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Rothamsted Research

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PUBLICATIONS

Physics Department

1. SCHOFIELD, R. K. 1949. *Calculations of surface areas of clays from measurement of negative adsorption*. Trans. Brit. Ceramic Soc., **48**, 207-213.

An outline is given of the way in which Gouy's theory of ionic equilibrium in the diffuse component of the electric double layer has been extended in order to calculate the deficit of repelled ions per unit area. Combining this calculation with measurements of negative adsorption, estimates are made of the surface area of a sample of bentonite investigated by Mattson. It is shown that the montmorillonite in this bentonite had separated almost completely in separate 10 Å "leaflets." Preliminary measurements with a sample of kaolin give an estimate of surface area in close agreement with the values previously computed from particle size and nitrogen adsorption.

2. PENMAN, H. L. 1949. *A general survey of meteorology in agriculture and an account of the physics of irrigation control*. Q. J. Roy. Met. Soc., **75**, 293-302.

Weather problems in farming fall into three groups. *Statistical* problems include the forecasting of weather for strategical and tactical use in planning farming operations, and the forecasting of crop yields from weather data. *Biological* problems arise in studies of growth and of the spread of disease, and demand a wider knowledge of techniques suitable for use in micro-meteorology. *Physical* problems are largely transport problems in the building up of plant and animal environments.

A typical problem from the last group is the disposal of available solar energy, and it is shown that an energy balance sheet can be drawn up to leave evaporation as the only unknown under prescribed conditions that make the treatment directly applicable to control of irrigation operations. Such an application is described for an experiment on irrigation of sugar beet during the summer of 1948. Results were as satisfactory as the weather of the growing season would permit, the application of a total of 2.6 in. of irrigation (based on weather data) giving a slightly better yield of sugar than a total of 4.7 in. applied whenever expert inspection of the crop decided that irrigation was necessary.

3. SCHOFIELD, R. K. 1949. *The physics of water retention in soil and water extraction by plant roots*. (Paper read at B. A. meeting, Newcastle-on-Tyne, Sept. 1949.)

Surface tension and viscosity account satisfactorily for the behaviour of water in coarse-grained soils. The swelling and shrinking of clay is a distinct phenomenon and appears to be connected with the exchangeable cations which balance the negative charges carried by the clay particles. Several processes are thus involved in the retention of water in soil, but their net effect can be expressed as a potential or free energy. Plants can draw water from soil provided that this free energy throughout the root zone does not sink below a well-defined limit at which 'permanent wilting' occurs.

4. PENMAN, H. L. 1949. *The heat balance of the soil*. (Paper read at B. A. Meeting, Newcastle-on-Tyne, Sept. 1949.)

Recent theoretical and experimental work has made it possible to draw up an energy balance sheet for turf-covered soil. Radiative components include short-wave radiation from sun and sky, and an exchange of long-wave radiation between soil and atmosphere. The net radiant energy retained is shared among three heat sinks:—(i) heating of soil; (ii) heating of air; and (iii) evaporation of water in the process of transpiration. Of these, the third is the most important, for over one-half of the incoming solar radiation is used in providing latent heat for transpiration.

OTHER PAPERS

5. SCHOFIELD, R. K. 1950. *Clay minerals and colloid chemistry. A general introduction*. Clay Minerals Bull. No. 4. (In the press.)
6. PENMAN, H. L. 1949. *Meteorology in agriculture*. Nature, **163**, 591.
7. PENMAN, H. L. 1949. *Weather and farming in India*. Nature, **163**, 696-697.

Chemistry Department

8. BREMNER, J. M. 1949. *Use of the Van Slyke-Neil manometric apparatus for the determination of organic and inorganic carbon in soil and of organic carbon in soil extracts.* Analyst, **74**, 492-498.

Rapid and accurate methods for the determination of organic and inorganic carbon in soils are described. It is shown that the techniques have advantages over established procedures and are suitable for the routine analysis of soils.

9. BREMNER, J. M. 1949. *Studies on soil organic matter. I. The chemical nature of soil organic nitrogen.* J. Agric. Sci., **39**, 183-193.

The acid hydrolysis of six soils with nitrogen contents ranging from 0.1 to 2.38 per cent. has been studied by determining the amounts of ammonia-, humin- and α -amino-N present in the soil hydrolysates after various periods of hydrolysis. Under the conditions of hydrolysis employed (3 ml. of 6 N-HCl/g. soil) the period required for maximum liberation of amino-acids from the soils was about 12 hr. 24.2-37.1 per cent. of the total nitrogen of the soils examined was liberated as α -amino-N in this period. Further hydrolysis led to destruction of amino-acids. Similar amounts of α -amino-N were liberated by hydrolysis of the soils with alkali (5 N-NaOH).

From 69 to 87 per cent. of the total nitrogen of the soils was brought into solution by acid hydrolysis; the amount dissolved by hydrolysing with alkali or with alkali under reducing conditions (alkali-stannite) was not significantly different. It was concluded that most of the insoluble nitrogen found after acid hydrolysis is not derived from protein material, and it was suggested that some of this nitrogen is in the form of heterocyclic nitrogen compounds.

Tests showed that volatile amines could have been present only in traces in the soil hydrolysates. Tryptophane could not be detected in either acid or alkaline hydrolysates of the soils. Acid hydrolysates gave positive tests for amino sugars.

The results show that at least one-third of the organic nitrogen of soil is in the form of protein.

10. BREMNER, J. M. and (LEES, H.) 1949. *Studies on soil organic matter. II. Extraction of organic matter from soil by neutral reagents.* J. Agric. Sci., **39**, 274-279.

A survey of the extracting powers of various neutral reagents has been made to find mild but reasonably efficient methods of extracting organic matter from soil. Sodium pyrophosphate proved to be the most satisfactory of the neutral reagents tested, and the optimum conditions for extraction of organic matter from soil by this reagent have been defined.

11. BREMNER, J. M. 1949. *Studies on soil organic matter. III. The extraction of organic carbon and nitrogen from soil.* J. Agric. Sci., **39**, 284-282.

The amounts of organic carbon and nitrogen extracted from different soils by various inorganic reagents have been determined. The results show that the organic carbon and nitrogen of soil are so intimately associated that, under the influence of any one of the reagents tested, the organic carbon is dissolved only along with, and in proportion to, the organic nitrogen. The relative proportions of carbon and nitrogen extracted vary, however, with both the soil and the extractant.

12. BREMNER, J. M. 1950. *Some observations on the oxidation of soil organic matter in the presence of alkali.* J. Soil Sci., **1**, 198-204.

The results of a study of factors affecting the uptake of oxygen by soil/alkali suspensions are described. It is shown that although little or no uptake of oxygen occurs when soils are treated with neutral reagents, extracts obtained by the use of such reagents contain organic matter that absorbs oxygen rapidly when treated with alkali. Contrary to the work of Chaminade, it was found that oxidation of soil organic matter in contact with alkali did not lead to an increase in the amount of alkali-soluble material.

13. COOKE, G. W. 1950. *Placement of fertilizer for row crops.* J. Agric. Sci. (In the press.)

Fertilizer placed in contact with the seed damaged the germination of sugar beet, mangolds, swedes and peas in 1947; damage was also caused by fertilizer placed directly below the seed. In 1947 and 1948 some damage to the germination of sugar beet was caused by fertilizer in bands three inches

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below the soil surface and one inch to the side of the seed; in both years bands of fertilizer three inches to the side of the seed were safe. Where placement of medium or full fertilizer dressings is adopted for row crops, the bands should be placed not less than two inches from the seed to avoid the risk of injury to germination.

All methods of placing gave consistently higher yields of peas than broadcasting fertilizer, the average advantage of placing being over 2 cwt. of peas per acre. In all the experiments on peas in 1948, early applications broadcast and worked deeply into the seedbed were somewhat superior to late applications made at sowing time.

Yields of sugar beet were reduced by methods of applying fertilizer which reduced the plant population. There was little difference between the mean yields for all experiments given by broadcast fertilizer and fertilizer placed in safe positions near the seed. Placed fertilizer promoted much more vigorous growth of sugar beet tops than broadcast fertilizer during spring and early summer but by harvest time this superiority had vanished. Mangolds and sugar beet behaved in much the same way to placed fertilizer.

In experiments on swedes in 1947, average yields were very low due to drought during the summer. Fertilizer placed either directly below or below and to the side of the seed gave consistently higher yields of swedes than broadcast fertilizer.

Placement of fertilizer is of considerable benefit to crops with a short growing season and limited root range and also to crops made sensitive to nutrient deficiency by the poverty of the soil or the immobilisation of nutrients by drought.

14. COOKE, G. W. 1949. *Apparatus for fertilizer placement field work*. Chem. and Ind. 615-618.

The characteristics necessary for special machines used in fertilizer placement experiments are discussed. Commercial placement drills do not deliver fertilizer with the accuracy needed in experimental work. Special apparatus constructed for experiments on potatoes and on other row crops is described. The factors affecting the apparent density of fertilizers and hence the rate of application by top-delivery fertilizer mechanisms were found to be: 1. Compression by the upward force needed to deliver fertilizer. 2. Vibration and jolting. 3. The condition of the fertilizer. The results of experiments on fertilizer placement for potatoes were described.

15. COOKE, G. W. 1949. *Fertilizer placement*. Fertilizer Soc. Proc. No. 6. 1-15. Reprinted in *Fertilizer and Feeding Stuffs*, 35, 359-365, 392-398 and *Amer. Fertilizer*, 110, 9-11, 22, 24, 26, 28, 30.

A general review of the advantages of placement, the special machines needed for experiments and the results of experiments on cereals, potatoes and other row crops.

16. COOKE, G. W. 1949. *Recent developments in fertilizer placement*. Farming, 3, 231.

A review of recent experimental work on potatoes, mangolds, swedes, sugar beet and threshed peas.

17. COOKE, G. W. 1949. *Fertilizer placement*. World Crops, 1, 32.

A general review of placement practices in Britain and in other countries. The results of recent experiments on cereals and on row crops are stated.

18. COOKE, G. W. 1949. *Fertilizer placement experiments*. Agric. Eng. Record, 2, 227-229.

The results of experiments on fertilizer placement for potatoes are discussed.

19. CROWTHER, E. M. 1949. *Field experiments as the basis for planning fertilizer practice*. U.N. Conf. on the Conservation and Utilization of Resources. Experience paper prepared for Section Meetings: Land Resources 5(a) Improving Soil Productivity.

Extensive series of field experiments are needed to establish the general principles of manuring, to compare new forms of fertilizers or methods of applying them, and to determine the returns for various rates of application. The problems of determining the optimal amount of fertilizer to provide and the best way to distribute it became particularly acute in the United Kingdom from 1940 onwards. Each farmer received a fertilizer permit based on fixed rates for specified tillage crops and additional allowances for soils known to be specially deficient here in diphosphate or potash. The rates

were determined to ensure the highest marginal returns for additional imports.

Principles of fertilizer allocation can be established by using an expression for the Law of Diminishing Returns to bring together results from all available field trials and to calculate the most profitable dressings. Fertilizers are used to best advantage when all fields are manured to a constant amount below the most profitable dressings, due allowance being made for local soil and climatic conditions and the use of dung.

Although the approximate form of the response curves relating yields to amounts of fertilizer are known sufficiently well for interpolation within the range of dressings realized in practice, it is dangerously misleading to use arbitrary constants not determined from the field experiments themselves. Mitscherlich's nitrogen factor implies grossly exaggerated maximal responses, which have been used by Willcox for extravagant claims about the potentialities of fertilizers.

20. CROWTHER, E. M. 1949. *The effects of plants and animals on soil fertility. A review of Rothamsted work.* Specialist Conf. in Agriculture, Australia. 1949. Section D: Soil Fertility.

The effects of systems of land management on soil productivity provide some of the most important and most difficult problems in agricultural science. Early attempts at analysing the factors involved are reviewed in terms of the pioneering work of Lawes, Gilbert and Warington. Attention is drawn to the marked influence of climate on the responses to manurial treatments. Relatively few field experiments have yet been carried out to test the long-term effects of alternative rotations, including leys and fallow, and the residual effects of crop residues and manures, but some progress has been made in the more formal problems of design. Pioneer experiments at Woburn, Rothamsted and the Sudan Gezira are described. Similar experiments are urgently needed in many countries and particularly in the tropics.

