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Report for 1956

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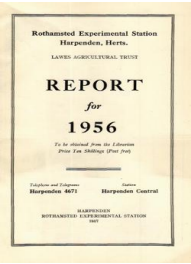
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PUBLICATIONS

Physics Department

1. EMERSON, W. W. (1956). Liquid crystals of montmorillonite. *Nature, Lond.* **178**, 1248.

2. LONG, I. F. (1957). Instruments for use in micro-meteorology. *Quart. J. R. met. Soc.* **82**. (In the press.)

Descriptions are given of modifications and innovations in instrumentation for measuring—mainly by continuous recording—temperature, humidity and ventilation in and above crops. Details are provided for an arrangement that gives a direct measure of vapour-pressure gradient, and another that avoids spurious records from faulty contacts in a remote-reading anemometer.

3. MCCULLOCH, J. S. G. & PENMAN, H. L. (1956). Heat flow in the soil. *Rep. 6th int. Congr. Soil Sci.* **B**, 275–280.

The usual analysis of the progress of the daily temperature wave into the soil is replaced by a treatment that takes into account the variation of diffusivity with depth. Applied to one set of data, the new analysis shows a 14-fold change of thermal diffusivity within 7·5 cm., and a similar range of thermal conductivity within 20 cm.

4. MONTEITH, J. L. (1956). The effect of grass-length on snow melting. *Weather*, **11**, 8–9.

5. MONTEITH, J. L. (1956). The heat balance of soil beneath crops. *Proc. Australia UNESCO Symposium on Arid Zone Climatology.*

Changes in the heat content of soil, estimated with flux plates, showed a day-time storage equal to about 20 per cent of net radiation (positive) and a night-time storage, depending on wind speed and soil moisture, frequently approaching 100 per cent net radiation (negative).

6. PENMAN, H. L. (1956). Evaporation from Lake Volta. In: *The Volta River Project*, **2**, App. III, 37–47. London: H.M. Stationery Office.

It is estimated that if a new Lake Volta is created in Ghana it will have a mean annual evaporation rate of 66 inches/year.

7. PENMAN, H. L. (1956). The movement and availability of soil water. *Soils & Fert.* **19**, 221–225.

Availability for transpiration and availability for growth are distinguished, and the former discussed in terms of potential gradient and conductivity against the background of the concepts of Veihmeyer, van Bavel and others.

8. PENMAN, H. L. (1956). Weather and water in the growth of grass. In: *The Growth of Leaves*, ed. F. L. Milthorpe, 170–177. London: Butterworth.

With water non-limiting, constant soil environment and prescribed nutrient status "constant" (in a limited sense of the word), the growth of grass (measured as dry matter in the leaves) appears to be closely proportional to the total energy supply available at the ground surface. As most of this "heat budget" is used in providing latent heat for transpiration, and the fraction so used is nearly constant, the growth is also closely proportional to the potential transpiration. Smaller deviations from exact proportionality could arise from uncertainty in the energy estimates: larger deviations, at establishment and in spring, could arise from root development at the expense of leaf development. Water appears to become limiting to growth at small values of the soil-moisture deficit, and the check occurs first on the crop

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receiving smaller nitrogen dressings. The data available are too few to permit these statements being regarded as conclusions: they are merely clues to guide future thought and research.

9. PENMAN, H. L. (1957). Soil, plant and weather factors in irrigation. In: *Sprinkler Irrigation Manual*. Ringwood (Hants): Wright Rain Ltd., pp. 34–44.

A general review of basic ideas and the results of recent irrigation experiments.

Chemistry Department

GENERAL PAPERS

10. BREMNER, J. M. (1956). Some soil organic-matter problems. *Soils & Fert.* **19**, 115–123.

A review of current problems under the headings:

Effect of organic matter on soil structure.
Separation of organic matter; metal–organic matter complexes.
The organic–nitrogen fraction.
The organic–phosphorus fraction.
Cation-exchange property.

11. COOKE, G. W. (1956). *The agricultural value of phosphate fertilizers which economize in the use of sulphuric acid.* [Report on Project No. 162 of the European Productivity Agency.] Paris: O.E.E.C. Pp. 90.

The results of field and pot experiments testing processed phosphate fertilizers which may be considered as alternatives to superphosphate are summarized. The work discussed was carried out in the member countries of O.E.E.C., which co-operated in this study. The fertilizers tested in the experiments were: dicalcium phosphate, nitrophosphates, phosphate fertilizers made by a variety of high-temperature processes, triple superphosphate, ammonium phosphates, calcium metaphosphate, ammoniated superphosphates and under-acidulated superphosphates. The residual effects of various types of phosphate fertilizers are also summarized. The availability of phosphate in relation to soil characteristics is discussed.

12. COOKE, G. W. (1956). Fertilizer placement. *Outl. Agric.* **1** no. 2, 43–51.

A summary of recent fertilizer placement research carried out in Britain. The value of placement for common crops is assessed, and the factors which affect the value of placement are discussed.

13. COOKE, G. W. (1956). Fertilizer placement for horticultural crops. *Comm. Grower*, 3168, 593–595.

14. HAINES, W. B. (1956). A comparison of methods of soil analysis for phosphorus and potassium with field response in a group of experiments on sugar beet. *C.R. Assembl. Inst. int. Rech. betterav.* **19**. (In the press.)

15. MATTINGLY, G. E. G. (1956). Application of isotopes to soil and fertilizer research. *N.A.A.S. quart. Rev.* **33**, 93–101.

A short review of some of the applications of isotopes to soil and fertilizer research during the past ten years with special reference to field experiments.

16. TALIBUDEEN, O. (1956). Isotopes in soil and fertilizer research. *Research, Lond.* **9**, 426–435.

The article deals with the application of tracer techniques to physical and chemical investigations of soils. The methods currently used in the analysis of soil constituents are reviewed, and the preparation of labelled compounds is described.

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17. WIDDOWSON, F. V. (1956). Improving the efficiency of fertilizer dressings. *Agric. Rev., Lond.* **1** no. 11, 20–26.

The advantages and disadvantages of various methods of applying fertilizer for peas, beans, horticultural and forage crops are described. A summary gives the best methods of application for a wide range of crops.

RESEARCH PAPERS

18. ARNOLD, P. W. (1956). Paper ionophoresis of inositol phosphates with a note on the acid hydrolysates of phytic acid. *Biochem. biophys. Acta*, **19**, 552–554.

A paper ionophoretic method for the fractionation of inositol phosphates is described. The method was used to follow quantitatively the hydrolysis of phytic acid at pH 3·0 and 120° C. Experimental results were compared with calculated figures based on a dephosphorylation involving six consecutive first order reactions with a single velocity constant.

19. BENZIAN, B. (1956). Nutrition problems in forest nurseries. Summary report for 1954. *Rep. For. Res. For. Comm. for* **1954/55**, 71–72.

20. BENZIAN, B. & WARREN, R. G. (1956). Copper deficiency in Sitka spruce seedlings. *Nature, Lond.* **178**, 864–865.

For several years a symptom referred to as "needle tip-burn" has been observed in Sitka spruce seedlings grown on a highly leached sandy soil at Wareham, Dorset. The symptoms had been common in seedlings grown with inorganic fertilizers, but were absent from those grown on seedbeds treated with a compost made from bracken and hop-waste. In 1955 a foliar application of a copper sulphate solution with about 0·05 per cent copper greatly reduced "needle tip-burn", it increased the height of the seedlings by nearly 50 per cent and the copper content by 40 per cent. The absence of tip-burn in seedlings grown on bracken and hop-waste compost has been ascribed to the high copper content of the hop-waste.

21. BREMNER, J. M. (1956). Alkaline decomposition of β-hydroxy-α-amino acids. *Biochim. biophys. Acta*, **20**, 579–581.

The effect of hot alkali on serine, threonine, glucosaminic acid, β-hydroxyaspartic acid, β-hydroxyglutamic acid, β-hydroxyvaline, β-hydroxynorvaline, β-hydroxyleucine, β-hydroxynorleucine, β-phenylserine and β-p-hydroxyphenylserine was investigated by paper chromatographic techniques. It was found that all of these β-hydroxy-α-amino acids gave glycine when heated with alkali, that most also yielded the product $R{\cdot}CH_2{\cdot}CH(NH_2){\cdot}COOH$, and that some gave small amounts of other ninhydrin-reacting substances.

22. BREMNER, J. M. (1957). Studies on soil humic acids. II. Observations on the estimation of free amino groups. Reactions of humic acid and lignin preparations with nitrous acid. *J. agric. Sci.* **48**, 352–360.

Free amino groups in humic acid preparations isolated from 0·5*M*-sodium hydroxide and 0·1*M*-sodium pyrophosphate (pH 7·0) extracts of various soils have been estimated by the nitrous acid method of Van Slyke (1929) and the fluorodinitrobenzene technique of Sanger (1945). The results obtained by the Van Slyke method using a reaction time of 15 minutes indicated that from 12 to 30 per cent of the total nitrogen in the preparations examined was in the form of free amino groups. No free amino groups could be detected by the fluorodinitrobenzene technique. It is shown that lignin interferes with the estimation of amino groups by the Van Slyke method, and it is suggested that lignin or lignin-derived material may be largely responsible for the high apparent amino-nitrogen values obtained with humic acid preparations by this method. The reaction of humic acid with nitrous acid resembles the reaction of lignin with nitrous acid in that it is accompanied by the fixation of nitrogen and the destruction of methoxyl groups. The reaction of lignin

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with nitrous acid is similar in many respects to its reaction with nitric acid. Only about one-third of the nitrogen fixed by lignin in its reaction with nitrous acid is removed by prolonged hydrolysis with 6*N*-HCl, and most of this nitrogen is in the form of ammonia. A small amount of the nitrogen liberated by acid hydrolysis is in the form of hydroxylamine.

23. BREMNER, J. M. & SHAW, K. (1957). The mineralization of some nitrogenous materials in soil. *J. Sci. Fd Agric.* (In the press.)

The mineralization in soil of various nitrogenous materials, including waste formalized casein from the plastics industry and products prepared from other waste materials such as lignin and sawdust, has been followed by determining the amounts of mineral nitrogen produced on incubation of the materials with soil under controlled conditions in the laboratory. Formalized casein and formalized hoof were found to decompose more slowly and uniformly than the unformalized materials. Deamination of casein had little effect on its rate of decomposition. Products prepared by treating lignin with nitric acid and with nitrous acid decomposed at similar rates and more rapidly than lignin–ammonia reaction products. Nitrated sawdust decomposed very slowly, and cellulose nitrate was highly resistant to decomposition.

24. COOKE, G. W. (1956). Field experiments on phosphate fertilizers. *J. agric. Sci.* **48**, 74–103.

The results of over 400 field experiments testing different kinds of phosphate fertilizers are summarized and are discussed with special reference to the reactions of the soils used. The classifications were: "very acid" soils, pH below 5·5; "acid soils", pH 5·6–6·5; neutral soils, pH over 6·5. All comparisons are made in terms of fertilizers supplying the same amounts of total phosphorus.

In war-time experiments Gafsa and Morocco rock phosphates were about two-thirds as efficient as superphosphate for swedes and turnips grown on very acid soils. In 1951–53 experiments on very acid and acid soils Gafsa phosphate was practically equivalent to superphosphate for swedes, but for potatoes it was as effective as only one-third as much phosphorus supplied as superphosphate; on neutral soils Gafsa phosphate was useless. For establishing grassland on acid soils Gafsa and Morocco phosphate were equivalent to about one-third as much phosphorus supplied as high-soluble basic slag. Rock phosphates were somewhat more effective for promoting growth of established grassland, but they remained inferior to high-soluble basic slags and to superphosphate. Curaçao rock phosphate was roughly equivalent to Gafsa phosphate for swedes and grass. Florida pebble phosphate was much less effective, and was judged unsuitable for direct application. Mixtures of rock phosphate with superphosphate were not more efficient than equivalent amounts of the separate components used correctly.

Silicophosphate was practically as effective as superphosphate for swedes grown on very acid and acid soils; it was less efficient on neutral soils. For potatoes silicophosphate was nearly as effective as superphosphate on very acid soils; it was much less efficient on acid and neutral soils. Silicophosphate was roughly equivalent to high-soluble basic slag for grassland.

Mixtures of superphosphate with lime, serpentine and low-grade basic slag were prepared, most of the water-soluble phosphorus being converted to insoluble forms. In experiments on swedes and potatoes these basic superphosphates were not superior to untreated superphosphate. For establishing grassland on very acid soils, the mixtures were slightly superior to ordinary superphosphate.

Dicalcium phosphate was practically equivalent to superphosphate for swedes on all groups of soils. For potatoes dicalcium phosphate was more efficient than superphosphate on very acid soils; on less acid and neutral soils it was inferior to superphosphate.

Nitrophosphates made by three different processes involving treatment of rock phosphate with nitric acid were tested in the field experiments. A product made by adding ammonium sulphate to the reaction mixture was most successful, perhaps because it contained an appreciable proportion of water-soluble phosphorus. Another product, made by using a mixture of nitric and sulphuric acids, was somewhat less effective; a third nitrophosphate, made by removing surplus calcium nitrate, was least successful. All the

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nitrophosphates were less efficient than superphosphate for potatoes and for grassland; they were more effective on acid than on neutral soils. For swedes grown on acid soils all three nitrophosphates were equivalent to superphosphate.

A few experiments on swedes and grass grown on acid soils confirmed the use of the 2 per cent citric acid test for distinguishing between basic slags of differing agricultural values. Bessemer process basic slag was compared with superphosphate in many experiments. On average of all swede experiments Bessemer basic slag was as effective as only three-quarters as much phosphorus applied as superphosphate; for potatoes it was half as efficient as superphosphate. For both crops Bessemer slag was most effective on very acid soils and less useful on acid and neutral soils.

In a few experiments on potatoes and swedes triple superphosphate was roughly equivalent to ordinary superphosphate. Calcium metaphosphate was less effective than superphosphate for swedes.

Some experiments were continued to compare the residual effects of the tested phosphates. There was no evidence to suggest that superphosphate, silicophosphate, Bessemer basic slag and basic superphosphate mixtures differed in residual values for arable crops. Experiments on reseeded grassland indicated that highly-soluble phosphates have advantages for establishing the grass but that the less-soluble phosphates became more effective in later years. Slowly-acting nitrophosphates were relatively more effective in the second year than in the first year of experiments on grass.

Conventional solubility tests distinguish between processed phosphate fertilizers in powder form, but they may not be satisfactory for valuing granulated fertilizers containing phosphates insoluble in water.

None of the materials tested were as consistently satisfactory for potatoes and grass as equivalent amounts of superphosphate. Water-soluble phosphates are particularly effective on neutral soils. Swedes and allied crops grown on acid soils make full use of citric-soluble phosphates and also of certain rock phosphates.

25. Cooke, G. W. (1956). The value of rock phosphates for direct application. *Emp. J. exp. Agric.* **24**, 295–306.

In field experiments Gafsa, Curaçao and Morocco rock phosphates were more effective than Florida pebble phosphate. For swedes and turnips Gafsa phosphate was nearly equivalent to superphosphate on soils with pH values below 6·5; for potatoes and for grassland Gafsa phosphate was only one-third as effective as super, even on acid soils. In both pot and field experiments rock phosphates were almost useless on neutral and alkaline soils.

A number of different crops were grown in a pot experiment. Morocco phosphate was equivalent to superphosphate for radish; for swedes, rape and buckwheat it was about half as effective. For mustard, clover, ryegrass, timothy, wheat, barley, rye and lettuce Morocco phosphate was of little use.

Rock phosphates from a number of countries were tested in pot experiments on radish. Materials from Morocco, Algeria, Java, Egypt and Curaçao were a little less effective than that from Gafsa. Nauru Island phosphate was much less effective than Gafsa phosphate. Florida pebble phosphate, phosphatic chalk from Taplow (Berks) and phosphates from Nigeria, Christmas Island, Kola (U.S.S.R.), Uganda and Rhodesia were of very little use when applied to radishes grown in acid soils.

