both sheep and steers in four different periods. The dacron bags used in the steers were of three different ages, since age can affect pore size which in turn affects nitrogen disappearance. Replication was such that three supposedly identical sub-samples could be sent to the analytical chemists from any one sample per time, period and animal. Analysis of the components of variance showed that the component between sub-samples was always the largest and this often made it impossible to estimate the other components, indicating that some refinement in technique may be required.

There were significant differences between animals for the two concentrates and between periods for all feeds. These would have little effect on the eventual protein degradability value unless the response to time was different, that is, if significant interactions were found between time and the animal used or between time and period. The former were found for hay and soya and the latter for all feeds except fishmeal. Thus, in future both types of animal may have to be used, and the trials done more than once in different periods. There was little evidence of a bag age effect, except with hay, where the newest bags gave the lowest nitrogen disappearance values. (Altman)

The analysis of an experiment designed at Rothamsted, to investigate the effect of anthelmintic treatment on the milk yield of dairy cows, has been completed. Although

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the 9166 cows that completed the trial were well below the numbers required by the design, the analysis showed that over all age groups, anthelmintic-treated cows produced about 42 kg more milk, 1·8 kg more fat and 1·4 kg more protein per lactation than those that were untreated or received a placebo. However, these effects were subject to large statistical errors, so that the 95% confidence interval for the milk yield response ranged from 2 to 82 kg. The effects were also not consistent over all age groups with the older cows unexpectedly giving the best results. (Altman, with Dr J. R. Michel and Mr M. Richards, Central Veterinary Laboratory)

The long-term pig breeding experiment on criss-cross mating, referred to in earlier Annual Reports, is now in its final phase. We analysed two more years' data and produced pooled estimates for the generations in which the breed proportions were approximately $\frac{2}{3}$ and $\frac{1}{3}$. So far the first-cross hybrid sows have produced on average 0·4 piglets more per litter at birth than criss-cross sows, but this average conceals a marked difference in response between the participating farms. Summaries were presented to a meeting of farm cooperatives in London and, in poster form, at the Smithfield Show. Analysis of the performance of progeny from the respective crosses showed few differences between the two crossing systems. (Spechter and George)

During spring 1982 litter size and piglet mortality were monitored by ADAS staff on 21 commercial units. The objective was to investigate in some detail post-natal mortality on commercial units and its relation to factors such as litter size, month of farrowing and age of piglet. About 6000 data records have been analysed. Crushing and starvation accounted for about half of piglet mortality. Scouring was also an important cause of piglet death. Most deaths occurred within 48 h of birth. (Spechter, with Mr P. Smith, ADAS)

Surveys. Paper 23 was written on the variability of wheat yields in England and Wales under practical farming conditions (Church and Mr R. B. Austin, Plant Breeding Institute), and we collaborated with other members of the Wheat Commodity Group on supplementary analysis and reporting of the 1979 multifactorial experiment on winter wheat at Rothamsted. (Church and Todd)

There is continuing interest in obtaining information from surveys about factors influencing yields. Although we view the interpretation of such information with much caution, and regard surveys as no substitute for critical experiments, data from them should not be neglected when reliable yields are available as a by-product of other survey activities. Together with Broom's Barn, our collaboration on planning and analysis of surveys of the sugar beet crop was extended. Pre-harvest sample yields, primarily obtained for other purposes, have been linked to survey information on crop conditions and growers' practices and critical examination of these data is in progress. Factors associated with differences in the incidence of virus yellows have also been examined using limited information for 1981 only. Objective methods have been developed for predicting sugar factory throughput from pre-harvest samples using yield data for 10 years. (Church, Gnanasakthy and Leech)

Fertilizer practice. Results of the 1981 survey were reported (Church and Leech) and a similar survey of 1400 farms in England and Wales was organized for 1982 in collaboration with ADAS Regional Soil Scientists and representatives of the Fertilizer Manufacturers' Association. Preliminary results based on the first half of the sample show that the main trend in practice is a continuing increase in N use on winter cereals, but the sharp increase on spring cereals in 1980, which was tentatively attributed to weather conditions, has not been sustained. More detailed examination of data on methods and timing of cereal manuring over the last 4 years showed that both numbers of N dressings

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given and average individual dressings have increased, while differences in practice associated with previous cropping remain small compared with those between recommendations. (Church, Elsmere and Leech)

Calf-rearing survey. Tabulation and critical analysis of this behavioural study coordinated by the Department of Animal Husbandry, Bristol University, was completed and contributions made to preliminary reporting. A main statistical interest has been the assessment of the importance of subjective differences between observers and their elimination from key comparisons by linear modelling. (Church, Gnanasakthy)

Other surveys. Consulting on other surveys and sampling methods included work for MAFF's Economics Division and for ADAS Agricultural Science and Veterinary Services.

