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SCIENTIFIC PAPERS

(Published 1936, and in the Press)

PLANT GROWTH, PLANT PRODUCTS, AND ACTION OF MANURES.

(Departments of Bacteriology, Botany, Chemistry, Fermentation, Physics, Plant Pathology, Sections of Biochemistry and Field Experiments, and the Imperial College Staff.)

(a) PLANT GROWTH

- I. E. J. RUSSELL. "*The Story of Rothamsted.*" Agricultural Progress, 1937, Vol. XIV, pp. 1-13.
- II. E. J. RUSSELL. "*The Culture of the Soya Bean in England.*" Journal of the Ministry of Agriculture, 1936, Vol. XLIII, pp. 24-30.
- III. E. J. RUSSELL. "*Les travaux de la Station Experimentale de Rothamsted.*" Lecture given May 1935 at l'Institut Superieure de l'Agronomie, Lisbon.
- IV. E. J. RUSSELL. "*Fünfzig Jahre Dauerfeldversuche in der Versuchsstation Woburn, einer Abteilung der Versuchsstation in Rothamsted.*" Landwirtschaftliche Jahrbücher, 1937, Vol. LXXXIV, pp. 161-312.
- V. D. J. WATSON. "*The Effect of Applying a Nitrogenous Fertiliser to Wheat at Different Stages of Growth.*" Journal of Agricultural Science, 1936, Vol. XXVI, pp. 391-414.

The effect of applying a nitrogenous fertiliser to wheat at seven different times and three rates, was studied in pot culture. The later the time of application the smaller was the increase in the yield of total dry matter and of straw. The increase in the yield of grain, on the other hand, was constant for the first six times of application, the last of which was made on May 25, but a later application made after ear emergence produced no increase.

Analysis of the grain yield showed that early application produced its effect by increasing the number of ears per plant. Later applications caused a smaller increase in ear number, but also increased the number of grains per ear and 1000-corn weight. There was no evidence of a critical time for tiller formation such as has been postulated by Doughty and Engledow.

The increase in total nitrogen uptake was equal for all times of application, but the ratio of nitrogen in grain to nitrogen in straw and chaff was greater, the later the time of application.

- VI. F. J. RICHARDS and W. G. TEMPLEMAN. "*Physiological Studies in Plant Nutrition. iv. Nitrogen Metabolism in Relation to Nutrient Deficiency and Age in Leaves of Barley.*" Annals of Botany, 1936, Vol. L, pp. 367-402.

Barley was grown in sand culture under four nutrient treatments, i.e. complete nutrients and deficiency of nitrogen, of phosphorus, and of potassium. On eight selected dates the successive individual leaves were separately grouped, dried immediately, and subsequently analysed for certain nitrogen fractions.

Differences in composition of the successive leaves at the time of their emergence were found, together with differences in the changes occurring as the leaves aged. In general, total nitrogen and most of the estimated fractions rose to a maximum about the period of Leaves 2-4, and thereafter declined to a minimum at Leaf 8 or 9, the last leaves again showing a rise. Nitrogen content fell continuously with leaf age in the earlier leaves, but in later ones rose for some time after expansion. The relation between nitrogen supply and ageing of the leaf is discussed.

Differences in nitrogen level induced by deficiency of that element are very marked, but there is little indication of departure from the usual protein cycle, and the observed fractions bear much the same relations to one another as in high-nitrogen plants.

Under phosphorus deficiency large differences are found. Protein is reduced even in early stages of the leaf history, and rapidly declines with the age of the leaf. The most marked characteristic of phosphorus deficiency is a greatly increased amide concentration. Clearly there is a check in protein synthesis beyond the stage of the production of asparagine.

The main effects of potassium deficiency on the various fractions are (1) a very rapid disappearance of protein with advancing leaf age although at the time of emergence these leaves have a normal protein content; (2) a marked increase in amino and amide-nitrogen, and (3) accumulation of nitrate in later leaves. The very different types of plants obtainable under varied conditions of potassium deficiency are stressed. The hypothesis that potassium plays an essential part in protein synthesis is examined, and an alternative view that appears to be more in accord with the known facts is presented.

VII. W. E. BRENCHLEY. "*The Essential Nature of Certain Minor Elements for Plant Nutrition.*" *Botanical Review*, 1936, Vol. II, pp. 173-196.

Much of the extensive literature on the rôle of minor elements deals with toxic and fungicidal aspects. The present review discusses recent work on the effect of some sixteen elements on plant growth. Small amounts of boron and manganese are essential to the growth and health of many, if not all, species of plants. Copper and zinc are necessary in many cases, though it is uncertain at present whether this need is universal. For other minor elements, only isolated cases of improvement have as yet been established. The possibility that specific elements are necessary for specific plants may have scientific and economic consequences.

VIII. E. A. ROWE. "*A Study of Heart-rot of Young Sugar Beet Plants Grown in Culture Solutions.*" *Annals of Botany*, 1936, Vol. L, pp. 735-746.

The fact that boron is an essential element for the healthy growth of sugar beet is confirmed. Some of the plants were grown with or without boron throughout the experiment, and others received it for a limited period only, either at the outset or at a later stage of development.

In the absence of boron the first tissues to degenerate are the apical meristem of the shoot, together with the youngest leaves and the newly developed cambia of the beet. Cells of the vascular rings in process of differentiating, and sporadic groups of parenchyma cells adjacent to conducting elements are also sensitive to the deficiency. Hypertrophy of the cambial cells, and also of the adjacent parenchyma cells, together with complete disintegration of the phloem, characterizes the later stages of heart-rot disease. It is suggested that plugging of the sieve-tubes is the first indication that the tissue is suffering from boron-deficiency.

Recovery in boron starved plants, as a result of the addition of boron, involves the activation of axillary buds at the top of the beet, each of which develops its own independent system of secondary vascular rings. The secondary vascular zones in the beet are downward continuations of the vascular supply of the leaves and the influence of any factor adversely affecting the leaves is very quickly reflected in the corresponding vascular rings of the beet. Since the root-tip does not degenerate, but merely ceases to grow in the absence of boron from the nutrient solution, either the requirements of this meristem, or the conditions obtaining in it must be different from those of the shoot-apex.

IX. W. E. BRENCHLEY. "*The Resistance of Plants to Poisons and Alkalies.*" 3rd. Congrès International de Pathologie comparée à Athenes, 1936, pp. 3-23.

When plants are attacked by poisons, either through the roots or by vapours or sprays, the consequence is either death, or a check to the normal processes of growth. Different plant species and even comparable individuals of one species vary in their response to the same poison.

Nutrient salts are toxic if supplied too lavishly, mixtures usually being less toxic than the individual salts. Other inorganic substances, as copper, arsenic, lead, zinc, manganese, etc., are poisonous in much smaller quantities. Organic compounds, as hydrocyanic acid, and various gases and sprays are also toxic, and the degree of resistance of plants to their action is of great economic importance.

The degree of resistance varies with the nature as well as the quantity of poison, and with individuals within a species. The stage of development of a plant, its relative weakness or strength, environmental conditions of light, temperature, moisture and food supply all affect resistance. But the marked differences in resistance between certain species can often be exploited by using poisons that suppress harmful plant growths without appreciably injuring the main crop. Such knowledge has already saved agriculturists much money, and research on the differential use of toxic substances, and on mitigating damage due to poisons in the soil will open further possibilities.

- X. W. E. BRENCHELY AND K. WARINGTON. "The Weed Seed Population of Arable Soil. III. The Re-establishment of Weed Species after Reduction by Fallowing." *Journal of Ecology*, 1936, Vol. XXIV, pp. 479-501.

Delay in cultivation after harvest allows some weed species, already developed, to continue seed production, and others have time to germinate and reach the seeding stage. The numbers of extra seeds thus produced may be greater than those destroyed by fallowing, so that the reducing effect of the operation is entirely nullified.

The first wheat crop after one year's fallowing is often heavy, and competition with the weeds is increased. Some species fail to reassert themselves, but others are able to withstand the competition and can replenish their stores of seed in the soil by the time the first wheat crop is harvested. A few species vary in their response, either remaining at a low level or re-establishing themselves quickly after fallowing, and in some cases, notably *Alopecurus agrestis* and *Stellaria media*, they may be much more plentiful after three years under crop than they were before fallowing began. The varying rate of re-establishment produces a definite change in the balance of the weed flora. Though *Papaver rhoeas* was only reduced to about half its original number by fallowing it has failed to increase appreciably, and is no longer a dominant feature.

