ROTHAMSTED RESEARCH

Report for 1931

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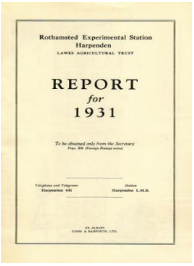

Summaries of Papers Published in 1931 - I. Scientific Papers

Rothamsted Research

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SCIENTIFIC PAPERS

Published 1931 and in the Press

CROPS, PLANT GROWTH, PLANT PRODUCTS AND ACTION OF MANURES

(Chemical, Fermentation, Mycological and Statistical Departments; and the Imperial College Staff.)

(*a*) CROPS

I. E. J. RUSSELL. "*The Changing Outlook in Agriculture.*" Presidential Address to Section M (Agriculture) at the British Association Centenary Meeting, September, 1931.

A survey of the chief changes in practical agriculture and of the chief movements in agricultural science during the past 100 years.

II. E. J. RUSSELL. "*Die Wirkung von Düngemitteln auf den Ernteertrag. Ergebnisse der von Lawes und Gilbert begonnenen Feldversuche an der landwirtschaftlichen Versuchsstation Rothamsted*, 1843-1930." Archiv für Pflanzenbau, 1931, Vol. VIII, pp. 1-69.

A summary of the chief results of the Rothamsted field experiments from the year 1843 to 1930. This is based on lectures delivered by the author in Denmark, Germany and Holland, and it includes discussions of many of the points raised by agricultural experts in those countries.

(*b*) PLANT GROWTH

III. W. O. JAMES, "*Studies of the Physiological Importance of the Mineral Elements in Plants. II. Potassium: its Distribution, Movement and Relation to Growth in the Potato.*" Annals of Botany, 1931, Vol. XLV, pp. 425-441.

The fresh weight, dry weight, and weight of potassium were determined at regular intervals in the leaves, stems and tubers of potato plants throughout the season of growth. From these data, relative growth rates, potassium and water contents, and rates of absorption and migration of potassium are calculated.

The relative growth rate of the whole plant is similar to those already established for maize and other plants. The curves of the individual organs show a much shorter initial lag phase than that of the whole plant. The latter is shown to be due mainly, though not entirely, to the diminishing weight of the mother tubers. The residual lag may represent the growth of the meristem, i.e. increase in the number of dividing cells.

The time curve of potassium content of the whole plant (expressed either as percentage of dry weight or of water content) shows a significant connection with the relative growth-rate curve ($r=0.9448$, $P=>0.01$). This connection disappears in the individual organs owing to the comparatively short periods of rising relative

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growth rate. In later phases growth rate declines more rapidly than potassium content, but less rapidly than potassium absorption, suggesting a heaping up of potassium in non-meristematic regions.

There is a significant positive correlation ($P > 0.01$) between potassium and water contents through the growth period and a definite connection in spatial distribution. It is suggested that the mechanism of the relation is complex, involving at least solution tension, osmotic pressure, and adsorption forces. The result is a tendency to establish an equilibrium between potassium and water at somewhere between 1 and 0.5 per cent. potassium, in the active parts of the plant, and somewhat lower in the mature tubers.

It is shown that potassium ions may move from one organ to another either with or against the average concentration gradient between them. The movements contrary to such gradients are always in the normal direction of the transpiration stream, while those with the gradients are against the stream.

These movements, together with the heaping up and final removal of potassium from the leaves, suggest that a continuous circulation of the element goes on. The upward movement probably depends mainly on mass movement in the transpiration stream, while the downward movement is due to some different mechanism, dependent upon concentration gradients, but faster than diffusion.

IV. F. G. GREGORY, AND F. CROWTHER. "*A Physiological Study of Varietal Differences in Plants. II. Further Evidence for the Differential Response in Yield of Barley Varieties to Manurial Deficiencies.*" Annals of Botany, 1931, Vol. XLV, pp. 579-592.

Further evidence is presented for the existence of a differential response of varieties of barley to various types of manuring.

Three varieties were grown, namely, the hybrid Plumage Archer and the parent forms Plumage and English Archer. Four types of manuring were used: fully manured controls, and deficiency in nitrogen, in phosphorus, and in potassium. Forty-two replicates of each variety for each manuring were used, giving 504 cultures in all.

Each set of replicates was sampled fortnightly throughout the period of vegetative growth, each harvest representing a random sample of six pots.

The resulting data were treated by the analysis of variance method, and values for differential response of significance far greater than 100 to 1 are obtained for each part of the plant.

The behaviour of the varieties is compared with the previous results of 1927, and a large measure of agreement is found, showing that with some certainty the varieties studied may be characterised by their manurial efficiencies.

The hybrid form appears to inherit specific manurial efficiency from both parents.

V. "ALUMNUS." "*A Comparison of the Effect of Rainfall on Spring and Autumn-dressed Wheat at Rothamsted Experimental Station, Harpenden.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 101-114.

During the first twenty-four years of the Broadbalk wheat experiment the nitrogenous manures were applied wholly in the

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autumn. This paper describes an enquiry into the possibility that the large average loss of yield ascribable to winter rain on Broadbalk had been due especially to this early period. It is found that the curves of loss due to rainfall would in fact be scarcely changed had the manurial treatments been applied always as they are now.

An additional fact which attracted notice and was verified by further data is that the advantage of spring-dressed over autumn-dressed plots, though little influenced by winter rain, is considerably affected by summer rain. In fact, it appears that before a dry summer the autumn dressing is the more advantageous.

VI. J. O. IRWIN. "*On the Influence of Soil Temperature on the Germination Interval of Crops.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 241-250.

The data collected under the Agricultural Meteorological Scheme of the Ministry of Agriculture have provided information for a number of years in a number of places on the dates of sowing and appearance above ground of wheat, winter oats, spring oats, spring barley, turnips and swedes.

The present paper summarises these data, and determines the correlations and regressions of germination interval on soil temperature.

For all the cereal crops the correlations are significant, and, except for spring barley, high. The results for the winter-sown cereals are different from the spring-sown and we may summarise them by saying that the "germination interval" for winter wheat and oats is shortened by from 1.5 to 2 days for each increase of a degree F. in 4 in. or 8 in. soil temperature; for spring cereals the corresponding shortening is about a day.

VII. J. O. IRWIN. "*Precision Records in Horticulture.*" Journal of Pomology, 1931, Vol. IX, pp. 149-194.

The present study is based on observations made on apple trees planted in connection with the Ministry of Agriculture's Horticultural —Meteorological Scheme. This scheme had as its object the study of the relation between weather and the growth of horticultural crops.

A meteorological station, where one did not already exist, was set up in every station participating in the scheme and observations on apples, plums, black currants and peas were made in each place. The observations were started in 1925 and are still continuing. It was laid down that the varieties used were to be the same in each place, and a standardised programme of observations was drawn up.