21. CROWTHER, E. M. 1949. (As contributing joint author). *Efficient use of fertilizers.* Edited by V. Ignatieff, F.A.O. Agric. Studies, No. 9, 183 pp.

A co-operative review by many authors of current problems and practices in the use of fertilizers and manures.

22. CROWTHER, E. M. 1949. *The effect of potassium and sodium fertilizers on the yield and composition of sugar beet.* 12th Congress Inst. Inter. de Recherches Betteravieres, Annexe III.

The results of several series of field experiments on sugar beet are reviewed in relation to the effects of sodium and potassium chlorides on yield, the uptake of sodium and potassium by the plant, the time of application of sodium chloride and the relative effects of sodium nitrate and ammonium sulphate, when used alone and with sodium chloride. For practical agricultural purposes potassium and sodium may be regarded as almost interchangeable for sugar beet and mangolds, but not, of course, for most other crops which can absorb only small quantities of sodium.

23. CROWTHER, E. M. 1949. *Condition in fertilizers.* Fert. Soc. Proc., No. 5, 1-8.

A review of current problems in the storage and use of fertilizers on the farm with special reference to hygroscopicity, "drillability," the use of conditioners and the comparison of granular and powdered fertilizers.

24. CROWTHER, E. M. 1948. *Soils and fertilizers.* J. Roy. Agric. Soc., 109, 71-82.

25. DEB, B. C. 1949. *The movement and precipitation of iron oxides in podzol soil.* J. Soil Sci., 1, 112-122.

Consideration of the mechanisms proposed for the movement of iron in podzol profiles suggested that the iron moved either as a negatively charged humus-protected iron-oxide sol or as a complex organic ion.

In a study of the mutual coagulation and peptization of iron oxide and humus sols it was found that the amount of humus necessary for the full peptization of a sol containing 100 parts of iron oxide per million parts of solution with a pH value around 4.0 was not more than about one-third the amount of iron oxide. This is a much smaller ratio of humus to iron oxide than was formerly believed to be necessary.

No evidence could be found to support the view that precipitation of iron from humus-protected sols is effected by exchangeable calcium in the B

horizons of podzols or that the adsorption of iron from complex salts of organic acids is influenced by the pH or amounts of exchangeable bases present in the soil. It therefore appears necessary to postulate a microbiological mechanism for the precipitation of iron.

26. HEINTZE, S. G. 1949. *Liming experiments on light land at Tunstall. Part 2. Soil reaction and loss of lime.* J. Roy. Agric. Soc., **110**, 98-103.

Soil samples were examined periodically from an experiment started in 1932 on a light sandy soil at Tunstall, Sussex. The soil had initially a pH value of 4.6 and a "lime requirement" by the Hutchinson-McLennan method of 17 cwts. CaCO_3 per acre. 0,1,2,3,4,5 tons ground chalk per acre were compared in a 5×5 Latin square. For the first few years, when sodium nitrate was used, the pH values remained steady and the annual loss from the limed plots amounted to about 2.3 cwt. CaCO_3 per acre. When sodium nitrate was replaced by ammonium sulphate the loss of lime from the limed plots was rapidly increased. In the early years of the experiment sugar beet failed on soils with pH around 5.0 but fair crops were obtained where only 1 ton CaCO_3 per acre had been given. Towards the end of the experiment a modest crop was obtained on plots in which the pH of the surface soil had fallen to pH 5.0. The crops on these plots must have utilized subsoil calcium retained from the dressings of chalk many years earlier.

Pedology Department

27. BLOOMFIELD, C. 1950. *Some observations on gleying.* J. Soil Sci. (In the press.)

The gleying reaction may be produced in the laboratory by incubating soil in a sugar medium. Under these conditions the chief effect is the removal of amorphous ferric oxide coating the clay particles of the original material.

The grey colour of the gleyed clay appears to be due to small amounts of organic that are which is concentrated with the smaller particles of the clay fraction.

28. BROWN, G. 1950. *Location of the exchangeable cations in montmorillonite.* Clay Minerals Bulletin. (In the press.)

The exchangeable cations in the glycerol-montmorillonite complex have been shown by Fourier methods to take up a position midway between the inorganic layers. The Fourier curves also lend support to the structure proposed by Hofmann for montmorillonite rather than that suggested by Edelman.

29. BROWN, G., and MACEWAN, D. M. C. 1950. *The interpretation of X-ray diagrams of soil clays. II. Structures with random interstratification.* J. Soil Sci. (In the press.)

Graphs are presented showing the calculated basal plane scattering (using the Hendricks-Teller formulae) for mica, or montmorillonoid, and kaolin-type structures with randomly interstratified layers of water or glycerol. The application of such graphs to the identification of random mixtures in soil clays is discussed.

30. CHENERY, E. M. 1949. *Aluminium in the plant world. II. Monocotyledons and Gymnosperms.* Kew Bull., No. 4.

Every family of monocotyledon and every genus of gymnosperm were examined for aluminium-accumulators. They were found only in the rare tropical family Rapateaceae and in the anomalous genus Aletris of the Liliaceae. They were entirely absent from the gymnosperms.

31. CHENERY, E. M. 1949. *Aluminium in the plant world. III. Cryptogams.* Kew Bull., No. 4.

In the ferns and fern allies aluminium-accumulators were found almost exclusively in the most ancient families: Lycopodiaceae, Marattiaceae, Matoniaceae, Gleicheniaceae, Cyatheaceae, Loxsomaceae, Dipteraceae, Plagiogyriaceae, the genera Cheiroleuria and Tapeinidium of the Polypodiaceae and three anomalous species of Blechnum. In the mosses aluminium-accumulators occur chiefly in the ancient sub-class Andreaobrya and the advanced families Polytrichiaceae and Dawsoniaceae.

32. MACEWAN, D. M. C. 1949. *The mineralogical analysis of clays by X-rays.* Research, **2**, 462.

An account of recent advances.

33. MAC EWAN, D. M. C. 1950. *Tres conferencias sobre la estructura cristalina de los minerales arcillosos*. Anales de Edafologia. (In the press.)

A summary of clay mineral work done in this Department, together with a provisional classification and nomenclature of clay minerals, as used here in describing the results of X-ray analysis.

34. MAC EWAN, D. M. C., and AMOROS, J. L. 1950. *Investigacion roentgenografica de las arcillas*. Anales de Edafologia. (In the press.)

A summarised description of the techniques of clay mineral analysis used here, together with a table of X-ray spacings and intensities.

35. MAC EWAN, D. M. C. 1950. *The montmorillonoid minerals*. BROWN, G., and MAC EWAN, D. M. C. 1950. *Structures with random interstratification*.

(GRIM, R. F., BRADLEY, W. F.), and BROWN, G. *The mica clay minerals*. Three chapters of the monograph on "The Identification and structural relationships of clay minerals," published by the Clay Minerals Group of the Mineralogical Society. (In the press.)

They include tabular and graphical representations of the available data for the identification, using X-rays, of the minerals in question, and full discussions of the use of such data.

36. MUIR, A. 1949. *Geochemistry in Metals Handbook*. Butterworth.

37. STEPHEN, I., and MAC EWAN, D. M. C. 1950. *Chloritic clay minerals in the Keuper Marl*. Clay Minerals Bull., No. 4. (In the press.)

Two new types of chloritic mineral were described in this paper. The first, found in a Keuper marl from near Birmingham is a hydrated chlorite analogous to hydrated micas, with interlamellar water molecules.

An X-ray investigation of samples of Keuper Marl from a dam construction site at Blithfield Reservoir, Staffordshire revealed the presence of a related chloritic material, with swelling properties analogous with those of the montmorillonoids. On glycerol treatment the material shows an expansion from 14A to 17·8A, corresponding to one layer of glycerol molecules between the chlorite sheets. Glycerol-montmorillonoids also give a 17·8A reflection, but the minerals can be distinguished by heating to 500° C., the chlorite giving a 14A reflection, whereas with montmorillonoids the spacing is condensed to 10A.

Soil Microbiology Department

38. CRUMP, L. M. 1950. *The influence of the bacterial environment on the excystation of amoebæ from soil*. J. Gen. Microbiol. 4, 16-21.

Cysts of two amoebæ from soil were grown in single cell cultures to test the effect upon excystation of the presence or absence of bacteria, age and type of bacteria, age of cyst, and the concentration of sodium chloride. Within the limits of the experiments excystation in one species was independent of the presence of bacteria, and unaffected by their age and type or by the age of cyst. The other was more sensitive and could not excyst without living bacteria of a suitable type, and the cysts become less likely to develop with age. Excystation in both species was adversely affected by increasing the concentration of sodium chloride, distilled water giving the best results.

39. ERIKSON, D. 1948. *Differentiation of the vegetative and sporogenous phases of the Actinomycetes*. 3. *Variation in the Actinomycetes cœlicolor species-group*. J. Gen. Microbiol., 2, 252-259.

Variation in the Actinomycetes cœlicolor species-group comprises loss of pigment and aerial mycelium, and occasionally of agar liquefaction. Stable variants may arise from degenerate, aged, vegetative mycelium, but do not normally do so when the vegetative mycelium is kept in vigorous condition by frequent subcultivation in suitable media. Single spore isolations from the aerial mycelium of typical and of variant colonies show that there may be inherent differences in the sister-spores of the same chain. Thus, in an agar-liquefying strain 3 of 15 spores had lost the power to produce pigment and to liquefy agar; and an atypical colony of the same strain yielded three viable isolates each with a strong tendency towards sectoring, with the ultimate production of a colourless, non-agar-liquefying variant as well as the typical growth. A non-agar-liquefying strain, which by prolonged cultivation in the vegetative phase had lost its power of producing the red-blue indicator pigment, yielded a variant giving rise to sectoring colonies with occasional

restoration of the blue pigment. Spontaneous occurrence of variants may be detected in certain spores of the aerial mycelium of well-grown typical colony, although it is more readily seen in the spores of degenerate colonies which have been rendered atypical by artificial methods of cultivation.

40. ERIKSON, D. 1949. *Differentiation of the vegetative and sporogenous phases of the Actinomycetes. 4. The partially acid-fast Proactinomycetes.* J. Gen. Microbiol., **3**, 361-368.

About three hundred strains of proactinomycetes were isolated from Rothamsted soils and examined together with certain strains from the National Collection of Type Cultures and other sources. Although little more than 9 per cent. were partially acid-fast on immediate isolation, subcultivation on rich media such as milk or nutrient glucose broth increased the percentage to 31 per cent. The strains showed a range of features, from the soft mycobacterial type of growth with transient vegetative mycelium and very sparse aerial mycelium, if any, to the harder, more actinomycete-like variety. Of the acid-fast species *Proactinomyces opacus*, *Proactinomyces salmonicolor*, and *Proactinomyces paraffinæ* predominated. In all, ninety-two strains were observed continuously for nearly two years on a variety of complex and simple media, and were stained at frequent intervals. Acid-fast cell elements occurred more often in complex protein- and fat-containing media, and in chemically defined media containing paraffin or large quantities of glycerol. They varied in shape and size according to the species and the age and quality of the growth. It is thought that differences of permeability of the cytoplasmic membrane in different environments may account for these variations. No evidence was obtained of any 'resting spores' or 'chlamydo-spores' in the vegetative mycelium. Since there are no true spores in the aerial mycelium when it is present, the proactinomycetes in general may be regarded as asporogenous.

41. ERIKSON, D. 1949. *The morphology, cytology and taxonomy of the Actinomycetes.* Ann. Rev. Microbiol., **3**, 23-54. (Review.)

42. KLECZKOWSKA, J. 1950. *A study of phase resistant mutants of Rhizobium trifolii.* J. Gen. Microbiol. (In the press.)

Phage resistant mutants were obtained from four strains of *Rhizobium trifolii*. Mutations to phase resistance tended to coincide with mutations in other features, such as morphology of colonies or effectiveness in nitrogen fixation. The accompanying mutations occurred independently, and their frequency varied widely from strain to strain.

