ROTHAMSTED RESEARCH

Report for 1933

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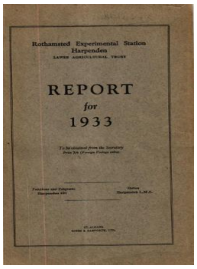

Summaries of Papers Published in 1933 - I. Scientific Papers

Rothamsted Research

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SCIENTIFIC PAPERS

Published 1933 and in the Press

PLANT GROWTH, PLANT PRODUCTS AND ACTION OF MANURES

(Departments of Bacteriology, Botany, Chemistry, Fermentation and Statistics)

(*a*) PLANT GROWTH.

1. E. J. RUSSELL. "*The Rothamsted Experiments on the Growth of Wheat*, 1843-1933. *Ninety years of continuous wheat on one field.*" Proceedings of the World's Grain Exhibition and Conference, Regina, Canada, 1933. Vol. II (also Mezogazdasagi Kutatasok. 1933. Vol. VI, pp. 522-543.)

The broad conclusion from these experiments is that wheat can be grown year after year on the same land, but even with good cultivation the yield deteriorated. Better yields are obtained by growing the wheat in alternate years with fallow in between and deterioration is then slower to set in, but it comes all the same. Still better yields are obtained by growing wheat only once in four years and having other crops in between ; here also there may be deterioration but it takes very much longer to set in and is easily avoided. At Rothamsted the continuously cropped wheat fell off in yield in the first 25 years, from 17 bushels down to 11 bushels per acre but for the past 65 years there has been only little further fall. The alternate wheat-fallow also fell to 11 bushels per acre but took 60 years to do it instead of 25. The four-year rotation has been going on for 85 years and the yields of wheat are as good as they were 70 years ago on the continuous plots, so that we must apparently wait a good deal longer before the 11 bushel level is reached.

At Rothamsted it seems impossible to obtain an average of less than 10 bushels per acre by mere exhaustion of the land and so long as weeds are kept down. If, however, weeds are allowed to grow, the yields rapidly fall to low levels. We know of no way of reducing crop yields more effective than permitting the competition of weeds.

The continuous growth of wheat at Rothamsted has not, apparently, led to increased tendency to disease.

II. H. H. MANN. "*Report on Tea Cultivation in the Tanganyika Territory and its Development.*" Crown Agents for the Colonies, London, 1933, pp. 1-54.

This report was the result of a visit to the Tanganyika Territory in the summer of 1932. As a result the opinion is expressed that the conditions are favourable for the extension of tea cultivation to an area of 50,000 acres. The areas suitable lie both in the Usambara Mountains in the north of the Territory, and in the Southern Highlands in the south.

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III. H. H. MANN. "*Report on Tea Cultivation and its Development in Nyasaland.*" Crown Agents for the Colonies, London, 1933, pp. 1-41.

The author visited Nyasaland in 1932 on behalf of the Colonial Office, and this report is based on observations made during that visit. In this colony there is a well-developed tea area, lying in the extreme south, and the cultivation already extends to a little over 12,000 acres. It lies on soils derived from a series of granite ranges, and has proved itself very favourable to the crop. The report makes a criticial examination of the present position of the industry with suggestions for its improvement, especially in the matter of increasing the yield and improving the quality of the tea.

IV. H. H. MANN. "*The Climatic and Soil Requirements of Tea.*" Empire Journal of Experimental Agriculture, 1933, Vol. I, pp. 245-252.

This paper summarises the information at present available on the soil and climatic needs of tea culture, especially as they have been revealed by the recent work done in India and Ceylon.

V. R. J. KALAMKAR. "*The Influence of Rainfall on the Yield of Mangolds at Rothamsted.*" Journal of Agricultural Science, 1933, Vol. XXIII, pp. 571-579.

Analysis shows that the variation in the yield due to annual causes cannot be accounted for by a single weather element, rain.

An additional inch of rain above the normal, during the period extending from the middle of March to about the end of May, is harmful, possibly because of the difficulty in securing a proper tilth and delay in sowing, which results in a shortening of the growing period.

The yield appears to be benefited by an additional inch of rain above the normal, particularly during the months of June and July.

VI. K. WARINGTON. "*The Influence of Length of Day on the Response of Plants to Boron.*" Annals of Botany, 1933, Vol. XLVIII, pp. 430-457.

The delay in appearance both of flowers and of boron deficiency symptoms observed in spring and autumn compared with summer grown plants is due to the reduction in length of day rather than the lowered temperature, but no special association between the function of boron and flower production has been found except in so far as all meristematic processes are affected by a lack of this element. Within a range of 7-16 hours, the length of day has no bearing on the need of the plant for boron and the characteristic deficiency symptoms are similar under long or short day conditions, though they tend to be less pronounced in the latter instance. Shortening the day does not result in degeneration effects as are induced by a lack of boron, but the influence of the two factors may bear a superficial resemblance to each other as where flowering is prevented. The presence of each factor modifies the effect of the other, but the lack of boron exerts the more fundamental influence on the plant.

(*b*) PLANT PRODUCTS.

VII. E. J. RUSSELL and L. R. BISHOP. "*Investigations on Barley. Report on the Ten Years of Experiments under the Institute of Brewing Research Scheme.* 1922-1931." Journal of the Institute of Brewing, 1933, Vol. XXXIX, pp. 287-421.

A summary report which brings together the results of laboratory and field experiments over ten years on the effects of soil, season, manuring, variety and cultivation on the yield and quality of barley and on the relationship of the chemical composition of the barley to the properties of the malt and beer prepared from it.

VIII. L. R. BISHOP and F. E. DAY. "*Prediction of Extract, II. The Effect of Variety on the Relation between Nitrogen Content and Extract.*" Journal of the Institute of Brewing, 1933, Vol. XXXIX, pp. 545-551.