In order to determine whether phenological phenomena in horticulture are capable of precise and objective measurement by the sampling method, an experimental trial was made at East Malling in the spring of 1930.

(*c*) PLANT PRODUCTS

VIII. L. R. BISHOP. "*The Practical Application of the Results of Research to the Production of Malt and Wort.*" Journal of the Institute of Brewing, 1931, Vol. XXXVII, pp. 345-359.

A study of results partly obtained by Miss E. M. Thomas under the late Professor Schryver. It is shown that about 35 per cent. of the nitrogen in the barley becomes "permanently soluble nitrogen" in the wort from the resulting malt. For six rowed barleys

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the figure is 29 per cent. Differences from this figure reveal differences in modification. The highest value is obtained at a mashing temperature of 50°C, and declines on each side of this temperature. Ammonia, amide and amino nitrogen increase slightly with increase in barley nitrogen content but, in this case and with change in mashing temperature, the main changes are due to changes in "peptide" and "undetermined" nitrogen.

The simultaneous studies of the carbohydrates showed that, other factors being constant, maltose production has a sharply marked optimum at 60°C., while the dextrinous substances in wort increase slowly to an optimum above 70°C.

IX. F. E. Day. "*Laboratory Brews with the New Hops.*" Journal of the Institute of Brewing, 1931, Vol. XXXVII, pp. 202-205.

The author's laboratory method for small scale brewing was improved in details and shown to be of value in investigations involving questions of flavour. It was successfully applied in the examination of small quantities of hops under more controlled conditions than are possible in large scale trials.

X. A. G. Norman, "*Studies on the Gums.* II. *Tragacanthin—the Soluble Constituent of Gum Tragacanth.*" Biochemical Journal, 1931, Vol. XXV, pp. 200-204.

Tragacanthin, the soluble constituent in gum tragacanth, may be separated by ordinary filtration in extreme dilution. Uronic acid units are found to be present and to constitute about one-half of the molecule. Arabinose was the only sugar found; no galactose could be detected. Hydrolysis products were prepared, the analytical figures for which give rise to the suggestion that a portion of the arabinose is united to the uronic acid to form a resistant nucleus, and the residue attached by glucosidic linkage, and therefore easily removable.

XI. H. L. Richardson. "*The Use of Hydrogen Peroxide for Estimating Humification.*" Soil Science, 1931, Vol. XXXII, pp. 167-171.

Six per cent. hydrogen peroxide, as used for measuring "degree of humification," was found to exercise a considerable action on a wide range of unhumified plant materials, and this action was increased by the presence of soil. Consequently, the method may be useful for following progressive stages in the decomposition of a single material, but it can give only approximate results and should not be used for comparing materials of different origin.

(*d*) Action of Manures

XII. T. J. Mirchandani. "*The Effect of Summer Green Manures on the Ammonia and Nitrate Contents of Soil Cropped for Winter Wheat.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 458-468.

At the Woburn Experimental Station it was found that winter wheat after summer tares was poorer than that after summer mustard in the early years of continued experiments both when the green crops were ploughed in directly and when they were folded off by sheep. Further, after a few rotations the wheat yields in all cases

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sank to a very low level. Systematic soil analyses throughout two seasons showed very low contents of nitrate and ammonia, and small scale plot experiments within the main wheat plots gave very large responses to nitrate of soda. It is concluded that the low fertility of these plots is caused by an acute shortage of available nitrogen in late spring and early summer when the wheat has a high nitrogen requirement.

XIII. E. M. CROWTHER AND T. J. MIRCHANDANI. *"Winter Leaching and the Manurial Value of Green Manures and Crop Residues for Winter Wheat."* Journal of Agricultural Science, 1931, Vol. XXI, pp. 493-525.

It is suggested that the striking failure of winter wheat grown in rotation with two summer crops of tares or mustard on the sandy soil of the Woburn Experimental Station is due to the production of nitrate and ammonia from the green manures at times when the wheat is unable to use them efficiently and the consequent loss of nitrate in the drainage. Owing to the low C/N ratio in tares, the nitrogen nitrifies very rapidly and the loss by leaching is very great. Mustard, on the other hand, reduces the winter loss, but the nitrogen present in the mustard and that absorbed in the decomposition of the excess carbon compounds are liberated too slowly to be utilised efficiently by the wheat and much of the nitrate subsequently produced is also lost by leaching.

Nitrification experiments in the laboratory and pot experiments on wheat showed that nitrogen was made available more rapidly and more completely from materials with 13C/1N (tares, mustard+ blood, straw + blood) than from those with 26C/1N (tares + straw mustard, straw + blood). The yields in unleached pots were much higher with materials with 13C/1N, but in pots leached systematically during the winter the two types of organic matter were equally effective. The reduction of crop by leaching was closely correlated with, but not proportional to, the extent of early nitrate formation as measured by the amount of nitrate leached from the pots. It is suggested that early nitrate formation reduces the yield not only by increasing the removal of nitrate by leaching, but also by increasing the amount converted by the soil micro-organisms into forms which become available again only very slowly.

Tares material formed nitrates and mustard material removed it more rapidly and completely than equivalent mixtures. The less intimate association of the proteins and cellulosic substances in the mixtures appears to be sufficient explanation of these differences. There was no evidence of specific toxins or stimulants in mustard or tares. The bearing of these results on crop rotations and green manuring on light soils is discussed.

XIV. E. M. CROWTHER AND R. G. WARREN. *"Report on Laboratory and Pot Culture Work and Discussion of the Yields and Composition of the Experimental Crops from the Field Experiments on Phosphatic Fertilisers."* Appendix to Ninth Interim Report of Permanent Committee on Basic Slag, 1931, Ministry of Agriculture, pp. 7-31.

An account is given of a series of phosphatic fertiliser trials on grassland both for hay and with repeated mowing in partial imitation

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of grazing conditions. The herbage in all cases was analysed for nitrogen and phosphoric acid so as to assess improvement in feeding value and the recovery of the added phosphoric acid. Pot experiments on some of the more recent types of low soluble slags gave results only very slightly superior to those of the older types.

XV. E. M. CROWTHER AND H. L. RICHARDSON. "*Studies on Calcium Cyanamide. I. The Decomposition of Calcium Cyanamide in the Soil and its Effects on Germination, Nitrification and Soil Reaction.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 300-324.

These studies were undertaken as an investigation of the modern standardised form of Calcium Cyanamide. Its rates of decomposition by various powdered minerals and in a number of soils were compared. In different soils the rate varied considerably, but given thorough mixing, most of the cyanamide was converted to urea or ammonia within a few days. The rate of disappearance in a soil was found to follow a logarithmic law, being proportional to the concentration of cyanamide in the soil solution.

