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## Report for 1953

[Full Table of Content](#)



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## Publications / Abstracts of Papers

### Rothamsted Research

Rothamsted Research (1954) *Publications / Abstracts of Papers* ; Report For 1953, pp 188 - 221 -  
DOI: <https://doi.org/10.23637/ERADOC-1-75>

## PUBLICATIONS

### Physics Department

1. EMERSON, W. W. & GRUNDY, G. M. F. (1954). The effect of rate of wetting on water uptake and cohesion of soil crumbs. *J. agric. Sci.*, **44**.

Short columns of air-dry soil crumbs were wetted at different rates and, after draining to a standard suction, the amount of water taken up by each column determined. It was found that this increased continuously with rate of water application. The corresponding progressive decrease in the cohesion of the wetted crumbs has been measured by their resistance to break down under the impact of falling water drops. By developing this into a rapid and sensitive method, it has been found that the loss of cohesion is due almost entirely to entrapped air, non-uniform swelling of the clay being a negligible factor in weakening crumbs.

The aggregates investigated were taken from adjacent fields differing only in their cropping treatment; one being under continuous arable and the other under continuous grass. The extrapolated value of the cohesion of the grassland crumbs at zero rate of wetting was twice that of the arable, indicating an additional cohesive force in the grassland crumbs. The cohesion of the arable soil fell much more rapidly with increased rate of wetting than that of the grassland, probably because the roots in the grassland crumbs provide easy escape passages for the air.

The increase, with rate of wetting, of the amount of water held by a soil sample against a given suction is important, at least up to 200 cm. of water. This dependence of the pF curve on rate of wetting is of particular significance for laboratory studies of water movement in soils.

2. HIRST, J. M., LONG, I. F. & PENMAN, H. L. Micro-meteorology in the potato crop. *Proc. Toronto Met. Conf.* 1953. (In the press. To be published by Royal Met. Soc., London. For summary see 99.)
3. PENMAN, H. L. (1952). Water and plant growth. *Agric. Progress*, **27**, 147.

In this survey of the causes of the need of plants for water a number of principles emerge, some based on reasonable certainty, others a little less certain and yet others are frankly speculative. Two statements are made and accepted as almost axiomatic. They are :

When water supply is non-limiting the plant's rôle in transpiration is the passive one of providing a conducting channel between the soil and the atmosphere.

Maximum transpiration is a necessary condition for maximum growth. It may not be a sufficient condition.

The basic principles are :

When water supply is non-limiting the transpiration rate is determined by prevailing weather.

Apart from minor effects, this rate, known as the potential transpiration rate, is the same for all short crops of about the same colour and completely shading the ground.

The potential transpiration rate is less than the evaporation rate from an open water surface exposed to the same weather. The open-water evaporation rate can be estimated from weather data.

Principles still in evolution include :

Potential transpiration is less than open-water evaporation because : (i) the stomata impede the flow of vapour ; (ii) transpiration opportunity is largely restricted to daylight, and so varies with season and latitude. As a rider : an empirical conversion factor has proved widely useful in a variety of applications, including the control of irrigation operations.

A modified treatment is needed for crops where ventilation between



plants is possible. The most important case is an extreme, namely in an open orchard. A first attack on this problem has met with success.

The following are somewhat more speculative :

Each type of crop has a root constant, which is the amount of water that can be transpired at the potential rate.

This constant is largely independent of the type of soil, but will depend on the stage of biological development of the plant, and may be modified by the weather cycle or crop management.

4. SCHOFIELD, R. K. & SAMSON, H. R. (1953). The deflocculation of kaolinite suspensions and the accompanying change-over from positive to negative chloride adsorption. *Clay Min. Bull.*, **2**, 45.

Pure kaolinite washed first with 1M-NaCl containing 0.001M-HCl and then with distilled water remains firmly flocculated when salt free. In this state the kaolinite retains exchangeable Na, which shows that the crystals are negatively charged.

When re-dispersed in 0.005M-NaCl, the crystals positively adsorb chloride, which proves that parts of their surfaces (presumably the edge faces) are positively charged. The attraction of the positive charges on the edge faces for the negative charges in the body of the crystals is regarded as the cause of the flocculation which occurs in the absence of salt.

Deflocculation of the salt-free suspension occurs on the addition of a small but sufficient amount of NaOH. When kaolinite so treated and then air-dried is re-dispersed in 0.005M-NaCl, the crystals negatively adsorb chloride, showing that the edge faces are no longer positively charged.

Deflocculation can also be brought about by adding small amounts of sodium oxalate, sodium pyrophosphate, sodium polymetaphosphate, sodium alginate and sodium bentonite. Regardless of the agent used, when the kaolinite is deflocculated in the absence of free salt, the crystals repel chloride ions when placed in dilute NaCl.

An explanation of the variation of the charge on edge faces with pH is put forward based on the crystal structure of kaolinite, coupled with the idea that a small degree of isomorphous replacement gives rise to a permanent negative charge.

## Chemistry Department

### GENERAL PAPERS

5. COOKE, G. W. (1953). Fertilizer placement for threshed peas. *British Fmr.*, February, p. 3.
6. COOKE, G. W. & CHALMERS, G. R. (1953). Placement drills are costly—but they pay. *Fmr. & Stk.-Breed.*, 24th February, p. 65.
7. COOKE, G. W. (1953). Are compound fertilizers worthwhile? *Grower*, **39**, (12), 583.
8. CROWTHER, E. M. (1952). The evaluation of soil fertility. *Trans. Joint Meeting of Commissions II and IV, Intern. Soc. Soil Sci. Dublin*, **2**, 14.

General lecture given at the Opening Session of a joint meeting of the Commissions for Soil Chemistry and Soil Fertility and Plant Nutrition, reviewing some of the obstacles to applying what is known and to obtaining new knowledge.

### RESEARCH PAPERS

9. BREMNER, J. M. (1954). A review of recent work on soil organic matter. Part II. *J. Soil Sci.* (In the press.)

A review of recent work on the extraction and fractionation of soil organic matter, the interaction of organic and inorganic soil colloids, the humic and fulvic fractions and the lignin-like complexes of soil organic matter.



10. BREMNER, J. M. (1953). Identification of hydroxylamine and hydrazine by paper chromatography. *Analyst*. (In the press.)

A method for the separation and identification of microgram quantities of hydroxylamine and hydrazine is described. It involves paper chromatography with acidic solvents and identification by  $R_F$  values and by the colours produced with picryl chloride and other detecting reagents.

11. BREMNER, J. M. & SHAW, K. (1953). Studies on the estimation and decomposition of amino sugars in soil. *J. agric. Sci.* (In the press.)

The amounts of amino sugar-N present in acid hydrolysates of six soils with nitrogen contents ranging from 0.17 to 2.82 per cent have been estimated by colorimetric and alkaline decomposition methods. Recovery of amino sugar-N after hydrolysis of chitin or glucosamine was found to be unaffected by the presence of soil during hydrolysis. Substances known to interfere with the methods of amino sugar analysis employed were not detectable in the soil hydrolysates. From the amounts of amino sugar-N liberated by acid hydrolysis it is deduced that 5-10 per cent of the total nitrogen of the soils examined was in the form of amino sugars. The decomposition of amino sugars in soils has been studied by comparing the rates of decomposition of chitin, glucosamine, casein and yeast nucleic acid when incubated with soil under conditions found to produce rapid nitrification of ammonium sulphate. Glucosamine and chitin are readily decomposed by soil micro-organisms, but not so rapidly as casein or yeast nucleic acid.

12. CHAMBERS, W. E. (1953). Nutrient composition of the produce of the Broadbalk continuous wheat experiment. Part I. Changes over seventy years. *J. agric. Sci.*, **43**, 473.

A rapid extraction procedure of dried ground plant material was used in conjunction with the Lundegårdh flame method of spectrographic analysis and its accuracy shown to be comparable with that for ashing with gravimetric analyses. The effects of fertilizer treatments on yield and nutrient composition of the crops and their changes with time were summarized. The recovery of potassium was estimated, and it was shown that the exhaustion or accumulation of soil potassium was related to the exchangeable potassium contents of the soils, but that the net gains or losses of potassium were many times greater than those found in the exchangeable or readily soluble potassium of the surface soils. Sodium or magnesium sulphates increased crop yields by increasing the supply of potassium from non-exchangeable forms.

13. CHAMBERS, W. E. (1953). Nutrient composition of the produce of the Broadbalk continuous wheat experiment. Part II. Changes occurring during one season's growth. *J. agric. Sci.*, **43**, 479.

Throughout a season the total uptake of nutrients increased to a maximum and then decreased. The losses of potassium and magnesium from the stems and leaves were particularly large due to translocation to the ears, but there were also net losses of potassium and calcium from the plant. The changes were similar for all fertilizer treatments. The composition of the crop at harvest reflected its composition throughout the season.

14. COOKE, G. W. (1953). The correlation of easily-soluble phosphorus in soil with responses of crops to dressings of phosphate fertilizers. *J. Sci. Fd. Agric.*, No. 8, p. 353.

When sufficient numbers of soils are examined empirical determinations of easily-soluble soil phosphate can be used to forecast crop responses to fertilizer dressings. Correlations between soil analyses and crop behaviour fail for individual soils, and the causes have been examined.

Dilute acids dissolve relatively large quantities of phosphate from some soils where crops respond to phosphate fertilizers owing to: (1) dissolution of iron and aluminium phosphates; (2) use of too much solvent; (3) use of an unsuitable solvent; and (4) dissolution of phosphate from the interior of particles of calcium carbonate in calcareous soils.

Other soils contain very little phosphate soluble in dilute acid, but, nevertheless, crops grown on them do not respond to phosphate fertilizers. In



such cases crop growth may be limited by some other factor, such as drought. Phosphate dissolved by dilute acids is immediately reprecipitated by some soils; the extent of such reactions may be estimated by repeated extractions in the presence of added phosphate. Most mineral soils in eastern England fix very little phosphate during acid extraction, but fen soils and ferruginous soils may fix considerable amounts.

Changes in the amounts of soil phosphate that are soluble in dilute acid may occur when air-dried soils are stored. Such changes are accentuated by incubating moist soils with or without calcium hydroxide. Incubation experiments may be used to forecast increases in dilute-acid-soluble phosphate that occur during the growing period of crops and changes which occur in easily-soluble phosphate when acid soils are limed. Incubation with lime was used to measure reserves of soil phosphorus that were easily converted into forms soluble in dilute acids; such measurements were more satisfactory than simple extraction with dilute acid in relating crop responses and soil-phosphorus status in one group of field experiments.

15. COOKE, G. W. (1954). Designs of fertilizer distributors and their mechanisms. *J. Inst. Brit. Agric. Engng.* (In the press.)

The types of mechanisms used in commercial distributors are described and classified as: (1) gravity feed (unassisted); (2) assisted gravity feed; (3) metered gravity feed; (4) top-delivery feed.

The following factors cause irregularities in delivery rates: (1) "head" of fertilizer; (2) inclination of the mechanism; (3) incorrect speed; (4) incorrect delivery port openings; (5) inherent periodicity in delivery from some mechanisms; (6) compacting of fertilizer; (7) the hygroscopic and other physical properties of fertilizers.

Feed systems which meter and remove fertilizer from hoppers horizontally are superior to assisted gravity feeds, where fertilizer flows vertically. Top-delivery mechanisms are generally superior to all types of gravity feed.

Possible future developments in fertilizer distribution (including bulk spreading, aerial distribution, and the use of liquid fertilizers) are discussed. Distributors should be designed to deal specifically with fertilizers having definite physical properties. Different mechanisms may be needed to dispense materials such as free-flowing granules, dry powders and hygroscopic powdered fertilizers. Co-operative work is needed to standardize physical characteristics of fertilizers, so that in future distributors design may have a scientific basis.

16. COOKE, G. W. (& DADD, C. V.) (1953). Fertilizer placement experiments on threshed peas. *Agriculture, Lond.*, **60**, 34.

Experiments were carried out by the National Agricultural Advisory Service to extend comparisons of placed and broadcast phosphate-potash fertilizer for threshed peas to more distant areas of the Eastern Counties.

The results of earlier Rothamsted Experiments and of the N.A.A.S. experiments were consistent. The gain from placement (over broadcasting) on the average of seventeen Rothamsted experiments was 1.9 cwt./acre of peas, and the corresponding gain in the N.A.A.S. experiments was 2.0 cwt./acre of peas.

The gains in yield from drilling PK fertilizer at the side of the seed were greater than from broadcasting twice as much fertilizer. Relatively small quantities of placed fertilizer are sufficient for maximum yields and on soils where threshed peas respond to phosphate and potash fertilizers it will pay farmers to use placement drills to apply dressings beside the seed.

17. COOKE, G. W., JACKSON, M. V. & WIDDOWSON, F. V. (1954). Placement of fertilizers for potatoes planted by machines. *J. agric. Sci.*, **44**. (In the press.)

A two-row hand-dropping potato planter was modified by adding fertilizer equipment and was used in thirty-three experiments in 1951 and 1952 to plant potatoes from flat land, and compare broadcast dressings of granulated compound fertilizer with dressings placed near to the seed.

Fertilizer placed either in one band at the side and below the level of the seed or in contact with the seed gave considerably higher yields than broadcast dressings. Broadcast fertilizer gave yields similar to those given by only



one-half to two-thirds as much placed fertilizer. On the average of all the experiments placing fertilizer gave about 1 ton/acre more potatoes than broadcasting. The advantages of placement were greatest when low rates of dressing were used.

Broadcast fertilizer was cultivated deeply into the seedbed in nineteen experiments in 1952, and gave slightly lower average yields than late dressings broadcast on the seedbed.

Fertilizer placed in bands on the soil surface immediately in front of the seed-shoes gave yields similar to those given by dressings broadcast over the seedbeds in fourteen experiments in 1951. In average planting conditions fertilizer broadcast on the seedbeds or placed in front of the seed-shoes was thrown to the middle of the ridges and concentrated above the seed.

