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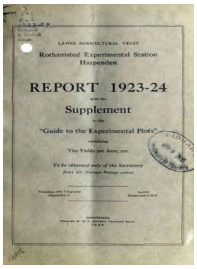
Report for 1923-1924 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



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Statistical Methods and Results

Rothamsted Research

Rothamsted Research (1925) *Statistical Methods and Results ;* Report For 1923-1924 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 44 - 48 **- DOI: https://doi.org/10.23637/ERADOC-1-116**

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in the cortical tissues, and the bacteria do not swell out to form the so-called "bacteroids." In plants grown without boron, the number of nodules that attain macroscopic size is much reduced. When weakly developed strands enter the nodule, the amount of tissue containing bacteroids is closely correlated with the extent of the strands.

In the plants bearing these abnormal nodules the quantity of nitrogen fixed per nodule is small, being, in one experiment, less than one-tenth of that fixed in normal plants. The defective vascular supply is thus accompanied, on the one hand, by a reduced development of "bacteroid" forms and, on the other hand, by reduced nitrogen fixation.

In the absence or weak development of vascular strands in the nodule, the bacteria tend to become parasitic, attacking the protoplasm of the host cell. This attack is chiefly directed towards the more densely protoplasmic cells of the nodule. It is suggested that this change in the relations between the micro-organism and its host is connected with the loss or reduced supply of the carbohydrate energy material normally brought into the nodule by the vascular strands, the bacteria thus being reduced to making use of the protoplasm of the host as a source of energy.

IV. E. J. Russell. Journal of the Institute of Brewing. A full account of the work discussed on p. 17 of this report.

V. H. Lloyd Hind. *"Report on the Analyses of the Barleys of* 1922 *and of the Malts made from them."* Journal of the Institute of Brewing, 1924. Vol. XXX., pp. 969-986.

This report gives the results of the analyses of the barleys grown under the auspices of the Institute of Brewing Barley Research Scheme in 1922, together with those of the malts made from them.

The first season's determinations were necessarily of an exploratory character, quality being a very elusive property which has not yet been reduced to exact chemical terms. The relationships between the total nitrogen and the other quantities generally estimated in malt analyses have been studied. The usual physical valuation of barley, good as it often is in the hands of experts, is shown to fail in certain conditions, some of the low valued barleys giving quite useful malts. The influence of regional conditions, soil, season, etc., on the composition of the barley and malts is shown to be greater than that of the different manurial treatments at each centre.

(*b*) Statistical Methods and Results.

Agreement of Theory and Observation.

VI. R. A. Fisher. *"Statistical Tests of Agreement between Observation and Hypothesis."* Economica, 1923. Vol. III., No. 8, pp. 139-147.

In all quantitative work, both in biology and in agriculture, tests of agreement between observation and hypothesis assume

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a critical importance. Unfortunately, as early as 1900, a mathematical error was introduced into the statistical theory of goodness of fit, which has led to many inconsistencies. This error, in its application to contingency tables, was pointed out by Fisher (1922), and the method of correction was at the same time indicated. In the present paper the disputed case of the fourfold table is treated in detail. A mathematical proof of the corrected formula is given, and the experiments of Yule, designed to test this specific point, are shown to agree well with the corrected formula, while they are wholly inconsistent with the formula previously in use.

ERRORS OF OBSERVATION.

VII. R. A. Fisher. *"Note on Dr. Burnside's recent Paper on Errors of Observation."* Proceedings of the Cambridge Philosophical Society, 1923. Vol. XXI., pp. 655-658.

In small sample work, such as prevails in agricultural experimentation, the traditional methods standardised in biometry and in the theory of errors break down, so that more precise methods must be used. The first of these was developed by "Student" in 1908. In 1923 Burnside independently arrived at formulæ similar to, but not identical with, those of "Student." In the present note attention is drawn to "Student's" paper, and an exact proof is given of the accuracy of his formulæ.

THE PARTIAL CORRELATION COEFFICIENT.