The toxicity to germinating seeds was examined in laboratory experiments, and was found to be caused by the cyanamide itself, not by impurities or products of decomposition of the fertiliser. It fell off rapidly as the interval between applying Calcium Cyanamide and sowing the seeds increased, in accordance with the rapid disappearance of the cyanamide.

Ammonification and nitrification were studied in pot and field experiments; within a few days the soil ammonia content was practically the same whether nitrogen was added as sulphate of ammonia or as Calcium Cyanamide, but the final stage of nitrification was often slower with the latter. The extent of the retardation depended on the type of soil and on environmental conditions, showing a reduction with improved aeration in the pot experiments, and being very slight in the field experiments.

The effect of Calcium Cyanamide on soil reaction was consistently good as compared with the acidifying action of sulphate of ammonia, and it was shown that the use of Calcium Cyanamide was equivalent to the addition of its own weight of quicklime with a corresponding dressing of sulphate of ammonia.

XVI. B. K. MUKERJI. "*Studies on Calcium Cyanamide. II. Microbiological Aspects of Nitrification in Soils under Varied Environmental Conditions.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 335-347.

Extensive series of bacterial counts and determinations of CO_2 production showed that under laboratory conditions both of these were increased by the addition of Calcium Cyanamide to soil. Bacterial numbers were also increased in pot experiments. The ammonification and nitrification of Calcium Cyanamide in soil were studied in the laboratory, and the degree of aeration was found to influence considerably the rates of disappearance of urea, and of production and disappearance of ammonia, as well as the rate of nitrification. In solution cultures Calcium Cyanamide was more

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toxic than dicyanodiamide to nitrifying organisms, although in soils the toxic action of the former is relatively less because of its much more rapid disappearance.

XVII. H. L. RICHARDSON. "*Studies on Calcium Cyanamide. III. Storage and Mixing with Superphosphate.*" Journal of Agricultural Science, **1932**, Vol. XXII, pp. 348-357.

There was no appreciable loss of nitrogen from Calcium Cyanamide during storage under good farm conditions for two years, and only slight changes in the forms of the nitrogen present. Less than 1 per cent. was converted to dicyanodiamide after one year. Mixing Calcium Cyanamide and superphosphate caused changes that varied greatly with the conditions ; in a farm mixture spread in a thin layer after mixing, one-sixth of the nitrogen was changed to dicyanodiamide within a day, and one quarter in a month. In a series of laboratory mixtures the proportion of nitrogen converted to dicyanodiamide varied regularly with the composition, a maximum of 50 per cent. being reached in the mixture containing 20 per cent. of Calcium Cyanamide.

Both this paper and the first in the series contain appendices describing the special analytical methods used in the investigations.

STATISTICAL METHODS AND RESULTS
(Statistical Department)

(*a*) MATHEMATICAL THEORY

XVIII. R. A. FISHER. "*The Moments of the Distribution for Normal Samples of Measures of Departure from Normality.*" Proceedings of the Royal Society of London, A, **1930**, Vol. CXXX, pp. 16-28.

Two methods are given for discussing the distribution of the ratios of the symmetric functions k_3, k_4 . . . obtained from samples from a normal distribution to the powers of k_2 of the same degree.

The first method consists in the development of recurrence relations expressing the ratios from a sample of n in terms of the corresponding ratios from a sample of n—1 observations, and of a parameter distributed independently in a known distribution. Theoretically, all the properties of the general distribution could be obtained from these relations in conjunction with a study of samples of 3, 4, 5 . . . observations.

The relations are used to derive the exact values of the first three even moments of the simplest ratio γ, and of the simpler non-vanishing moments of the simultaneous distribution of all the ratios. It is observed that these moments are very simply related to the corresponding moments of the distribution of k_3, k_4 . . . given in a previous paper.

The second method is an application of the method of symbolical operators developed by the author, which confirms the generality of the relationship found. The moments of the one distribution may thus be inferred directly from that of the other for which the combinatorial procedure is available.

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XIX. J. WISHART. "*The Mean and Second Moment Coefficient of the Multiple Correlation Coefficient, in Samples from a Normal Population.*" Biometrika, 1931, Vol. XXII, pp. 353-361.

The exact distribution of the multiple correlation coefficient was given in the Proceedings of the Royal Society, A (Vol. CXXI, pp. 654-673) in 1928. From this any required property of the distribution may be directly obtained. In the present paper the mean and variance of R^2 for $n_2=2$, 4, and 6 are calculated, and the general formula inferred. It is pointed out that the moments of R itself do not seem to be capable of simplification.

XX. J. WISHART. "*Notes on Frequency Constants.*" Journal of the Institute of Actuaries, 1931, Vol. LXII, pp. 174-177.

A note on the notation and use of statistics derived from sums of powers of the observations, with especial reference to previous discussions by Lidstone and Steffenson on the moments of Pearson and the semi-invariants of Thiele.

XXI. R. A. FISHER AND J. WISHART. "*The Derivation of the Pattern Formulae of Two-way Partitions from those of Simpler Patterns.*" Proceedings of the London Mathematical Society, 1931, Series 2, Vol. XXXIII, pp. 195-208.

A method is developed of calculating the function of n to be associated with any two-way partition in the evaluation of the cumulants of the sampling distribution of the appropriate moment statistics k, by expanding it in terms of the functions of partitions having simpler patterns. When columns of two or three entries occur the simplification is extremely rapid. The method is, however, generalised for all cases.

A proof is given of the vanishing of the functions corresponding to all patterns in which the rows may be divided into two groups having only a single column in common.

XXII. J. WISHART. "*The Analysis of Variance Illustrated in its Application to a Complex Agricultural Experiment on Sugar Beet.*" Archiv für Pflanzenbau, 1931, Vol. V, pp. 561-584.

A description is given of a complex experiment on the manuring of two varieties of sugar beet, carried out at Rothamsted in 1929. The special experiment described is of a complex type, but is treated by determining a number of standard errors appropriate to special comparisons. While there is less certainty in such a case as to the genuine validity of these errors in their appropriateness for all the comparisons possible, the great advantage in precision to be obtained by combining diverse enquiries in large and complex experiments seems at this early stage to outweigh the convenience of simply demonstrable estimates of error.

XXIII. J. O. IRWIN, "*Mathematical Theorems involved in the Analysis of Variance.*" Journal of the Royal Statistical Society, 1931, Vol. XCIV, pp. 284-300.

In this paper proofs are given of the essential theorems involved in the "analysis of variance" method which R. A. Fisher has inven-

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ted. An endeavour has been made to treat them in an elementary manner, so as to make them available in one place for the mathematical-statistical student of average ability, or any others interested in the subject. For this reason somewhat full proofs have been given and points dealt with in detail which will appear obvious to the highly trained mathematical statistician.