The effects of nitrogen content and thousand corn weight on extract yield proved to be similar for all varieties of barley tested. For constant values of nitrogen content and thousand corn weight there are constant differences between varieties. A list of these varietal constants is given.

IX. L. R. BISHOP and D. MARX. "*Regularities in the Carbohydrate Composition of Barley Grain.*" Journal of the Institute of Brewing, 1934, Vol. XL, pp. 62-73.

In each variety the individual carbohydrates of barley grain increase regularly with the total carbohydrate. There are small differences between individual varieties which are more marked in the general distinction between two- and six-row barleys. The carbohydrates of extract (" reserve carbohydrates ") increase more rapidly than the remaining carbohydrates (" cell carbohydrates ") with increase of total carbohydrate. The unit on which these relations show most accurately is for quantities calculated at so much per corn (or per thousand corns).

In each of the above respects the behaviour of the carbohydrates parallels that of the proteins. Both suggest the regularities result from equilibria of a mass action type during development of the grain.

The similarity between the proteins and carbohydrates also holds in malting, during which the proteins are broken down to give asparagine and the carbohydrates to sucrose.

X. L. R. BISHOP. "*Prediction of Extract, III.*" Journal of the Institute of Brewing, 1934, Vol. XL, pp. 74-91.

The carbohydrate regularity principle has been applied to give practical results in the form of an extract prediction equation, which can be used where the variety of the barley is unknown—a common position in practice. It appears to be particularly accurate and useful with Californian barleys.

The size of the protein factor in this equation demonstrates the incompleteness of the original hypothesis of Haase, that protein simply replaces carbohydrate and so exerts a corresponding reduction of extract. While this is responsible for half the observed effect the other half is due to a " sealing up " of carbohydrate by protein,

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which becomes more marked in high nitrogen barleys. This applies to the Institute of Brewing Standard Method of Extract Determination ; with fine grinding " sealing up " does not occur.

The success of the insoluble carbohydrate factor over a wide range of barleys affords strong support to the " carbohydrate regularity " hypothesis.

XI. A. G. NORMAN. " *A Preliminary Investigation of the Development of Structural Constituents in the Barley Plant.*" Journal of Agricultural Science, 1933, Vol. XXIII, pp. 216-227.

Barley plants were sampled weekly during the season and various analyses, especially for structural constituents were carried out. The natural cellulose fraction increased from 30 to 35 per cent. The amount of cellulosan in this fraction increased with development and markedly so after the point at which growth increments lessened. In the later stages the quantity remained constant. Lignin increased steadily till the last week or so. In the young plant the major portion of the total pentose material is in the polyuronide hemicellulose, while in the mature plant it is accounted for by the cellulosan.

XII. (*a*) A. G. NORMAN and S. H. JENKINS. "*A New Method for the Determination of Cellulose Based upon Observations on the Removal of Lignin and Other Encrusting Materials.*" Biochemical Journal, 1933, Vol. XXVII, pp. 818-831.

XII. (*b*) A. G. NORMAN and S. H. JENKINS. " *Lignin Content of Cellulose Products.*" Nature, 1933, Vol. CXXXI, p. 729.

In any method for the estimation of cellulose, the cellulosan fraction should remain intact. Many methods heretofore proposed involve some pre-treatment, either alkaline or acid or both, which attacks or removes the fraction in part. A new method is proposed suitable for all classes of material, employing neutral and acidified sodium hypochlorite followed by sodium sulphite and avoiding the use of gaseous chlorine.

The products obtained from cereal straws are found to be not quite lignin-free, even after allowance is made for an error in that determination. The error is due to the production of some resistant material from pentosan groupings in the presence of 72% H_2SO_4. The magnitude of the error in lignin content of natural materials such as woods, due to this disturbing factor, is very considerable, and there is reason for believing that the figures hitherto quoted for straw and hardwoods are as much as 25-30% too high, but for soft woods rather less, owing to their lower pentose content.

(*c*) ACTION OF MANURES.

XIII. H. G. THORNTON and HUGH NICOL. " *The Effect of Sodium Nitrate on the Growth and Nitrogen Content of a Lucerne and Grass Mixture.*" Journal of Agricultural Science, 1934, Vol. XXIV, pp. 269-282.

Inoculated lucerne was grown alone and in association with Italian rye grass, in pots of sand watered with food solution and given three different doses of sodium nitrate. The dose of nitrate did not affect the dry weight or nitrogen content of lucerne when

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grown alone, save that the highest dose checked the root growth somewhat.

When lucerne and Italian rye grass were grown in association, the growth of the grass varied directly with the dose of nitrate applied, and the growth of the lucerne varied inversely to it. Checking of the lucerne growth was probably due to root competition with the grass. The nitrogen contents of the combined lucerne and grass tops and that of the combined roots were also inversely related to the quantity of nitrate applied. There was evidence that within 3 months of sowing the grass had obtained nitrogen fixed by the lucerne nodules.

XIV. J. A. DAJI. "*The Decomposition of Green Manures in Soil.*" Journal of Agricultural Science, 1934, Vol. XXIV, pp. 15-27.

The following four materials were used as green manures and their decomposition in admixture with soil was studied under laboratory conditions : sugar beet tops, young mustard, young tares and mature mustard. Soluble carbohydrates, hemicellulose as measured by the furfuraldehyde yield, and cellulose are chiefly responsible for the total loss of organic matter during decomposition. The ratio of available carbohydrate to available nitrogen determines the rate of decomposition, this being rapid when the ratio is low and slower when the ratio is high. Young plant materials used as green manure decompose so quickly that nitrogen may be lost either by very rapid nitrification or by some process as yet unknown.