Fertilizer placed in contact with the seed gave higher average yields than dressings in a sideband at both rates of manuring in the 1951 experiments. In 1952 contact placement was slightly superior to sideband placement at low rates of fertilizer and slightly inferior at high rates. In most experiments in each year emergence was delayed by ten to fourteen days when the heavy dressing was placed in contact with the seed. Early growth was poor, but at most centres the crops recovered later in the season and gave good yields. There is most risk of damage from contact placement on light soil, on badly prepared seedbeds and in dry years. Dressings of 10-12 cwt./acre of ordinary-strength compound fertilizers are likely to be quite safe when applied in contact with the seed. If heavier dressings are to be used, part should be applied in contact with the seed and part broadcast; such split applications were satisfactory in experiments in 1951.

Farmers planting even moderate acreages of potatoes by machines will benefit by using a suitable fertilizer attachment. Equipment is needed to place fertilizer at the side of the seed so that heavy dressings can be used to secure maximum yields without risk.

18. COOKE, G. W. & WIDDOWSON, F. V. (1953). Placement of fertilizers for row crops. *J. agric. Sci.*, **43**, 348.

In experiments on peas, beans, carrots, kale, beetroot and spinach appropriate dressings of fertilizers placed in one band 3 inches below the soil surface and 2 inches to the side of the seed did not damage germination. Peas and beans are likely to be injured when even small dressings of soluble fertilizers are drilled in contact with or below the seed.

In sixteen experiments on peas and nineteen experiments on beans in 1949-51 broadcast fertilizer gave small increases in yield of beans and peas in dry years and larger increases in wet years. In about one-quarter of all the experiments fertilizer broadcast early and either ploughed or cultivated deeply into the soils gave significantly higher yields than late dressings worked into the seedbeds. In roughly one-third of all the experiments on each crop there were significant increases in yield from placing as compared with broadcasting fertilizer. The average extra yields produced by placing fertilizer were 1.8 cwt./acre of threshed peas, 9.3 cwt./acre of green peas, 1.0 cwt./acre of winter beans and 1.3 cwt./acre of spring beans. For spring-sown crops extra yields from placement were greater than the increases from broadcasting fertilizer. There was little advantage from splitting the fertilizer dressing, broadcasting half and placing the remainder beside the seed.

In most experiments on peas and beans, yields given by a single dressing of placed fertilizer were equal to, or greater than, the yields given by double dressings of broadcast fertilizer. When placed in the correct position quite small quantities of fertilizer are sufficient for maximum yields of such crops. There was no advantage from placing fertilizer at the side of the seed for carrots, kale or beet. Placed fertilizer gave a higher yield of spinach than broadcast fertilizer.

Placing fertilizer at the side and below the level of the seed is likely to give better yields than broadcast fertilizer for crops having short growing seasons or poorly developed roots and when broadcast nutrients are immobilized in the surface soil by drought.

19. COOKE, G. W. & WIDDOWSON, F. V. (1953). Methods of applying fertilizer for herbage crops. *J. agric. Sci.*, **43**, 358.

Phosphate-potash fertilizer was drilled in bands 20 inches apart and 3 inches below the soil surface and compared with similar dressings broadcast



on the surface for established crops of sainfoin. On unmanured plots yields were not reduced by cutting grooves for the fertilizer bands. Broadcasting fertilizer on the surface produced consistently more sainfoin hay than dressings placed in bands. In similar experiments on permanent grass broadcast fertilizer also gave consistently more hay than bands of fertilizer placed 10 inches apart. In the absence of fertilizer small decreases in yields of grass were caused by cutting grooves. The advantages of an equal supply of nutrients to all the plants in an established sward, obtained by broadcasting fertilizers, outweighs any disadvantage from confining the application to the soil surface.

Two experiments on lucerne in 1950-51 gave similar results for broadcast and placed fertilizer in the seedbed.

In a lucerne experiment laid down in spring 1952, a "starter-dose" of superphosphate drilled directly beneath the seed gave much better early growth and higher yields of lucerne than any of the dressings of broadcast phosphate and potash.

There is no case for introducing special equipment to place fertilizer in bands below the surface of established swards. For establishing lucerne and other ley crops, where fertilizers may be applied at or before sowing, there are no advantages from using special drills to place the full dressing of fertilizer at a safe distance to the side of the seed. Where combine-drills are used for sowing herbage crops they should be modified to place a small quantity of superphosphate directly beneath the seed, and the remainder of the fertilizer should be broadcast before sowing.

20. CROWTHER, E. M. & BENZIAN, B. (1953). Nutrition problems in forest nurseries. Summary report on 1951 experiments. *For. Comm. Rep. on For. Res., 1951-52*, 94.

Annual report on investigations reviewed in the Rothamsted Report for 1951, p. 41.

21. CROWTHER, E. M., WARREN, R. G. & COOKE, G. W. (1953). The agricultural value of alternative phosphate fertilizers (other than silicophosphate) Part II. Field experiments. *Ministry of Supply, Permanent Records of Research and Development. Monograph 11*, 109.

The work described was initiated in 1940 by the Controller of Chemical Research and Development, Ministry of Supply, as a general investigation of phosphate fertilizers made without the use of sulphuric acid.

A large variety of phosphate fertilizers were tested against standard materials in greenhouse pot experiments, and the more promising new materials were compared in field experiments on arable crops and on grass with either superphosphate or with Bessemer basic slag.

Of several mineral phosphates Gafsa was the most successful for all crops; Florida mineral phosphate was of little value for any crop. The better mineral phosphates when applied for swedes were equivalent to superphosphate supplying from one-half to three-quarters as much phosphorus. The experiments demonstrated that mineral phosphates are satisfactory only on very acid soils (below pH 5.5); their use should be restricted generally to areas in the north and west, where swedes, turnips and grass are important crops. Mineral phosphates are of little value for potatoes.

Mixtures of superphosphate with mineral phosphate gave disappointing results, and were generally of very little more value than the mineral phosphates from which they were made.

Other experiments showed that it may not be necessary to grind mineral phosphates as fine as is customary.

Mixtures of superphosphates with low-grade basic slag, with lime and with serpentine generally gave lower yields than equivalent superphosphate. There was no evidence to justify the additional cost of preparing such basic superphosphates.

Experiments on swedes and grass with different types of basic slag confirmed that the 2 per cent citric acid test differentiates satisfactorily between the more-active and less-active basic slags.

Bessemer basic slag gave its best results for establishing reseeded grass on very acid soils. For swedes and potatoes it was less efficient than superphosphate. Triple superphosphate and ordinary superphosphate gave

N



similar yields of swedes and potatoes. Yields of swedes given by calcium metaphosphate were equal to those from superphosphate supplying half the quantity of phosphorus.

Where arable experiments were continued for more than one year the effects of all fertilizers in the second year were small, and there were no clear differences between the residual values of superphosphate and of the other fertilizers tested. The differences in growth of grass produced by different phosphate fertilizers became smaller when the observations were continued over several seasons.

22. RICKSON, J. B. (1953). Surface properties of some calcium phosphates. *Proc. Oxford Isotopes Technique Conf.*, 1951, **1**, 411.

An account of preliminary experiments on isotopic exchange with preparations of calcium phosphates, distinguishing rapid and slow reactions.

### Pedology Department

23. BLOOMFIELD, C. (1953-54). A study of podzolization.
- (a) Part 1. The mobilization of iron and aluminium by Scots pine needles. *J. Soil Sci.*, **4**, 5.
  - (b) Part 2. The mobilization of iron and aluminium by the leaves and bark of *Agathis australis* (Kauri). *J. Soil Sci.*, **4**, 17.
  - (c) Part 3. The mobilization of iron and aluminium by the leaves and bark of *Dacrydium cupressinum* (Rimu). *J. Soil Sci.*, **5**, 39.

An account of the ability of sterile aqueous extracts of the leaf and bark material to dissolve hydrous ferric and aluminium oxides. Ferric-iron is reduced to the ferrous state, and although the extent of solution-reduction is decreased by raising the pH and by aeration, the reaction still proceeds under fully aerobic conditions at pH 7.5. Evidence is given for the complex nature of the ferrous and aluminium reaction products.

24. BLOOMFIELD, C. (1954). Part 4. The mobilization of iron and aluminium by picked and fallen larch needles. *J. Soil Sci.*, **5**, 46.

A comparison of the properties of its picked and fallen needles. Only quantitative differences were found. The fallen needles appear to be more active in dissolving the hydrous oxides.

25. BLOOMFIELD, C. (1953). Part 5. The mobilization of iron and aluminium by ash and aspen leaves. *J. Soil Sci.*, **5**, 50.

The ability of water extracts of fallen aspen leaves to dissolve the hydrous sesquioxides is only slightly decreased by raising the pH from *c.* 5 to over 7. This is in agreement with the frequently observed alkaline reaction of the podzolic grey-wooded soils, which are formed under a predominantly aspen cover. Extracts of ash leaves have a smaller but appreciable solution effect, despite the fact that the ash is not known to possess any podzolizing properties in the field.

26. BLOOMFIELD, C. (1953). Sesquioxide immobilization and clay movement in podzolized soils. *Nature, Lond.*, 1953, **172**, 958.

The ferrous and aluminium reaction products of the solution of ferric and aluminium oxides are strongly sorbed on soil colloids. It is suggested that this process is responsible for the formation of the B horizon of podzolized soils.

Leaf leachates have been found to deflocculate clay suspensions, both kaolinite and montmorillonite.

27. BROWN, G. (1953). The occurrence of lepidocrocite in some British soils. *J. Soil Sci.*, **4**, 220.

Lepidocrocite of pedological origin in gleyed soils of North-west England and North Wales appears to be responsible for the orange mottling which is often



found in these soils. Peroxidation of surface soils is shown to give calcium oxalate trihydrate. A method of differentiating lepidocrocite, boehmite and calcium oxalate trihydrate, all of which give a strong reflection at 6.2 Å, is given.

28. BROWN, G. (1953). A semi-micro method for the preparation of soil clays for X-ray diffraction studies. *J. Soil Sci.*, **4**, 229.

A method whereby the clay from small amounts of soil can be quickly prepared for study by X-ray-diffraction methods by using Perspex centrifuge tubes to make oriented aggregates. It is pointed out that for an understanding of soil processes the soil must be studied in greater detail than the usual bulk horizon samples.

29. BROWN, G. (1953). The dioctahedral analogue of vermiculite. *Clay Min. Bull.*, **2**, 64.

For summary see report.

30. BROWN, G. (1954). Soil morphology and mineralogy. A qualitative study of some gleyed soils from North-west England. *J. Soil Sci.*, **5**, 145.

For summary see report.

31. BROWN, G. & SMITHSON, F. (1953). Distribution of dickite in some British sandstones. *Nature, Lond.*, **172**, 317.

A well-crystallized mineral of the kaolin group has been found in some British sandstones, and selected samples were shown to be dickite by X-ray diffraction. The sandstones where dickite has been found are Lower Carboniferous, Caernarvonshire, Millstone Grit, Anglesey and Yorkshire and Middle Jurassic, Yorkshire. Where well-formed crystals are observed microscopically there is usually evidence of alteration of other minerals.

32. BUTLER, J. R. (1953). The geochemistry and mineralogy of rock weathering. (1) The Lizard area, Cornwall. *Geochim. et cosmochim. Acta*, **4**, 157.

The Cornish rocks: (i) adamellite; (ii) granodiorite-gneiss; (iii) gabbro, and (iv) tremolite-serpentine are described, together with their weathering products. Illite and kaolin are present in all the clays derived from the rocks by weathering, but chlorite and vermiculite are less widespread, and talc and montmorillonoid occur in one clay only. Both mineralogically and chemically the clays resemble each other more than do the rocks. The rôle of the minor elements in the rocks, minerals and clays is discussed.

33. BUTLER, J. R. (1954). Trace element distribution in some Lancashire soils. *J. Soil Sci.*, **5**, 156.

Variations in the concentration of the elements B, Be, Co, Cr, Cu, Fe, Ga, Ge, La, Li, Mn, Mo, Ni, Pb, Rb, Sn, Sr, V, Yt and Zr in profiles of Meadow or Gley soils and a Brown Earth are discussed. Mn varies erratically, Sn and Pb increased markedly from the base to the surface of the profile and all the other elements increase with depth.

34. BUTLER, J. R. (1953). Geochemical affinities of some coals from Svalbard. *Norsk Polarinst. Skr.*, 96.

An attempt is made to decide whether or not element distribution on ash or coal basis in a particular coal seam is sufficiently distinctive to enable it to be correlated in different localities and distinguished from another seam.

The boron contents of the coals studied were similar; in ash-poor coals boron reached 1 per cent in the ash.

35. GOLDSCHMIDT, V. M. (1954). [Book :] *Geochemistry*, edited by A. MUIR (Oxford : Clarendon Press).



36. GREENE-KELLY, R. (1953). Identification of montmorillonoids in clays. *J. Soil Sci.*, **4**, 253.

The difficulties which occur when identifying the members of the montmorillonoid group in clays are discussed. The lithium saturation and heating test is shown to distinguish between the dioctahedral members of the group, and its use is illustrated by several examples.

37. GREENE-KELLY, R. (1953). Irreversible dehydration in montmorillonite. Part 2. *Clay Min. Bull.*, **2**, 52.

The effect of preheating to 200° C. on the montmorillonoids demonstrated that montmorillonite alone showed anomalous loss of interlamellar expansion to glycerol after heating. This loss of expanding power occurred only when montmorillonite was saturated with small cations, for example lithium and magnesium. These observations are discussed with reference to the idea of cation migration into the vacant octahedral positions of the silicate sheet.