After prolonged fallowing, (four years) re-establishment of species follows the same lines as after a shorter period, but the number of buried seeds is reduced more drastically and their return to the original numbers is delayed. The period of natural dormancy of most species on Broadbalk ranged from four to nine years, but for a few species may exceed ten years.

Bartsia odontites showed very strongly marked periodicity of germination, as every seedling appeared between February and June, the majority appearing early in the year.

Relatively few abnormal seedlings have been observed in over 600,000 which germinated. A few albinos occurred in *Alopecurus agrestis* and *Papaver rhoeas*, and also a number of tricotyledonous seedlings belonging to seven species, chiefly *Papaver spp.*, *Alchemilla arvensis* and *Veronica hederifolia*.

- XI. F. M. L. SHEFFIELD. "The Early Development of the Cotton Fibre." *The Empire Cotton Growing Review*, 1936, Vol. XIII, pp. 277-285.

A detailed cytological examination, with illustrations, is given of the development of the fibre from primordial cells in the epidermis from the date of the opening of the flower. Emphasis is laid on the variability from cell to cell in a single seed, and from seed to seed within a single boll.

(b) PLANT PRODUCTS.

- XII. A. G. NORMAN. "The Composition of Forage Crops. I. Rye Grass, (Western Wolds)." *Biochemical Journal*, 1936, Vol. III, pp. 1354-1362.

The composition of fortnightly cuts of rye grass was studied, particular attention being given to the structural constituents. The contents of cellulose and lignin increased rapidly as maturity approached and the percentage of xylan in the cellulose also increased with age. The polyuronide hemicelluloses,

as judged by furfuraldehyde yield, did not exhibit any regular increase and were slightly lower in the mature grass than the young grass. A water-soluble fructosan or laevan, was found in considerable amounts in the younger samples, reaching a peak of over 37 per cent. As maturity was reached the fructosan content fell rapidly. The fructosan on isolation was unusually easily hydrolysed. Losses in hay making were of the order of 10 per cent., mostly accounted for by loss of this water-soluble constituent.

- XIII. A. G. NORMAN. "*The Composition of some Vegetable Fibres, with particular reference to Jute.*" *Biochemical Journal*, 1936, Vol. XXX, pp. 831-838.

Vegetable fibres of many types fall into two well-defined groups, according as the cellulose of the fibre is low or high in xylan. The first group, low in xylan, includes the high grade fibres such as flax, ramie and Italian hemp. The second group, high in xylan, consists of fibres of the coarser type, such as jute, manilla hemp and sisal, all of which contain also appreciable amounts of lignin and encrusting hemicelluloses. No direct relationship between quality and xylan content was found in a wide range of jute samples. The resistance or susceptibility of isolated cellulose to such treatments as boiling with dilute alkalis cannot be deduced from the xylan content, owing to the presence of varying amounts of easily extractable hexosan.

- XIV. A. G. NORMAN. "*The Association of Xylan with Cellulose in certain Structural Celluloses.*" *Biochemical Journal*, 1936, Vol. XXX, pp. 2054-2072.

The cellulose of most plants and woods differs from that of cotton in containing associated polysaccharides, known as cellulosans, which are tenaciously retained as an integral part of the cellulose aggregate. Heat-drying produces some change in the properties of both components of such a cellulose, which is manifest in an increased availability to extracting and hydrolysing agents. The effect of heat treatment may be observed repeatedly on the same sample and must involve breakage of the cellulose chains, though the xylan fraction is affected to a much greater extent. Preparations of the water-soluble material produced as a result of heat-treatment are mixtures which can be partially separated to give a portion of higher xylan content. Some oxidation undoubtedly occurs, and uronic groupings are present.

The xylan may be removed from celluloses by treatment with either acid or alkali, but a concurrent loss of hexosan material takes place in all cases. In acid hydrolysis there is no apparent break in the continuity of the reaction. The reducing value of dilute acid extracts indicates that the material removed is not completely hydrolysed to reducing sugars. Continued boiling with alkali removes hexosan at a greater rate than xylan, and in effecting the same total loss a higher concentration of alkali in a short period extracts more xylan than a lower concentration for a longer period. Plant celluloses show considerable differences of behaviour towards hydrolytic and extracting agents and reveal distinct individualities.

By solution and reprecipitation of a cereal cellulose, the organised molecular structure may be destroyed, and the xylan, which was initially extracted only to a small extent by water and dilute alkali, becomes almost completely soluble. No equivalent change occurs in the properties of the hexosan material.

These observations support the view that the cellulosan fraction of the cellulosic aggregate of plant materials and woods is oriented and participates in the micellae, being retained by secondary valency forces identical with those which obtain between parallel cellulose chains in pure cotton cellulose.

- XV. A. NOWOTNÓWNA. "*The Distribution of Mannan in some Gymnosperms.*" *Biochemical Journal*, 1936, Vol. XXX, pp. 2177-2184.

Conditions suitable for the determination of mannan in woods and wood pulps are discussed. The precipitation of mannose as the phenylhydrazone is not quantitative in low concentrations, but over a limiting value almost complete recovery may be obtained.

The major part of the mannan in softwoods is associated with the cellulose. Considerable variation in the proportion of mannan to xylan is found. Mannan may be removed from the cellulose by dilute acid hydrolysis along with the xylan. At the same time there is some loss of hexosan. The mannan and xylan are affected to different extents on treatment of the cellulose with alkali.

- XVI. M. F. NORMAN. "The Oxidation of Amino-Acids by Hypochlorite I. Glycine." *Biochemical Journal*, 1936, Vol. XXX, pp. 484-496.

Glycine is rapidly oxidised by hypochlorite. At least five times as much chlorine as glycine must be present for completion of the reaction, in which circumstance 1 mg. glycine uses 4.26 mg. chlorine, equivalent to 9 atoms of chlorine per mol. of glycine. The rate of oxidation is most rapid between the limits of acid and alkali concentrations of 0.05 m. mol. per 100 ml. Outside these limits the reaction is greatly retarded. As oxidation proceeds the mixture becomes more acid, the optimum pH range being 7-9. The oxidation of possible intermediates was tested, from which it was established that the probable route of reaction is through the formation of HCN, CO₂, and water, the HCN then hydrolysing to formic acid and ammonia, both of which are further oxidised to CO₂, water and gaseous N. Quantitative recovery of carbon dioxide was obtained.

- XVII. C. N. ACHARYA. "Structure in Relation to Chromic Oxidation of Nitrogenous Substances." *Biochemical Journal*, 1936, Vol. XXX, pp. 1026-1032.

The nature of the products obtained by chromic oxidation of nitrogenous substances varies with the structure of the compound. Compounds in which the nitrogen atoms are attached to different carbon atoms, with the exception of hydroxylamine and hydrazine derivatives, yield full recovery of nitrogen in the form of ammonia accompanied by small quantities of nitrate; those having two or three nitrogen atoms attached to the same carbon atom lose a portion of the total nitrogen in the form of nitrous oxide. Hydroxylamine derivatives are converted into nitrous oxide and nitrate, while hydrazine derivatives yield mainly elementary nitrogen; in both cases, the amount of ammonia formed is inappreciable.

An improved wet combustion apparatus has been described which includes the analysis of gaseous products and is applicable to the determination of nitrogen in all types of organic compounds.

- XVIII. R. K. SCHOFIELD AND G. W. SCOTT BLAIR. "The Relationship between Viscosity, Elasticity and Plastic Strength of a Soft Material as Illustrated by some Mechanical Properties of Flour Dough. IV. The Separate Contributions of Gluten and Starch." *Proceedings of the Royal Society of London, A*, 1937, Vol. CLX, pp. 87-94.

These experiments support the view that in a flour dough the gluten forms an elastic network which dominates the mechanical behaviour. When a cylinder of dough is first stretched some of the links in the network are ruptured, since it will not return to its original length. Enough remain unbroken, however, for a continuity of structure to be preserved until the cylinder has been extended to five or six times its original length. The "work-hardening" of dough is thus accounted for. The elastic network is not completely built up until some time after the dough is mixed. Its strength is greatly reduced by drastic remixing of the dough but is largely recovered on further standing. The addition of hydrochloric acid in slight excess of the acid binding capacity destroys the strength of the network. This shows that the electrostatic attraction between oppositely charged groups in neighbouring molecules is an important factor in the strength of the gluten network.

