ROTHAMSTED RESEARCH

Report for 1934

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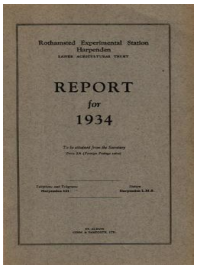

Scientific Papers Published in 1934

Rothamsted Research

Rothamsted Research (1935) *Scientific Papers Published in 1934 ;* Report For 1934, pp 89 - 110 **- DOI: https://doi.org/10.23637/ERADOC-1-66**

SCIENTIFIC PAPERS

Published 1934 and in the Press.

PLANT GROWTH, PLANT PRODUCTS, AND ACTION OF MANURES.

(Departments of Bacteriology, Botany, Chemistry, Fermentation, Insecticides and Fungicides, Physics, and the Imperial College Staff.)

(*a*) PLANT GROWTH.

I. E. J. RUSSELL. "*Chemical Problems in Crop Production.*" Journal of the Chemical Society, January, 1935, pp. 48-53.

II. E. J. RUSSELL. "*Applications of Chemistry in Modern Agriculture.*" Journal of the Society of Chemical Industry, 1935, Vol. LIV, pp. 325-327.

III. K. WARINGTON. "*Studies in the Absorption of Calcium from Nutrient Solutions with Special Reference to the Presence or Absence of Boron.*" Annals of Botany, 1934, Vol. XLVIII, pp. 743-776.

Over a nine-week period the quantity of calcium absorbed per week by *Vicia faba* increased up to the seventh or fourth week respectively, according as to whether or not a trace of boron was present, indications of periodicity in uptake being obtained in the former case. Less calcium was absorbed from solutions renewed at weekly or fortnightly intervals than from unrenewed solutions when boron was present, but the reverse was the case if boron were not provided. This difference is attributed to the fact that renewal of the solution delays the appearance of the boron deficiency symptoms, and thus prolongs the absorbing capacity of the plant.

The quantity of the calcium absorbed was approximately proportional to the calcium supplied, irrespective of the presence or absence of boron, although the total calcium taken up was much reduced under the latter conditions. No correlation was found between the calcium supplied and the nitrogen or potash content of the plant, both the latter showing a closer affinity with the production of dry matter.

Under full nutrient conditions the N/Ca and K/Ca ratios in the plant fell as its age increased, the fall being more marked in the presence than in the absence of boron. A lack of boron, therefore, reduced the uptake of calcium more than that of nitrogen or potash.

In the presence of boron, the calcium absorbed per unit of dry matter produced was higher from a pure solution of calcium chloride than from a complete nutrient medium containing a similar quantity of calcium. In the absence of boron, death ensued the more rapidly in the plants grown in the single salt solution, so that the presence of other nutrients apparently increased the requirement of the plant for

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both calcium and boron. Although the evidence is not conclusive, indications of an association between boron and calcium were, therefore, obtained.

IV. W. E. BRENCHLEY. "*The Effect of Rubidium Sulphate and Palladium Chloride on the Growth of Plants.*" Annals of Applied Biology, 1934, Vol. XXI, pp. 398-417.

Comparisons have been made between the action of rubidium sulphate and palladium chloride on the growth of barley, wheat, oats, peas and beans in complete nutrient solutions.

Over a wide range of concentrations rubidium sulphate was not found to exercise either a beneficial or a harmful action on the growth of any of the species tested. The germination of the seed was likewise not affected.

No benefit was derived from palladium chloride, but at a comparatively low concentration a harmful action occurred which became more intense with increasing concentration. Stunting of the main root and laterals was a characteristic feature of this toxicity. With the lower concentrations the check was temporary, and the roots eventually made normal growth, as good as that in the control plants. With increasing amounts of palladium chloride the poisoning effect became more persistent, until a concentration was reached which did not allow of any root or shoot recovery.

The tolerance of palladium varies with the species, as was indicated by the measure of recovery. Barley appeared to be the least, and oats the most sensitive of the three cereals tested. Peas responded at much the same concentrations as barley, but broad beans made a complete recovery from the initial checking, and the dry weights were not reduced even by the strongest concentration tested. The effect of palladium poisoning was similar whether the seeds were germinated in the presence of palladium or whether the seedlings were not introduced to it until they were about a week old.

V. J. T. MARTIN and F. TATTERSFIELD. "*The Effect of Environmental Conditions upon Pyrethrum* (Chrysanthemum cinerariaefolium). I." Annals of Applied Biology, 1934, Vol. XXI, pp. 670-681.

The effect of soil fertility upon the insecticidal value of the flowers has been studied in a series of pot experiments. On heavy soil the pyrethrin I content of the flowers was not increased by the application of fertilisers. The plants produced good yields of flowers, rich in pyrethrins, when grown in soil of low fertility.

Under conditions of normal growth and vitality, the extent of production of the pyrethrins in the flowers was characteristic of the individual plant and was dependent upon some factor which appeared to be genetical in character. A plant initially producing flowers of high or low percentage poison content continued to give flowers of the corresponding degree of richness in succeeding years, independently of the application of manures, or apparently of the number of heads produced. Plants derived from rooted shoots produced flowers corresponding in quality with those initially yielded by the parent plant. The insecticidal value of pyrethrum flowers may be improved by plant selection, followed by vegetative propagation.

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In the fully-opened flowers, the complete disc florets contained 90 per cent. of the total pyrethrins present in the flowers, and of this the greater part was found to be located in the ovaries.

VI. J. T. MARTIN and F. TATTERSFIELD. *"The Effect of Environmental Conditions upon Pyrethrum* (Chrysanthemum cinerariaefolium) II." Annals of Applied Biology, 1934, Vol. XXI, pp. 682-690.