38. GREENE-KELLY, R. (1953). Interpretation of D.T.A. diagrams: the low temperature peak. *Clay Min. Bull.*, **2**, 79.

The low-temperature endothermic peak obtained during the D.T.A. of montmorillonoids often shows two maxima if the exchange cations are lithium or are divalent. In contrast, if the cations are sodium or potassium the peak appears to be simple. Experimental work is described which suggests that this difference is a natural consequence of the fact that montmorillonoids possess an expanding lattice.

39. MUIR, A. (1953). Vineyard Soils in England. [In: *Vineyards in England*. Edited by E. Hyams. London: Faber & Faber Ltd.]

A discussion of the distribution of mediaeval vineyards in England in relation to soil type with comparisons of continental vine-growing areas.

40. STEPHEN, I. (1953). A petrographic study of a tropical black earth and grey earth from the Gold Coast. *J. Soil Sci.*, **4**, 211.

A comparative study of two profiles derived from feldspar-quartz-schist and hornblende-garnet-gneiss of the Archaean Complex near Accra, Gold Coast, has shown the influence of the parent rock in determining the character of the derived soil. The basic gneiss weathers to give a sandy clay soil characterized mineralogically by quartz-garnet sand and montmorillonitic clay. The acid schist gives a quartzose sandy soil with smaller amounts of clay comprising both kaolin and montmorillonite.

#### Soil Microbiology Department

41. BROMFIELD, S. M. (1953). Sulphate reduction in partially sterilized soil exposed to air. *J. gen. Microbiol.*, **8**, 378.

H<sub>2</sub>S was evolved from soil treated with CCl<sub>4</sub> when moistened with sucrose and (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> solution and incubated aerobically. H<sub>2</sub>S formation took place when the soil moisture was less than field capacity, and over a range of pH values from 5 to 8. The organism responsible was isolated and identified as *Bacillus megaterium*. Several strains of this organism reduced sulphate in well-aerated sterilized soil and liquid media, but not in soil or liquid incubated anaerobically.

The action of CCl<sub>4</sub> in fresh soil is to check or destroy certain fungi and bacteria which normally inhibit sulphate reduction by *B. megaterium*. Some of these organisms were isolated and shown to be sensitive to CCl<sub>4</sub> and to inhibit sulphate reduction by *B. megaterium* in sterilized soil. The isolates did not exhibit antibiotic action when grown in certain defined media.

42. KLECZKOWSKI, J., & KLECZKOWSKI, A. (1953). The behaviour of *Rhizobium* bacteriophages during and after exposure to ultra-violet radiation. *J. gen. Microbiol.* **8**, 135.

After inactivation by ultra-violet radiation, particles of two *Rhizobium* bacteriophages interfered temporarily with the multiplication of active particles of the homologous phage, in liquid cultures of their respective host



bacteria. Inactivated particles did not affect the number of plaques produced by active particles in bacterial cultures on agar.

No evidence was found that particles that were inactive singly became active when two or more of them infected the same bacterial cell.

The rate of inactivation approximated closely to that of a first-order reaction. Exposing infected bacteria to visible light increased the residual activities of irradiated phage preparations by amounts equivalent to decreasing the doses of ultra-violet irradiation by a constant factor. Exposing either the irradiated phage preparations or the bacterial cultures separately to visible light had no effect.

Those ultra-violet-irradiated phage particles which remained active were so altered that they became relatively unstable.

43. KLECZKOWSKI, J. & KLECZKOWSKI, A. (1952). Effect of specific polysaccharides from the host bacteria and of ribonuclease on the multiplication of rhizobium phages. *J. gen. Microbiol.*, **7**, 340.

Two serologically unrelated strains of nodule bacteria produced two different polysaccharides, only one of which precipitated with antiserum to its parent bacterium. Both polysaccharides interfered with the multiplication of two bacteriophages in liquid cultures of the two bacterial strains, each of which was susceptible to only one of the two bacteriophages. One polysaccharide was slightly more effective than the other in interfering with multiplication of both bacteriophages; one phage was much more susceptible than the other to the interfering action of both polysaccharides. Crystallized pancreatic ribonuclease interfered with multiplication of bacteriophages much more strongly than did the polysaccharides. Neither the polysaccharides nor ribonuclease destroyed the phage particles.

44. KLECZKOWSKI, J. & KLECZKOWSKI, A. (1954). A study of the mechanism of inhibition of bacteriophage multiplication by chymotrypsin. *J. gen. Microbiol.*, **10**. (In the press.)

When 0.01 per cent chymotrypsin is added to mixtures of *Rhizobium* bacteriophage and bacteria in liquid cultures, the multiplication of phage is prevented, and the phage gradually becomes inactive. The rate and extent to which phage and bacteria combine are unaffected by the chymotrypsin, whose effect seems directed against an early stage in the interaction between the two. This stage persists, on an average, for less than 1 minute from the moment of combination. A phage particle combined with a bacterium becomes inactive, and the bacterium is thus protected against lysis and remains able to multiply. Chymotrypsin does not interfere with combination between phage and bacteria killed by ultra-violet radiation; the combination leads to loss of phage activity, irrespective of the presence of chymotrypsin. The multiplication of the phage is unaffected by previous incubation of either the phage or of the host bacteria separately with 0.01 per cent chymotrypsin.

Chymotrypsin has no effect on phage-host interaction in an agar medium.

45. MEIKLEJOHN, J. (1953). Microbiological aspects of soil nitrification, with special reference to the Kawanda Nitrate Experiment. *E. Afr. agric. J.*, **19**, 54.

In the nitrate accumulation experiment at Kawanda, Uganda, it has been observed that more nitrate accumulated in fallow soil exposed to the sun than in fallow soil shaded from the sun or covered with a grass mulch. Cultures of autotrophic nitrifying bacteria were obtained from the surface soil of fallow plots treated in all three ways; but, contrary to expectation, the least-vigorous cultures were obtained from the exposed soil, where the most nitrate had accumulated. The nitrifying bacteria obtained from the exposed fallow were not thermophilic; and all the nitrifying cultures grew better in a neutral medium than in an acid one, although the pH of the surface soil was 4.6-5.0.

46. MEIKLEJOHN, J. (1953). The effect of bush burning on the microflora of some Kenya soils. *6th Int. Congr. Microbiol.*, Rome, Sept.

The burning of shrubs, undergrowth and grass, in order to clear the land for planting, is a very widespread farming practice in the tropics, but scientifically it has been very little studied. In the present work the microflora of the



surface soil from three sites at Muguga, Kenya, was studied before and after burning. Two of the soils had carried Black Wattle (*Acacia decurrens*) and a light undergrowth of small shrubs; the third was an abandoned African cultivation site, which had carried rough grass for two years.

In all three sites burning caused an immediate reduction in the numbers in the top inch of soil of microfungi, actinomycetes and bacteria. There was also evidence that nitrifying bacteria, and both aerobic and anaerobic free-living nitrogen-fixers, were killed by burning the grass and shrubs above the soil.

47. MEIKLEJOHN, J. (1953). Life in the Soil. *Proc. Nairobi sci. and philos. Soc.*
48. READ, M. P. (1953). The establishment of serologically identifiable strains of *Rhizobium trifolii* in field soils in competition with the native microflora. *J. gen. Microbiol.*, **9**, 1.

Field trials were made at thirteen centres in varied localities to test whether a strain of clover *Rhizobium* used as a seed inoculum in the field could establish itself in the crop in competition with the native strains already present in the soil. Each experiment comprised four sets of quadruplicate plots, one uninoculated and the other three each sown with seed inoculated with a different strain of *Rhizobium*.

The difficulty in identifying a strain re-isolated from a nodule was met by using as inocula strains whose antigenic composition made them readily identifiable by agglutination tests. From each plot twenty-five nodules were selected, and isolates from these tested against selected antisera. This method of identification enabled the percentage of nodules produced by each inoculant strain to be ascertained. Strains differed in their ability to establish themselves in the field; a suitable strain gave rise to 50 per cent or more of the nodules. In sand culture competition between pairs of inoculant strains was not related to their ability to establish themselves in the field, but each strain whose establishment was superior also showed competitive dominance on at least one date of sampling.

49. SKINNER, F. A. (1953). Inhibition of *Fusarium culmorum* by *Streptomyces albidoflavus*. *Nature, Lond.*, **172**, 1191.

*Streptomyces albidoflavus* arrested the growth of *Fusarium culmorum* by antibiotic secretions in agar media containing 10 g. glucose per litre. On media with lower glucose contents the fungus continued to grow towards the actinomycete, but there was evidence that traces of antibiotic material were formed by the latter. Both organisms grew on a variety of natural organic materials supported on buffered agar, but fungal growth was arrested at a distance from the actinomycete only when dried grass was used as source of nutrients. Filtrates of liquid cultures of the actinomycete contained a substance inhibitory to growth of *F. culmorum*, but this could be inactivated by additions of bentonite, other clays, whole soils and organic matter. In sand moistened with liquid medium containing glucose the actinomycete limited growth of the fungus by antibiotic action, by a direct attack on the fungal mycelium and by competition for the available nutrients. The effectiveness of all these antagonistic mechanisms was reduced when the glucose concentration was lowered. Antibiotic and direct-attack phenomena could not be detected when bentonite was added to the cultures. Neither antibiotic attack nor direct attack on the fungus could be demonstrated in sterile soil, though there was evidence of competition between the organisms for nutrients or space.

50. THORNTON, H. G. & SKINNER, F. A. (1953). The interaction of actinomycetes with other micro-organisms in soil. *6th Int. Congr. Microbiol. Symposium on Actinomycetales*, 174.

The antagonism displayed by many soil actinomycetes against other micro-organisms, particularly bacteria and fungi, in artificial culture and in soil, is discussed in this review paper. Particular attention is paid to the complexity of the interactions between these micro-organisms in soil and to the possible importance of antibiotic production, competition for nutrients and the presence of soil colloids.



51. WALKER, N. (1954). Preliminary observations on the decomposition of chlorophenols in soil. *Plant & Soil*, **5**. (In the press.)

It has been shown that *o*-chlorophenol is much less persistent in soil than *p*-chlorophenol or 2:4-dichlorophenol and that the decomposition of *o*-chlorophenol in soil is a biological process. There is evidence that *p*-chlorophenoxyacetic acid is subject to biological decomposition in soil.

52. WALKER, N. & WILTSHIRE, G. H. (1953). The decomposition of naphthalene and  $\alpha$ -chloro- and  $\alpha$ -bromo-naphthalenes by soil bacteria. *6th Int. Congr. Microbiol.*, Riassunti delle Comunicazioni, **1**, 175.

A strain of a naphthalene-utilizing bacterium will grow with either  $\alpha$ -chloronaphthalene or  $\alpha$ -bromonaphthalene as carbon source. 3-Chlorosalicylic acid and a chloronaphthalene diol have been isolated from cultures grown on  $\alpha$ -chloronaphthalene. Similarly, in bromonaphthalene cultures, a diol has been detected, and an acid which is probably a bromosalicylic acid has been isolated.

### Botany Department

53. HUMPHRIES, E. C. (1954). Mineral components and ash analysis. (*Modern methods of plant analysis*. Edited by K. Paech and M. V. Tracey. Section III. Heidelberg: Springer-Verlag. (In the press.)

54. THORNE, G. N. (1954). Absorption of nitrogen, phosphorus and potassium from nutrient sprays by leaves. *J. exp. Bot.*, **5**. (In the press.)

Barley, Brussels-sprout, French-bean, tomato and sugar-beet plants grown in soil in pots and sprayed, usually daily, for several weeks, with nutrient solutions containing nitrogen, phosphorus, potassium and a spreader, with precautions to prevent the spray solution falling on the soil, had higher nutrient contents and dry weights than control plants sprayed with water and spreader only. Increase in nutrient content occurred with high or low levels of nutrient supply to the roots, and was approximately proportional to the concentration of spray and to the frequency of spraying.

The nitrogen content of sugar-beet plants was increased equally by spraying with solutions supplying ammonium sulphate, calcium nitrate or urea in equivalent concentrations.

Nutrient uptake from solutions sprayed on leaves influenced uptake by the roots, so that the additional amounts of nutrient contained in sprayed plants may be greater or smaller than the amount absorbed from the spray by the leaves.

55. THURSTON, J. M. (1954). The biological approach to the problem of wild oats control. *Proc. Brit. Weed Control Conf.*, 1953. (In the press.)

Present knowledge of the biology of wild oats, based on experiments and observations in Great Britain and abroad, is summarized, and its relation to control measures is discussed.

56. WARINGTON, K. (1950). Work on trace elements in England, Scotland and Ireland. *Proc. Soil. Sci. Soc. Fl.*, **10**, 181.

A review of investigations carried out in Great Britain from 1896 to 1950, contributed to a symposium on trace elements.

57. WARINGTON, K. (1954). The influence of iron supply on toxic effects of manganese, molybdenum and vanadium on soybean, peas and flax. *Ann. appl. Biol.*, **41**, 1.

Reduction of the standard iron supply in the nutrient solution accentuated the toxicity of 2.5 or 5 p.p.m. vanadium to soybean and flax, but injury from



high manganese (10 p.p.m.), molybdenum (40 p.p.m.) or vanadium (2.5 p.p.m.) was counteracted by increasing the iron to 20 or 30 p.p.m. Fe. The range of concentrations tested varied with the crop, the lowest levels being 1.25, 2.5 or 5.0 p.p.m. Fe for peas, soybean and flax respectively. Ferric citrate was the source of iron. Varying the iron supply had little effect on growth when the concentration of the three elements was low. Where increased iron had reduced the chlorosis caused by high manganese or vanadium, it also reduced the amount of these elements in the shoot, but the molybdenum content was lowered by high iron only when given in non-toxic concentration (0.1 p.p.m. Mo) combined with excess manganese.

The iron content of the shoot was scarcely affected by variation in the amount of iron supplied, but was generally reduced by high concentrations of manganese, molybdenum or vanadium.