Some mutants seemed stable in their newly acquired features, whereas some others continued to mutate at high rates.

Some of the mutants as regards nitrogen fixation were stable or could eventually be stabilised but others derived from one of the parent strains remained unstable even after replating or reisolation from nodules.

43. MEIKLEJOHN, J. 1949. *Isolation of Nitrosomonas from Rothamsted soil.* Nature, **164**, 667.

Nitrosomonas europæa Winogradsky, a bacterium which oxidises ammonia to nitrate, has been isolated in pure culture from the soil of Broadbalk field, Rothamsted.

44. MEIKLEJOHN, J. 1949. *Reduction des nitrates et anærobiose.* Ann. Inst. Pasteur, **77**, 389-394.

In a review of the present state of knowledge on nitrate reduction by bacteria, it is argued that, of the two reduction products important in the nitrogen cycle in soil, nitrogen gas is produced by facultative anærobes, and ammonia by strict anærobes. Reduction to nitrogen (denitrification) requires a suitable organic compound to act as a hydrogen donor, but reduction to ammonia uses hydrogen itself. Whether nitrogen or ammonia is formed in nature by reduction of nitrate depends on the oxidation-reduction potential of the surroundings, and on the hydrogen source available.

45. MEIKLEJOHN, J. *The isolation of Nitrosomonas europæa in pure culture.* J. Gen. Microbiol. (In the press.)

The method used to isolate *Nitrosomonas europæa* was a modification of that invented by Winogradsky. It involved (1) building up the population of nitrifiers in enrichment cultures; (2) removal of the bacteria from chalk particles in the enriched culture with a stream of carbon dioxide; (3) picking colonies from poured silica gel plates. The organism isolated has small oval cells, $1.2 - 1.7 \times 1.0 - 1.2\mu$, is non motile and Gram-negative. On silica

gel it forms minute colonies, only 100 μ across; it oxidises ammonia to nitrite in a mineral medium.

46. NUTMAN, P. S. 1949. *Physiological studies on nodule formation. II. The influence of delayed inoculation on the rate of nodulation in red clover.* Ann. Bot. N.S., **13**, 261-283.

The rate of nodule formation on red clover growing on a N-free medium is influenced by the time at which inoculation is made. With an effective strain of bacteria moderate delay, up to about 20 days from sowing, leads to an increase in rate of nodule formation which is maintained. Longer delay is followed by discontinuous nodulation, the rate being at first normal and then ceasing altogether for varying periods depending on the duration of pre-inoculation growth.

With ineffective strains of bacteria delay in inoculation always results in a lower rate of nodule formation.

These results are interpreted in terms of root morphogenesis, as follows. Infection is limited to (i) the zones of the root bearing developing root hairs and (ii) the foci from which lateral roots normally develop. Development at these points of incipient meristematic activity is regulated by the production of an inhibitor in the root and nodule meristem. Thus, normal nodule formation with an effective strains leads to a lowering of the meristematic potentiality of the root by the replacement of inhibitory but self-reproducing laterals with inhibitory and non-self-reproducing nodules. Delay in inoculation thus allows the development of a larger actively reproducing meristematic system with a higher susceptibility to infection.

With ineffective strain inoculation the nodule meristem is ephemeral and therefore non-inhibitory so that delayed inoculation does not result in an enhanced rate of infection. On this view the larger number of nodules produced by an ineffective strain is a result of the degeneration of the nodule meristem.

47. NUTMAN, P. S. 1949. *The nuclear and cytoplasmic inheritance of resistance to infection by nodule bacteria in red clover.* Heredity, **3**, 263-291.

The heredity resistance described is due to a simple recessive factor (r) which acts in conjunction with a maternally transmitted component (cytoplasmic factor σ). Wild susceptible plants appear to be of two types heterozygous for the factor r, and homozygous dominant. Susceptibles of both types breed true; the recessive homozygote being lethal in the absence of σ cytoplasm. Crosses between resistant plants and related susceptibles and among derived susceptibles show normal segregation of resistant plants except where an intercalary susceptible generation is interposed. Here there is a zygotic and post-zygotic elimination of resistants which may be due to the dilution of the cytoplasmic factor.

Resistant plants breed true in most families and where they do not breeding experiments suggest the existence of supplementary genetic susceptibility factors. Resistant plants are generally less vigorous than susceptibles and show growth abnormalities. Root hairs of resistant plants show curling in presence of nodule bacteria but are not penetrated. On grafting no transference of resistance or susceptibility occurs. The gene is not linked with the sterility alleles (S) and is inherited independent of factors determining early or late nodulating habit, the number of nodules formed, and a recessive factor (i) for ineffectiveness in N. fixation.

In the experimental stocks six simple recessives factors affecting appearance of leaf, flower and root were identified; these were not more frequent in resistant lines than elsewhere. Other genetically indetermined abnormalities were, however, more frequent in the outcrosses of resistant plant than in the reciprocal crosses due to the presence of σ cytoplasm.

48. NUTMAN, P. S. 1949. *The influence of strain and host factors on the efficiency of nitrogen fixation in clover.* British Specialist Conf. on Agriculture, Australia, 1949.

49. SINGH, B. N. 1949. *The effect of artificial fertilizers and dung on the numbers of amœbæ in Rothamsted soils.* J. Gen. Microbiol., **3**, 204-210.

The total numbers (active + cystic) and the numbers of active amœbæ in plots treated with complete minerals + ammonium sulphate and with farmyard manure were much higher than in the untreated plots. The complete minerals plot of Barnfield had a just significantly lower total count of

amœbæ than the farmyard manured plot, although no significant difference existed between the counts of active amœbæ. The difference in the numbers of both the total and the active amœbæ between the complete minerals and farmyard manure-treated plots on Broadbalk was not significant. No correlation was found between the percentage of organic carbon in the soils and the number of amœbæ.

50. SWABY, R. J. 1949. *The relationship between micro-organisms and soil aggregation*. J. Gen. Microbiol., **3**, 236-254.

The physical condition of soil is improved by adding readily decomposable organic material. Microbial cells and metabolic products affect soil structure by binding loose soil particles into water-stable aggregates.

Experimentally, the relative aggregating power of pure cultures of micro-organisms was as follows: fungi > actinomycetes and a few gum-forming bacteria > many gum-producing bacteria > yeasts, proactinomycetes, and many bacteria; the last three groups did not improve aggregation. Fungal hyphæ entangled soil particles into stable aggregates; weaker crumbs were formed by the frailer threads of actinomycetes. A few bacterial strains produced gums capable of glueing soil into water-stable aggregates, but the majority of bacterial slimes were almost useless because they remained water-soluble after drying. The cementing properties of these gums was not improved by treatment with H or Ca ions. Bacterial gums stabilized the aggregates produced from completely dispersed soils and kaolin, but not those formed with bentonite or ferric hydroxide. The pH value of the soil played a very minor part in influencing the aggregation produced by pure cultures of micro-organisms or even by soil inoculum.

Mixed cultures of fungi or of actinomycetes gave slightly better aggregation than pure cultures, but neither capsulated nor non-capsulated bacteria in mixtures gave better results than single strains. More complex mixtures containing fungi, actinomycetes and bacteria gave good aggregation when all micro-organisms were compatible, but poor results when antagonistic bacteria inhibited the growth of either fungi or actinomycetes. The fair aggregation obtained with soil inoculum as reproduced in the laboratory by inoculating sterilized soil with complex mixtures of micro-organisms.

A study was made of the relative merits of glucose, starch, blood, yeast, fungal mycelium, straw clover and farmyard manure for encouraging aggregation by mixtures of fungi, actinomycetes and bacteria.

Aggregates bound by mycelia did not last long because the hyphæ were decomposed by bacteria. The temporary improvement of soil structure after the addition of organic materials can be partly explained by the action of microbes, but the permanent crumb structure of many soils must be due mainly to other causes.

51. SWABY, R. J. *Influence of humus on soil aggregation*. J. Soil Sci. (In the press.)

Several methods were used for extracting humus from a number of widely different soil types. The cementing power of the various humates was tested by mixing them with soil and determining the weight of water stable aggregates surviving wet sieving. In general α humic acid > Tuilin's group 2 b. humates > group 2 a. humates > group 1 humates > fulvic acid. Greater stability was obtained when the humates were fixed as films over the soil particles by H or Ca ions.

An attempt was made to fractionate humic acid into its component colloidal cements without success. Various chemical treatments, such as hydrolysis, deamination, esterification and acetylation, modified the glueing qualities of humic acid, suggesting that colloidal substances with NH₂, COOH and OH polar groups were partly responsible for the cementing action of humates.

A study was made of the influence of various organic substances on soil aggregation. Resins, fats and some proteins cemented soil into aggregates so impervious to water that slaking was prevented. Some microbial gums and other polysaccharides acted as good soil glues, while others were useless. Lignates were only slightly inferior to humates as soil cements, but tannin and cationic detergents were of little value. The glueing properties of proteins and polyuronides were considerably altered by various chemical treatments.

The structure of puddled soils was sometimes restored by repeatedly wetting, incubating and drying them. Acid, lateritic soils high in sesquioxide cements were rapidly restored; chernozems containing much colloidal humus

and clay took longer, but other types showed little improvement even after prolonged treatment. Sterilization of soil rendered the humus more available for micro-organisms, which then able to improve soil structure temporarily. Micro-organisms reduced the stability of aggregates cemented by films of calcium humate.

52. SWABY, R. J. 1950. *Influence of earthworms on soil aggregation*. J. Soil Sci. (In the press.)

The experiments indicate that earthworms only improve the structure of soils well supplied with nutritive organic matter. An abundant food supply increases the number of intestinal bacteria some of which produce gums and glue the casts into stable aggregates. Under the conditions of restricted aeration inside the earthworm fungi do not flourish. This mechanism for increasing the stability of worm casts differs from that produced directly in soil by the incorporation of readily decomposable material, where the effect of fungal mycelium is more important than that of slime producing bacteria.

Botany Department

53. BRENCHLEY, W. E. 1949. *The use of weedkillers on paths*. Gardener's Chronicle, **125**, 124.
54. HUMPHRIES, E. C. 1950. *Wilt of Cacao Fruits (Theobroma Cacao)*. V. *Seasonal variation in potassium, nitrogen, phosphorus and calcium of the cacao tree*. Ann. Bot., **14**, 149-164.

The seasonal changes in potassium, phosphorus, nitrogen and calcium in the bark and wood of the cacao tree at levels of 1 ft., 6 ft., and 12 ft., from the base of the trunk were followed over a period of 14 months. A consideration of the negative gradients of calcium in the wood indicated that uptake of minerals from the soil had practically ceased before the end of the dry season. There was a negative gradient of potassium between 1 ft., and 6 ft., and a positive gradient between 6 ft., and 12 ft., indicating a predominately structural and storage gradient in the lower part of the trunk and a dynamic transport gradient in the upper. The dynamic gradient increased and the storage gradient decreased at times of greatest demand on the potassium reserves. Similar gradients and changes occurred in the case of total nitrogen and non-carbohydrate alcohol-soluble material.

Statistical analysis showed that potassium was depleted as size of crop increased and also that potassium was the chief factor limiting crop size.

55. WATSON, D. J. 1950. *Inflammability of cereal crops in relation to water content*. Empire J. Expt. Agric. (In the press.)

Field crops of barley became inflammable, in the sense that a fire continued to spread indefinitely and did not die out spontaneously, when the water content of the straw fell below about 30 per cent. of fresh weight.

In laboratory tests, a flame was propagated indefinitely along a single wheat or barley straw when its water content was lower than about 30 per cent. In barley, a node acted as a barrier to the passage of flame along an isolated stem when the water content was above 25 per cent.

In 1941, an abnormally wet season, the water content of oat and wheat straw of field crops never fell below the critical value for inflammability; that of barley straw fell to the critical value only when the crop was left standing for two weeks after it was dead ripe. It is suggested that delay in harvest after the stage when the crop becomes fit for cutting is probably the chief source of fire risk.