The effects of light, temperature and dormancy upon pyrethrum have been studied. The partial shading of the plant during the five months preceding flowering resulted in the production of smaller flowers with a reduced pyrethrin content.

The successful flowering of the plant was largely dependent upon the relative temperatures experienced throughout the year. A dormant period, dependent upon sufficiently low winter temperatures, was shown to be necessary for the normal production of large numbers of flowers.

VII. F. J. RICHARDS. *"On the Use of Simultaneous Observations on Successive Leaves for the Study of Physiological Change in Relation to Leaf Age."* Annals of Botany, 1934, Vol. LXVIII, pp. 497-503.

Only in very exceptional cases is it permissible to use the leaves present on a shoot at one time as representative of a simple age series from which the history of single leaves at successive stages may be deduced. Included in the differences observed between the numbers are differences due to the fact that, even at comparable ages, the successive leaves constitute a series of inherently different physiological structures. To determine the effect of age on a particular leaf the corresponding leaves at various stages on replicate plants must be used, even though this involves larger errors of sampling. Further, it must be recognised that the age effect need not be uniform from leaf to leaf. Finally, it is impossible to separate effects which may be possibly ascribed to age as such from those due to change in conditions of nutrition, etc. As a leaf ages it becomes further removed from the growing point and passes successively from the position of the topmost leaf on the shoot to that of the lowest living leaf, a change which in itself must have a far-reaching effect.

VIII. E. M. CROWTHER. *"Soil Organic Matter and Crop Rotation."* Second Conference on Cotton Growing Problems, Empire Cotton Growing Corporation, 1934, pp. 319-329.

The experience of cotton experiment stations in different parts of the Empire on crop rotation in relation to the maintenance of soil fertility was reviewed in the light of recent investigations on the decomposition of organic matter in the soil. The effects of crop residues on the production of available nitrogen in the soil may generally be interpreted in terms of the composition of the materials added, the weather conditions, and the aptitude of the soil to store water and soluble nutrients. There is an urgent need for rotation experiments on cotton including such treatments as fallow, a leguminous crop and a cereal, tested in conjunction with different

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manurings and cultivations. The report of the discussion on the paper contains a number of interesting comparisons of native and European methods of cultivation in the tropics.

IX. HUGH NICOL. *"The Derivation of the Nitrogen of Crop Plants, with Special Reference to Associated Growth."* Biological Reviews, 1934, Vol. IX, pp. 383-410.

A résumé is given of some early views concerning the forms of nitrogen supposed to be taken up by plants ; the modern view which assigns pre-eminence to nitrate-nitrogen is questioned. Hitherto the manurial value of legumes has been assumed to lie in their residual effects. In this paper evidence is presented that non-leguminous plants can profitably utilise compounds of nitrogen built up by the symbiotic life of nodule bacteria within their host plants. These products of symbiosis, being excreted by the legumes, are available to other plants growing in association with them. It follows that the most economical method of manuring mixed vegetation (such as pasture) is to supply enough lime, phosphate, and potash for the legumes, which will then supply the necessary nitrogen. The importance of the double association of nodule bacteria and legumes with non-legumes has not been fully appreciated.

A section is devoted to the discussion of accessory plant-growth factors, since it is thought possible that leguminous plants play a special part in the provision of such substances in addition to acting as a source of nitrogen for simultaneous and later crops.

X. H. G. THORNTON and HUGH NICOL. *"Further Evidence upon the Nitrogen Uptake of Grass grown with Lucerne."* Journal of Agricultural Science, 1934, Vol. XXIV, pp. 540-543.

This paper supplements the information given earlier (See Paper XIII, Report for 1933, pp. 66-7). Italian rye-grass grown in the presence of lucerne in sand with no added nitrogen contained, after 18 weeks' growth, more than twice as much nitrogen as did grass of the same age similarly grown but in the absence of lucerne.

XI. H. G. THORNTON and HUGH NICOL. *"Some Effects of Clipping the Tops upon the Root Development of Lucerne."* Journal of Agricultural Science, 1934, Vol. XXIV, pp. 532-539.

Inoculated lucerne was grown in pots of sand and watered with nitrogen-free food solution. In some of the pots the lucerne was clipped once, in some twice, and in some it was left unclipped. Pots were harvested on four dates at intervals of about three weeks. Counts and measurements of nodules were made and dry weights and nitrogen content of tops and roots were obtained.

Clipping did not significantly alter the nodule numbers, their mean size, or the total nitrogen contents of the plants, *i.e.*, in tops, including clippings, *plus* roots.

Clipping, however, resulted in a decrease in the nitrogen content of the roots of about 40 per cent. as compared with unclipped plants. This nitrogen was transferred to the tops where it was removed in the clippings.

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In clipped plants the total yield of the tops, including clippings, was slightly increased, but that of the roots was greatly depressed. This resulted in a reduction in total dry weight of the whole plants.

XII. HUGH NICOL. *"Yield, Duration and Drought-Resistance of Lucerne as Influenced by Frequency and Time of Cutting."* Empire Journal of Experimental Agriculture, 1934, Vol. II, pp. 380-390.

It is recommended that lucerne should be sown early in the season, and that it should not be cut more than once in its seedling year. Neglect of these precautions induces small root growth, whence a sparse, short-lived, stand may result. If lucerne is sown in summer on soil liable to dry out, it should not be cut in the year of sowing if drought resistance and a long duration of stand are desired.

A brief discussion of the effects of clipping other plants is added.

(*b*) PLANT PRODUCTS.

XIII. A. G. NORMAN and S. H. JENKINS. *"The Determination of Lignin. Part I. Errors Introduced by the Presence of Certain Carbohydrates."* Biochemical Journal, 1934, Vol. XXVIII, pp. 2147-2159.