The upward bend of the reloading curve up to the point where flow (i.e. the rupture of further links) occurs is probably mainly due to the irregularity of assembly of the elastic members, but may also indicate that individual chains are approaching the limit to which they can be extended.

The evidence suggests that the starch paste penetrating the gluten network has a "yield value" so that there is elastic hysteresis even when the cycle is carried out slowly enough to avoid elastic after-effect.

- XIX. R. K. SCHOFIELD AND G. W. SCOTT BLAIR. "Über die grundlegenden mechanischen Eigenschaften des Mehlteiges." *Kolloid-Zeitschrift*, 1937, Vol. LXXIX, pp. 148-154.

A résumé of work on the viscosity and shear modulus of flour doughs is given. Study of such fundamental properties is essential for an understanding of the behaviour of doughs, either as purely physical systems or in their relation to the bread-making industry.

The starch paste penetrating the gluten network has a "yield value" in consequence of which there is elastic hysteresis even when the cycle is carried out slowly enough to avoid elastic after-effect. It has been found, moreover, to be thixotropic, the breakdown of the gel which forms on standing being exhibited in an "elastic fatigue." The effect is complicated by a rise in the elastic modulus due, presumably, to the establishment of new linkages in the gluten network.

Through the action of the starch, the mechanical properties of the dough are more influenced by age and moisture content when measured at low than at high stresses. The elastic recovery of dough cylinders extended only 20 per cent. in a given time varies both with the age and moisture content of the dough and with the nature of the flour.

No plastic flow occurs during elastic recovery. The presence of a "plastic after-effect" would invalidate the method used to evaluate the viscosity and rigidity-modulus.

- XX. P. HALTON AND G. W. SCOTT BLAIR. "*A Study of Some Physical Properties of Flour Doughs in Relation to their Bread-Making Qualities.*" *Journal of Physical Chemistry*, 1936, Vol. XL, pp. 561-580.

Methods described in earlier papers for measuring the viscosity and rigidity modulus of flour doughs have been extended and developed.

The physical properties of dough are markedly affected by excessive handling hence the methods used have to be carefully controlled.

Viscosity and modulus measured under standard conditions of stress and strain both decrease with increasing water content or with increasing age of the dough.

Good bread-making quality is associated with a relatively high viscosity and low modulus; the relaxation time, i.e., viscosity-modulus ratio, therefore, appears to be the chief single criterion of quality.

Yeast in small amounts has little effect on viscosity or modulus, and its importance in bread-making appears to be entirely due to its gas-producing activities.

Preliminary work indicates that tensile strength is a major factor in determining the extensibility and gas-holding properties of a dough.

Stickiness is an independent property which can be roughly measured. Its principal importance lies in its effect on the handling properties of the dough.

The investigations have disclosed relationships between the physical properties of flour doughs and their bread-making qualities, and their development should increase our knowledge of the nature of flour quality.

- XXI. P. HALTON AND G. W. SCOTT BLAIR. "*The Relationship between Conditions Governing Rupture and Flow in Flour Doughs.*" *Journal of Physical Chemistry*, 1936, Vol. XL, pp. 811-819.

The shortness (i.e. ease of tearing) of flour doughs is closely paralleled by the rate at which viscosity falls with increasing stress (structural viscosity). A perfect correlation is not obtained, partly because neither property can be determined with great accuracy. The effect on structural viscosity of certain substances (fats, amino-acids, etc.) known to alter the shortness of dough has been measured, and the nature of the processes involved discussed. The significance of shortness in terms of heterogeneity of dough, and its relation to tensile strength and ductility are tentatively discussed.

- XXII. P. HALTON AND G. W. SCOTT BLAIR. "*A Study of some Physical Properties of Flour Doughs in Relation to their Bread-Making Qualities.*" *Cereal Chemistry*, 1937, Vol. XIV, pp. 201-219.

The baking quality of a flour has been found to depend on the physical properties of the dough and a picture is given of the mechanism of dough behaviour during fermentation based on these physical properties. Viscosity and elasticity modulus are of chief importance, and methods of measuring these in absolute units have been devised. The viscosity and elasticity modulus are not constants but depend on the magnitude of the stress and strain to which the dough is subjected. They also vary with the water content, age, and temperature of the dough.

The baking quality of a flour depends primarily on the spring and shortness of the doughs. The spring of dough depends on the relationship between viscosity and elasticity modulus, the higher the viscosity/elasticity modulus ratio the better the spring. Shortness in doughs is connected with structural viscosity in the rate at which viscosity falls under increasing stress.

- XXIII. G. W. SCOTT BLAIR AND P. POTEL. "*A Preliminary Study of the Physical Significance of Certain Properties Measured by the Chopin Extensimeter for testing Flour Doughs.*" *Cereal Chemistry*, 1937, Vol. XIV, pp. 257-262.

A preliminary analysis of the physical properties of dough measured by the Chopin extensimeter indicates that water absorption capacity and a complex function of viscosity and modulus are the principal factors involved. Under the conditions of the test, the former is directly related to viscosity, and the latter depends on a complex mixture of "spring" and shortness which has been only partially resolved.

The increasing use of the Chopin instrument as a criterion of wheat and flour quality independent of any baking test, emphasises the importance of a wider understanding of the nature of the factors measured.

- XXIV. HUGH NICOL. "*The Two Ends of Straw.*" *Agricultural History*, 1936, Vol. X, pp. 3-13.

Most published analyses of straw relate to the entire stem, and thus show only average values. The first demonstration of differences in chemical composition of the upper and lower ends of straw, and in some other parts of stems was made by James F. W. Johnston for cereals and bamboo and was published in 1842; his differential analyses of barley straw remained unique for nearly a century. Johnston's pupil, John P. Norton, performed more detailed analyses of oat straw (1847). The work of Pierre, on wheat straw, published in 1863 and 1866, is probably the most elaborate series of analyses of a plant species ever performed. In the present paper it is suggested that Pierre's work bears upon the hypothesis of regressive or downward migration of plant nutrients, put forward recently by Professor Deleanu of Bukarest.

The early work on differences of composition along the stem appears to have been forgotten in spite of its practical value (see Papers XCII, XCIII).

(c) ACTION OF MANURES.

- XXV. J. CALDWELL AND H. L. RICHARDSON. "*The Growth of Clover in the Presence of Ammonium Sulphate.*" *Journal of Agricultural Science*, 1936, Vol. XXVI, pp. 263-267.

In pot experiments with alsike and red clovers, fortnightly dressings of ammonium sulphate applied in solution at rates up to 1 gm. per pot did not injure the plants. The total amount of ammonium sulphate applied to the alsike was relatively enormous, of the order of 24 tons per acre. Soil and plant analyses showed that although abundant ammonia and nitrate (including water-soluble ammonia) were present in the soil there was little extra nitrogen in the treated plants. It was concluded that the adverse effect of ammonium sulphate on clovers in grassland was due not to the toxicity of ammonium ion but to competition with the extra growth of grass produced.

- XXVI. E. M. CROWTHER AND R. G. WARREN. "*Report on Field Experiments in England and Pot Culture and Laboratory Work at Rothamsted.*" Appendix I to Fourteenth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture, 1936.

A series of pot culture experiments on eleven slags using repeatedly-cut perennial rye grass was continued for a second season. Only the heavier dressings of the more soluble slags had appreciable effects on the crops. In total dry matter and in total phosphoric acid uptake the results followed the citric acid solubilities of the slags, about 60 per cent. of the added citric acid-soluble phosphoric acid being taken up by the crops.

In a repeated mowing experiment on neutral grassland continued for five seasons about 30-40 per cent. of the phosphoric acid added in high-soluble slag or superphosphate was recovered in the herbage, but less than 10 per cent. was recovered from low-soluble slag and mineral phosphate.

- xxvii. E. M. CROWTHER (with D. N. McARTHUR). "Report on Scottish Field Experiments in 1935." Appendix II, Fourteenth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture, 1936.

