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Statistics Department

F. Yates

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STATISTICS DEPARTMENT

By F. YATES

During 1949 the work of the department has developed along the lines which have been outlined in previous reports. Considerable progress has been made in our relations with the National Agricultural Advisory Service. Work on surveys of the operational research type has been intensified, and the year has seen the installation of Hollerith equipment.

The outstanding new survey carried out during the year is the Survey of Marginal Land. This was undertaken at the request of the Agricultural Research Council. The object of the survey was to investigate how far marginal land of the type not included in the Hill Farming Act, and not producing cash crops such as dairy products, was likely to repay any scheme of rehabilitation. The survey is being carried out in three regions ; that for East Wales and the Welsh Borders has already been completed and a preliminary report prepared.

The Survey of Maincrop Potatoes was continued, and the pilot survey of Methods of Milk Production was also continued, though a report has not yet been issued. Some analytical work on the Survey of Fertilizer Practice was carried out. A Survey of Opencast Coal Sites is being planned.

DESIGN AND ANALYSIS OF EXPERIMENTS

The design and analysis of experiments for Rothamsted and other research stations has continued on the usual lines. In addition to the design of field experiments a number of laboratory experiments have been designed for other departments. Similar work has been undertaken on request for other research stations.

The grazing experiment on the residual manurial value of feeding stuffs, which was being conducted at Rothamsted on behalf of the Royal Agricultural Society of England, came to an end in 1948 and members of the department corroborated in a report on this survey which has now been prepared for publication in the Society's journal (56).

Co-operation with the National Agricultural Advisory Service in the field of experimental design and analysis has made very satisfactory progress. We are now consulted by all the provinces, and Dr. Boyd or some other member of the department usually attends meetings of Provincial Experiments Committees in most provinces. Although this involves the department in a good deal of work it should produce valuable results both in raising the standard of design of individual experiments, and what is even more important, in providing a basis for the joint planning and co-ordination of experimental investigations. After a slow start there are now also welcome signs that the machinery set up by the Ministry of Agriculture to assist in this planning and co-ordination is beginning to function. It is hoped that during the coming year this headquarters organization will have an increasing influence both on the planning of co-operative experiments carried out by the National Agricultural Advisory Service on commercial farms and also on the planning of experiments on the Ministry's experimental husbandry farms.

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Various problems in the theory of the design of experiments have been investigated in the course of the year. Mr. F. J. Dudley, of the National Institute of Poultry Husbandry, and Mr. D. R. Read published a paper on the design of experiments in egg production of poultry (58). Dr. P. M. Grundy prepared a paper on the estimation of error in rectangular lattices (59), and Mr. M. J. R. Healy and Dr. Grundy have prepared a paper on the use of the principle of restricted randomization in quasi-Latin squares (60). The general basis of this principle, which is of fairly wide application, was discussed by Dr. Yates in two lectures on the logical basis of experimental design, and recent developments in the subject, given in Paris to the Institut Henri Poincaré in December, 1949 (69), (70). Dr. Yates contributed a paper on the place of experimental investigations in the planning of resource utilization to the Plenary Session of the United Nations Scientific Conference on the Conservation and Utilization of Resources (66), though he was unable to attend the Conference. He also gave a paper on experimental techniques which are of value in plant improvement to the meeting of the Biometric Society held in Geneva (68). Mr. Healy also attended this meeting. Mr. H. D. Patterson carried out some research into change-over trials such as are suitable for animal feeding trials, and has prepared a paper on this subject (64). He also prepared a thesis on which he was awarded the degree of M.Sc. at the University of Leeds (63). Mrs. P. M. Cox (Clarke) has written up an account of the analysis of $p \times q$ lattice designs (57).

SAMPLING METHODS

Various members of the department have continued work in this field. Mr. D. R. Read published a paper on the accuracy of sampling methods for the estimation of egg production and mean egg weight (65). Dr. Yates attended the third meeting of the United Nations Sub-Committee on Statistical Sampling which was held in Geneva, and he and Mr. Healy attended the meeting of the International Statistical Institute held in Berne. At the latter Dr. Yates gave a paper on the use of sampling survey methods and operational research techniques in agriculture (67). Dr. Yates gave two papers on recent developments in sampling methods to the Institut de Statistique in Paris (71), (72). He also gave four lectures on sampling methods to the school (Centre Europeen) set up by the Food and Agriculture Organization of the United Nations for the training of official statisticians in the collection of population and agricultural statistics.

The book on sampling methods in censuses and surveys referred to in the 1948 report was published in May, 1949. From correspondence which has been received from Colonial workers and others and from personal discussions, it is clear that the book is fulfilling its purpose of providing a standard textbook whereby workers without extensive statistical training who are concerned with the conduct of sampling surveys can undertake them with confidence. A number of plans for sample censuses and surveys based on the methods explained in the book have been submitted to us for our opinion, and it is gratifying to find that the proposals have almost invariably been sound.