Field and pot experiments failed to provide any consistent evidence that rock phosphates should be ground more finely than is customary (80–90 per cent passing the 100-mesh B.S. Sieve).

Rock phosphates acted more slowly than superphosphate in pot experiments on radishes; their efficiencies tended to increase as the experiments were continued. The solubilities of rock phosphates were not appreciably increased by "composting" under acid conditions with wheat chaff in laboratory and pot experiments.

26. Cooke, G. W., Widdowson, F. V. & Wilcox, J. C. (1957). The value of mid-season top-dressings of nitrogen fertilizer for main-crop potatoes. *J. agric. Sci.* (In the press.)

Twenty-one field experiments were carried out from 1953 to 1955 on main-crop potatoes to compare dressings of nitrogen applied wholly to the seedbed

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(as ammonium sulphate), with equivalent dressings applied partly to the seedbed (as ammonium sulphate) and partly as a top-dressing (of "Nitro-Chalk") just before the final ridges were set up.

There were consistent increases in yield from seedbed dressings of 0·5 and 1·0 cwt. N/acre. Seedbed dressings of 1·5 cwt. N/acre increased yields further in some experiments on light soils, but depressed yields at most heavy-land centres. In general, a dressing of 1·0 cwt. N/acre given to the seedbed was nearly sufficient for maximum yields.

The second increment of 0·5 cwt. N/acre increased yields at four-fifths of the centres when applied to the seedbed, but gave increases at only two-thirds of the centres when applied as a top-dressing. When the seedbed dressing was 1·0 cwt. N/acre a further seedbed dressing of 0·5 cwt. N gave increases in half of the experiments, but the same amount given as a top-dressing increased yields at only one-third of the centres. Splitting the dressing was inferior to applying it all to the seedbed in practically all experiments on medium and heavy soils. There was a slight advantage from splitting the dressing in about half of the experiments on light soils, but most of these gains were very small. On average, dressings of nitrogen applied wholly to the seedbed produced higher yields than equivalent amounts applied partly to the seedbed and partly as top-dressing.

In a subsidiary series of experiments top-dressings of "Nitro-Chalk" were applied to commercial crops which had been given normal manuring by the farmers at planting. On average of six experiments top-dressings gave only small increases in yield, none of the effects at individual centres was significant.

In both series of experiments top-dressings failed to prolong growth at centres where the crops were considered to have died prematurely. There is no justification for applying top-dressings of nitrogen fertilizer to potatoes which have received adequate amounts at planting. On the kinds of soil used for these experiments any loss of nitrogen (applied to the seedbed as ammonium sulphate) by leaching does not appear to be sufficient to reduce yields substantially.

27. Cooke, G. W., Bates, J. A. R. & Tinker, P. B. (1957). Investigations on soil nitrogen. I. The influence of nitrogen fertilizers and rainfall on soil nitrate concentrations. *J. Sci. Fd Agric.* (In the press.)

Changes in the concentrations of nitrate in soils taken from field experiments on cereals were followed for two months in spring 1955. At centres where nitrogen fertilizer increased yields of wheat and barley, soil nitrate at planting did not exceed 7 p.p.m.; in two experiments where the crops did not respond to fertilizer nitrogen there were 10 p.p.m. or more of nitrate present. Soil nitrate levels were markedly increased by additions of calcium nitrate and, to a lesser extent, by ammonium sulphate. Light rainfall which did not percolate deeply into the soil did not reduce nitrate concentrations seriously in the surface layers, but nitrate was reduced to very low levels at all centres by rain which percolated through 20 in. of soil.

28. Haines, W. B. & Benzian, B. (1956). Some manuring experiments on oil palm in Africa. *Emp. J. exp. Agric.* **24**, 137–160.

Results from ten manuring experiments on oil palm in Nigeria, Cameroons and the Belgian Congo are presented. Highly economic returns from the use of potassium were established in most cases, with smaller and more variable responses to phosphorus, and only uncertain or uneconomic ones to nitrogen. Calcium and magnesium limestone and magnesium sulphate were tested without sufficient response. Differences in response were shown between two soil types and between Lisombe and Deli palms. The differences could be related to the analysis of the soils for total P and K, although the conventional estimates of soluble or exchangeable fractions failed to show any clear relationship.

Possible interference from edge effects was taken into account in the design and recording of the experiments, and these effects are shown to develop in a way clearly due to poaching of fertilizers by palm roots crossing plot boundaries. This necessitated important corrections in the later years.

In addition to a definite annual yield cycle dependent on rain seasons, the

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data revealed marked cycles in yield with three- to five-year periods, relatively large amplitudes and complicated phase relationships, which are probably influenced by the fertilizers. If this is not taken account of it can render the conventional interpretation of short-term results obscure and even misleading, and it produces unusual features in the analysis of variance.

29. MATTINGLY, G. E. G. (1957). Effects of radioactive phosphate fertilizers on yield and phosphorus uptake by ryegrass in pot experiments on calcareous soils from Rothamsted. *J. agric. Sci.* (In the press.)

Two pot experiments with ryegrass grown on calcareous soils taken from long-term experiments on Hoosfield, Rothamsted, are described. The effects of the method of application of ^{32}P-labelled phosphate, of the amount of ^{32}P tested and of the amount of phosphate applied are discussed.

Yield and total phosphorus uptake were slightly greater in the early stages of growth when superphosphate was applied as a powder than when an equal amount of monocalcium phosphate was applied in solution; this effect disappeared in later cuts of grass. Total phosphorus uptake was not significantly altered by the amounts of ^{32}P tested and yield was only significantly reduced at one sampling date in one experiment. The uptake of labelled (fertilizer) phosphorus decreased in both experiments at the higher rates of application of ^{32}P.

The addition of superphosphate or monocalcium phosphate increased the uptake of soil phosphorus on all soils on which there was a yield response to phosphate. On these soils the recovery of fertilizer phosphorus, estimated radiochemically, was less therefore than the increase in phosphorus uptake by the ryegrass.

The quantity of labile phosphate in the soils, which was shown to be almost independent of the amount of labelled phosphate added, increased by about one-third of the difference in total phosphate content on soils that had received heavy applications of superphosphate or farmyard manure over fifty years ago. The labile phosphate in soils that had recently received superphosphate in the field decreased in three years by more than the amount of phosphate taken up by the crop. In calcareous soils that had recently received rock phosphate, the labile phosphate was lower and did not decrease with time.

30. MATTINGLY, G. E. G. & WIDDOWSON, F. V. (1956). The use of ^{32}P-labelled fertilizers to measure "superphosphate equivalents" of fertilizers in field and pot experiments. *Rep. 6th int. Congr. Soil Sci.* **B**, 461–470.

"Superphosphate equivalents" of phosphate fertilizers and fertilizer residues were determined in pot and field experiments from measurements of (*a*) yield response, (*b*) phosphate uptake and (*c*) the specific activity of the crops. Concordant results for "superphosphate equivalents" were obtained by the three methods with calcareous soils in pots, but high results were obtained with rock phosphates by the radiochemical method on acid soils. It is suggested that phosphate is taken up preferentially from phosphate-rich spots produced in such soils around particles of rock phosphate as they dissolve.

There was good agreement between results from all three methods in field experiments with dicalcium phosphate and rock phosphate, and for residues from superphosphate at an early stage of growth. At harvest, "superphosphate equivalents" determined from phosphate uptake and by the radiochemical method were much higher than from yield response, probably because of phosphorus uptake late in crop growth from fertilizer residues buried by ploughing.

31. TALIBUDEEN, O. (1957). Isotopically exchangeable phosphorus in soils. Part II. Factors influencing the estimation of labile phosphorus. *J. Soil Sci.* (In the press.)

Methods used to determine isotopically-exchangeable phosphorus in soils are described and briefly analysed. The influence of soil : solution ratio, orthophosphate ions added with radio-phosphorus, the equilibrium pH and the removal of increasing amounts of phosphate from the soil are investigated.

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A scheme is suggested for the subdivision of the total soil phosphate into four fractions on the basis of their abilities to exchange PO_4 ions with the phosphate in the soil solution. The relation between the labile pool of soil phosphate and this scheme is discussed.

32. CANO RUIZ, J. & TALIBUDEEN, O. (1957). Surface properties of phosphate materials by isotopic exchange. Part I. Rock phosphates. *J. Sci. Fd Agric.* (In the press.)

Radioactive phosphorus was used to estimate the surface phosphate of apatite rock. Surface areas of these materials calculated from these estimates were smaller than those from gas-adsorption methods. Less than 2·5 per cent of the total phosphorus existed as surface phosphorus in the 100-mesh-size fraction of these materials.

33. WARREN, R. G. (1956). N.P.K. residues from fertilizers and farmyard manure, in long-term experiments at Rothamsted. *Proc. Fertil. Soc.* **37**, 1–33.

The gain in soil nitrogen after farmyard manure had been applied annually for about a hundred years was between one-sixth and one-seventh of the total amount of nitrogen added in the manure. During the early years the gain was rapid and then continued to rise more slowly. Near the end of the period the nitrogen content of the farmyard manure plot on Broadbalk fell as a result of the fallows which were introduced into the cropping cycle. On the comparable plot on Hoosfield the nitrogen content of the soil rose but slightly during the last thirty years, indicating that the level, 0·27 per cent N, was close to the maximum for the rate and frequency of manuring in this experiment.

The organic matter residues from applications of farmyard manure given more than seventy-five years ago appear to be very stable. The residues provide only a small amount of mineral nitrogen for the barley crop.

In the years immediately after the year of application of farmyard manure the yields of potatoes, barley, ryegrass and wheat declined rapidly in the first residual year and then more slowly. For the wheat crop the fall can be ascribed to the shortage of available N, but the yields of potatoes, barley and ryegrass may also have been governed by the supplies of P and K or both.

P residues from superphosphate applied every fifth year over a period of twenty-five years gave increases in all four residual years in potatoes, barley and ryegrass. Wheat did not respond even in the year of application of the phosphate. For potatoes the increase in each of the last four residual years of the experiment was about half the increase obtained in the year of application of superphosphate : for barley the increase was one-third.

P residues from superphosphate and farmyard manure applied annually for a number of years last century increased the yield of barley grain by 7–10 cwt./acre fifty years after the last application. The P recovered in the crop each year from the residues was approximately 0·5 per cent of the total P applied as superphosphate or farmyard manure.

Five methods of soil analysis for P were used. Each method distinguished between soils that had received phosphate from those without added phosphate. The results by Olsen's method agreed more closely with the phosphorus content of the crops than did the citric acid, acetic acid and hydrochloric acid methods. Because the last three methods employed acid extractants which dissolved inactive mineral phosphate from the soils receiving this fertilizer, they did not distinguish between these soils and those that had received superphosphate and so failed to classify correctly the soils to which mineral phosphate had been applied. Olsen's method was successful in this respect.

Soils which had received potassium sulphate or farmyard manure for a number of years up to the end of the last century, but with none since, contained more readily soluble or exchangeable K than the untreated soils. For crops which contained similar quantities of P the amounts of K taken up from the K fertilizer and farmyard manure residues were related to the soil-K analyses.

34. SCHOFIELD, R. K. & REES, D. H. (1956). Calculation of membrane pressure for a sol of spherical particles. *J. colloid Sci.* **11**, 617–622.

Electronic computation has been used to obtain the Poisson–Boltzmann

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distribution of counter ions between an outer spherical surface, radius R_o, where the potential gradient is zero, and an inner concentric surface, radius R, representing a uniformly charged spherical particle. Here c_o is the concentration of the counter ions at the outer surface, and c_m is their mean concentration in the volume between the two surfaces. The results of the computations are given in a plot of c_o/c_m against $\ln \frac{R}{R_o}$. For given values of R and R_o, c_o at first increases linearly with the number of counter ions per particle, but ultimately approaches a limit. Values of the membrane potential, p_o, are calculated from the equation $p_o = NkT(c_o + C)/1{,}000$ for 1 per cent and 0·1 per cent sols of particles 10^{-6} cm. in radius.

Reviews

35. Bremner, J. M. (1956). "Modern Methods of Plant Analysis", edited by K. Paech & M. V. Tracey (4 volumes) [Review]. *Agriculture, Lond.* **63**, 299.

36. Widdowson, F. V. (1956). "Lucerne Investigations, 1944–53" (Grassland Research Institute memoir No. 1) [Review]. *Outl. Agric.* **1**, no. 3, 124.

Pedology Department

37. Bloomfield, C. (1956). The deflocculation of kaolinite by aqueous leaf extracts: the role of certain constituents of the extracts. *Rep. 6th int. Congr. Soil Sci.* **B**, 27–32.

A number of aqueous leaf extracts are very similar in their action on kaolinite; the compounds involved differ from species to species.

The activity of a Huon pine leaf extract appears to reside solely in its polysaccharide constituent, while Kauri and rimu barks appear to owe their deflocculating properties to the presence of polyphenols.

Aspen leaf extracts contain a polysaccharide and an acid of high molecular weight. Each of these is an active dispersing agent giving little or no reflocculation at high concentration. When acting together, an antagonistic effect operates, since a greater degree of reflocculation is produced.

38. Bloomfield, C. (1956). The solution-reduction of ferric oxide by aqueous leaf extracts; the role of certain constituents of the extracts. *Rep. 6th int. Congr. Soil Sci.* **B**, 427–432.

In the reaction between aqueous leaf extracts and ferric oxide, the greater part of the solution-reduction activity resides in the smaller molecular weight constituents of the extract. While removal of the constituents of higher molecular weight results in an intensification of the solution effect, addition of this fraction to an untreated extract leads to decreased solution of ferric oxide. It is apparent, therefore, that certain of the larger molecular weight components exert an inhibiting action in the solution-reduction process.

Kauri or rimu bark extracts exhibit a similar inhibiting action when added to their respective leaf extracts.

The solution-reduction process appears to be largely the result of the joint action of relatively simple acids and reducing compounds.

39. Bloomfield, C. (1956). The experimental production of podzolization. *Rep. 6th int. Congr. Soil Sci.* **E**, 21–23.

Periodic treatment of columns of ferruginous sand with dilute aqueous leaf extracts leads to discoloration of the ferric oxide. The ultimate appearance of the sand column is reminiscent of a podzol profile; the colour is not removed by washing with water. Most of the coloured substance is removed from the ferric oxide by dilute alkali, and the solution thus obtained is brown in colour and contains iron.

The substances responsible for the colour formation are chiefly of small molecular weight.

If, after treatment with the extracts, the columns are allowed to dry, E

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horizons are formed at a short distance below the boundary between the dry and wet sand.

40. Brown, G., Dibley, G. C. & Farrow, R. (1956). An extrusion method for bonded powder specimens. *Clay Min. Bull.* **3**, 19–21.

A method of extruding powder specimens using a hypodermic syringe is described.

41. Brown, G. & Farrow, R. (1956). Introduction of glycerol into flake aggregates by vapour pressure. *Clay Min. Bull.* **3**, 44–45.

A vapour-pressure method of glycerol treatment of clays is described and its advantages over normal methods noted.

42. Brown, G. & Dibley, G. C. (1956). Moderately low angle measurements with a 9·0 cm. powder camera. *Clay Min. Bull.* **3**, 46–47.

A method of adapting a 9·0-cm. camera is described.

43. Brown, G. & Ollier, C. D. (1956). Collophane from the chalk. *Miner. Mag.* **31**, 339–343.

Samples of Upper and Middle Chalk from the Chilterns yielded fragments of fish scales, spines and bones, which consist of collophane. X-ray examination by powder methods showed that the material has an apatite-type structure with cell dimensions close to those previously reported for francolite. Examinations of single grains show that the optical anisotropy is due to preferred orientation of the *c*-axes of the crystallites, and this direction corresponds to the faster vibration direction. Such grains are found to be pseudo-uniaxial negative. Preferred orientation could not be detected in isotropic grains.