Some of the disturbing factors concerned in the determination of lignin by the 72 per cent. H_2SO_4 method have been studied. Certain of the sugars, particularly xylose and fructose, give an insoluble residue on standing with acid of this concentration, and increase the apparent lignin figure when added to plant materials. Polysaccharides containing pentose sugars produce a similar effect. The disturbance caused by the presence of such carbohydrates increases with time of contact with 72 per cent. acid, and at 2 hours the effect is small.

In plant materials the effect of the presence of xylose in the hemicellulose may be almost excluded by a hydrolytic pretreatment with dilute mineral acid, or minimised by reducing the time of contact to 2 hours. The validity of an acid pretreatment is not yet proved, since the action of dilute acids on lignin is not known.

Because of the presence of xylose, the figures generally quoted for lignin are, in most cases, too high, and must be revised. The disturbance due to pentose is caused by the slow production of furfuraldehyde and its condensation with lignin to form an insoluble phenolfurfuran resin. Furfuraldehyde itself may give an insoluble product by dehydration and condensation, but the former reaction probably takes precedence as long as there are lignin groups unsatisfied.

XIV. A. G. NORMAN and S. H. JENKINS. *"The Determination of Lignin. Part II. Errors Introduced by the Presence of Proteins."* Biochemical Journal, 1934, Vol. XXVIII, pp. 2160-2168.

Proteins alone give no precipitate on standing with 72 per cent. H_2SO_4, but when added to plant materials increase the apparent lignin content. The lignin residue then obtained contains nitrogen.

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The magnitude of the disturbance produced is quite different if the material is previously subjected to a hydrolytic pretreatment, indicating an interaction between the hydrolysable constituents and protein, which enhances the disturbing effect of both. The protein disturbance is probably due to the linkage of protein fission products with lignin. Direct linkage between protein and lignin is unlikely, because the ratio of increment produced to nitrogen present is very variable. Small additions of protein cause a proportionately greater disturbance than do larger amounts. The magnitude of the disturbance cannot be reduced by decreasing the time of contact with the acid but may be reduced in most cases by dilute acid pretreatment.

xv. L. W. Samuel. "*The Determination of Amino-Acids in Wheat Flour.*" Biochemical Journal, 1934, Vol. XXVIII, pp. 273-282.

The claim that proteolysis occurs in flour extracts has been studied for the few hours immediately subsequent to separation of the extract. The technique of Brown for the estimation of amino-acids by the Sørensen method has been applied to flour extracts. Proteolysis, as measured by the production of amino-acids, did not occur in the flour extracts studied.

For one flour of the four studied (a low grade) the amino-acid determinations made on the extract at varying *p*H values showed an increase with time if the solution were titrated to *p*H 9.0 before and after the addition of formaldehyde, but no increase if the titration were carried to *p*H 8.0 only. It is suggested that this is due to the enzymic production of substances containing carboxyl and amino-groups and having a low acid dissociation constant, which do not titrate even in the presence of formaldehyde until *p*H 9.0 is reached.

(*c*) Action of Manures.

xvi. H. L. Richardson. "*Studies on Calcium Cyanamide IV—The Use of Calcium Cyanamide and Other Forms of Nitrogen on Grassland.*" Journal of Agricultural Science, 1934, Vol. XXIV, pp. 491-510.

Ammonia added as sulphate of ammonia disappeared rapidly from a pasture grassland soil, while very little nitrate accumulated. Winter applications of sulphate of ammonia produced less increase in yield or nitrogen content of repeatedly mown herbage than did spring or late autumn applications. Calcium cyanamide in late autumn or early winter was on the whole less effective than sulphate of ammonia, but in spring the two were substantially equal. There was little evidence that calcium cyanamide was "slow-acting" in comparison with sulphate of ammonia. A fortnight after application there was little difference in the soil inorganic nitrogen from the two fertilisers. Dicyanodiamide was practically inert so far as the effect of winter dressings on yield or nitrogen uptake was concerned. The greatest recovery of added nitrogen in the herbage was less than 40 per cent.; part of the remainder may have been locked up by microbiological action. The response of the repeatedly mown herbage to 2 cwt. per acre of sulphate of ammonia was rapidly

exhausted and later in the year there was a marked reduction in yield through the depression of clovers in summer by the heavier growth of grass after a spring application of nitrogenous fertiliser.

XVII. H. L. RICHARDSON and E. M. CROWTHER. "*Studies on Calcium Cyanamide V. The Utilisation of Calcium Cyanamide in Pot Culture Experiments.*" Journal of Agricultural Science, 1935, Vol. XXV., pp. 132-150.

In pot culture experiments with barley and mustard conducted in several soils over a number of years, the yield differences between calcium cyanamide and ammonium sulphate were generally small. Calcium cyanamide gave slightly poorer results than ammonium sulphate in soils with high responses to added nitrogen but definitely better ones in soils which contained much available nitrogen and in which calcium cyanamide greatly retarded nitrification.

The pot culture experiments confirmed the conclusion from earlier laboratory work that in normal soils calcium cyanamide was converted through urea into ammonia within a few days. Nitrate accumulation was less complete and slower from calcium cyanamide than from ammonium sulphate. In one soil the nitrogen from calcium cyanamide remained as ammonia for several weeks, the nitrate content being below that even of unmanured soil.

Where the ammonia from calcium cyanamide remained for several weeks, tillering of barley was more rapid and the final yields and nitrogen contents were higher than with ammonium sulphate. It is suggested that the young barley plant utilises ammonia nitrogen more readily than nitrate, provided the ammonia is thoroughly distributed through the soil. It is clear that the amount of nitrate obtained in nitrification tests should not be used as a measure of the relative values of calcium cyanamide and other nitrogenous fertilisers.

