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Report for 1979 - Part 1

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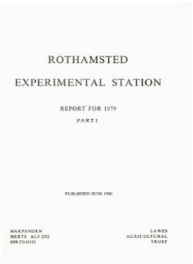

Statistics Department

J. A. Nelder

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Introduction

The three groups of clients who provide the mainstay of our consultancy service come from other Rothamsted Departments, from the Agricultural Development and Advisory Service (ADAS) and from overseas (through our Overseas Development Administration (ODA) connection). Use of our computer programs by other centres continued to increase and a small but important fraction of our time was again devoted to the development of statistical theory.

Practical applications

The items to be described illustrate the range of our collaborative work, but constitute only a sample of our total activity in this area.

Experiments on pea moth. Further experiments were carried out on the effects of pheromone trap spacings on the flight behaviour of male pea moth (*Cydia nigricana*).

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The catches in traps aligned along the wind were found to depend on the number of traps in the line, the attractant and the dose, and the range of attraction of a trap containing 1·0 mg of (E)-10-dodecen-1-yl acetate, the attractant used in monitoring, was shown to be greater than 50 m. The qualitative differences in the types of trap interaction for different attractants and doses have further delayed formulation of a mathematical model to explain results. An experiment was conducted in a field of mature barley to investigate the relationship between concentrations of nitrous oxide released from a point source and the angle subtended by the wind direction and a line joining source to detector, which was placed at several heights and positions in the field. A provisional experimental programme has been agreed with workers at Leiden to study the range of attraction to pheromone traps of moths of the small ermine (*Yponomeuta*) family. (Perry, with Legg, Physics Department and Wall, Entomology Drepartment)

Population dynamics of cyst nematodes. Further research was based on the simulation model constructed in previous years, and included investigation of maxima of absolute density and increase in density; effectiveness of nematicides and determination of parameters from field data, under various rotations; implications of genetic, rather than environmental, determination of sex; rotational policies; and allowance for random variation. (Perry, with Jones, Nematology Department)

Translocation of carbon in barley. A simple model has been developed for the translocation of carbon in barley from anthesis to harvest. An experiment was set up using ^{14}C measurements to determine whether there is any form of temporary storage pool within the plants which is later used for grain-filling. (Pearlman, with Lawlor, Botany Department)

Other work for Rothamsted. Work has continued on the survey of nitrogen responses in crops. Results from about 150 experiments on barley have been combined to give summary information, as was done previously for wheat. Further analysis of the wheat experiments has been concentrated mostly on the relationship between nitrogen content and climatic conditions. (Lane, with Benzian, Soils and Plant Nutrition Department) The results of the Saxmundham II Rotation experiment (1969–74), relating the response of barley, sugar beet and potatoes to phosphate have been summarised, and a paper has been prepared. (Lane, with Johnston and Mattingly, Soils and Plant Nutrition Department)

The properties of a small set of nematode taxa and related tests were used to construct a key and a diagnostic table and attempts were made to form irredundant sets of properties, i.e. smallest sets allowing each taxon to be uniquely identified. It confirmed previous opinions that the taxa were difficult to identify uniquely, since the key had a number of end points with multi-taxa. (White, with Stone, Nematology Department)

Dilution assays were used to assess the numbers of *Rhizobium* bacteria in the soil of plots of various experiments at Rothamsted, Woburn and elsewhere. Our program MLP was used to analyse the effect on the numbers of different crop sequences, changes in N, P and K fertilisers, and depth of sampling. (White, with Nutman and Hearne, Soil Microbiology Department)

Work for ADAS. Our involvement in the design and analysis of both crop and livestock experiments undertaken by ADAS continues, and the following paragraphs exemplify some of this work.

Eight series of experiments sponsored by ADAS soil scientists have been summarised and one or more substantial reports written on each, three of which will eventually be

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published. Towards the end of the year, R. H. Wimble and J. Wood took part in a review of the current ADAS fertiliser recommendations for cereals. The existing ones were based on data up to 1976 and the subsequent 3 years of trials have suggested that recommended optima for N might be too low. Increases in the estimated optima for winter wheat and winter barley on several extensive soil groups were agreed.