A series of seven 48-plot field experiments was carried out to compare single and double dressings of four kinds of basic slag and also of ground limestone. The relative effects of high- and low-soluble slags followed their citric acid solubilities, but of two new medium-soluble slags one was better and the other worse than would be judged from their citric acid solubilities. Second year residual effects on oats were very small and were shown only by the two more soluble slags which had given the best immediate results.

STATISTICAL METHODS AND RESULTS

(Department of Statistics)

(a) DESIGN OF EXPERIMENTS

- xxviii. F. YATES "Incomplete Randomized Blocks." *Annals of Eugenics* 1936, Vol. VII, pp. 121-140.

The paper describes a general method of arranging replicated experiments in randomized blocks when the number of treatments to be compared is greater than the number of experimental units in a block. This new type of arrangement, for which the name of symmetrical incomplete randomized blocks is proposed, is such that every two treatments occur together in a block the same number of times. This restriction enables estimates of the treatment effects and of the experimental error to be obtained expeditiously by the ordinary procedure of the analysis of variance. Estimates of block differences can also be obtained if required. The special case in which the blocks are formed of pairs of experimental units is capable of specially simple treatment. The method of symmetrical incomplete randomized blocks is likely to be of most use in cases in which the experimental material naturally divides itself into groups, such as litters of experimental animals, containing numbers less than the number of treatments that it is desired to test, especially if the differences between these natural groups are of interest.

The necessary formulae are presented and their application illustrated by numerical examples, one based on the numbers of local lesions produced by a virus on half leaves of susceptible plants, the other on the scores of rats in a discrimination test. The minimum number of replications required for different numbers of treatments and block sizes is discussed, and actual arrangements are given for the cases likely to be of general utility. A short discussion of the relative efficiency of an arrangement of this type and an arrangement in ordinary randomized blocks is also included.

- xxix. M. M. BARNARD. "An Enumeration of the Confounded Arrangements in the $2 \times 2 \times 2$ Factorial Designs." Supplement to the *Journal of the Royal Statistical Society*, 1936, Vol. III, pp. 195-202.

The structure of the 2^n factorial system is described, and the various possible types of confounding are enumerated for designs involving up to six factors.

- xxx. F. YATES. "A Further Note on the Arrangement of Variety Trials: Quasi-Latin Squares." *Annals of Eugenics*, 1937, Vol. VII, pp. 319-331.

The principles of quasi-factorial design are extended so as to enable varietal trials involving a number of varieties which is a perfect square (not 6^2 or some other numbers, however) to be arranged in the field so that differences between rows and between columns are eliminated from the varietal comparisons. It is proposed to call this type of arrangement an arrangement in quasi-Latin squares, from the analogy with ordinary Latin square design.

As a numerical example a quasi-Latin square design for twenty-five varieties is superimposed on the uniformity trial on oranges which was used in a previous paper to illustrate quasi-factorial designs in randomized blocks. A gain in efficiency over an arrangement in ordinary randomized blocks of 91 per cent. resulted, the corresponding gain in a quasi-factorial design in randomized blocks (two groupings) being 41 per cent.

Various other possible applications of the quasi-Latin square principle are briefly discussed.

XXXI. F. YATES. "*The Design and Analysis of Factorial Experiments.*" Imperial Bureau of Soil Science. Technical Communication No. 35, 1937. Price. 5s.

This Communication has been written to satisfy the growing need of experimenters in agricultural and other fields for a comprehensive survey of the principal types of factorial design, and the appropriate statistical analyses. It can be regarded as a logical continuation of Technical Communication No. 10* of this series, and as a useful supplement to Prof. R. A. Fisher's recent book "*The Design of Experiments.*"

Factorial designs with factors at two levels only are first discussed, since these are capable of specially simple treatment, and enable the structure of confounded arrangements to be more easily understood than do designs containing factors at three or more levels. There follows an account of designs with factors at three levels, with factors both at two and three levels, and with factors at two, four and eight levels. Finally various special types of design, such as designs with split-plots and their derivatives, and designs for variety trials involving a large number of varieties, are described. Attention has throughout been paid to providing numerical illustrations of all new statistical processes.

The following designs and processes are described for the first time in this communication :

(1) The adaptation of confounding to Latin-square designs, so as to enable, for instance, a 2^5 experiment to be arranged in the form of an 8×8 Latin square.

(2) Latin-square designs with whole rows, or rows and columns, subjected to auxiliary treatments, e.g., sown with different varieties, or cultivated differently.

(3) Designs containing five and six factors at two levels only.

(4) Designs involving some factors at two and some at three levels, in particular $3 \times 2 \times 2$, $3 \times 2 \times 2 \times 2$, $3 \times 3 \times 2$ and $3 \times 3 \times 3 \times 2$ designs in blocks of 6 plots.

(5) $3 \times 3 \times 3 \times 3$ design in blocks of 9 plots, this being an extension of the popular $3 \times 3 \times 3$ design.

(6) New methods of analysing experiments with factors at two levels only, and the $3 \times 3 \times 3$ design.

(7) *The Graeco-Latin square*, which is similar to the old "semi-Latin square" design, but overcomes the statistical defects inherent in this design in its original form. Graeco- and hyper-Graeco-Latin squares provide useful designs for varietal trials involving 10-20 varieties. Thus 7 replications of 14 varieties can be arranged in a 7×14 rectangle of plots, and 7 replications of 21 varieties in a 7×21 rectangle.

XXXII. W. G. COCHRAN. "*A Catalogue of Uniformity Trial Data.*" Supplement to the Journal of the Royal Statistical Society, 1937, Vol. IV.

Uniformity trial data have many uses in the study of field experimental technique. Among the important questions on which they throw light are the optimum size and shape of plot, the advisability of discarding edge rows, the gain in efficiency due to confounding, the relative accuracy of any newly proposed type of design, the bias in systematic arrangements and the applicability of the t- and z-tests to the results of actual field experiments.

This catalogue is an attempt to make accessible to students the yields of trials which have been carried out and to rescue from oblivion trials which have never been published. The information given about each trial is the crop, the size and shape of the smallest unit harvested, the number of plots and the source whence the individual yields may be obtained. Where the yields have not been published, the author has been invited to file a copy at Rothamsted ; some 25 trials have come to light in this way, and it is hoped that future authors will be encouraged to send us a copy of their yields.

*R. A. Fisher and J. Wishart. The arrangement of field experiments and the statistical reduction of the results.

(b) ANALYSIS OF DATA

- XXXIII. W. G. COCHRAN. "The χ^2 Distribution for the Binomial and Poisson Series, with Small Expectations." *Annals of Eugenics*, 1936, Vol. VII, pp. 207-217.

Some examples are given of the agreement between the exact and the tabular χ^2 distribution in samples from the binomial and Poisson series with small expectations. The ordinary χ^2 distribution tends slightly to underestimate the probability of discrepancies in the region used in tests of significances, but appears to give a satisfactorily close agreement except in very extreme cases (e.g. with expectations less than unity). Correction for continuity does not improve the agreement.

A method is given for obtaining for any population approximations to any given order for the mean and variance of χ^2 in samples in which the mean of the sample is fixed, and from this the exact normal approximation to the χ^2 distribution for the binomial series is obtained. Except for the Poisson series, this is not the same as the normal approximation to the ordinary χ^2 distribution.

A brief discussion is given of the general problem of testing discrepancies between observation and hypothesis, in which it has been suggested that the likelihood, as defined by Fisher, is more appropriate than χ^2 as a test criterion.

- XXXIV. W. G. COCHRAN. "The Efficiencies of the Binomial Series Tests of Significance of a Mean and a Correlation Coefficient." *Journal of the Royal Statistical Society*, 1937, Vol. C, pp. 69-73.

In a preliminary survey of a set of data, a rapid test of significance of the mean of a set of differences is sometimes useful. With a symmetrical distribution of errors, such a test may be obtained by ignoring the sizes of the differences and counting the number of positive differences. A similar test of the correlation coefficient may be made by counting the number of pairs of deviations from the respective means of like sign.

A table is given of the 5 per cent. significance points. With a normal distribution of errors, the efficiencies of the method from the point of view of the estimation of the mean or the correlation coefficient are calculated, and in particular the efficiencies of the tests of significance are shown to be $2/\pi$ or 64 per cent. for the mean and $4/\pi^2$ or 41 per cent. for the correlation coefficient.