XVIII. H. L. RICHARDSON. "*Field Experiments on the Action of Calcium Cyanamide on Germinating Seeds and on Charlock in Barley.*" Empire Journal of Experimental Agriculture, 1935, Vol. III, pp. 41-49.

Field experiments on the effect of time and method of application of calcium cyanamide to seed-beds showed that there was no interference with germination by dressings up to 3 cwt. per acre, given one week or more before sowing. The interval between sowing the fertiliser and the seed might safely be reduced to a few days, or even in favourable conditions to a few hours, for moderate applications, provided that the fertiliser was cultivated into the soil before the seed was sown. A moderate application two days after sowing the seed was found to be safe if the fertiliser was left undisturbed on the surface of the soil.

In a replicated field trial on charlock-destruction in barley, with comparisons under different weather conditions, calcium cyanamide proved much less efficient in destroying the charlock than kainit or a solution of copper sulphate. Both the barley and the weeds that survived the cyanamide treatment responded to the added nitrogen.

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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

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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.

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(*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.

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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.

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THE SOIL.

(Department of Physics.)

(*a*) Soil Cultivation.

XXVIII. B. A. Keen. "*The Functions of Mechanical Power in Soil Cultivation.*" Journal of the Institute of Automobile Engineers, 1934-5, Vol. XXIX, pp. 179-194.

This paper reviews the cultivation studies made at Rothamsted and described in previous Reports. It describes experiments in which rotary cultivation was compared with the traditional methods. The immediate effect of the implements on the soil was measured by taking blocks of soil immediately before and after cultivation, and sieving them on a set of sieves. (See Paper No. XXIX, Report for 1933, p. 73.) It was shown that for spring cultivation, the extent of disintegration produced is controlled far more by the character of the preceding winter weather than by the implement. Rotary cultivation does not produce a much finer tilth than traditional implements, as is frequently alleged, but a much looser one.

Experiments on intensive surface cultivation between the rows of root crops such as kale and sugar beet, gave the unexpected result that cultivation in excess of the minimum necessary to keep down weeds, not only gave no benefit, but actually reduced the yield. The result was obtained both on a light sandy soil and a heavy loam, but it needs repetition in a variety of seasons before a final conclusion can be given.

(*b*) Physical Properties.

XXIX. E. W. Russell. "*The Interaction of Clay with Water and Organic Liquids as Measured by Specific Volume Changes and its Relation to the Phenomena of Crumb Formation in Soils.*" Philosophical Transactions of the Royal Society of London, A, 1934, Vol. CCXXXIII, pp. 361-389.

Clay particles can form strong aggregates, or crumbs, when dry, only if the clay particles are sufficiently small, if there are a sufficient number of small exchangeable ions on the clay, and if the clay has been dried from a dispersion medium whose molecules are polar and sufficiently small.

Individual clay particles have an appreciable interaction with the molecules of polar liquids ; they do not interact, or only slightly, with non-polar liquids. On the hypothesis that no differential interaction occurs between the exchangeable ions on the clay and a non-polar hydrocarbon, the magnesium ions on the clay have about seven and the calcium ions about three more molecules of water of hydration than the sodium or potassium ions. Independent evidence is given for this conclusion.

Clays interact with water and organic liquids containing a polar group by causing a contraction in volume of the liquid. For homionic clays, saturated up to *p*H7 with base, this contraction is nearly proportional to the number and mean charge density on the surface of the exchangeable ions on the clay and, to a less extent, it varies with a parameter specifying the shape of the titration curve of the clay.

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These results have been interpreted on the hypothesis that cations can orientate polar molecules of the dispersion liquid around them, and this power is proportional to their surface density of charge. This power is also possessed by the free negative charges on the clay particle. When the dispersion liquid has nearly all been removed the cations bind the negative charges on two clay particles together by means of bridges of strongly orientated molecules of the polar dispersion liquid.

XXX. E. W. RUSSELL and R. S. GUPTA. "*On the Measurement of Imbibitional Water.*" Journal of Agricultural Science, 1934, Vol. XXIV, pp. 315-325.

Two methods of determining the weight and one method of determining the volume of water imbibed by a soil have been discussed. The results of these methods have been shown to be concordant by an independent method.

The tentative conclusion reached is that the weight of water a soil imbibes can be readily determined by Fisher's method or from the Keen Raczkowski box, but that the volume of imbibed water cannot yet be directly determined accurately.

XXXI. B. A. KEEN. "*Physical Measurements of Soil in Relation to Soil Type and Fertility.*" Second Conference on Cotton Growing Problems, Empire Cotton Growing Corporation, 1934, pp. 311-319.

This paper summarises a number of separate investigations at Rothamsted which have one underlying principle in common—to ascertain what types of physical measurements on soil are most suited to distinguish differences in the natural or inherent fertility of different soils and, as a related investigation, to what extent soil types can also be distinguished by physical measurements. A wide variety of soils was employed, for which, as was expected, a number of general correlations existed between the results of different methods. But, as would also be expected, the relationships become more diffuse when an endeavour is made to distinguish one soil type from another. It seems possible that, when two different measurements are plotted together, a soil type will be characterised by an area on the paper and not by a curve ; one pair of measurements—the sticky point and exchangeable bases—showed a general segregation of the soil types examined into separate areas.

The assessment of inherent fertility by physical or physico-chemical tests is, naturally, a still more difficult problem. However, in the case of a series of Malayan soils, where the yield of rubber afforded some guide to the local worker in forming an estimate of the inherent soil fertility, it was found possible to differentiate between good fertility soils and the remainder by measuring the ignition-loss of the soil, and the ignition-loss per gram of clay.