The *Technical Report on the National Grassland Manuring Trials* (GM20), a series of experiments at 21 sites, spread over 4 years, is now in the press. It presents the principal summary statistics from each site and relationships between annual yield statistics and explanatory variables such as available-water-holding capacity of the soil and rainfall during the growing season. The slope of the N response curve was practically linear up to 300 kg N ha^{-1} under most circumstances and an inverse quadratic model was found to represent the shape of the curves well. A paper (21) comparing five mathematical models for representing the relationship between annual dry matter yield of grass herbage and fertiliser N has been published. (Sparrow)

Harvesting of ADAS cereal experiments has for many years been done by farmers' combine. In some areas recently there have been difficulties in such harvesting, and ADAS have had to consider using either mini-combines or estimating plot yields from hand-cut crop samples. A sampling scheme was developed which involved taking 16 systematically arranged sub-samples, each consisting of 50 cm of two adjacent rows. These were harvested as two inter-leaved samples of eight and the sampling errors estimated from differences between them. A pilot investigation at two sites indicated that the sampling error introduced by using hand-cut samples of size eight may be between 6 and 7% of the mean yield. (Wimble)

A report on the 1978 results of experiments on late nitrogen top dressing for winter wheat was prepared, the main interest in this series being to estimate whether N is better applied all at once or whether it should be split into two dressings. Over the 26 sites the average yield for the single dressing was about 0·1 t ha^{-1} less than for the split dressing. This contradicted the previous year's results in which the single dressing was the highest yielding. (Dyer)

Livestock Experiments. The statistical support provided on the design and analysis of ADAS animal experiments is still increasing. As a consequence of our continuing policy of visiting EHF and regional staff, many more enquiries have been made concerning the design of experiments. The following paragraphs exemplify the varying nature of our work.

Invitations were received to present two papers to two very different groups of scientists. The first, entitled 'Statistical Perspectives in the Application of Analytical Results', was presented to a group of analytical and nutrition chemists and has led to several enquiries from the former on designing trials to estimate the variability in their laboratory techniques. The second paper was presented to a group of dairy specialists at an ARC Seminar entitled 'Feeding Strategies for Dairy Cows'. This attempted to resolve the many conflicting ideas concerning the different methods of gaining knowledge about feeding dairy cows. (Altman)

Summaries of the 3-years' results of a trial to assess the performance of finishing steers in a slatted beef house or in a straw-bedded yard have been completed. These results show that the liveweight gain of the steers in the bedded yard was 0·18 kg $\pm$ 0·027 kg more per day than for those housed on slats. This appears to be due to their greater dry-matter intake. As both treatment groups had continuous access to food, two 24-h observation studies were carried out. The results of these show that the steers housed on slats spend more time lying down in preference to eating. (Altman)

Analysis and interpretation of a trial to estimate the effect of extra feeding prior to

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calving and up to 8 weeks post-calving have been completed. The trial was conducted over 3 years and involved 337 cows. Feeding extra concentrates before calving did not influence milk yield but did improve percentage of butterfat. Extra concentrates fed in early lactation increased milk yields during the early phase. There was a carry-over effect of this feeding, and cows fed such extra early concentrates continued to yield more during late lactation. There appeared to be no interaction of extra feeding before calving with extra feeding in early lactation. (Garnett)

Work continued on the long-term co-ordinated experiment on the criss-cross mating of pigs, the main aim being to compare the fertility of cross-bred sows bred from Large White and Landrace stock by one of two methods. We have now analysed both the sow and piglet data for four parities, and an interim tabular summary was presented to a meeting chaired by the co-ordinator, Mr. K. Deeble (ADAS Reading). Because of hybrid vigour, the first crosses bred from pure-bred Large White and Landrace pigs were expected to be more prolific than criss-crosses. However, in the experiment to date, neither breeding system has proved to be superior, in terms of either litter size at birth or litter weight of piglets produced. (Spechter)

We helped to design and analyse a series of three trials to study the effects of room temperature and dietary energy concentration on the growth and feed conversion by broilers. Four levels of dietary energy concentration (11·7–13·3 MJ kg^{-1}) and room temperatures ranging from 15° to 27°C were tested with split-plot experiments in the Gleadthorpe EHF climate rooms. Consistent results were obtained in all three trials supporting the hypotheses that the dietary energy requirement of broilers varies with room temperature and that the birds to some extent adjust their feed intake in response to the dietary energy concentration.