58. WATSON, D. J. (1953). Research on virus diseases of sugar beet. *Brit. Sug. Beet Rev.*, **22**, 27.
59. WATSON, D. J. (1954). Measurement of photosynthesis in field conditions, and The physiological limitations of crop yield and the possibilities of increasing it. *Landbouwk. Tijdschr., 's-Grav.*, 66. (In the press.)

Text of two lectures on the results of growth-analysis studied on field crops given in a course on photosynthesis at the University of Wageningen.

## Biochemistry Department

### GENERAL PAPERS

60. PIRIE, N. W. (1952). Large scale production of edible protein from fresh leaves. *Rep. Rothamsted exp. Sta.*, 1952, 173.
61. PIRIE, N. W. (1953). The efficient use of sunlight for food production. *Chem. & Ind.*, 443.
62. PIRIE, N. W. (1953). Research for Plenty. No. 8, New foods for a crowded world. *Agriculture, Lond.*, **60**, 116; and reprint by Bles.
63. PIRIE, N. W. (1953). Ideas and assumptions about the origin of Life. *Discovery*, **14**, 238; and in the *Literary Guide*, January 1954.
64. PIRIE, N. W. (1953). Cellulase as a subject for speculation and commercial enterprise. *Biochem. Soc. Symp.*, **11**, 51.
65. PIRIE, N. W. (1953). Some host components that affect viruses during isolation. In symposium "Interaction of viruses and cells," Rome, 1953.
66. TRACEY, M. V. (1953). Cellulases. *Biochem. Soc. Symp.*, **11**, 49.  
A survey of the present state of knowledge of cellulases. Emphasis is laid on the importance of the insoluble nature of cellulose in interpreting the action and hydrolytic properties of the enzymes. Reference is also made to similar properties of chitinases.

### RESEARCH PAPERS

67. HOLDEN, M. (1953). A comparison of the applicability to plant extracts of three methods of determining deoxyribonucleic acid. *Analyst*, **78**, 542.  
The diphenylamine method (Dische, 1930) and a modification of the tryptophan-perchloric acid method of Cohen (1944) have been found to be satisfactory for determining deoxyribonucleic acid in extracts from plant tissues. The cysteine-sulphuric acid method (Stumpf, 1947) has given erratic results. A number of substances, some of which are likely to be present in plant extracts, have been tested under the conditions of the three methods.



68. KENTEN, R. H. (1953). The oxidation of phenylacetaldehyde by plant saps. *Biochem. J.*, **55**, 350.

1. Many plant saps oxidize phenylacetaldehyde. The system in pea-seedling sap consists of a thermolabile factor which appears to be a peroxidase and a thermostable factor which can be partially replaced by manganous ions. A system with similar properties to that in the pea-seedling sap can be constructed using horseradish peroxidase preparations and manganous ions.

2. The oxidation when catalysed by either pea-seedling sap or horseradish peroxidase and manganous ions proceeds with the formation of benzaldehyde and formic acid.

69. KENTEN, R. H. & MANN, P. J. G. (1953). The oxidation of certain dicarboxylic acids by peroxidase systems in the presence of manganese. *Biochem. J.*, **53**, 498.

1. The oxidation of oxalate, oxaloacetate, ketomalonate and dihydroxytartrate by oxygen is catalysed by peroxidase systems in the presence of  $Mn^{2+}$ .

2. It is suggested that these oxidations and that of dihydroxymaleate in presence of peroxidase systems and  $Mn^{2+}$  involves the oxidation of  $Mn^{2+}$ .

70. PIRIE, N. W. (1954). The fission of tobacco mosaic virus and some other nucleoproteins by strontium nitrate. *Biochem. J.*, **56**, 83.

Tobacco mosaic virus is split at room temperature into denatured protein and free nucleic acid by solutions of strontium nitrate more concentrated than 1M.

Other nucleoproteins are less easily split in this way, and other related salts are not so efficient as strontium nitrate.

Nucleic acid is decomposed by more intense treatment.

71. SMITHIES, W. R. (1953). The lysing action of enzymes on a sample of mycelium of *Penicillium griseofulvum* Dierckx. *Biochem. J.*, **55**, 346.

1. Air-dried mycelium of *Penicillium griseofulvum* was subjected to autolysis. The suspended matter in the final product contained 16 per cent of the original protein, 6 per cent of the carbohydrate and 50 per cent of the chitin. The solution contained dispersed protein and carbohydrate, but no  $\alpha$ -amino acids or reducing sugar.

2. Air-dried mycelium after two to three years' storage was autolysed. The suspended material contained 39 per cent of the original protein, 7 per cent of the carbohydrate and 70 per cent of the chitin. The solution contained amino acids reducing sugar and *N*-acetylglucosamine.

3. The protease of the mycelium is stable to storage. Much polysaccharide-splitting and chitinase activity is lost on drying, but some of the residual activity remains after three years. Such stored mycelium contains a very weak glucose oxidase, but no  $\alpha$ -amino-acid oxidase, which was presumably very active in the fresh dry mycelium.

4. Little change takes place in the composition of the mycelium on storage, except for a slight hydrolysis of protein.

5. 10-15 per cent of the mycelium protein resists digestion with proteases; 10-25 per cent of the carbohydrate and about 10 per cent of the chitin resists digestion with juice from the alimentary tract of snails.

72. WALKER, N. & WILTSHIRE, H. (1953). The decomposition of naphthalene and  $\alpha$ -chloro- and  $\alpha$ -bromo-naphthalenes by soil bacteria. *Proc. 6th Int. Congr. Microbiol.*, **1**, 175.

For summary see No. 52.

73. WILTSHIRE, G. H. (1953). The optical form of glutamic acid in tumours. *Brit. J. Cancer*, **7**, 137.

One normal tissue and four tumours were analysed for isomers of glutamic acid by methods applied to purified proteins. The percentage of *D*-glutamic acid found was in all cases very small, and not more than would be formed by the inversion of the *L*-isomer during hydrolysis.



74. WILTSHIRE, G. H. (1953). The estimation of D- and L-glutamic acid in proteins. *Biochem. J.*, **55**, 46.

Total glutamic acid was estimated by amino-nitrogen analysis after separation from other amino acids on buffered ion-exchange columns. The carbon dioxide released by enzymic decarboxylation of the L-isomer was measured manometrically. Five per cent of L-isomer was produced from L-glutamic acid under the conditions of acid hydrolysis and subsequent analysis.

D-Glutamic acid in excess of that estimated to be formed by inversion was found in hydrolysates of proteins which had been treated with dilute alkali, and in the cells of *Lactobacillus casei*, but not in four purified plant and animal proteins or in tobacco mosaic virus protein.

75. WILTSHIRE, G. H. (1953). The oxidation of tryptophan in pea-seedling tissues and extracts. *Biochem. J.*, **55**, 408.

The oxidation of tryptophan in tissue slices and extracts from pea seedlings was accelerated by addition of certain amines, which are concurrently oxidized with production of hydrogen peroxide. In the extract a compound having some of the properties of 3-hydroxykynurenine was formed. The reaction of one molecule of tryptophan with two molecules of hydrogen peroxide was catalysed by peroxidase, both in purified extracts and in model systems employing peroxide-donating enzymes and purified peroxidases.

76. (BOYLAND, E.) & WILTSHIRE, G. H. (1953). Metabolism of polycyclic compounds. The metabolism of naphthalene, 1-naphthol and 1 : 2-dihydroxy-1 : 1-dihydronaphthalene by animals. *Biochem. J.*, **53**, 636.

Repeated doses of naphthalene to male rats resulted in an increased proportion excreted as naphthalene diol and a decreased proportion excreted as glucuronide.

### Plant Pathology Department

#### GENERAL PAPERS

77. BAWDEN, F. C. (1953). The control of plant diseases. In *Research for Plenty*. London: Geoffrey Bles. p. 35.
78. BAWDEN, F. C. (1953). The initiation and development of virus infection. *Symposium, Istituto Superiore di Sanita, Rome, 6th Int. Congr. Microbiol.*
79. BROADBENT, L. (1952). The epidemiology of aphid-borne virus diseases. *Trans. 9th Int. Congr. Ent.* **1**, 619.
80. BROADBENT, L. (1953). Aphid control to combat lettuce mosaic. *Grower*, **40**, 774.
81. BROADBENT, L. (1953). Aphids and virus diseases in potato crops. *Biol. Rev.*, **28**, 350.
82. GLYNNE, MARY D. (1953). Wheat yield and soil-borne diseases. *Ann. appl. Biol.*, **40**, 221.
83. GLYNNE, MARY D. (1953). Lower seed rates to save lodging. *Times agric. Rev.*, Autumn 1953.
84. GREGORY, P. H. (1953). The fungi of Hertfordshire: Supplement I. *Trans. Herts. Nat. Hist. Soc.*, **24**, 38.
85. HULL, R. (1953). Assessment of disease incidence in the sugar-beet crop. *Ann. appl. Biol.*, **40**, 603.
86. HULL, R. (1953). Assessments of losses in sugar beet due to Virus Yellows in Great Britain 1942-52. *Plant Pathology*, **2**, 39.



87. SALT, G. A. (1953). A field experiment on wheat infected with eyespot. *Ann. appl. Biol.*, **40**, 224.

RESEARCH PAPERS

88. BAWDEN, F. C., HAMLYN, BRENDA M. G. & WATSON, MARION A. (1954). The distribution of viruses in different leaf tissues and its influence on virus-transmission by aphids. *Ann. appl. Biol.*, **41**.

Exposing both surfaces of leaves systemically infected with cabbage black ring spot virus (CBRSV) or with henbane mosaic virus to ultra-violet radiation decreases the infectivity of expressed sap to about one-fifth. As irradiation probably inactivates virus only in the epidermis, which occupies about one-quarter the volume of the leaves, these viruses seem to occur at much higher concentrations in sap from the epidermis than in sap from other cells. By contrast, tobacco mosaic virus seems not to occur predominantly in the epidermis.

CBRSV and henbane mosaic virus are normally transmitted most frequently by previously fasted aphids that feed for only short periods on infected leaves, but aphids treated like this transmit rarely from leaves that have been exposed to ultra-violet. Irradiation has relatively little effect on the proportion of aphids that transmit after long infection feedings. Fasting seems to increase transmission by increasing the probability that aphids will imbibe sap from the epidermis of leaves they newly colonize. With longer periods on infected leaves, the ability of fasted aphids to transmit probably decreases, because they then feed from deeper cells and their stylets contain sap with less virus. Only virus contained in the stylets seems to be transmitted, not virus taken into the stomach. About half the transmissions of henbane mosaic virus by aphids that have colonized tobacco leaves for hours may be caused by insects that temporarily cease feeding on the phloem and newly penetrate the epidermis.

Irradiating infected leaves affected the transmission of sugar-beet mosaic virus in the same way as that of henbane mosaic virus, but had little effect on the transmission of beet yellows virus, whose vectors become more likely to transmit the longer they feed on infected plants.

89. BAWDEN, F. C. & KASSANIS, B. (1954). Some effects of thiouracil on virus-infected plants. *J. gen. Microbiol.*, **10**, 160.

Submerging leaves in water soon after they are inoculated with viruses can prevent infection, and for studying factors that affect the rate of virus multiplication leaves should not be placed in solutions until a day after inoculation.

The rate at which viruses multiply in tobacco leaves is decreased by spraying with solutions of thiouracil, but less so than by floating leaves in the solutions. The physiological state of floated leaves affects the extent to which thiouracil impedes virus multiplication; least virus is produced in the presence of thiouracil when the condition of leaves otherwise most favours virus formation. Multiplication of virus can be checked at any time by thiouracil, but is most affected when leaves contain little virus; multiplication is resumed when thiouracil is removed. Thiouracil impedes the multiplication in tobacco of all viruses tested, but not of a tobacco necrosis virus in French bean or broad-bean mottle virus in *Vicia faba*.

When mixed with inocula, thiouracil can prevent infection from occurring, both in tobacco and French bean. It also affects the growth and appearance of both plants. These effects, unlike the impedance of virus multiplication in tobacco, are not counteracted by an excess of uracil. Tobacco leaves in which tobacco mosaic virus is multiplying develop necrotic spots and rings when treated with thiouracil, and local lesions can be made evident by spraying inoculated leaves. Necrotic lesions also occur on *V. faba* infected with broad-bean mottle virus and treated with thiouracil.

90. BROADBENT, L. (1954). The different distribution of two brassica viruses in the plant and its influence on spread in the field. *Ann. appl. Biol.*, **41**.

Previous knowledge did not explain the greater prevalence of cauliflower mosaic than of cabbage black ring spot virus. Both viruses are spread by



*Myzus persicae* and *Brevicoryne brassicae*, and both are transmitted equally readily from infected seedlings. Cabbage black ring spot virus has the wider host range.

Part of the difference between the rate at which the two viruses spread can be accounted for by the different manner in which they are distributed in old infected plants. Cauliflower mosaic virus occurs in high concentration in young leaves of old plants, whereas cabbage black ring spot virus occurs in quantity only in the older leaves, where it is localized in parts that show symptoms. After flying, most aphids alight on the upper parts of plants, where they are less likely to acquire cabbage black ring spot virus than cauliflower mosaic virus. In cabbage the old leaves are more favourably placed to catch alighting aphids than in cauliflower, and cabbage crops are often extensively infected with cabbage black ring spot virus.

91. BROADBENT, L. & TINSLEY, T. W. (1953). Symptoms of cauliflower mosaic and cabbage black ring spot in cauliflower. *Plant Pathology*, **2**, 88.

The succession of symptoms in plants infected with cauliflower mosaic and cabbage black ring spot viruses is described, together with variations caused by changes of temperature, light intensity and manuring.

92. (BRODIE, HAROLD J.) & GREGORY, P. H. (1953). The action of wind in the dispersal of spores from cup-shaped plant structures. *Canad. J. Bot.*, **31**, 402.