A multiple regression on time, accumulated rainfall, and daily maximum temperature accounted for 50-80 per cent. of the variance between sampling times in the water content of the straw of wheat and barley crops. The water content of oat straw was apparently not dependent on rainfall. The water content of barley straw was more sensitive to rainfall and temperature than that of wheat straw. Most of the position deviations of observed values of water content from the values calculated from the regression equations occurred on days when surface moisture was present on the plants.

Statistics Department

SCIENTIFIC AND TECHNICAL PAPERS

56. BOYD, D. A., CROWTHER, E. M., MOFFATT, J. R. and YATES, F. 1949. *A grazing experiment on the residual manurial value of feeding stuffs consumed on grass*. J. Roy. Agric. Soc.

A grazing experiment has been conducted on old pasture at Rothamsted over twelve seasons to compare the residual manurial value of feeding stuffs with those of the fertilizer equivalents given in current residual value tables.

Nine plots, each of about five acres, were arranged in three blocks and grazed in a three-year cycle. In the first year of each cycle the plots of one block were grazed by cattle, those on one plot of the block receiving additional feeding stuffs. A second plot received the estimated fertilizer equivalent in the following winter or early spring and for two seasons the three plots were grazed by cattle and sheep in a fixed ratio of grazing days. The manurial effects were estimated from the live-weight increases and the maintenance requirements.

Over the whole period of the experiment the fertilizers and the residues from the feeding stuffs each increased the total output of the plots by nearly one-tenth. Although this result supports the current tables of residual values, it is subject to great uncertainty through the irregularities inevitable in experiments on large plots with few replicates.

The experiment has provided valuable guidance for future grazing trials. In seeking a compromise between the requirements for good management and good experimental design, the present tendency is to use much smaller plots and to estimate the productivity of the individual plots by cutting, weighing and analysing the herbage.

57. COX, P. M. 1949. *Rectangular two-dimensional lattices*.

The paper extends the theory of two-dimensional lattices to the case of pq varieties or treatments, where p and q are similar, but not equal, in magnitude, thus increasing the range of available lattice designs. Blocks are not all of the same size, there being q blocks of p plots and p blocks of q plots in each pair of replications.

58. DUDLEY, F. J. and READ, D. R. 1949. *The design of experiments in egg production of poultry*. Harper Adams Utility Poultry J., **34**, 3-20.

The systems adopted for keeping poultry for egg production are presented, and discussed from the viewpoint of the experimenter. The organisation and administrative aspects of experimental work in this field are briefly reviewed.

Reference to earlier work points to the necessity for improvement in experimental procedure and this is substantiated by certain analytical evidence.

It is emphasised that adequate replication of experimental units must be made in order to achieve efficient operation and the attainment of valid conclusions, and this point particularly is to be borne in mind in considering the establishment of new experimental plant.

The possibilities of adopting more efficient designs are discussed.

59. GRUNDY, P. M. 1949. *The estimation of error in rectangular lattices*. Biometrics, **6**, 25-33.

The rectangular lattices considered are those for $p(p + 1)$ varieties in blocks all of p plots. The opportunity is taken to record the formulae for any even number of replications. Formulae for estimation of error are given which have some technical advantages over those suggested by Harshbarger, and are also simpler.

60. GRUNDY, P. M. and HEALY, M. J. R. 1949. *Restricted randomization and quasi-Latin squares*. J. R. Statist. Soc. (Series B). (In the press.)

Ordinary randomization of designs for factorial experiments sometimes has the unfortunate result that some main effect is measured by a contrast obviously liable to be inaccurate. In this paper a new type of restricted randomization is described, which preserves the property of giving an unbiased estimate of error variance, and at the same time excludes certain patterns likely to be particularly inaccurate. Applications to the 8×8 quasi-Latin square, and to other designs for factors at two and three levels are given, and the general question of the validity of experimental designs is briefly discussed.

61. HEALY, M. J. R. 1949. *Routine computation of biological assays involving a quantitative response*. Biometrics, **5**, 330-334.

A nomogram is described for rapid computation of routine biological assays using a 6-point design.

62. JOLLY, G. M. 1949. *Use of probits in combining percentage kills*. Ann. Appl. Biol. (In the press.)

The problem is discussed of how to combine percentage kills obtained in an experiment repeated under different sets of conditions. Interaction of treatments with replicates is defined in terms of probits, and, assuming the absence of such interaction, a method is evolved of finding maximum likelihood estimates of the treatment differences. An example is used to illustrate details of the method.

63. PATTERSON, H. D. 1949. *The statistical analysis of certain long-term experiments*. Thesis for M.Sc., University of Leeds.

The thesis is divided into three parts. Part I consists of a discussion of the methods of analysis appropriate to experiments in which each unit (e.g. plot in field trial) is associated with a single treatment. These methods differ according to the structure of the underlying variation. In Part II the analysis of a certain type of fixed crop-rotation experiment, of which the three-course rotation experiment at Rothamsted is an example, is considered.

Part III deals with experiments over several periods in which each unit is associated with a given cycle of treatments. These are of considerable importance, particularly in connection with animal nutrition research. The number of possible cycles of length p periods from t treatments is $\frac{t^p - 1}{t - 1}$, usually

very large, but in many cases suitable designs are available for only a fraction of this total number. Methods of analysis are developed for designs in which there are $t(t-1)$ units in blocks of t based on complete sets of orthogonal Latin squares or rectangles. This analysis is not difficult if residual effects do not persist for more than one period and direct and residual effects are additive. Systematic elements may, however, enter into the uncontrolled variation, and produce biases in the analysis of variance. It is shown how 'inter-unit' information, which may be of importance when t is much greater than p , may be utilized.

Some consideration is also given to the more complicated cases in which there are

- (1) direct effects, and several residual effects but no interactions;
- (2) direct effects, single residual effects and single interactions.

64. PATTERSON, H. D. 1949. *Design and analysis of change-over trials. Parts I and II*. J. Agric. Sci. (In the press.)

The use of designs involving Latin squares in certain long-term experiments, particularly those connected with animal nutrition research, has been advocated in recent years. When there are no residual effects of treatments it is easy to see that these designs are valid, but in other cases it is shown that certain difficulties arise and these difficulties are examined. A method of analysis taking into account the ordering of the periods is developed.

In many cases it is essential to keep the total number of experimental units (e.g. cows), and periods as low as possible so that the use of Latin squares is rather limited. Consideration is given to designs based on Latin rectangles (incomplete squares) and to designs involving the principles of confounding and incomplete blocks of single period experiments.

65. READ, D. R. 1949. *Study of the accuracy of simple sampling methods for the estimation of egg production and mean egg weight*. J. Agric. Sci., 39, 260-264.

Sampling methods for the estimation of annual production and mean egg weight have been examined, and an attempt made, by a combination of theoretical considerations and practical observations, to derive general expressions for the standard error of such estimates. Numerical values of these errors have been tabulated in a form suitable for direct application by the practical poultry worker.

66. YATES, F. 1949. *The place of experimental investigations in the planning of resource utilization*. U.N. Conf. on the Conservation and Utilization of Resources. Paper prepared for Plenary Meeting: Methods of Resource Appraisal 9(a).

Experimental investigations are of use not only in fundamental scientific research, but also in the technological research required to establish "scientific know-how." It is this latter type of experiment which is of particular value in planning resource utilization.

Technological experiments introduce new problems of experimental design, and their efficiency has been very greatly increased during recent years by the development of this subject. They constitute a new and still developing technique of which the possibilities are as yet imperfectly realised.

The paper outlines the considerations governing the planning of technological experiments for resource utilization, and discusses their relation to surveys and other forms of observation. The problems encountered in agricultural development are specially considered. Questions that arise are the degree to which experiments should attempt to mirror practical conditions, how far a problem can be broken down into component parts for experimental purposes, the degree of replication that is required in space and time, the place of large-scale pilot experiments, allocation of resources to the different problems, and the timing of experimental work in relation to other work required in planning for resource utilization.

67. YATES, F. 1949. *Agriculture, sampling and operational research*. Proc. Inst. Int. Statist. (In the press.)

The paper describes the use of sampling methods and surveys in what it is fashionable to call "operational research," for which a suggested definition is given as: "the application of the methods of scientific research to problems arising in administration and planning." Operational research involves a combination of observation (including surveys), experiment, and reasoning (both deductive and inductive). The qualifications which are needed of operational research workers are discussed, and two examples of operational research in the agricultural field are described. The first is the work carried out on the utilization of fertilizers in the United Kingdom during the war, the second is the investigation now in progress into the growing of potatoes.

68. YATES, F. 1949. *Experimental technique in plant improvement*. Biometrics. (In the press.)

The paper discusses the problems which arise when planning a testing scheme for the large number of new lines and varieties which are produced in the course of any programme of plant improvement.

69. YATES, F. 1949. *Bases logiques de la planification des expériences*. Ann. Inst. Poincaré. (In the press.)

The general theory entering into the design of experiments and into inductive inferences from their results is developed, with particular attention to the implications of randomisation.

70. YATES, F. 1949. *Quelques développements modernes dans la planification des expériences*. Ann. Inst. Poincaré. (In the press.)

Various developments in modern experimental design which are of general mathematical interest are described. The principle of restricted randomisation, which enables particularly unfavourable randomisation patterns to be avoided without biasing the estimate of error, is here described for the first time.

71. YATES, F. 1949. *Quelques développements récents dans la théorie des sondages. I. Méthodes appropriées à des unités de sondage de taille différente*. (Communication to the Institut de Statistique de Paris.)

The methods of sampling applicable to sampling units of different size, and the various methods of estimation that can be used in conjunction with them, are described. The paper presents certain new results in connection with the estimation of error when a stratified sample with variable sampling fraction is used and the domains of study cut across the strata.

72. YATES, F. 1949. *Quelques développements récents dans la théorie des sondages. II. Sondages à plusieurs degrés et à plusieurs phases*. (Communication to the Institut de Statistique de Paris.)

The paper gives an account of the ramifications of multi-stage and multi-phase sampling and the various methods which can be adopted for the estimation of errors and relative efficiency.

REPORTS

73. BOYD, D. A., DYKE, G. V. and CREASEY, Monica A. 1949. *Survey of maincrop of potatoes, 1948*. Reports for National Agricultural Advisory Service Provinces. West Midland, East Midland, Montgomeryshire, South Western, Northern, South Eastern, Eastern, Monmouth, Yorks and Lancs.
74. BOYD, D. A. and DYKE, G. V. 1949. *Survey of maincrop potatoes, 1948*. Report on the first year's results of a survey of farm practice and yields in England and Wales.
75. BOYD, D. A. and DYKE, G. V. 1949. *Survey of maincrop potatoes, 1949*. Preliminary report on sampling for yield.

76. DYKE, G. V. and POULTON, Emily P. 1949. *Report of the Standing Sub-Committee on methods of analysis of vegetable insecticides on the world-wide collaborative analysis of pyrethrum flowers*. The statistical analysis of the results.

REVIEW

77. HEALY, M. J. R. 1949. "Mathematical Biophysics" by N. Rashevsky. *Sci. Prog.*, **37**, 783.

Plant Pathology Department

GENERAL PAPERS

77. BAWDEN, F. C. 1949. *Some implications and limitations of recent work on plant viruses*. Fourth Int. Cong. Microbiol., p. 59.
78. ——— 1949. *Some factors affecting the susceptibility of plants to viruses*. Proc. Fifth Int. Cong. Compar. Path.
79. ——— 1949. *Research on plant viruses and virus diseases*. Brit. Agric. Bull., **2**, 347.
80. BROADBENT, L. 1949. *Potatoes and weather*. Q. J. Roy. Met. Soc., **75**, 302.
81. GLYNNE, Mary D. 1948. *Lodging of cereal crops*. *Farming*, **2**, 323.
82. ——— 1949. *Check take-all and eyespot*. *Farmer and Stockbreeder*, p. 2283.
83. HULL, R. 1949. *The control of virus yellows in sugar beet and mangold seed crops*. *Seed Trade Review*, **1**, 198.
84. ——— 1949. *The relative importance of seed crops and mangold clamps as sources of beet yellows virus in Great Britain*. Proc. Int. Inst. Sugar Beet Research, XII meeting, Brussels, 1949.
85. ——— 1949. *Sugar beet yellows and the mangold crop*. *J. Min. Agric.*, **55**, 450.
86. GREGORY, P. H. 1949. *Notes on Hertfordshire fungi in 1945, 1946 and 1947*. *Trans. Hertfordshire Natural History Soc.*, **23**, 54.
87. SHEFFIELD, F. M. L. 1949. *The virus in the plant cell*. Proc. Sixth Int. Cong. Expt. Cytology.