A detailed study involving measurements taken from 82 240 eggs was carried out to examine the effects of various factors in the design of battery cages on egg-shell cracking. Results indicate that a dense plastic mesh floor angled at 11·5° gives a low incidence of shell cracking, and that plastic mesh floors require a steeper tilt than wire mesh floors to minimise cracking. (Spechter)

Surveys

Fertiliser practice. This series of surveys, based each year on a representative sample of about 1400 farms, was continued in 1979 on the same basis as in recent years. (Additional work was involved in preparing the sample this year, because up-to-date lists were not available in time for use.)

Preliminary estimates of fertiliser use on individual crops were produced for a representative sub-sample of the data at the end of September and extensive tabulations on the complete sample early in December. An abstract of results is included in Part 2 of the *Rothamsted Report*.

As well as a general report on the 1978 results, information on the extent of use of different types of inorganic and organic fertilisers, lime and trace elements was reported during the year. (Church, Elsmere and Leech)

Representative soil sampling. This scheme for regular soil sampling of representative fields at intervals of 5 years was described last year. A report has been prepared on the pH and lime requirements of agricultural soils in England and Wales, in which trends have been estimated by comparing data for 1969 and 1970 with those for the same fields sampled in 1974 and 1975. Of the sampled grassland, 13% had a pH of less than 5·5 in 1974/75 compared with 8% 5 years earlier. Regional estimates, subject to large sampling errors, suggest that the average pH of agricultural soils was maintained in Central and

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Eastern England but may have declined slightly elsewhere during this period. Considerable progress has been made by ADAS with analytical work on more recent soil samples; it is therefore hoped to obtain more broadly based and up-to-date estimates of trends soon. (Church)

Other surveys. Analysis of the anthelmintic survey, which was planned in collaboration with the Central Veterinary Laboratory, has been substantially completed, though further work may be needed after the tabulations have been discussed.

The Weed Beet Survey, 1979 (British Sugar Corporation) was small and very straightforward, and the basic analyses were completed within about 3 weeks using modified 1978 programs. A start has been made on further analysis after discussions with the originator. (Church and Leech)

Routine analysis. The service we provide for the punching and verification of data and their subsequent analysis has again been widely used, with at least 142 workers from other departments and 11 from outside stations submitting jobs. Data comprising 1·50 million items were involved, a decrease of 13% on last year. There was a 75% decrease in the number of items processed for ODA users (0·13 million compared with 0·52 million in 1978). By contrast, work for Rothamsted increased by 27% and that for ADAS by 10%. The average turn round time was decreased by 1 day to 7 working days. (Dunwoody, Dyer, Smith and Todd)

Since many of the Genstat programs required to analyse Rothamsted field experiments are similar, a series of six macros has been written. These macros have been used to analyse all Rothamsted experiments except a few of the classical ones. Printed skeleton analysis sheets have also been produced. The combination of these macros and skeleton analysis sheets has reduced the punching effort considerably. (Todd)

Summaries of all the Rothamsted, Woburn and Saxmundham field trials were again prepared for publication. The improvement in the schedule was maintained and the 1978 edition of *Yields of the Field Experiments* was for the second year in succession, published before the *Rothamsted Report*. (Dunwoody and Todd, with McEwen, Field Experiments Section)

The evaluation of data-entry systems using magnetic media, word-processors and mini-computers was continued. The scope of the investigation was widened to include the word-processing needs of the Station as a whole. (Alvey, Dunwoody and Todd, with Gledhill, Computer Department)

Theory

Non-linear inference. The geometry of non-linear inference was studied both theoretically and graphically, in particular the relationship between expected values and parameters in both data space and parameter space. Data values with the same maximum likelihood estimate lie on a locus which is orthogonal to the solution locus if errors are Normally distributed, but may be curved and oblique for other distributions. These loci may be plotted directly or, by suitable likelihood-symmetrising transformations of the data space, be made approximately linear and orthogonal. For example, for binomial errors the appropriate transformation is the incomplete beta function I $(x, 1/3, 1/3)$, which may be approximated by a rational function on the cube root scale. These loci show how data space is divided into regions where the solution is unique, non-existent, or ambiguous.