Theory

Quasi-complete Latin Squares. When Latin Squares are used for experiments with a genuine two-dimensional layout, the experimenter sometimes wants to ensure that any effects of neighbouring treatments are balanced over the experiment. In several recent papers, G. H. Freeman defined a Latin Square to be *quasi-complete* if each pair of treatments occurs twice as horizontal neighbours and twice as vertical neighbours. A method of constructing, enumerating and validly randomizing such squares has been discovered. (Bailey)

Restricted randomization. Ordinary randomization can occasionally produce layouts in which the pattern of treatments is too much like the spatial patterns of the plots. There are many reasons why it is not good practice simply to re-randomize; for example (i) lack of perceived objectivity, (ii) the ease of finding *post hoc* faults in *any* randomization, (iii) invalidation of the randomization-based analysis. With restricted randomization one specifies unacceptable layouts in advance, and finds a randomization scheme which does not produce them and yet is varied enough to ensure validity of the analysis. A general method, and a catalogue of good initial arrays for several combinations of block size and number of levels of treatment factors, is given in Paper 15. (Bailey)

Individual-differences scaling. An alternative model for individual-differences scaling that can be fitted by a simple algorithm has been investigated. Initial comparisons with the results from the usual model and algorithm show some differences that need elucidation. The new algorithm can handle incomplete data, allowing the use of experimental designs with balanced incomplete data-sets, so saving time and resources. (Digby, with Dr H. J. H. Macfie, MRI)

Metrics and multidimensional graphics. A review of similarity and related measures included a study of metric properties of dissimilarity coefficients. Some coefficients are non-metric, some metric and some Euclidean. Only Euclidean metrics lend themselves readily to graphical plotting so these results are important in the development of computer graphic representations of multivariate samples. However, it turns out that two coefficients, one of which is Euclidean and the other not, may be related by a near-linear monotonic transformation. (Gower)

Uniqueness of solutions in curve fitting. It is well known that when fitting a non-linear statistical model there are some data sets for which there is no solution and others for which there are several solutions. Some models allow data sets to be classified by the

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number of associate solutions. For example, the exponential curve has three parameters; with four points the number of solutions is unaffected by changes of origin and scale, so the description of data-sets may be reduced to two dimensions by fixing two of the data points, and the number of parameters reduced to one. Points corresponding to a given parameter-value form loci on the two-dimensional chart; where these loci intersect there are multiple solutions, and there may be blank areas indicating absence of solutions. The loci may be displayed on a third dimension to form a ruled surface; the surface overlaps like a breaking wave over the region of multiple solutions, as in catastrophe theory. (Ross)

Parallel model analysis. To compare parameters of the same model fitted to several data sets, a hierarchical sequence of models is required, in which the first q parameters are common to all sets and the remaining $p–q$ parameters are separately estimated for each set. Rapid procedures are required for fitting these models efficiently, and for estimating the standard errors of particular parameters. Simultaneous fitting of all parameters tends to be unreliable. When the specific parameters are all linear the problem reduces to a single optimization with respect to the common parameters. When non-linear, two possible approaches are to alternate the fitting of the two sets of parameters and to perform a two-level nested optimization of one set within the other. The alternating approach is simple to program but slow to converge; the nest approach is reliable but awkward to program. A compromise was devised which works very well for the calibration curve problem, that of fitting the same curve to all data sets displaced on one axis by an amount to be estimated. Approximate standard errors are a by-product of this method; they depend on being able to ignore correlations between specific parameters of different data sets. (Ross)

