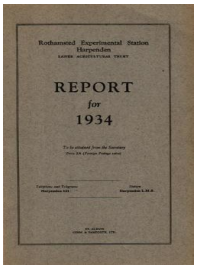
ROTHAMSTED RESEARCH

Report for 1934

Full Table of Content



Statistical Methods and Results

Rothamsted Research

Rothamsted Research (1935) *Statistical Methods and Results ;* Report For 1934, pp 96 - 99 **- DOI: https://doi.org/10.23637/ERADOC-1-66**

XIX. E. M. CROWTHER. "*Comparative Field Trials on Calcium Cyanamide and Other Nitrogenous Fertilisers on Arable Crops*". Empire Journal of Experimental Agriculture, 1935, Vol. III, pp. 129-144.

In a series of 22 field trials at Rothamsted and other centres on spring crops—barley, potatoes, and sugar beet—calcium cyanamide and sulphate of ammonia gave similar yield increases in 11 of the 15 experiments in which there were significant responses to added nitrogen, and calcium cyanamide was less efficient than sulphate of ammonia in the other four.

In five experiments at Rothamsted on winter cereals there was no clear difference between autumn and spring dressings of nitrogenous fertilisers or between calcium cyanamide and sulphate of ammonia, except with repeated small applications during winter and spring when calcium cyanamide was worse than sulphate of ammonia. Autumn dressings of dicyanodiamide, either alone or mixed with calcium cyanamide, gave good results on winter wheat.

XX. E. M. CROWTHER. "*Basic Slags and Mineral Phosphates.*" Journal of the Royal Agricultural Society of England, 1934, Vol. XCV, pp. 34-53.

The production and use of basic slags and mineral phosphates are discussed in relation to (*a*) recent work on the constitutions of their phosphatic compounds, and (*b*), the results of comparative trials on a number of phosphates in grassland experiments and pot cultures. It is suggested that the comparatively poor results from low-soluble slags may be due not merely to the circumstance that most of the phosphorus is present as an insoluble fluorapatite, but also to the associated basic calcium silicate which tends to neutralise the acids in the vicinity of the apatite crystals and so protects them from attack. The poor results generally obtained from mineral phosphates on recently limed or calcareous soils may also be explained by the very low solubility of apatites in nearly neutral solutions of calcium salts.

XXI. E. M. CROWTHER and R. G. WARREN. "*Report on Field and Laboratory Work.*" Appendix to Twelfth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture, 1934, Vol. XII, pp. 4-13.

This report summarises the results of field trials of two basic slags, superphosphate and mineral phosphate for five hay trials over four years, and for two repeated manuring trials for three and four years respectively.

STATISTICAL METHODS AND RESULTS.

(Department of Statistics).

(*a*) MATHEMATICAL THEORY.

XXII. F. YATES. "*Some Examples of Biased Sampling.*" Annals of Eugenics, 1935, Vol. VI.

It has long been known that the choice of representative samples by deliberate selection on the part of the observer is extremely difficult. In order to avoid conscious or unconscious bias the observer

https://doi.org/10.23637/ERADOC-1-66

is frequently instructed to make a " random " selection. It has not been sufficiently realised, however, that it is equally impossible to make a truly random selection unless some selective process is adopted which completely eliminates the necessity of free choice.

In this paper an account is given of three examples of sampling in which the observer did not take sufficient steps to eliminate this element of choice. The resultant samples were in all cases strikingly biased, and form excellent illustrations of the importance of a proper process of random selection.

Opportunity is taken to give an account of the principles which must be fulfilled if sampling is to be unbiased, and if an estimate of the sampling error is to be available.

XXIII. F. YATES. " *Contingency Tables Involving Small Numbers and the* χ^2 *Test.*" Supplement to the Journal of the Royal Statistical Society, 1934, Vol. I, pp. 217-235.

The χ^2 test, as applied to contingency tables, is admittedly approximate. The accuracy of this approximation depends on the numbers in the various cells, and in practice it has been customary to regard χ^2 as sufficiently accurate if no cell has an expectation of less than 5.

In this paper the exact test for any given 2×2 contingency table is established. It is then shown, by comparison, that the ordinary χ^2 test is seriously in error even with expectations greater than 100, but that a very simple modification of the test greatly enhances its precision.

The limits of applicability of this modified test are also investigated, and a table is presented whereby the range of usefulness of the test is still further extended, so that it is rarely necessary to perform the exact test mentioned above.

The exact test is also applicable to contingency tables involving more than one degree of freedom, but then becomes very laborious. Reasons are given, however, for believing that the ordinary χ^2 test is here considerably more reliable.

XXIV. R. A. FISHER and F. YATES. " *The* 6×6 *Latin Squares.*" Proceedings of the Cambridge Philosophical Society, 1934, Vol. XXX, pp. 491-507.

The problem of the enumeration of the different arrangements of n letters in an $n \times n$ Latin square, that is in a square in which each letter appears once in every row and once in every column, was first discussed by Euler (1782). A complete algebraic solution has been given by McMahon in two forms. The manipulation of the algebraic expressions, however, is considerably more laborious than the direct enumeration of the possible squares by a systematic and exhaustive series of trials.