In parameter space the notion of a parameter locus, of values which exactly predict a particular datum, may be extended to the situation where linear parameters are estimated

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by regression. The non-linear parameters then relate to differences and ratios of data values. These studies provided new stable transformations for the double exponential and compartment models, and allowed the separation of cases where the components of a mixture model occur as sums or differences. The concept of 'parameter loadings' was extended to general functions of parameters to show the influence of each datum on functions of interest. (Ross)

Asymmetry in multivariate analysis. Work has started on the Procrustean problem of matching two skew-symmetric matrices. This proved less tractable than that of matching two sets of distances (symmetric matrices) but progress has been made and a feasible solution found. The method has value as an immediate tool for statistical analysis but it is hoped that the results will also be of theoretical value in investigating the robustness of least-squares fits to skew matrices.

When departures from symmetry can be expressed in the form of a function of $(a_i - a_j)$ then analysis may proceed within the framework of generalised linear models. Certain immigration–emigration data were found to satisfy a model of this form and were analysed in part by using GLIM with Poisson, Lognormal and Normal errors. An invited paper was given at the 10th International Biometric Conference. (Constantine and Gower)

Multidimensional scaling. Criteria for scaling of multivariate data can be divided into metric and non-metric types. A general appraisal has begun of several metric scaling criteria and how these criteria can be legitimately compared and contrasted. Several interesting results have been discovered which have computational and theoretical implications.

A more general question concerns the comparison of multidimensional scalings, whether metric or non-metric, how such comparisons can be made and what can be learnt from them. An invited paper, presented at a workshop sponsored by the Social Science Research Council (Paper 11), gives a unified account of the area and contains some new results. In particular it gives a linear-programming solution to the problem of finding the permutation of the rows of a matrix that best fits another matrix. (Gower).

Identification keys. Identification keys have often been constructed, by hand or by computer, in which the user is offered a choice between two (or more) alternative tests at each stage. However, there seems to have been no detailed discussion of how these alternatives can be detected. General principles for doing this have been devised, in particular for when test results are variable, and criteria have been devised for selecting a useful subset from the full set of alternative tests. These principles are used to implement the selection of alternative tests in GENKEY.

The identification of genera and other higher-order groupings of taxa is a frequent requirement in both biological and other work. If the groupings are sufficiently well defined, diagnostic keys and tables can be constructed in the normal way, using information about the overall values of the attributes within each group. However, there will often be too few attributes constant within the groups for this to be possible. Ways have been devised to adapt the usual methods to allow construction based on information about the individual group members, rather than the overall group information. (Payne)

Tests for spatial pattern. Collaboration continues with Mr. R. Mead (University of Reading) in a study of the power of some tests for detecting spatial pattern when sampling methods not involving quadrats are used. Little is known of the power of tests based

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on distance methods under sensible spatial alternatives to randomness, but the mosaic of squares provides a realistic and flexible method of modelling plant patchiness. (Perry)

Statistical programming

Genstat. There are now 103 licensees in 20 countries. During the year 36 new licences were issued to organisations in the United Kingdom (10), the rest of Europe (14), Australasia (5), Africa (2) and North America (5). Again universities and research institutes predominated. Four licences were not renewed. During the year negotiations were concluded with the Numerical Algorithms Group (NAG) of Oxford whereby NAG will take over the distribution of Genstat, including the printing and distribution of documentation. Program ownership, maintenance and development remains with us, but the agreement will relieve us of a considerable amount of office work. (Alvey and Watson)

Releases. The version 4.01 of Genstat is now available on ten machine ranges. Recently completed versions (with their convertors) include those for the Burroughs B6700 (Dr. B. G. Cox, University of Otago, New Zealand), Prime (Simpson), ICL 1906A (Dr. P. Griffiths, University of Oxford) and DEC System-20 (Mr. I. D. Griffiths, University of Nottingham). The Prime version is the first capable of being used interactively, and was successfully demonstrated at the August meeting of the American Statistical Association in Washington, D.C.

Release 4.02, released at Rothamsted in December 1978, has now been converted for use on IBM 360/370, CDC 7000 and CDC 6000 ranges. Versions for the IRIS 80 (Mlle. A. Bouvier, Jouy-en-Josas, France) and Honeywell (under GCOS) (Mr. J. Lemon, University of Aberdeen) are in progress. The Honeywell version is unusually difficult because the operating system does not provide for the automatic overlaying now commonly available elsewhere.