Statistical programming

Genstat. Eight conversions of Genstat 4.03 were completed in 1982. Dr F. W. Maier of the University of Salzburg modified the standard IBM version to run under DOS. Dr R. Valder of the University of Düsseldorf prepared the Siemens versions which superseded the last extant version of release 4.01 (there were no extant users of 4.02). The version for Honeywell computers running under MULTICS was produced by Mr D. Clark of the University of Bath. The remaining five conversions were for machines on which Genstat had not appeared before:

1. Harris	(Mr S. Morris, Chelsea College)
2. Perkins-Elmer	(Mr G. Jagger, Life Science Research, Occold)
3. SEL	(Mr C. Hallam, Shade, Calne)
4. Telefunken TR440	(Mr A. Schütt, University of Osnabrück)
5. Xerox Sigma 6	(Mr G. West, H.M.G.C.C., Hanslope)

The CRAY conversion did not proceed and that for the HP3000 seems unlikely to be completed. The final state of release 4.03 shows 25 separate conversions completed, on at least 18 different machines from 17 distinct manufacturers. (Simpson)

Code has been written for a new directive, PREDICT, to form predictions from generalized linear models fitted to unbalanced data. Predictions may be adjusted for some effects in a model, using marginal, equal or other weights. The GLM section was modified for release 4.04 to improve output and provide more flexibility. For example, new options were added to control stepwise regression and a new keyword to allow formation of standardized residuals.

A new directive, FOURIER, to a specification provided by Dr G. Tunnicliffe Wilson

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(Lancaster University), has been added to Genstat using a published fast-Fourier-transform algorithm.

Ross's Gauss–Newton algorithm, written originally for MLP, has been included in Genstat and the opportunity taken to remove the limits on numbers of model parameters. (Lane)

New facilities in the Mk 4.04 release of Genstat ANOVA include (i) the printing of probabilities for F ratios in the AOV table, (ii) the ability to take an output structure, formed in one ANOVA, and re-input it to a subsequent ANOVA (particularly useful with interactive versions of Genstat) and (iii) the extraction of covariate regression coefficients for future use. (Payne)

Documentation and support. The third Genstat video-tape, *Users Talking*, is now available. This shows interviews with users of Genstat, and was filmed at the 1981 Genstat conference. (Alvey, Lane and Nelder, with Dr D. Clark and Mr A. Cotton, London University Audio-visual Unit)

A primer for Genstat, entitled *An Introduction to Genstat*, has been published by Academic Press. This introduces the basic facilities of the system, with the aid of examples from a wide range of applications (Alvey and Lane, with Dr N. Galwey, Cambridge University). A pocket-sized reference card has been prepared to act as an aide-memoire to the basic Genstat syntax. (Harding, Lane, Payne, Todd and White)

Genstat manuals are now available in three languages other than English. In addition to the Italian Manual (written and published last year by Dr C. Brambilla and Dr P. Gherardini of the Instituto per le Applicazioni del Calcolo, Rome), a French Manual written by Professor R. Tomassone and other staff of the Paris Universities and of the Institut National de la Recherche Agronomique), and the English manual has been translated into German by Professor C. E. V. Leser of the University of Leeds.

Courses on Genstat have been given at Bristol, Chichester, Guildford and Harrow in Britain, and abroad in Rome and in Hyderabad (Alvey, Digby, George, Lane, Murray, Riley and Simpson). Genstat was demonstrated at the COMPSTAT 82 Conference in Toulouse. (Gower, Nelder and Payne)

Genkey. Genkey Mk 3.02 was converted to the CDC 7600 range. Mk 3.03 is in preparation and will contain facilities for automatic typesetting of keys, using the Oxford University Lasercomp system. (Payne)

MLP. Version 3.07 was released after a period of testing at Rothamsted, and conversion is complete or in progress on 13 machine ranges. Over 40 sites are now using 3.07 or earlier versions. (Ross, Harding)

New facilities under development in version 3.08 include the extension of parallel-curve analysis to estimate displacements in the x variate. For frequency distributions, several samples may now be processed to give a between-and-within-samples analysis. The Poisson–Pascal distribution has been added to the set of discrete distributions. Parallel-model analysis in FIT MODEL has several forms: non-linear parameters common to all sets, the first k parameters in common, or the same model for each set apart from a variable origin in one variate. New functions for integration (using cubic interpolation) and differential equations (using the Runge–Kutta method with an auxiliary sub-routine) simplify the specification and solution of models defined by differential equations.