RESEARCH PAPERS

88. BAWDEN, F. C. and KASSANIS, B. 1950. *Some effects of host-plant nutrition on the multiplication of viruses*. *Ann. Appl. Biol.*, **37**, 138.

The amounts of tobacco mosaic virus present in systemically infected tobacco plants varied greatly with the mineral nutrition of the plants and were related to the effects on plant growth. With plants in soil, supplements of phosphorus produced the greatest increases in plant size, in virus concentration of expressed sap, and in total virus per plant; nitrogen increased plant size only when phosphorus was also added, and only then increased virus concentration and total virus per plant. Combined supplements of phosphorus and nitrogen doubled the virus concentration of sap and increased the total virus per plant by factors up to forty. Potassium slightly reduced the virus concentration of sap, though it usually increased plant size and total virus per plant. From all plants, only about one-third of the virus contained in leaves was present in sap. Virus production seemed to occur at the expense of normal plant proteins, and the ratio of virus to other nitrogenous materials was highest in plants receiving a supplement of phosphorus but not of nitrogen.

The effects of host nutrition on the production of virus in inoculated leaves resembled those in systemically infected leaves, but were more variable.

No evidence was obtained, with plants grown in soil or sand, that host nutrition had any consistent effect on the intrinsic infectivity of tobacco mosaic virus.

The concentration of virus in sap from potato plants systemically infected with two strains of potato virus X was not consistently affected by fertilizers; the chief effect of host nutrition on virus production was indirect by altering plant size.

89. BAWDEN, F. C. and KASSANIS, B. 1950. *Some effects of host nutrition on the susceptibility of plants to infection by certain viruses*. *Ann. Appl. Biol.*, **37**, 46.

Fertiliser treatments that greatly influenced the growth of tobacco and potato plants in pots had little effect on the number that became infected with potato virus Y when the plants were colonised by equal numbers of infective

aphids, though the number was slightly decreased by nitrogen and increased by phosphorus.

The number of local lesions produced on leaves of tobacco and *Nicotiana glutinosa* by tomato aucuba mosaic and tobacco mosaic viruses was increased by additions of both nitrogen and phosphorus, provided that these also increased growth. The predominant effect of both nutrients in increasing susceptibility was indirect by increasing plant size, but over certain critical ranges both elements also increased the numbers of lesions produced per unit leaf area. Conditions of maximum susceptibility approximated closely to those producing optimal growth, and susceptibility, whether measured by lesions per half leaf or per unit area, was decreased by a deficiency or excess of either element. Sometimes the addition of nitrogen reduced susceptibility when still increasing plant growth.

90. BAWDEN, F. C. and (VAN DER WANT, J. P. H.). 1949. *Bean stipple-streak caused by a tobacco necrosis virus*. Tijdschrift over Plantenziekten, **55**, 142.

Stipple-streak of French bean, a serious disease in some parts of the Netherlands, is caused by a strain of the Rothamsted tobacco necrosis virus. The two viruses are serologically related, crystallize in the same manner and have particles of similar sizes, but differ in the manner in which they affect beans. The Rothamsted virus rarely spreads beyond inoculated leaves, whereas the stipple-streak virus does. Stipple-streak virus can also invade stems and leaves when introduced into roots.

91. BAWDEN, F. C., KASSANIS, B. and NIXON, H. L. 1950. *The mechanical transmission and some properties of potato paracrinkle virus*. J. Gen. Microbiol., **4**, 210.

With the aid of abrasives, paracrinkle virus, hitherto transmitted only by grafting, was transmitted to Arran Victory potatoes by inoculation with sap from infected plants, either symptomless King Edward or diseased Arran Victory. The proportion of plants that became infected was increased when they were kept in darkness for some days before inoculation.

Tomato plants were more readily infected than Arran Victory potatoes, no abrasive being needed. Infected tomatoes were symptomless, but electron microscopy showed their sap to contain rod-shaped particles of variable lengths and about 10 m μ wide. Such particles have not been found in uninfected tomatoes and they are presumed to be the virus; they were destroyed by heating at 60°C.

The nature of similar particles in King Edward and Arran Victory potatoes with paracrinkle is uncertain, because rod-shaped particles were also found in uninfected Arran Victory. Rod-shaped particles also occurred in uninfected plants of all other potato varieties examined and in newly raised potato seedlings; they were not transmitted, either by inoculation or by grafting, to tomato or other hosts tested, and they withstood heating to 98°C.

These results with paracrinkle parallel those with certain other plant viruses. They invalidate theories that postulate its origin as a consequence of grafting and render unnecessary the concept that it is intrinsic to King Edward potatoes.

92. BROADBENT, L. 1949. *The grouping and overwintering of Myzus persicae Sulz. on Prunus species*. Ann. Appl. Biol., **36**, 334.

The aphid *Myzus persicae* Sulz. overwintered successfully on an almond-peach hybrid for three consecutive years. Experiments provided no evidence in favour of the theory that the olfactory sense is used by aphids to find their host, nor were flying aphids attracted to other *M. persicae* or to honeydew on the host. Having found their host, presumably by chance, alate gynoparae tended to associate in groups.

93. BROADBENT, L. 1950. *The correlation of aphid numbers with the spread of leaf roll and rugose mosaic in potato crops*. Ann. Appl. Biol. **37**, 58.

An analysis of the results of experiments in different parts of England and Wales from 1941-1947 on the spread of potato leaf roll and rugose mosaic showed that leaf roll spread was correlated with the number of alate *Myzus persicae* (Sulzer) caught on sticky traps throughout the potato-growing season; there was some correlation with the maximum count of *M. persicae* per 100 leaves, but this possibly results from the correlation between trapped aphids and the number per 100 leaves. Spread of rugose mosaic (potato

virus Y) was correlated to a lesser degree with number of *M. persicae*, perhaps because other aphids species are often vectors. With both diseases higher correlations were obtained when the infected plants were dispersed among the healthy crop than when they were placed together in a row. It is concluded that it is possible to predict the average health of potato stocks in the following year from average trap data; further work may enable the health of individual stocks to be predicted.

94. BROADBENT, L., CORNFORD, C. E., HULL, R. and TINSLEY, T. W. 1950. *Overwintering of aphids, especially Myzus persicae Sulz. in root clamps*. Ann. Appl. Biol., **36**, 513.

Mangold clamps in many districts of the British Isles were found to provide overwintering sites for *Myzus persicae* (Sulz.), *Hyperomyzus staphyleae* (Koch) and *Aulacorthum solani* (Kalt). After a severe winter, when other means of overwintering are few, clamps may be the most important source of *M. persicae*. Only *M. astalonicus* Doncaster was found in swede clamps.

Factors affecting the infestation of clamped mangolds by *M. persicae* were the number of aphids on the crop when lifted, the methods of topping and clamping the roots, and the temperature in the clamp. *M. persicae* was introduced on the leaves, and close topping was often an efficient means of control. Close topping did not control *H. staphyleae*; normally, this aphid does not seem to be a root-feeding species, but with artificially colonized mangolds it fed on both exposed roots and foliage. It is not known how this species enters the clamps. The temperature in clamps was influenced by that of the outside air and the type of cover, but changes were long-term and did not reflect diurnal variations in external air temperature. Straw, covered with soil, was the best form of cover.

In addition to harbouring *M. persicae*, mangold clamps are also important sources of sugar-beet yellows virus.

95. CAPOOR, S. P. 1949. *The movement of tobacco mosaic viruses and potato virus X through tomato plants*. Ann. Appl. Biol., **36**, 307.

Tomato aucuba mosaic virus, tobacco mosaic virus and potato virus X took 3.5-4, 5 and 3 days respectively to move from inoculated tomato leaflets into the petioles and stems.

On reaching the stem each virus usually first moved downward, but in some plants both upward and downward movement occurred simultaneously and in a few upward movement occurred first.

All three viruses travelled through the stem at approximately the same rate. Each was capable of travelling more than 80 cm. during the first 12 hr. after entering the stem, giving a minimal average rate of about 8 cm. per hr.

Uninfected pieces of stem invariably occurred between infected pieces. Maximum length of stem through which virus particles had apparently passed without causing infection, were 44.5, 49 and 39 cm. for the three viruses.

96. CHAUDHURI, R. P. 1950. *Studies on two aphid-transmitted viruses by leguminous crops*. Ann. Appl. Biol. (In the press.)

Pea mosaic virus was transmitted by *Myzus persicae* Sulz., *Macrosiphum pisi* Kalt., *M. solanifolii* Ash. and *Aphis fabae* Scop., but not by *Hyperomyzus staphyleae* Koch. It is a 'non-persistent' virus (Watson and Roberts 1939) and is most readily transmitted when vectors are fasted and then given a short infection-feeding. Vector efficiency was not increased by increase in preliminary fasting beyond 15 min. or with increasing infection-feeding beyond one hour. Most aphids became non-infective within 15 min. when feeding, but fasting aphids remained infective for 3 hr. Species that fed readily on the infected plants were less efficient vectors than those which did not. Seed set by infected plants produced healthy seedlings.

Pea enation mosaic virus persisted in *M. persicae* and *M. pisi* for more than 140 hr.; its transmission was unaffected by preliminary treatments of aphids. No transmission was obtained until at least 4 hr. after aphids had left infected plants; usually the 'latent' period exceeded one day and its duration was apparently unaffected by the length of the infection-feeding.

97. GLYNNE, Mary D. and MOORE, F. Joan. 1949. *Effect of previous crops on the incidence of eyespot on winter wheat*. Ann. Appl. Biol., **36**, 341.

Surveys of winter wheat from 1939 to 1946 show that eyespot (*Cercospora herpotrichoides* Fron.) occurs throughout Britain and that its incidence depends largely on previous cropping and on weather. Examination of 551

crops on land whose cropping for the previous 4 years was known showed that the incidence rose steadily with increasing numbers of preceding wheat and barley crops; where neither crop had been taken for 4 years the proportion of crops with more than 70 per cent. infected straws as 2 per cent., rising to 45 per cent. where three or four such crops had been taken and the average straws infected rose from 6 to 55 per cent.

The percentage infection to be expected in various groups of crops was calculated from previous cropping; it was compared with the actual infection and so used to assess the importance of other factors in determining the incidence of eyespot. High spring rainfall, early sowing and a dense plant increased incidence and low spring rainfall, late sowing and a thin plant reduced it.

Eyespot was not usually severe on newly ploughed grassland until the third or fourth crop of wheat, but under very wet conditions it was sometimes severe in the second crop.

Oats is much less susceptible than wheat or barley, but some crops were found with a third of their straws infected.

A brief survey of winter wheat in Holland suggested possible causes for the rise and fall of eyespot in recent years and for its present lower incidence there as compared with East Anglia.

98. GREGORY, P. H., (PEACE, T. R. and WALLER, S.) 1949. *Death of sycamore trees associated with an unidentified fungus*. *Nature*, **164**, 275.

A description is given of what appears to be a lethal disease of sycamore (*Acer pseudoplatanus* L.). It is caused by an unidentified fungus which stains the heartwood and ultimately produces large numbers of dry spores in the bark. About 200 trees in a small area in Essex have been killed.

99. KASSANIS, B. 1949. *Potato tubers freed from leaf-roll virus by heat*. *Nature*, **164**, 881.

All potato tubers infected with leaf-roll virus that survived 25 or more days at 37.5°C. produced healthy plants; when heated for periods of between ten and twenty days some produced healthy and others infected plants. Treatment for 40 days did not free plants from potato virus X.