44. Greene-Kelly, R. (1956). The sorption of saturated organic compounds by montmorillonite. *Trans. Faraday Soc.* **52**, 1281–1286.

A number of new complexes of montmorillonite and compounds (some of biological importance) containing saturated chains and rings are reported. These complexes are compared with other similar complexes previously described and their structures discussed. The importance of single-bond rotation in intercalated chain molecules is emphasized.

45. Greene-Kelly, R. (1956). The swelling of organophilic montmorillonites in liquids. *J. Coll. Sci.* **11**, 77–79.

The crystalline swelling of amine-montmorillonites is shown to take place in certain liquids other than water. The relation between the steric requirements of the two kinds of intercalated molecules is discussed.

46. Greene-Kelly, R. (1956). Montmorillonite complexes with saturated ring compounds. *J. phys. Chem.* **60**, 808–809.

Two structural types of complex are found. The first in which the mean axis of the ring is parallel and the second perpendicular to the plane of the silicate sheets. The similarity to aromatic complexes is noted.

47. Nixon, H. L. & Weir, A. H. (1957). The morphology of the Unter-Rupsroth montmorillonite. *Miner. Mag.* (In the press.)

Electron micrographs of Na-saturated Unter-Rupsroth montmorillonite show that many of the individual flakes, which are probably 10 Å. thick, have straight edges meeting in 120° angles. This is evidence in support of the pseudohexagonal structure of montmorillonite. Similar pictures were obtained with Li-saturated clay, and with "Calgon" dispersed material. The usefulness of electron microscopy for the study of clay mineral morphology depends upon the efficiency of dispersion and the details of the mounting techniques rather than the nature of the exchange cation of the particular dispersing agent employed.

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48. (SMITHSON, F.) with X-ray identifications by BROWN, G. (1956). The habit of pyrite in some sedimentary rocks. *Miner. Mag.* **31**, 314–318.

Authigenic pyrite crystals or their pseudomorphs found in heavy residues from sedimentary rocks are cubes, octahedra or pyritohedra. Combinations of these forms are common; trapezohedron and rhombic dodecahedron faces are rare. The cube is most often recorded in the literature, but the octahedron is dominant in some districts and may be favoured by calcareous environment. X-ray tests have been applied for identification and goethite and haematite detected as alteration products.

49. STEPHEN, I., (BELLIS, E.) & MUIR, A. (1956). Gilgai phenomena in tropical black clays of Kenya. *J. Soil Sci.* **7**, 1–9.

An account is given of the occurrence of gilgai phenomena on tropical black earths in Kenya. Reference is made to examples from other parts of Africa. The Kenya soils are derived from intermediate lavas which weather to give montmorillonitic clays. The mineralogy of the sand fractions is described, and chemical and physical data given to illustrate the high swelling power of these heavy clay soils.

Soil Microbiology Department

50. KLECZKOWSKA, J. (1957). A study of distribution and effects of bacteriophage of root nodule bacteria in the soil. *Canad. J. Microbiol.* (In the press.)

Bacteriophage to clover nodule bacteria can be found on roots and nodules of all naturally grown clover plants and also in the soil surrounding the roots, but not in the soil where there are no clover plants. Alternative hosts for the phage of clover bacteria are pea bacteria, and vice versa. The bacteria and the phage are heterogenous in the sense that only a proportion of strains of clover bacteria and of pea bacteria are susceptible to lysis by a given race of phage, and only a proportion of races of phage can lyse a given bacterial strain. There does not seem to be any necessary association between susceptibility of bacterial strains to lysis by a phage and any of such other features as antigenic structure and effectiveness in nitrogen fixation. There may be an association with avirulence, i.e., inability to infect the host plant.

The behaviour of phage–bacterial mixtures depends on the surrounding medium. The longevity of phage in soil, or in a soil-like medium such as the vermiculite mixture, is relatively short, and the effect of phage can be localized so that phage-susceptible bacteria and the phage can exist close to each other without any apparent interaction. However, as long as the phage is present phage-resistant bacterial mutants are also usually present. The phage-resistant mutants may also be mutants in other respects, such as effectiveness in nitrogen fixation. In the presence of weakened phage in such a system bacterial mutants that differ from the parent form in effectiveness but resemble it in being susceptible to the phage were found to occur.

51. MEIKLEJOHN, J. (1956). Preliminary notes on numbers of nitrogen fixers on Broadbalk field. *Rep. 6th int. Congr. Soil Sci.* **C**, 243–248.

1. Counts of Azotobacter made on Broadbalk field in the summer and autumn of 1955 showed very small numbers in all cases.

2. On the fallow section of the unmanured plot 3, the numbers of Azotobacter rose during the summer and autumn; no such rise was observed in the fallow section of plot 10 (ammonium sulphate), where the numbers remained small, as they did in the sections that were carrying their fourth successive wheat crop.

3. On plots 5 (minerals only) and 7 (minerals and ammonium sulphate) there was an increase in numbers in the fallow section, not so much as in plot 3. In the cropped sections the Azotobacter numbers were higher than in the same sections of 3 and 10, but did not rise during the season.

4. Approximate counts of Clostridium show that the numbers are much higher than those of Azotobacter.

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52. MEIKLEJOHN, J. (1957). Numbers of bacteria and actinomycetes in a Kenya soil. *J. Soil Sci.* **8**. (In the press.)

1. The estimates of numbers of bacteria and actinomycetes derived from plate counts made from soil samples taken at Muguga, Kenya, varied with the extent to which the soil was diluted. Low dilutions gave small, and high dilutions large, estimates.

2. The ratio between direct counts and plate counts on the same sample was wide at first, but became narrow as the drought of early 1953 was prolonged.

3. The percentage of actinomycete colonies on plates was less than 30 at first, but rose to over 90 when the drought was well established.

4. It is concluded that the drought-resistant part of the micro-flora in this surface soil is almost entirely composed of actinomycete spores.

53. NUTMAN, P. S. (1956). The influence of the legume in root-nodule symbiosis. A comparative study of host determinants and functions. *Biol. Rev.* **31**, 109–151.

54. NUTMAN, P. S. (1957). Symbiotic effectiveness in nodulated red clover. III. Further studies on inheritance of ineffectiveness in the host. *Heredity*. (In the press.)

A recessive host factor (*ie*) is described which effects the symbiosis between red clover and normally effective strains of nodule bacteria in such a way that no fixation of nitrogen occurs. With exceptionally effective strains of bacteria an effective response is found in nodules of some *ie* plants but not in others. Ineffective *ie* homozygotes bear variable numbers of nodules, some of which attain a large size. The ineffective response in *ie* plants is found to be influenced by other hereditary factors in the host which appear to promote effectiveness in a proportion only of the nodules formed on a root. Ineffectiveness in *ie* homozygotes differs from that produced by the factor i_1 (previously described) in (1) absence of a high degree of specificity with respect to bacterial strain, (2) types of nodulation and (3) mode of action of host modifying factors.

55. NUTMAN, P. S. (1957). Studies on the physiology of nodule formation. V. Further experiments on the stimulatory and inhibitory effects of root secretions. *Ann. Bot. Lond.* (In the press.)

The influence of root secretions on nodulation of clover and lucerne in agar culture is examined using a technique of preplanting. Root secretions are shown to have two effects : nodulation of the seedling is induced at an earlier stage (stimulation), but takes place at a reduced rate (inhibition). These effects do not depend upon the presence of the bacteria in the preplanting phase of an experiment. The species used differed both in production of and reaction to secretions giving these effects. As a donating plant lucerne is more active than clover, and selected early nodulating lines of clover are more active than late lines. Stimulation of lucerne is promoted by lower levels of secretion than clover, and early nodulating lines are less affected than late lines. The influence of secretions on nodulation rate is greater for lucerne than for clover at lower levels, and does not differ between early and late nodulating lines. In contrast to lucerne, inhibition of nodulation on clover is proportional to duration of the preplanting, suggesting that secretions accumulate during growth.

The hypothesis is put forward that the stimulating reaction represents an increase in the availability of the infective foci already present on the root and that the inhibiting reaction represents a reduction in the number of these foci.

56. PURCHASE, H. F. & NUTMAN, P. S. (1957). Studies on the physiology of nodule formation. VI. The influence of bacterial numbers in the rhizosphere on nodule initiation. *Ann. Bot. Lond.* (In the press.)

The direct examination of the relation between inoculum size and infection rate for the nodulation of a legume is difficult because of the rapid multiplication of the nodule bacteria in the rhizosphere. This has been overcome by

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(1) using mixtures of normal (virulent) and mutant avirulent strains of clover nodule bacteria, the avirulent acting as a diluent of the virulent, and (2) by employing large original inocula to reduce multiplication. By these means the numbers of virulent clover bacteria were maintained during an experiment at approximately predetermined levels. When a strain of lucerne nodule bacteria was used as diluent the multiplication of clover-nodule bacteria was not suppressed.

Nodule number was found to approach the maximum asymptotically with bacterial density; very few bacteria (of the order of 10) were required to give rise to a single nodule only on a plant during an experiment, under conditions where the full nodulating capacity of a root is saturated by a total rhizosphere population of the order of 10^4 bacteria. This relationship supports the view that infection only takes place at discrete foci on the root.

A good fit of the experimental data was given by a compound Mitscherlich curve and by a combination of a normal and a modified Mitscherlich equation. This latter model takes into account the multiplication of sites of infection which occurs in the early seedling stage from foci not occupied at high dilution of virulent bacteria. Multiplication of this kind has also been demonstrated by delayed inoculation experiments.

In the preliminary experiments it was found that comparable rhizosphere stimulation of bacterial growth took place in sand culture, water culture and agar culture and with plants of diverse nodulating habit.

57. STEENSON, T. I. & WALKER, N. (1957). The pathway of breakdown of 2 : 4-dichloro- and 4-chloro-2-methyl-phenoxyacetic acid by bacteria. *J. gen. Microbiol.* **16**, 146.

The metabolism of 2 : 4-dichlorophenoxyacetic acid and 4-chloro-2-methylphenoxyacetic acid by a strain of *Flavobacterium peregrinum* and an *Achromobacter sp.*, respectively, has been studied. It was found that bacterial cells from young cultures were more active than those from older ones in oxidizing these substrates. Evidence is presented that adapted cells of these organisms dissimilate 2 : 4-dichlorophenoxyacetic acid through 2 : 4-dichlorophenol and 4-chlorocatechol and that 4-chloro-2-methyl-phenoxyacetic acid is dissimilated through 5-chloro-2-cresol. Bacteria adapted to 2 : 4-dichlorophenoxyacetic acid do not oxidize any of the other five possible isomers, but can oxidize 2 : 4-dibromo-, 4-bromo-2-chloro, 4-chloro- and, to a small extent, 2-chlorophenoxyacetic acid.

58. STEVENSON, I. L. (1956). Antibiotic activity of actinomycetes in soil as demonstrated by direct observation techniques. *J. gen. Microbiol.* **15**, 372.

Direct observation techniques were used to determine the antibiotic effects of eight actinomycete species on *Helminthosporium sativum* in soil and *in vitro*. In actinomycete-inoculated sterilized soils the inhibition of germination of fungal spores corresponded with the degree of inhibition of the fungus produced by the same actinomycetes in Petri plate culture. The effects of the actinomycetes on the vegetative growth of *H. sativum* in soybean-supplemented soils varied with the individual actinomycetes and, with one exception, were identical with the effects caused by the actinomycete antibiotics *in vitro*. These hyphal changes in soil included : suspension of further mycelial development; lysis; characteristic morphological effects such as stunting, distortion, excessive branching and the formation of hyphal protuberances. Lysis of the fungal hyphae only occurred in the presence of soil, and was shown to be due to the combined effect of the antibiotic and some unidentified soil factor. Evidence was also obtained which demonstrated the ability of the actinomycetes to produce antibiotics in unsupplemented soils. Additional proof of antibiotic activity in soil was obtained by using the antibiotic actinomycin and strains of *Streptomyces antibioticus*, the organism responsible for its production. In Petri plate culture both crystalline actinomycin and the actinomycete produced a characteristic swelling, distortion and stunting of the vegetative growth of *Helminthosporium sativum*. When introduced into sterile soils, identical morphological changes were evidenced by the fungus in the presence of either the pure antibiotic or the actinomycetes.

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59. THORNTON, H. G. (1956). The ecology of micro-organisms in soil. (Leeuwenhoek Lecture.) *Proc. roy. Soc. Lond.* (*B*), **145**, 364–374.

60. THORNTON, H. G. (1956). The development and present problems of soil microbiology. *J. Sci. Fd Agric.* **2**, 93–101.

61. THORNTON, H. G. (1956). Soil organisms and root relationships. *Sci. Hort.* **12**.

Botany Department

GENERAL PAPERS

62. THORNE, G. N. (1957). Application of nutrients to crops as leaf sprays. *Agric. Rev., Lond.* **2**, 42–45.

63. THURSTON, J. M. (1957). Towards the control of wild oats. *J. R. agric. Soc.* (In the press.)

64. WATSON, D. J. (1956). Measurement of photosynthesis in field conditions. The physiological limitations of crop yield, and the possibilities of increasing it. *Landbouwk. Tijdschr., 's-Grav.* **68**, 581–594.

Text of two lectures given in 1953 in a course on Photosynthesis at the University of Wageningen.

65. WATSON, D. J. (1956). Leaf growth in relation to crop yield. In : *The Growth of Leaves.* (Ed. F. L. Milthorpe, Proc. 3rd Easter School in Agric. Sci., Univ. Nottingham.) London : Butterworth. Pp. 178–191.

RESEARCH PAPERS

66. OWEN, P. C. (1957). The effect of infection with tobacco etch virus on the rates of respiration and photosynthesis of tobacco leaves. *Ann. appl. Biol.* (In the press.)

Unlike tobacco mosaic virus, which increases the respiration of tobacco leaves within an hour of their being inoculated, a virulent strain of tobacco etch virus did not affect respiration rates until leaves showed external symptoms. The respiration rates of inoculated and systemically infected leaves with symptoms rose to 40 per cent above those of healthy leaves, three times the increase produced by tobacco mosaic virus. The increase in respiration rate occurred at all times of the year and was maintained through the life of the leaves.

Leaves infected with tobacco etch virus and showing symptoms had a rate of photosynthesis 20 per cent lower than that of healthy leaves.

67. OWEN, P. C. & WATSON, D. J. (1956). Effect on crop growth of rain after prolonged drought. *Nature, Lond.* **177**, 847.

After prolonged drought, rainfall in amounts very small compared with the soil moisture deficit and, therefore, with amounts used in orthodox irrigation practice, caused such large increases, both in leaf growth and in the rate of photosynthesis of unirrigated plants, that, temporarily, these plants grew faster than irrigated ones that had never been subjected to severe water stress.

68. THORNE, G. N. (1956). The effect of organophosphorus insecticidal sprays on the growth and phosphorus content of brussels sprouts. *Ann. appl. Biol.* **44**, 499–505.

No evidence was found that the insecticides schradan or demeton directly increase the growth of plants. The dry weight of brussels sprouts plants grown in soil supplying little or ample phosphorus was unaffected by spraying six times with schradan, demeton or sodium phosphate solutions supplying the

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same amount of phosphorus as the insecticides, except that in one experiment schradan decreased the dry weight of plants grown with a high supply of phosphorus in the soil.

Phosphorus content was affected neither by demeton nor by the equivalent sodium phosphate sprays. In one experiment schradan and the equivalent sodium phosphate sprays increased the phosphorus content of plants grown in soil supplying little phosphorus, but did not affect that of plants with high phosphorus supply.

69. THORNE, G. N. (1957). Application of an April top-dressing of nitrogen to winter wheat in a spray with 2 : 4-dichlorophenoxyacetic acid. *J. agric. Sci.* **48**, 266–272.