PRISM. Work continues on the development of the PRISM system. The syntax has been developed during the year to provide a unified system for all directives with easily

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included 'prompt' and 'help' facilities. The difficulties of designing a syntax that is both flexible and brief for the expert and 'user-friendly' for the novice has delayed the project. However, language design is a major factor in setting the style and accessibility of a package and well merits the time spent on it. Coding completed this year includes the program-control directives, simple data-reading, table manipulation and printing, the fitting and displaying of generalized linear models, simple graphics and histogram-plotting. (Baker, White, Payne, with Dr M. R. B. Clarke and Dr M. Slater, Queen Mary College, and Dr M. Green, Polytechnic of North London)

The AOV module of PRISM, which provides analysis of variance for designed experiments, is virtually complete. AOV is based on Genstat ANOVA, although many changes have been necessary to allow the code to run on smaller computers, and to tailor the output for interactive working. (Payne and White)

A successful GLIM/PRISM conference was held at the Polytechnic of North London in September. Over 80 participants attended the 3-day series of lectures, demonstrations and discussions. Topics ranged from the new facilities of PRISM to the competing facilities of a language like APL, from applications in genetics to insecticide evaluation trials, and from proposed extensions to the syntax of structure formulae to inferences based on the likelihood function. The proceedings were published simultaneously with the conference.

Other computing. Work progresses on the implementation of GKS, the international standard for two-dimensional graphics. Most of the high-level output routines are now complete and all the segment-handling is finished, but a large part of the input-handling remains to be coded. Tektronix, Datatype, Sigma and general GINO-F and GHOST back-ends have been written. A more general device-independent back-end that may easily be adapted to specific devices has been designed but not coded. When written it will simplify the tasks of adapting GKS to new devices. (Baker, White, with Dr M. Slater, Queen Mary College)

Microcomputers. The Midas microcomputer acquired last year has been used to implement an overlaid version of MLP. Initial versions ran slowly; however, improvements to the speed have been made and a viable version of the program is available. This work is encouraging and suggests that microcomputer versions of some of our other programs may be possible. The computer language Pascal has been used on the Midas to implement a general-purpose directory to enable statistical software to store attributes of statistical data structures, Paper 28. (Digby, Harding, Payne and Ross)

To bring the new Watanabe flat-bed plotter into use with the Midas microcomputer, a set of functions has been written in CBASIC to implement the functions available in the plotter, and to generate some additional functions such as automatic scaling to any chosen page size, the scaling and annotation of graph axes, and the production of line and continuous graph plots. These may be included at compile time in any CBASIC program and called as functions with parameters passed from the main program. Using these functions, several general-purpose graph-plotting programs have been written. These will accept data and instructions at run time to produce a variety of labelled graphs with a choice of symbols and line types. (George)

Overseas

Our ODA-funded Unit continues to provide a biometrics service for overseas agricultural research, particularly in relation to field experimentation. (Preece, Ryder and Riley)

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Overseas visits. In October, Ryder visited the Pakhribas Agricultural Centre, Nepal, to give statistical advice on the plant and animal experiments there. In November/December, Preece visited the Sudan, primarily to give advice at the Um Banein Livestock Research Station; while in the country, he also visited the Agricultural Research Corporation and the University of Gezira, both at Wad Medani, and the University of Khartoum.

Work for overseas projects. As usual, the experiments analysed were from many countries, including Tanzania (Preece, Ryder and Riley), Guyana, Belize and Paraguay (Preece), and Malawi (Riley and Ryder). For Malawi, as in previous years, Riley handled the data from a large set of Burley tobacco trials; she provided analyses for individual sites and summary analyses for groups of sites.

For an ODA project in Botswana, Ryder calculated the amounts of solar radiation falling on and being intercepted by various sorghum plots where the between- and within-row spacings varied. The data had been collected automatically, on paper tape.

Riley continued her collaboration with Dr A. B. Carles (University of Nairobi) on the analysis of a large data set involving the weaning weights of Kenyan calves.

For Messrs J. L. Grant and J. de W. Tiffin (Zimbabwe), Ryder analysed data from 6-year livestock production studies. Grant's data involved cow weights and progeny weights for cows assigned to different feeding regimes. Tiffin's data related to the effects of two weaning treatments, each in combination with two nutritional treatments, on each of two breeds of ranch cows; the analyses were of calf growth, cow fertility, and milk yields.