The next release (4.03) of Genstat is scheduled for February 1980 on the ICL 4-70, and work on it has continued through the year. New conversions will be made for Modcomp, Telefunken and DEC Vax range. (Simpson)

New facilities. The new version of Genstat contains a major extension dealing with the analysis of time series using autogressive models. The new directives follow the procedures of Box and Jenkins and provide tools for the selection of the model, the estimation of its parameters and the subsequent forecasting of future trends. The algorithms have been written by Dr. G. Tunnicliffe-Wilson of the University of Lancaster, and the interpreters, which embed them in the system, by P. W. Lane. Very careful preliminary specification of the interface has resulted in rapid progress in the inclusion of these new facilities.

A new major protection for the user has been provided whereby the redefinition of the size of one structure by him no longer causes unchecked inconsistencies to develop when the dimension of another structure depends upon it. Such inconsistencies are now automatically detected and inconsistent structures are deleted with suitable warning to the user. (Simpson)

A new directive simplifies the production of histograms, and new functions have been added to the CALCULATE directive to produce various forms of margins for tables. (Alvey and Watson)

This new version will be able to be mounted for use in either batch or interactive mode. (Simpson)

Macros. Genstat macros have been written for a variety of statistical procedures, including the bi-plot technique of Gabriel, a general multiway canonical decomposition,

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the analysis of cyclic incomplete block designs and the method of Prentice and Gloeckler for the analysis of grouped survival data. (Digby, Gower, Lane, Payne and Sparrow)

The Genstat macro library has been extended to include a macro (Permlev) which permutes, omits, or combines the levels of factors of a multiway table, any combination of the three possible operations being possible for any number of factors independently. (Bassill and Gower)

Documentation. Both the Genstat Installation Guide and the Implementer's Manual have been completely revised for release 4.03. A new edition of the newsletter was issued with manual updates, and a new prospectus and poster prepared. (Alvey, Simpson and Watson)

Support. The first Genstat conference was held at Cambridge in April. It lasted 3 days and was attended by 95 people from commerce, universities, research institutes, national and local government and from seven countries. The programme included 14 talks on advanced uses of the system, macros and applications to research. Comments by participants were encouraging. (Alvey, Banfield, Gower, Lane, Nelder and Simpson, with Beasley, Computer Department)

Courses for beginners were held at Rothamsted, Bedford College, London, and the University of London Computer Centre. (Alvey, Lane and Simpson)

Generalised linear interactive modelling (GLIM). The number of centres with this program has now risen to 246, and versions of the current release (3) are now available on 21 machine ranges. Distribution is handled by NAG, and technical queries, which we deal with, have not been extensive. A set of program updates to cope with the few known errors has been prepared. (Baker)

Two extensions have been developed whereby the basic framework of GLIM, particularly its data-handling facilities, is used with procedures other than the fitting of generalised linear models. One deals with spectral analysis and calculates the periodogram and autocovariances of a univariate time series, together with estimates of its spectrum, there being a choice of 'windows'. (Pearlman) The other (*Rothamsted Report for 1978*, Part 1, 313) concerns the Genstat algorithm for the analysis of designed experiments, being incorporated at the University of Western Australia; assistance was given with the output routines. (Baker and Payne, with Mr. J. D. Henstridge, Dr. B. P. Murphy and Professor T. P. Speed)

The housekeeping routines have been extensively revised to give greater efficiency and power, and the new version will form the kernel of the next release. (Baker, with Mr. M. R. B. Clarke, Queen Mary College) Further work has been done on the specification of the new facilities to be included in Release 4. (Baker and Nelder, with the Working Party on Statistical Computing)

Maximum Likelihood Program (MLP). The *MLP Manual* was completed and sent for printing in November.

Version 3.06 was released at Rothamsted in April with the following new facilities: the dispersion matrix for common non-linear parameters in a parallel curve analysis is now printed, and a second form of the two-compartment curve included. For general models there are improved algorithms for approximate support limits, allowing different critical levels. 'Function loadings' have been introduced to show the relationship between data and functions of parameters. A subroutine facility is now included to simplify the specification of differential equation models.