Uptake of nitrogen by winter wheat from 0·5 cwt. N/acre applied in April as solid was about twice that from a similar quantity applied as a single spray at 30 gal./acre. Solid fertilizer increased yield slightly more than did spray. Urea and ammonium nitrate had the same effects with both solid and spray applications.

When 2:4-D was included in the spray or applied separately to plots receiving solid fertilizer, it decreased the amount of weed slightly and did not affect the yield of wheat. The response to nitrogen in dry weight of straw, including weeds, in one experiment, and of shoots in another experiment, was decreased slightly by 2:4-D when nitrogen was applied in spray but not when it was applied as solid fertilizer.

70. WARINGTON, K. (1956). Investigations regarding the nature of the interaction between iron and molybdenum or vanadium in nutrient solutions with and without a growing plant. *Ann. appl. Biol.* **44**, 535–546.

Iron offset the toxicity of molybdenum or vanadium in nutrient solutions more effectively when it was supplied at the same time as the molybdenum or vanadium than when it was given separately in alternate 3-day periods.

Allowing nutrient solutions of pH 4·6 containing high concentrations of iron, with or without high vanadium, to stand 2–4 days before use reduced the iron content of the roots, and the vanadium content of both shoot and root, of peas. The presence of vanadium had little effect on iron uptake.

In parallel experiments with molybdenum, standing for 2–9 days reduced the iron content of the roots of soybean and peas, but the molybdenum content was unaffected or increased. High molybdenum greatly increased the iron in the root, but had little effect on that in the shoot.

Precipitation of iron in the nutrient solution was delayed by high concentrations of either ammonium or sodium molybdate if the initial pH was 4·6, but not if it was 6·6. Vanadium had no influence on the precipitation of iron at pH 4·6.

At least part of the compensating action of iron on molybdenum or vanadium toxicity appears to take place outside the plant.

71. WATSON, D. J. & WILSON, J. H. (1956). An analysis of the effects of infection with leaf-roll virus on the growth and yield of potato plants, and of its interactions with nutrient supply and shading. *Ann. appl. Biol.* **44**, 390–409.

The decrease in total dry weight of potato plants caused by infection with leaf-roll virus was almost entirely at the expense of the tubers; the dry weight of the leaves and stems was increased, and that of roots and stolons only slightly decreased. The percentage loss of dry weight of the tubers was decreased by nitrogenous fertilizer, but was unaffected by phosphorus or potassium.

Infection greatly decreased net assimilation rate (NAR) between May and early July, but subsequently infected plants had a higher NAR than healthy plants. Infection also decreased leaf area per plant until early July, but it delayed senescence of the leaves, so that in late July and August infected plants had more leaf area than healthy plants. The more rapid senescence of healthy plants probably accounts for their lower NAR at this time. The mean decrease in NAR by infection was about 20 per cent, and this was the chief cause of the loss of yield, for the mean decrease in leaf area was only 4

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per cent. The lower NAR of infected plants was mainly due to diminished photosynthetic efficiency of the older, rolled leaves. The effects of nitrogen, phosphorus and potassium on NAR, and their interactions with infection, were small and rarely significant.

At times when nitrogen, phosphorus or potassium increased leaf area they usually also increased the effect of infection, as this tended to reflect plant size. Infected plants had more leaves than healthy plants, because leaf production continued longer and more lateral branches developed.

Shading decreased NAR but increased leaf area; consequently it had no effect on yield. There were no interactions between shading and infection.

Biochemistry Department

General Papers

72. Pirie, N. W. (1956). The recognition, distribution and action of nucleic acids. *Proc. Chromosome Conf.*, ed. R. Prakken. Wageningen. Pp. 105–129.

73. Pirie, N. W. (1956). The use of higher plants for storing solar energy. *Trans. Conf. on Solar Energy*, ed. E. F. Carpenter. Tucson. (In the press.)

74. Pirie, N. W. (1956). Material in virus preparations not necessary for the manifestation of characteristic virus properties. In: *Ciba Foundation Symp. on the Nature of Viruses*, edited by G. E. W. Wolstenholme & E. C. P. Miller. London. Pp. 56–64.

75. Pirie, N. W. (1956). Nucleic acids and protein synthesis. (Chairman's Introduction to Biochem. Soc. Symp. No. 14.) Cambridge University Press. (In the press.)

76. Pirie, N. W. (1957). Chemical diversity and the origins of life. *Int. Union of Biochem., Symp. on the Origin of Life*, ed. A. I. Oparin. Moscow. (In the press.)

77. Pirie, N. W. (1957). Biochem ical engineering. *Research*, **10**, 29–34.

Research Papers

78. Byers, M., Fairclough, D. & Pirie, N. W. (1956). The large-scale production of leaf protein. *Biochem. J.* **63**, 33–34.

A description, for use when the Biochemical Society visited Rothamsted, of the equipment for making leaf protein. Figures are given illustrating the scale on which we work, the efficiency of extraction and the quality of the final product.

79. Clarke, A. J. & Mann, P. J. G. (1957). The oxidation of tryptamine to 3-indolylacetaldehyde by plant amine oxidase. *Biochem. J.* **65**, 763–774.

Plant amine oxidase catalyses the oxidation of tryptamine to 3-indolylacetaldehyde (IAc). This was established by the isolation of the 2 : 4-dinitrophenylhydrazone and dimedone derivatives of the IAc from the reaction mixtures. The oxidation of 5-hydroxytryptamine is also catalysed by the enzyme.

A method has been worked out for estimation of IAc based on its oxidation, with silver oxide, to 3-indolylacetic acid (IAA). The IAA so formed was estimated with Salkowski reagent.

Using this method, the effect of pH, substrate concentration and reaction time on the yield of IAc were investigated. The enzyme was rapidly inactivated at high tryptamine concentrations. With low tryptamine concentrations and short reaction times (15 minutes) yields of IAc of up to 90

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per cent of theory were obtained at pH 7–8. The yield decreased with increase in reaction time, particularly with alkaline reaction mixtures. This was probably due, in part at least, to polymerization of the IAc.

It is suggested that the reaction forms a useful method of obtaining IAc.

Two of the secondary reactions which occur when crude preparations of the amine oxidase are used to catalyse the reaction were identified as peroxidase-catalysed oxidations of tryptamine and IAc.

80. KENTEN, R. H. & MANN, P. J. G. (1957). Manganese oxidation in the pea plant (*Pisum sativum* L.) grown under conditions of manganese toxicity. *Biochem. J.* **65**, 179–185.

Pea plants grown in water culture containing toxic concentrations of manganese sulphate accumulate compounds containing manganese of valency greater than two in the stems. The presence of these higher valency forms was demonstrated colorimetrically by the benzidine test and the amount present estimated spectrophotometrically as manganipyrophosphate and manometrically by the oxidation of hydrazine. It is suggested that the oxidation is due to peroxidase systems. Under toxic conditions of manganese supply the rate of oxidation of Mn^{2+} ions may exceed the rate of reduction of higher valency forms of manganese by plant metabolites, thus leading to the observed accumulation of manganese higher oxides. In other plants examined under similar conditions the accumulation of higher valency forms of manganese could not be demonstrated, possibly owing to the fact that in these plants they are reduced as fast as they are formed. It is suggested that the function of manganese as an essential element in plant nutrition depends, to some extent, on such valency change.

81. PIERPOINT, W. S. (1957). The phosphatase and metaphosphatase activities of pea extracts. *Biochem. J.* **65**, 67–76.

Pea extracts have a hexametaphosphatase activity, which is closely associated with an unspecific phosphatase. A variety of procedures, including protein precipitations, heat denaturation, absorption and ion-exchange chromatography, do not separate these activities or appreciably alter their ratio.

The phosphatase liberates orthophosphate from tripolyphosphate, trimetaphosphate, β-glycerophosphate, ADP and ATP, but not from tetrametaphosphate. It does not liberate phenol from diphenylphosphate.

The phosphatase is inhibited by fluoride and molybdate, but not by a variety of compounds that combine with SH– groups.

Ion-exchange chromatography of the phosphatase reveals two distinct enzymically active components. Each component can be separated from the other and rechromatographed as a single peak.

The two components are very similar in properties. They have the same pH optimum, are not affected by magnesium ions or chelating agents, have similar heat stabilities and differ only quantitatively in their specificities.

82. PIRIE, N. W. (1956). Unexploited technological possibilities of making food for man and animals. *Proc. Nutr. Soc.* **15**, 154–160.

A discussion of the factors that limit the use of leaves in human nutrition and of the techniques available for making edible protein concentrates from inedible leaves.

Some technical details of the equipment we use are given.

83. PIRIE, N. W. (1957). Macromolecular nucleoproteins from healthy tobacco leaves. *Biokhimiya.* (In the press.)

The microsome fraction made by ultracentrifuging extracts from healthy tobacco leaves contains ribonucleoprotein, ribonuclease, calcium and magnesium.

Particles with varying composition can be made by ultracentrifuging from fluids of different compositions, and this affects the stability of the particles and the rate at which they autolyse.

Plant virus preparations, made by gentle methods, contain similar particles.

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Plant Pathology Department

Book

84. BROADBENT, L. (1957). *Investigation of virus diseases of brassica crops.* (A.R.C. Report series No. 14.) Pp. ix, 94; 8 plates, 25 text figures. Cambridge University Press.

General Papers

85. BAWDEN, F. C. (1956). The transmission of plant viruses. (In: *Symposium on biological aspects of the transmission of disease.* Edinburgh: Oliver & Boyd.)

86. BAWDEN, F. C. (1956). The multiplication of plant viruses. (In: *The nature of viruses.* A Ciba Foundation symposium. London: Churchill.)

87. BAWDEN, F. C. (1956). Research on viruses and virus diseases. *J. R. agric. Soc.* **117**, 75–83.

88. BAWDEN, F. C. (1956). The impact of viruses on society. *Impact,* **7**, 85–101.

89. BAWDEN, F. C. (1956). Cure and prevention of virus diseases in plants. *World Crops,* **8**, 393–397.

90. BROADBENT, L. (1956). Keeping seed from your own potatoes. *Grower,* **45**, 31–32.

91. BROADBENT, L. (1956). Brassica virus diseases. *Agriculture, Lond.* **63**, 69–72.

92. GLYNNE, MARY D. (1957). Eyespot and take-all of wheat and barley. *Agric. Rev.* **2**, no. 10, 10–15.

93. HULL, R. (1956). Sugar Beet Yellows in Great Britain, 1955. *Plant Path.* **5**, 130.

94. KASSANIS, B. (1956). Effects of changing temperature on plant virus diseases. *Advanc. Virus Res.* **4**, 221–241.

95. KLECZKOWSKI, A. (1956). Effects of non-ionizing radiations on viruses. *Advanc. Virus Res.* **4**, 191–220.

96. WATSON, M. A. (1957). The specificity of transmission of non-persistent viruses. *Proc. 10th int. Congr. Ent.* (In the press.)

Research Papers

97. BAWDEN, F. C. (1956). Reversible, host-induced, changes in a strain of tobacco mosaic virus. *Nature, Lond.* **177**, 302–304.

A strain of tobacco mosaic virus already unusual in that it can infect leguminous plants systemically is even more unusual in that its properties depend on the identity of the host plant in which it has been produced. From systemically infected solanaceous plants, it closely resembles the type strain of tobacco mosaic virus, whereas obtained from systemically infected leguminous plants it is less infective towards, and produces a different type of local lesion in, *Nicotiana glutinosa,* has a different antigenic constitution, different electrophoretic mobility and is more susceptible to inactivation by ultra-violet radiation.

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98. BROADBENT, L., BURT, P. E. & HEATHCOTE, G. D. (1956). The control of potato virus diseases by insecticides. *Ann. appl. Biol.* **44**, 256–273.

Replicated trials in the years 1950, 1951, 1953 and 1954 showed that the spread of leaf-roll virus and virus Y in potato crops could be decreased by some insecticides. The crops were sprayed at intervals of 10 or 14 days, according to the stage of growth of the plants, with a tractor-mounted spraying machine at 100 gal./acre/application. DDT emulsion, DDT suspension, endrin, schradan, "Mipafox", malathion, parathion and "Systox" prevented the spread of leaf-roll virus and decreased the spread of virus Y. Dieldrin and toxaphene were ineffective.

99. BUXTON, E. W. (1956). Heterokaryosis and parasexual recombination in pathogenic strains of *Fusarium oxysporum*. *J. gen. Microbiol.* **15**, 133–139.

Mutants of *Fusarium oxysporum* f. *pisi* (cause of pea wilt), distinguished from the parent types by their different morphology, pathogenicity and nutritional requirements, were obtained by ultra-violet irradiation. Pairs of mutants with different nutritional requirements (auxotrophs) formed balanced heterokaryons on non-supplemented medium. Most of the auxotrophs were less pathogenic than the wild-types, whereas heterokaryons between the mutants were not.

Single conidia of a heterokaryon between an auxotroph from race 1 and one from race 2 of *Fusarium oxysporum* gave a small proportion (**3 in 10^8**) of colonies which were able to grow on non-supplemented medium. These three prototrophs were presumably diploid because vegetatively they gave new strains with various combinations of colour, nutritional requirements, actinomycete tolerance and pathogenicity.

The results indicate that, in fusaria, heterokaryosis plays a part in variation of virulence and that *Fusarium oxysporum*, which has no known sexual stage, has a system similar to the parasexual cycle described by Pontecorvo for certain other Fungi Imperfecti and that this permits the segregation and recombination of genetic factors.

100. BUXTON, E. W. (1957). Some effects of pea root exudates on physiologic races of *Fusarium oxysporum* Fr. f. *pisi* (Lindf.) Snyder & Hansen. *Trans. Brit. mycol. Soc.* **40**. (In the press.)

Exudates from the roots of the pea cultivars, Onward, Alaska and Delwiche Commando, which differentiate between three physiologic races of *Fusarium oxysporum* f. *pisi*, affected spore germination in the three races differentially, depressing the germination of races they resisted more than of those to which they were susceptible. Exudates from young seedlings depressed germination more than did those from roots of older plants, and the activity of exudates increased temporarily when side roots were first formed.

When concentrated root exudates were contained in porcelain cylinders on agar sown with spores, zones of differential growth formed around the cylinders; when the exudate was from a cultivar resistant to the race whose spores were plated, the zone was one of growth inhibition, and when from a susceptible cultivar, it was one of growth stimulation. Notwithstanding this effect on spore germination, exudates from the different cultivars had no differential effect on the rate at which germ tubes or mycelium of the individual races grew.

Sections through roots of cultivars inoculated with a race they resist showed that the mycelium invaded only the outer cortex.

Plants susceptible to *F. oxysporum* wilt less when simultaneously infected with *F. solani*; extracts of the bases of pea plants infected with *F. solani* inhibited the germination of spores of *F. oxysporum*, whereas extracts from normal stem bases did not.

101. HARRISON, B. D. (1956). The infectivity of extracts made from leaves at intervals after inoculation with viruses. *J. gen. Microbiol.* **15**, 210–220.

When leaves are macerated at intervals after being inoculated with plant viruses, the infectivity of the extracts obtained decreases with increasing

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time until newly produced virus becomes detectable. Infectivity does not start to increase until approximately twice the time apparently needed for virus to multiply in the epidermis and spread from there to the mesophyll. Epidermal cells infected by inoculation seem to produce too few virus particles to be detected by infectivity tests, or else the first-formed particles are unstable *in vitro*.

No evidence was obtained, with Rothamsted tobacco necrosis virus (RTNV) in leaves of tobacco and French bean, that the initial decrease in infectivity occurs because of changes in virus particles that succeed in infecting and causing lesions. If such changes occur they are obscured by the inactivation of particles that do not multiply and cause lesions. Washing inoculated leaves removes 95 per cent of the inoculated virus, but only slightly decreases the numbers of infections, and adding "Celite" to the inoculum greatly increases the numbers of lesions without increasing the amount of virus retained by washed leaves. Neither washing nor adding "Celite" to the inoculum affects the rate at which the infectivity of successive extracts from inoculated leaves decreases. Infectivity continues to decrease after virus appears to have multiplied in and spread from the epidermis.