XV. E. M. CROWTHER and H. H. MANN. "*Green Manuring and Sheep Folding on Light Land—An Account of the Green Manuring Experiments at the Woburn Experimental Station* 1893-1933," Journal of the Royal Agricultural Society of England, 1933, Vol. XCIV, pp. 128-151.

The agricultural details and the wheat yields of the two series of green manuring experiments at the Woburn Experimental Station are summarised and discussed in relation to the composition of the soil and the green crops, and to the results of recent pot culture and laboratory experiments on the manurial value of green manure material. It is concluded that a large mustard crop rapidly grown in soil of moderate to high fertility provides a means of avoiding loss by carrying over some of the nitrogen and other nutrients to a later period when they may be utilised by some more valuable crop. A good crop of tares provides a direct addition of nitrogen in a form which becomes available at once. Whether it is used or lost depends on the immediately following crop and the weather. The whole art of successful green manuring on light land lies in careful adjustment of the cropping so that the nutrients in the green manures will be efficiently used by the following crop.

XVI. HUGH NICOL. "*Rothamsted Experiments on Residual Values of Leguminous Crops.*" The Empire Journal of Experimental Agriculture, 1933, Vol. I, pp. 22-32.

The results of cropping experiments lasting from 1899 to 1922 showed that the effect of preceding crops of legumes could be traced

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by increased yields of grain for several years after legumes had ceased to be grown. The residual value of lucerne was markedly superior to that of red clover and six other legumes.

XVII. E. M. CROWTHER AND W. E. BRENCHLEY. *"The Fertilising Value and Nitrifiability of Humic Materials Prepared from Coal."* Journal of Agricultural Science, 1934, Vol. XXIV, pp. 156-176.

Humic acids and ammonium humates prepared by a patented process of gentle oxidation of coal were examined as fertilisers by laboratory nitrification experiments and pot-culture tests on four soils and by a number of field experiments on a range of soils and crops during a single season. In all tests the effects of ammonium humate could not be distinguished from those of ammonium sulphate of equal ammonium content. The nitrification tests and the pot cultures afforded some evidence of a slow production of nitrate or available nitrogen from the humic acid. In the field experiments, as in the pots, there was no clear evidence of any fertiliser value apart from that due to the ammonium present. The close agreement between laboratory measurements on nitrate accumulation and yields and nitrogen contents of barley for seven treatments in four soils shows that the laboratory technique afforded an adequate measure of the availability of the fertiliser nitrogen.

XVIII. E. M. CROWTHER AND R. G. WARREN. *"The Fertiliser Value of Basic Slags and Other Phosphates."* Agricultural Progress, 1934, Vol. XI, pp. 99-105.

The results of recent field and pot experiments carried out under the aegis of the Ministry of Agriculture Permanent Committee on Basic Slag are reviewed. Most of the field experiments were on land mown for hay for four seasons, but a few experiments were also made on frequently-mown young grass. In all of the experiments the phosphoric acid percentage in the produce was considerably increased by the more active fertilisers, and in several of them the protein content of the hay was also increased. The percentage recovery in the crops of three or four years of the phosphoric acid added gave consistent results throughout the series of experiments. The mean recoveries were : for superphosphate, 21 per cent. ; for high soluble slag, 20 per cent. ; for low soluble slag, 6 per cent. Basic slags with from 20 to 35 per cent. of their phosphoric acid soluble in the conventional 2 per cent. citric acid are much less effective as sources of available phosphate than those with more than 80 per cent. of their phosphoric acid soluble in this reagent. A sharp distinction must be drawn between acid soils (pH about 5) and neutral soils in considering the value of mineral phosphate. On the acid soils it was as effective as the more soluble phosphates (17 per cent. recovery), but on the neutral soils it was as ineffective as the low soluble slag (6 per cent. recovery).

In an experiment on grassland which was grazed for most of the year the effects of the phosphatic fertilisers were similar to those on repeatedly mown young grass.

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STATISTICAL METHODS AND RESULTS

(Department of Statistics)

(*a*) Mathematical Theory

XIX. R. A. Fisher. "*The Sampling Error of Estimated Deviates, together with Other Illustrations of the Properties and Applications of the Integrals and Derivatives of the Normal Error Function.*" Mathematical Tables, 1931, Vol. I, pp. xxvi-xxxv.

The mathematical properties of the Hermite functions H_n and the closely related functions G_n are summarised, together with their relationship to the integrals I_n of the probability integral. The definition of I_n is extended to include positive and non-integral values of n.

It is shown that if the deviate of the mean of a normal distribution from a fixed value is estimated by the deviate of the mean of a sample and this deviate is expressed as a fraction t of the estimated standard error of the sample, then the distribution of t can be obtained in terms of I functions.

The moments of the truncated normal distribution about its terminus are easily expressed in I functions. The method of moments, when applied to estimating the parameters of the distribution, is in this case efficient, giving the same solution as the method of maximum likelihood.

If the parameter m of a simple Poisson series is a variate, then with certain distributions of m the resultant modified distributions of the variate x of the Poisson series are expressible in terms of the I functions.

XX. F. Yates. "*The Analysis of Multiple Classifications with Unequal Numbers in the Different Classes.*" Journal of the American Statistical Association, 1934, Vol. XXIX, pp. 51-66.

A type of problem which frequently confronts the statistician is the analysis of data which can be classified simultaneously in two or more different ways, as, for example, the analysis of the incidence of disease in different towns, where the towns might be classified according to population and also according to geographical position.

The statistical procedure appropriate to the case where the numbers in the various sub-classes are equal is specially simple, and has been very fully developed in connection with the replicated field trials in agriculture. The procedure is a special case of the method known as the analysis of variance. When analysing tables in which the numbers of the various sub-classes are unequal the procedure appropriate to equal numbers requires considerable modification. This paper considers the general case of a $p \times q$ table, as well as the more special case of a $2 \times q$ table, and is largely a fuller exposition of the methods advocated in a previous paper.