- XXXV. W. G. COCHRAN. "Problems Arising in the Analysis of a Series of Similar Experiments." Supplement to the *Journal of the Royal Statistical Society*, 1937, Vol. IV, pp. 102-118.

The importance of repeating the same field trial at a number of centres or for a number of years is now realised in most comprehensive schemes of agricultural research. The statistical analysis of the results of such experiments has, however, received little attention.

The analysis of variance, used with discretion, provides a convenient preliminary analysis of the data when the individual experiments may be regarded as having equal accuracy; but this is rarely the case. As a preliminary to a more detailed examination of such questions as the correlation of the treatment responses with weather, soil type or mean yield, the experimenter wants to know whether the responses have varied from centre to centre. A test of significance for this question is given which takes into account the variation in the precision of the different experiments.

The estimation of the mean response is important when the response has not varied from centre to centre. A comparison is made of the efficiency of four types of mean. The weighted mean, weighing inversely as the estimated variance, is recommended if at least 15 degrees of freedom are available in the estimates of the weights. With fewer degrees of freedom, the extra precision given by the maximum likelihood solution is worth the additional labour it involves. With very few degrees of freedom to estimate the weights, the method of weighing inversely as the estimated variance, but with an arbitrarily chosen upper limit to the weights, is useful. The tests of significance of these means are discussed.

When the responses vary from centre to centre, the unweighted mean is generally to be recommended. The test of significance of the mean in this case is discussed, though it is important mainly where the causes of variation in response cannot be controlled or predicted.

(c) SAMPLING

- XXXVI. F. YATES. "*The Place of Quantitative Measurements on Plant Growth in Agricultural Meteorology and Crop Forecasting.*" Conference of Empire Meteorologists, 1935, Memorandum No. 36.

An account is given of the reasons that have led to the introduction of the "Precision Records" on Wheat in the Crop-Weather Scheme of the Ministry of Agriculture and Fisheries. The purpose of these measurements, and the directions in which they are likely to be useful, are briefly described, and a plea is entered for their extension to other crops. A complementary scheme, recently introduced, of sampling commercial fields in order to test the feasibility of providing objective estimates of wheat yields throughout the country, is also described.

- XXXVII. F. YATES. "*Applications of the Sampling Technique to Crop Estimation and Forecasting.*" Manchester Statistical Society. Collected Papers. Session 1936-7.

This address (read before the Manchester Statistical Society) gives an account of the methods that are likely to be of use in the estimation and forecasting of agricultural crops, and describes the results already obtained with wheat. The general principles underlying a sound sampling technique are also discussed and illustrated by actual examples of defective sampling.

THE SOIL

(Departments of Chemistry and Physics)

(a) CULTIVATION AND DRAINAGE

- XXXVIII. B. A. KEEN. "*The Scientific Basis of the Art of Cultivation.*" Programme and Papers of the Second Conference on Mechanized Farming. Oxford, 1937, pp. 27-35.

The capillary-tube theory of water movement in soil, which has long been used to explain the control of soil moisture by cultivation operations, is shown to be erroneous. The pore-space of the soil must be regarded as a series of cells communicating with one another through relatively narrow necks. The boundaries of these cells and necks are formed by the soil aggregates or crumbs, which can be likened to small sponges. The crumbs imbibe water from the rain that percolates down the pore-space, and water is held at the points of contact of the crumbs and also partially fills the pore-spaces. Any surplus drains away and eventually reaches a water-table. When drying conditions occur at the surface, evaporation proceeds by the progressive downward drying of the top layers of crumbs rather than by the upward movement of water from below to the surface. In other words, most soils are naturally "self-mulching." Similarly, when root hairs absorb water, inward movement to the region of absorption will be very slow and over very limited distances. The water held by the soil is to be regarded as relatively static; modern theory shows, in fact, that it resists movement.

The effects on soil water content and movement attributed to operations such as harrowing and rolling are therefore much less than the old capillary theory asserted. The main function of cultivation is not to exercise a delicate and precise control of soil moisture, but to remove the competition of weeds, to obtain a seed-bed of suitable consistency, and to prevent crusts or "caps" forming on certain classes of soil.

- XXXIX. B. A. KEEN and G. H. CASHEN. "*Some Aspects of Cultivation and Other Power Operations on the Farm.*" Journal and Transactions of the Society of Engineers (Inc.), 1936, Vol. XXVII, pp. 114-135.

(This paper was awarded the Bessemer Premium of the Society of Engineers)

Two contrasting aspects of farming are discussed in this paper; (a) the value of soil cultivation, and (b) the comparison of electricity and oil fuel as sources of power for farm machinery.

Numerous cultivation trials made by the Soil Physics Department have led to the unexpected conclusion that cultivation has much less effect on the yields of produce than is generally supposed. These conclusions, however, are in harmony with the laboratory studies of soil water movement made in the Department which show that little or no control of soil moisture is effected by cultivation operations.

The comparison of the electric motor and the internal combustion engine has been made to obtain a reliable figure for the relative power consumption (units of electricity and gallons of fuel) for the same job of work. This figure is needed by farmers who have the choice of both forms of power.

For threshing a G.E.C. Witton 20 h.p. portable motor and an International 10-20 h.p. tractor were compared; each was running at approximately 50 per cent. of full load. The paraffin equivalent of 10 kilowatt hours was 1.75 gallons; this figure was about 7 per cent. higher than it need have been as the tractor was not running on the weakest possible mixture.

For grinding, the power requirements naturally depend greatly on the degree of fineness, the feeding rate, the moisture content of the grain, etc. Comparable tests over a power range of 4.5-5.3 h.p., were made with a G.E.C. 5 h.p. "Drumotor" and Bamford 6 h.p. diesel engine. The equivalent of 10 kilowatt hours was found to be 5.0 pints of diesel oil.

With the above equivalents of electricity and fuel oil, a comparison of the total costs of the alternative sources of power can be made for any given set of conditions for electricity rates, cost of fuel, depreciation of power units and machinery, etc.

- XL. B. A. KEEN. "*Land Drainage: the Area of Benefit.*" Journal of the Ministry of Agriculture, 1936, Vol. XLIII, pp. 521-526.

The Land Drainage Act of 1930 brings within the rating area of Internal Drainage Boards those lands which "derive benefit or escape danger" as a result of drainage operations. The working rule for agricultural areas is to include all land up to the contour line drawn 8 ft. higher than the level of the highest recorded flood, but provision is made for meeting special cases, either by exclusion or differential rating. The adoption of the 8 ft. line has increased the rateable area, and the objection of the occupiers is understandable, especially when the existing drainage works are adequate and no fresh constructions are contemplated. Their response to the explanation that the land is henceforward to bear its fair share of benefits hitherto received free, is the very natural one of denying that it benefits in any way: in other words they suggest that a lower contour than 8 ft., or even flood level itself, should be taken.

This article explains the general principles underlying the movement of water in the soil and shows that the contour line 8 ft. above the highest recorded flood is a very reasonable level up to which land can be considered to derive benefit or avoid danger as a result of drainage operations.

(b) SOIL STRUCTURE

- XLI. E. M. CROWTHER. "*Subsoil Structure and Crop Nutrition.*" Transactions of the Third International Congress of Soil Science, 1936, Vol. III, pp. 126-129.

It is suggested that work on crop nutrition and soil morphology could be linked up by the hypothesis that some of the more deeply rooted farm crops in humid temperate climates utilise water, nitrates and possibly other soluble nutrients stored through the winter in the lower horizons of loams and heavier soils, provided that these are well drained and have a well-expressed soil structure.

Evidence in support of this hypothesis is advanced from systematic analyses of soils in rotation experiments, the statistical analysis of seasonal rainfall effects on contrasted soils, and the composition of drainage waters. A simple apparatus for measuring suction pressures at various depths in cropped and uncropped soils was used to estimate the rate of growth of sugar beet roots down to about 1 metre.

(c) CHEMICAL ANALYSIS

- XLII. C. N. ACHARYA. "*Determination of Carbon and Nitrogen by the Action of Chromic Acid under Reduced Pressure.*" Biochemical Journal, 1936, Vol. XXX, pp. 241-247.

A procedure is described for the estimation of carbon and nitrogen in soils, plant materials and organic compounds by the action of a mixture of chromic and sulphuric acids under reduced pressure.