100. KLECZKOWSKI, A. 1950. *Interpreting relationships between the concentrations of plant viruses and numbers of local lesions*. *J. Gen. Microbiol.*, **4**, 53.

The effect of dilution on numbers of local lesions produced by plant viruses was tested graphically and statistically for compatibility with contrasting hypotheses. Experimental results are incompatible with the hypothesis that lesions are produced because of chance encounters between single virus particles and susceptible regions of a uniform type, and that variations in response to similar inoculation between different leaves or plants occur solely because of variations in numbers of such regions. The results are compatible with the hypothesis that individual susceptible regions vary in susceptibility so that different numbers of virus particles are needed to produce a lesion, (variations being such that logarithms of minimal effective doses are normally distributed). The second hypothesis is, therefore, more probably correct, but the first can be fitted to experimental results by introducing various auxiliary assumptions, such as the existence of qualitatively different virus particles and susceptible regions. Conclusive evidence is unlikely to come from mathematical treatment of existing results, but only from a new experimental approach.

101. KLECZKOWSKI, A. and NIXON, H. L. 1950. *An electron microscope study of potato virus x in different states of aggregation*. *J. Gen. Microbiol.*, **4**, 220.

Electron micrographs of potato virus X show tenous rod-shaped particles of variable length but constant width of about 10 μ . Lightly shadowed rods lying along the direction of shadowing show a regular cross banding at intervals of about 10 m μ . Attempts to purify the virus cause the particles to aggregate and become entwined to form extensive rope and netlike structures. This aggregation may be responsible for the loss of solubility that often accompanies purification, though similar structures are visible in micrographs of both soluble and insoluble preparations of the purified virus. Hydrolysis by chymotrypsin produces products too small to be resolvable, and the material remaining after most of a preparation has been hydrolysed appears similar to that in unincubated preparations.

102. WATSON, M. A. 1949. *Some notes on plant virus diseases in South Australia*. J. Austr. Inst. Agric. Sci., **15**, 76.

Viruses collected in Adelaide, South Australia, from *Nemesia* and *Petunia* were provisionally identified as cucumber virus 1, and tobacco ringspot virus respectively. A virus from subterranean clover, (*Trifolium subterraneum*) was identified with the "sub-clover virus" described by Aitken and Grieve, (J. Austr. Inst. Agr. Sci. **9**, No. 2, 1943). It was not related to a virus found in garden peas, which was provisionally identified as common pea mosaic.

103. WATSON, M. A., HULL, R. and (HARTSUIJKER, K.) 1949. *Yellowing disease of "Family 41" sugar beet*. Nature, **163**, 910.

The paper by Clinch and Loughnane entitled "Seed transmission of virus yellows of sugar beet" is misleading because it suggests that beet yellows virus is seed transmitted, and there is much evidence to show that it is not. The yellowing disease found in a breeder's pure line of sugar beet, Family 41, resembles yellows in some respects, and there is some evidence that it is caused by an aphid-transmitted virus, but this does not appear to be a strain of beet yellows virus.

Biochemistry Department

104. (BOWES, J. H.) and KENTEN, R. H. 1948. *The amino acid composition and titration curve of collagen*. Biochem. J. **43**, 358-365.
105. (BOWES, J. H.) and KENTEN, R. H. 1948. *The effect of alkalis on collagen*. Biochem. J. **43**, 365-372.
106. (BOWES, J. H.) and KENTEN, R. H. 1949. *The effect of deamination and esterification on the reactivity of collagen*. Biochem. J. **44**, 142-152.
107. (BOWES, J. H.) and KENTEN, R. H. 1949. *Some observations on the amino acid distribution of collagen, elastin, and reticular tissue from different sources*. Biochem. J. **45**, 281-285.
108. (BOWES, J. H.) and KENTEN, R. H. 1950. *The swelling of collagen in alkaline solutions 1. Swelling in solutions of sodium hydroxide*. Biochem. J. **46**. (in the press).
109. HEINTZE, S. G. and MANN, P. J. G. 1949. *Studies on soil manganese. 1. Pyrophosphate as extractant of soil manganese. 2. The exchange properties of the manganese of neutral and alkaline organic soils*. J. Agric. Sci. **39**, 80-95.

1. The presence and distribution of divalent and trivalent manganese in pyrophosphate extracts of mineral and highly organic soils were studied.
2. A method for estimating divalent manganese in neutral pyrophosphate solutions was developed from the dismutation reaction
$$2\text{Mn}^{+++} + 2\text{H}_2\text{O} = \text{Mn}^{++} + \text{MnO}_2 + 4\text{H}^+$$
3. By means of this reaction it was possible to show that the manganese of pyrophosphate extracts at pH 9.4 of mineral soils of low organic matter content was in the divalent form.
4. The reverse dismutation reaction may occur during extraction of soils with neutral pyrophosphate solution. The presence of trivalent manganese in such extracts cannot therefore be taken as proof of the existence of trivalent manganese in the soils. Nor, since pyrophosphate extracts of organic soils reduce manganese dioxide and the manganese higher oxides of manganese in soils, can the presence of divalent manganese in these extracts be taken as proof of the existence of divalent manganese in the organic soils.
5. The use of the reverse dismutation reaction to investigate the nature of manganese higher oxides in soils is restricted to mineral soils low in organic matter. Organic soils retain part of the divalent manganese added in pyrophosphate at pH 7 in a form not readily exchangeable with NH_4^+ Ca^{++} or other polyvalent cations. The manganese so held can, however, be recovered by extraction with pyrophosphate at pH 9.4.
6. Only a small part of the manganese taken up by organic soils in the presence of ammonium acetate could be recovered by subsequent repeated extractions with ammonium acetate. The recovery was markedly increased by the addition of low concentrations of copper, cadmium, nickel or zinc salts to the M-ammonium acetate.

M

With these salt mixtures considerably higher figures were also obtained for the exchangeable manganese of soils to which no manganese has been added than with M-ammonium acetate alone. Where copper sulphate was added the additional manganese may have been liberated by reduction of the higher oxides of manganese.

7. In attempting to extract metal organic complexes three main fractions of organic matter were obtained; the first being water-soluble after extracting the soil with sodium chloride, the second being soluble in pyrophosphate, and the third in 2 per cent. sodium hydroxide. Manganese or copper added as sulphate during the sodium chloride extraction and retained in a form not exchangeable with Na ions was recovered in the subsequent water and pyrophosphate extracts. Evidence was obtained that in the water extracts the manganese and copper were still combined with the organic matter, apparently in the form in which they were originally present in the soil.
8. The hypothesis is advanced that part of the manganese of neutral and alkaline organic soils is present as complexes with the organic matter. Conditions under which the combination of the soil manganese in such complexes could cause manganese deficiency in the plant are discussed.
110. KENTEN, R. H. and MANN, P. J. G. 1949. *The oxidation of manganese by plant extracts in the presence of H₂O₂*. *Biochem. J.* **45**, 255-263.
 1. A system which oxidizes manganese in the presence of hydrogen peroxide has been demonstrated in horse-radish root extracts. This system also exists in other root extracts.
 2. Under suitable conditions (*i.e.* in pyrophosphate or citrate at pH 7) the oxidation product accumulates as a coloured manganic complex. Using horse-radish root extract, manganese dioxide was isolated by the dismutation of manganipyrophosphate at weakly alkaline reaction. The oxidation product decomposes hydrazine and can be estimated manometrically by means of this reaction.
 3. An increase in the rate of decomposition of hydrogen peroxide was observed on adding small amounts of manganous sulphate to horse-radish extracts. This effect was attributed to manganese oxidation.
 4. The manganese oxidising system in horseradish extract consists of a thermostable and a thermolabile factor together with hydrogen peroxide. Partially purified peroxidase preparations in the presence of certain peroxidase substrates and hydrogen peroxide, oxidize Mn⁺⁺. It is suggested that the thermostable and thermolabile factors in the extract are peroxidase and peroxidase substrate respectively.
 5. The hypothesis is advanced that the manganese reduces the oxidized peroxidase substrate and thereby is itself oxidized. This involves the substrate in a cycle of oxidation and reduction. At low hydrogen peroxide concentrations, the manganese oxidation product may react with plant metabolites other than hydrogen peroxide; this would involve the manganese in an oxidation-reduction cycle, which may explain its effect on plant respiration.
111. KENTEN, R. H. and MANN, P. J. G. 1950. *The oxidation of manganese by peroxidase systems*. *Biochem. J.*, **46**. (in the press).
 1. Plant peroxidase preparations from horseradish and turnip in the presence of certain phenolic substrates and H₂O₂ have been shown to oxidise manganese.
 2. Oxidation of manganese could be demonstrated with phenol, p-cresol o-cresol and resorcinol, as phenolic substrate, but not with hydroquinone, catechol, pyrogallol and caffeic acid.
 3. The effect of variation in the peroxidase, phenolic substrate, and H₂O₂ concentrations have been studied. An active system could be demonstrated with 1μg of p-cresol.
 4. The results are in agreement with the hypothesis previously advanced that the manganese reduces an oxidation product of the phenolic substrate and thereby is itself oxidised.
112. MANN, P. J. G. 1950. *Manganese and plant metabolism*. Spec. Conf. in Agriculture, Australia, 1949.

113. PATERSON, J. S. and PIRIE, N. W. 1949. *The chemical and biological properties of antigenic fractions from Brucella abortus*. Proc. Fourth Int. Cong. Microbiol. p.234.
114. PIRIE, N. W. 1949. *Introductory article to the symposium "Nature of the bacterial surface."* Edited by A. A. Miles and N. W. Pirie.
115. PIRIE, N. W. 1949. *The association of viruses with other materials in the cell and in extracts*. Proc. Sixth Int. Cong. Expt. Cytology, 1947. Expt. Cell. Res. Suppl. L., 183-191.
116. PIRIE, N. W. 1949. *Structure and activities of the bacterial surface*. Nature, **163**, 897.
117. ELSDEN, S. R. and PIRIE, N. W. 1949. *Obituary Notice—Marjorie Stephenson*. J. Gen. Microbiol., **3**, 329.

Nematology Department

119. FENWICK, D. W. *Viability studies on the potato-root eelworm Heterodera rostochiensis. 1. The estimation of total cyst content*. Accepted for publication by J. Helminthology.

The general principles underlying the estimation of cyst contents are discussed and a final technique to this end described. Attention is paid to the selection of a representative sample from a mass of cysts, the treatment of cysts prior to dissection, the method of dissection and enumeration of eggs and larvæ obtained. The paper is followed by an appendix by Miss E. Reid on an improved method of cyst dissection.

120. FENWICK, D. W. 1949. *Investigations on the emergence of larvæ from cysts of the potato-root eelworm Heterodera rostochiensis. 1. Technique and variability*. J. Helminthology, **23**, 157-170.

Data obtained by hatching 750 individual cysts in potato-root diffusate are presented. The variation exhibited by these cysts is estimated and the effect of different methods of analysis described. It is concluded that except for very special purposes single cyst hatching is not an economical use of time and the use of multiple samples of at least 100 cysts is advocated.

121. FENWICK, D. W. 1950. *Investigations on the emergence of larvæ from cysts of the potato-root eelworm Heterodera rostochiensis. 2. The form of hatching curve*. J. Helminthology, **24**, 75-86.

Individual cysts as well as groups of 100 cysts were exposed to the action of potato-root diffusate and the number of larvæ liberated at the end of certain intervals of time recorded. The sigmoid nature of the hatching curve when plotted against log-time was established. The implications of this are discussed. It is concluded that probit analysis of hatching data in conjunction with the total number of larvæ liberated is sufficient to enable comparisons to be made between different sets of hatching data.

122. FENWICK, D. W. 1950. *Investigations on the emergence of larvæ from cysts of the potato-root eelworm Heterodera rostochiensis. 3. Larval emergence in soil under the influence of potato-root diffusate*. J. Helminthology, **24**, 15-86.

The effect of leachings from three varieties of potato plants on three soils naturally infested with *Heterodera rostochiensis* was investigated. Soil leachings alone resulted in a 50 per cent. hatch whilst leachings from growing plants caused 86 per cent. of the larvæ to emerge. Significant differences were detected between soils and there was evidence of differences in degree of emergence due to leachings from different host varieties.