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XXI. CH. ZINZADZE. "*Bibliography of Statistical Methods, chiefly on the Application of the Analysis of Variance.*" Duplicated copies, Rothamsted Experimental Station, 1933.

In the last few years the application of statistical methods to biology has grown considerably, and the new methods associated with the name of R. A. Fisher have spread far afield. But it has already become very difficult to find the widely scattered papers published on this subject in many countries and different journals. Therefore it has become necessary to arrange a classified bibliography.

There are two objects in view in presenting this bibliography : (*a*) to introduce the beginner to the study of the analysis of variance ; and (*b*) to supply the advanced research workers with the principal publications up to the end of 1933.

The following are the classes in which the bibliography has been arranged : (1) Field Experimentation ; (2) Horticulture ; (3) Plant Physiology ; (4) Soil Science and Soil Bacteriology ; (5) Meteorology ; (6) Fisheries ; (7) Books and General Works in Statistics.

(*b*) TECHNIQUE OF FIELD EXPERIMENTS

XXII. F. YATES. "*The Formation of Latin Squares for use in Field Experiments.*" Empire Journal of Experimental Agriculture, 1933, Vol. I, pp. 235-244.

The value, as a means of eliminating fertility differences, of square arrangements of plots, satisfying the conditions of the Latin square, was early recognised. When first introduced, however, the importance of an unbiased estimate of error was not realised, and the arrangements adopted were all systematic, usually of some specially simple type, or alternatively of a type which was believed would remove most completely the soil differences ordinarily existing.

Randomisation has now been practised for some years, but the exact procedure of randomisation appropriate to a Latin square has never been clearly defined. In this paper it is shown that the randomisation of rows and columns, or either and letters, among themselves, will provide an unbiased estimate of error, but that there is something to be said when using squares of small size for making a random selection from all possible squares of that size.

The squares up to size 6×6 have now been completely enumerated and are here presented in a form suitable for making a random selection from all possible squares. Specimen squares from 7×7 to 12×12 are also given from which by randomisation of rows, columns and letters, or any two of these, squares may be obtained for experimental use.

XXIII. F. YATES. "*The Analysis of Replicated Experiments when the Field Results are Incomplete.*" Empire Journal of Experimental Agriculture, 1933, Vol. I, pp. 129-142.

The principles of randomisation and replication, recently introduced into the design of agricultural field trials, have greatly increased their accuracy, and have rendered possible valid tests of significance and estimates of the experimental errors. But as in all experimental work, it sometimes happens that accidental causes

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upset the original design, so that the methods of analysis which are ordinarily appropriate require modification. In general, replicated field trials are so arranged that the mean yield of all the plots receiving a given treatment provides the best estimate of the effect of that treatment, free from any extraneous effects, such as fertility differences, which are allowed for in the design.

If the yields of some plots are lost, or unreliable, the balance of the original design disappears. The simplest method of obtaining unbiased estimates of the treatment effects, and making tests of their significance, is to estimate the yields of the missing plots, and then perform the analysis of variance on the completed set of values. The formulæ appropriate to the case of a single missing plot of a randomised block or Latin square were first given by Miss Allan and Dr. Wishart. A simpler method of deriving these formulae is here described, and the procedure appropriate to the case where several values are missing is developed. The validity of the ordinary tests of significance is also examined, it being shown that there is no serious disturbance.

A new use of the missing plot technique is suggested for analysing interactions which are believed to be due to a few anomalous values.

XXIV. R. K. S. MURRAY. "*The Value of a Uniformity Trial in Field Experimentation with Rubber.*" Journal of Agricultural Science, 1934, Vol. XXIV, pp. 177-184.

Sanders' method of utilising previous crop records to correct experimental results by means of a linear regression is briefly described.

The method is applied to yield figures from rubber trees in Sumatra, and the precision of a dummy experiment is thereby increased nearly four-fold when the "preliminary" and "experimental" years are consecutive. When the "experimental" year is three years later than the "preliminary" year the error of the adjusted yields is reduced to about a half.

It is concluded that not only has the method of correction been of value in the particular instance investigated, but that a uniformity trial utilised in this way should be of practical value in any major field experiments with rubber.

XXV. F. YATES AND D. J. WATSON. "*Observer's Bias in Sampling Observations on Wheat.*" The Empire Journal of Experimental Agriculture, 1934, Vol. II, pp. 174-177.

An experiment carried out at Rothamsted to determine the bias of different observers in making plant and shoot counts of wheat is described. The observers were those making sampling observations on wheat at various centres, under the scheme of the Agricultural Meteorological Committee, in order to determine the principal events which mark the progress of the wheat plant from germination to maturity. The experiment is of interest in showing that large biases in plant counts can occur (due to the difficulty of deciding what are plants and what are tillers), and emphasises the need of arranging comparative trials for observers who have to take measurements liable to bias.

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(*c*) GENETICS

XXVI. R. A. FISHER. "*The Evolutionary Modification of Genetic Phenomena.*" Proceedings of the Sixth International Congress of Genetics, 1932, Vol. I, pp. 165-172.

The possibility of explaining observed genetic phenomena in terms of evolutionary modifications is reviewed. It is shown that the phenomena of dominance and recessiveness, of multiple allelomorphism and other genetic phenomena, together with many apparent anomalies, may be satisfactorily accounted for by the processes of natural selection as the result of evolutionary modification of the whole gene complex which conditions the manifestations of the particular genes being studied.

XXVII. R. A. FISHER. "*Selection in the Production of the Ever-Sporting Stocks.*" Annals of Botany, 1933, Vol. XLVII, pp. 727-733.

