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## Rothamsted Report for 1946

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### Statistics Department

#### F. Yates

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## DEPARTMENT OF STATISTICS

By F. YATES

During the year 1946 we have suffered from our share of immediate post-war difficulties. In particular, shortage of statisticians trained and experienced in agricultural and biological work has made it very difficult to keep abreast of our commitments. Many more of our Universities are now recognising the need for providing training in research statistics for their students. In the long run this may be expected to bear fruit in an increased supply of able recruits, but for the moment the demands of the Universities for staff have accentuated the scarcity created by increased realization of the importance of statistics in many branches of research.

The position of the Department as a central Statistical Research Centre has been clarified, and work for other stations has continued to expand. Moreover, we have been able to give greater assistance this year than during the war years to the staff of other departments at Rothamsted, and members of the Department have made good progress in writing up completed work.

### FIELD EXPERIMENTS AND EXPERIMENTAL DESIGN

In spite of difficulties the Department has begun to fulfil its new function as consultant in the problems of experimental design arising in other agricultural research stations in this country. During the course of the year the volume of these enquiries has been steadily growing. In addition, the volume of enquiries from our colonial dependencies, particularly in Africa, has been increasing concurrently with the revival of experimental work in these territories. The nature of these enquiries indicates that the Department has a useful function to perform in this respect.

The output of numerical analyses of the results of field experiments at Rothamsted has continued to be high, and we have also carried out a number of analyses for other stations.

Various members of the Department have given assistance to members of other departments at Rothamsted, particularly Entomology, Plant Pathology and Microbiology in the planning and analysis of their experiments.

Dr. Yates continued to serve on the Field Experiments Committee of the Agricultural Improvement Council and on the Supervisory Committee of the Grassland Improvement Station.

Four papers on experimental design have been published in the course of the year. Arising out of work at Rothamsted Mr. Finney completed his description of fractional replication (49). Mr. Kempthorne has given an account of the design and analysis of lattice squares with split plots, a type of design which has proved very useful in investigating the responses to the standard plant nutrients (N, P, K) in conjunction with different organic fertilisers (50). He also developed a simple method of generating complicated designs involving confounding and fractional replication (51). In the course of this work he carried out a further investigation on a point that has often troubled those concerned with modern experimental design, namely that if in a confounded

experiment the responses to one of the factors varies from block to block (i.e. interacts with blocks), this will appear in the analysis as a spurious interaction between other factors. Using the results of the fertiliser trials on sugar beet conducted during the war years he confirmed the previous conclusion (based on much less extensive data) that there is no evidence that such interactions are of any importance in practice (52).

#### ANIMAL EXPERIMENTS

In cooperation with the National Institute for Research in Dairying and the Rowett Research Institute a start has been made on the investigations of problems of design and analysis arising in experiments on animal nutrition and animal husbandry. The development of the technique of experiments on animals has lagged behind that on crops and it is hoped that during the next few years Rothamsted may be in a position actively to continue this work.

#### SAMPLING SURVEYS AND OTHER SAMPLING PROBLEMS

Research on statistical problems arising in sampling surveys has been continued during the year. The review of recent developments in sampling and sampling surveys, read before the Royal Statistical Society in January, 1946 (as noted in the 1939-45 report), was well received and has provoked considerable discussion in the course of the year. Some research on systematic sampling has now almost been completed. Progress on the book on sampling surveys has unfortunately been held up by pressure of other work.

A short investigation by Mr. Anscombe and Mr. Quenouille was carried out on the problem of drawing balanced samples. Dr. Yates gave a course of lectures in the Michaelmas term, 1946, at the London School of Economics on "Survey Techniques and Problems". Investigations into the sampling errors of various types of sampling for botanical composition of herbage, etc., have been carried out by Dr. Boyd for Dr. William Davies of the Grassland Improvement Station and for Dr. Iorwerth Jones of the Welsh Plant Breeding Station.

#### SURVEY OF FERTILISER PRACTICE

During 1945-6 a survey of Fertiliser Practice was continued in the following provinces: Aberystwyth, Harper Adams, Midlands, Newcastle, Seale Hayne and Wye. Duplicated reports have been issued for the following counties: Cumberland, Gloucestershire, Huntingdonshire, Merioneth, Shropshire, Somerset.

The analysis of the surveys of the following counties was also completed: Durham, Holland division of Lincolnshire, Isle of Ely, Lindsey division of Lincolnshire, Northumberland, South Essex, Warwickshire, Westmorland, West Riding.

Publication of all the reports issued since the inception of the survey is under discussion.

#### ASSESSMENT OF YIELDS OF GRAZED PASTURES BY GRASS CUTTING TECHNIQUES AND OTHER GRASSLAND PROBLEMS

The work begun in 1945 on the evaluation of the yield of pasture by grazing and by grass-cutting in conjunction with the

Chemistry Department and with the Grassland Improvement Station was continued at Rothamsted in 1946; grass-cutting was also undertaken at one of the R.A.S.E.'s grazing trials at Old Warden, Bedfordshire. The statistical analysis of these experiments and of three others carried out in the Northern, East Midland and Welsh Provinces has been carried out by Dr. Boyd and a duplicated report has been issued.

Mr. A. E. Jones carried out an investigation into the difficulties involved in estimating errors from the live-weight increase of grazing animals. This, however, has still to be reported.