Version 3.05 is now available on the following machine ranges: ICL 4-70, IBM 3.60,

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ICL 1906, Cyber 7600, CDC 6600 and CDC 7600, Iris and conversion is proceeding for the Prime. Conversion of version 3.06 is expected to begin soon on the Univac range, and possibly also for the PDP 11 with 64K store. (Ross and White)

Other programs. Genkey was converted for use on the CDC 7600 computer. (Payne) For the cluster-analysis program CLASP new facilities were introduced to provide automatic re-ordering of variates based on the information provided by the KEY and RELATE directives, so that the output from LIST shows blocks of similar data values. (Ross and White)

The program KYST from the Bell Telephone Laboratories has been converted for the 4.70. KYST is a Fortran program to do Multidimensional Scaling and Unfolding and has been used on several sets of data. (Bassill)

Commonwealth and Overseas

Overseas visits and tours. During August D. A. Preece visited Bolivia, Brazil and Paraguay. In Bolivia he visited the Misión Britanica en Agricultura Tropical, Santa Cruz, to 'discuss and advise on problems encountered locally in the field of biometry'; in Paraguay he toured Technical Cooperation Projects to 'advise on the experimental programmes in sugar cane and tobacco, particularly with regard to the design of trials and to the analysis of results'.

Under the Technical Cooperation Scheme of the Colombo Plan, K. Ryder visited the Palm Oil Research Institute of Malaysia (PORIM) in September for the following purposes:

(a) to give advice about the design of experiments on oil palm and its products and about the processing, storage and statistical analysis of data therefrom;
(b) to advise on how PORIM might best organise its statistical and data processing facilities; and
(c) in relation to (a) and (b), to take into consideration locally available facilities and methods for handling data.

Most of his time was spent at Kluang (Johore State), where most of the Biology Division of PORIM is based. For the rest of his time, he was quartered in Kuala Lumpur, where the PORIM headquarters is temporarily sited. He visited the Malaysian Agricultural Research and Development Institute (MARDI), the Rubber Research Institute of Malaysia (RRIM), the Federal Land Development Authority (FELDA), Guthrie Research (Chemara), Computer Processing Services, and the Statistics Department (Government).

This was followed by a visit to Nepal, again under the Technical Cooperation Scheme of the Colombo Plan, to discuss the design and layout of experiments being planned for Pakhribas Agricultural Centre, and to become familiar with the problems of Nepalese field experiments, with the aim of improving the statistical service that Rothamsted provides for agricultural experimenters in Nepal.

In March and April, under the auspices of the British Council, D. A. Preece visited The Institute of Agricultural Research and Training (University of Ife), Ibadan, Nigeria to 'advise and assist in setting up the statistical services necessary to support the agricultural research programme of the Institute'. He gave lectures on the design and analysis of experiments, and offered detailed advice on the planning, design, layout, administering and analysis of the Institute's own experiments. At the University of Ibadan he visited the Faculty of Veterinary Medicine and the Department of Statistics. He also visited the International Institute of Tropical Agriculture (IITA), the Nigerian Horticultural

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Research Institute, the Forest Research Institute of Nigeria and the Cocoa Research Institute of Nigeria.

Work on ODA projects. Most of this work concerned the design and analysis of agricultural experiments. The experiments were on many crops (including cassava, maize, rice, barley, wheat, triticale, millet, sorghum, sugar cane, cowpea, soyabean, groundnut, sesame, sunflower, cotton and tobacco) and were in many lands (Belize, Bolivia, Paraguay, the Falkland Islands, Ghana, Sierra Leone, Tanzania, Malawi, Botswana and Nepal). The large amount of unsatisfactory data-recording that came to light during the year is a matter for serious concern, and one aspect has already stimulated Preece to draft a paper on 'Distributions of Final Digits in Data'.

In conjunction with Mr. A. R. McWalter and Professor E. W. Russell, K. Ryder examined data from the final cycles (6 and 7) of the long-term rotation/fertiliser trial at Serere, Uganda. The experiment followed a 5-year rotation and was divided into five series, each of 90 sub-plots, which were begun in the years 1936–40 inclusive. Each phase of the rotation was represented each year and each crop of the rotation was grown on each of the five series in turn. Each series consisted of two replicates, each of 15 main plots; these accommodated all combinations of three crop-rest sequences and five types of resting treatment, which lasted 1, 2 or 3 years, and consisted of natural regeneration, planted grass, either grazed or left undisturbed, and a leguminous cover crop, either lopped or dug-in. Each main plot was split into three sub-plots with three levels of farmyard manure.