SURVEY OF MARGINAL LAND

A survey of marginal land in England and Wales is being undertaken at the request of the Agricultural Research Council, with the object of investigating what improvement in production is possible from this type of land, and what expenditure would be necessary to attain it. The survey has been organized and carried out under the direction of Professor W. E. Ellison of the University College of Wales, Aberystwyth, and Dr. Boyd. Three areas have been selected for field survey: East Wales and the Welsh Border, Northern England, and South-Western England. The Welsh survey was begun at the end of September and a preliminary report was completed before the end of the year. Field work is in progress in the Northern and South-Western counties.

The boundaries of the surveyed regions have been chosen so as to include those areas in which the farms were not, in the main, producing cash crops, fat stock or milk, and which were not eligible for full benefits under the Hill Farming Act (1946).

The sampling procedure for the Welsh region was as follows. Within the region a stratified random sample of eight parishes or part parishes was selected for survey. Within these parishes or part parishes either all, or a random half of the farms of over 25 acres crops and grass were included in the survey, with the exception of farms that were receiving Hill-Sheep subsidy at the full rate, or of which more than 30 per cent. of the acreage consisted of land of good natural fertility. One hundred farms in all were included in the sample. Each of these was visited by a surveyor who recorded sales and purchases of crops and stock and made a field-by-field survey of the farm. This field survey involved a record, for the years 1948 and 1949, of the cropping, the yields or stock-carrying capacity (estimated or actual), and the manuring and liming. The surveyor also recorded what improvements he considered to be required in respect of cultivations, manuring, draining and fencing; their cost; and what yield or stock-carrying capacity could be expected from the field over a period of six years following the improvement. The surveyor was instructed to consider what improvements were desirable from the point of view of the farm as a unit, so that, for example, one field might be scheduled for arable production and another for direct reseeded, in the light of the probable needs of the farm as a whole and aiming as far as possible at self-sufficiency throughout the year. The extent to which improvements to buildings, roads and services were required was recorded by a special fieldman who visited about one third of all the surveyed farms.

SURVEY OF MAINCROP POTATOES

This survey, which was organized at the request of the Agricultural Improvement Council and begun in 1948 (73), (74), has been continued on the same lines in 1949. The field work has been carried out by officers of the National Agricultural Advisory Service.

The survey is intended to furnish comprehensive and precise information on the agricultural practices followed in growing maincrop potatoes, including cultivations, manuring, varieties, source of seed, pests, diseases, etc. It is also designed so as to test the possibility of estimating the yield of the potato crop by

digging up and weighing short lengths of row as near to lifting date as conveniently possible. In 1949 weights of sample lengths of row on some of the fields were also taken in August, in order to investigate the possibility of predicting the yields from measurements of this type.

In 1948, which was a particularly good year for potatoes, the sample yields gave results decidedly above the official estimates of the Ministry of Agriculture. The results for the mean of all the surveyed counties were as follows:

	tons per acre
Gross yield of samples (1¼ in. riddle)	10.8
Less	
Ware left in ground after harvest	0.8
Correction for change of riddle (1¼ in.—1½ in.) ..	0.3
Correction for headlands, etc. included in acreage	0.4
	—
Total	1.5
	—
Estimated corrected yield of ware	9.3
Ministry of Agriculture's estimate	8.1
	—
Difference	1.2

A similar comparison should be available in the near future for 1949, but at present we are awaiting the Ministry's estimate. The mean sample yield for 1949 over all the counties surveyed was about 2 tons per acre less than 1948 (75).

The corrections given in the above table for ware left in the ground after harvest and for differences in area were estimated by sampling methods. It will be seen that the amount of ware left in the ground after harvest, 0.8 tons per acre, is very considerable. A check on the accuracy of the sampling and of these corrections was obtained by comparison with farmers' weighed yields, where the latter were available. The mean excess of the gross sample yields was found to be 1.6 tons per acre, agreeing closely with the total correction of 1.5 tons given above. The sampling standard error from all causes was approximately 40 per cent. per field. About 1,600 fields were included in the survey, but allowing for variations in weighting the "effective" number was of the order of 1,000, giving a sampling error of about ± 0.12 tons per acre.

Apart from yield estimates the most striking result that emerged from the 1948 survey results was the marked association between late planting and low yields. Indeed, the time of planting was the factor amongst all those recorded which produced the largest apparent effect on yield. In those parts of the country where early planting was common (in particular the south-west and the Fens) there is a general indication that March plantings yielded at least a ton more than those in the first half of April, although the later plantings show little further loss. Data for the south-eastern and southern counties and for the West Midlands suggest that time of planting had little effect on yield up to the middle of April, but that, for seed put in after this time, delayed plantings gave a substantial loss, amounting to about three quarters of a ton per acre per week. It is, of course, too early yet to say whether this effect

is likely to occur in all seasons, but the result agrees with such few experiments as have been done on the effects of late planting. These experiments have indicated on the average a steady loss on the total yield of just over 0.5 tons for each week's delay up to the beginning of June. It is clear that further experimental work is required on this point.