When smoke flowed over conical glass funnels in a wind tunnel, two eddy systems were observed. The first took the form of twin vortices, one on either side of the median line in the funnel. Each vortex was smallest at the narrowest part of the funnel and widened upwards. The second system was a single permanent elliptical eddy near the funnel mouth. The upper side of this eddy moved with the wind, the lower against it.

Observation of *Lycopodium* spores in glass vessels of various sizes and shapes subjected to winds ranging from 0.6 to 7.1 metres per second, showed that spores are blown from funnel- or egg-shaped vessels more readily than from rectangular vessels or horizontal glass slides. *Lycopodium* spores were not visibly dispersed from a funnel with mouth 4 cm. diameter at wind speeds below 3 metres/second.

Soredia of the lichen *Cladonia* were blown out of their funnel-shaped podetia by winds of 1.5–2 metres/second (3.3–5.3 m.p.h.) although no soredia were blown from a horizontal glass slide at the same wind speeds.

The two eddy systems created by wind blowing over funnel-shaped plant structures are thought to be adequate to remove spores and bodies of comparable size. The twin vortices suck spores from the bottom of the funnel, and the rotation of the upper elliptical eddy raises the spores along the upwind wall of the funnel and ejects them into the wind above.

This kind of dispersal could occur in a variety of plants, including Discomycetes and wind-pollinated plants.

93. (CROXALL, H. E., GWYNNE, D. C.) & BROADBENT, L. (1953). Turnip Yellow Mosaic in broccoli. *Plant Pathology*, **2**, 122.

Turnip yellow mosaic virus infected many winter cauliflower and other brassica crops in a small area on the coast of North-east England during 1952–53. This outbreak, the first to be recorded in broccoli in Britain, was probably caused by virus spread by flea-beetles, which were exceptionally numerous in these years. Plants infected in autumn were either killed by frost or failed to produce marketable curds.

94. (GENDRON, YVES) & KASSANIS, B. (1954). The importance of the host species in determining the action of virus-inhibitors. *Ann. appl. Biol.*, **41**.

The saps of some plant species from which viruses are difficult to transmit to other species by sap-inoculation contain substances that inhibit infection. The extent to which they inhibit infection depends on the species of plants inoculated and not on the identity of the virus. The inhibitors do not prevent infection of species that contain them.

Infection of cucumber was less affected than any of the other species by all the inhibitors tested.



95. GREGORY, P. H., HIRST, J. M. & LAST, F. T. (1953). Concentrations of basidiospores of the dry rot fungus (*Merulius lacrymans*) in the air of buildings. *Acta allerg., Kbh.*, **6**, 168.

The spore content of the air in two buildings affected by *Merulius lacrymans* was estimated during autumn 1952, using power-operated suction traps. In a bomb-damaged house in London concentrations ranged from 79,500 spores/cu. metre in a cellar with active fruit-bodies to 16,000/cu. metre on a first-floor room without fruit bodies. In a country house concentrations ranged from 360,000 spores/cu. metre in a cellar to 1,630 spores/cu. metre in a first-floor corridor, both with active fruit-bodies. The undisturbed air in an old unaffected cottage in Harpenden contained no spores of *Merulius lacrymans* and less than 10 spores/cu. metre of any kind.

96. GREGORY, P. H. & STEDMAN, O. J. (1953). Deposition of airborne *Lycopodium* spores on plane surfaces. *Ann. appl. Biol.*, **40**, 651.

The deposition of *Lycopodium* spores on sticky surface traps, including vertical and horizontal microscope slides and Petri dishes as used in routine aerobiological survey, was studied in a small wind tunnel at wind speeds from approximately 0.5–9.5 metres/second.

Deposition results from several processes acting singly or in combination. The pattern of deposit on a microscope slide orientated at angles varying from 0 to 90° to the wind, with gravity either positive, neutral or negative, indicates that, except on a surface parallel to the wind at the lowest wind speed, sedimentation under gravity plays a minor part in deposition on plane surfaces. As the wind speed is increased the deposit is decreased because of "edge shadow". At the highest wind speed the deposit is as large on the lower as on the upper surface on the horizontal slide, which suggests deposition by turbulence. Deposition by impaction against a vertical strip increases with wind speed and efficiencies observed are lower than for cylinders of the same diameter. The deposit on slides inclined at angles of 45° or less to the wind direction is increased by impaction of an "edge drift". The interaction of these various deposition processes on mean deposition at different angles and wind speeds gives a series of curves with a maximum at 90° and 9.5 metres/second and with minima at 0°, 90° and 180° at wind speeds lower than 9.5 metres/second. At these lower wind speeds there are two maxima in the range 20–70° and 135–150° respectively.

Deposits on Petri dishes show rim effects differing at different wind speeds. These can be eliminated by sinking the dish below a flat surface.

Blow-off from non-sticky surfaces is least at about 45°, and greatest at 0°.

Spore concentration in air is difficult to estimate from the deposits on plane-surface traps, because horizontal traps under-record at medium wind speeds, and because vertical traps are very sensitive to changes in wind speed. Power-operated suction traps are to be preferred when data on spore concentrations are required.

97. HAMLYN, BRENDA M. G. (1953). Quantitative studies on the transmission of cabbage black ring spot virus by *Myzus persicae* (Sulz.). *Ann. appl. Biol.*, **40**, 393.

Factors affecting the transmission of cabbage black ring spot virus by *Myzus persicae* (Sulz.) were studied quantitatively using the local lesions produced on tobacco leaves. Aphids prevented from feeding for 15 minutes or more, before feeding for a few minutes on an infected plant, caused more infections than unfasted aphids. Fasted aphids acquired virus from infected plants in feeding times as short as 10 seconds, and infected healthy plants in test-feeding times of 5 seconds. Increasing test-feeding times to 30 minutes increased the numbers of infections. Increasing infection-feeding times from ten seconds to 5 minutes had little effect, but increasing to more than 5 minutes greatly reduced the number of transmissions. This reduction was partly offset if the aphids were prevented from feeding continuously while on the infected plants. With undisturbed infection-feeding periods of 15 minutes or longer, previously fasted aphids caused no more infections than unfasted aphids.



Infective aphids lost their ability to produce lesions more rapidly when feeding than when fasting.

Winged and wingless aphids were equally efficient vectors.

98. HIRST, J. M. (1953). Changes in atmospheric spore content: Diurnal periodicity and the effects of weather. *Trans. Brit. mycol. Soc.*, **36**, 375.

The use of a power-operated suction trap, in which spores are impacted on the sticky surface of a slowly moving slide, made it possible to estimate accurately the concentration of different kinds of spore in the air at any given time. The catches often consisted predominantly of small hyaline spores, types rarely caught by other kinds of trap. Changes in the types of spore caught at different times of day showed that some species have a well-defined diurnal periodicity; the catches also reflect changes in weather.

In dry weather, pollen grains and spores of such fungi as *Cladosporium*, *Erysiphe*, *Alternaria*, smuts and rusts, are the main components of the air spora; they are most abundant in the afternoon and least in the early morning. *Phytophthora infestans* and *Polythrincium trifolii* also occur, but are earlier and reach their maximum concentration before noon. Prolonged rain removes most of these spores, and for a time there are few in the air. Within a few hours of the start of rain, the typical dry-air spora is replaced by hyaline spores; few of these can be identified, but they include splash-dispersed types, ascospores and basidiospores. Except after rain, this damp-air spora occurs in quantity only at night when dew is formed, and the greatest concentration is reached between midnight and dawn.

Basidiospores were at times the dominant type of spore. Hyaline forms, often mainly *Sporobolomyces* sp., rapidly reached large numbers in the early hours of the morning, particularly when there was heavy dew, and then disappeared almost completely. Coloured basidiospores mainly from the Agaricales were also commonest at night, but their occurrence depended less on weather than the hyaline forms, and their diurnal periodicity was less pronounced.

99. HIRST, J. M., LONG, I. F. & PENMAN, H. L. (1954). Micro-meteorology in the potato crop. *Quart. J. R. met. Soc.*

Two main causes of reduced potato yields are virus diseases and blight. Some of the virus diseases are aphid-transmitted. Measurements of temperature, humidity and wind in potato crops showed that weather among the plants often favoured aphid flight when weather outside did not.

During the summers of 1952 and 1953 wet- and dry-bulb temperatures were continuously recorded at six heights in and above a potato crop (10–320 cm.). For part of the period a dew balance also recorded the changes in weight of a potato shoot as dew condensed and later re-evaporated. These changes were in phase with vapour-pressure gradients in the air, which was saturated, or very nearly so, at all levels up to 160 cm. during the period the leaves were wet.

100. KASSANIS, B. (1953). Some effects of sucrose and phosphorus in increasing the multiplication of tobacco mosaic virus in detached tobacco leaves. *J. gen. Microbiol.*, **9**, 467.

Tobacco mosaic virus reached higher concentrations when inoculated tobacco leaves were placed in a solution containing 10 g./l. sucrose and 0.2 g./l. calcium phosphate than when in water. Detached leaves in water usually produced more virus than leaves left on the plants. Other sugars and phosphates also increased virus production. Sugar and calcium phosphate sometimes separately increases the concentration of the virus, but the response was usually greatest to both together. The increase varied with the nutritional state of the plants from which the leaves came and with some other environmental conditions. Virus concentration, and the effect of sucrose and calcium phosphate in increasing it, was greater when leaves were in the light than in the dark. Conditions which increased virus concentration also increased the total carbohydrates of the leaves.



101. KASSANIS, B. (1954). Tobacco necrosis viruses affecting tulips. *Plant Pathology*. (In the press.)

Different methods of inoculation were tried, but all failed to reproduce the lethal necrotic symptoms usually seen when forced tulips are naturally infected. The only result was some necrotic spotting of the leaves, varying in severity with different varieties of tulips. Observations made in natural outbreaks of the disease in forced tulips suggest that the infection occurred the year before.

102. KLECZKOWSKI, A. (1954). Stability of chymotrypsin and tobacco mosaic virus decreased by ultra-violet radiation. *Biochem. J.*, **56**, 345.

When proteins with specific activities are exposed to ultra-violet radiation, the specific activity is not necessarily lost by the first alteration produced. Chymotrypsin molecules can be altered by the radiation so that their stability at temperatures around 37° at pH 7 is decreased, although they are still proteolytically active. The increased rate at which tobacco mosaic virus is denatured on heating after irradiation results from a series of changes succeeding those associated with the loss of infectivity.

103. (NUTMAN, F. J.) & ROBERTS, F. M. (1953). Two new species of fungi on clove trees in the Zanzibar Protectorate. *Trans. Brit. mycol. Soc.*, **36**, 229.

Two species of fungi pathogenic to clove (*Eugenia aromatica*) are described. *Valsa eugeniae* sp. nov. always occurs in clove-trees which have died of the sudden-death disease, and it also causes die-back.

*Cryptosporella eugeniae* Nutman & Roberts is a severe wound parasite that attacks clove-trees of all ages and often kills young trees.

104. TINSLEY, T. W. (1953). The effects of varying the water supply of plants on their susceptibility to infection with viruses. *Ann. appl. Biol.*, **40**, 750.

Increasing the amount of water supplied to plants before they were inoculated with viruses greatly increased their susceptibility to infection; plants that received unlimited water produced ten or more times as many local lesions as plants that received only enough to prevent wilting. Susceptibility was increased throughout the year, but the full response occurred in two weeks in winter and four weeks in summer. Plants that received unlimited water for the two weeks immediately preceding inoculation were no more susceptible than those that received it during the previous two weeks, although the external appearance of the plants differed at the time of inoculation. Varying water supply after inoculation did not affect the numbers of lesions.

The differences in susceptibility to infection produced by differential watering were decreased, but not abolished, by growing plants under shade or by incorporating a diatomaceous earth in the inoculum.

Increasing water produced plants with larger and more succulent leaves; the cuticular layer was thinner, and the palisade tissue was less regularly arranged than in the plants kept dry. The increased susceptibility caused by abundant water may be partly due to these structural differences, which allow the leaf to be damaged more easily when inoculated.

105. WATSON, MARION A. & NIXON, H. L. (1953). Studies on the feeding of *Myzus persicae* (Sulz.) on radioactive plants. *Ann. appl. Biol.*, **40**, 537.

Adult apterae of fasted *Myzus persicae* (Sulz.) were fed on leaves containing radioactive phosphorus. The weight of sap imbibed by the aphids after various feeding times was estimated by relating their radioactivity to the activity per unit weight of the leaf on which they fed. The calculations were made on the assumption that <sup>32</sup>P is uniformly distributed in the leaf.

The mean rates of uptake were about 10 μg. of sap for the first hour of feeding; 40 μg./hour between 1 and 4 hours feeding, and 17 μg./hour between 6 and 24 hours feeding. The decrease in apparent rate of uptake with the longer feeding times is attributed to loss of <sup>32</sup>P in nymphs born during the feeding period.



When aphids were fed on seedlings raised in water-culture solution containing  $^{32}\text{P}$ , no activity was detected after 5 minutes' feeding and only a trace after 15 minutes, but when the isotope was introduced by immersing the leaves for several days in the culture solution, aphids fed for 5 minutes were detectably active.

The increase in rate of uptake after 1 hour of feeding indicates that aphids do not start to feed normally until they reach the phloem, but the activity after short feeding times suggests that previously fasted aphids do feed on other tissues, possibly the epidermis.

## Nematology Department

### GENERAL PAPERS

106. PETERS, B. G. (1953). Control of plant nematodes. *Rep. Progr. appl. Chem.*, **37**, 276.
107. PETERS, B. G. (1953). The golden nematode in Britain. *Amer. Potato J.*, **30**, 226.

### RESEARCH PAPERS

108. BROWN, E. B. & FRANKLIN, M. T. (1953). Experiments on control of eelworm in black currants. *Plant Pathology*, **2**, 101.

Spraying with 0.025 per cent parathion in early summer reduced the numbers of live eelworms in the buds of black-currant bushes, as did also severe pruning. A later spraying appeared to be without effect. The treated bushes showed less damage than the untreated in the following year. Appreciable numbers of black-currant eelworms were found in the weeds surrounding infested bushes.