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XXXII. J. M. ALBAREDA. "*Caracterización de Suelos Tropicales y Sub-Tropicales mediante Determinaciones Físicas y Físicoquímicas.*" (*The Characterisation of Tropical and Sub-Tropical Soils by Means of Physical and Physico-Chemical Determinations*). Publicado en la Revista de la Academia de Ciencias, de Madrid, 1934, Vol. XXXI, pp. 320-350 and 457-514.

An attempt is made to extend the method of "single-value" determinations, introduced by Keen and Coutts, to the classification of soils into their appropriate genetical type. A large number of "single value" determinations was made on 125 soils from four different soil types. By taking pairs or functions of these determinations, and plotting the value of one member against that of the other member of each pair for the soils, it is possible to pick out

(*a*) those groups of determinations which are measuring approximately the same fundamental property of the soil, so can give no information about differences between one soil type and another;

(*b*) those groups of determinations which are measuring soil properties that are more or less characteristic of the soil in any one soil type, but which vary from one type to another. While no pairs of determinations that were found rigidly belonged to either of these groups, several were found which nearly did, so that it is possible to make a fair separation of these soils into their four genetic types by the method of "single value" determinations.

XXXIII. J. M. ALBAREDA. "*Sobre la Fertilidad de Algunos Suelos Tropicales.*" (*The Fertility of Rubber Soils*). Publicado en la Revista de la Academia de Ciencias, de Madrid, 1934, Vol. XXXI, pp. 515-519.

An attempt is made to extend the method of "single value" determinations to the grading of rubber soils into different fertility groups. Two methods have been found which are reasonably efficient classifiers of the soils into the two groups of good and poor rubber soils, but there is as yet no method that can give a finer classification than this simple dichotomy.

XXXIV. R. K. SCHOFIELD. "*Soil Water.*" Transactions of the First Commission of the International Society of Soil Science, 1934, pp. 185-191.

Soil acts as a reservoir of water which is available to plants. Some of this water may be held between the cleavage planes of the clay minerals. The free energy of binding of the stored water can be found from determinations of freezing point depression and equilibrium humidity. The first determination covers the moisture range for normal plant growth and indicates that the sharp decrease in permeability with falling moisture is a dominating factor in wilting. The moisture content at 50 per cent. humidity and the heat of wetting are connected with base exchange, a cluster of water molecules being held rather firmly to the active "spots" where base exchange takes place. Base exchange capacity and fineness of subdivision largely influence the permeability of the compact masses in the soil, while these and also the humus content mainly control their

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structure stability. The circumstance that water within the compact masses will not drain away and can only be removed by suction of plants on neighbouring drier soil, or by direct evaporation, has its reflection in traditional agricultural practices.

XXXV. G. W. SCOTT BLAIR. *"Definition and Translation of Rheological Terms used in Soil Physics."* Transactions of the First Commission of the International Society of Soil Science, 1934, pp. 159-167.

Rheology is defined as the science of the flow of matter, and a great many terms used in soil physics therefore may be classed as "rheological terms."

The use of such terms in the international literature is subject to two types of uncertainty: (*a*) uncertainty as to definition of terms; (*b*) uncertainty as to translation of terms. With regard to (*a*), it is desirable that definitions should conform as far as possible to established usage not only in Soil Science, but also in other fields, and should not conflict with the traditional meaning of words. The term "plasticity" is discussed in this connection. Although (*b*) is a separate problem, it is a closely allied one. As an example, the translation of the English term "stickiness" is discussed.

It is recommended that a committee should investigate these problems, and standardise usage as far as is possible.

MICROBIOLOGY.

(Departments of Bacteriology, and Fermentation.)

(*a*) BACTERIA.

XXXVI. H. G. THORNTON and P. H. H. GRAY. *"The Numbers of Bacterial Cells in Field Soils, as Estimated by the Ratio Method." With appendix* by R. A. FISHER, F.R.S. Proceedings of the Royal Society of London, Series B, 1934, Vol. CXV, pp. 522-543.

There are two serious difficulties in estimating the bacterial numbers in a soil sample from the microscopic examination of stained films of that soil. The first is that of determining with sufficient accuracy the mass of soil in the film and the second that of estimating from random microscope fields the numbers of organisms in the film when these organisms are not distributed through it at random.

A technique is here described in which these difficulties are avoided, by determining, in random microscope fields from a parallel series of stained films, the ratio between the number of bacteria and the number of indigo particles, of which a counted suspension has previously been added to a given mass of soil. The bacterial numbers calculated from such ratios are, of course, independent of the mass of soil in the film.

It is found that the ratios obtained from parallel microscope fields are distributed at random, although counts of bacteria taken by themselves from the same fields are much less uniform.

The accuracy of the method has been tested in the following experiments:

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(*a*) The bacterial numbers in four portions of a single soil sample agreed within a standard error of 3.3 per cent.

(*b*) The numbers found in films prepared by three workers from the same soil sample showed no significant differences.

(*c*) The numbers found by two workers independently counting different microscope fields from the same films agreed as random samples.

(*d*) Counted suspensions of bacteria added to sterilized soil were estimated with a standard error of 3.5 per cent.

The bacterial numbers found in Rothamsted field soils by this method range from 1,000 to 4,000 million per gram of soil.

Samples taken from some of the Hoos field plots showed a relationship between the total bacterial numbers and the average yield of straw taken over a number of years.

Caution is at present necessary in discussing results obtained from samples taken on a single occasion, since there is evidence of rapid changes in numbers of bacteria with time. Successive samples taken from garden soil showed significant changes in total bacterial numbers during the course of a day.