Cells of *Nicotiana glutinosa* that are infected by tobacco mosaic virus spreading from inoculated epidermal cells die only a few hours after the infectivity of leaf extracts starts to increase; few cells seem to become infected from virus produced in these secondarily infected cells and, at 20°, infectivity reaches a maximum in 2 days. Mesophyll cells of French bean leaves at 22° seem to synthesize new RTNV particles within 5 hours of becoming infected from the epidermis and to continue synthesizing for another 30 hours, when they probably contain about 10^6 virus particles/cell. Although the cells then die, the virus spreads to further cells and the infectivity of leaf extracts increases for at least five days.

102. HIRST, J. M. & STEDMAN, O. J. (1956). The effect of height of observation in forecasting potato blight by Beaumont's method. *Plant Path.* **5**, 135–140.

Records of wet- and dry-bulb temperature made with distant-reading mercury-in-steel thermographs were analysed to compare the occurrence of Beaumont periods at two heights. The sensitive elements of the instruments were placed either in standard louvred screens 4 feet above ground or in crops, beneath well-ventilated shelters, level with the crests of the potato ridges and mid-way between two. Computation of relative humidity was simplified by examining the records beneath a transparent plastic grid.

Observations from 1951 to 1955 show that in dry summers crop instruments allow relatively late outbreaks of blight to be predicted more accurately, whereas in wet summers Beaumont periods more often occur at both heights simultaneously. In dry seasons there tend to be more periods in screens than in crops, because crop instruments are near to bare soil which heats quickly when dry.

103. KASSANIS, B. (1956). Serological relationship between potato paracrinkle virus, potato virus S and carnation latent virus. *J. gen. Microbiol.* **15**, 620–628.

Evidence is given that potato paracrinkle virus, potato virus S and carnation latent virus are serologically related and should be considered as related virus strains, although they differ considerably in their host range and pathogenicity, and only carnation latent virus is transmissible by aphids. It is suggested that the three have evolved from a common aphid-transmitted ancestor. In addition to the antigens the three have in common, each has many specific ones, and the two strains from potato are more closely related to one another than to the carnation virus.

No plant of the potato variety King Edward was found free from paracrinkle virus, and no Arran Victory plant free from virus S.

Minor variants of both paracrinkle virus and of virus S were detected: it is suggested that the variations in severity of symptoms developed when Arran Victory plants are grafted with King Edward scions reflect the various degrees to which different isolates interfere with each other's multiplication. Most isolates of virus S interfere only slightly with the multiplication of paracrinkle virus.

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104. KLECZKOWSKI, A. (1957). A preliminary study of tobacco mosaic virus by the gel diffusion precipitin tests. *J. gen. Microbiol.* **16**, 405–417.

A number of proteins can be separated from purified preparations of tobacco mosaic virus. They differ from each other antigenically, and all differ from the intact virus by not possessing all antigenic determinant groups possessed by the virus. Some of these proteins are easily detached from the virus by such mild treatments as placing it in a protein solution or in agar gel. These are antigenically identical with "*X*-protein" that remains in the supernatant fluid when the virus is sedimented by ultracentrifugation from sap of infected plants. More of these proteins are detached from the virus by placing it in boric acid–borax buffer at a pH about 8·7. When a more drastic treatment is applied, such as incubation at a pH about 10, when a proportion of the virus is disintegrated, still more of these proteins are released, but then some proteins antigenically different from those of "*X*-protein" are also released.

105. NIXON, H. L. (1956). An estimate of the number of tobacco mosaic virus particles in a single hair cell. *Virology*, **2**, 126–128.

The number of virus particles in a single hair cell from a systemically infected tobacco plant was estimated at 6×10^7 in a cell of about 250,000 μ^3, by counting virus particles in a section of known volume. Although inaccuracies are inseparable from such estimates, the figure is of the same order as that calculated from infectivity tests for the virus content of mesophyll cells in comparable leaves.

106. NIXON, H. L. & FISHER, H. L. (1957). An improved spray droplet technique for quantitative electron microscopy. *Brit. J. appl. Phys.* (In the press.)

Improvements are described to the spray droplet method of Backus and Williams (*J. appl. Phys.* **21**, 11 (1950)) for counting particles directly with the electron microscope. Decreasing the droplet size makes it possible to use much higher magnifications without sacrificing the ability to photograph each droplet trace entire on one frame, and droplets of the desired size are sorted and collected in a reproducible manner in a cascade impactor. The technique is also useful for studying the state of aggregation of a suspension.

Some factors affecting the accuracy of measurement of the polystyrene latex standard particles are discussed. Different methods yield different values, and there is at present no valid basis for selecting the best estimate.

107. NIXON, H. L. & WEIR, A. H. (1957). The morphology of the Unter-Rupsroth Montmorillonite. *Miner. Mag.* (In the press.)

For summary see no. 47.

108. SALT, G. A. (1957). Effects of nitrogen applied at different dates, and of other cultural treatments on eyespot, take-all and yield of winter wheat. *J. agric. Sci.* **48**, 326–335.

A field experiment to test effects of cultural treatments on eyespot (*Cercosporella herpotrichoides* Fron.), lodging and yield of winter wheat, begun in 1952, was continued on the same site in 1953. In 1952 only eyespot and lodging were severe, but in 1953 take-all (*Ophiobolus graminis* Sacc.) and weeds were severe also.

Squareheads Master 13/4 and Cappelle, each sown at 1½ and 3 bushels/acre, were top-dressed at four different dates with ammonium sulphate at 0, 2 and 4 cwt./acre. Sulphuric acid (12½ per cent B.O.V. at 100 gal./acre) was sprayed on 4 of the 8 blocks of 10 plots in March to control eyespot.

Halving the seed rate decreased the percentage of severe eyespot from 63 to 52 per cent, decreased the area stunted by take-all from 36 to 14 per cent and increased yield by amounts ranging from 8·3 cwt. in nitrogen-deficient plots to 2·6 cwt./acre in plots well supplied with ammonium sulphate. The fertilizer applied to Squareheads Master at 0, 2 and 4 cwt./acre had little effect on the incidence of eyespot lesions at harvest, but increased the area lodged from 28 to 53 and 60 per cent respectively; it decreased the area stunted by

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take-all from 47 to 19 and 10 per cent respectively, and increased yield from 13 to 17 and 18 cwt./acre. Cappelle did not lodge, and the fertilizer decreased take-all patches from 51 to 28 and 18 per cent respectively, and increased grain from 15 to 20 and 21 cwt./acre. The time when nitrogen was applied to either variety had no important effect on disease incidence or yield.

Sulphuric acid sprayed in 1953 on blocks unsprayed in 1952, and so having a higher initial infection of eyespot and weeds, decreased the area lodged and the area covered by weeds, but did not decrease the percentage of straws with eyespot below that in unsprayed plots.

109. THRESH, J. M. (1956). Some effects of tannic acid and of leaf extracts which contain tannins on the infectivity of tobacco mosaic and tobacco necrosis viruses. *Ann. appl. Biol.* **44**, 608–618.

The inhibition of infection by tobacco necrosis and tobacco mosaic viruses by tannic acid, and by extracts of raspberry and strawberry leaves, was associated with the precipitation of the viruses. Precipitation and inhibition were reversible, and infective virus was obtained from the precipitate formed between the viruses and tannins. Infectivity was fully restored by diluting mixtures of virus and tannin adequately and partially restored by adding alumina or nicotine sulphate.

Viruses and tannins are thought to form non-infective complexes, in which the virus and tannin components are held together by co-ordinate linkages or hydrogen bonds.

Macerating tobacco leaves infected with tobacco mosaic virus together with raspberry leaves greatly decreased the infectivity of the extracts; adding nicotine sulphate to the mixture of leaves before it was ground increased the infectivity, even though nicotine sulphate alone decreases the infectivity of tobacco mosaic virus. Even in the presence of nicotine sulphate, much of the virus was precipitated by substances from the raspberry leaves.

Extracts of roots of *Fragaria vesca* plants infected with a tobacco necrosis virus were more infective when made by macerating the roots with four times their weight of buffer at pH 8 than when made without buffer. Various methods are suggested for facilitating the transmission of viruses from plants that contain tannin.

110. TINSLEY, T. W. & RICHARDSON, D. E. (1956). Lucerne mosaic virus in potato—a new record for the British Isles. *Plant Path.* **5**, 133–134.

A strain of lucerne mosaic virus was found in apparently healthy potatoes growing in Northern Ireland. The virus was perpetuated in only a small percentage of tubers set by infected plants. French bean var. Prince is recommended as a test plant for identifying the virus.

111. WATSON, M. A. (1956). The effect of different host plants of potato virus C in determining its transmission by aphids. *Ann. appl. Biol.* **44**, 599–607.

A stock of potato virus C derived from Edgecote Purple potatoes in 1945 was not then transmitted by aphids, although more than 2,000 aphids were used in conditions optimal for transmitting the serologically related potato virus Y. This stock of virus C has been propagated continuously since, by manual inoculation in a series of *Nicotiana glutinosa* and *N. tabacum*, and in 1955 it was transmitted by the aphid *Myzus persicae* (Sulz.); about one in twenty of the aphids transmitted it compared with one in two for potato virus Y.

Virus C derived from the Edgecote Purple potatoes in 1955 was not transmitted by aphids; both stocks of virus C produced only local lesions in Majestic potato leaves, and gave similar symptoms in tobacco.

When inoculated to Majestic potatoes and then returned to tobacco plants, potato virus C usually ceased to be aphid-transmitted and did not recover this property in any of the subsequent subcultures.

Transmission from stock by aphids did not isolate a strain of virus C which was any more readily transmitted by aphids; indeed, for the first two or three subcultures, aphids usually transmitted more readily from plants

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inoculated manually. But the few isolates which remained aphid-transmissible after a second passage through potato were rather readily transmitted.

These results suggest that the ability of a virus to be aphid-transmitted is, at least in part, determined by the host plant in which it is multiplying, but the nature of the changes which determine this ability are unknown.

112. WATSON, M. A. & MULLIGAN, T. (1957). Cereal yellow dwarf virus in Great Britain. *Plant Path.* (In the press.)

A virus which appears to be cereal yellow-dwarf virus has been isolated from cereals and grasses in Great Britain. In a preliminary field experiment, yields of barley were reduced by 37 per cent when plants were infected on 25 April and 18 per cent when plants were infected on 3 May.

113. WATSON, M. A. & (RUSSELL, G. E.) (1956). The value of glasshouse tests with seedlings in selecting plants tolerant to beet yellows virus. *Ann. appl. Biol.* **44**, 381–389.

Commercial strains of sugar beet, and breeders' lines of *Beta vulgaris* and *B. vulgaris* subsp. *maritima*, were exposed to infection with SBY and SBYN strains of beet yellows virus, using varying numbers of *Myzus persicae* as vectors, so as to cause a wide range of symptoms. The severity of the symptoms was assessed by scoring for superficial veinal necrosis ("etch"). All varieties of sugar beet tested were susceptible to infection, but the severity of the symptoms varied, particularly between the cultivated and wild beet types.

The scores for severity of symptoms made in the glasshouse were positively correlated with similar scores made in a field experiment using two cultivated and two wild beet types. The symptom scores were also positively correlated with losses in root and sugar yields caused by the virus.

Nematology Department

114. DONCASTER, C. C. (1956). Some observations on the hatching responses of the cabbage-root eelworm, *Heterodera cruciferae* Franklin. *Ann. appl. Biol.* **44**, 283–291.

Larval emergence from cysts of *Heterodera cruciferae* was stimulated to a comparable degree by root diffusate from sprouts, swedes, rape-kale and white mustard. When mustard-root diffusate was added to leachings from the other species tested there was no apparent effect on larval emergence. For both sprouts and mustard-root diffusates, the hatching curves were similar in form. Estimates were obtained of the log activity values of leachings from the four species of plants and from soil.

115. DONCASTER, C. C. (1957). Growth, invasion and root diffusate production in tomato and black nightshade inoculated with potato-root eelworm. *Nematologica*, **2**, 7–15.

Comparisons were made between the variations in growth, root diffusate production and extent of root invasion by the potato-root eelworm, *Heterodera rostochiensis* Woll. in tomato (*Lycopersicon esculentum* Mill.) and black nightshade (*Solanum nigrum* L.). Nematode inoculation more seriously affected root development in tomato, the more favourable of the two hosts, than it affected black nightshade. Although both host species were invaded, the nematodes reached maturity only in tomato; they failed to develop beyond the third larval stage in nightshade. During the first month of the experiment, tomato bore the greater density and the greater total number of nematodes in the roots. Thereafter there was a decline, but the numbers in the nightshade roots continued to increase. The effect of nematode inoculation on tomato-root diffusate output was to cause an apparently permanent reduction, while on nightshade it merely delayed the peak production of root diffusate.

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116.* (DUDDINGTON, C. L.), JONES, F. G. W. & (MORIARTY, F.) (1956). The effect of predacious fungus and organic matter upon the soil population of beet eelworm, *Heterodera schachtii* Schm. *Nematologica*, **1**, 344–348.

In microplots containing soil very heavily infected with beet eelworm, an experiment was undertaken to test the effect of very heavy dressings of fungal mycelium and organic matter upon the yield of beet and the final eelworm population. Both fungus (*Dactylaria thaumasia* Drechsler) and organic matter (bran) increased yield. Fungus had no effect upon the final cyst population, but organic matter caused a significant depression. Neither affected the final egg population.

117.* (DUDDINGTON, C. L.), JONES, F. G. W. & (WILLIAMS, T. D.) (1956). An experiment on the effect of a predacious fungus upon the soil population of potato-root eelworm, *Heterodera rostochiensis* Woll. *Nematologica*, **1**, 341–343.

A microplot experiment was made to test the effect of a predacious fungus (*Dactylaria thaumasia* Drechsler) and three types of organic material (leaf mould, compost and chopped cabbage) upon potato-root eelworm. The initial population of the eelworm was low, and the treatments were without effect upon the yield of potatoes or upon the final cyst and egg populations.

118. FENWICK, D. W. (1956). The breakdown of potato-root diffusate in soil. *Nematologica*, **1**, 290–302.

In experiments on the stability of potato-root diffusate in soil, 90 per cent of the active principle was lost in four days in a medium-grade loam. Comparative tests with soil components showed that breakdown was most rapid in sand and gravel and slowest in peat; clay gave an intermediate value. When repeated applications of diffusate were made to a loam, successive breakdown curves were each steeper than the previous, suggesting the presence of a micro-organism capable of utilizing the active principle as a substrate. This is confirmed by results with sterilized loam; newly sterilized loam is known to inhibit the action of root diffusate but, on standing for about six weeks, it loses this property: if diffusate be applied to this, then the breakdown is slower than in untreated soil. This, in conjunction with the result in peat, adds considerably to the theory of breakdown by micro-organisms.

119. FENWICK, D. W. (1956). The production of sterile viable larvae of the potato-root eelworm, *Heterodera rostochiensis*. *Nematologica*, **1**, 331–336.

Experiments are described on the production of sterile infective larvae of the potato-root eelworm. A variety of antiseptics gave sterile larvae, but the latter were not infective. Attempts to sterilize the eggs proved difficult because of a mucoid layer around them preventing the antiseptic reaching the egg wall. Treatment with 20-volume hydrogen peroxide for 5–8 hours proved effective, and such treated eggs hatched in root diffusate sterilized by filtration. This is the first stage in an attempt to set up infestations of this eelworm in sterile plant tissue cultures in order to investigate the mechanism of host–parasite specificity.

120. FENWICK, D. W. (1956). Red Ring disease of coconuts in Trinidad and Tobago. Report to Colonial Office. (Mimeographed; in production.)