Riley continued her work for the Grasslands Trials Unit in the Falkland Islands. Data were received for three large sheep trials and three grass-species experiments on white-grass; the data for the latter were incomplete, because of the Argentinian invasion, and only simple analyses could be done. Also analysed were three fertilizer-for-maintenance grass trials. At the end of the year, results began to arrive of initial assessments from the Camber grass-species trials, designed when Riley visited the Islands in 1981; these trials survived the invasion, and already indicate that European grass species can establish well in the Falklands.

For Dr P. B. Tompsett (Royal Botanic Gardens), Ryder analysed data on the germination of tree seeds submitted to different storage regimes after being brought to this country from Papua New Guinea.

Microcomputers. Ryder reviewed a set of statistical analysis modules, SAM, for use on a microcomputer. His report appeared in the Computer Department Newsletter in August.

Other co-operative work. For Dr T. W. Parr (Institute of Terrestrial Ecology), Riley analysed an experiment comparing different seed rates for mixtures of grass species.

Methodology. In collaboration with Mr R. Mead (University of Reading), Riley has continued her work on the methodology of intercropping research. Her bibliography of intercropping, produced in collaboration with Drs R. W. Willey and C. Floyd (ICRISAT), neared completion.

Computing Unit

The Computing Unit came into existence on 1 October and is staffed by some of the members of the old Computer Department. These staff bring several areas of expertise with them, notably in graphics, microcomputer systems, communications and systems.

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The Unit staff also brought with them several projects already being undertaken for Rothamsted Departments; these projects continue and new projects have started. The Unit gives the Station the opportunity of integrating the various Departmental computing activities associated with their research programmes, thus enabling the full potential of rapidly developing modern computing techniques to be utilized.

The major work of the Unit since establishment has been to begin the assessment of the Station's current and future computing requirements and to prepare for the installation of a new general-purpose computing system in 1983.

Much of the work of the Unit is in collaboration with Rothamsted Departments; other investigative work is inspired by known objectives of the research activities, and aims to provide a range of software tools that will broaden the scope of standard products and introduce the most recent computing techniques.

Graphics. SURFACE II is a package for the display of spatially distributed data. It was obtained from the University of Kansas and has been mounted on the System 4. An implementation has also been provided on the Prime 550 system for the Molecular Structures Department (Bicknell, Summerfield). A number of errors were found in the package and extensive testing was undertaken to identify and cure all problems arising from them.

AREAS is an image-processing package obtained for the Soil Survey of England and Wales from the University of South Dakota. It has been implemented on the Prime 550 with modifications to produce output files compatible with GHOST 80. The output files can be transferred to System 4 for plotting on a Benson drum plotter. (Bicknell, Summerfield)

GEN3D is an interactive program (Summerfield) for drawing three-dimensional graphs from regularly spaced data. This program now includes contour plotting (Bicknell) and is available on the Prime 550.

A small graphics suite has been produced for CP/M-based microcomputers to interface with flat-bed plotters (Verrier). This software is used by the Entomology Department and Soil Survey of England and Wales on their Midas microcomputers. Further development is under way to include screen and printer displays from the same package. (Summerfield)

Data logging. A Microfin hand-held data-logging terminal for the collection of field data has been purchased by the Soil Survey. This terminal can be programmed to allow user-defined data-entry formats. The production of the necessary program is facilitated by a special development system which has been obtained from Microfin. The development system has been converted to run on CP/M systems (Barrett), and programs and data can be loaded to and from the Microfin terminal directly from the CP/M system. The terminal will undergo field trials early in 1983.

Service activities. The Unit provides a service role for general-purpose computer equipment within the Station. To date, hardware and system maintenance for the main Jacquard word processor system and system maintenance for the Midas microcomputers of Entomology, Soil Survey, Soil Microbiology, Biochemistry, together with the Unit's own systems, are all covered by the applications and systems-support groups. Other computer systems will be supported by the Unit as our expertise grows to match the requirements.

Service activities frequently lead to long complex investigations and software development; two examples of the Unit's activities in these areas are outlined below.