An outline of Winge's theory of doubleness in stocks is given, and of its implications.

A simple method of diagrammatic representation applied to Miss Saunders' data of 1911, shows both that the observed excess of doubles is due solely to their greater viability, and that one family there reported was exceptional in giving only one quarter doubles, as should the progeny of a plant freed from the pollen lethal.

The close linkage between the pollen lethal and the factor for doubleness is due to selection acting automatically in the propagation of the ever-sporting lines, which has thus built up the ever-sporting character.

XXVIII, H. J. BUCHANAN-WOLLASTON. "*Some Modern Statistical Methods. Their application to the Solution of Herring Race Problems.*" Journal du Conseil International pour l'Exploration de la Mer, 1933, Vol. VIII, pp. 7-47.

The form of the distribution of vertebral count of herrings has been used by Schnakenbeck as a criterion of racial difference.

It is here shown that the observed changes of form can be wholly accounted for by differences in the mean vertebral number. The vertebral numbers in a shoal may be regarded as highly grouped normal data, any apparent skewness or other differences of form being due to variation of the mean in relation to the boundaries of the grouping interval. Moreover the variance does not differ significantly from shoal to shoal.

Methods of fitting the normal curve to highly grouped data by the method of maximum likelihood have been developed (the method of moments being inefficient).

A discussion of the general principles of the analysis of variance is included, in connection with the analysis of the geographical distribution of the mean vertebral number of the different shoals.

THE SOIL

(Departments of Chemistry, General Microbiology, Physics and Statistics)

(*a*) Soil Cultivation

xxix. B. A. Keen. "*Experimental Methods for the Study of Soil Cultivation.*" Empire Journal of Experimental Agriculture, 1933, Vol. I, pp. 97-102.

Samples of the soil immediately before and immediately after cultivation are sieved on a set of four sieves with mesh sizes from 1½ ins. square to $\frac{1}{10}$ in. The fraction remaining on each sieve is weighed and expressed as a percentage of the total. Comparison of the pre- and post-cultivation figures affords a measure of the disintegration produced by the passage of the implement.

Results show that on the heavy loam soil of Rothamsted, the implement is much less effective than the weather in producing disintegration. Trials were also made with rotary cultivation, which showed the incorrectness of the common assertion that the rotary cultivator produces too fine a seed-bed. The soil disintegration is no greater than that produced by a ridging or bouting plough. The real difference is that the tilth is much looser : a 4-in. entry of the tines into ordinary compact soil produces a tilth that is 6 to 7 inches deep.

(*b*) Physical Properties

xxx. E. W. Russell. "*The Significance of Certain 'Single Value' Soil Constants.*" Journal of Agricultural Science, 1933, Vol. XXIII, pp. 261-310.

A detailed statistical examination, using multiple regression analysis, has been made of Coutts' 64 Natal soils. The purpose was to discover what type of information is given by each physical constant and thus to specify which constants give the maximum amount of independent information about the soil.

Several physical measurements, such as the sticky-point, the moisture content at 50 per cent. relative humidity, and the weight of water held per gram of soil in the Keen-Raczkowski box (Report 1921-22, p. 41) are closely correlated with the base-exchange capacity as measured by Schofield's potassium phosphate buffer method. The clay content is of minor importance in predicting these properties.

The swelling and pore-space parameters in the Keen-Raczkowski box are more complex. The swelling depends on the base-exchange-capacity and a soil structure term ; the pore-space depends on the clay content and a soil structure term.

The xylene equivalent measures a property of soil that is independent of the organic matter present, since it can be almost completely predicted from other measurements made on the soil after it has been treated with hydrogen peroxide to remove humified organic matter.

The so-called imbibitional water, as determined from the xylene and moisture equivalents, is of little value for prediction purposes ; the two primary variates are always considerably better.

Given the Keen-Raczkowski box parameters, and the xylene equivalent for these Natal soils, none of the other parameters add very much extra information.

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XXXI. H. JANERT. *" The Application of Heat of Wetting Measurements to Soil Research Problems."* Journal of Agricultural Science, 1934, Vol. XXIV, pp. 136-150.

The author's modification of the method used by Mitscherlich is described.

Measurements of the heat of wetting, obtained with a number of single-base (homoionic) clays prepared in the laboratory, show that this value represents a specific proportion of the heat of hydration of the adsorbed cation in its free state.

The heats of wetting with water and with organic liquids are proportional. The heats of wetting with a given liquid are not completely determined by its dipole moment and molecular volume.

The heat of wetting is correlated with other physical measurements. The method also distinguishes changes in the physical condition of some of the permanent plots at Rothamsted and Woburn.

XXXII. R. S. KOSHAL. *" The Effects of Rainfall and Temperature on Percolation through Drain Gauges."* Journal of Agricultural Science, 1934, Vol. XXIV, pp. 105-135.

Partial regression equations representing the average drainage observed in any month in terms of the temperature and rainfall of that month, and including terms representing the mean secular rate of change of the drainage discharge and of its regression coefficients on rainfall and temperature, have been fitted to the thirty-six series of observations provided by the three Rothamsted drain gauges in the twelve months of the year.

An account is given of adequate and direct numerical methods of handling equations involving observed quantities, and chosen functions of them, as independent variates, and of calculating standard errors appropriate to the several sorts of comparison which are to be made.

In the absence of direct knowledge of the amount of water contained from time to time in the soil mass of the gauge it has been customary to assume that the lower average drainage of the summer months is directly due to a greater amount of evaporation taking place in these months. The results of the present enquiry direct attention to a second possibility, namely that the water content of the gauges differs considerably at different times of the year, and that the high drainage in winter is in part to be ascribed to the accumulation of water during the rainy months of autumn, while the lower drainage in summer is due to the partial depletion of the gauges during the lower rainfall of the spring months.