This is a report on the author's visit to Trinidad to investigate Red Ring disease of coconuts caused by the nematode *Aphelenchoides cocophilus*. Little evidence was found that weevils were important vectors, although they were important pests in their own right. It was considered probable that the worm gained entry into the roots from the soil and penetrated into the base of the trunk, thereafter migrating upwards to form the characteristic cylinder of reddened tissue. Although the disease primarily affects young trees, a number

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of older trees were found suffering from it, but its importance in this respect is uncertain. There is some evidence that dropped nuts may be a factor in spreading the infection.

121. FORSTER, A. R. (1956). The development of *Heterodera rostochiensis* and *Meloidogyne incognita* in cross-grafted solanaceous plants with different susceptibilities. *Nematologica*, **1**, 283–289.

Two experiments were done to find out whether cross-grafting resistant and susceptible solanaceous plants would affect the development of nematode parasites within their roots. First, cross-grafted plants of susceptible tomato (*Lycopersicum esculentum* Mill.) and resistant black nightshade (*Solanum nigrum* L.) were inoculated with larvae of *Heterodera rostochiensis* Woll. In these plants the larvae developed normally irrespective of the scion, cysts being found on plants with a tomato root-system and none on those with a *S. nigrum* root-system. Secondly, larvae of *Meloidogyne incognita* (Kof. & White) Chitwood, 1949, were inoculated into soil around the roots of cross-grafted plants of susceptible tomato and resistant *Lycopersicum peruvianum* (L.) Mill. Very few female nematodes were found in the plants with *L. peruvianum* root-systems. In plants with tomato root-systems many females were found, but the total numbers and the percentage of those with eggs were significantly lower on those with *L. peruvianum* scions than on the self-grafted tomatoes. Thus, while there was apparently no transference of susceptibility from the tomato scion to the resistant *L. peruvianum* rootstock, a scion of *L. peruvianum* decreased the susceptibility of a tomato rootstock to attack by larvae of *M. incognita*.

122. GOODEY, J. B. (1956). The susceptibility of potato varieties to infestation by the eelworms *Ditylenchus destructor* and *D. dipsaci*. *Ann. appl. Biol.* **44**, 16–24.

Twenty-five varieties of potato in common commercial cultivation were found to be susceptible to tuber attack by potato-derived populations of *Ditylenchus destructor* in experiments in fields and in pots. Stunting and leaf deformation may also be caused by the eelworms, but appear less consistently. A race of *D. destructor* from mushroom spawn had almost no effect on potatoes. Various races of *D. dipsaci* can reproduce in the shoot tissue of potato, sometimes causing damage. One population of this stem eelworm produced lesions on the tubers.

123. GOODEY, J. B. (1956). Observations on species of the genus *Iotonchium* Cobb, 1920. *Nematologica*, **1**, 239–248.

Three new species of *Iotonchium* described by Meyl in 1954 have been critically examined and redescribed. Species of *Iotonchium* show precocious development in the males, and the heads of the males change in shape at the final moult from a radial symmetry to a bilateral one, becoming tri-lobed with dorso-ventral flattening.

124. GOODEY, J. B. (1957). *Laboratory methods for work with plant and soil nematodes*. (3rd edition of T. Goodey, 1949 & 1951.) London : H.M.S.O.

In this third edition the original material has been rearranged and added to and some outmoded techniques omitted. There are sections on Collection and Extraction, Estimating *Heterodera* populations in the soil, Counting, Handling nematodes, Staining nematodes within plant tissues, Culture and Drawing nematodes. Two appendices give names of suppliers of apparatus and references to other techniques and equipment. There is an extensive bibliography and an index.

125.* JONES, F. G. W. (1956). Soil populations of beet eelworm in relation to cropping. II. Microplot and field plot results. *Ann. appl. Biol.* **44**, 25–56.

Experiments on specially constructed microplots were undertaken to

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overcome some of the difficulties associated with population studies using field plots. In these microplots Cruciferae caused greater increases in beet-eelworm populations than Chenopodiaceae when the initial population was low, and greater decreases when it was high. Non-hosts and inefficient hosts caused reductions of the same order as host plants in the same families.

When sugar beet was grown at varying initial populations, the final population tended to rise to a "ceiling" which varied with soil and season. The "ceiling" effect is also observed in the field and in pot tests, and may be used as a measure of the efficiency of different host plants or, if the same host plant is grown, as a measure of the effect of different soils and seasons. A linear relationship exists between the logarithm of the initial eelworm population and the yield of roots and tops.

Eelworm attack upon sugar beet renders the plants incapable of profiting from favourable growing conditions and reduces the size of the plants without affecting the percentage sugar content of the roots. Within certain limits, the final eelworm population is independent of yield or plant density. Cruciferae are far less susceptible to injury by root invasion than the cultivated varieties of *Beta vulgaris*.

It is suggested that host efficiency in raising and supporting eelworm populations and susceptibility to injury are distinct and independent attributes of host plants. Decay of populations in land under fallow or non-host crops in non-host families was approximately 20, 40 and 50 per cent per annum for cysts, cysts with contents and eggs respectively, and appears to be largely independent of initial population level. The average egg content of cysts with contents falls from 177 eggs/cyst in the first winter after the cultivation of a host crop to 131, 118 and 114 in the second, third and fourth respectively. The *in vitro* hatch from beet-eelworm cysts is affected by previous cropping. Low hatches are sometimes obtained in the winter and spring after the cultivation of host crops, especially where there has been considerable increase. A period of maturation appears to be necessary before eggs are fully sensitive to hatching stimuli.

The implications of the microplot results are briefly discussed. Population increase appears to be limited by intraspecific competition rather than by specific enemies. The development and decline of infestations follow a course similar to that in other pests, but, because of lack of mobility, the time factor is greatly extended. The differential effects of soil, season and host crop render set rotations ineffective as a measure of control once land has become generally infested. At this stage a system of advice based on soil sampling is described.

125*a*.* JONES, F. G. W. (1956). Soil population studies using microplots. *Nematologica*, **1**, 109–110.

A summary of the foregoing paper given at the Third International Nematology Symposium.

126.* JONES, F. G. W. (& MORIARTY, F.) (1956). Further observations on the effects of peas, beans and vetch upon soil population levels of pea-root eelworm, *Heterodera göttingiana* Liebscher. *Nematologica*, **1**, 268–273.

In microplot and garden-plot experiments peas caused marked rises in cysts and egg populations of pea-root eelworm. Vetch doubled the number of cysts but gave only a small increase in eggs. Field bean also nearly doubled the number of cysts but barely maintained the egg population. Longpod and Windsor beans caused relatively small increases in cyst numbers and reduced the egg populations. Despite the high initial egg populations of some plots, no symptoms of pea "sickness" appeared in 1955, probably because of the cool, moist weather during the growing period and possibly also because of the nitrogenous fertilizer applied to the plots.

127.* JONES, F. G. W. (& MORIARTY, F.) (1956). A preliminary experiment on the effect of various cereals on the soil population

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of cereal-root eelworm, *Heterodera major* O. Schmidt. *Nematologica*, **1**, 326–329.

In an experiment with microplots, oats and barley caused greater increases in cereal-root eelworm populations than did wheat. The highest population followed barley, variety Herta. A slight decline followed barley, variety Kron, and wheat, variety Bersee, both of which gave final populations significantly lower than most other cereal varieties tested. Because of the previous uniform treatment of the plots, population changes were adequately measured by cyst counts which gave greater precision than the egg counts.

128.* JONES, F. G. W. (1957). Sugar-beet pests. *Bull. Minist. Agric., Lond.* no. 162. (In the press.)

An illustrated bulletin for farmers giving the life history, biology and control of the more important insect and nematode pests of sugar beet and allied crops and incorporating the results of recent research.

129.* WALLACE, H. R. (1956). Soil aeration and the emergence of larvae from cysts of the beet eelworm *Heterodera schachtii* Schmidt. *Ann. appl. Biol.* **44**, 57–64.

Moisture content, pore size, depth and oxygen consumption in the soil, which influence soil aeration, have been studied in relation to larval emergence from cysts of the beet eelworm. Experiments show that the rate of larval emergence increases with aeration. In studies of larval emergence in the field, emphasis should be laid on soil structure rather than on a mechanical analysis. Those factors associated with good soil tilth favour high rates of larval emergence.

130.* WALLACE, H. R. (1956). The emergence of larvae from cysts of the beet eelworm, *Heterodera schachtii* Schmidt, in aqueous solutions of organic and inorganic substances. *Ann. appl. Biol.* **44**, 274–282.

The rate of larval emergence from cysts of the beet eelworm in a variety of aqueous solutions containing organic and inorganic substances is significantly higher than the emergence rate in water. It is suggested that differences between larval emergence rates in monoamino-monocarboxylic amino-acids may be related to the lipid solubility of these substances and their ability to penetrate the egg membranes. The larval emergence rate in fructose, glucose, sucrose and maltose was significantly higher than that in water, but in raffinose, arabinose and xylose the rate of emergence was no higher than in water. A high rate of larval emergence occurred in sodium chloride, potassium chloride and mercuric chloride, but not in magnesium chloride or calcium chloride. Experiments with several other organic solutions are described. There is an optimum concentration for larval emergence in beet diffusate. The osmotic pressure of the diffusate when maximum emergence occurred was 0·48 atm. Measurements of shrinkage of unhatched larvae in various concentrations of urea, sodium chloride and sucrose showed that decreasing rates of emergence at higher concentrations may be due to changes in the unhatched larvae brought about by an osmotic effect. High concentrations of beet diffusate may have a similar effect.

131.* WALLACE, H. R. (1956). Migration of nematodes. *Nature, Lond.* **177**, 287–288.

An apparatus is described for the study of the relation between the hydrostatic pressure-deficiency and the migration of *Ditylenchus dipsaci* in sand particles 200–400 μ and water. With an increase in the pressure-deficiency from 5 to 40 cm. of water the migration of the eelworm rose correspondingly; when the increase was greater than 40 cm. of water migration declined. At the pressure-deficiency for maximum mobility of 40 cm. of water in the sand particles about 25 per cent of the pore space is occupied by air. Experiments in progress suggest a similar relationship between the distribution of water in sand and the migration of *Heterodera schachtii*.

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132.* WALLACE, H. R. (1956). The effect of soil structure on the emergence of larvae from cysts of the beet eelworm. *Nematologica*, **1**, 145–146.

The influence of pore-size, moisture content and aeration on the emergence of larvae from cysts of the beet eelworm are discussed. A soil in good tilth which favours plant growth also favours larval emergence. In studies on larval emergence in the soil the influence of soil structure as distinct from soil type may be important.

133.* WALLACE, H. R. (1956). The seasonal emergence of larvae from cysts of the beet eelworm, *Heterodera schachtii* Schmidt. *Nematologica*, **1**, 227–238.

Field experiments in 1954 and 1955 showed that there was a high rate of larval emergence from cysts of the beet eelworm during April and May, followed by a low emergence rate from June to September. It is shown that low soil moisture content was probably the chief factor inhibiting emergence during the summer months. Larval emergence probably does not occur in soil where the pressure deficiency exceeds 150 cm. of water. Recording of pressure deficiency in four soil types during 1955 showed that from June to September the pressure deficiency was mostly above this level. A comparison of larval emergence from cysts within and between soil crumbs was made. At least 50 per cent of the cyst population occurred within crumbs, but the rate of larval emergence from these cysts was very low. It is suggested that when counts of cysts in soil are made a dispersing agent such as "Calgon" should be used to release cysts enclosed in soil crumbs.

134. WELCH, H. E. (1956). *Studies on a number of nematodes parasitic in insects.* Ph.D. Thesis, University of London.

This thesis gives the results of work on species of *Aphelenchoides* parasitic in *Drosophila* spp. and a critical review of the family *Mermithidae*.

Insecticides Department

GENERAL

135. LAST, F. T. (1956). Use of Antibiotics against plant diseases. *Nature, Lond.* **178**, 1330–1331.

136. LORD, K. A. (1956). Insect rearing and methods of testing insecticides. *Proc. biochem. Soc.* **63**, 35–36.

137. POTTER, C. (1956). Resistance of insects to insecticides: the effect of age and stage of development and nutrition. *Chem. & Ind.* (no. 42), 1178–1181.

138. POTTER, C. (1956). Resistance of insects to insecticides. *Nature, Lond.* **177**, 355–357.

139. POTTER, C., ELLIOTT, M. & WARD, J. (1956). Pyrethrins: a British viewpoint. *Pyrethrum Post*, **4**, 15.

140. WAY, M. J. (1956). A full crop of beans. *Fmr & Stkbreed.* 29 May, 57.

141. WAY, M. J., GLYNNE JONES, D. G. & JOHNSON, C. G. (1956). Work in England on the effect of insecticides and other chemicals used in plant protection on beneficial insects and insect populations. *Proc. 5th tech. Mtg int. Union Prot. Nature.* Copenhagen, 1954.

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Research

142. Broadbent, L., Burt, P. E. & Heathcote, G. D. (1956). The control of potato virus diseases by insecticides. *Ann. appl. Biol.* **44**, 256–273.

For summary see no. 98.

143. Last, F. T. & Hamley, R. E. (1956). A local-lesion technique for measuring the infectivity of conidia of *Botrytis fabae* Sardiña. *Ann. appl. Biol.* **44**, 410–418.

Discrete lesions developed when conidial suspension of *Botrytis fabae* Sardiña were rubbed with the forefinger on leaves of broad bean plants (*Vicia faba* L.) subsequently kept in a water-saturated atmosphere. The numbers of lesions which developed were directly proportional to the concentration of inoculum. At equal concentrations, conidia from young cultures produced more lesions than conidia from old cultures.

Variation in lesion numbers between plants within a pot always considerably exceeded the variation between opposite half-leaflets of a leaf, as did variation between pots and between leaves of old, but not of young plants.

As the standard error of the number of lesions developing per half-leaflet (x) increases as the mean increases, the values of x need to be transformed before being statistically analysed. A suitable transformation is

$$z = \log_{10}\tfrac{1}{2}[x + c + \sqrt{(x^2 + 2cx)}], \text{ where } c = 20.$$

144. Lord, K. A. & Solly, S. R. B. (1956). The rate of disappearance of paraoxon from two strains of houseflies. *Chem. & Ind.* (no. 45), 1352–1353.

A normal strain of housefly and one twice as resistant to poisoning by paraoxon were examined for differences in the *in vitro* inhibition of enzymes which hydrolysed acetyl choline, triacetin and phenylacetate respectively. No differences could be detected. *In vitro* tests failed to demonstrate the hydrolysis of paraoxon by housefly tissue extracts.

Tests on whole flies treated with paraoxon showed a rapid disappearance of the poison at apparently the same rate in both strains of flies. The disappearance of paraoxon was followed both by the inhibition of added cholinesterase and chromatographic methods.

145. Tattersfield, F. & Kerridge, J. (1957). The effect of repeated spraying of insects on their resistance to insecticides. IV. The effect of diet and of population factors upon resistance. *Ann. appl. Biol.* (In the press.)

(1) The effect of diet and population factors upon the resistance to DDT of a strain of adult *Drosophila melanogaster* have been investigated. Resistance was lowered by the omission of protein from the insects' diet, and raised by both bakers' yeast and casein (water-soluble and vitamin-free) added to an agar medium containing sugar solution (molasses, honey, dextrose). When yeast, both alive and dead, was added to the medium, the insects completed their reproductive cycle, whereas casein had little or no effect on their development, although the larvae were slightly larger than with sugar solution alone. When sugar alone and sugar plus casein were used, the larvae, from eggs laid by adults reared on a yeasted medium, remained undersized until they died before or during pupation. Yeast emulsion heated to 100° C. and added to an agar–sugar medium enabled the life cycle to be completed, but fewer adults were developed than with live bakers' yeast, and the resistance to DDT was less.