The results for nitrogen in soils and plant materials are too low because one portion is oxidised to nitrate and another is lost in gaseous form. If the aliquot taken contains about 5 mg. or less of nitrogen the gaseous portion is also fixed

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as nitrate and correct figures are obtained by the estimation of the ammoniacal and nitrate-nitrogen present. For amounts higher than 5 mg. an average correction of 10 per cent. on the ammoniacal nitrogen formed gives results agreeing to within 98-100 per cent. of the Kjeldahl figure.

A procedure is described for the estimation of small amounts of nitrate in presence of large quantities of sulphuric and chromic acids.

MICROBIOLOGY

(Departments of Bacteriology, Fermentation and General Microbiology)

(a) BACTERIA

- XLIII. H. G. THORNTON. "*The Present State of our Ignorance Concerning the Nodules of Leguminous Plants.*" *Science Progress*, 1936, Vol. XXXI, pp. 236-249.

This outline of our knowledge of the nodule bacteria and their association with the host legume is intended to emphasise how great and important are the gaps in this knowledge—gaps which occur at the critical point in almost every line of investigation. The nodules on legumes afford problems, whose solution would illuminate much wider fields in biology: such as those of bacterial genetics, growth-promoting substances, and the formation of pathological growths. The great mystery of biological nitrogen-fixation itself remains unsolved.

(b) PROTOZOA

- XLIV. A. DIXON. "*Soil Protozoa; their Growth on various Media.*" *Annals of Applied Biology*, 1937, Vol. XXIV, pp. 442-456.

The investigation was started to test the present methods of culturing soil protozoa on peptone agar, as two earlier workers had obtained higher numbers by the use of soil-extract agar. Some 55 soils were used, from the tobacco growing regions of the U.S.S.R., sent by the State Institute of Tobacco Culture, Krasnodar. Protozoa of these soils, when grown on soil-extract agar and peptone agar gave, with three exceptions, considerably higher numbers with the former medium. The higher numbers of Rhizopoda and Ciliata were particularly noticeable. A complete list of protozoa from these soils on the two media is given. The same media were also used for samples of Woburn and Rothamsted soils, and for the latter soil extract and hay infusion as well. Soil extract agar and liquid soil extract as media gave the fullest record of protozoa, particularly for Rhizopoda and Ciliata. Hay infusion was useful for the development of Ciliata and an improvement on peptone agar.

(c) BIOLOGICAL ACTIVITIES

- XLV. J. MEIKLEJOHN. "*The Reduction of Nitrate by Individual Strains of Free-living Bacteria.*" *Transactions of the Third International Congress of Soil Science*, 1935, Vol. I, pp. 180-183.

Eighty free-living strains of bacteria were tested for their ability to reduce nitrate in media of known composition. Five types of reaction with regard to nitrate were observed, and an attempt was made to relate the known physiological properties of each strain to the type of reaction it gave; it was found that the strains conforming to each type had other properties in common.

- XLVI. J. MEIKLEJOHN. "*The Oxygen Uptake of Suspensions and Cultures of a Free-living Bacterium.*" *Journal of Experimental Biology*, 1937, Vol. XIV, pp. 158-170.

The oxygen uptake of pure cultures and suspensions of a bacterial species isolated during the effluent investigations was measured at 26°C. Cultures in a liquid medium gave the greatest oxygen uptake per cell at 48 hours after inoculation, and the greatest total oxygen uptake 72 hours after inoculation. The maximum stationary phase of growth was reached about 96 hours after inoculation, after which the oxygen uptake of successive samples rapidly fell to a very low value.

In suspensions deprived of nitrogen, and showing no growth, and in cultures in the stationary phase, oxygen uptake proceeds at a constant rate. But in both suspensions and cultures where active growth is taking place, the rate of

oxygen uptake rises continuously ; after a preliminary period of adjustment this rise is logarithmic. The rise in oxygen uptake in a growing suspension is proportionately greater than the rise in bacterial numbers ; it is therefore suggested that the respiration of a growing culture can be divided into two parts—"maintenance" respiration and "growth" respiration ; and a technique is outlined for estimating the amount of oxygen uptake due to each factor.

XLVII. S. H. JENKINS. "*The Biological Oxidation of Stearic Acid in Percolating Filters.*" *Journal of the Society of Chemical Industry*, 1936, Vol. LV, pp. 315T-319T.

Stearic acid in the form of soap is a constituent of domestic sewage and its decomposition by methods which are ordinarily used for purifying sewage is therefore of interest. The decomposition of the acid in biological filters was studied with and without the addition of sewage using percolating filters made of glass and filled with glass medium.

The first filter without sewage developed a thick white film in the upper half and after operating for four months became clogged with growths. The growths consisted of fungal hyphae, bacteria and yeasts, and half of the film was stearic acid. About 80 per cent. of the stearic acid was removed from the crude liquid supplied to the filter. With domestic sewage over 90 per cent. of the impurity present in the crude liquid was removed by filtration, and as there was considerably less stearic acid present in the film in this filter than in the filter supplied with stearic acid alone it is assumed that the fatty acid was more completely oxidised in the presence of sewage. Thick growths of film containing bacteria, yeasts and algae developed in the upper part of the filter supplied with stearic acid and sewage, and in three months' time almost clogged the filter.

The experiments showed that high concentrations of stearic acid could be readily decomposed in percolating filters in the absence of sewage, and that the acid was more completely decomposed when it was present together with sewage liquors.

THE PLANT IN DISEASE : CONTROL OF DISEASE

(Departments of Entomology, Insecticides and Fungicides, and Plant Pathology, and Biochemistry Section)

(a) INSECTS AND THEIR CONTROL

XLVIII. C. B. WILLIAMS. "*Collected Records Relating to Insect Migration. Third Series.*" *Proceedings of the Royal Entomological Society of London, A*, 1936, Vol. XI, pp. 6-10.

Information is given relating to eighteen movements of butterflies and one of dragonflies, of which accounts have been sent in by correspondents in different parts of the world.

XLIX. K. J. GRANT. "*The Collection and Analysis of Records of Migrating Insects. British Isles 1931-1935.*" *Entomologist*, 1936, Vol. LXIX, pp. 125-131.

An analysis of records collected through the Insect Immigration Committee of the South Eastern Union of Scientific Societies, shows considerable evidence for a northerly flight of Red Admiral Butterfly (*Vanessa atalanta*) in Great Britain in May, June and the beginning of July, and a southerly return flight in September and October.

L. P. S. MILNE. "*A Device for the Rapid Counting of Large Numbers of Small Insects.*" *Bulletin of Entomological Research*, 1936, Vol. XXVII, pp. 269-271.

The device is a large rotating trough which can be passed under the field of a low power binocular microscope. When the insects are counted they are drawn back into the storage box by suction current of air.

- LI. C. B. WILLIAMS. "The Influence of Moonlight on the Activity of Certain Nocturnal Insects, particularly of the Family Noctuidae, as indicated by a Light Trap." Philosophical Transactions of the Royal Society of London, B, 1936, Vol. CCXXVI, pp. 357-389.

Catches of insects in a light trap are definitely influenced by moonlight. The catches are lower at full moon and higher at no moon. The curve of lunar influence is asymmetrical and these asymmetries can be explained by the combined effect of intensity and duration of moonlight, and by asymmetries in the rate of change of the duration of moonlight during the hours of darkness.

The effect is greater in some groups of insects than in others. It is particularly high in the family Noctuidae and is not found in dark and dawn flying groups.

The effect is greater in the autumn than at mid-summer, corresponding to the higher altitude of the full moon in the sky.

- LII. R. D. PINCHIN and J. ANDERSON. "On the Nocturnal Activity of Tipulinae Diptera as Measured by a Light Trap." Proceedings of the Royal Entomological Society of London, A, 1936, Vol. XI, pp. 69-78.

The times of appearance of eleven species of crane flies in a light trap in 1933 and 1934 are discussed, also their time of flight during the night, proportion of sexes and the influence of cloud, moonlight and temperature on their changes of abundance from night to night.

- LIII. W. R. S. LADELL. "A New Apparatus for Separating Insects and other Arthropods from the Soil." Annals of Applied Biology, 1936, Vol. XXIII, pp. 862-879.