(*b*) GENETICS

XXIV. R. A. FISHER. "*The Evolution of Dominance.*" Biological Reviews, 1931, Vol. VI, pp. 345-368.

The theory that the genetical phenomenon of dominance is itself a product of the evolutionary process rather than a necessary consequence of the biochemical organisation of the nucleus, was first put forward in 1928, in connection with the facts which are now known about mutations in species bred in large numbers for genetical purposes such as *Drosophila* and *Gammarus*. Since this publication very numerous groups of genetical facts have been brought to the attention of the author respecting the domesticated species, and species showing polymorphism in nature, which strongly confirm and amplify the original proposition, and in conjunction with it, throw much light upon the genetic situations in these forms. This paper draws together the evidence from various fields, and indicates the special cases in which the theory may be tested by further experiment.

XXV. R. A. FISHER, F. R. IMMER AND OLOF TEDIN. "*The Genetical Interpretation of Statistics of the Third Degree in the Study of Quantitative Inheritance.*" Genetics, 1932, Vol. XVII, pp. 107-124.

A genetical interpretation is given for various second and third moment statistics which are of use in studying quantitative inheritance.

Published data taken from lettuce and maize, and unpublished data from barley crosses are used to illustrate how the problem may be attacked. The special needs of data adequate for this purpose are illustrated, and certain possible precautions in planning the experiments are pointed out.

A study of the skewness of seven distributions for strains of mice selected for high and low tailring number indicated that the theoretical negative association between the statistics k_1 and k_2 in selected strains could probably be evaluated.

Formulae are given by which the effect of the dominance bias in the heterozygote in relation to the measurable characters of the homozygotes in F_2 or F_3 distributions or various types of crosses may be calculated.

The two common sources of bias (metrical and dominance) are discussed and data from a barley cross used to illustrate the results obtained when the former is of major importance.

Since the combined effect of the dominance and metrical biases may be obtained experimentally in many different ways, an empirical test of the consistency of the genetical interpretations is available, as well as an opportunity of evaluating and eliminating the metrical bias.

Standard errors are given for the different statistics used.

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THE SOIL

(Chemical and Physical Departments)

(*a*) Soil Classification

XXVI (A). E. J. Russell. "*Principles and Methods of Soil Utilisation with Illustrations from the British Empire.*" Proceedings of Second International Soil Congress, Russia, 1930.

XXVI (B). E. J. Russell. "*The Soil Resources of the Empire.*" Proceedings of a Conference on Soil Science Problems held at the Rothamsted Experimental Station, September 16th-18th, 1930. Imperial Bureau of Soil Science Technical Communication No. 17, 1931, pp. 23-28.

These two papers contain accounts of the methods by which the soils of the most important types in the Empire have been brought into cultivation and in many instances made to increase in productiveness.

A survey of the soil resources of the Empire is urgently needed in view of the important social and economic problems involved in further development and land settlement. Much progress has been made in mapping the soils of Australia, and material is being assembled in other parts of the Empire on which a preliminary survey could be based.

XXVII. E. M. Crowther. "*Soils and Climate.*" Ministry of Agriculture, Report on Agricultural Meteorological Conference, 1931, pp. 5-11.

Earlier work (*cf.* Report 1930, XXXI, p. 82) is briefly reviewed and supplemented by an analysis of the distribution of soil types in European U.S.S.R. in relation to climatic factors as measured by the mean annual rainfall and temperature. It was found that for points distributed at distances of about 70 miles over the area between 65° N. and 45° N. and 28° E. and 58° E. the soil type, as shown on Prassolov's map on the scale of 1 to 2,500,000, the values for an arbitrary index of climate (R—30 cms. $\div$ T + 4° C) fell within the following limits for 290 out of 318 points: Brown soils and alkali soils, negative; chestnut soils, 0 to 0.5; southern Chernozem, 0.5 to 1.0; ordinary Chernozen, 0.75 to 2.0; thick and Azov Chernozems, 1.0 to 3.0; degraded and leached Chernozems, 2.0 to 4.0; strongly degraded soils (secondarily podsolised), 2.0 to 4.0; podsolised, peaty podsolised, gley podsolised and bog soils, greater than 3.0. For the areas covered by seven of these soil types there were significant regressions of rainfall on temperature. The degraded Chernozems and the secondarily podsolised soils fell into the same climatic band and the distinction between these soils may therefore depend on the interval since the forest invaded the steppe. The graphs illustrating the above groupings and the form of the empirical relationship chosen show quite clearly that Lang's "Regenfaktor" (R$\div$T) fails completely to group climates in accordance with soils. The factor (3 cms. per °C) used to separate highly leached soils from all others agrees closely with that derived from American and other data in the earlier paper.

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(*b*) Mechanical Analysis

XXVIII. Erik Troell. "*The Use of Sodium Hypobromite for the Oxidation of Organic Matter in the Mechanical Analysis of Soils.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 476-483.

Freshly prepared solutions of sodium hypobromite may be used with advantage instead of boiling hydrogen peroxide in mechanical analysis by the pipette method. Soils containing manganese dioxide or large amounts of organic matter may be treated rapidly ; changes in the clay are minimised ; the reagents are cheaper and more stable, and the method allows further simplifications in technique.

(*c*) Physical Properties

XXIX. R. K. Schofield and G. W. Scott Blair. "*The Influence of the Proximity of a Solid Wall on the Consistency of Viscous and Plastic Materials. III.*" Journal of Physical Chemistry, 1931, Vol. XXXV, pp. 1212-1215.

In earlier work evidence was obtained that when clay pastes are forced through narrow tubes, the consistency of the material near the wall differs from that of the bulk of the material. A construction was developed for obtaining plastic constants referring to the paste in the central part of the tube, by assuming that the modified layer was of small thickness compared with the tube radius. A simpler and more complete treatment is now given which indicates that although the thickness of the modified layer may be appreciable, the original construction proposed still gives a close approximation to the true values of the material in bulk. The treatment has now been carried up to the limit of the present accuracy of the experimental methods.

XXX. R. K. Schofield and G. W. Scott Blair. "*Depth and Rigidity of Sediment in Flocculated Clay Suspensions.*" Transactions of the Faraday Society, 1931, Vol. XXVII, pp. 629-632.

An extension of experimental work on the phenomena of rigidity in weak clay suspensions, (Schofield and Keen, '*Nature*,' 1929, 123, 492) with reference to the rigidity and volume of the sediment.

The strength of the rigid structure depends on the exchangeable ions and the added salt, but the relationship is not at present understood. The volume of the sediment after flocculation of the clay with varying quantities of different ions seemed to depend only on the nature and concentration of the clay, suggesting that the measurement might be of use in soil investigations.

XXXI. Ashutosh Sen and C. H. Wright. "*The Electrical Conductivity of Aqueous Soil Suspensions as a Measure of Soil Fertility.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 1-13.