(*b*) Biological Activities.

xxxvii. C. N. Acharya. "*Studies on the Anaerobic Decomposition of Plant Materials. I. The Anaerobic Decomposition of Rice Straw* (Oryza sativa)." Biochemical Journal, 1935, Vol. XXIX, pp. 528-541.

Many of the changes taking place in the soil during the cultivation of rice are brought about by micro-organisms acting in the presence of small amounts of air. The anaerobic decomposition of organic manures is therefore of particular interest in the growing of this crop.

The course of anaerobic decomposition of rice straw and its major constituents has been followed. Decomposition appears to proceed in two distinct stages, *viz.* (1) the formation of organic acids, and (2) the conversion of these into gaseous products: acetic and butyric acids are the main products of the first stage, and carbon dioxide and methane the main products of the second. From 100 gm. of straw either about 20 gm. of organic acids, or over 20 litres of gas containing 50 per cent. methane, are obtainable. This yield is equivalent to about 7,200 cu. ft. of gas per ton of straw. The nitrogen requirement for anaerobic digestion is low, 100 gm. of straw requiring about 0.1 gm., or less, of nitrogen, while for aerobic decomposition 0.6-0.7 gm. of nitrogen is necessary.

xxxviii. C. N. Acharya. "*Studies on the Anaerobic Decomposition of Plant Materials. II. Some Factors Influencing the Anaerobic Decomposition of Rice Straw* (Oryza sativa)." Biochemical Journal, 1935, Vol. XXIX, pp. 953-960.

A temperature range of 30-35°C, *p*H 7.5-8.0 and straw : water ratio of about 1 to 10 are found optimum for the anaerobic digestion of rice straw by mesophilic organisms. The organisms required to decompose the straw are contained by the straw itself and further inoculation is unnecessary. Additions of phosphate have no stimu-

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lating effect. Finely ground straw does not ferment quicker than chaffed straw. NH_4HCO_3 and $KHCO_3$, either singly or better still in admixture, are found most suitable for neutralising the organic acids formed during anaerobic digestion. The reaction of the medium can also be controlled by periodic additions of alkali. Urea or cyanamide may replace ammonium bicarbonate, but not proteins. The amount of CO_2 and CH_4 produced is approximately the same irrespective of the volume of free space above the culture medium, provided accumulated gases are removed so as to prevent high concentrations of CO_2, or the reduction of the *p*H value of the medium.

XXXIX. C. N. ACHARYA. "*Studies on the Anaerobic Decomposition of Plant Materials. III. Comparison of the Course of Decomposition of Rice Straw under Anaerobic, Aerobic and Partially Aerobic Conditions.*" Biochemical Journal, 1935, Vol. XXIX, pp. 1116-1120.

The greatest loss of dry matter is recorded when rice straw is fermented under aerobic conditions. The loss is less under partially aerobic conditions, such as those existing in swamp soils, and least of all under strictly anaerobic circumstances. Cellulose and lignin are more easily attacked under water-logged than under anaerobic conditions. Partially aerobic conditions resemble anaerobic conditions in regard to the nature of the products obtained. Under the former set of conditions smaller amounts of organic acids and methane, and larger amounts of CO_2, are formed. The nitrogen factor and nitrogen equivalent decrease in the following order: aerobic (0.536 ; 1.11 respectively), water-logged (0.395 ; 0.961), and anaerobic (0.069 ; 0.169), which also shows a progressive decrease in the amount of protein accumulated. The protein formed under aerobic conditions is mostly insoluble in water, while under water-logged conditions it remains in solution.

XL. E. H. RICHARDS and J. G. SHRIKHANDE. "*The Preferential Utilization of Different Forms of Inorganic Nitrogen in the Decomposition of Plant Materials.*" Soil Science, 1935, Vol. XXXIX, pp. 1-8.

Experiments were carried out to discover whether the organisms concerned in the decomposition of cellulosic matter exercise any preference for ammoniacal or nitric nitrogen, when both forms are available to them in equal concentrations. The results showed that in the early stages of breakdown there is a definite preference for ammonia rather than for nitrate. This selection appears to be shown only in the early stages ; after straw had been fermented under optimum conditions for 14 days, about equal amounts of ammonia and nitrate remained unassimilated.

The nitrogen factor is always lower when nitrate is the source of nitrogen than when ammonia is used. The loss of nitrogen is greatest when nitrate is present. As a result of this loss of, presumably,

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elementary nitrogen from nitrate, the relative assimilation of ammonia may be greater than the figures indicate, since the drop in nitrate includes nitrogen lost besides that assimilated.

XLI. S. H. JENKINS. "*The Biological Oxidation of Carbohydrates. IV. The Phosphorus Requirements of Percolating Filters.*" Biochemical Journal, 1935, Vol. XXIX, pp. 116-132.

Previous work has shown that the oxidation of carbohydrates in biological filters is influenced by the supply of available compounds of nitrogen. In the work described in this paper, experiments were made to find the requirements of phosphorus compounds by a filter supplied with sucrose and an ample amount of nitrogen. The results showed that the biological film of organisms responsible for sugar oxidation reached maximum activity in a very short period when excess of available phosphorus compounds was supplied; once this efficient state had been reached, the film was able to exist without any diminution in activity on a much smaller ration of phosphorus.

Inorganic compounds of phosphorus were found to be more readily available to micro-organisms than the organic phosphorus compounds present in beet sugar factory effluent. The former were used preferentially when both sources were present simultaneously.