The analysis of the last two cycles has caused difficulties, as the treatments were altered after the completion of the arable phase of cycle 5, the original experiment being split into two experiments. One fifth of the original main plots were used in one experiment to monitor the effects of

(a) changing crop/rest sequences to a continuous cropping system, and
(b) introducing nitrogen fertiliser into the system,

while the manure levels applied to the sub-plots were altered to measure the effects of stopping/starting to apply the manure. The remaining four-fifths of the original plots were also used to measure the effects of (a) above, and also of introducing nitrogen fertiliser but with and without phosphates; the sub-plot treatments were altered to include a rate of application of double the previous maximum.

In both experiments the interactions of the old crop/rest sequences and of the new fertiliser treatments were partly confounded with the replicates which complicates the interpretation of the results.

Another important set of trials were those on the interaction of variety and environment in cowpea, analysed for IITA and consisting of 25 varieties grown at ten sites covering a large part of West Africa. The data consisted of the variety means at each site for nine variables. Cluster analyses were requested on (a) sites and (b) varieties for each of the variables, and analyses of variance were produced in which both sites and varieties were classified into groups and the interaction partitioned accordingly. (Ryder)

Among many other analyses undertaken was that of 9 years' calf-weaning data from Kenya, where lengthy preliminary examination and severe non-orthogonality complicated the work, and a combined analysis of 3 years' data from the Burley Tobacco trials in Malawi. (Riley, with Mr. J. B. Abington, Malawi)

Intercropping. This subject remains very important in tropical agriculture, and Janet Riley has continued compiling a bibliography. She has joined Mr. R. Mead (Department

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of Applied Statistics, University of Reading) in the preparation of a review of statistical methods used in intercropping research.

Visitors. About 30 visitors were received, including both representatives from overseas institutions and several established and newly-appointed Technical Cooperation Officers. These visitors were concerned with agricultural work in Afghanistan, Bolivia, Botswana, Brazil, the Caribbean, the Falkland Islands, Ghana, Kenya, Malaysia, Nepal, Nigeria, Sudan, Tanzania, Thailand, and Vietnam.

Training. Mrs. S. B. Husin, a statistician from MARDI (Serdang), visited us for training for a week in July/August.

Staff and Visiting Workers

W. J. Lessells retired in January after 29 years in the Department, and A. J. Vernon retired after 21 years. C. F. Banfield left in August and P. E. Sparrow in June.

P. G. N. Digby and Gillian M. Carter were appointed.

R. W. Payne returned from a year at the Division of Mathematics and Statistics, CSIRO, in November and in October R. J. Baker left for a 3-month visit to the University of Western Australia in Perth.

In September past and present members, also Temporary Workers of the Department, celebrated the 60th anniversary of its founding by the late Sir Ronald Fisher.

J. A. Nelder gave a course of lectures on statistical computing at Imperial College in February and March. In October he visited the University of Copenhagen to lecture on GLIM and Genstat. In November he presented a paper (Paper 21) to the Second IRIA Symposium 'Data Analysis and Informatics' at Versailles. In August he presided over the 10th International Biometric Conference in Guarujá, Brazil, accompanied by J. C. Gower, D. A. Preece and G. J. S. Ross; Gower and Ross gave invited papers.

N. G. Alvey gave a talk on Genstat at a course entitled 'Applications Software for Operations Research' held in London during June.

J. C. Gower lectured on multivariate analysis at the University of Nice, and gave two lectures at the University of Liège. He also presented an invited paper to a joint meeting of the Royal Statistical Society and Society of Chemical Industry.

J. G. Pearlman presented an invited paper on multilinear system theory at an international symposium in Delft in July. J. N. Perry attended a Mathematical Ecological Workshop of the Biometric Society in Glasgow and presented a paper at a meeting of the Mathematical Ecology group. He was an invited discussant at sessions of a working group on the use of pheromones in integrated control, Wadenswil, Switzerland in October.

D. A. Preece gave a talk at a course organised by the Commonwealth Forestry Institute, Oxford, and R. H. Wimble lectured on experimental design to ADAS Soil Science Assistants at Nottingham University. He, C. F. Banfield, C. J. Dyer and J. Wood gave a 2-day course in statistics to ADAS crop scientists.

Our visiting scientists Professor L. P. Lefkovitch of Agriculture Canada and Professor J. B. Whitney of the University of Waterloo, Canada left the Department in July and August respectively. Mr. N. S. Mountier of the University College of Agriculture, New Zealand spent 3 months in the Department at the beginning of the year and Dr. A. G. Constantine of the Division of Mathematics and Statistics CSIRO Adelaide, joined the Department in April for a year.

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