The soil is stirred up with a strong solution of magnesium sulphate (Sp. Gr. 1.11) which is denser than any of the soil animals. These rise to the top of the solution in a froth produced by a stream of fine air bubbles passing from the bottom upwards through the liquid. The froth is passed on to a filter paper in a Buchner funnel where the soil animals are retained.

By the use of this apparatus a large number of samples can be examined in a short time. Very high figures have been obtained for the soil population much in excess of those recorded by other workers.

The maximum catch was obtained on grass-land indicating a population of 487 million soil animals per acre, including 475 million insects.

- LIV. H. F. BARNES. "Notes of Cecidomyiidae.—11." Annals and Magazine of Natural History, 1936, Vol. XVII, pp. 272-279.

Descriptions and notes on gall midges of economic importance received for identification from Uganda, Sierra Leone, India, New Zealand, Kenya Colony and Egypt. Four species, *Dasyneura lini*, *Hyperdiplosis triticina*, *Stephodiplosis nothofagi* and *Lestremia ugandae* are described for the first time.

- LV. H. F. BARNES. "Almond and Peach Buds Attacked by a Gall Midge in Greece." Journal of the South-Eastern Agricultural College, Wye, Kent, 1936, No. 38, pp. 75-77.

Notes and description of *Odinadiplosis amygdali* (Anagnos.), a midge which is responsible for the "blastomanie" or "gommose" disease of almond trees.

- LVI. H. F. BARNES and S. P. MERCER. "Damage to Panicles of *Alopecurus pratensis* L. by *Apamea secalis* L." Annals of Applied Biology, 1936, Vol. XXIII, pp. 653-657.

A new type of damage to the panicles of meadow foxtail grass by *Apamea secalis* is reported from Hertfordshire and Northern Ireland. This caterpillar usually damages the central shoots of grasses.

- LVII. J. T. ANDERSON. "Gall Midges (Cecidomyiidae) whose Larvae attack Fungi." Journal of the South-Eastern Agricultural College, Wye, Kent, 1936, No. 38, pp. 95-107.

An annotated list of gall midges throughout the world whose larvae have been recorded as feeding on fungi, rusts and mildews.

- LVIII. A. C. EVANS. "A Note on the Hibernation of *Micraspis sedecimpunctata* L. (Var. 12-Punctata L.), (Col. Cocc.), at Rothamsted Experimental Station." Proceedings of the Royal Entomological Society of London, A, 1936, Vol. XI, pp. 116-119.

The activity of a group of lady-birds during hibernation on an exposed post at Rothamsted in the winter of 1935-36 is shown to depend on climatic factors, chiefly temperature. Dispersal occurred during a hot day in May.

- LIX. A. M. LYSAGHT. "A Note on the Adult Female of *Anguillulina aptini* (Sharga), a Nematode Parasitising *Aptinothrips rufus* Gmelin." Parasitology, 1936, Vol. XXVIII, pp. 290-292.

Notes are given on certain structures in which the female eel-worms as examined by the writer appear to differ from the original description by Sharga.

- LX. A. M. LYSAGHT. "A Note on an Unidentified Fungus in the Body Cavity of Two *Thsanopterous* Insects." Parasitology, 1936, Vol. XXVIII, pp. 293-294.

The presence is recorded of spores of an unidentified fungus in the body cavity of *Limothrips cerealium* and *Aptinothrips rufus* at Rothamsted. No trace of mycelium was found, nor could the spores be cultivated on any medium. Thirty-five *A. rufus* were found infested out of about 17,000 examined and one *L. cerealium* out of about 100 examined.

- LXI. A. G. NORMAN. "The Destruction of Oak by the Death-watch Beetle." Biochemical Journal, 1936, Vol. XXX, pp. 1135-1137.

Certain of the oak timbers of Rothamsted House which had been extensively damaged by wood boring insects were analysed and compared with sound timber and the borings or frass to which much of the wood had been reduced. The carbohydrates of the cell-wall had been utilised to a considerable extent, the cellulose loss accounting for about 80 per cent. of the total loss which must have been in the region of one-third of the weight. Lignin is apparently resistant and had consequently accumulated.

- LXII. J. T. MARTIN and F. TATTERSFIELD. "The Problem of the Evaluation of Rotenone Containing Plants. II. *Derris elliptica*, *Derris malaccensis* and the Sumatra-Type Roots." Annals of Applied Biology, 1936, Vol. XXIII, pp. 880-898.

The determination of purified rotenone, ether extract, dehydro compounds, ether-soluble resin after potash treatment, and of the rotenone plus "deguelin concentrates" are each shown to be inadequate as a means of assessing the relative insecticidal activities of the "Sumatra-type," *D. malaccensis*, and *D. elliptica* roots.

The toxicarol present in the "Sumatra-type" *derris* appears to play a small but definite part in the insecticidal activity of the root.

The resin recovered from the material precipitated by potash from an ether extract of the "Sumatra-type" root is optically active, and appears to be rich in the precursor of inactive toxicarol.

Rotenone, if present, will separate readily from a carbon tetrachloride solution of "Sumatra-type" resin from which the toxicarol has been removed. The possibility of a standard method of rotenone determination, dependent on suitable pretreatment of the resins, is suggested.

- LXIII. F. TATTERSFIELD and J. T. MARTIN. "The Problem of the Evaluation of Rotenone Containing Plants. III. A Study of the Optical Activities of the Resins of *D. elliptica*, *D. malaccensis* and the 'Sumatra-type' Roots." Annals of Applied Biology, 1936, Vol. XXIII, pp. 899-916.

A study has been made of the rotations of the resins from three types of *derris* root, and of a fraction rich in toxicarol separated from two of them. No strictly quantitative relationship between their rotations and their toxicities to *Aphis rumicis* has been found. The addition of caustic potash in methyl alcohol to the benzene solutions of the resins induces a characteristic change from laevo- to dextro-rotation in the samples rich in toxicarol. The induced dextro-rotation then declines in value with time. This effect is shown by the "toxicarol" resin. The rate of the decline is accelerated by increasing the amount of methyl alcohol.

(b) FUNGUS DISEASES.

- LXIV. M. D. GLYNNE. "Some New British Records of Fungi on Wheat. *Cercospora herpotrichoides* Fron., *Gibellina cerealis* Pass., and *Ophiobolus herpotrichus* (Fr.) Sacc." Transactions of the British Mycological Society, 1936, Vol. XX, pp. 120-122.

Three fungi not previously recorded on cereals in this country, were observed on wheat at Rothamsted in 1935. These are briefly described with spore measurements. *Cercospora herpotrichoides* Fron., considered one of the most important of the fungi causing foot-rot in parts of Europe and America was found fairly commonly on Broadbalk and occasionally on other fields. *Gibellina cerealis* Pass., recorded in Northern Italy causing "white straw disease" was found on the "alternate wheat and fallow" plot on Hoos field. *Ophiobolus herpotrichus* (Fr.) Sacc. generally regarded as a weak parasite, was found on stubble.

(c) VIRUS DISEASES.

- LXV. M. A. WATSON. "Factors Affecting the Amount of Infection Obtained by *Aphis* Transmission of the Virus Hy. III." Philosophical Transactions of the Royal Society of London, 1936, Vol. CCXXVI, pp. 457-489.

In the one plant, leaves of different ages differ in susceptibility to infection and in infected plants differ in concentration of the contained virus. It is, therefore, desirable to use leaves of corresponding ages in all comparative feeding experiments with insects. A maximum percentage infection was obtained during the winter months and a minimum during the summer months.

The percentage infection increases with the number of aphids used per plant; and the infections obtained are local and independent. The percentage infection increases with increased feeding time on the healthy plant, but there is nothing to indicate a preliminary time period where no infection is obtained. Infection decreases rapidly with increasing time on the infected plant from 2 minutes to 1 hour, after which period it increases slightly with increased feeding periods. The time required for the insect to effect penetration of the leaf increases with decreasing external humidity. The insect is capable of infecting two consecutive healthy plants without intermediate access to a source of infection, but the number of second infections falls rapidly with increasing time on the healthy plant, and is negligible after 1 hour.

- LXVI. F. C. BAWDEN, N. W. PIRIE, J. D. BERNAL and I FANKUCHEN. "Liquid Crystalline Substances from Virus-infected Plants." Nature, 1936, Vol. CXXXVIII, pp. 1051-1052.