Although sugar is believed to be oxidised in the living cell *via* the stage of hexose-phosphate, all the evidence obtained indicated that intermediate compounds of sugar and phosphorus were absent from the solutions undergoing oxidation: the hexose-phosphates exist within the cell itself, and under natural conditions are not ordinarily found outside it.

XLII. A. G. NORMAN. "*The Biological Decomposition of Plant Materials. Part IX. The Aerobic Decomposition of Hemicelluloses.*" Annals of Applied Biology, 1934, Vol. XXI, pp. 454-475.

The decomposition of the hemicelluloses of plant materials occurs rapidly under normal aerobic conditions. Over seventy common fungi were tested as to their ability to utilise on agar plates the crude hemicellulose from straw. All of the fungi grew well, the majority at least as well as on glucose, and a number better than on that sugar. It seems likely that the ability to ferment hemicelluloses is a general property of common fungi.

From soil and manure were isolated twenty aerobic bacteria capable of utilising hemicelluloses. Their morphological characters and biochemical reactions were determined. All the organisms utilised an exceptionally wide range of sugars and polysaccharides, so that differentiation by the usual means was difficult. Certain of the forms agreed with the description of *Achromobacter ubiquitum*. None of these organisms in pure culture could be described as very active in decomposing isolated hemicellulose, or that *in situ* in straw.

This survey led to the view that fungi are more active and important in the natural decomposition of hemicelluloses than bacteria.

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

THE PLANT IN DISEASE: CONTROL OF DISEASE.

(Departments of Entomology, Insecticides and Fungicides, and Plant Pathology.)

(*a*) Insects and their Control.

XLIII. H. F. Barnes. "*Studies of Fluctuations in Insect Populations. III. The gall midge,* Rhabdophaga heterobia *H.Lw., on Black Maul variety of* Salix triandra *at Syston, Leicestershire,* 1927-33." Journal of Animal Ecology, 1934, Vol. III, pp. 165-81.

The changes in populations of the midge and its parasites in the overwintering generation have been traced over a period of six years. A drought which seriously damaged the growth of the willows is claimed to have caused a great diminution in numbers of both the host midge and its parasites. A sudden fall in relative parasitism in 1933 is discussed and compared with a similar occurrence in the second of this series of studies.

XLIV. H. F. Barnes. "*Some Biological and Economic Aspects of the Gall Midges.*" Science Progress, 1934, Vol. XXIX, pp. 73-86.

A comprehensive survey of this family of flies dealing specially with the biological phenomena exhibited and its economic importance. Recent and hitherto unpublished data are included.

XLV. F. Tattersfield. "*An Apparatus for Testing Contact Insecticides.*" Annals of Applied Biology, 1934, Vol. XXI, pp. 691-703.

A description is given of the design of two atomisers for use in quantitative laboratory spraying for testing contact insecticides.

Tables and graphs are given showing the weights of spray delivered by each form upon known areas placed in different positions inside the spray jars, and an examination is made of the change in the distribution of the spray with the progressive closure of the orifice and increase in the distance from the orifice of the surface sprayed.

XLVI. F. Tattersfield and J. T. Martin. "*The Loss of Activity of Pyrethrum.* II." Journal of Agricultural Science, 1934, Vol. XXIV, pp. 598-626.

The loss of activity of pyrethrum flowers and preparations has been studied.

The degree of concordance between the content of pyrethrin I, as determined by the acid method, and the insecticidal value of pyrethrinised dusts, before and after exposure to air and artificial illumination, has been statistically examined. The pyrethrin I values, corrected for a small residual amount of extraneous matter, indicate fairly closely the degree of activity of the samples. The loss of pyrethrins on exposure has been traced out quantitatively.

A comparison was made between two samples of pyrethrum flowers, one rich and the other poor in pyrethrins, in order to

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determine the degree of concordance between the pyrethrin I content and their toxicity. The pyrethrin I value as determined by the acid method, subject to a small correction, gave a good indication of the relative activities of the samples.

Pyrethrum flowers, both finely and coarsely ground and as whole heads, have been exposed under various conditions for different periods up to one year. There was a relatively rapid loss of pyrethrin I in cases where the ground flowers were exposed to sunlight and air, but when stored in covered trays or tins the loss of pyrethrin I was much slower. The pyrethrins undergo change at a slower rate in flowers stored as whole heads than in the ground state.

Pyrethrinised dusts and ground flower-heads lose their pyrethrin content when exposed to sunlight in an atmosphere of air of nitrogen. The loss in nitrogen is less rapid than in air and appears to be due to a reaction other than oxidation by free oxygen. The effect of temperature upon the rate of loss of the pyrethrins is shown.

The rate of loss of the pyrethrins in a methyl alcoholic extract of flowers, when exposed to sunlight and air, was studied.

The stabilising effect of tannic acid and hydroquinone when added to a talc-pyrethrum dust was confirmed. It was shown that such mixtures lose their pyrethrins at a slower rate when exposed in thin layers to air and artificial illumination. Biological trials showed that the addition of these anti-oxidants did not augment the initial insecticidal activity of the pyrethrins.

(*b*) VIRUS DISEASES.

XLVII. J. CALDWELL. "*The Physiology of Virus Diseases in Plants. V. The Movement of the Virus Agent in Tobacco and Tomato.*" Annals of Applied Biology, 1934, Vol. XXI, pp. 191-205.

It has been found that the virus may be present in tissues which do not show symptoms, and that symptoms of mosaic appear in those tissues which develop after infection. The concentration of virus is higher in the chlorotic areas than in the green areas. In no case was the virus found to be transmitted in the embryo. Under some conditions, the virus apparently travels in a direction opposite from metabolites.

XLVIII. J. CALDWELL. "*The Physiology of Virus Diseases in Plants. VI. Some Effects of Mosaic on the Metabolism of the Tomato.*" Annals of Applied Biology, 1934, Vol. XXI pp. 206-224.

