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## Report for 1929

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## Statistical Methods and Results

### Rothamsted Research

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STATISTICAL METHODS AND RESULTS.

(Statistical Department.)

- IX. A. J. PAGE. "*On the Annual Revision of Forecasting Formulas based on Partial Regression Equations.*" Journal of the American Statistical Association, 1929. Vol. XXIV, pp. 123-126.

A simple labour-saving formula is developed, by means of which multiple regression equations may be modified appropriately for the inclusion of a new set of observations. The process is recommended as a routine measure for official crop forecasts and other purposes, in which it is important to keep the prediction formula employed up to date, and to make use of all available information.

- X. R. A. FISHER. "*Tests of Significance in Harmonic Analysis.*" Proceedings of the Royal Society (A), 1929. Vol. CXXV, pp. 54-59.

Considerable discrepancy exists among meteorologists and others as to the test of significance to be applied to real or imaginary periods apparent in the data. Schuster's test is correct for testing the significance of a Fourier submultiple chosen in advance, if the variance of the individual values is known *a priori*. Walker's test is appropriate to the largest amplitude among the Fourier submultiple periods. In practice, the variance must be estimated from the observations, and formulæ are given for both cases in which exact allowance is made for the sampling errors of the estimate.

- XI. J. O. IRWIN. "*Note on the  $\chi^2$  Test for Goodness of Fit.*" Journal of the Royal Statistical Society, 1929. Vol. XCII, pp. 264-266.

A critical note on two different methods of applying the  $\chi^2$  test of goodness of fit. In the first, no allowance is made for the reduction of the number of degrees of freedom when estimates of the population parameters are made from the sample. In the second, the allowance is made. The author points out the differences between the hypotheses on which the two methods are based and gives his reasons for preferring the second method.

- XII. J. O. IRWIN. "*On the Frequency Distribution of any Number of Deviates from the Mean of a Sample from a Normal Population and the Partial Correlations between them.*" Journal of the Royal Statistical Society, 1929. Vol. XCII, pp. 580-584.

An extension of a result which had previously been obtained only for one or two deviates.

- XIII. J. WISHART. "*The Correlation between Product Moments of any Order in Samples from a Normal Population.*" Proceedings of the Royal Society of Edinburgh, 1929. Vol. XLIX, Part I, pp. 78-90.

It is shown that by means of a new method of attack, devised by R. A. Fisher, problems on the correlation between product



moments, which had hitherto been solved only to a limited extent and by approximate methods, can be worked out in their full generality. The correlation between the  $t^{\text{th}}$  semi-invariant estimates is shown to be equal to the  $t^{\text{th}}$  power of the correlation between the variates in the normal population considered, while that between any two estimates of the product semi-invariants is also worked out.

- XIV. A. R. CLAPHAM. "*The Estimation of Yield in Cereal Crops by Sampling Methods.*" *Journal of Agricultural Science*, 1929. Vol. XIX, pp. 214-235.

Cereal plots were sampled for yield by three different methods. In one, the location of units (metre-lengths of drill) was wholly systematic, in a single regular pattern: in the second, five drills were selected at random, but six units were cut at different intervals along each row: and in the third, ten units were selected at random from each third of the plot. The results were subjected to statistical analysis, and the disadvantages of the first two methods were clearly demonstrated. These disadvantages were further emphasised in an analysis of earlier data on sampling methods, which made it evident that a direct estimate of sampling error is greatly superior in accuracy to an indirect estimate. It is important, therefore, when carrying out investigations on the precision of such methods, and on possible means of increasing the precision, to ensure that a direct estimate shall be obtainable. This is achieved only by securing some element of random location of units.

By the use of a random sampling method, such as the third (whose superiority to the second depends on the greater representativeness of the sample), the variance due to sampling errors can be made a satisfactorily small fraction of the total variance of cereal experimental plots about 1/40th acre in area.

- XV. J. WISHART AND A. R. CLAPHAM. "*A Study in Sampling Technique: the Effect of Artificial Fertilisers on the Yield of Potatoes.*" *Journal of Agricultural Science*, 1929. Vol. XIX, pp. 600-618.

Methods for sampling cereal crops have already been discussed. Certain modifications of these are necessary in the case of a root crop such as potatoes, owing to the fact that the variability usually met with in the spacing makes the individual plant the logical unit, while for ease in working, a systematic method of selecting the plants is to be preferred. The statistical requirements are satisfied by a simple systematic distribution within the sampling unit, provided at least two randomly chosen sampling units are taken from each plot to constitute the sample. An analysis is made of the yields of part of the Rothamsted potato experiment of 1928, both as estimated by a sampling method and as determined by large scale lifting. It is concluded that a larger proportion of plants than were actually taken is necessary to give a sampling error as small as 4 per cent., and that it would then be profitable only to sample plots of 1/20th acre or more in area.