The increase, on standing, in the electrical conductivity of an aqueous extract of soil over its initial value serves as a qualitative measure of soil fertility (Atkins. Journal of Agricultural Science, 1924, 14, 198). Measurements were therefore made on old soil samples from the Rothamsted classical plots which have been taken

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and carefully preserved in sealed bottles at intervals since the early days of the field experiments. The increase in conductivity is highly correlated with the recorded crop yield of the season in which the given soil sample was taken. The correlation is shown to be an expression of the progressive decline in the fertility of the soil over the period of the experiment.

XXXII. Ashutosh Sen. "*The Measurement of Electrical Conductivity of Aqueous Soil Suspension and its Use in Soil Fertility Studies.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 212-234.

The effects of season, cropping, manuring, and cultivation on the change in the electrical conductivity of aqueous extracts of soil, were studied, in view of the possible use of this measurement as an index of soil fertility.

There is practically no change in the measurements for unmanured plots of low yield.

The addition of easily decomposible organic material causes, in general, a marked increase in the measurement.

Continued fallowing has little effect.

For soil under permanent grass there are marked seasonal variations, and where comparisons are being made the soil samples should be taken at the same season and under comparable meteorological conditions, while for arable soils the most suitable time is after the soil is prepared for the crop, but before manures are sown.

(*d*) Physical Chemistry

XXXIII. J. K. Basu. "*Studies on Soil Reaction VII. An Electrodialysis Apparatus for the Determination of Replaceable Bases in Soils.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 484-492.

A six-unit apparatus of two compartment cells is described and it is shown that the technique may be modified to exclude the kations from soluble salts from either the total bases as determined by direct titrations of the dialysate or from the individual bases as determined by analysis.

XXXIV. E. M. Crowther and J. K. Basu. "*Studies on Soil Reaction VIII. The Influence of Fertilisers and Lime on the Replaceable Bases of a Light Acid Soil after Fifty Years of Continuous Cropping with Barley and Wheat.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 689-715.

At the completion of a 50-year cycle of continuous cropping with both wheat and barley on a light sandy soil at the Woburn Experimental Station, soil samples from all of the plots were analysed for replaceable bases.

The soil had little or no calcium carbonate originally and comparison with early soil samples showed that the unmanured plots lost about half of their replaceable calcium in the 50 years. The loss of calcium was much greater on plots with ammonium sulphate and the crops failed completely in about 20 years. Plots with sodium nitrate or farmyard manure retained considerably more calcium than the unmanured plots.

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The effect of superphosphate was so slight that for practical purposes it may be regarded as without effect on the replaceable bases.

The final replaceable calcium was reduced at the rate of 0.8 mol. CaO per mol. of ammonium sulphate added throughout the experiment, and increased at the rate of 0.5 mol. for the equivalent amount of sodium nitrate. The relatively low value for the ammonium sulphate effect is due to the low base content of the very acid soils and the low calcium bicarbonate content of the water. To increase the replaceable calcium of the ammonium sulphate plots to that of the sodium nitrate plots required 2.8 mol. of CaO per mol. of ammonium sulphate when the lime was applied at intervals of about 10 years. A rule is proposed for calculating the effects of various nitrogenous fertilisers on the lime content of the soil.

Most of the added lime was recovered many years later when the original lime content was low, but added lime was rapidly lost by leaching from soils of relatively high replaceable calcium content.

A new method was devised determining the " degree of unsaturation " or " exchangeable hydrogen " of soils. A mixture of soil and calcium carbonate is extracted with *N*.NaCl, and the difference between the calcium and the bicarbonate contents of the extract is taken as a measure of the replaceable calcium and hydrogen.

(*e*) Organic Chemistry

XXXV. M. M. S. Du Toit and H. J. Page. " *Studies on the Carbon and Nitrogen Cycles in the Soil. IV. Natural and Artificial Humic Acids.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 115-125.

The preparation of natural humic acids from soil, peat (Dopplerite) and " Adco," and of artificial " humic " acids from sucrose, cellulose, dextrose and glycine (Maillard), hydroquinone and lignin, and their purification are described.

Their elementary compositions and their behaviours under conductimetric titration with ammonia have been studied. The artificial products from sucrose and furfural did not behave as acids but all the natural products, and the artificial products from cellulose, hydroquinone and lignin possessed the properties of colloidal acids.

Preliminary investigations into the " humification " of furfural and ω-hydroxymethyl furfural, and into the interaction of dextrose with amino bodies, are described.

SOIL ORGANISMS

(Bacteriological, Fermentation, General Microbiological, and Mycological Departments)

(*a*) Bacteria

XXXVI. H. L. Jensen. " *A Comparison of Two Agar Media for Counting Soil Micro-organisms.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 832-843.

A statistical test was made of the variation between bacterial and actinomycete colony numbers on parallel plates on dextrose-casein agar, the medium used for the counts involved in the author's

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work on manure decomposition. (See Papers XLVI to XLVIII). The medium was compared in this respect with Thornton's mannitol-asparagine agar, and like the latter medium, gave generally satisfactory results, though on both media counts of actinomycetes tended to give subnormal variance.

(*b*) Protozoa

XXXVII. L. de Telegdy-Kovats. "*The Growth and Respiration of Bacteria in Sand Cultures in the Presence and Absence of Protozoa.*" Annals of Applied Biology, 1932, Vol. XIX, pp. 65-86.

Experiments were carried out on carbon dioxide production from sand treated with peptone and glucose solution, or with glucose and ammonium sulphate solutions of different C/N ratios. The media were inoculated with various types of bacteria and protozoa. It was found that while the presence of protozoa increased the carbon dioxide production, especially in the case of mixed bacteria cultures, and also caused greater bacterial efficiency, yet the number of bacteria was lower ; an increase in the number of protozoa beyond a certain point, however, reduced the output of carbon dioxide. Reducing the concentration of glucose from 0.6 to 0.2 per cent. resulted in a greater percentage production of carbon dioxide, and an intensification of the effect caused by the presence of protozoa. An increase in the C/N ratio in the presence of protozoa was followed by a marked increase in carbon dioxide production, while in their absence there was no definite effect. Where the C/N ratio was reduced to less than 10/1 there was a fluctuation of numbers in bacterial cultures.

(*c*) Fungi

XXXVIII. W. B. Brierley. "*Biological Races in Fungi and their Significance in Evolution.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 420-434.

A discussion of biological races and fungal variation in relation to the species concept and the evolution of new species. An " orbital conception " of systematic categories and evolutionary relationships is put forward.

(*d*) Biological Activities

XXXIX. D. Ward Cutler and B. K. Mukerji. "*Nitrite Formation by Soil Bacteria, other than Nitrosomonas.*" Proceedings of the Royal Society (B), 1931, Vol. CVIII, pp. 384-394.