(2) Wild yeasts, such as *Sporobolomyces roseus* and N.C.Y.C. 365 (*Saccharomyces cerevisiae*—var. *ellipsoideus*), were effective food substitutes for bakers' yeast, and the resistance to DDT of adults fed on a medium on which *S. roseus* were grown, was somewhat higher than on that containing *S. cerevisiae*.

(3) Changing the adults to fresh media every few days induced higher resistance. The nearer the administration of fresh food to the date of spraying the higher the resistance, and this may have ameliorated the effect of ageing, particularly if the sexes were separated each day.

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(4) The separation of the sexes appeared to affect the males deleteriously, but the presence of larvae in the medium slightly increased the resistance of both sexes to DDT, possibly because the larvae broke up the surface of the medium.

(5) Population density of the larvae had a significant effect on the life cycle of *D. melanogaster*; the weight of the adult declining with density, and the length of the life cycle increased whether the adults or the larvae were overcrowded.

With the adults, lowering the population pressure of the females increased resistance to DDT until a relatively constant level was reached. With the males, the resistance measured at the L.C. 50 was higher if females were absent from the population and, except at the highest densities, appeared to be independent of numbers.

The effect of increased population density of the larvae was to increase resistance to DDT of the resulting adults. This might be correlated to some extent with decline in size, but only within certain limits, and the indications were that a more intense selection had taken place with increasing density.

Entomology Department

Book

146. Barnes, H. F. (1956). *Gall midges of economic importance.* Vol. VII : *Gall Midges of Cereal Crops.* London : Crosby Lockwood and Son Ltd.

General Papers

147. Barnes, H. F. (1956). Gall midges as pests of farm crops. *Agriculture, Lond.* **63**, 265–267 and 336–339.

148. Johnson, C. G. (1956). Changing views on aphid dispersal. *N.A.A.S. quart. Rev.* **32**, 62–67.

149. Johnson, C. G. (1956). Ecological aspects of aphid flight and dispersal. *Rep. Rothamst. exp. Sta. for* **1955**, 191–201.

150. Mellanby, K. (1956). Acclimatization in insects. *Sci. News, Harmondsworth,* **40**, 71–77.

Research Papers

151. Banks, C. J. (1956). The distributions of coccinellid egg batches and larvae in relation to numbers of *Aphis fabae* Scop. on *Vicia faba.* *Bull. ent. Res.* **47**, 47–56.

152. Banks, C. J. (1956). Observations on the behaviour and mortality in Coccinellidae before dispersal from the egg shells. *Proc. R. ent. Soc. Lond.* (*A*), **31**, 56–60.

153. Banks, C. J. (1956). A second record of a tachinid parasite bred from one of the Coccinellinae (Col., Coccinellidae). *Ent. mon. Mag.* **92**, 188.

154. Carter, C. I. (1956). Massing of *Tetranychus tiliarum* (Hermann) (Acarina, Tetranychidae) on the trunks of Lime Trees. *Ent. mon. Mag.* **92**, 73–74.

155. Dobson, R. M. (1956). A new species of *Carpophilus* Stephen (Col. Nitidulidae) associated with stored products. *Ent. mon. Mag.* **92**, 41–42.

A description of a new species of the *C. dimidiatus* (F.) complex emanating from the U.S.A., Brazil and Morocco.

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156. DOBSON, R. M. (1956). A note on the relative abundance of flea beetles (*Phyllotreta* Stephens and *Psylliodes* Berthold) on different cruciferous crops. *J. hort. Sci.* **31**, 291–294.

Differences in compositions and densities of flea-beetle population of different adjacent cruciferous crops are noted and discussed.

157. DOBSON, R. M. & LOFTY, J. R. (1956). A simple cage for comparing small insects during experimental exposure to fumigants, etc. *Ent. mon. Mag.* **92**, 157–158.

Small cages made of washers and fine metallic gauze are described.

158. DOBSON, R. M. & LOFTY, J. R. (1956). Observations on the effects of BHC (Hexachlorocyclohexane) on the soil fauna of arable land. *Rep. 6th int. Congr. Soil Sci.* **C**, 203–205.

Some effect on the soil fauna of applying BHC to the soil of a four-course rotation are discussed.

159. DOBSON, R. M. & (SATCHELL, J. E.) (1956). *Eophila oculata* at Verulamium; a Roman earthworm population? *Nature, Lond.* **177**, 796–797.

During archaeological excavations living worms were found amongst layers of blackened organic material in a filled-in Roman ditch between 8 and 15 feet below ground level. The circumstances suggested that they may have been breeding there since the ditch was filled in during Roman times.

160. FRENCH, R. A. (1955). Migration records 1954. *Entomologist*, **88**, 123–130.

161. FRENCH, R. A. (1956). Migration records 1955. *Entomologist*, **89**, 139–145, 174–180.

162. FRENCH, R. A. (1956). Insect migration in 1955. *Countryside*, **17**, 462–465.

163. JOHNSON, C. G. (1956). Distribution and dispersal of aphids in the air. *Mitt. biol. BundesAnst. Berl.* **85**, 22–23.

164. JOHNSON, C. G., SOUTHWOOD, T. R. E. & ENTWISTLE, H. (1957). A new method of extracting arthropods and molluscs from grassland and herbage with a suction apparatus. *Bull. ent. Res.* (In the press.)

165. MELLANBY, K. (1956). Mosquito populations at Ibadan in Nigeria. *Bull. ent. Res.* **47**, 125–136.

For over 2 years 70 earthenware pots filled with water were exposed in different types of environment. Every 5 days the water was strained, all mosquito larvae being removed, counted and identified. Data showing fluctuations in numbers of *Anopheles gambiae*, *Aedes aegypti*, *Lutzia tigripes* and various Culicines are given. The limitations of this and other sampling techniques are discussed.

166. MELLANBY, K. & FRENCH, R. A. (1957). Some effects of changes of temperature and of the physical nature of the environment on the activity and behaviour of mealworm larvae (*Tenebrio molitor*). *Brit. J. Anim. Behav.* **5**. (In the press.)

167. MILNE, D. L. (1956). Gall midges affecting seed production in clover. *Ann. appl. Biol.* **44**, 669–670.

168. MURPHY, P. W. (1956). A modified funnel method for extracting soil meiofauna. *Rep. 6th int. Congr. Soil Sci.* **C**, 255–262.

Details of the split-funnel extractor, a modified funnel method for extracting soil fauna are given, together with results of an experiment to test the

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apparatus, and the effect of sample treatment on extraction efficiency. With heathland samples best results are obtained when litter and raw humus are extracted separately, the latter in thin layers (1·3–1·9 cm.), in an undisturbed condition. There is little difference between room temperature and a heated funnel (air temperature 30–35° C.) for extraction of litter, although with raw humus the latter is more effective.

Both desiccation and temperature appear to be important factors in the process. Treatment results indicate the importance of a temperature stimulus in the early stages of extraction, and that good recovery will depend upon striking a balance between a temperature which, although not providing a too rapid drying rate, is sufficient to cause a definite negatively thermotactic response.

169. MURPHY, P. W. (1956). Soil faunal investigations. *Rep. For. Res., Lond. for* **1954/55**, 83–84.

170. MURPHY, P. W. (1956). Soil-fauna systematics. "Die Nordost-Alpen im Spiegel ihrer Landtierwelt", by H. Franz [Review]. *Soils & Fert.* **19**, 4–6.

171. RAW, F. (1956). The abundance and distribution of Protura in grassland. *J. Anim. Ecol.* **25**, 15–21.

Using a flotation method, 1,425 Protura were extracted from 90 soil samples taken from selected Park Grass plots at Rothamsted in October 1950. Of these 85 per cent were identified as *Proturentomon minimum* (Gisin), the rest as a species of Eosentomon, probably *E. armatum* Stack.

The Protura were aggregated in such a way that the majority of individual sample counts fell within the range one-half to twice the geometric mean of the population. The degree of aggregation appeared to be independent of the population density. Their distribution was associated with conditions induced by liming. Both species were correlated with exchangeable calcium. *P. minimum* was also correlated with soil pH and the abundance of *Helicotrichon*, *Trisetum* and *Dactylis* spp. The significance of their aggregation and distribution is briefly discussed.

172. STOKES, B. M. (1956). A chemotactic response in wheat bulb fly larvae. *Nature, Lond.* **178**, 801.

A method of growing young wheat plants in petri dishes of sodium alginate jelly for use in testing the larval reactions of wheat bulb fly is described.

In a series of experiments, cubes of this jelly, taken without including any part of the wheat plant, were placed on damp filter-paper in a closed petri dish together with similar cubes taken from a dish in which no wheat had been grown. Newly hatched wheat bulb fly larvae were placed centrally and moved into the "wheat-jelly" cubes, but they failed to show any reaction towards the non "wheat-jelly" cubes. It is possible that a response to some such stimuli may enable the larvae to find their host plants, and the paper outlines further lines of investigation.

173. STOKES, B. M. (1957). Observations and experiments on the Hessian Fly (*Mayetiola destructor* Say). *Ann. appl. Biol.* **45**, 122–132.

Experiments showed that a stem midge collected at Rothamsted on *Agropyrum repens* and similar midges on wheat, barley and rye were of the same species, *Mayetiola destructor* Say. There were three main flights per year, with some overlapping of the generations. In experiments, *Aegilops ovata*, *Triticum compactum*, *T. dicoccoides*, *T. durum*, *T. spelta* and *T. turgidum* were successfully used as host plants besides wheat, barley, rye and couch grass. Individual female midges when moved from plant to plant gave rise to families on the different host plants; similarly, succeeding generations of midges were able to breed on various host plants other than those from which they themselves were reared. Oviposition also took place on plants on which larvae failed to establish themselves. In experiments, wheat was a more favourable host plant for developing larvae than couch grass, both when the parent midges had themselves been collected from couch grass and when

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laboratory stocks with predecessors from a number of host plants were used as parents. More midges were reared from young plants than from mature ones.

Unisexual families occurred in about half the experiments. The following parasites were bred: *Trichacis didas* Walker, *Eupteromalus* ? *hemipterus* Walker, *Platygaster* sp., *Chrysocharis* sp. and *Tetrastichus* sp.

174. WILLIAMS, C. B., COMMON, I. F. B., FRENCH, R. A., MUSPRATT, V. M. & WILLIAMS, M. C. (1957). Observations on the migration of insects in the Pyrenees in the autumn of 1953. *Trans. R. ent. Soc. Lond.* (In the press.)

Observations were made on extensive movements to the south of many species of Lepidoptera and Diptera at several localities in the Pyrenees; there was little evidence of a similar movement of Odonata.

Bee Department

RESEARCH PAPERS

175. BAILEY, L. (1956). Aetiology of European Foul Brood; a disease of the larval honeybee. *Nature, Lond.* **178**, 1130 only.

The method of culture of *Streptococcus pluton* is described, and a summary is given of experiments showing that this disease appears to be caused by the simultaneous growth of *S. pluton* and *Bacterium eurydice*.

176. BAILEY, L. (1956). A device for collecting samples of bees. *Bee World*, **37**, 70–71.

A description is given of a simple hand-operated suction device which enables the operator to collect up to 200 live bees from a hive in 15–30 seconds.

177. BAILEY, L. & CARLISLE, E. (1956). Tests with acaricides on *Acarapis woodi* (Rennie). *Bee World*, **37**, 85–94.

Full details are given of laboratory and field trials with various acaricides including the newer di-(*p*-chloro-phenyl) derivatives. The use of the latter, applied as a smoke, during warm weather has been found very effective; much benefit is achieved by a single treatment, and elimination of infection is possible by two treatments.

178. BUTLER, C. G. & (HAIGH, J. C.) (1956). A note on the use of honey-bees as pollinating agents in cages. *J. hort. Sci.* **31**, 295–297.

Equipment is described which makes it possible to use a colony of honey-bees to pollinate plants in a screen-cage in the field without contamination from unwanted pollen and without heavy loss of bees. The hive is sited outside the cage, and the bees can be directed either into the cage or into the open air by adjustment of a simple slide and without opening the hive.

179. BUTLER, C. G., FREE, J. B. & SIMPSON, J. (1956). Some problems of red clover pollination. *Ann. appl. Biol.* **44**, 664–669.

The abilities of bumblebees and honeybees to pollinate red clover are discussed, and the various methods that have been employed in attempts to increase the numbers of these insects visiting red clover fields are reviewed. Owing to the difficulties and uncertainty of success of the methods so far devised, it is suggested that efforts should be made to determine whether insufficient pollination is, in Britain, an important cause of poor red clover seed yields.

180. BUTLER, C. G. & SIMPSON, J. (1956). The introduction of virgin and mated queens, directly and in a simple cage. *Bee World*, **37**, 105–114.

It was found to be much easier to introduce a queen to a colony from which a similar queen (virgin, mated, etc.) had just been removed than to one

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from which a dissimilar queen had been taken. When a large-mesh cage was used to introduce mated tested queens, without attendants or food, to colonies which had just been dequeened, at least 90 per cent success could be obtained when the queens removed were mated and laying, and at least 80 per cent when they were virgin. The successes achieved with various types of queens and colonies, at different times of year, both by direct and cage introduction, are discussed.

181. FREE, J. B. (1955). The collection of food by bumblebees. *Insectes soc.* **2**, 303–311.

Data are given on the time factors involved in the collection of food by bumblebees. The uptake of sugar syrup by worker bumblebees was investigated in order to obtain information about the collection of nectar by foragers under natural conditions.

182. FREE, J. B. (1956). A study of the stimuli which release the food begging and offering responses of worker honeybees. *Brit. J. Anim. Behav.* **4**, 94–101.

Excised heads alone are sufficient to release the food begging and offering responses of worker honeybees. Bees beg from the lowest part of a head irrespective of its orientation. The antennae on a head provide a contact stimulus with a releasing function, and their effect can be simulated by the use of "model" antennae. The scent of a head is an important stimulus, and heads possess a greater releasing value if taken from bees belonging to the same colony as that of the offering and begging bees. Whereas movement appears to play no part in releasing the begging response, it is significant in releasing the offering response. Bees whose antennae had been removed were able to offer food but not to beg for it. Both food begging and offering are innate reactions which improve in precision with age independent of conditioning.

Statistics Department

GENERAL PAPERS

183. BOYD, D. A. (1956). Fertilizers can be used to better effect. *Times Agric. Rev.* Spring 1956, p. 5.

184. BOYD, D. A. (1956). Sugar-beet manuring: a re-examination of the experimental data. *Brit. Sugar Beet Rev.* **25**, 19–22.

185. (TANNER, J. M.) & HEALY, M. J. R. (1956). The genetics of human morphological characters. *Advanc. Sci.* **13**, 192–194.

RESEARCH PAPERS

186. BOYD, D. A. (1956). The effect of potash on crop yield. *Potassium Symposium*, 1956. (In the press.)

The paper brings together the results of a large number of annual experiments carried out in Great Britain on the effect of potash on crop yield. Expressed as a percentage of the mean yield, the largest responses were obtained from potatoes, and somewhat smaller responses from root crops and beans; in general, the effect of potash on cereals was small. Responses in Scotland were approximately double those obtained in England.

The average effects of potash obtained from a four-course rotation experiment at Saxmundham and of six-course rotation experiments at Rothamsted and Woburn are also discussed. At Saxmundham, where the fertilizer treatments are repeated annually on the same plots, beans and clover were more sensitive to shortage of potash than wheat, mangolds or barley. At Rothamsted and Woburn, where substantial maintenance dressings of potash were applied during the rotation, only potatoes at Rothamsted gave substantial responses.

The interactions of potash with farmyard manure and with other fertilizers are briefly discussed.

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187. Boyd, D. A., Garner, H. V. & Haines, W. B. (1957). The fertilizer requirements of sugar beet. *J. agric. Sci.* (In the press.)