123. FENWICK, D. W. 1950. *"Buried bag" technique for testing 'D-D' as a soil fumigant against the potato-root eelworm*. Nature, **165**, 694.

Pot experiments were carried out on the effect of D-D on *Heterodera* cysts. It was found that mortality induced in cysts enclosed in bags which were buried in the pots of soil was very much higher than that induced in cysts occurring naturally in the soil. The need for caution in interpreting such results is stressed.

124. FENWICK, D. W. *Varying nematocidal effects of different samples of D-D against the potato-root eelworm Heterodera rostochiensis*. Accepted for publication by J. Helminthology.

Four samples of D-D were investigated for their nematocidal effect against *Heterodera rostochiensis*. Five dosages of D-D were investigated together with

one control. Probit curves were plotted for each sample and the probable dosage of each sample needed to give different kills was computed. Significant differences in dosage were needed to give 95 and 99 per cent. kills; nearly seven times as much of one sample as of another was required to give a 99 per cent. kill.

125. FENWICK, D. W. and FRANKLIN, M. T. *Further studies on the identification of Heterodera species by larval length*. Accepted for publication by J. Helminthology.

Using a standard technique described in a previous paper, larvæ were measured from cysts of eight populations of *Heterodera* from known host plants. The data thus obtained were analysed and parameters derived for the mean lengths and standard deviations for each population. Methods of identifying populations by means of these parameters are described.

An appendix by Mr. G. V. Dyke is concerned with the theory of statistical analysis used in this paper.

126. FRANKLIN, Mary T. 1949. *A quick method of demonstrating nematodes of the genus Aphelenchoides in leaves*. J. Helminth. **23** (1/2), 91-93.

By this method nematodes of the genus *Aphelenchoides* parasitic in leaves can be stained *in situ*. Infested leaves are plunged, without previous preparation, into boiling lactophenol containing 0.1-0.5 per cent. acid fuchsin for about five minutes. The leaves are left in the lactophenol while it cools, differentiated in 50 per cent. alcohol and then transferred to concentrated phenol where they are cleared until the worms can be seen stained red in the unstained leaf tissue.

127. FRANKLIN, Mary T. 1950. *Two species of Aphelenchoides associated with strawberry bud disease in Britain*. Ann. Appl. Biol. **37**, 1-10.

Two species of *Aphelenchoides* have been recognised in the buds of eelworm-diseased strawberry plants. They are identified as *A. fragariæ* (Ritzema-Bos 1891) and *A. ritzema-bosi* (Schwartz 1911). The chief diagnostic characters are described and reasons given for regarding *A. olesistus* (Ritzema-Bos 1893) as a synonym of *A. fragariæ* (Ritzema-Bos 1891). A suggestion is made that *A. ribes*, the blackcurrant eelworm, may be synonymous with the strawberry eelworm, *A. ritzema-bosi*, owing to their morphological similarity and to the successful transfer, in inoculation experiments, of each to the normal host of the other.

128. FRANKLIN, Mary T. 1950. *The cyst-forming species of the genus Heterodera Schmidt 1871*. Technical Communication No. 1 of the Commonwealth Bureau of Agricultural Parasitology (in press).

This is a review of the published work on the 8 cyst-forming species and two varieties of *Heterodera*. The morphology, bionomics, effects on the host plants, host ranges and distribution are dealt with, and brief accounts are given of some of the more recent work on control. There is a bibliography of references to work published up to the end of 1948.

129. FRANKLIN, Mary T. and GOODEY, J. Basil. 1949. *A cotton blue-lactophenol technique for mounting plant-parasitic nematodes*. J. Helminthology **23**, 175-178.

A method is described by which small nematodes such as species of *Aphelenchoides*, *Ditylenchus*, *Monochus* and *Dorylaimus* may be brought rapidly from fixative to lactophenol containing .01 per cent. cotton blue, in which they are stained. They can then be transferred to and permanently mounted in slightly tinted lactophenol. The method depends on the temperature of the first lactophenol being between 60° and 80°C., if it is lower the worms will collapse. The whole process can be accomplished in a matter of minutes compared with the weeks usually required for processing in glycerine.

130. GOODEY, J. Basil. 1949. *The control of Anguillulina dipsaci on the seed of teazel and red clover by fumigation with methyl bromide*. J. Helminthology, **23**, 131-174.

It is shown that infested seed of both teazel and red clover can be successfully treated with methyl bromide using the method devised by T. Goodey in 1945 for onion seed. The germination of both teazel and red clover was slightly improved by fumigation which also controlled fungi and bacteria very well. It is reported that eelworm disease of teazel was first discovered in England by Staniland and Miss Britton in 1948 and that of 503 samples of red clover seed examined by T. Goodey in 1944 about 6 per cent yielded specimens of *A. dipsaci*.

131. GOODEY, J. Basil. 1950. *The "Hemizonid", a hitherto unrecorded structure of members of the Tylenchoidea.* (Ready for press).
132. GOODEY, J. Basil. 1950. *The potato tuber-rot nematode, Ditylenchus destructor Thorne, 1945, the cause of eelworm disease in bulbous iris.* (Ready for press).
133. GOODEY, T. and GOODEY, J. Basil. 1949. *Tuber-rot eelworm of potato and its weed hosts.* J. Helminth. **23**, 89-90.

It was found in Prince Edward Island that the potato tuber-rot eelworm *Ditylenchus destructor*, can cause lesions on the underground stems of Corn Mint, *Mentha arvensis* L. The authors confirm the occurrence of lesions on Corn Mint rhizomes in fields in the Fens where in 1947 potato tubers had been severely infested with this eelworm. They were able to find *D. destructor* in these lesions and in similar ones on the rhizomes of another common weed, Corn Sowthistle, *Sonchus arvensis* L. Both weeds were abundant in wheat and barley stubble in late August, 1948 and it is clear that they can serve as alternative hosts on which the parasite can perpetuate itself in the absence of potatoes.

134. GOODEY, T. 1949. *Laboratory methods for work with plant and soil nematodes.* Min. Agric. and Fish. Tech. Bull. No. 2. H.M.S.O.

A number of laboratory methods and techniques are described and illustrated suitable for collecting, processing, staining and mounting plant and soil nematodes.

135. GOODEY, T. 1950. *Soil and fresh water nematodes.* (In the press).
136. PETERS, B. G. 1949. *Potato root eelworm, D-D, and soil sterilization. III. Results for 1947.* J. Helminth., **23**, 73-88.

A factorial pot experiment to test the effects on potatoes of steam sterilization of soil, infestation with *Heterodera rostochiensis* cysts; and injection of D-D (applied in that order) was repeated in the second year, with the addition of mixed fertilizers as a fourth factor. The first-year findings were reversed in that the infestation had a significant negative effect, and that the positive effects of steam sterilization and the "soil amendment" action of D-D did not re-appear. In addition to the positive fertilizer effect, a negative (fertilizer x eelworm) interaction occurred; this was interpreted as a wastage, some of the fertilizer being used in effect for the production of eelworm cysts.

137. PETERS, B. G. and FENWICK, D. W. 1949. *Field trials with D-D mixture against potato-root eelworm.* Ann. Appl. Biol. **36**, 364-382.

D-D mixture was used against *Heterodera rostochiensis* at seven 2-acre sites on sands, silts and blackland soils. Apart from a pilot trial where soil was injected in spring, injections were carried out in the autumn, and potatoes were grown the following year. Factors investigated were rate of application (0, 200, 400 and 800 lb. D-D/acre), depth of injection (4 or 8 in.) and the effect of rolling after injection. At the most responsive of the sites (Wainfleet), increases in yield, kill, and the post-crop eelworm population were all roughly proportional to the rate of application. Under favourable circumstances a 50 per cent. in yield and something like a 50 per cent. reduction in eelworm population 4 weeks after injection can be expected from 800 lb./acre, but the reduction is more than made good during the growth of the subsequent crop; accelerated multiplication of eelworm on the treated plots leads to their having a larger population than the untreated controls at lifting time. Of the sites tested, the blackland soils gave a lower eelworm kill and a much lower yield increase from D-D than silts or sands. After autumn injection the nematocidal, and probably the phytocidal effects of D-D persist in the soil for many weeks. After spring injection a taint was detectable in the crop, with a chemical correlate in the form of some unknown, fixed chlorine compound.

138. PETERS, B. G. 1949. *Potato root eelworm a serious and easily-spread pest. Control measures discussed.* Ann. J. R. Lancs. Agric. Soc., Year 1949, 23-27.
139. PETERS, B. G. 1949. *Control of plant nematodes.* Rep. Progr. Appl. Chem., **33**, 479-480.
140. PETERS, B. G. 1948. *Final report on trials with D-D against potato eelworm (Heterodera rostochiensis).* Confidential report to the Agricultural Research Council, 36 pp.

Entomology Department

BOOK

141. BARNES, H. F. 1949. *Gall midges of economic importance*. Vol. 6. *Gall midges of miscellaneous crops*. Crosby Lockwood and Son, Ltd.
The sixth volume of the series deals with the gall midges injurious to Bamboos, Basket Willows, Beverage Plants, Dye and Textile Plants, Herbs (Aromatic, Culinary and Medicinal) Insecticide plants, Spices and Sugar plants.

PUBLICATIONS

142. BARNES, H. F. 1949. *The slugs in our gardens*. *New Biology*, 6, 29-49.
A popular account of the ecology of slugs.
143. ——— 1949. *The control of slugs on allotments and gardens*. The Northern Allotment and Garden, 1, 99-102, 125-128, 153-156.
144. ——— 1949. *Slugs*. *Wye*, 1, 50-53.
A precis of the above.
145. EVANS, A. C. 1948. *On some earthworms from Iowa, including a description of a new species*. *Ann. Mag. Nat. Hist.* (II) 14, 514.
146. EVANS, A. C. 1948. *A method of studying the burrowing activities of earthworms*. *Ann. Mag. Nat. Hist.*, (II) 14, 643.
147. EVANS, A. C. 1948. *The identity of earthworms stored by moles*. *Proc. Zool. Soc. London*. 118, (2), 356-359.
148. EVANS, A. C. 1948. *Studies on the relationships between earthworms and soil fertility*. II. *Some effects of earthworms on soil structure*. *Ann. Appl. Biol.*, 35, (1), 1-13.
149. EVANS, A. C. and GUILD, W. J. McL. 1948. *On the cocoons of some British Lumbricidæ*. *Ann. Mag. Nat. Hist.*, (II) 14, 714.
150. EVANS, A. C. and GUILD, W. J. McL. 1948. *Some notes on reproduction in British earthworms*. *Ann. Mag. Nat. Hist.*, (II) 14, 654.
151. EVANS, A. C. and GUILD, W. J. McL. 1948. *Studies in the relationships between earthworms and soil fertility*. IV. *On the life cycles of some British lumbricidæ*. *Ann. Appl. Biol.*, 35, (4), 471-484.
152. EVANS, A. C. and GUILD, W. J. McL. 1948. *Studies in the relationships between earthworms and soil fertility*. V. *Field populations*. *Ann. Appl. Biol.*, 35 (4), 485-493.
153. GUILD, W. J. McL. 1948. *Studies on the relationships between earthworms and soil fertility*. III. *The effect of soil type on the structure of earthworm populations*. *Ann. Appl. Biol.*, 35, (2), 181-192.
154. JOHNSON, C. G. 1949. *Development of research in the insect aerofauna*. *Brit. Sci. News*. 2, 243-246.

The development of research on insect aerobiology during the last 50 years is described along with special problems now being investigated at Rothamsted and Cardington.

155. ——— 1950. *The infestation of a bean field by Aphis fabæ Scop. in relation to wind direction*. *Ann. Appl. Biol.* (In the press).

The primary migration of the bean aphid from winter hosts to beans was studied in relation to wind direction. The infestation of the bean crop was heaviest along the edges facing the prevailing wind during primary migration. Other factors in addition to wind direction which may have influenced the infestation pattern are discussed.

156. ——— 1950. *A suction trap for small airborne insects which automatically segregates the catch into successive hourly samples*. *Ann. Appl. Biol.* 37, 80-91.