Four species of non-spore-forming bacteria capable of oxidising ammonia into nitrite have been isolated from Rothamsted soil and all differ widely from *Nitrosomonas* or *Nitrosococcus*.

These organisms are able to carry out this reaction in artificial media as well as in soil, and some are able to assimilate nitrite.

Rapid growth takes place on nutrient agar, and the presence of 0.1 per cent. sucrose stimulates nitrite production.

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XL. N. W. BARRITT. "*The Liberation of Elementary Nitrogen by Bacteria.*" Biochemical Journal, 1931, Vol. XXV, pp. 1965-1972.

Much confusion exists in the literature regarding the liberation of nitrogen by bacteria. This is due chiefly to inaccuracies in analytical methods and insufficient attention to the occurrence of nitrates or nitrification.

In addition to the liberation of nitrogen by reduction of nitrates it is shown that free nitrogen may be formed by the interaction of amino compounds and nitrites when the reaction falls below pH 6.0. In this way fermentation of carbohydrates by producing an acid reaction may result in the liberation of free nitrogen.

Ammonium nitrite in culture solutions is quite stable at ordinary temperatures and does not give rise to free nitrogen.

XLI. N. W. BARRITT. "*The Biological Filtration of Dilute Sucrose Solutions.*" Biochemical Journal, 1931, Vol. XXV, pp. 1419-1446.

Bacterial oxidations involve organic synthesis which in the case of sucrose involves from 25 per cent. to 33 per cent. of the material. This synthesis accounts for the incomplete absorption of oxygen in the 5-day oxygen absorption test and the accumulation of film in a biological filter.

The use of sectional filters showed the relation of nutrition gradient to the structure and functioning of the filter. The rate of purification is proportional to growth of film which is determined by the concentration of the nutrient. Growth of film tends to limit aeration which is essential to oxidation and this imposes limits on the size of the particles constituting the medium of the filter. The use of gravel passing $\frac{1}{2}$ inch mesh is to be avoided since it favours the development of anaerobic conditions, indicated by a lowering of pH in the upper sections due to the formation of organic acids.

The growth of the film and the efficiency of the filter depend upon definite nitrogen and phosphorus requirements, viz., a C/N ratio of 15 and C/P_2O_5 ratio of 10. Nitrogen fixation occurs in the filter but not to a sufficient extent to ensure adequate purification.

Nitrification occurs when the concentration of oxidisable organic matter falls below the equivalent of 0.03 per cent. sucrose.

XLII. S. H. JENKINS. "*The Biological Oxidation of Carbohydrate Solutions. I. The Oxidation of Sucrose and Ammonia in Sectional Percolating Filters.*" Biochemical Journal, 1931, Vol. XXV, pp. 147-160.

A study was made of a percolating filter which consisted of six independent sections. The solution fed to the filter contained sugar plus ammonia. When the biological film was mature the amounts of sugar and nitrogen oxidised by each section were found. The results showed that the first section was most effective in oxidising sugar, while the last section was least effective. However, if the last section was placed in the position occupied by the first, and thus received a more concentrated solution of sugar it became quite as efficient as the first section. The oxidation of ammonia was found to proceed

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mainly in the lower sections although nitrification could occur to a limited extent in the upper sections of the filter in the presence of 0.06 per cent. of sugar.

XLIII. A. G. NORMAN. "*The Biological Decomposition of Plant Materials. IV. The Biochemical Activities on Straws of some Cellulose-Decomposing Fungi.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 244-259.

A number of fungi isolated from rotting straw were tested for ability to utilise different carbohydrate constituents. In general all substances but lignin were attacked to a degree relatively proportional to the apparent total loss of organic matter. The nitrogen factor, i.e., nitrogen immobilised by 100g. of straw, was determined in each case. The differences are considerable and varietal. They are not related to any particular straw constituent.

XLIV. E. H. RICHARDS AND A. G. NORMAN. "*The Biological Decomposition of Plant Materials. V. Some Factors Determining the Quantity of Nitrogen Immobilised During Decomposition.*" Biochemical Journal, 1931, Vol. XXV, pp. 1769-1778.

The amount of additional nitrogen immobilised during decomposition of plant materials represents only the equilibrium between immobilisation and ammonification. Besides the added nitrogen, plant proteins may also be attacked, or microbial nitrogen may be liberated and re-utilised. The term "nitrogen equivalent" is suggested as a measure of the efficiency of the microbial tissue in decomposition, and defined as the nitrogen immobilised in the course of removal of 100g. of organic matter from any material.

XLV. A. G. NORMAN. "*The Biological Decomposition of Plant Materials. VI. The Effect of Hydrogen-ion Concentration on the Rate of Immobilisation of Nitrogen by Straw.*" Biochemical Journal, 1931, Vol. XXV, pp. 1779-1787.

The rate of immobilisation of available nitrogen in dilute solutions of various hydrogen ion concentrations was studied by percolation of the solutions through straw filters. Slightly alkaline conditions favour immobilisation and more organic matter is fermented away than under neutral or slightly acid conditions. The alkaline filter showed an initial lag not observed in either of the others. This lag is due to a primary flora relatively inactive in cellulose decomposition. The loss of hemicellulose is more gradual in filters than in compost heaps.

XLVI. H. L. JENSEN. *The Microbiology of Farmyard Manure Decomposition in Soil. I. Changes in the Microflora and their Relation to Nitrification.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 38-80.

When farmyard manure was added to soil the energy material contained in it produced a rapid increase in bacteria, actinomycetes and fungi which resulted in a part of the manure nitrogen being locked up in the form of protein. Only after the numbers of micro-organisms passed their maximum did the production of nitrate

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become active. After passing the maximum this nitrification diminished gradually, leaving, after a year, a considerable portion of the manure in an unavailable form. This fraction was contained partly in the cells of the micro-organisms themselves and partly in the ₀-humus which is very resistent to decomposition and which tended to increase slightly during the period.

XLVII. H. L. JENSEN. "*The Microbiology of Farmyard Manure Decomposition in Soil. II. Decomposition of Cellulose.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 81-100.

Addition of farmyard manure to approximately neutral soil (pH 6.5-7.0) gave rise to an abundant development of cellulose decomposing bacteria of the genus *Vibrio*. When it was added to faintly acid soils (pH 5.7-6.2) these organisms were partly replaced by *Spirochaeta cytophaga*. At lower pH values only fungi were active in the decomposition of the cellulose. Similar results were obtained by adding filter paper or straw to soils of different reactions. Cellulose decomposing bacteria did not form humus-like compounds when growing on filter paper in sand culture but at least two fungi *Mycogone nigra* and *Stachybotrys sp.* gave rise to such compounds when growing in sand and in sterilised soil.

XLVIII. H. L. JENSEN. "*The Microbiology of Farmyard Manure Decomposition in Soil. III. Decomposition of the Cells of Micro-organisms.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 1-25.