The sap of tobacco and tomato plants infected with strains of tobacco mosaic virus contains from five to ten times as much protein as sap from uninfected plants. This extra protein can be precipitated by treatment which does not precipitate the protein of uninfected plants, and from 1 to 2 gm. can be isolated from a litre of sap. It is usually infectious in dilution of 10^{-9} ; and sediments in a centrifugal field of 23,000 times gravity. Highly purified solutions of over 2 per cent. strength separate on standing into two layers, of which the lower is liquid crystalline, and the upper shows anisotropy of flow on agitation. X-ray analysis shows a pattern suggesting an arrangement of parallel rod-like molecules in the solution. The minimum cross-section area of the rods is 20,100 sq. A. for the dry gel; the length appears to be not less than ten times the width.

- LXVII. R. J. BEST and G. SAMUEL. "The Reaction of the Viruses of Tomato Spotted Wilt and Tobacco Mosaic to the pH Value of Media containing them." Annals of Applied Biology, 1936, Vol. XXIII, pp. 509-537.

In the absence of oxygen and at 0°C., spotted-wilt virus is rapidly inactivated above pH 10 and at or below pH 5. At pH 7 it retains its activity for 6 hours as a rule, and sometimes for as long as 11 hours. Tobacco mosaic virus is inactivated above pH 8.2 and below pH 2, the extent of inactivation varying with the acidity and being complete at pH 11 and 0.5. At pH 9 there is a rapid fall for a time until a state is reached which then remains steady. Readjustment to pH 7 brings about a reactivation, which gets less as the time at pH 9 is prolonged.

- LXVIII. R. J. BEST and G. SAMUEL. "The Effect of Various Chemical Treatments on the Activity of the Viruses of Tomato Spotted Wilt and Tobacco Mosaic." *Annals of Applied Biology*, 1936, Vol. XXIII, pp. 759-780.

The virus of tomato spotted wilt is inactivated rapidly in the presence of free oxygen, and at room temperature even in its absence. Addition of reducing agents protected against inactivation for a time, but oxidising agents accelerated it. The effect of a number of other substances was examined. Tobacco mosaic virus was similarly tested with fifteen chemicals, of which only KMnO_4 and chlorazene caused rapid inactivation.

- LXIX. J. CALDWELL. "Factors Affecting the Formation of Local Lesions by Tobacco Mosaic Virus." *Proceedings of the Royal Society of London, B*, 1936, Vol. CXIX, pp. 493-507.

A possible method is suggested for determining whether the reducing effect on infection caused by additions to virus juice is an action on the virus itself or on the host plant. The effect of various enzymes, of normal serum and of silver nitrate is examined experimentally and found to be due to action on the virus.

- LXX. F. M. L. SHEFFIELD. "The Susceptibility of the Plant Cell to Virus Disease." *Annals of Applied Biology*, 1936, Vol. XXIII, pp. 498-505.

Spraying experiments show that virus cannot enter a plant unless some of the cells are injured, the number of infections falling off as the time after the injury increases. Micropipette inoculation into single cells gives only about 10 per cent. of successful infections.

- LXXI. F. M. L. SHEFFIELD. "The Rôle of Plasmodemes in the Translocation of Virus." *Annals of Applied Biology*, 1936, Vol. XXIII, pp. 506-508.

Although intracellular inclusions may occur in every cell over large areas of the epidermis, none has been found in the guard-cells of the stomata. No protoplasmic connections could be found between the guard-cells and the surrounding tissues. These facts support the view that virus is carried from cell to cell by the protoplasmic bridges, when it moves in the ground tissue of the host.

APICULTURAL PROBLEMS

(Section for Bee Investigations, and Physics Dept.)

- LXXII. H. L. A. TARR. "Bacillus alvei and Bacillus para-alvei." *Zentralblatt Bakteriologie*, 1936, Vol. XCIV, pp. 509-511.

It was found that *B. alvei* can be distinguished from *B. para-alvei* by the change in shape of the vegetative cell during sporulation, and by the form of the endospore produced. In other respects the organisms were apparently identical.

- LXXIII. H. L. A. TARR. "Studies on European Foul Brood of Bees. II. The Production of the Disease Experimentally." *Annals of Applied Biology*, 1936, Vol. XXIII, pp. 558-584.

Experiments showed that *Bacillus alvei* and *Streptococcus apis* would not infect healthy colonies of bees directly, but would do so when first used to inoculate larvae which were starved and were subsequently introduced into the colonies after infection had developed. It was also found that a filterable virus is in no way implicated as cause of the disease, the etiology of which is not yet certain. Two varieties of *S. apis* were found and these have recently been shown to be apparently identical with *S. liquefaciens* and *S. glycerinaceus*.

- LXXIV. G. W. SCOTT BLAIR and D. MORLAND. "A Physical Test for Ling Honey." *Journal of the Ministry of Agriculture*, 1936, Vol. XLIII, pp. 653-657.

There is considerable confusion among bee-keepers as to the distinction between density and viscosity of honey. The general significance of the two properties is explained, and the importance of viscosity is discussed. Honeys

from many floral sources have been examined, and all except those derived from *Calluna vulgaris* and *Leptospermum scoparium* are found to have viscosities which are unaffected by stirring. Honey from these two exceptional plants increases in viscosity on standing undisturbed, but the viscosity decreases on stirring. This property, well known in many other materials is called thixotropy.

A simple method for measuring the thixotropy of honey is described in detail. Thixotropic honeys can hold more water without fermenting than can non-thixotropic honeys, and for this and other reasons, the property is of practical importance.

An investigation is in progress on the effect of soil, climate, and elevation on the thixotropy of ling honey.

TECHNICAL AND OTHER PAPERS

GENERAL

- LXXV. C. B. WILLIAMS. "*A Modified Greenwich Night-Cloud Recorder used for Ecological Work.*" *Journal of Animal Ecology*, 1936, Vol. V, pp. 348-350.

An apparatus is described which by photographing the track of the pole star at night gives an indication of when this is obscured by cloud and hence an average measure, in these latitudes, of the cloudiness of the night sky. The apparatus will not work in the tropics or the southern hemisphere.

- LXXVI. R. K. SCHOFIELD and G. W. SCOTT BLAIR. "*Bemerkung zum Mechanismus der Spinnbarkeit.*" *Kolloid-Zeitschrift*, 1937, Vol. LXXIX, p. 308.

If a glass rod dipping into certain materials is withdrawn, Erbring has shown that strands of material can be formed, the length of strand depending on the rate of withdrawal, and on a property of the material which he calls "Spinnbarkeit" (Fibrosity).

It is shown that certain honeys called in the trade "stringy" are fibrous, and that when a drop of fibrous honey is extended into a strand on a mercury bath its behaviour is highly elastic, the strand reforming into a spherical drop when the stress is released. The phenomenon is believed to be akin to work-hardening in flour doughs. (See Paper VII in 1932 Report.) Fibrous honeys appear to obey Poiseuille's law fairly exactly when caused to flow through capillary tubes.

- LXXVII. G. W. SCOTT BLAIR. "*Ein Mikroviskosimeter für Nicht-Newton'sche Flüssigkeiten.*" *Kolloid-Zeitschrift*, 1937, Vol. LXXVIII, pp. 19-21.

An apparatus is described for measuring the viscosity of small samples of materials. It is especially suited to determine the extent of deviation from Poiseuille's law in the case of non-Newtonian liquids and thixotropic systems, and gives an empirical measure of degree of thixotropy.

- LXXVIII. R. K. SCHOFIELD and G. W. SCOTT BLAIR. "*Influence of Viscosity Variation on the Rupture of Plastic Bodies.*" *Nature*, 1935, Vol. CXXXVI, p. 147.

- LXXIX. B. A. KEEN. "*A Preliminary Report on the Behaviour of the Ashby and Owens Evaporimeters.*" Ministry of Agriculture Report on Agricultural Meteorological Conference, 1935.

- LXXX. HUGH NICOL. "*Quiescence at the Surface of a Liquid Disturbed by at least Two Agencies.*" "*The School Science Review*," 1936, pp. 87-90.

CROPS, SOILS AND FERTILISERS.

- LXXXI. E. J. RUSSELL. "*Soils and Fertilisers.*" *The Farmer's Guide to Agricultural Research in 1935*. Royal Agricultural Society of England, 1936, pp. 177-229.