The 1949 results are now under analysis, and the comparison between the results of the two seasons, which were meteorologically very different, should prove of considerable interest.

COLONIAL WORK

The department has agreed to accommodate a statistician to be appointed by the Colonial Office. This statistician would be required to summarize the results of previous colonial experimental work, and assist in the Colonial advisory work undertaken by the department, particularly in the fields of experimental design and analysis, and sampling methods for censuses and surveys. A suitable candidate for this post was in fact found, but unfortunately through administrative delays the appointment fell through, and no other suitable candidate has yet offered himself.

We have had the usual volume of consultant work for the Colonies, in particular Mr. Church has continued his work for the West African Cacao Research Institute and has been invited to pay them a short visit. Four workers from the Colonies worked in the department for varying periods and we have had a large number of visitors from the Colonies.

OTHER WORK

Many miscellaneous problems have been submitted to the department in the course of the year. In particular Mr. Dyke and Miss Poulton carried out an analysis of the results of a series of world-wide collaborative tests on the analysis of pyrethrum flowers (76). Mr. Dyke has continued to act as statistical adviser to the Advisory Entomologists. Mr. Healy has been giving assistance in the analysis of a series of anthropometric observations to the Department of Anatomy, Birmingham University. In addition, Mr. Healy prepared a paper on the routine computation of biological assays involving a quantitative response (61), and Mr. Jolly has evolved a method for the use of probits in combining percentage kills (62).

HOLLERITH EQUIPMENT

A Junior Rolling Total Tabulator was installed in June, 1949, as promised, and has been in active operation since then. It has already proved its value. As was expected, having a machine on the spot under the direct control of the research workers has resulted in a far more enterprising and flexible approach to punch-card work than was the case when all tabulations had to be carried out at a separate bureau. The choice of the Junior Tabulator has also proved a happy one, as this machine is sufficiently simple to be mastered by the research workers who require to use it in the course of their research, and at the same time is capable of a wide variety of operations, which are of use in research work. We are at the moment negotiating with the Company for some special modifications which will further increase the utility of the machine. In addition to its use in the analysis of survey work, we are exploring

the possibilities of carrying out the analyses of the more complicated experiments on this machine—particularly those which involve a number of different measurements on which analyses of co-variance as well as variance are required. This type of analysis has proved to be too heavy for routine work on desk calculating machines, and consequently has tended to be neglected.

STAFF

The following appointments were made in the course of the year: Dr. P. M. Grundy (October, 1949. Previously working at Rothamsted as a Ministry of Agriculture scholar); Mrs. M. Hale; Mr. P. R. D. Avis (December, 1949) from Nottingham University.

The following members of the department left to take up appointments: Mrs. M. Hale (October, 1949) Spectrographic Department, Magnesium Electron Ltd.; Mrs. P. M. Cox (Clarke) (December, 1949) National Institute for Research in Dairying; Miss M. A. Creasy (October, 1949) to take up a Ministry of Agriculture Scholarship at Oxford University.

Ministry of Agriculture Scholars: Dr. P. M. Grundy (to October, 1949); D. H. Rees (October, 1949) from Imperial College, London University.

Workers from other Stations: Mr. C. P. Cox (National Institute for Research in Dairying, Shinfield) was accommodated in the department until December, 1949. Mrs. C. P. Cox also worked here from her appointment in November, 1949 until the end of the year. Mr. J. A. Nelder, who was appointed in October, 1949 as statistician to the newly set-up Vegetable Research Station, is working at Rothamsted until accommodation is ready for him at this Station. Eight temporary workers from other organizations, four of them from the Colonies, worked in the department for varying periods during the year:—

<i>Name</i>	<i>Location</i>	<i>Period</i>
<i>British Isles</i>		
P. N. Harvey	Norfolk Agricultural Station, Sprowston, Norwich	March 1949— April 1949
G. Carruthers	Royal Navy (afterwards to University of Cambridge)	May 1949— September 1949
R. M. Jones	University of Cambridge	May 1949— July 1949
Miss H. Wilton	Grassland Research Station, Drayton	November 1949
<i>Gold Coast</i>		
J. Quartey	West African Cacao Research Institute, Tafo	April 1949—April 1950
R. Wickens	West African Cacao Research Institute, Tafo	November 1949— March 1950
<i>Nigeria</i>		
A. N. C. Thomas	Department of Agriculture, Nigeria	September 1949— October 1949
<i>East Africa</i>		
W. B. Tripe	Census Officer, Dar es Salaam, Tanganyika	October 1949— November 1949