The paper describes the results of over 300 factorial experiments carried out in each factory area in the years 1934–49 for the Sugarbeet Research and Education Committee of the Ministry of Agriculture as a result of co-operation between Rothamsted workers and the agriculturists and fieldmen attached to the beet factories. All the experiments tested the effects of levels of nitrogen, phosphate and potash, and rather more than half tested the effect of salt also.

Except on fen soils, nitrogen gave substantial responses in all factory areas, especially in the presence of high levels of potash or salt. Large variations in response from season to season were closely associated with the rainfall of the preceding winter months, responses being greater after wet winters than dry ones.

In spite of some selection of sites in favour of greater responses, the average net returns from phosphate were relatively small.

The effect of potash was closely linked with the amount of nitrogen applied; in the presence of nitrogen, dressings well above the level of 1·2 cwt. K_2O/acre tested in the experiments are likely to give a useful net return. Soils derived from the Chalky Boulder Clay seem to be exceptional in showing no response. Apart from this, there were only small variations in responses to nitrogen and potash between factory areas. The application of 5 cwt. salt gave substantial responses in almost all parts of the country, whether or not potash was also applied; on the other hand, responses to potash were usually small when salt was also applied.

Whilst there was a general relationship between soil analysis for phosphate and potash (citric acid method) and crop response, adjustments to the optimal dressings according to soil analysis were not of sufficient reliability to be of much practical value.

188. Boyd, D. A. (1957). The manuring of sugar beet. *J. agric. Sci.* (In the press.)

Information on how growers actually manure their crops is available from the Survey of Fertilizer Practice, carried out by the Provincial Soil Chemists of the National Agricultural Advisory Service, in collaboration with Rothamsted. These data indicate that, taking into account the nutrients in farmyard manure, the average amounts of nitrogen and potash applied are not far from the optimal amounts suggested by experiment, whilst phosphate dressings are on the average at least double requirements. This may be due in part to the fact that few compounds are available with a low ratio of phosphate to other nutrients.

189. Boyd, D. A. (1957). A scrutiny of the British potato crop. *Operat. Res. Quart.* **8**, 6–21.

The paper describes an example of the application of operational research to agricultural problems, based on the Survey of Maincrop Potatoes and on summaries of experiments on aspects of potato husbandry carried out by members of the Rothamsted staff.

Except in one or two factory areas, the use of salt on sugar beet is still very limited.

190. Boyd, D. A. (1956). Weedkiller usage in England and Wales: Information from surveys of farm practice. *Rep. 3rd British Weed Control Conf.* (In the press.)

In the course of surveys of fertilizer practice, information has been obtained from a considerable number of counties in England and Wales on the use of weed-killers on farm crops. In the years 1954–56 between one-third and two-thirds of the cereal acreage in the arable districts of eastern and northern England has been sprayed annually with some form of weed-killer. Whilst the use of weed-killing sprays is most widespread in arable districts, recent surveys in Gloucestershire, Somerset and Wiltshire show that even in some typical dairying districts the practice of spraying cereals is becoming

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common. In Wales and much of the south-west, however, the use of weed-killers is still exceptional, none of the surveyed areas having more than a tenth of their cereal crops sprayed. All but one-tenth of the cereal acreage in the surveyed counties in 1955–56 were sprayed with MCPA. Sowing of undersown cereals was rare in 1954, but is now becoming widespread. The use of weed-killers on peas grown for human consumption has increased rapidly, half the acreage being treated in some of the surveyed districts.

191. (BULLEN, E. R.) & LESSELLS, W. J. (1957). The effect of nitrogen on cereals. *J. agric. Sci.* (In the press.)

Average standardized responses of the yields of wheat, barley and oats have been estimated from the results of 270 experiments carried out during the last decade in England and Wales.

With the exceptions noted below, wheat and barley crops have produced an average grain response of 3·0–3·5 cwt./acre to a standard dressing of 0·25 cwt. N/acre; this agrees well with earlier results obtained by Crowther and Yates. The widely grown winter wheat varieties, Hybrid 46, Cappelle Desprez, Bersee and Nord Desprez each produced an average response of more than 4·0 cwt./acre to the standard dressing. Of the spring barleys, Kenia, Proctor and Herta are also of greater than average responsiveness. The average response of spring oats to the standard dressing was only 1·2 cwt./acre.

The number of experiments is insufficient to allow precise conclusions to be drawn on the effect of autumn dressings, but the evidence suggests that in the drier Eastern Counties autumn nitrogen may give as good a response as the equivalent spring applications. Small dressings of nitrogen provide equal responses whether applied early or late in spring; larger applications need to be applied in early spring (March or April) to obtain the highest yields. There is no evidence that divided dressings are more responsive than a single dressing applied early in spring.

For the highly responsive varieties of winter wheat and spring barley a dressing of 0·6–0·7 cwt. N/acre is recommended, producing a net return of about £10 per acre. For other wheat and barley crops a recommended dressing of 0·5 cwt. N/acre produces a net return of about £5 per acre.

192. CHURCH, B. M. (1956). Cereal varieties grown in England and Wales, 1952–54. *J. nat. Inst. Agric. Bot.* (In the press.)

The cereal varieties grown by farmers were recorded in the course of fertilizer surveys on random samples of farms in England and Wales during 1952–54. This note summarizes the information obtained, indicating the relative popularity of the different cereal varieties.

193. (FISHER, R. A.) & HEALY, M. J. R. (1956). New tables of Behrens' test for significance. *J. R. statist. Soc. B*, **18**, 212–216.

An explicit expression for the probability integral involved in Behrens' test of significance for the difference between two means is developed for the case when both numbers of degrees of freedom are odd. This has been used to tabulate the significance points for very small samples.

194. (FOSTER, G.) & REES, D. H. (1957). Upper percentage points of the generalized beta distribution. *Biometrika.* (In the press.)

The upper percentage points of the generalized beta distribution have been tabulated. These tables can be used for tests of significance in multivariate analysis.

195. HEALY, M. J. R. (1957). A rotation method for computing canonical correlations. *Math. Tab., Wash.* (In the press.)

This paper describes a technique for computing simultaneously all the canonical correlations and the corresponding linear functions of the variates from a sample of $(p + q)$-variate data. The method is analogous to the Jacobi rotation method for computing latent roots and vectors of a symmetric matrix.

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196. (ASHTON, E. H.), HEALY, M. J. R. & LIPTON, S. (1957). The descriptive use of discriminant functions in physical anthropology. *Proc. roy. Soc. B.* (In the press.)

This paper describes a large-scale analysis of measurements on the teeth of humans and the great apes undertaken to clarify the relation to these groups of the recently discovered fossil anthropoids. Several measurements were taken on each tooth; the method of presentation involved the construction of a few linear functions of the measurements which provided the best discrimination between the groups. In all the teeth studied, two such functions effectively contained all the available information, and the positions of the groups could then be indicated on a plane diagram on which the fossil teeth could also be plotted. It was also possible to test whether the fossils actually lay close to the plane defined by the extant groups. In this way, the overall situation is much easier to appreciate than when the measurements are considered one at a time. The fossils studied included *Pithecanthropus pekinensis*, *Proconsul spp.* and representatives of the Australopithecinae, and the relations of these to the extant groups are discussed.

197. LEECH, F. B., (EGDELL, J. W. & THOMAS, S. B.) (1956). A survey of methods of milk production. II. Statistical analysis of bacteriological tests on milk samples. *J. agric. Sci.* **48**, 187–193.

The results of a survey of the methods of milk production on a random sample of farms in four counties of England and Wales were used in conjunction with bacteriological and keeping-quality tests of the milk produced, to estimate the influence of factors in equipment and technique on milk quality.

Of the many factors in technique investigated, only the cooling of the milk and the sterilization of utensils appeared to affect milk quality. The effects of these two factors differed in some degree with the four tests used.

Milk samples from machine-milked herds had significantly greater thermoduric colony counts than samples from hand-milked herds. No other factor of equipment showed appreciable association with milk-quality tests.

Brief recommendations are made about the conduct of any future field survey of factors affecting bacteriological and keeping quality of milk.

198. LIPTON, S. (1957). Some statistical applications of electronic computers. *Appl. Statist.* (In the press.)

The paper describes in general terms some of the work that has been carried out by the Statistics Department at Rothamsted Experimental Station, using an electronic computer.

199. LIPTON, S. (1957). Two programming techniques for one-plus-one address computers. *J. Ass. Comput. Machinery.* (In the press.)

A general description is given of a routine for printing programmes in logical order. The routine provides a powerful method of detecting certain types of error in the examined programme. The paper also describes the use of a special form of link order for which only some of the digits have their normal connotations, the remainder specify parameters.

Both techniques are suitable for one-plus-one address computers.

200. (PATERSON, A. B., STUART, P.) & LEECH, F. B. (1957). The use of tests on slaughterhouse cattle for estimating relative potencies of tuberculins and for the calculation of discrimination tests. *J. Hyg., Camb.* (In the press.)

The potency of PPD tuberculin made from AN5, a bovine strain, was high when WR medium was used and low when BAI medium was used. PPD tuberculin made from strains of the human type grown on BAI medium was intermediate in potency between the two bovine PPDs.

The standard deviation of the difference between responses to duplicate injections of human type PPD at 2·0 mg./ml. concentration was $\pm 2{\cdot}59$ in the Islington and $\pm 1{\cdot}84$ in the Weybridge experiment on tuberculous animals, and $\pm 1{\cdot}11$ at Islington and $\pm 1{\cdot}13$ at Weybridge on tubercule-free animals.

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Differences greater than 1·5 mm. were relatively infrequent on tubercule-free animals.

The Elliott 401 electronic computer at Rothamsted was used to calculate discriminant functions and to estimate the discriminating power of different "tests", each test involving an injection of a mammalian and an injection of avian tuberculin.

There were some differences between the mammalian preparations in their power to discriminate between tuberculous and tubercule-free animals, but these differences were closely allied to differences in potency. It seems probable that if concentrations of equivalent potency were used there would be little if any difference in their discriminating power.

The contribution of avian tuberculin to the discrimination test was demonstrated; the greatest contribution came from a concentration of 0·25 mg./ml. used in the Islington experiment. The Weybridge results were quite consistent with the assumption that a maximum contribution is made by a concentration less than 0·5 mg./ml.

Methods for deducing rules for the interpretation of comparative tuberculin tests (using a mammalian and an avian tuberculin) are demonstrated and results given for the type of population sampled in these experiments. The principle on which this rule might be modified where the population is believed to be free of infection is outlined and discussed.

201. PATTERSON, H. D. (1957). The analysis of a non-replicated experiment involving a single four-course rotation of crops. *Biometrics*. (In the press.)

This paper considers the estimation of the errors of an unreplicated four-course rotation experiment on the residual effects of various organic and phosphatic treatments. Separate estimates of plot error and plots × years error are obtained from the year-to-year variances of selected contrasts known to be small in magnitude. As a result of the lack of replication plot totals are not orthogonal with certain treatment comparisons which cannot be ignored. This difficulty is resolved by replacing the plot totals by quantities exhibiting the required property of orthogonality. The separation of blocks × years in the analysis of variance is shown to be unnecessary in this particular experiment.

202. (RHYS, I. W., CULPIN, S., FORSYTH, G. E.) & WESTMACOTT, M. H. (1957). Diets for laying fowls. An experiment testing the use of home-grown grains, and comparing protein from animal and vegetable sources as supplements to ground whole cereals. *Exp. Husb.* no. 2, 50–68.

The results of an experiment lasting three years at Gleadthorpe Experimental Husbandry Farm are presented and discussed. Four diets were compared in four different systems of housing, using a total of 7,371 hens. A diet consisting mainly of home-grown grains was as satisfactory for egg production as one containing 25 per cent of imported maize and wheat offals. A diet containing no animal protein gives 15 per cent fewer eggs in the year than a diet containing 10 per cent of fish meal, when the birds were housed in batteries. There was no difference, however, when the birds were housed in colony houses or in folds. A diet containing only 2 per cent of fish meal was slightly inferior to that containing 10 per cent of fish meal in the batteries, and was quite adequate under other conditions.

203. (SCHOFIELD, R. K.) & REES, D. H. (1956). Calculation of membrane pressure for a sol of spherical particles. *J. Colloid. Sci.* **11**, 617–622.

For summary see no. 34.

204. WESTMACOTT, M. H. & (WHITWELL, A. W.) (1957). Some experiments on the feeding of procaine penicillin to pigs. *Exp. Husb.* no. 2, 43–49.

Five trials on the feeding of penicillin to pigs are reported, and the results are compared with those of a series of experiments carried out under the aegis of the Agricultural Research Council in 1951–52. Taking the results of the

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two sets of trials together, the gain in rate of growth from feeding penicillin in the fattening period, to pigs which have not had it in the creep, was about 8 per cent, and the saving in food consumption per lb. weight gain about 5 per cent. There appeared to be very little effect from feeding penicillin in the creep to normal litters.

205. YATES, F., HEALY, M. J. R. & LIPTON, S. (1957). Routine analysis of replicated experiments on an electronic computer. *J. R. statist. Soc. B.* (In the press.)

Since the installation of the electronic computer at Rothamsted, programmes have been written for analysing the common types of experimental design, and a large number of analyses are now carried out annually. The paper describes the methods used in the analyses and the organization of the input of data and of the presentation of the results.

206. YATES, F. & LIPTON, S. (1957). An automatic programming routine for the Elliott 401. *J. Ass. Comput. Machinery.* (In the press.)

The paper gives a brief description of an automatic programming routine developed for the Elliott 401 computer. This routine permits the orders to be written in a simplified code without specification of the address of the next order. These orders are then recoded by the machine in such a manner that all the standard conditions required by the programming rules are satisfied and the timing is reasonably optimal. At the same time any definite or probable errors which can be detected from internal evidence are indicated.

TABLES

207. (FISHER, R. A.) & YATES, F. (1957). *Statistical tables for biological, agricultural and medical research.* 5th Edition. Edinburgh : Oliver & Boyd.

REVIEW

208. HEALY, M. J. R. (1956). "Principles and practice of field experimentation", by J. Wishart and H. G. Sanders. 2nd Edition. *J. R. statist. Soc. A*, **119**, 89.

REPORTS

209. DUNWOODY, J. H. A. & (THOMSON, D. C. G.) (1956). Report on plant distribution yield trials 1954 and 1955. British Sugar Corporation Ltd. *Comm. Pap. Sugar Beet Res. Comm.*, 411.

210. LEECH, F. B. (1956). The testing of drugs intended for use against trypanosomiasis. Colonial Office duplicated report, TFTC(CP)(O)(56)2.

211. SIMPSON, H. R. (1957). The effect of sterilized males on a natural tsetse fly population. Report to Colonial Office.

Soil Survey of England and Wales

212. AVERY, B. W. (1956). A classification of British soils. *Rep. 6th int. Congr. Soil Sci.* **E**, 279–285.

Following a primary division into automorphic and hydromorphic soils, 10 major soil groups are distinguished, primarily by water relationships and humus form and further divided into 39 sub-groups with specific profile characteristics. It is suggested that soil mapping units, including soil series, might be considered primarily as geographic concepts and not directly related to taxonomic soil groups.

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213. OSMOND, D. A. (1956). *Report on some Cyprus soils.* London: Colonial Office. Pp. 81.

An account of a visit to Cyprus to initiate a soil survey. Profile descriptions are given of the soils seen and a provisional classification drawn up.

214. OSMOND, D. A. (1956). Recent advances in pedology. *Sci. Progr.* **44**, 682–687.

215. SEALE, R. S. (1956). The heavy minerals of some soils from the neighbourhood of Cambridge, England. *J. Soil Sci.* **7**, 307–318.

The presence of characteristic heavy minerals assists in differentiating between glacial drifts that are the parent materials of the soils.

General Publications

216. BOALCH, D. H. (1956). Rothamsted Experimental Station. *Library resources in the Greater London area,* 5 (Agricultural libraries), 7–10.