109. DONCASTER, C. C. (1953). A study of host-parasite relationships. The potato-root eelworm, *Heterodera rostochiensis* in black nightshade, *Solanum nigrum* and tomato. *J. Helminth.*, **27**, 1.

It is recorded that larvae of the potato-root eelworm penetrate the roots of black nightshade, but usually fail to develop. Many degenerate and die, and infected roots usually become necrosed. Tomato roots are more readily invaded than roots of black nightshade, and whereas necrosis is less evident, heavily infected roots tend to become swollen.

110. FENWICK, D. W., PETERS, B. G. & LIBBEY, R. P. (1953). Effects of repeated field injections of D-D mixture against potato-root eelworm. *Ann. appl. Biol.*, **40**, 208.

Autumn injections of D-D mixture have been annually repeated for three years on a silt soil at Moulton (Holland, Lincolnshire) and a black fen soil at Prickwillow (Ely, Cambridgeshire), with different results. At Moulton there was an increased yield of tubers each time D-D was used, with no significant residual effects after the first year, and no marked long-term effect on the eelworm population. At Prickwillow D-D gave an increased yield in the first season only, with no positive residual effects on yield, and an apparent stimulating effect on the eelworm population. At Moulton in 1948 and 1950 (but not in 1949) the cost of the D-D treatment was heavily outweighed by the value of the resultant increase in crop. However, on the organic soil at Prickwillow D-D treatment was ineffective in 1949 and 1950, and the eelworm population, initially higher than at Moulton, remained at a level inducing failure of the potato crop.

111. FENWICK, D. W. & REID, E. (1953). Population studies on the potato-root eelworm (*Heterodera rostochiensis* Woll.). *J. Helminth.*, **27**, 119.

This paper describes a series of pot experiments on population fluctuations of the potato-root eelworm. Data are presented on the degree of cyst emptying which occurs in the vicinity of a potato plant and on the build-up following



invasion. Rate of build-up following different initial levels of infestation is discussed; there is a negative correlation between the number of new cysts produced and their larval content.

112. PETERS, B. G. (1953). Trial of ammoniacal gas liquor against potato-root eelworm. *Plant Pathology*, **2**, 65.

Ammoniacal gas liquor used in a pot test at about 1,800 gal./acre had negligible effect, both on the eelworms and on subsequently grown potatoes. At 9,000 gal./acre it killed 35 per cent of the eelworms and led to a greatly increased growth of tubers and roots; the latter supported a large eelworm population, which was finally 3.5 times that in the untreated controls.

113. PETERS, B. G. (1953). Vertical migration of potato root eelworm. *J. Helminth.*, **27**, 107.

A simple apparatus is described in which was measured the vertical migration of *Heterodera rostochiensis* larvae in soil, in the presence of the host plant. The migrations upwards and downwards are comparable and limited to about 8 inches; they can be inhibited by water-logged soil and greatly reduced if the cysts (when near the surface) are exposed to insolation under glass.

114. PETERS, B. G. (1953). Changes in potato-root eelworm population with time and depth. *J. Helminth.*, **27**, 113.

By growing potatoes in infested soil in sectional wooden boxes, changes in the population of potato-root eelworm have been observed at 5, 9, 13 and 19 weeks after planting, and at five 2-inch levels in the soil. Results show that most of the increase in population occurred during the last six weeks of the experiment and that the normal population changes proceed more slowly in the topmost level, leading to a lower final population there than at deeper levels.

## Insecticides and Fungicides Department

### GENERAL PAPERS

115. POTTER, C. (1953). The control of crop pests. *Brit. med. J.*, no. 4819, 16th May 1953, p. 1093.
116. POTTER, C. (Part author), (1952). Rothamsted experiments on field beans. Part 2. *J. Roy. agric. Soc.*, **113**, 70.
117. POTTER, C. (1953). Fifty years of research at Long Ashton Research Station. *Chem. & Ind.*, 1168.
118. (FURLONG, J. F.) & POTTER, C. The pyrethrum industry of Kenya and Tanganyika with reference to research and analytical control. Colonial Products Advisory Bureau. 16th January 1953.

### RESEARCH PAPERS

119. CONNELL, J. U. & GLYNNE JONES, G. D. (1953). Observations on the entry of dusts into the respiratory system of the adult worker honey bee, *Apis mellifera* L. *Bull. ent. Res.*, **44**, pt. 2, 291.

A description is given of the hair structures associated with the spiracles of the adult worker honeybee, *Apis mellifera* L.

The surface hairs around the spiracular orifices vary in size, density and arrangement and with the exception of those of the third, fifth and sixth abdominal spiracles appear to be capable of holding back particles greater than 30 microns.

When living bees were exposed to dust clouds of charcoal and cuprous cyanide, no particles were found in any internal part of the respiratory system beyond the spiracles, except in the case of the trachea of the first thoracic spiracle, which contained charcoal particles less than 5 microns.

The mechanism of tracheal ventilation was considered, and evidence accumulated to suggest that all spiracles could have an inspiratory function.

O



120. LORD, K. A. & POTTER, C. (1953). Hydrolysis of esters by extracts of insects. *Nature, Lond.*, **172**, no. 4380, 679.

Extracts of most of the insect species examined hydrolyse phenyl acetate much more rapidly than acetyl choline. In some species it is difficult to detect the hydrolysis of acetyl choline owing to endogenous acid production. Some evidence is also available that this enzyme is inhibited in whole extracts of some species.

121. MUKERJEA, T. D. (1953). The relationship between the stage of development and susceptibility to DDT and the pyrethrins of *Diataraxia oleracea* L., *Tenebrio molitor* L., and *Periplaneta americana* L. *Bull. ent. Res.*, **44**, pt. 1, 121.

A review of the literature is given which shows that changes in the susceptibility of insects to insecticides occur during development when the poison is applied as a fumigant, as a stomach poison and as a contact poison.

The basis of assessment of toxicity may be the concentration required to kill a given number of individuals, or the amount of poison required to kill unit weight of insect material. A mathematical method is given for transforming the results obtained in terms of concentration to kill a given number of individuals into weights of poison to kill unit weight of insect material. Rearing methods are outlined which enable batches of various stages of *Diataraxia oleracea* (L.) (tomato moth), *Tenebrio molitor* L. (meal worm) and *Periplaneta americana* (L.) (American cockroach) to be obtained at a known age and stage of development.

On the basis of the concentration of insecticide required to kill a given percentage of individuals, it is shown that great differences can occur in the resistance of different instars of one species, and considerable differences may occur within the instar. If the data for the larval and nymphal instars are considered on the basis of the weight of poison required to kill unit weight of insect material, differences still exist, but are much reduced.

The figures show that the range of variation of resistance during development may be very large, over 250 times in the case of DDT and *D. oleracea*, where the pupa is resistant. The maximum variation that was found within an instar was 16.6 times, where the resistance to pyrethrins of the one-day-old pupa of *T. molitor* was compared with that of the four-day-old pupa. The data show that the amount of variation in resistance that can occur varies with the test species and with the insecticide, furthermore, that the order of resistance of the developmental stages of any given species will differ with the insecticide, and that with any given insecticide the order will vary with the species.

It may be inferred from these data that any comparison between insecticides on one stage of development of one instar of one species will not necessarily hold true of any other stage of development of that species or of any other species.

Using data given in the literature and from some preliminary experiments on respiration rates, it was possible to deduce some correlation between metabolic rate and susceptibility, and changes in the permeability of the cuticle and chorion and susceptibility, but the evidence is unsatisfactory and the causes of the changes in susceptibility await further detailed investigation.

122. SALKELD, E. H. & POTTER, C. (1953). The effect of the age and stage of development of insect eggs on their resistance to insecticides. *Bull. ent. Res.*, **44**, pt. 3, 527.

Laboratory spraying experiments were carried out with DDT, allethrin, the triethanolamine salt of 3:5-dinitrocresol (TDNOC) and HETP against eggs of different ages of *Diataraxia oleracea* (Lepidoptera) and with allethrin HETP and TDNOC against eggs of different ages of *Ephestia kühniella* (Lepidoptera) and *Dysdercus fasciatus* (Hemiptera) under controlled temperature and humidity conditions.

The shape of the resistance-age curves obtained varied with :

- (1) the incubation temperature;
- (2) the species of egg;
- (3) the insecticide.

In eggs of *Diataraxia oleracea* very small differences in susceptibility with age were found with any of the insecticides at 75° F. and 60-70 per cent



relative humidity, but definite resistance-age curves were obtained with allethrin and TDNOC when the eggs tested had been incubated at 57° F. In this case the youngest (one-day) and the oldest eggs (fourteen-day) tested were the least resistant. DDT and HETP were tested only against the eggs of *D. oleracea* incubated at 75° F.; only small differences were found at this temperature. There were indications that the one-day-old eggs were the most resistant to these insecticides, but the results were barely significant.

The shape of the resistance-age curves for the two species of Lepidoptera tested under similar experimental conditions varied slightly but had a general similarity, but those for the Hemipteran eggs were very different. This is ascribed to differences in chorion structure and process of development between these two species of eggs.

With any one species of egg, the shape of the resistance-age curve differed from one insecticide to another. Usually, however, the shapes of the curves obtained for allethrin and TDNOC were much the same. The different type of curve with HETP is ascribed to its ease of hydrolysis.

Details are given of the effect of the poison on embryonic development.

The appearance of eggs killed at an early stage in their development was characteristic for each insecticide. When development is inhibited by TDNOC the eggs turn brown and several small brown circles, which appear to be composed of yolk material, become closely applied to the chorion; with allethrin the yolk contents become dark in colour and quite liquid; with HETP the yolk contents are colourless and the chorion opaque.

From a study of the structure and composition of the protective envelopes in different ages of eggs of *L. oleracea* it has been found that membranes are formed by the ovum during development which may hinder the penetration of insecticides to the embryo. Maximal development of these membranes occurs near the middle of the incubation period. It was possible at this time to remove the embryo enclosed within these membranes from the chorion without apparent injury to the embryo itself. Details are given of the structure and development of the egg-shell of *D. oleracea*.

The results of dipping and washing experiments with eggs of *D. oleracea* indicated that the resistance-age relationships found was due to a difference in the ability of the insecticide to penetrate the shell layers and membranes rather than to differences in the inherent susceptibility of the embryos of different eggs.

The speed of penetration of TDNOC into eggs of *D. oleracea* as determined in respiration experiments was very rapid, irrespective of the age of the egg. The poisoned eggs showed a marked initial rise in oxygen consumption, the extent of which depended upon the age of the egg, a greater increase being noticed in the one- to two- and five-day eggs than in the three- and four-day eggs. Although the metabolism of these eggs was affected, the embryos continued their development apparently normally until reaching one of the two critical stages. It is suggested that the number of embryos that succeed in passing the critical stages and in hatching depends upon the extent of the initial metabolic disturbance caused by the poison, which in turn depends upon the amount of poison reaching the embryonic material. The extent of the metabolic disturbance is an index of the amount of poison entering the egg-shell, and therefore of ultimate toxicity. The shape of the respiration curves indicates that the majority of the poison reaches the embryo either soon after application or towards the end of the incubation period, when the serosal membrane and fluids are resorbed. Thus differences in resistance that occur in the eggs of different ages are due to changes in the permeability of the egg-shell which allow more or less poison to reach the embryo.

A close correlation appears to exist between the age of eggs which shows maximum resistance to the insecticide and the age of eggs in which the embryonic membranes are present at their maximum stage of development.

123. TATTERSFIELD, F., KERRIDGE, J. R. & TAYLOR, J. (1953). The effect of repeated spraying of insects in increasing their resistance to insecticides. I. Development of resistance to DDT in a strain of *Drosophila melanogaster* Meig. *Ann. appl. Biol.*, **40**, no. 3, 498.

Successive spraying with DDT suspensions of the adults of a wild colony of *Drosophila melanogaster* and the progeny of survivors enhanced the resistance of that insecticide.



The rate at which resistance increased depended on: (1) the relative proportion of resistant to susceptible individuals; or (2) the intensity of selection as measured by the concentration of DDT and the proportion killed; or on both. The resistance of the populations of the insects fluctuated considerably whether subjected to successive sprayings or not, and in one sprayed series there was some indication of a rhythm, with peaks of susceptibility occurring at regular intervals.

Enhanced resistance may show a change of slope in the probit log concentration regression line, leading to different relative values at different levels of mortality, or by a parallel shift of the regression line. The former appears to be a preliminary stage of selection, and indicates a change in the frequency distribution within a population.

Increasing the concentration of DDT, slowly or rapidly, may have enhanced resistance at an increased rate, but the series sprayed with the lower initial concentration reached finally the same end point, as judged by the values of log L.C. 50.

During the course of these experiments the insects developed sensitivity to carbon dioxide (used in anaesthesia). Its bearing on our work is considered in Part II.

124. TATTERSFIELD, F. & KERRIDGE, J. R. (1953). The effect of repeated spraying of insects in increasing their resistance to insecticides. II. The effect of carbon-dioxide sensitivity on the toxicity of DDT within a strain of *Drosophila melanogaster*. *Ann. appl. Biol.*, 40, no. 2, 523.

During the selection of a stock of *Drosophila melanogaster* for resistance to DDT, in which carbon dioxide was used for purposes of anaesthesia, a sensitivity to this gas developed. The phenomena closely paralleled those shown by the CO<sub>2</sub>-sensitive ebony stock isolated by L'Héritier and his co-workers. An experimental analysis of its effect upon DDT sensitivity was made. It was found that a stock selected for CO<sub>2</sub> resistance gave the same probit regression line as the original stock. A CO<sub>2</sub>-sensitive stock, whether anaesthetized with nitrogen or carbon dioxide, gave the same regression line at a temperature of 25° C. at which CO<sub>2</sub> sensitivity disappeared, or at 15° C. if adjustment to the proportion of deaths in the control was made. The effect of CO<sub>2</sub> was therefore to limit the population from which selection is made for DDT resistance, rather than to alter the distribution of DDT resistance within the stock.