A new trap has been developed—namely the suction trap—to overcome objections to existing methods of trapping aphids and other small insects. The apparatus which is described here has a device for separating up the daily catch in 24 successive hourly samples.

157. ——— 1950. *The comparison of suction trap, sticky trap and tow-net for the quantitative sampling of small airborne insects*. *Ann. Appl. Biol.* (In the press).

The performances of suction trap, sticky trap and tow-net are compared. At low wind-speeds the sticky trap and tow-net are very inefficient; at higher wind-speeds they suffer from the defect of obtaining samples with a variable and unknown degree of weighting due to simultaneous variation

of wind-speed and insect density. The suction trap which samples air at a constant rate in all wind-speeds appears to give more accurate results.

158. JOHNSON, C. G. and EASTOP, V. F. 1950. *Aphids captured in a Rothamsted suction trap five feet above ground level from June to November, 1947*. Proc. Roy. Ent. Soc. (In the press).
159. JOHNSON, C. G. and SOUTHWOOD, T. R. 1949. *Seasonal records in 1947 and 1948 of flying Hemiptera Heteroptera, particularly Lygus pratensis caught in nets 50 ft. to 3,000 ft. above the ground*. Proc. Roy. Ent. Soc. London. A. **24** (10-12), 128-130.
160. TAYLOR, L. R. 1950. *Synchronous movements of bean aphid*. Ent. Mon. Mag., **84**, 52.
161. WILLIAMS, C. B. 1949. *Jaccard's generic coefficient and coefficient of floral community in relation to the logarithmic series*. Ann. Bot. N.S. **13** (9), 53-58.

A discussion of the validity of Jaccard's Coefficients suggesting that they are both influenced by the size of the sample as well as by the Diversity of the population.

162. ——— 1949. *Migration in lepidoptera and the problem of orientation*. Proc. Roy. Ent. Soc. London. C. **13**, 70-84.

A survey of evidence showing that the direction of the wind is not likely to be the determining cause in the orientation of migratory flights in lepidoptera.

163. ——— 1949. *An attempt to forecast changes in insect populations*. British Sci. News, **2**, 360-362.

A brief account of the work done on this problem at Rothamsted, particularly designed for oversea readers and press.

165. ——— (1950). *The application of the logarithmic series to the frequency of occurrence of plant species in quadrats*. J. Ecol., **37**, 1-30.

A discussion of the frequency distribution of plant species in quadrats showing that if the plants are distributed in a log-series—or in any frequency which gives a straight line relation between the number of species and the log. of the number of quadrats (*i.e.* area sampled)—then the distribution of species depends on the size of the quadrats and on a measure of Diversity. Since the size of the quadrat is purely a matter of selection by the observer—the real ecological factor which is being measured is the Diversity.

Bee Department

166. BUTLER, C. G. 1949. *Some trends in bee research today*. Ann. Rpt. Cent. Assoc. British Beekeepers' Association.

167. RIBBANDS, C. R. 1949. *The effect of anaesthetics upon the foraging behaviour of the honeybee*. (Ready for press).

Anaesthesia with chloroform does not impair the memory, change the foraging behaviour or reduce the longevity of worker honeybees. Although anaesthesia with carbon dioxide does not impair the memory of treated bees it effects their foraging activities and results in the elimination or reduction of their pollen collecting tendencies, but has no direct effect upon their longevity. Treatment of newly emerged bees with carbon dioxide eliminates most of their brood-rearing and wax-secreting activities and causes them to forage at an early age.

The effects of anaesthesia with nitrogen are similar to those with carbon dioxide and both would appear to exert their effects by causing a temporary oxygen lack.

168. SIMPSON, J. 1949. *Humidity in the winter cluster of a colony of honeybees*. (Ready for press).

Outside weather conditions have little effect on the humidity within a winter cluster at moderate winter temperatures. High external humidities can only affect the colony by causing water vapour discharged from the cluster to condense within the hive.

The atmosphere in a cluster containing brood has a lower saturation deficiency than that found in the same cluster without brood. The absolute humidity of the atmosphere varies from point to point in the cluster, and in general follows the temperature in such a way that throughout much of the cluster the saturation deficiency only varies within small limits.

BOOK

169. Butler C. G. 1949. *The Honeybee. An Introduction to her Sense-Physiology and Behaviour.* Oxford University Press.

Insecticides Department

GENERAL PAPERS

170. POTTER, C. 1948. *Modern insecticides and methods of application.* J. Roy. Agric. Soc., **109**, 175-193.
171. TATTERSFIELD, F. 1948. *Early experiments on Pyrethrum growing in England.* Pyrethrum Post, **1**, No. 1, 3-8.
172. POTTER, C. 1948. *The development of pyrethrum-oil sprays for the control of Insect pests of stored products.* Pyrethrum Post, **1**, No. 2, 5-7.
173. WAY, M. J. *Insects and insecticides.* Chem. and Druggist. September and October, 1948.

RESEARCH PAPERS

174. McINTOSH, A. H. 1949. *Relation between particle size and shape of insecticidal suspensions and their contact toxicity. II. DDT and rotenone suspensions against *Oryzaephilus surinamensis* L. with some time mortality studies.* Ann. Appl. Biol., **36**, 535.

DDT. suspensions previously tested on adult *Tribolium castaneum* Hbst. (Part I.) were tested on *Oryzaephilus surinamensis* L. and gave similar results. *i.e.* toxicity increases with increase in size of crystals in suspension within the limits tested. No tests were made on the effect of crystal shape on toxicity, nor of the effect of time on mortality.

Five types of rotenone suspension were prepared :—(1) Colloidal rotenone. (2) Small elongated plate shaped crystals. (3) Small hexagonal plates in aggregates. (4) and (5) Two suspensions containing hexagonal plate shaped crystals of different sizes. The toxicity of these suspensions to adult *O. surinamensis* L. was inversely related to particle size up to 150μ . The variation in toxicity may be 500 times. Crystal shape seems to be unimportant. It appears therefore, that results with rotenone are the opposite of those with D.D.T.

The variation of mortality with time was also studied. Crystalline rotenone like D.D.T. (Part I.) gives a gradually increasing kill ; colloidal rotenone gives an initial paralytic effect followed by recovery of the insects.

175. LORD, K. A. 1949. *The effect of insecticides on the respiration of *Oryzaephilus surinamensis* L. An attempt to compare the speed of action of a number of D.D.T. analogues.* Ann. Appl. Biol., **36**, 113-138.

A method has been devised for observing the effects of a number of non-volatile contact poisons on the oxygen uptake of groups of *Oryzaephilus surinamensis* L. Toxic concentrations of D.D.T. and of its analogues applied as dusts increase the rate of oxygen uptake ; sub-lethal concentrations appear to have no effect. The total oxygen uptake of groups of starving *O. surinamensis* appears to be constant, whether or not they are treated with D.D.T. or its analogues. In each case a linear relationship appears to exist between length of life and total volume of oxygen respired before death.

The magnitude of the stimulus of D.D.T. to increase respiration appears to be independent of the concentration of the dust. The stimuli resulting from the action of D.D.T. and its analogues are approximately equal as are the rates at which the insects die. There is, however, an apparent correlation between molecular weight and length of life, *i.e.*, there is a tendency for the insects treated with the poisons of lower molecular weight to die more rapidly than those treated with the analogues of high molecular weight. The effect of benzene hexachloride on the respiration of *O. surinamensis* has been shown to be similar to that of D.D.T. The effects of a number of insecticides may be classified into two groups (a) Those stimulating respiration *e.g.* D.D.T., B.H.C., and the pyrethins and (b) Those depressing respiration *e.g.* rotenone, and the organic thiocyanate Lethane B.71.

176. PRADHAN, S. 1948. *Studies on insecticides film with special reference to the effects of temperature and humidity. 1. Preliminary investigations, especially on concentration-time-mortality relations.* Bull. Ent. Res. **40**, 1-25.
177. PRADHAN, S. 1948. *Studies on insecticide films with special reference to the effects of temperature and humidity. 2. Effect of temperature on the toxicity of D.D.T. films.* Bull. Ent. Res. **40**, 239.

178. PRADHAN, S. 1948. *Studies on insecticide films with special reference to the effects of temperature and humidity*. 3. Effect of relative humidity on the toxicity of films. *Bull. Ent. Res.* **40**, 431.
179. TATTERSFIELD, F., POTTER, C., LORD, K. A., GILLHAM, E. M., WAY, M. J., and STOKER, R. I. 1949. *Insecticides derived from plants*. Kew Bulletin, No. 3.
180. WAY, M. J. 1949. *A technique for determining the Stomach Poison effect of insecticides used against leaf eating insects*. *Ann. Appl. Biol.* **36**, 86-112
181. WAY, M. J. 1949. *Laboratory experiments on the effect of D.D.T. and B.H.C. on certain aphidophagous insects and their hosts*. *Bull. Ent. Res.* **40**, 279-297.

It was found that Syrphid larvæ were remarkably resistant to D.D.T. films on foliage. Adults were susceptible and even sublethal concentrations inhibited oviposition. Field concentrations of B.H.C. preparations were destructive only to young Syrphid larvæ. Adults were highly susceptible. Field strengths of D.D.T. and B.H.C. dusts and sprays on foliage were toxic to adults and larvæ of certain Coccinellids and to adults of Braconid species and larvæ of a Cecidomyid. In general the aphid hosts were more resistant than their parasites and predators to the D.D.T. and B.H.C. preparations used.

182. WAY, M. J., HOPKINS, Barbara and SMITH, Pauline M. 1949. *Photoperiodism and diapause in insects*. *Nature*, **164**, 615.

At a constant temperature of 24°C. it was found that day length during the larval period of *Diataraxia oleracea* (the tomato moth) influenced diapause in the resulting pupæ. Practically 100 per cent. of pupæ from larvæ reared at 0, 4 and 8 hours artificial light per 24 hours were of the diapause type. When larvæ were reared with 16 hours light per 24 or under continuous light, practically all the resulting pupæ were non diapause. Light has some influence on diapause of *Pieris brassicæ* (Large white butterfly) *Mamestra brassicæ* (Cabbage Moth) and *Phædon cochleariæ* (Mustard beetle).

Woburn Experimental Station

PUBLICATIONS FROM THE STATION IN 1948-9

183. (1) MANN, H. H. and BARNES, T. W. 1949. *The competition between barley and certain weeds under controlled conditions*. IV. *Competition with Stellaria media*. *Ann. Appl. Biol.* (In the press).
184. (2) MANN, H. H. and BARNES, T. W. 1949. *The behaviour of nitrogenous manures in the soil*. I. *The loss of manurial nitrogen*. *J. Agric. Sci.* (In the press).
185. (3) BARNES, T. W. 1949. *The formation of nitrates in soil following various crop rotations*. *J. Agric. Sci.* (In the press).
186. (4) MANN, H. H. 1949. *Soya beans in England*. *The Countryman*, December, 1949.

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187. GARNER, H. V. 1948. *The irrigation of sugar beet*. *Brit. Sugar Beet Rev.*, **16**, 109.
188. GARNER, H. V. 1948. *Top dressing wheat*. *Farming*, **2**, 268.
189. GARNER, H. V. 1949. *Manuring of root crops*. I. *Sugar beet*. *Farming*, **3**, 36.
190. GARNER, H. V. 1949. *Manuring of root crops*. II. *Mangolds and turnips*. *Farming*, **3**, 76.
191. OGG, W. G. 1948. *Soil and the farmer*. *J. Farmers' Club*, **2**, 14.
192. OGG, W. G. 1948. *The role of fertilizers in the national economy*. *Fertilizer Society*, June 1948. Also published in *Ann. Agron.*, **6**, 687.
193. OGG, W. G. 1949. *Improving soil productivity: temperate climates*. U.N. Conf. on the Conservation and Utilization of Resources. Introductory paper prepared for Section Meetings: Land Resources 5(a). *Improving Soil productivity*.
194. OGG, W. G. 1949. *Fertilizers in present-day agriculture*. "The Times" Supplement on British Agriculture, December 1949.