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Data preparation. In October, the data-preparation service switched from data entry on punch cards to a key-to-disc system using a microcomputer. The commercially available DATASTAR package was chosen for the data-entry software. DATASTAR was known to be inadequate, but was the best available product, and detailed investigation (Lessells, Thomas) led to the design and development (Higgins, Lessells) of a replacement data-entry software system that can handle hierarchical forms of data, and provide simple verification and good error messages. The data-preparation service produced 6000 card-image equivalents in October alone. It is anticipated that the service will have capacity for producing a minimum of two million characters of verified data per annum.

Media conversion. Programs and data files are obtained on floppy discs from many microcomputers both within the Station and from external sources. There is little standardization of the physical format of such discs, and we have been investigating the reading of files in diverse formats; software is now available to take the files and transmit them to the Prime 550 system for forwarding to System 4. Discs from DEC RT11 systems, Casu, Rair and Midas CP/M systems can currently be converted. (Moore, Pallett)

Staff and visiting workers of the Department and Computing Unit

N. G. Alvey retired in May after 16 years with the Department. Sheryl L. Brunton and Sheila Neale left. Diane P. Dawkins and Angela C. Piears joined the secretarial staff.

J. A. Nelder visited the National Bureau of Standards and the Office of Naval Research in Washington, DC, for a week in April. At the end of May he lectured to the Statistical Society of Canada on 'An heretical view of linear models', had discussions with the statisticians of Agriculture Canada and visited the University of Toronto. For 3 months from September, he was a Visiting Fellow at the University of Western Australia, and also lectured at the University of Adelaide and other centres.

J. C. Gower gave lectures at the NATO Advanced Study Institute on 'Numerical taxonomy' at Bad Windsheim, West Germany and the International Union of Food Science Technology Symposium on 'Food research and data-analysis' in Oslo. He gave a series of lectures to the NATO Advanced Study Institute on Data Analysis at Montreal, Canada; this was also attended by P. G. N. Digby.

R. W. Payne spent 2 months in Brisbane as a guest of the CSIRO Division of Mathematics and Statistics. J. Riley gave a Genstat course to overseas workers attending a University of Reading summer course on 'Management and analysis of statistical data'.

The Department was well represented at the COMPSTAT 82 Conference at Toulouse. R. J. Baker, P. G. N. Digby, J. C. Gower, R. W. Payne, G. J. S. Ross, and R. P. White contributed papers and talks, and Genstat, MLP and PRISM were demonstrated. At the Biometrics Conference, also in Toulouse, talks and papers were given by R. J. Baker, P. G. N. Digby, J. N. Perry, D. A. Preece, J. Riley, and G. J. S. Ross. R. A. Bailey gave a lecture at the first Anglo-German Statistical Conference in Dortmund. J. Perry gave an invited paper at the Royal Statistical Society conference in York, and R. J. Baker, J. C. Gower, and J. A. Nelder addressed local groups of the Society. D. A. Preece organized the session entitled 'Teaching of the design and analysis of experiments' at the International Statistical Institute's First International Conference on the Teaching of Statistics, held in Sheffield in August; he also contributed a paper to that Session. B. J. George gave an invited paper at the ADAS Soil Scientists Technical Conference at Loughborough, and H. H. Spechter gave an invited paper to the UK Branch of the World Poultry Science Association.

Professor M. Greenacre from the University of South Africa paid two visits to the Department, the first of 4 months duration and the second of 3 months. Miss Gul Alpar

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from McMaster University, Canada, has been with the Department since 4 August and Dr Y. Schektman of Paul Sabatier University, Toulouse, visited for 2 weeks in February and again in June. Dr N. Carter of the Game Conservancy Board is modelling the effects of predators on cereal aphid populations and will be with us for 15 months. Dr G. N. Wilkinson, University of Adelaide, visited for 2 weeks from 22 November. Visitors to the ODA Unit included Mr M. A. Malik from Pakistan, Mr Smarn Chinbenjaphol from Thailand, and Mr J. L. Grant and Mr J. de W. Tiffin from Zimbabwe.

K. E. Bicknell serves on the GHOST Graphical Technical Committee, has been elected to the UK Eurographics Committee and also lectured to the Inter-Universities Workshop on Census Data on the use of SURFACE II.

F. Yates received an honorary D.Sc. from the University of London.

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COMPUTING UNIT

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