125. TURNER, N. & BLISS, C. I. (1953). Tests of synergism between nicotine and the pyrethrins. *Ann. appl. Biol.*, 40, no. 1, 79.

Synergism between nicotine and pyrethrum applied by injection to adult *Oncopeltus fasciatus* Dal. has been reported by Turner (1951).

When these insecticides were applied alone and as a mixture to adult *Tribolium castaneum* Hbst., using a dipping technique, the data indicated that independent joint action occurred. Similar action could be eliminated because the two insecticides had varying relative potency.

Since the effect of the pyrethrins has been short-lived in some insects, it was postulated that the absence of synergism might be caused by failure of the nicotine to reach a site of action while the pyrethrins were still acting.

Application of nicotine, followed later by treatment with pyrethrins, gave evidence of synergism. A test in which the interval between treatments was varied from  $\frac{3}{4}$  to 6 hours showed that toxicity was greatest with the shortest interval between applications, and evidence of synergism had practically disappeared after 6 hours. The maximum amount of synergism observed was about twofold.

126. WARD, J. (1953). Separation of the "Pyrethrins" by displacement chromatography. *Chem. & Ind.*, no. 24, 586-587.

The technique of displacement chromatography has been used to isolate pyrethrin I, pyrethrin II, cinerin I and cinerin II from a purified extract of pyrethrum flowers. Adsorbent alumina was contained in a glass column which gradually tapered to a small bore at the bottom. The extract, dissolved in *n*-hexane, was allowed to percolate into the top of the column, and the adsorbed "pyrethrins" were then eluted with a solution of stearic acid in



*n*-hexane. The pyrethrin content of the eluate was followed by measuring its ultra-violet absorption. The materials emerged in the order: cinerin I, pyrethrin I, cinerin II, pyrethrin II. The molecular extinction coefficients and the biological activities of the constituents were measured.

### Entomology Department

127. BARNES, H. F. (1953). Outlines of insect phenology. *Trans. 9th Int. Congr. Entom.*, **2**, 163.

Definition of "phenology"; landmarks in the origin and development of the science; and phenology as exemplified in the Cecidomyidae or gall midges.

128. BARNES, H. F. (1953). The Wheat Blossom Midges. *New Biol.*, **14**, 82.

An essay based on twenty-five years' investigation of these gall midges as they occur on Broadbalk.

129. BARNES, H. F. (1953). The absence of slugs in a garden and an experiment in re-stocking. *Proc. zool. Soc. Lond.*, **123**, 49.

The introduction and subsequent observation of 1,000 Grey Field slugs in a garden where they were absent has shown that most probably this species had died out during some previous dry spell owing to the failure of the almost humus-free soil to retain moisture.

130. BARNES, H. F. (1953). The biological approach to the species problem in gall midges (Dipt., Cecidomyidae). *Ann. ent. fenn.*, **19**, 2.

An account of the use that has been made of the biological approach during the past quarter of a century and an indication of some immediate needs.

131. BARNES, H. F. (1953). Description of the new gall midge found by M. R. Pussard on Lavender, together with notes on the damage caused by some other species. *Bull. Soc. ent. Fr.*, **58**, 125.

132. BARNES, H. F. (1953). The Shasta Daisy Midge and other insects in flowers of *Chrysanthemum* species. *Plant Pathology*, **2**, 52.

Preliminary information on the biology, the range of oviposition on *Chrysanthemum* species and the distribution in the British Isles of the Shasta Daisy Midge (*Contarinia chrysanthemi*), together with notes on the distribution of two other primary gall midge species, as well as other gall midges, flies, weevils, moths and hymenoptera.

133. BARNES, H. F. & (PALMER, RAY) (1953). Bedfordshire plant galls. Preliminary list. Part I. Diptera. *Bedfordshire Naturalist*, **7**, 21.

134. (BUXTON, P. A.) & BARNES, H. F. (1953). British Diptera associated with fungi. 1. Gall midges (Cecidomyidae) reared from the larger fungi. *Proc. R. ent. Soc. Lond.*, **B**, **22** (11/12), 195.

Includes the description of a new species reared from *Auricularia auricalajudae*.

- 134a. JOHNSON, C. G. (1952). The role of population level, flight periodicity and climate in the dispersal of aphids. *Trans. 9th Int. Cong. Entom.* **1**, 429.

135. JOHNSON, B. (1953). Flight muscle autolysis and reproduction in aphids. *Nature, Lond.*, **172**, 813.



- 135a. JOHNSON, B. (1953). The injurious effects of the hooked epidermal hairs of French Beans (*Phaseolus vulgaris* L.) on *Aphis craccivora* Koch. *Bull. ent. Res.* **44**, 779.
136. JOHNSON, C. G. (1954). Aphid migration in relation to weather. *Biol. Rev.*, **29**, 1.
137. (TAYLOR, C. E.) & JOHNSON, C. G. (1954). Wind direction and the infestation of bean fields by *Aphis fabae* Scop. (In the press.)
- 137a. LONG, D. B. (1953). Effects of population density on larvae of *Lepidoptera*. *Trans. R. ent. Soc. Lond.*, **104**, 543.

A study has been made in some detail of effects on the morphology, physiology and behaviour of larvæ. In some species crowded cultures were darker in colour than their solitary controls and the factors involved have been considered. Crowding increased the rate of development and decreased the number of instars. This was accompanied by a more simultaneous development which in a multi-voltine species could under favourable conditions lead to a population build-up. In general the effects were shown to be comparable with the "phases" of locusts.

138. SOUTHWOOD, T. R. E. (1953). The morphology and taxonomy of the genus *Orthotylus* Fieber (Hem., Miridae), with special reference to the British species. *Trans. R. ent. Soc. Lond.*, **104**, 415.

An account of the general morphology of the genus and a reassessment of the taxonomic value of various characters. The structure of the genus, which is divided into four sub-genera, two of which are new, is discussed. A key is given to the eighteen British species.

139. SOUTHWOOD, T. R. E. (1953). Interspecific copulation between *Nabis ferus* (L.) and *N. rugosus* (L.) (Hem., Nabidae). *Ent. mon. Mag.*, **89**, 294.

A brief account of an observation which suggests the existence of a mechanical barrier to pairing in these two sympatric species.

140. STOKES, B. M. (1953). The host plant range of the Swede Midge (*Contarinia nasturtii* Kieffer) with special reference to types of plant damage. *Tijdschr. PLZiek.*, **59**, 82.
141. STOKES, B. M. (1953). Biological investigations into the validity of *Contarinia* species living on the Cruciferae, with special reference to the Swede Midge, *Contarinia nasturtii* (Kieffer). *Ann. appl. Biol.*, **40** (4), 726.

142. WILLIAMS, C. B. (1953). Comment on a query about a missing value in an insect bait trap experiment. *Biometrics*, **9** (3), 425.

Showing that the working out of a missing value in a trapping experiment on insects may give unreliable results if the catches are used on an arithmetic scale. The use of a geometric (logarithmic) scale is believed to give more reliable results.

143. WILLIAMS, C. B. (1954). The statistical outlook in relation to ecology. *J. Ecol.*, **42** (1), 1.

Presidential address to the British Ecological Society dealing with the effect of the mathematical and statistical outlook on various ecological problems, including the layout and interpretation of experiments, and particularly studies made at Rothamsted on the relative abundance of species; on the numbers of species in different genera; on the measurement of diversity; and on intra-generic competition in animals and plants.

## Bee Department

### BOOKS

144. BUTLER, C. G. (1954). *The world of the honeybee*. (New Naturalist Series). London: Collins.
145. RIBBANDS, C. R. (1953). *The behaviour and social life of honeybees*. London: Bee Research Association Ltd.



GENERAL PAPERS

146. BUTLER, C. G. (1953). The present status of beekeeping in Ceylon and possibilities for its future development. *Brit. agric. Bull.*, **6** (no. 26), 125.
147. BUTLER, C. G. (1953). A report on the results of an investigation into the possibilities of beekeeping in Ceylon, together with some suggestions for the future development of beekeeping in the Island. *Sessional Paper, Govt. of Ceylon*.

RESEARCH PAPERS

148. BAILEY, L. (1953). The effect of fumagillin upon *Nosema apis* (Zander). *Nature, Lond.*, 171, 212.

The curative effect of fumagillin upon an established infection within individual bees is described. The drug acts upon the developing intracellular stage of the parasite, but relapses occur even after continuous treatment for seventeen days.

149. BAILEY, L. (1953). The treatment of *Nosema* disease with fumagillin. *Bee World*, **34**, 136.

The results of autumn treatment of infected colonies with fumagillin are given. The preventive effect of this treatment upon the resurgence of the disease during the following spring was striking. However, a low level of infection became apparent in treated colonies in late spring. It is considered to have arisen from the old comb, which still contained viable spores from the previous year.

150. BAILEY, L. (1953). The transmission of *Nosema* disease. *Bee World*, **34**, 171.

The carrying over of the disease from one year to the next by spores upon comb has been demonstrated. The transference of colonies from old combs to new comb foundation during early summer has been shown to be effective in breaking the cycle of infection, as the transmission of this disease from infected to healthy bees virtually ceases during the flying season.

151. RIBBANDS, C. R. & SPEIRS, NANCY (1953). The adaptability of the homecoming honeybee. *Brit. J. anim. Behav.*, **1**, 59.

Groups of foraging bees of known ages were marked individually and introduced to a colony of bees. One to five days later the breedchamber housing this colony was turned through 90° and changed in height. Two days later it was turned through a further 90° and its height was changed again. The marked bees reorientated quickly and completely in these experiments, and their age had no effect upon their adaptability. Colony odour facilitated reorientation.

152. RYLE, M. (1954). The influence of nitrate, phosphate and potash on the secretion of nectar. Part I. *J. agric. Sci.* (In the press.)

153. RYLE, M. (1954). The influence of nitrate, phosphate and potash on the secretion of nectar. Part II. *J. agric. Sci.* (In the press.)

These two papers describe the results of work on the effect of fertilizer treatment on nectar secretion in mustard, buckwheat, apple and red clover. It has been shown that in the case of apple-trees the mean quantity of sugar produced per flower can be significantly increased by extra potash. In experiments with the other plants mentioned it was found that any treatment which checked growth at flowering time, apart from a shortage of potash, increased the yield of nectar.



154. WYKES, GWENYTH, R. (1953). The sugar content of nectars. *Biochem. J.*, **53**, 294.

The sugars present in nectar secreted by twelve species of plants were separated on paper chromatograms, and quantitative determinations were made of the glucose and fructose present. It was found that the proportions of glucose and fructose varied greatly in nectar from the different species, but, for any one species, the proportions of these sugars appeared to remain relatively constant.

## Statistics Department

### BOOKS

155. YATES, F. (1953). *Sampling methods for censuses and surveys*. 2nd Edition. London: Griffin.

Two new chapters have been added. These amplify certain aspects not fully dealt with in the first edition and contain accounts of various recent developments. Some space is also devoted to problems arising in the analysis of investigational surveys.

(Translations of the 1st Edition into French (1951) and Japanese (1953) have also been published.)

156. FISHER, R. A. & YATES, F. (1953). *Statistical tables for biological, agricultural and medical research*. 4th Edition. Edinburgh: Oliver & Boyd.

New material included in the fourth Edition is: a table providing a test for the existence of a periodic component; a table of segmental functions which serve to specify the frequencies of non-recombinant and recombinant gametes in terms of the metrical positions of the centromere, a series of markers and the terminus of the chromosome arm; random permutations of ten and twenty numbers for use in the construction of experimental arrangements; an additional table of the normal integral with the deviation from the mean of the distribution as argument. The section of the introduction on dosage mortality tests involving a natural death-rate has also been re-written.

### RESEARCH PAPERS

157. BOYD, D. A. & LESSELLS, W. J. (1954). The effect of seed-rate on the yield of potatoes. *J. agric. Sci.* (In the press.)

This paper examines the relation between seed-rate and yield of maincrop potatoes, using data from experiments reported in the literature. Optimum seed-rates are presented for a range of prices of seed and produce, and these are compared with estimates, derived from the Survey of Maincrop Potatoes and the Survey of Fertilizer Practice, of the actual amounts planted by growers in different parts of the country.

Provided the optimum seed-rate is attained, the precise combination of seed size and spacing distance appears to be of minor importance. The optimum rate of planting of certified seed is estimated to be 16-17 cwt./acre in the main potato-growing areas of the country, while the normal planting rate in these districts is over 1 ton/acre. The failure to plant at the optimum seed-rate results in an estimated loss of 20-25s./acre. For once-grown seed the optimum seed rate is at least 1 ton/acre, whilst the average weight of seed planted is only about 17 cwt./acre, resulting in a loss per acre of 10-15s.

The explanation of the discrepancy between experiment and practice appears to be that a grower usually maintains the same spacing between sets regardless of their size; certified seed tends to be larger in size than does once-grown seed.

158. BOYD, D. A. & LESSELLS, W. J. (1954). Influence of fertility levels on grassland output. I. Review of fertilizer experiments on grassland in relation to current fertilizer usage. *Brit. J. Grassl. Soc.* (In the press.)

The paper sets out to summarize very briefly the results of experiments carried out on the effect of fertilizers applied to grassland. The yield of starch



equivalent from nitrogen applied to dried grass, silage and hay varies between 10 and 15 per cwt. N according to the quality of the product. Responses of hay to phosphate and potash are also quoted. For grazed land, which amounts to over two-thirds of the total grassland acreage each year, very little experimental data on fertilizer responses is available; what there is suggests that moderate quantities can be applied without unduly affecting the legumes in the sward, when they give as good a return as in the experiments on conserved grass, but that the successful use of larger quantities demands a high standard of grazing management.