The 6×6 squares are too numerous to be enumerated *seriatim* without risk of error. Since this size is eminently suitable for agricultural purposes, new methods of enumeration have been developed, and are here described. The number of reduced 6×6 Latin squares was found to be 9408. Certain properties of Latin squares in general are also discussed, and Euler's confident prediction that no 6×6 Graeco-Latin square exists is verified.

https://doi.org/10.23637/ERADOC-1-66

(*b*) TECHNIQUE OF AGRICULTURAL EXPERIMENTS.

XXV. A. V. COOMBS. "*The Border Effect in Plot Experiments.*" Empire Journal of Experimental Agriculture, 1934, Vol. II, pp. 315-323.

In field experiments, particularly manurial trials, the influence of the more favourable treatments on the edge rows of those less favourable has long been apparent. The object of this paper is to illustrate the inadvisability of including the edge rows in variety trials and cultivation experiments with narrow or very small plots. It is shown that the rejection of the edge rows in these experiments has no deleterious effects on the efficiency of the experiments, and that there are border effects attributable to competition and to the trespassing of the treatments, which, when the entire plot is harvested, may result in a considerably biased estimation of the treatment differences.

In manurial trials the rejection of edge rows involves a further factor, since the relative yields of edge rows and centre rows will be affected by any uneven distribution of the manures. The advisability of rejecting edge rows is thus considerably more doubtful, and it appears that special precautions should be taken in experiments with small or narrow plots to ensure that the edge rows receive their proper share of the manures.

XXVI. F. YATES. "*Complex Experiments.*" Supplement to the Journal of the Royal Statistical Society, 1935, Vol. II.

This paper, which was read before the Industrial and Agricultural Research Section of the Royal Statistical Society, contains a full review of the methods of complex experimentation, better called *factorial design*, which have been evolved at Rothamsted in the course of the last ten years. Since the inception of these methods it has been abundantly clear that they are of very wide application, and are therefore of interest to experimental workers in almost all branches of science and technology and especially to all biological workers.

The essential principle of factorial design is the inclusion in the same experiment of all combinations of several factors. Thus, if for a certain crop information is required on manurial response to a given fertiliser, and also on differences between varieties, three levels of the fertiliser may be applied to each of a representative selection, say four, of varieties, giving twelve treatment and varietal combinations in all. Such an experiment, with suitable replication and arrangement of the plots, is capable of furnishing far more information than two simple experiments, one on the fertiliser and one on the varieties, together involving the same number of plots. For not only are all the plots used twice over, furnishing information both on the average response to the fertiliser over all varieties and on the average varietal difference over all levels of fertiliser, but information is also obtained on the differential response of the varieties to the fertiliser, i.e. the *interaction* of the two factors, and, most important of all, a wider inductive basis is provided for any conclusions that may be drawn.

https://doi.org/10.23637/ERADOC-1-66

The paper gives an account of the different types of design that have proved useful in agriculture, and the appropriate methods of analysis. The method of confounding high order interactions with fertility differences, in order to reduce the number of plots per block, and the method of estimating experimental error from certain unimportant interactions, are described.

The whole method of complex experimentation in agriculture has been condemned by certain workers on the ground that the resultant increase in block size gives rise to serious loss of efficiency. The actual losses likely to occur are considered in the light of the Rothamsted results, and it is shown that such losses are by no means great enough to outweigh the immense advantages of factorial design.

The disturbance due to unequal response to a fertiliser in different blocks is also considered, and is shown to be unimportant in the Rothamsted material.

Reasons are advanced for believing that the half drill strip method (or other methods involving the comparison of pairs of plots only) are likely to be less efficient in agriculture than the method of randomised blocks and the Latin square.

XXVII. F. YATES. *"A Complex Pig-feeding Experiment."* Journal of Agricultural Science, 1934, Vol. XXIV, pp. 511-531.

The need for improvement in the methods of livestock experimentation, on the lines that have been so successful in agronomic experiments, has been felt for some time, and recently there have been many moves, both here and in America, towards the development of a better technique. The present paper sets out the requirements of an efficient and statistically sound experimental technique, and gives a detailed description of the design and analysis of a pig-feeding experiment at Rothamsted, which was carried out with a view to attempting some contribution towards the solution of the problems involved.

The pigs were fed individually, starting at weaning and finishing at bacon weight. Food consumption was recorded for each pig. The experiment itself was set out so as to compare feeding on a wet and dry meal, and to determine the effect of green food, and the effect of variation of numbers in a pen. The design was complex, i.e. all combinations of the various groups of treatments were included. The results obtained were : (1) complete failure of pigs without green food ; (2) more rapid rate of growth of pigs on wet meal, attributable to the greater quantity of food consumed ; (3) no effect of variation of numbers in a pen.

The experimental errors obtained have been compared with those of a series of similar experiments at Cambridge. The Cambridge experiment, in which a system of rationed feeding was used, proved to be the more accurate. The reasons for this are discussed.

Various modifications and improvements in experimental technique are suggested.

https://doi.org/10.23637/ERADOC-1-66