VIII. R. A. Fisher. *"The Distribution of the Partial Correlation Coefficient."* Metron., 1924. Vol. III., pp. 329-332.

In 1915 Fisher gave the exact sampling distribution of the correlation coefficient, and showed that the current formula for its probable error was inadequate when applied to small samples. In the present paper it is shown that the same formula, with a simple modification, is applicable to the distribution of the partial correlation coefficient. The theoretical result so obtained is shown to be in agreement with the experimental data hitherto available.

STATISTICAL REQUIREMENTS OF ACCURATE TESTS.

IX. R. A. Fisher. *"The Conditions under which χ^2 measures the Discrepancy between Observation and Hypothesis."* Journal of the Royal Statistical Society, 1924. Vol. LXXXVII., pp. 442-450.

In making tests of goodness of fit the expectations have often, or indeed usually, to be reconstructed from the actual data with which they are to be compared. In such cases it had not been observed that it is necessary that the methods used in this reconstruction should not involve errors of fitting comparable to the errors of random sampling. In the present paper it is demonstrated that this requirement can only be fulfilled if the statistics used in the reconstruction, are not only consistent, but efficient statistics. When all statistics so employed satisfy the criterion of efficiency, it is demonstrated that the measure of discrepancy, χ^2, may, in large samples, be used with precision.

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YIELD OF BARLEY.

X. W. A. MACKENZIE. "*Studies in Crop Variation. III. An Examination of the Yield of Dressed Grain from Hoos Field.*" Journal of Agricultural Science, 1924. Vol. XIV., pp. 434-460.

Records of the barley yields for 70 years have been analysed in the same manner as in the earlier study of the Broadbalk wheat results. Thirteen of the plots supply an unbroken record of manurial treatment. The variation of these is analysed into three portions representing (I) annual variations ascribable to variations in the weather; (II) steady deterioration ascribable to soil exhaustion; (III) slow changes other than steady deterioration. The annual variations are in general similar in comparable plots to those found with wheat, barley being on the whole the more variable. The average yields bring out the striking fact that no gain in yield can be ascribed to dressings of sulphate of potash, although the responses to superphosphate, rape cake and silicates (in the absence of superphosphate) are in all cases excellent. The failure of potash to improve the yield is brought out decisively by a comparison of the rates of deterioration, which seem to indicate that plots receiving potash have fallen off more rapidly than parallel plots without potash. The slow changes other than steady deterioration are smaller than on Broadbalk, and do not indicate, as on that field, any single simple explanation.

EFFECT OF MANURES ON GOUT FLY ATTACK.

XI. "MATHETES." "*Statistical Study of the Effect of Manuring on Infestation of Barley by Gout Fly.*" Annals of Applied Biology, 1924. Vol. XI., pp. 220-235.

This paper is a statistical analysis of the extensive data on gout fly infestation compiled by the Entomological Department for the years 1922 and 1923. (*See* Paper XLIX.) A preliminary examination of the agreement of parallel samples showed that in the data from Woburn and from the several experiments with malting barley the infestation was homogeneous over each plot. In two of the malting barley series significant differences appeared in the infestation of different plots; the same effect was even more strongly shown at Woburn. On Hoos field (1922) the individual plots were not homogeneous in infestation, but the differences between plots were so large and so consistently related to manurial treatment as to deserve a more detailed investigation.

Of ten comparisons possible with superphosphate all indicated that this manure materially decreases gout fly infestation, even in the two cases where, in the absence of nitrogenous manuring, it has little effect upon the yield. The percentage infested, which in the absence of this manure ranged from 20 to 11, is reduced on the average by 5.1; similarly, rape cake reduced the percentage by 4.2; potassium, sodium and magnesium salts by 3.8;

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nitrate of soda by 3.4; and ammonium salts by 2.1. Silicates, although in the absence of phosphate they materially increase the yield, have no apparent effect upon gout fly infestation.

The data for 1923 were more satisfactory in that the plots this year were homogeneous. The differences in infestation associated with manurial treatment were on the whole similar to those of 1922. Phosphates, potassium, sodium and magnesium salts and rape cake again reduced infestation materially; silicates were again inoperative, but the small reduction in infestation ascribable in 1922 to nitrogenous mineral manures was absent.

RAINFALL AND WHEAT YIELDS.