The effect of aucuba mosaic on the tomato, as regards growth and metabolism is examined. The carbohydrate content of the tissues is reduced by the disease while the respiration rate is actually increased. Nitrogen metabolism is apparently unchanged.

XLIX. J. CALDWELL, G. C. AINSWORTH and G. H. BERKELEY. "*A Comparison of English and Canadian Tomato Virus Diseases.*" Annals of Applied Biology, 1934, Vol. XXI, pp. 566-580.

The mosaic and streak diseases and their causative virus or groups of viruses, found in Canadian and English houses were examined and compared.

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L. F. M. L. SHEFFIELD. *"Experiments Bearing on the Nature of Intracellular Inclusions in Plant Virus Diseases."* Annals of Applied Biology, 1934, Vol. XXI, pp. 430-453.

The intracellular changes resultant on infection with aucuba mosaic and Hy. III diseases are described and are compared with the cytological effects of tobacco mosaic virus. With the two former viruses, inclusion bodies are formed by the aggregation and fusion of minute particles which appear in the cytoplasmic stream. With tobacco mosaic disease an amoeba-like body is produced and this persists for some weeks before suddenly disappearing again. It is accompanied by striate material all of which ultimately fuses into one large body. Similar amoeboid inclusions and sometimes also striate material are formed on infection with Wingard's ringspot disease of tobacco.

Attempts have been made to parallel these conditions in healthy cells of Solanaceous plants by treatment with substances known to coagulate protoplasm. Almost all the re-agents used induced stimulation of the cytoplasmic stream similar to the initial sign of virus infection. With salts of molybdic acid, all the cytological abnormalities due to aucuba mosaic or Hy. III disease have been imitated. Treatment with lactic acid induces the formation of amoeboid bodies like the X-bodies of tobacco mosaic, but these bodies persist for only a few hours.

Attempts have also been made to inhibit the formation of inclusion bodies induced by several different diseases in a number of hosts but no success was obtained.

The experiments support the view that the intracellular inclusions of plant virus diseases are essentially products of the host cell.

LI. M. A. WATSON. *"Some Factors Influencing the Probability of Infection by Aphids with the Virus Hy. III."* Report of the Third Imperial Mycological Conference, 1934, p. 19.

Regular weekly infections with Hy. III into Hyoscyamus and Tobacco showed that the per cent. infection bears a positive relation with the number of aphids used. Seasonal variations occur in the per cent. infection which may be correlated with (*a*) the amount of virus present in the host plant, (*b*) the condition of the plant to be infected, or (*c*) the condition of the aphid vectors. These variations may be due to differences in temperature or total radiation.

In winter and in cool dull weather the per cent. infection appears to be higher than in summer, or in bright sunny weather. This may be tested in the field by spraying experiments which should be most successful in the optimum infection periods of cool or overcast weather.

LII. J. M. BIRKELAND. *"Serological Studies of Plant Viruses."* Botanical Gazette, 1934, Vol. XCV, pp. 419-436.

Juice from virus-diseased plants contains an antigenic fraction inseparable from the virus in addition to the antigenic constituents of a normal healthy plant. This fraction is specific to the particular virus, and the anti-bodies induced by one virus differ qualitatively

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from those induced by other viruses. It is possible to free a virus from the antigenic constituents of normal plants, but not possible to separate it from the antigenic factor accompanying it, and the latter is probably either the virus itself or a virus-protein complex of haptene nature.

LIII. J. M. BIRKELAND. *"Photodynamic Action of Methylene Blue on Plant Viruses."* Science, 1934, Vol. LXXX, pp. 357-358.

Unlike certain animal viruses, the viruses of aucuba, tobacco mosaic and tomato streak were found highly resistant to the photodynamic action, though (Wingard's) ring-spot virus was quickly inactivated.

TECHNICAL & OTHER PAPERS

GENERAL.

LIV. E. J. RUSSELL. *"The School and the Research Institute."* Durham County Association of Teachers' Magazine, "Deira," November, 1934.

LV. E. J. RUSSELL. *"Wireless and the Farmer."* Discovery, 1934, Vol. XV, pp. 245-246.

LVI. W. G. COCHRAN. *"Recent Advances in Mathematical Statistics* 1933." Journal of the Royal Statistical Society, 1934, Vol. XCVIII, pp. 83-127.

The sections contributed to this review cover papers dealing with moments and semi-invariants of sampling distributions and with orthogonal polynomial theory.

LVII. O. GATTY. *"An Apparent Paradox in the Theory of Heats of Dilution of Completely Dissociated Electrolytes."* Philosophical Magazine, 1934, Vol. XVIII, pp. 46-63.

LVIII. O. GATTY. *"Membrane Equilibria and the Phase Rule."* Philosophical Magazine, 1934, Vol. XVIII, pp. 273-288.

LIX. G. W. SCOTT BLAIR and R. K. SCHOFIELD. *"The Constancy of Strong Lithium Chloride Solutions at Low Velocity Gradients."* Philosophical Magazine, 1934, Vol. XVII, pp. 225-229.

Measurements of the logarithmic decrement of a cylinder executing rotational oscillation while immersed in a strong lithium chloride solution revealed no inconstancy in the viscosity, even though the final amplitude was so small that the maximum velocity gradient was only 0.003 $sec.^{-1}$.

The data confirm and extend that obtained by Ostwald and Malss using a capillary viscometer in which the velocity gradient at the wall for the lowest stress was 0.6 $sec.^{-1}$.

The anomalies reported earlier by the authors appear to have been due to the ability of the strong salt solutions used to " creep "

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