The addition of microbial substances to soil resulted in a rapid but temporary increase in bacteria and especially actinomycetes. A fraction of the microbial substance was readily nitrified but there remained a very resistant residue. This was not identical with fungal chitin which is readily nitrified. In the case of *Mycogone nigra* and *Stachybotrys*, the humus-like substance contained in their mycelia formed part of this resistent residue.

THE PLANT IN DISEASE: CONTROL OF DISEASE

(Entomological, Insecticides and Fungicides, and Mycological Departments)

(*a*) INSECTS, AND THEIR CONTROL.

XLIX. H. F. BARNES. "*Observations on Gall Midges Affecting Fruit Trees.*" Journal of the South-Eastern Agricultural College, 1931, No. 28, pp. 170-177.

Notes on the bionomics and control of *Dasyneura pyri* Bouché, *Contarinia pyrivora* Riley, both on pear; *Thomasiniana oculiperda* Rübs. on rose and apple, and *Dasyneura* sp. on black currant. This information, which deals with recent literature and the author's own investigations, brings up to date the section dealing with the same subject in a previous paper (Barnes, *Material for a Monograph of the British Cecidomyidae or Gall Midges*, Journal of the South-Eastern Agricultural College, 1927, No. 24, pp. 65-146).

L. H. F. BARNES. *" Further Results of an Investigation into the Resistance of Basket Willows to Button Gall Formation."* Annals of Applied Biology, 1931, Vol. XVIII, pp. 75-82.

Twelve commercial varieties of *Salix triandra* have been proved, under experimental conditions, to be very susceptible to attack by the button top midge (*Rhabdophaga heterobia* H.Lw.) ; three varieties of *S. purpurea*, one variety of *S. viminalis*, three hybrids of *S. viminalis* and *purpurea*, and *S. alba* var. *vitellina* have proved to be totally immune. It is suggested that hybridisation of *S. triandra* and *S. purpurea* or *S. viminalis* or *S. alba* should be attempted.

LI. H. F. BARNES. *" The Sex Ratio at the Time of Emergence and the Occurrence of Unisexual Families in the Gall Midges (Cecidomyidae)."* Journal of Genetics, 1931, Vol. XXIV, pp. 225-234.

Unisexual families are shown to occur in *Rhabdophaga heterobia* H.Lw. and *Thomasiniana oculiperda* Rübs.

LII. H. F. BARNES. *" Gall Midges (Cecidomyidae) whose Larvae Prevent Seed Production in Grasses (Gramineae)."* Bulletin of Entomological Research, 1931, Vol. XXII, pp. 199-203.

Brief notes are given on 18 species of Cecidomyidae, the larvae of which have been recorded from various parts of the world as preventing seed formation in grasses, with a list of the grasses attacked showing the gall midges concerned and the country of origin.

LIII. A. STEEL. *" On the Structure of the Immature Stages of the Frit Fly (Oscinella frit Linn.)."* Annals of Applied Biology, 1931, Vol. XVIII, pp. 352-369.

The morphology of the immature stages of *Oscinella frit* Linn. are described and figured and certain observations of a biological nature are recorded.

LIV. H. C. F. NEWTON. *" On the so-called ' Olfactory Pores ' in the Honey-Bee."* Quarterly Journal of Microscopical Science, 1931, Vol. LXXIV, pp. 647-668.

The structure of the campaniform sensillae on the wing-bases of the honey bee is described together with the essential features of the later developmental phases in the pupae. The observations made lend no support to the view that the nerve fibres of the sensillae are exposed to the air so rendering them specially suitable to the reception of chemical stimuli from a distance. The origin of the cellular elements composing the sensillae is discussed and it is suggested that the neuron of the sensory system connected with these organs is situated in the hypodermis and is in fact the sensory cell itself.

LV. MARION A. HAMILTON. *" The Morphology of the Water Scorpion, Nepa cinerea. Linn. (Rhynchota Heteroptera)."* Proceedings of the Zoological Society of London, 1931, pp. 1068-1134.

A description of the morphology and histology of a common freshwater Heteropteran, the " Water Scorpion." A short account

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of the biology and life-history is given followed by a detailed account of the anatomy, both external and internal. Particular attention is paid to the muscular and nervous systems not hitherto described, and showing various interesting adaptations and modifications to the unusual mode of life. The respiratory system and some of its peculiar points of anatomy and physiology receive considerable attention. In Nepa a great many of the normal functions of insects have become subjugated to the more pressing immediate need for air, with the result that such organs as wings and wing muscles, spiracles, etc., are being used in ways, and for purposes which are almost unique, owing to the adoption of a permanent sub-aqueous habitat. Finally an account is given of the integument and sense organs which have also been rather neglected by morphologists, with the one outstanding exception of the abdominal sense organs. These are again unique structures pertaining to the abdominal spiracles and owing their existence to the unusual needs of the insect.

LVI. R. P. Hobson. "*Calcium and Hydrogen Ion Concentration and the Interfacial Tension of Pyrethrum Extracts.*" Journal of Agricultural Science, **1931**, Vol. XXI, pp. **101-114.**

The addition of a pyrethrum extract to a petroleum solvent, semi-refined white spirit, considerably lowers its interfacial tension against water. The tension also depends upon the reaction of the aqueous phase, decreasing as the alkalinity increases.

The addition of agral W.B. to a solution of pyrethrum extract further lowers the interfacial tension more especially against acid solutions, thereby decreasing the sensitivity of the tension value to the pH of the aqueous phase.

The presence of calcium salts in the aqueous phase raises the interfacial tension of solution of pyrethrum extract.

Alkaline salts counteract the effect of calcium salts and the resulting tension values can be correlated with the ratio of calcium to hydroxyl ion concentration.

LVII. J. T. Martin and F. Tattersfield. "*The Evaluation of Pyrethrum Flowers* (*Chrysanthemum Cinerariaefolium*)." Journal of Agricultural Science, **1931**, Vol. XXI, pp. **116-135.**

The analytical methods of Tattersfield, Hobson and Gimingham, and Gnadinger and Corl for the determination of the pyrethrins in pyrethrum flowers are compared, and certain modifications in technique suggested.

Good concordances have been obtained between analytical data and insecticidal tests employing *Aphis rumicis*.

A new method for the rapid and approximate evaluation of unadultered samples, employing small quantities of material, is described.

Observations on the pyrethrin content of individual flowers in the various stages of development are recorded, making use of a modification of the method indicated

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LVIII. F. TATTERSFIELD AND R. P. HOBSON. "*Extracts of Pyrethrum: Permanence of Toxicity and Stability of Emulsions.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 203-243.

Pyrethrum flowers (*Chrysanthemum cinerariaefolium*) both as whole heads and as powder retain their insecticidal properties at ordinary temperatures and at 28°C. for considerable periods if stored in closed vessels. If exposed to the atmosphere in a thin layer as finely ground powder there is risk of loss of toxicity.