(*c*) PHYSICAL CHEMISTRY

XXXIII. R. K. SCHOFIELD. *" Rapid Methods of Examining Soils. II. The Use of* p*-Nitrophenol for Assessing Lime Status."* Journal of Agricultural Science, 1933, Vol. XXIII, pp. 252-254.

By the use of a solution of *p*-nitrophenol in lime water a rapid and simple measurement can be made of the lime taken up by a soil sample in reaching neutrality. The same method applied to

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acid-washed samples gives the exchangeable base content at pH7. With slight modifications in the technique other weak acids may be used, such as acetic acid and phenol. These enable the lime uptake to be measured to pH 4.6 and 9.8 respectively. By combining these determinations with the amount of base dissolved out of the soil by N/20 HCl the general course of the buffer curve can be traced from pH 1.4 to pH 9.8.

XXXIV. R. K. SCHOFIELD. "*Rapid Methods of Examining Soils. III. The Use of Dihydrogen Potassium Phosphate in Study-Base Exchange Capacity.*" Journal of Agricultural Science, 1933, Vol. XXIII, pp. 255-260.

The reduction in the electrical conductivity of a mixed solution of K_2HPO_4 and KH_2PO_4 caused by the addition of soil is a measure of the potassium uptake, and is therefore an indication of the "base exchange capacity" of the soil at pH7. Two disturbing factors are noted, and it is concluded that the method is likely to be most useful where a rapid comparison of soils of a similar nature and pH is required.

XXXV. E. M. CROWTHER AND S. G. HEINTZE. "*Oxides of Manganese and Quinhydrone Error in Measurements of Soil Reaction.*" Proceedings and Papers of the Second International Congress (1930) of Soil Science, 1933, Vol. II, pp. 1-6.

In earlier papers (Paper XVIII, Report 1929, p. 58 and Paper XXXVIII, Report, 1930, p. 84) the error of the quinhydrone electrode in many soils was attributed to the production of basic material by the reduction of oxides of manganese by the quinhydrone. Confirmation of this explanation was obtained by the demonstration that soils showing the quinhydrone error yielded up to 2.5 mg. equivalents per cent. of manganese, when extracted with potassium chloride saturated with quinhydrone, whereas soils without quinhydrone error never gave more than minute traces of manganese. Further, the amount of manganese reduced by quinhydrone and extracted by potassium chloride was sufficient to account quantitatively for the quinhydrone error, on the assumption that the manganese dioxide was reduced to hydroxide and after allowing for the buffer capacity of the soil. It was also shown that oxides of iron caused no disturbance and that the changes in the ratio of quinone to hydroquinone could have only trivial effects on the pH value.

XXXVI. S. G. HEINTZE. "*The Use of the Glass Electrode in Soil Reaction and Oxidation-Reduction Potential Measurements.*" Journal of Agricultural Science, 1934, Vol. XXIV, pp. 28-41.

The glass electrode with an electrometer triode valve as amplifier gives accurate pH measurements on soil suspensions and on soil crumbs moist enough to wet the glass. It has the advantages that it may be used in highly oxidising or reducing systems and in alkaline

soil, but it has little merit over the quinhydrone electrode, where this is known to be reliable. The glass electrode forms a satisfactory reference electrode in oxidation-reduction potential measurements, as it allows both Eh and pH measurements without alteration to the system, whilst its high resistance minimises polarisation. Oxidation-reduction potentials of soils depend so closely on the pH values of the soils that they should not be considered separately. For constant pH values highly contrasted soil types may give similar oxidation-reduction potentials. After waterlogging in the laboratory for one or two days, there is a marked fall in potential for soils known from the conditions of their formation to contain organic matter which is capable of rapid decomposition as soon as moisture temperature and soil reaction become favourable. In the main soil zones of European Russia, this change on waterlogging reaches its maximum in the chernozem belt.

(*d*) Organic Chemistry

XXXVII. A. Walkley and I. Armstrong Black. "*An Examination of the Degtjareff Method for Determining Soil Organic Matter, and a Proposed Modification of the Chromic Acid Titration Method.*" Soil Science, 1934, Vol. XXXVII, pp. 29-38.

The chromic acid-hydrogen peroxide method of Degtjareff for the rapid determination of soil carbon was shown to give entirely fictitious results. The hydrogen peroxide not only served no useful purpose, but introduced a fundamental error, since its reaction with chromic acid follows a different course in the determination with soil from that in the corresponding blank. Two molecules of CrO_3 react with four molecules of H_2O_2 in the absence of soil but with three in the presence of soil or ignited soil. The gain in apparent carbon through this error approximately balances the incompleteness of oxidation for the conditions under which Degtjareff appears to have worked. A new approximate method giving about 76 per cent. recovery of carbon was proposed. Finely divided soil is treated with standard potassium dichromate and twice the volume of sulphuric acid added to raise the temperature ; after being stirred for a minute the mixture is diluted and the excess dichromate titrated. This procedure is more rapid than others so far proposed, and it is believed that it may prove useful for comparative purposes where no very exact determination is required.

XXXVIII. J. A. Daji. "*The Determination of Cellulose in Soil.*" Biochemical Journal, 1932, Vol. XXVI, pp. 1275-1280.

Cellulose in soil mixed with plant materials is determined by treating it with hot dilute alkali and acid and then with a solution of sodium hypochlorite in the cold. Cellulose is then extracted with Schweitzer's reagent, precipitated with alcohol and determined by loss of weight on ignition. This method will recover almost the whole of the cellulose added when different plant materials are mixed with soil.