Results from the Survey of Fertilizer Practice show that whilst the amount of nitrogen used in practice rose considerably from the very low level during and before the war, it has remained practically unchanged since 1950, although there was evidence of a slight upward trend in 1953. More than half the leys and three-quarters of the permanent grass received no nitrogen in 1952-53. There are considerable variations within the country; intensive dairying districts like West Cheshire and the Fylde district of Lancashire are using about 0.25 cwt. N per acre on temporary grass and 0.1 cwt. N per acre on permanent grass, whereas in many less-intensive rearing and feeding districts less than one-quarter of these amounts is being used.

A simple calculation shows that if the acreage of grassland dressed with nitrogen could be doubled the gross return for expenditure of about 70,000 tons N would be about 0.8 m. tons starch equivalent, giving a net return of something like £10 m. Such an increase could not, however, be attained without at the same time effecting an improvement in management so that the extra feed produced was actually utilized.

For phosphate and potash there is little clear evidence of how much is required, except for permanent meadows and leys cut for hay, silage, etc. Whilst there are still individual farms and districts where phosphate deficiencies have not been overcome, the phosphate status of most of our grassland has improved substantially in recent years, and the average consumption at about 0.2 cwt.  $P_2O_5$  per acre does not appear unduly low. It is, however, much less than the amount used by many successful graziers, and here again there is a great need for extensive experimental work.

159. CHURCH, B. M., (JACOB, F. H. & THOMPSON, H. V.) (1953). Surveys of rabbit damage to wheat in England and Wales, 1950-52. *Plant Pathology*, **2**, 107.

In 1950 a pilot survey was carried out in Kent to estimate rabbit damage on spring wheat by comparing yields on protected and unprotected plots. The methods used in this survey, and in the 1952 survey of winter wheat in England and Wales, are described. The survey results show that the differences between the average yields on protected and unprotected plots must be almost entirely due to rabbit damage. The estimated average loss of winter wheat throughout the country in 1952 due to rabbit grazing was  $1\frac{1}{2}$  cwt. grain per acre.

160. (CONSTABLE, D. H.) & HODNETT, G. E. (1953). The manuring of *Hevea brasiliensis* at Dartonfield, Ceylon. *Emp. J. exp. Agric.*, **21**, 131.

The data on girth of the trees and yield of rubber obtained during the first thirteen years of a fertilizer trial on *Hevea brasiliensis* at Dartonfield have been analysed. With both girth and yield the principal response was to phosphate. The results of this experiment did not indicate any appreciable interactions.

161. DYKE, G. V. & AVIS, P. R. D. (1953). A survey of maincrop potatoes, 1948-1950. I. Estimates of yield. *J. agric. Sci.*, **43**, 450.

A survey of maincrop potatoes was carried out by members of the National Agricultural Advisory Service in 1948, 1949 and 1950 in collaboration with the Statistics Department. Potato-growing farms in forty counties were grouped according to potato acreage, and random selections were made with differing sampling fractions. Each farm was visited several times, and many particulars obtained; the present paper deals only with estimates of yield.



These were based on small samples dug by hand from specified locations in (at most) two fields per farm.

The standard error of the mean (based on about 1,000 sampled fields) was about 0.2 tons/acre (2 per cent). The sample estimates were compared with yields calculated from the total weights of produce per field wherever these were obtainable. This showed good agreement in 1948 and 1949, but an excess of the sample estimates of 0.9 tons/acre in 1950, possibly because a late infection of blight reduced the final yield.

The official estimates issued by the Ministry of Agriculture are shown to be less than the sample estimates by about  $1\frac{1}{2}$  tons/acre in each year. Under-estimation seems to arise almost entirely from the counties which in a particular year have high yields, yields of 7 tons and under being estimated without serious bias by the official Crop Reporters.

162. HEALY, M. J. R. (1953). A method for comparing fly-repellant sprays. *Biometrics*, **9**, 290.

In a standard method for comparing two fly-repellant sprays, batches of mice are treated with the two materials under test and are subsequently exposed to attack by *stomoxys* flies. An untreated batch is included for purposes of comparison, and it is found that the attack rate in the controls varies considerably from one batch to another. If  $p_0, p_1, p_2$  are the observed mean attack rates in the controls and the two sets of treated mice on any one occasion, it is assumed that only a proportion  $p_0$  of the flies were liable to attack in the treated batches, so that  $p_1/p_0, p_2/p_0$  are estimates of the attack rates in the treated mice if all the flies were liable to attack. Assuming these "true" attack rates to be essentially constant, a method is given for estimating them from observed data and for making statistical comparisons.

163. HEALY, M. J. R. (1953). Principles of biological assay. (In: *Modern methods of plant analysis*, edited by K. Paech and M. V. Tracey.)

An outline is given of the commoner statistical techniques used in biological assay. The subjects covered include direct assays, parallel line and slope-ratio assays with a quantitative response and probit assays. There are discussions of the planning of assays and of suitable experimental designs, and worked examples of the recommended techniques.

164. HEALY, M. J. R. & DYKE, G. V. (1954). A Hollerith technique for solving normal equations. *J. Amer. statist. Ass.* (In the press.)

In the critical analysis of survey data it is often necessary to fit constants to observed data by the method of least squares. The resulting simultaneous equations are most readily solved by a process of successive approximation, and a technique is given for carrying out this process on a Hollerith sorter and tabulator. In data arising from a survey of maincrop potatoes involving some thirty equations, the method was about five times as fast as hand computation.

165. LEECH, F. B. & (BAILEY, G. L.) (1953). The effect on the health of lactating cows of treatment with galactopoietic doses of thyroxine or iodinated casein. *J. agric. Sci.*, **43**, 236.

The effect on cow health of galactopoietic stimulation with thyroactive materials was determined from a statistical study of the results of a large field experiment involving 2,000 cows over a three-year period. The same experimental procedure was followed on thirty-seven farms scattered over England, Scotland and Wales. This procedure was planned to ensure that half the cows in each herd would receive a course of treatment with iodinated casein or thyroxine, and that the other half would constitute a suitable set of controls. Cows that remained in the herds received second and third treatments in successive lactations. The galactopoietic stimulation was started at a fixed interval after calving, irrespective of the season of the year.

The use of the thyroactive materials in successive lactations did not have any serious adverse effects on the health of cows. The effect on productivity was less than had been expected, since the increase in milk yield resulting



during the period of hormonal treatment was often largely or completely negated by a shortening of the lactation period. The incidence of disease was somewhat greater in the treated than the control group, the principal contribution to this difference being from the diseases described as digestive disorders. There were some other differences of lesser significance. The rate of disposal of treated and control groups was almost identical. There were no adverse effects on the reproductive life of treated cows; factors studied were the efficiency of coitus, interval between parturitions, length of gestation and incidence of abnormalities at parturition.

During the period of treatment, there was a marked response in daily milk yield, but the fat content of the milk was not raised. L-Thyroxine sodium replaced iodinated casein on twenty-six farms during the second and third years. There was no significant difference in the milk-yield responses resulting from the two drugs. Cows readily ate cubed feeding-stuffs containing thyroxine, but frequently did not relish similar cubes fortified with iodinated casein.

166. (PATERSON, A. B.) & LEECH, F. B. (1954). Factors affecting the intradermal tuberculin reaction on the guinea-pig. *Amer. Rev. Tuberc.* (In the press.)

Differences in the dose-response curves of PPD and OT tuberculins were demonstrated on guinea-pigs sensitized with dead organisms in oil; such differences can be measured only in large-scale assays. Similar results were obtained when the same experiment, using a fresh randomization scheme, was repeated after an interval of three months, on the same set of sensitized guinea-pigs.

Multiple tuberculin injections in the sensitized guinea-pig depressed the response to the individual injection. The depression is probably related to the degree of systematic response, and is not a local influence of one tuberculin reaction on an adjacent one.

167. PATTERSON, H. D. (1954). The errors of lattice sampling. *J. R. statist. Soc. B.* (In the press.)

Samples can be selected from a  $p \times p \times p \times \dots$  classification with one unit in each sub-class in such a way that they include equal numbers of units from each main class or from each combination of two, three or more main classes in different classifications. Such samples can be named *lattice samples*. The paper provides a discussion of the errors of lattice samples.

Methods for (a) determining the errors of lattice sampling from the population data and (b) estimating the errors (if this is possible) from the actual sample data, are described in detail for the cases of the  $p \times p$  classification and the  $p \times p \times p$  classification. The results are extended to the general case of  $p^n$  classification. In addition, examples of lattice sampling from  $p \times p \times q$  classifications and lattice sampling at a single stage of multi-stage sampling are briefly considered.

168. YATES, F. (1954). The analysis of experiments containing different crop rotations. *Biometrics.* (In the press.)

The problems arising in the analysis of experiments containing different crop rotations are investigated. When the design of the experiment is such that each block contains plots which sometimes carry a given crop but do not all carry the crop in the same set of years the year-block totals will not be orthogonal with the plot totals. In most such cases the fitting of constants must be resorted to in order to obtain separate estimates of plot error and plot  $\times$  year error which are free of year  $\times$  block interactions. The method is illustrated by application to a rice-pasture experiment containing rotations of different lengths and with different proportions of rice to pasture.

169. YATES, F. (1953). The wider aspects of statistics. (Address given at the inauguration of the Sixth Annual Meeting of the Indian Society of Agricultural Statistics.) *J. Ind. Soc. agric. Stat.* (In the press.)

The need for statisticians to play their part in the planning of experimental programmes, the critical appraisal of their results as a whole and the



application of these results to the improvement of agricultural production is emphasized.

170. YATES, F., (FINNEY, D. J. & PANSE, V. G.) (1953). The use of fertilizers on food grains. *I.C.A.R. Res. Series, No. 1.*

All readily available facts on responses of Indian food grains to sulphate of ammonia and superphosphate are summarized. It was found that the nitrogen responses are in the main very consistent, 2.5 maunds of grain per acre from 20 lb. N per acre being a reasonably representative figure for all cereals. For phosphate, responses are smaller and more variable. One series of experiments on cultivators' fields consistently shows appreciable responses to potash for paddy and maize, suggesting that the usual statements about the adequacy of potash in most Indian soils need re-examination.

The economics of fertilizer application is outlined. The conclusion is reached that, at present prices, 20 lb. N per acre as sulphate of ammonia to food grains will be definitely profitable on most soils, and that an equal dressing of  $P_2O_5$  will be equally good if restricted to the more responsive soils. From the point of view of the national balance of payments, such manuring is relatively even more advantageous than it is to individual cultivators: a large-scale programme of fertilizer use, if necessary temporarily aided by imports of fertilizer, could go far towards removing India's food deficit.

171. YATES, F. & GRUNDY, P. M. (1953). Selection without replacement from within strata with probability proportional to size. *J. R. statist. Soc. B.*, **15**, 253.

In selection with probability proportional to size  $x$  from within strata without replacement, the usual method of selection gives rise to bias in the estimate of the total of a variate  $y$  derived by weighting the units by weights proportional to  $1/x$ . By means of numerical examples it is shown that the amount of this bias is usually quite trivial. If, however, unbiased estimates are required, the true total probabilities of selection of the different units can be easily calculated for samples of 2, and with considerably more labour for samples of 3.

The bias in the ordinary formula for the estimation of error is also investigated, and the formula is shown to be reasonably accurate. An unbiased estimator put forward by Horvitz and Thompson in 1952 is shown to be very inefficient, and a new unbiased estimator is given.

A method for revising the size measures so that with the usual method of selection the true total probabilities of selection are proportional to the original size measures is given for samples of 2. Horvitz and Thompson's solution of this problem does not appear to give satisfactory approximations in the cases met with in practice.

The selection of successive members of a sample with arbitrary sets of probabilities chosen solely so that the total probabilities shall be proportional to the original size measures, which has been advocated in various quarters, is criticized.

#### REVIEWS

172. HEALY, M. J. R. (1953). "The Statistics of Bioassay," by C. I. Bliss; "Statistical Method in Biological Assay," by D. J. Finney; "Probit Analysis," by D. J. Finney. *Biometrika*, **40**, 473.
173. HEALY, M. J. R. (1953). "The Design and Analysis of Experiment," by M. H. Quenouille. *J. R. statist. Soc. A*, **116**, 453.
174. PATTERSON, H. D. (1953). "Field Experimentation with Fruit Trees and Other Perennial Plants," by S. C. Pearce. *Nature, Lond.*, **172**, 221.
175. YATES, F. (1953). "Cambridge Elementary Statistical Tables," by D. V. Lindley and J. C. P. Miller. *Nature, Lond.*



REPORTS

176. (EDWARDS, D. A. W., HAMMOND, W. H.) HEALY, M. J. R. (& TANNER, J. M.). (1953). Design of skinfold calipers—preliminary report to the Medical Research Council Committee on Growth and Form.
177. HODNETT, G. E. (1953). Statistical methods for sample surveys. African Training Centre for Agricultural Statistics, F.A.O. ATCAS/C.3.
178. HODNETT, G. E. (1953). The responses of sugar-cane to fertilizers in British Guiana, Mauritius, Barbados and Antigua. Reports to the Colonial Office.

General Publications

179. BOALCH, D. H. (1953). *The manor of Rothamsted*. Harpenden : Rothamsted Experimental Station.
180. (GARDNER, H. W.) & GARNER, H. V. (1953). *The use of lime in British agriculture*. London : E. & F. Spon Ltd.
181. GARNER, H. V. (1952). More about salt. *Brit. Sug. Beet Rev.*, **21**, 75.
182. GARNER, H. V. (1953). Manuring of sugar beet. Chap. VIII of *Min. Agric. Bull.*, 153, 30.
183. OGG, Sir W. G. (1953). Organic manures and fertilizers. Contribution to discussion on organic manures and fertilizers and the production and composition of food for man and animals. *Proc. R. Soc. Med.*, **46**, (9), 791, Sept., 1953.