Alcohol and petroleum extracts of pyrethrum retain their toxicity in temperate climates over many months. Alcohol extracts readily give permanent emulsions when added to water ; petroleum extracts require the incorporation of an emulsifier. Water-miscible petroleum extracts of pyrethrum can be prepared by the addition of certain materials, such as ammoniated Agral W.B. and neutral turkey-red oil.

A study has been made of the degree of permanence of the active principles of alcoholic and water-miscible petroleum extracts at ordinary British temperatures and at 28°C. and also in emulsions of these extracts in alkaline spray fluids of varying pH. The active principles proved more permanent than has usually been supposed.

The readiness with which water-miscible petroleum extracts disperse in the aqueous phase and the stability of the emulsions formed under a variety of conditions have been investigated.

LIX. F. TATTERSFIELD. "*Pyrethrum Flowers: A Quantitative Study of Their Development.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 602-635.

An account is given of the examination of the flowers of pyrethrum plants (*C. cinerariaefolium*) grown in Harpenden. The plants were divided into blocks and randomised, the flowers being harvested from a dozen plants each week over a period of 8½ weeks, the flower heads ranged from the small bud stage in the first week to the over-blown stage in the last week.

The yield in numbers and weight of heads per plant, the diameters of the receptacles and the content of pyrethrin I and II were determined. There was a considerable amount of variation in all the factors in the flowers from different plants.

A statistical analysis showed that :

(*a*) there was no significant variation in the numbers of the flowers with time, but that position of the plant in the bed had a significant effect ;

(*b*) the time of harvesting had a significant effect upon the content of the pyrethrins, whether taken separately or together and whether expressed in percentages, parts per flower head or parts per plant.

There was a quantitative development of the active principles in the flower heads from the small bud stage up to the time of maturity of the flowers, which more than kept pace, on the whole, with the increase in weight of the flowers. Thus the content of pyrethrins, both relatively and absolutely, rises to a maximum at the maturity of the flowers.

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The mean percentage content of pyrethrins fell after pollination, and the fading of the flowers; this corresponds with the rapid increase in weight of the heads on the formation of seed. There would appear to be a loss, which might be serious, both in percentage content of active principles and in yield of flowers if harvested before being fully open.

(*b*) Bacterial Diseases.

LX. R. H. Stoughton. "*The Influence of Environmental Conditions on the Development of the Angular Leaf-Spot Disease of Cotton. III. The Influence of Air Temperature on Infection.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 524-534.

Experiments carried out in the Rothamsted control chambers on the influence of air temperature on the angular leaf-spot disease of cotton plants, resulting from spray inoculation of young plants, show that high air temperatures favour the development of the disease. Maximum infection occurs at an air temperature of 35-36°C. with decreasing incidence at progressively lower temperatures. At a constant air temperature of 39-40°C. cotton plants make no growth, and eventually die.

Infection takes place more readily when the inoculation is carried out during the non-illuminated period.

The relation of these results to the experiments on the influence of soil temperature is discussed.

(*c*) Virus Diseases

LXI. J. Caldwell. "*The Physiology of Virus Diseases in Plants. II. Further Studies on the Movement of Mosaic in the Tomato Plant.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 279-298.

The results of experiments discussed in this paper support the general view that the agent of virus diseases will travel only through living tissue. No entry into the living tissues is possible through the epidermis, the root hair, or the xylem vessel walls. The agent can and does travel, however, in the water stream, if it be injected mechanically into the xylem. The absence of the agent from the hydathode exudate has been demonstrated. The agent cannot enter an unbroken cell nor can it move through areas of dead cells. Traces of toxic substances from the inocula to be tested may prevent the infection of experimental plants, even when the virus agent is present. Movement upwards and downwards in the plant takes place more or less at the same rate. The agent appears to move along the protoplasmic strands rather than to be carried bodily in the phloem strands. The effect of darkness on the development of the virus in the plant and on the plant itself is discussed.

LXII. F. M. L. Sheffield. "*The Formation of Intracellular Inclusions in Solanaceous Hosts Infected with Aucuba Mosaic of Tomato.*" Annals of Applied Biology, 1931. Vol. XVIII, pp. 471-493.

A description is given of the mode of formation of intracellular inclusions produced by aucuba mosaic of tomato in *Solanum nigrum*,

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S. nodiflorum, *S. lycopersicum*, *Nicotiana tabacum* and *Hyoscyamus niger*.

Soon after infection the rate of streaming of the cytoplasm is increased, then minute particles of protein appear in the cytoplasm, which carries them passively about the cell. These particles aggregate and fuse to form large masses which are still carried passively but more slowly about the cell. These fuse until all the protein material is contained in one or occasionally more granular masses. In the three Solanum species examined this mass becomes rounded, and it may lose its granular appearance and become vacuolated. In *N. tabacum* the body does not always round off and in *H. niger* it very seldom does so, but remains as an irregularly shaped granular mass which may, however, become vacuolate.

There is no evidence at any time of autonomous movement, the particles and the fully formed body being carried, as are the cell nucleus, mitochondria, etc., of the normal plant, in the cytoplasmic stream.

After the spherical body is formed a spike-like crystal appears in the cell.

The cell remains at rest for the space of several weeks. Often the rounded inclusion body and the nucleus are juxtaposed, but there is no special significance in this, it is merely the accidental result of the mode of formation of the body. Particles tend to accumulate where a number of strands of plasm meet ; usually several strands converge on the nucleus.

Ultimately the body breaks down, giving a number of protein crystals. After some months these dissolve. In *H. niger* the inclusion bodies are confined to the chlorotic areas, where they are abundant in all tissues. In the other species studied they are distributed over green and yellow tissues. They are very abundant in the hairs, less so in the epidermis, and very rare in the palisade and spongy tissues. In *H. niger* the development of the palisade tissue is arrested, in the other species the development is not so obviously affected, although growth is retarded.

These inclusions appear not to be organismal in nature ; they seem to be products of reaction of the host cell to the virus, but they may contain the etiological agent of the disease.

TECHNICAL AND OTHER PAPERS

GENERAL

LXIII. G. W. Scott Blair and R. K. Schofield. "*On the Anomalous Flow of a Strong Solution of Lithium Chloride through Narrow Glass Tubes.*" Philosophical Magazine, 1931, Vol. XI, pp. 890-896.

In connection with plastometric measurements of clay pastes the behaviour of non-colloidal solutions was investigated in the plastometer. A strong solution of lithium chloride was found not to obey Poiseuille's law for the flow of viscous liquids through glass capillary tubes. It seems that small strains are not immediately dissipated during flow, possibly owing to the tendency of the ions to maintain a non-random distribution. In addition, evidence was

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