#### NATIONAL FARM SURVEY

Mr. Kempthorne and Dr. Boyd used the data obtained during the survey to investigate the relationship between the rental value and stock-carrying capacity of land (59). A similar investigation on the labour requirements of farms is in preparation. Maps showing the average rent per acre for every parish in England and Wales have been prepared and form a valuable field for further research. They are of particular interest to the Soil Survey Department.

Mr. Kempthorne has published an account of the methods of analysis by the use of punch-cards which was developed in connection with the analysis of the National Farm Survey (54).

#### RESAZURIN RESEARCH SCHEME

This work has made excellent progress during 1946 under the supervision of Mr. Kempthorne, assisted by Mr. Quenouille. The original enquiries have been extended to cover investigations on the alcohol precipitation and clot-on-boiling tests which appear for a number of purposes to be better than the Resazurin test; and on the temperature compensation of keeping quality tests in general. Two papers were prepared by Mr. Kempthorne before he left, which it is intended to publish shortly. A further general report on the progress of the scheme has been prepared. It is hoped that a comprehensive report on the whole of the conclusions will be published in the fairly near future when certain further investigations have been completed. The Department will continue to co-operate with the National Agricultural Advisory Service and with the National Institute for Research in Dairying in the supervision of the statistical aspects of the scheme.

#### ADVISORY ENTOMOLOGISTS CONFERENCE

Mr. Anscombe has acted as statistical advisor to the Advisory Entomologists, and in particular has been concerned with two matters:—

- (1) A uniform procedure for estimating potato eelworm cyst populations has been evolved, so that results of sampling carried out in different parts of the country will be comparable and the stage is set for a national survey if that should be required at any time.
- (2) A scheme of observation of certain pest insects at stated times of year (the "calendar insects") has been launched, with the object of recording the fluctuation from year to

D

year in insect population and in damage done to susceptible crops, and seeing what correlation exists between them. The first year's observations (1946) have provided not only interesting information about the distribution and intensity of infestations but also useful experience of possible methods of sampling. A revised programme of observations for 1947 has been prepared.

Arising from meetings with the Advisory Entomologists there has been some direct advisory work with individuals, in particular regarding the sampling of swede seed crops for insect damage (Wye Agricultural College).

An investigation into methods of fitting negative binomial distributions to insect counts is in progress.

#### INSTITUTE OF AGRICULTURAL PARASITOLOGY

Extensive trials are to be made of the new insecticide DD against potato eelworm and the Institute of Agricultural Parasitology has been in touch with Mr. Quenouille and Mr. Anscombe on the design and analysis of these trials. A preliminary experiment was conducted at Gamlingay in 1946, in order to gain experience of field and laboratory techniques, in particular of eelworm sampling techniques. The results are being analysed.

#### OTHER WORK

Dr. Yates has continued to serve on the Scientific Advisory Committee of the Ministry of Works. He gave a paper to the Agricultural Educational Association on the place of statistics in agricultural research (61), and prepared a short paper for "Contact" (62).

Mr. Finney published a paper based on work at Rothamsted on the analysis of factorial series of insecticide tests (53).

Mr. Kempthorne spent two months in Greece as part of an international team of observers on the conduct of the elections. A general report on the statistical aspects of this work has subsequently been prepared (60).

Dr. Boyd completed an investigation on the results of experiments on the manuring of beans and peas. The results of all available fertiliser experiments on these crops were summarised and reported (57). The paper also includes an account of the current manurial practice for these crops as shown by the survey of fertiliser practice. A more general duplicated report was prepared by Dr. Boyd and others for the Agricultural Improvement Council.

Mr. Anscombe published two papers concerned with sampling inspection (55, 56). He also delivered a lecture to the Science Masters Association entitled "Statistics in the School Science Course".

Mr. Quenouille assisted members of the physics department in the mathematical theory required for some of their experiments. He has also published a paper on the problem of random flights (48).

Mr. A. E. Jones completed his thesis on random sequences for Ph.D. at London University (47) and was subsequently awarded his degree. He also published a paper on the routine estimation of dispersion from large samples (46).

Dr. Cashen revised her report on the influence of rainfall on the

yield and composition of permanent grass at Rothamsted in a form suitable for publication (58).

In addition to supervising numerical analyses of the field experiments Mr. Weil carried out field work in connection with the factory sugar beet and other outside centre experiments.

#### STAFF

Mr. A. E. Jones left in October, 1946, to take up a lectureship at Imperial College. Mr. E. G. Davy joined the staff in April, 1946, from the Royal Air Force, and left in November, 1946, to take up an appointment as Assistant Director at the Observatory, Mauritius. Mr. O. Kempthorne left in December, 1946, to take up an appointment as Research Associate Professor at the Statistical Laboratory, Iowa State College, Ames, Iowa. Mr. M. H. Quenouille was granted leave of absence for a year's research at Cambridge in the academic year 1946-7 and has recently been appointed Lecturer in Statistics at Aberdeen University. Mr. R. T. Eddison, Mr. B. M. Church, Miss Pamela Clarke and Mr. P. Robinson were appointed to the staff at the end of 1946 but did not take up their appointments until 1947. Mr. Robinson is holding a temporary appointment and is returning to Cambridge to read for the Diploma in Mathematical Statistics.

Mr. D. R. Read spent three months from May to August, 1946, in the Department. He was then seconded as Assistant Statistician to the National Institute of Poultry Husbandry, Harper Adams Agricultural College.

Mr. J. Weil has been transferred to the Field Experiments Section where he is primarily concerned with the supervision of field trials.

Publications (including Summaries), page 100.