MICROBIOLOGY

(Departments of Fermentation and General Microbiology)

Biological Activities

XXXIX. J. G. Shrikhande. "*The Production of Mucus during the Decomposition of Plant Materials. I. The Effect of Environmental Conditions.*" Biochemical Journal, 1933, Vol. XXVII, pp. 1551-1562.

The conditions under which stickiness is produced in decomposing materials and manures has been investigated by means of a specially devised physical test. In the presence of a mixed natural flora, high values for stickiness are given with either sodium nitrate or mould tissue as the source of nitrogen. The final reaction of the manure profoundly influences the degree of stickiness if at all appreciable. A pH of 9.5 to 10.0, whether obtained by fermentation or subsequent adjustment, seems to give the maximum stickiness. Na or K ions are more effective in the manifestation of stickiness than Ca or Mg.

XL. J. G. Shrikhande. "*The Production of Mucus during the Decomposition of Plant Materials. II. The Effect of Changes in the Flora.*" Biochemical Journal, 1933, Vol. XXVII, pp. 1563-1574.

A number of soil fungi and two cellulose decomposing bacteria in pure culture and in different associations have been tested as to their effect on the production of stickiness. Either fungi or bacteria while working independently do not produce stickiness. Fungal decomposition followed by *Spirochaeta cytophaga* produced a markedly sticky manure, even if the period of action of the fungus was very brief. Simultaneous inoculation produced little stickiness.

XLI. J. D. Newton. "*A Study of the Composition and Utilisation of Alberta Peats.*" The Annals of Applied Biology, 1934, Vol. XXI, pp. 251-266.

The three elements commonly applied in the form of mineral fertilisers in farm practice did not produce rapid decomposition of filter paper cellulose in incubated cultures, whereas the addition of all "essential" elements produced rapid decomposition.

Fungi appeared to be more important than bacteria in the decomposition of the filter paper cellulose, and the numbers of ammonifying bacteria in cellulose fermentation cultures increased with each additional "essential" element or group of "essential" elements.

Different horizons or layers of the Alberta peats studied differ greatly in colour or stage of decomposition and in reaction or pH value, the surface samples of peat usually containing less ash than the deeper samples.

The nitrogen content of the different samples varies rather widely, and the subsurface layer usually contains about twice as much nitrogen as the surface layer.

The total phosphorus content of the different samples does not vary as much as the nitrogen content, and the calcium oxide percentages and the pH values indicate that the Carnwood and Spruce

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Grove peats require liming and that the Winterburn and Stonyplain peats do not require liming for satisfactory crop production.

The cellulose content of the peats varies from none to about 47 per cent. of ash-free cellulose, and the lignin from about 20 to 49 per cent. A decrease in cellulose content is usually accompanied by an increase in lignin. Cellulose, lignin, and ash together nearly always make up about two-thirds or more of the weight of the peat. Nitrogeneous organic matter would account for about 3 to 16 per cent., and petroleum-ether-soluble material for only 1 per cent. or less of the total peat.

Growth of oat seedlings and bacterial plate counts indicated that the fertility of Carnwood surface peat was not greatly increased or affected by the addition (about three to four months earlier) of ordinary applications of fertiliser salts.

At the end of an incubation period of 50 days appreciable losses of cellulose had occurred in the Carnwood peat cultures to which an abundant supply of fertiliser salts had been added; and bacterial numbers were increased by the addition of fertiliser salts. In the case of the Winterburn peat the losses of cellulose, if any, were within the experimental error of the determination.

After nineteen days' incubation at a relatively high temperature (55°C.), all of the cultures of Spruce Grove peat showed loss of cellulose, the largest loss occurring in the culture to which lime was given, in addition to an abundant supply of the other nutrient salts.

THE PLANT IN DISEASE: CONTROL OF DISEASE

(Departments of Entomology, Plant Pathology and Statistics)

(*a*) Insects and their Control

XLII. H. F. Barnes. "*Studies of Fluctuations in Insect Populations. II. The Infestation of Meadow Foxtail Grass* (Alopecurus pratensis) *by the Gall Midge* Dasyneura alopecuri (*Reuter*) (*Cecidomyidae*)." Journal of Animal Ecology, 1933, Vol. II, pp. 98-108.

It is shown that the relative times of emergence of the host insect and its parasites are important in regulating the subsequent numbers of the host insect. Early emergence of the parasites, together with late emergence of the host insect, may result in a greatly increased population of the injurious insect, in other words an epidemic outbreak.

XLIII. H. F. Barnes. "*Gall Midges* (*Cecidomyidae*) *as Enemies of Mites.*" Bulletin of Entomological Research, 1933, Vol. XXIV, pp. 215-18.

This paper concerns those gall midges whose larvae are predaceous on mites throughout the world. This is the third paper dealing with zoophagous gall midges. Previous papers dealt with those forms attacking Aphids (1929) and Psyllids, Tingids, Aleurodids and Coccids (1930).

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XLIV. H. F. BARNES. "*A Cambium Miner of Basket Willows* (*Agromyzidae*) *and its Inquiline Gall Midge* (*Cecidomyidae*)" Annals of Applied Biology, 1933, Vol. XX, pp. 498-519.

This contains a resumé of information about Dipterous cambium miners (Agromyzidae). The morphology and bionomics of *Dizygomyza barnesi* Hendel sp.n. are described. A list of *Salix* species, including the Cricket Bat willow, attacked by the larvae is given, as well as records of two Braconid parasites and an inquiline gall midge and its parasites.

XLV. H. C. F. NEWTON. "*On the Biology of some Species of* Longitarsus (*Col. Chrysom.*) *living on Ragwort.*" Bulletin of Entomological Research, 1933, XXIV, pp. 511-520.

The life histories of five species of *Longitarsus* feeding on Ragwort are described and their part in the biological suppression of the weed indicated.