XII. R. A. Fisher. *"The Influence of Rainfall on the Yield of Wheat at Rothamsted."* Philosophical Transactions of the Royal Society of London, B., 1924. Vol. 213, pp. 89-142.

This paper is the report of the methods and results of a large scale statistical reduction of the Rothamsted records of rainfall and wheat yields. The objects of the enquiry were (I) to ascertain the actual effects of varying rainfall as a factor in crop variation; (II) to discover the differential responses to rainfall of crops grown under different manurial treatments; (III) to lay a foundation both of statistical method and of ascertained fact for the agricultural evaluation of a particular season's weather, as is required for any effective system of agricultural insurance.

The greater part of the paper is devoted to the solution of mathematical problems, and the development of statistical methods, adequate to handle the type of data which it is required to treat. The procedure which emerges from the solution of these problems consists in making a detailed analysis of the weather sequence in each individual year for which crop records are available, so as to obtain measures of the several meteorological characteristics of each year. The yields are then expressed in terms of these measures in such a way that the average effect of a given weather variation upon the final crop can be calculated for all times of the year.

This procedure is applied to 65 rainfall sequences, and the average effect at all times of the year of an inch of rainfall is obtained for the 13 plots of Broadbalk wheat field which have been for the whole period under uniform treatment. Plots differently manured show very striking differences in the rainfall response, indicating that the prevailing climate is a considerable factor in determining the suitability of manurial dressings. All plots show that the rainfall of the district is on the average in excess of the requirements of wheat, but several plots indicate that more rain would be advantageous in October. All plots receiving nitrogenous fertilisers, including the 17 and 18 mineral series which receives only residual nitrogen, show a considerable loss of yield due to rain in January, which is apparently due to the loss of nitrates in drainage water. Those plots in which nitrogen deficiency is of rarest occurrence, such as the dunged

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plot and plots 10 and 11, show an even heavier loss due to rainfall in July and August.

Rainfall variations make an important contribution to the yield variation observed. In this respect rain is perhaps more important than any other single meteorological factor. It will not be possible to treat the other meteorological factors with the same precision, since the records of temperature and sunshine do not go back to the beginning of the experiments.

See also paper No. XVII.

II. METEOROLOGY.

(Physical and Statistical Departments.)

XIII. W. B. Haines. *"A Comparison of the Radiation Recorders at Rothamsted.* Journal of the Royal Meteorological Society, 1925. Vol. LI., pp. 95-100.

This paper deals with a comparison of the readings taken at Rothamsted with three types of radiation recorder. The first is a recorder of the Callendar pattern, depending upon the difference in temperature between a black and a bright resistance exposed to the sky. These readings are taken as standard. The second instrument (the Wilson Radio-integrator) reads the amount of alcohol which distils from a bulb exposed to the radiation into a similar shielded bulb. The third set of data is the record of hours of bright sunshine from the widely used Campbell-Stokes apparatus. Reference is also made to a fourth set of data, that given by an evaporimeter of the porous candle type, since the readings of this instrument are correlated to the amount of radiation.

The alcohol integrator gives readings much too low during the winter months. The readings can be fitted with fair accuracy by a formula of simple parabolic type. The possibility of introducing a temperature correction is discussed.

The hours of bright sunshine should be corrected by a factor depending upon the time of day and year (*i.e.,* upon the sun's altitude). A formula deduced by Ångstrom from the Stockholm data, for calculating total radiation from hours of bright sunshine, is examined and found fairly satisfactory for the Rothamsted data. It is concluded that such a formula, based upon the data at one station, could with due caution be adopted for another station.

The evaporimeter results follow the hours of sunshine very closely, but some care is needed in the choice of a site for this instrument.

XIV. W. D. Christmas. *"Notes on the Weather at Rothamsted."* "Nature," Oct. 27th, 1921; Jan. 16th, 1922. "The Times," Jan. 26th, July 4th, Aug. 2nd, Sept. 3rd, Oct. 1st, Nov. 2nd, Dec. 2nd, 1923; Jan. 2nd, Mar. 1st, June 2nd, Sept. 1st, 1924; Jan. 1st, 1925.