XLVI. H. C. F. NEWTON. "*On the Biology of* Psylliodes hyoscyami *Linn.* (*Col. Chrysom.*), *the Henbane Flea Beetle with Descriptions of the Larval Stages.*" Annals of Applied Biology, 1934, Vol. XXI, pp. 153-161.

P. hyoscyami, usually a rare beetle, occurred in epidemic numbers on the Henbane crop at a medicinal herb farm. Its life history was investigated and recommendations for control made.

(*b*) BACTERIAL DISEASES

XLVII. R. H. STOUGHTON. "*The Influence of Environmental Conditions on the Development of the Angular Leaf-spot Disease of Cotton. V. The Influence of Alternating and Varying Conditions on Infection.*" Annals of Applied Biology, 1933, Vol. XX, pp. 590-611.

A regular diurnal variation in soil temperature is shown to have the same effect on primary infection as a constant temperature near the mean of the fluctuations. The mean soil temperature at the time of sowing and for the first few days of germination is the chief controlling factor in primary infection. Similar results are obtained for the variation in air temperature. Plants kept in total darkness are entirely resistant to infection. The relations of the whole series of experiments on the influence of environmental conditions are discussed.

XLVIII. C. G. HANSFORD, H. R. HOSKING, R. H. STOUGHTON and F. YATES. "*An Experiment on the Incidence and Spread of Angular Leaf-Spot Disease of Cotton in Uganda.*" Annals of Applied Biology, 1933, Vol. XX, pp. 404-420.

Experiments on the incidence and spread of the angular leaf-spot disease of cotton, carried out at two centres in Uganda, are described.

Treatment of the seed by sterilisation with sulphuric acid and mercuric chloride resulted in a reduction in the amount of the disease throughout the season.

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Treatment of the seed with a bactericidal dust had a significant effect on total germination, the plots sown with this seed having a greater number of plants at the end of the season, independently of those killed by the disease.

Primary infection was almost entirely limited to plots sown with seed inoculated with the organism.

Spread of the disease occurred in a direction down the slope of the ground and along the lines of the surface wash.

The implications of the experiment are discussed and proposals made for modifications in technique.

(*c*) Virus Diseases

XLIX. J. Henderson Smith. "*Some Aspects of Virus Disease in Plants.*" Empire Journal of Experimental Agriculture, 1933, Vol. I, pp. 206-214.

A general account of the present position of research in virus diseases.

L. J. Caldwell. "*The Physiology of Virus Diseases. IV. The Nature of the Virus Agent of Aucuba or Yellow Mosaic of Tomato.*" Annals of Applied Biology, 1933, Vol. XX, pp. 100-117.

A method is discussed whereby it is possible to count the spots found on the leaves of *N. glutinosa* after inoculation with liquids containing different dilutions of aucuba mosaic virus. The fact that the number of spots found is proportional to the amount of dilution is taken as indicating the particulate nature of the virus. A method is suggested for counting the number of virus particles present in a juice. It is shown that the amount of virus present in a juice does not increase after agitation or after treatment with proteolytic enzymes. With trypsin and diastase the amount of virus is apparently decreased. This decrease, it is suggested, is due to the adsorption rather than to the destruction of the virus. The amount of multiplication of the virus in the tissues of *N. glutinosa* is examined and compared with the much greater multiplication in tomato tissues.

LI. F. M. L. Sheffield. "*Virus Diseases and Intracellular Inclusions in Plants.*" Nature, 1933, Vol. CXXXI, p. 325

Many virus diseases induce the occurrence of abnormal phenomena in the cells of the host, large protein bodies often being formed. Previous work on Aucuba Mosaic disease had suggested that these bodies were coagulation products of the cytoplasm. Attempts were therefore made to reproduce the phenomena by physico-chemical means. Various methods were used and varying degrees of success obtained. By treating plants with salts of molybdic acid it was possible to parallel all the microscopic effects of aucuba mosaic disease.

LII. F. M. L. Sheffield. "*The Development of Assimilatory Tissue in Solanaceous Hosts Infected with Aucuba Mosaic of Tomato.*" Annals of Applied Biology, 1933, Vol. XX, pp. 57-69.

The development of the chloroplasts in *Solanum nodiflorum*, *S. lycopersicum* and *Nicotiana tabacum* is described and comparisons are made with plants infected with aucuba mosaic.

In the normal plants after cell division ceases in the meristematic tissue certain minute bodies, which are present in the cytoplasm of all young cells, commence to enlarge. A vacuole is formed in each, and this gets bigger as the proplastid increases in size. A starch grain is formed in the vacuole. The outer stroma becomes pigmented and pores are formed in it. Increase in size continues, the mature plastid being about 5μ in diameter. A second or third starch grain may be formed in the vacuole. Chloroplasts sometimes divide.

In plants infected with aucuba mosaic certain of the leaf tissues are devoid of plastids and the cells may be undifferentiated. The absence of chlorophyll is brought about by the inhibition by the virus of the development of the plastid primordia. Usually the primordia are destroyed. If plastid development is not prevented in a very early stage, perfectly normal plastids are formed. Mature plastids are never affected by the virus but occasionally intermediate stages may be.

Soon after infection with aucuba mosaic disease, these plants are characterised by the production of large intracellular inclusion bodies in many of the cells. Such bodies are not found in the meristematic tissue, but incipient bodies appear when the cells are increasing in size and after plastid development is well advanced. For this reason inclusion bodies are formed indiscriminately in green and chlorotic areas, the virus presumably having reached the green tissues too late to inhibit plastid development.

An attempt was made to determine whether the prevalence of intracellular inclusion bodies in tegumentary tissues and their rarity in assimilatory tissues is due to differences in the pH of the tissues, but the results obtained were rather indefinite.

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